

**SPATIO-TEMPORAL ANALYSIS OF MOPANE WORM UTILISATION IN
SOUTH-WESTERN ZIMBABWE**

BY

TENDAYI GONDO

STUDENT NO:11635987

SUPERVISOR: PROF AINA THOMPSON ADEBOYEJO

CO SUPERVISOR: PROF. JAMES CHAKWIZIRA

UNIVERSITY OF VENDA

FACULTY OF SCIENCE ENGINEERING AND AGRICULTURE

**SPATIO-TEMPORAL ANALYSIS OF MOPANE WORM UTILISATION IN
SOUTH-WESTERN ZIMBABWE.**

**BY
TENDAYI GONDO**

STUDENT NO:11635987

**A PhD thesis submitted to the Department of Urban and Regional Planning in the Faculty
of Science, Engineering and Agriculture for the award of PhD degree in Urban and
Regional Planning.**

SUPERVISOR: PROF AINA THOMPSON ADEBOYEJO

CO SUPERVISOR: PROF. JAMES CHAKWIZIRA

2024

DECLARATION

I, Tendayi Gondo, student number: 11618377 hereby declare that this thesis - **LOCAL ECONOMIC DEVELOPMENT IMPLICATIONS OF SPATIO-TEMPORAL CHANGES IN MOPANE WORM UTILISATION IN SELECTED COMMUNITIES OF SOUTH-WESTERN ZIMBABWE** is my own work. It is being submitted for the fulfilment of Degree of **PhD degree in Urban and Regional Planning** at the University of Venda. This work has not been submitted before for any degree or publication to any other university. It is original in design and in execution, and all reference materials contained therein have been duly acknowledged.



25 October 2024

Signature

Date

STUDENT NO:11635987

DEDICATION

To my wife and children.

ACKNOWLEDGEMENT

I would like to express my deepest appreciation to my Promoter, **PROF AINA THOMPSON ADEBOYEJO** and my co-promoter **PROF. JAMES CHAKWIZIRA** for playing a significant role in supporting and guiding me throughout my PhD journey. This endeavour would not have been a success without all the feedback, guidance, and academic support he gave to me throughout my writing.

ABSTRACT

Rural areas of developing countries such as Zimbabwe and other emerging economies have in recent years become a source of several pertinent international concerns. Major areas of concern include extreme poverty and hunger, and rising spatial and interpersonal disparities, challenges that the concerned national governments and the wider international community have failed to make meaningful headway in addressing. With the share of traditional sectors of agriculture, mining and manufacturing declining, many rural households in southwestern district of Matobo District in Zimbabwe Mopane Worms (MWs) have emerged as an alternative resource that can be harnessed for the betterment of their local economies. Such attention have been complemented by efforts from international development partners such as the International Labour Organization (ILO), Department for International Development (DFID), Global Environment Fund (GEF) and local development agencies such as Southern Alliance Fore Indigenous Resources (SAFIRE), Institute of Environmental Studies (IES), and local academic institutions among others who have invested their efforts in trying to optimise local gains from MW utilisation. Such efforts have unfortunately missed the fundamental knowledge deficiencies associated with MW utilisation, that makes it currently difficult to craft a MW oriented LED strategy. There is currently dearth of research scholarship on the spatiotemporal dynamics associated with MW resource dependency. We also lack data on spatio-temporal factors that shape successful territorial dynamics that would lead to situations of growth in the MW industry and the local economy. We lack a complete understanding of resilience dynamics associated with MW territories and how such may limit or enhance capacities of concerned communities when faced with adversity. Finally, no single study has drawn important connections between MW utilisation and the local economy. The present study sought to bridge this knowledge gap by addressing these shortcomings using a case study of five villages drawn to the southwestern rural district of Matobo, in Zimbabwe. Using a combination of household survey data and a series of PRA studies conducted, the study employed a variety of statistical tools and calculation of partial LED indices such as The Gini Coefficient, Successfully Territorial Dynamic Index, Rural access index, Resilience capacity among others to estimate the impact of MW utilisation on the local economy. Logistic regression analysis was employed to understand MW resource dependency. Other approaches such as Data Envelop Analysis (DEA) were also used to assess the contribution of MW use towards addressing territorial imbalances. Our findings reveal that in addition to widely mentioned socio-demographic variables, MW resource dependency is heavily influenced by many special variables including rural access, distance to markets, market efficiency. A combination of results from DEA and use of clustering algorithms revealed that a MW territory's capabilities in terms of social, economic, institutional, ecological and engineering capability attributes is crucial in determining territorial success. The study also revealed important positive differences between the partial LED indices of communities where the intensity of trade measured by the Household commercialisation Index (HCI) was high. We found out that MW are reducing income inequalities, territorial imbalances, and in enhancing the resilience capacities of communities. We conclude by proposing a MW-oriented LED strategy that strikes a balance between pro-growth and pro-poor interventions. We proposed the implementation of both an input-oriented and output-oriented LED strategy that is place sensitive. A progressive entrepreneurial ecosystem frame is developed that may lead to situations of growth in the MW industry and local economy.

Key words: *mopane worms, mopane worm utilisation, local economic development, spatiotemporal analysis, territorial dynamics*

TABLE OF CONTENTS

DECLARATION	i
DEDICATION	ii
ACKNOWLEDGEMENT.....	iii
ABSTRACT.....	iv
CHAPTER ONE: The problem and its setting.....	1
1.0 Introduction.....	1
1.2 Background to the research problem.....	4
1.3 The problem statement.....	6
1.4 Objectives of the study.....	10
1.4.1 Broad objective	10
1.4.2 Specific objectives	10
1.5 Hypothesis	11
1.6 Expected outcomes	12
1.7 Policy significance	12
1.8. Scope of the study	14
CHAPTER TWO: NTFP resource dependency and associated dynamics: The need for spatiotemporal and Local Economic Development studies	15
2.0 Introduction.....	15
2.1 NTFPs and the rural economy: A local and Economic Development perspective	15
2.2.1 Establishing the need for spatiotemporal research in NTFP and Local Economic Development studies.....	15
2.2.2 Why place based territorial studies have gained credence in LED research.....	20
2.2.3 Distinguishing attributes of people and place-based approaches.....	22
2.2.4 People and place-based approaches: LED implications.....	27
2.2.5 Key LED related features worth analysing if the growth potential of NTFPs to be properly explored: In search of a methodological framework.....	28
2.2.6 MW resource dependence dynamics: To harvest or not harvest MWs.	32

CHAPTER THREE: MWs and the rural economy: A conceptual note on household interactions with local economy.....	36
3.0 Introduction.....	36
3.1 What are mopane worms?.....	36
3.2 Mopane worms and the local economy: General importance	38
3.3 MW use and its interactions with the rural economy.....	42
3.2.1 MWs versus the local economy: The required shift.....	44
3.2.2 Why current MW studies have failed to shape the LED agenda.	45
3.4 MW household Interaction with the local economy and beyond.....	45
3.4.1 A territorial / regional dynamism in marketing strategies approach	46
3.4.2 A food security perspective	48
3.4.3 A ‘resource to other sectors’ linkage perspective	52
3.4.4 Household Infrastructure and Services Index (HISI) approach	55
3.4.5 A ‘development as hanging in, stepping up and stepping out’ perspective.....	58
3.4.6 A ‘MW households as agents of change’ perspective.	65
3.4.7 MW innovation landscape as key to unlocking LED.....	71
3.5 Spatial distribution of mopane worm producing areas in Zimbabwe.	73
3.5.1 State of innovation in the MW industry	74
3.5.2 Mopane worm farming innovations.....	75
3.5.3 MW research scholarship gaps.....	77
3.6 The rural development Policy Landscape in Zimbabwe.....	78
3.6.1 The local Economic Development Context in Zimbabwe	78
3.6.2 Forest products as a potential solution to the poverty challenge	82
CHAPTER FOUR: MW use and territorial dynamism: Conceptualizing territorial success and resiliency in MW dependent communities	85
4.0 Introduction.....	85
4.1 Mopane Worm Resource Extraction, External Shocks and livelihoods implications.....	85
4.1.1 MWs and territorial resilience scholarship gaps	86

4.2 MW use and Successful Territorial Dynamics.	91
4.2.1 The social system	92
4.2.2 Ecological system	92
4.2.3 The governance system	94
4.2.4 The physical / engineering system	98
CHAPTER FIVE: <i>Research Methodology</i>	99
5.0 Introduction.....	99
5.1 The research design philosophy	99
5.1.1 Participatory Rural Appraisal (PRA) design philosophy for selected LED insights	99
5.1.2 Research Design.....	102
5.2 Research and Sampling design	102
5.4 Analysis of research Objectives	108
5.4.1 Objective 1: To estimate spatial and temporal changes in rural household dependency on the MW industry.....	108
5.4.2 Objective 2: To analyse spatiotemporal changes in factors explaining successful territorial dynamics that lead to situations of growth in the MW industry and the local economy at large.	116
5.4.3 Objective 3: To evaluate the nature and strength of MW farm household interactions with the local economy.	125
5.5 Research Ethics	138
Chapter 6: <i>Estimating spatial and temporal changes in rural household dependency on the MWs.</i>	140
6.0 Introduction.....	140
6.1 Spatial and temporal variation in demographics of harvesting households.....	140
6.1.1 Household headship and harvesting behaviours.	140
6.2 Spatial and temporal variations in the number of households and harvesters involved in harvesting.	144
6.2.1 Spatial and temporal variations in household size per village.....	144
6.3 Spatial and temporal changes in quantity of MWs harvested and sold.....	147
6.3.1 Spatial and temporal changes in quantity of MW harvested.....	147

5.3.1	Spatial and temporal changes in quantity of MW consumed.....	151
6.3.2	Spatial and temporal changes in quantity of MW sold.	155
6.4	Spatial and temporal changes in the intensity of MW resource commercialisation	157
4.4.1	Temporal variations in the HCI.....	157
6.4.2	Spatial and temporal changes in HCI.....	158
6.5	A cluster analytical creation of consumption and trading activities	159
6.5.1	Number of emerging unique clusters	159
6.6	Type of markets accessed by trading households.	161
6.6.1	Spatial and temporal changes in the type of markets mostly accessed byhouseholds....	161
6.6.2	Spatial and temporal changes in the prices of MWs according to typeof markets mostly accessed by households.....	162
6.7	Statistical estimation of factors that explain householddependency on MW resource.	163
6.8	Spatial variations in economic complexity and quantities ofMWs harvested and traded.	171
6.8.1	Spatial differences in the Village Economic Complexity Indices	171
6.8.1	Spatial variation in road pavement distress conditions andparticipation of local traders into the output market	173

CHAPTER 7: Spatiotemporal changes in factors explaining success and resilience of MW

Territories.....	177
7.0	Introduction.....
7.1	Spatial and temporal changes in factors explaining successfulterritorial dynamics that lead to situations of growth in the MWindustry and the local economy at large.....
7.1.1	Descriptive statistics on territorial attributes that define territorial success.....
7.1.2	Territorial cluster size and composition
7.2	Defining successful territorial dynamics.....
7.2.1	Detailed description of MW territories according to capability definingattributes.
7.3	Measuring territorial success: The Data Envelop Analysis (DEA)approach.
7.4	Spatial and temporal changes in MW territorial performance.....
7.4.1	Territorial performance based on quantity of MWs harvested.

7.4.2	Territorial performance based on quantity of MWs sold to the market.....	193
7.4.3	Territorial performance based on the Household Commercialisation Index (HCI).....	196
7.4.4	Territorial performance based on selected livelihood pathways.	197
7.5	Factors affecting territorial success.....	199
7.6	MW territorial space resistance to external changes and shocks in the local environment and beyond.....	203
7.6.1	Effect of external shocks on resilience strategy adoption	203
7.6.2	A cluster analytical creation of MW communities according to Territorial Resilience attributes.....	208
CHAPTER 8: An evaluation of the nature and strength of MW farm household interactions with the local economy.....		220
8.0	Introduction.....	220
8.1	A ‘regional / territorial dynamism in marketing’ approach	220
8.1.1	Decision mapping of household’s likelihood to interact with output markets.....	221
8.1.2	Distribution channel choice versus spatial concentration of MW trade.....	226
8.1.3	Household interaction with the local economy versus spatial concentration of MW trade	230
8.2	A ‘resource to other sectors linkage’ approach.....	233
8.2.1	Spatial and temporal changes in the MW income realised by households.....	234
8.2.2	Spatial and temporal changes MW income by village during the WRS	239
8.2.3	Nominal versus real MW income	244
8.2.4	A temporal perspective on MW income and its significance to various sectors of the local economy (WRS)	247
8.3	A ‘development as hanging in, stepping up and stepping out’ perspective.	253
8.3.1	Typology of livelihood strategies adopted by households during the WRS.	253
8.3.2	Typology of livelihood strategies adopted by households during the DRS.....	256
8.4	A ‘MW households as agents of change’ perspective	257

8.4.1	LED implications of households' appetite for MW innovations.....	258
8.4.2	LED implications of households' 'behavioural intent' to innovate.....	261
8.5	Spatial and temporal changes in the impact of MW income on inequality.....	262
8.5.1	Temporal changes in income inequality during the WRS and DRS	263
8.5.1	Spatial and temporal changes in income inequality during the WRS and DRS.....	266
8.6	An LED index development approach.....	270
8.6.1	Economic Complexity Index (ECI) and Intensity of Involvement in MW trade....	271
8.6.2	Household Infrastructure and Services Index (HISI).....	272
8.6.3	Rural access as measured by road pavement distress index.....	275
8.6.4	Inequality Index as measured by a localised Gini coefficient.....	276
8.6.5	Territorial Cohesion measured by the Global Territorial Dynamic Index.	276
8.6.6	Resilience Index	277
CHAPTER 9: Conclusions and recommendations		279
9.0	Introduction.....	279
9.1	Spatial and temporal changes in rural household dependency on the MWs.	279
9.2.	Spatio-temporal changes in factors explaining successful territorial dynamics that lead to situations of growth in the MW industry and the local economy at large.....	281
9.3	The nature and strength of MW farm household interactions with the local economy.....	283
9.4	To analyse the resistance of MW territorial space to external changes and shocks in the local environment and beyond.....	285
9.5	CONCLUSIONS ON HYPOTHESES TESTING.....	287
9.6	Mechanisms and policies that foster improvements in the MW industry and its subsequent contribution to the local economy.	291
9.6.1	MW growth-oriented LED strategies versus Pro-poor LED Strategies	291
9.6.2	Towards place sensitive MW-oriented LED strategies: 'Input-oriented' versus 'output-oriented' LED strategies.....	294
9.7	Areas for future Research.....	295
REFERENCES		296
APPENDICES.....		306

LIST OF TABLES

Table 2.1: Distinguishing attributes of people and place-based approaches.....	25
Table 2.2: A taxonomy of LED definitions	29
Table 2.3. Total area covered by mopane-dominated woodland in southern Africa.	37
Table 3.2. Nutritional composition of the MW.	49
Table 3.3 The HISI indicator variables	57
Table 3.4. Link between livelihood strategies, MW use and drivers of LED.	62
Table 3.5. ‘Agents of Change’ model attributes at assumptions	66
Table 3.6 Individual Measured Prevalence of Poverty, for Selected Years.....	81
Table 4.1 Select ecological system indicators emerging from existing MW scholarship.	93
Table 4.2. A categorisation of widely applied rules across three property management rules.	95
Table. 4.3. Regulatory regimes and associated MW related theoretical assumptions	97
Table 5.1 Sample frame and sample size.....	102
Table 5.2. Study time frames and activities undertaken.....	107
Table 5.3 Road pavement distress variables and measurement	112
Table 5.4. Template for recording and interpreting Pavement Distress Severity and Extent.....	113
Table 5.5 MW income-expenditure items and sectoral areas of influence	130
Table 5.6: Link between livelihood strategies, MW use and drivers of LED	132
Table 6.1 Spatial variations in household headship.	140
Table 6.2 Spatial variations in household harvesting behaviours	141
Table 6.3 Spatial variation in household wealth status	143
Table 6.4 Household involvement in MW harvesting according to wealth status.....	143
Table 6.5 Spatial and temporal variations in household size	144
Table 6.6. Temporal changes in quantity of MW harvested*	147
Table 6.7 Spatial and temporal changes in quantity of MW harvested*	148
Table 6.8 Temporal changes in amount of MW harvested per harvester.	149
Table 6.9 Spatial and temporal changes in amount of MWs harvested per harvester*.....	149
Table 6.10 Temporal variation in the amount MWs harvested by both low-income and high-income households.....	150

Table 6.11 Temporal variation in the amount MWs harvested according to headship status.	151
Table 6.12 Temporal changes in MWs consumed.....	151
Table 6.13 Spatial and temporal variations in the amount of MWs consumed byhouseholds....	152
Table 6.14 Temporal variation in the amount MWs consumed by low-income and high-income households.....	153
Table 6.15 Temporal changes in MWs traded by households.....	155
Table 6.15. Temporal changes in MWs sold per trader.	157
Table 6.16 Temporal variations in the HCI	157
Table 6.17 Spatial and temporal changes in HCI.....	158
Table 6.18 Spatial and temporal changes in the type of markets* mostly accessed byhouseholds in each village.	161
Table 6.19 Spatial and temporal changes in the prices of MWs according to type of marketsmostly accessed by households.....	162
Table 6.20 Median cut-off values for the dependent variables.	164
Table 6.22 Correlation matrix_WRS (Dependent variable: Quantity of MWs harvested)	165
Table 6.23 Determinants of household dependency on MWs (Dependent variable: quantity of MW harvested).....	166
Table 6.24 Correlation matrix_DRS (Dependent variable: (Household Commercialisation index)	169
Table 6.25 Determinants of household dependency on MWs (Dependent variable: Household Commercialisation Index).....	170
Table 6.26 Spatial differences in the Village Economic Complexity Indices (VECI)	171
Table 6.27 Relationship between VECI and quantities of MWs* harvested and traded	173
Table 6.28 Spatial variation Road Pavement Distress.....	174
Table 6.29 Extent to which Inherent Road pavement distress conditions are limiting localtrader participation in output markets.	175
Table 6.30 Application of queuing model concept to measuring spatial differences in ruralmarket efficiency.....	176
Table 7.1 Scale reliability Analysis.....	179
Table 7.2 Size of each Territorial Cluster.....	179
Table 7.3 Size and composition of each territorial cluster according to village	180

Table 7.4 Kruskal Wallis Test results: Statistical differences between territorial clusters	181
Table 7.5 PTDI and GTDI values for each territorial cluster based on Standardised Zvalues. ..	184
Table 7.6 PTDI and GTDI vales for each village based on Standardised Z values.	187
Table 7.7 PTDI and GTDI values based on distance to major markets and Standardised Zvalues.	188
Table 7.8. Partial and global territorial dynamic indices: the DEA method	189
Table 7.9 Kruskal Wallis H test summary: Evaluation field – Quantity of MWs harvested.....	191
Table 7.10 Pairwise comparison of Territorial clusters based on amount of MWharvested (WRS).	191
Table 7.11 Pairwise comparison of Territorial clusters based on the amount of MWharvested (WRS).	192
Table 7.12 Hypothesis Test Summary	194
Table 7.13. Pairwise comparison of Territorial clusters based on the amount of MW sold(WRS).	195
Table 7.14 Pairwise comparison of Territorial clusters based on the HCI (WRS).....	197
Table 7.15 Pearson’s coefficient depicting association between ESC and MW income.	200
Table 7.16. Pearson’s coefficient depicting association between ISC and MW income.....	200
Table 7.17 Pearson’s coefficient depicting association between SSC and MW income.....	201
Table 7.18 Pearson’s coefficient depicting association between EcSC and MW income.....	202
Table 7.19 Pearson’s correlation coefficient depicting association between PESC and MWincome.	202
Table 7.20 Screening resiliency capacity indicators via scale reliability analysis	209
Table 7.21. Unweighted and weighted Partial Resilient Capacity Indices (PRCIs).....	215
Table 7.22. ANOVA test results: difference between GRIs of Type 1 and Type 2 MWterritories.	216
Table 7.23 Pairwise comparison of GRIs of villages through the Kruskal Wallis Test	217
Table 7.24. ANOVA test results: difference between GRIs of proximal and distalcommunities.	218
Table 7.25. Classification table ^a	218
Table 7.26. Binary logistic results: determinants of resilience in MW territories.....	219

Table 8.1. Effect of ecohydrological conditions on number of ecosystem serviceprovisioning goods accessed by households.....	224
Table 8.2. Paired samples t - test results	235
Table 8.3 Percentile distribution of MW income per household.....	235
Table 8.4 Spatial and temporal changes in MW income per household and per village	240
Table 8.6 Nominal versus real MW income for WRS and DRS.....	244
Table 8.7 Temporal changes in MW income per household and per wealth status-WRS	245
Table 8.8 ANOVA test results depicting significant MW income differences between high-income and low-income households - WRS.....	245
Table 8.9 Temporal changes in MW income per household and per headship status-WRS	246
Table 8.10 Direction and strength of association between quantity of MWs traded and MWincome use area (WRS)	250
Table 8.11 Percental income distribution of harvesting households under combined income statistics of the WRS and DRS.	263
Table 8.12 Spatial and temporal changes in Gini coefficients between villages during theWRS and DRS.....	266
Table 8.14 Spatial and temporal changes in Gini coefficients between proximal and distal communities during the WRS and DRS	270
Table 8.15. Relationship between ECI and intensity of involvement in MW.....	272
Table 8.16 ANOVA test results: Statistical difference between ECI and intensity ofinvolvement in MW trade.	272
Table 8.17 Variation in HISI according to nature of involvement in MW harvesting	273
Table 8.18 ANOVA test results: Statistical difference between HISI and nature ofinvolvement in MW harvesting and trade.....	273
Table 8.19. Variation in HISI according to specific categories of involvement in MWharvesting	274
Table 8.20 Relationship between PDI and intensity of involvement in MW.....	275
Table 8.21 ANOVA test results: Statistical difference between PDI and intensity ofinvolvement in MW trade.	276
Table 8.21 ANOVA test results: Statistical difference between GRIs of harvesting and non-harvesting communities.	278

LIST OF FIGURES

Figure 1.1 Tracing the interest in NTFPs: a paradigm shift.....	13
Figure 2.1. Characterization of people-based approaches though the WWP model.....	23
Figure 3.1. Spatial distribution of mopane-dominated woodlands in southern Africa.	38
Figure 3.2. A framework for conceptualizing the value of MWs	39
Figure 3.3 Charactering MW trade as a binary variable – spatially dispersed versus spatially concentrated.	48
Figure 3.4. Image showing harvester collecting and degutting MWs using bare hands.....	54
Figure 3.5. Schema depicting livelihood pathways that confront MW users	60
Figure 3.6. Broad processes and elements of the livelisystems framework	64
Figure 3.7 Components of a Sustainable and dynamic EE for value creation.....	70
Figure 3.8. Mopane worm producing districts in Zimbabwe.....	74
Figure 3.9. MW farming booklets to guide prospective MW farmers on how to implement farming the worm.	75
Figure 3.10 Women in Kapeni village involved in DFID’s MW farming project.	76
Figure 3.11 Sample pupal pits for MW farming project.	76
Figure 3.12. Use of Kitchen gloves in degutting MWs	76
Figure 3.13. Samples of MW drying innovations shared with communities under the DFID project.	77
Figure 3.14 Percent Poverty Prevalence by Province for Households in Zimbabwe (PICES 2017)	79
Figure 3.15 Percent Extreme Poverty Prevalence by District for Households in Zimbabwe, (PICES 2017).	80
Figure 3.16: Linkages between Mopane worm consumption/ commercialization and food security	83
Figure 4.1. Overarching nature of resilience capacities.....	87
Figure 4.2. Hypothetical typologies of resilience characterising different Territorial systems	88
Figure 4.3. Dimensions and variables associated with territorial dynamics.	92
Figure 5.1 Spatial distribution of selected villages.	103
Figure 3.1 Location of proximal and distal communities in relation to major markets.....	105

Figure 5.2 Defining temporal changes in MW resource use.....	106
Figure 5.3 Study variables adopted to define successful territorial dynamics.	119
Figure 5.4 Hypothetical typologies of resilience characterising different Territorial systems....	124
Figure 5.5: Charactering MW trade as a binary variable – spatially dispersed versus spatially concentrated.	127
Figure 5.6: Schematic modelling of the MW production and marketing system.	128
Figure 5.7: Schema depicting livelihood pathways that confront MW users	131
Figure 5.8. A schema to measure the impact of MW harvesting on the local economy.	134
Figure 5.9 Lorenz curve illustration.....	137
Figure 5.10 With and Without MW income scenario and its effect on equality	138
Figure 6.1 Household harvesting behaviours according to headship status.....	142
Figure 6.2 Spatial and temporal trends in household size.....	145
Figure 6.3. A temporal perspective on the relationship between household size and number of harvesters per family during (a) the WRS and (b) the DRS.	146
Figure 6.4 Spatial and temporal changes in amount of MWs consumed by households.....	153
Figure 6.5 Temporal changes in the quantity of MWs consumed by household headship status	154
Figure 6.6 Correlation between quantity of mopane worms harvested and traded during (a) the WRS and (b) DRS.....	156
Figure 6.7 Correlation between quantity of mopane worms harvested and sold by location and wealth status during (a) the WRS and (b) DRS	156
Figure 6.8 Number and size of emerging unique clusters (WRS)Figure 4.8. Number and size of emerging unique clusters (WRS)	159
Figure 6.9 Comparison of clusters by median values and cell distribution characteristics.	160
Figure. 7.1 Defining territorial success.	177
Figure 7.2 Territorial cluster uniqueness according to administrative villages boundaries.....	181
Figure 7.3 Territorial performance based on mean ranks.....	182
Figure 7.4 Territorial performance according to territorial system capabilities.....	184
Figure 7.5 Independent-Samples Kruskal-Wallis Test results: global index differences between territories.	185
Figure 7.6 Independent-Samples Kruskal-Wallis Test results: partial index differences between territories.	186

Figure 7.7 Independent-Samples Kruskal-Wallis Test results: global index differences between villages.	188
Figure 7.8 Quantity of MWs harvested in each territorial cluster (DRS).	192
Figure 7.9. Territorial differences in the amount of MWs sold to the market (WRS)	194
Figure 7.10. Territorial differences in the amount of MWs sold to the market (DRS)	195
Figure 7.11 Territorial performance based on the HCI (WRS).	196
Figure 7.12 Territorial performance based on livelihood pathway strategy adopted (WRS).	198
Figure 7.13 Territorial performance based on livelihood pathway strategy adopted (DRS).	199
Figure 7.14. Effect of external shocks on reliance on risk limiting strategies (WRS).	205
Figure 7.15. Effect of external shocks on reliance on risk limiting strategies (DRS).	206
Figure 7.16. Effect of external shocks on households' interaction with outside markets.	207
Figure 7.17. Two-step clustering solution depicting two unique MW territories.	210
Figure 7.18. Resilience structure matrix based on standardised z-score values of resilient capacity study constructs.	210
Figure 7.19 Mann-Whitney U test results on territorial performance based on (a) Absorptive Capacity (b) Adsorptive Capacity and (c) Transformative Capacity.	211
Figure 7.20. Resilience structure matrix showing territorial performance according to Absorptive Capacity (AbC).	212
Figure 7.21. Resilience structure matrix showing territorial performance according to Adaptive Capacity (AdC).	212
Figure 7.22. Resilience structure matrix showing territorial performance according to Transformative Capacity (TC).	213
Figure 7.23 Resiliency capacity for each village stacked against unique clusters of resiliencies.	214
Figure 7.24 Resiliency capacity of proximal and distal communities stacked against unique clusters of resiliencies.	214
Figure 7.25. Global Resilience Indices for each village.	216
Figure 7.24. The GRIs of proximal and distal communities.	217
Figure 8.1. Gains plot: intensity of involvement (WRS)	222
Figure 8.2. household's likelihood to interact with output markets (WRS).	222
Figure 8.3. Gains plot: Intensity of involvement (DRS)	225

Figure 8.4. household's likelihood to interact with output markets (DRS).....	226
Figure 8.5 Charactering MW trade as a binary variable – spatially dispersed versus spatially concentrated.	227
Figure 8.6. Distribution choice by Village during the WRS	228
Figure 8.7 Distribution choice by Village during the DRS	228
Figure 8.8. Distribution channel choice by distance from major city markets	229
Figure 8.9 Distribution channel choice by distance from major city markets - DRS	230
Figure 8.10. Gains plot: spatial concentration of MW trade (WRS).....	231
Figure 8.11. Household interaction with the local economy versus spatial concentration of MW trade -WRS.....	232
Figure 8.12 Gains plot: spatial concentration of MW trade (DRS)	232
Figure 8.13 Household interaction with the local economy versus spatial concentration of MW trade -DRS.	233
Figure 8.13. Shape and distribution of MW income per household during (a) the WRS and	234
Figure 8.14 Temporal differences in extreme MW income earners.....	236
Figure 8.15 Shape and distribution patterns of MW income during the WRS of years (a)2000-2014; (b) 2014-2018 and (c) 2018-2022.....	237
Figure 8.16 Related -Samples Friedman's Two-Way Analysis of Variance (ANOVA) by Ranks test results.	238
Figure 8.17 Extreme MW income dynamics during the WRS of years 2000-2014; 2014-2018 and 2018-2022.	238
Figure 8.18 Percentile distribution of MW income for the WRS of years 2000-2014; 2014-2018 and 2018-2022.	239
Figure 8.19 Independent samples Kruskal-Wallis H.....	241
Figure 8.20 Spatial and temporal changes in MW income per capita and per village.....	242
Figure 8.21 Spatial and temporal changes on MW income per household and proximity to major markets_WRS	242
Figure 8.22 Temporal variations MW incomes per household and distance to major markets ...	243
Figure 8.23. Temporal changes in the use of MW income to buy livestock.	247
Figure 8.24 Temporal variations in the importance and size of MW income expenditure clusters during the WRS.....	248

Figure 8.25 Expenditure profile of each MW cluster in year 2000-2014 during the WRS	249
Figure 8.26 Expenditure profile of each MW cluster in year 2014-2018 during the WRS	249
Figure 8.27 Expenditure profile of each MW cluster in year 2018-2022 during the WRS	250
Figure 8.28 A temporal perspective on MW income and its significance to various sectors of the local economy (DRS).....	251
Figure 8.29 Expenditure profile of each MW cluster in year 2000-2014 during the DRS	252
Figure 8.30 Expenditure profile of each MW cluster in year 2014-2018 during the DRS	252
Figure 8.31 Expenditure profile of each MW cluster in year 2018-2022 during the DRS	253
Figure 8.32 Nature of Livelihood strategies adopted by MW farming households during the WRS	254
Figure 8.33 Dominant livelihood pathway followed by household from each village (2000-2014 - WRS).....	255
Figure 8.34 Dominant livelihood pathway followed by household from each village (2014-2018- WRS).....	255
Figure 8.35 livelihood strategies adopted by households during the DRS.	256
Figure 8.36 households' appetite for MW innovations	259
Figure 8.38 households' appetite for MW innovations by village	260
Figure 8.38 households' appetite for MW innovations	260
Figure 8.39 Profiling actual innovation behaviours.....	261
Figure 8.40 profiling actual innovation behaviours	262
Figure 8.41 Income inequality shifts under the 'with' and 'without' MW income scenarios of the WRS and DRS.	264
Figure 8.42 Disaggregated income inequality shifts under the 'with' and 'without' MW income scenarios of the WRS and DRS.	265
Figure 8.43 Proximity to major markets versus impact of MW income on inequality during the WRS.....	268
Figure 8.44 Proximity to major markets versus impact of MW income on inequality during the DRS	269
Figure 8.45 Pairwise comparison of harvesting households based on the HISI.	275
Figure 8.46. Difference between GRIs of harvesting and non-harvesting households.....	277

Figure 9.1 Proposed growth model for creating a progressive MW entrepreneurship ecosystem (EE).....	293

LIST OF APPENDICES

Case study 1: Mopane worm (<i>Imbrasia belina</i>) and rural household food security in Limpopo province, South Africa	83
Appendix 1. Amalgamated Questionnaire templated used to collate data from a series of surveys conducted.	306
Appendix 2. Descriptive statistics of attributes defining Territorial Dynamics.....	317
Appendix 3 Data screening procedures associated with resilience capacity Indicator variables.	322
Appendix 4 Correlation analysis between independent resilience variables	325
Appendix 5 Data screening procedures associated with resilience capacity Indicator variables.	330
Appendix 6 Correlation analysis between independent resilience variables	333
Appendix 7 Language editing certificate	334
Appendix 8 Ethics Clearance Certificate	335
Appendix 9 Turnitin Report	336

CHAPTER ONE: The problem and its setting

1.0 Introduction

The growing complexity of rural spaces, within and between countries, arguably requires local information and insights that serve as a vital entry point to address rural issues and understand how to tackle growing issues of concern such as poverty, food insecurity, interpersonal and spatial inequality (RodríguezPose and Hardy, 2015; Stanny & Komorowski, 2021; Harbiankova & Gertsberg, 2022). From this perspective, a place-based, spatial approach to understanding the local economic development implications of harnessing the resource potential of a rural region is better able to steer development forward, than traditional place neutral, sector led and often people centred approaches that have in the past failed to deal with challenges of rural poverty, inequality and food security among other pertinent concerns. Given the declining share of sector-based approaches, that have traditionally relied on the ailing agricultural and manufacturing sectors of most rural regions of the developing world, development experts and practitioners now concur that unlocking other resource potentials of rural regions may offer a lasting solution to inherent problems (Janc et al., 2023). It is this understanding that has seen research scholarship on NTFP sector and its potential to tackle rural decline and boost economic growth rising in recent years. Despite its potential, there is insufficient understanding of how NTFPs such as mopane worms (MWs), may potentially transform the fortunes of rural regions owing to limited place-based territorial research that is so crucial in the understanding of the LED implications thereof.

Agriculture, mining, and to some extent the manufacturing sector have traditionally served as the major building blocks for local and regional planning efforts that seek to redress regional disparities that characterise rural and urban landscapes of many developing nations. Such sectors have for many decades been platforms for economic diversification for many rural centres in Zimbabwe. The relative decline of income share to the rural economies of most developing and middle income countries have not spared Zimbabwe either. For the Zimbabwean government, development agencies, and academic institutions alternative income streams have become increasingly important as in other countries across the developing world. One important area of intervention has been the promotion of innovativeness in the utilisation of Non-Timber Forest Products (NTFPs) (Nghonda et al., 2023)

The widespread utilisation of Mopane Worms (MWs) in the south-western regions of Zimbabwe for example, has been identified as one potential area of intervention that has attracted the attention of Rural District Councils (RDCs), development agencies such as the Department for International Development (DFID), the Global Environment Fund (GEF), the Southern Alliance For Indigenous Resources (SAFIRE) and others in recent times. SAFIRE and the Rural District Councils have recently been involved in the setting up of MW marketing associations and marketing warehouses across the mopane worm producing regions – activities that are presumably premised on the perceived capabilities that the mopane worm industry can offer in transforming the concerned rural economies. The DFID, The Zimbabwe Forestry Commission (ZFC), Institute of Environmental Studies (IES) and the University of Zimbabwe were for instance involved in several scientific studies that culminated in the setting up of two mopane worm farming projects in Bulilima and Matobo districts of Zimbabwe. Hope *et al.* (2009) conducted choice experiment that sought to explore preferences of mopane worm (MW) harvesters across alternative farm management scenarios in four villages of rural Zimbabwe. Other research efforts that have recognised the potential value MWs have come from Gondo *et al.* (2010) who have explored options for the sustainable use of MWs in southwestern rural areas of Zimbabwe. More recently Manditsera *et al.* (2022) has conducted a study analysing the value chain system of MWs in the Gwanda District of Zimbabwe. Such studies reflect a great appreciation of the roles that MWs play in the local economies of the resource's users. It is hoped that such and other related efforts could provide rural communities with the much-awaited *magic bullet*, that could result in a virtuous cycle of improvements in their lives and would subsequently foster an economic transformation of the associated local and regional economies. The potential of the mopane worm industry to fill the gap created by the disappearance of traditional sectors of rural development and the sustainability of intervention efforts geared towards boosting returns from this emerging sector would to a larger extent rely on the availability of spatiotemporal data on the utilisation of the worm.

Larvae of the mopane emperor moth, *imbrasia belina*, colloquially referred to as “mopane worms” has for years been seen an important source of nutrition and income for poor people in the Southern African region, including in countries such as Botswana, Namibia, South Africa, and Zimbabwe (Kozanayi and Frost, 2002:1; Stack *et al.*, 2003:1, Hope *et al.*, 2009; Manditsera *et al.*, 2022). Overwhelming evidence in Southern Africa indicating that mopane worms (that feed almost exclusively on the mopane tree *Colophospermum mopane*) industry is a valuable Non-Timber

Forest Product (NTFP) resource that contributes substantially to rural economies and nutrition. The value of mopane worms in South Africa alone has been estimated at £2,850ha⁻¹ (Rebe 1999), and extrapolation from Styles's (1994a) (estimation of mopane worm density), shows that the annual population of mopane worms in South Africa's 20,000 km² of mopane veld is worth £57m, of which approximately 40% goes to producers who are primarily poor rural women. In addition to their value as an income source for poor rural women, MWs also provide nutritious food for rural households and urban dwellers (Ghazoul, 2006; Baiyegunhi et al., 2016; Mnisi et al., 2022; Conway et al., 2024).

Traditionally, mopane worms were harvested for subsistence use by rural households (Ashipala et al. 1996). Despite the absence of a proper assessment MWs are thought to make a significant contribution to rural diets of many. Since malnutrition, particularly with pre-school and primary school rural children, is a serious problem in many areas of Zimbabwe and South Africa (Vorster et al. 1997), Rebe (1999) suggests that a daily intake of mopane worms could play an important role as a source of nutrients for pregnant women and children in rural areas. Dried mopane worms have high protein content with 65.8 percent dry weight crude protein content and 53.3 percent dry weight digestible protein (Siame et al. 1996; Dreyer & Wehmeyer 1982). Increased supplies of mopane worms in both rural and urban areas therefore have the potential to address food security problems both by increasing incomes for poor mopane harvesters or producers (providing financial capital for food purchases) and by increasing the availability of a high-protein and popular food (Ghazoul, 2006; Numbi et al., 2022).

Despite its potential role in the livelihoods of rural households, there is lack of spatiotemporal information on the precise contribution of mopane worms to such livelihoods in terms of social and economic categories of people engaged in harvesting, processing, trading, and consuming mopane worms. This includes the dearth of information on the interactions that exist among the various components of people's livelihoods and among people with different livelihood strategies (Kozanayi and Frost, 2002: 1-2; Stack et al., 2003: 1). Understanding the spatiotemporal dimensions of mopane worm utilisation is therefore indispensable.

1.2 Background to the research problem

Gaps and research needs

A review of the literature on NTFPs in general and the mopane worm in particular shows several weaknesses and research gaps (Kozanayi and Frost, 2001; Stack et al, 2003; Hope et al, 2009; Baiyegunhi et al., 2016; Numbi et al., 2022; Mnisi et al., 2022; Conway et al., 2024). There is limited productive knowledge that could underpin NTFPs commercialisation projects, although it is generally suspected (from the snapshot studies carried over the years) that they may have a significant role to play in the rural household economy of the poor (Lawrence, 2003; Ros-Tonen and Wiersum, 2003; Belcher and Kusters, 2004; Sunderlin *et al.*, 2005; Bachiet al., 2023). There is consensus among researchers that despite recent growing research interest the potential contribution of NTFPs to the local economy, there exist numerous gaps in understanding the linkages between natural resource use and trade, livelihood, poverty and local economic benefits and that further empirical evidence is required (Arnold, 2002a; Hope *et al*, 2009).

Such knowledge gaps have also dominated the global agenda on NTFPs in the past decade (Shackleton, 2005). For example, the Quebec Declaration (2003) on “Strengthening global partnerships to advance sustainable development of non-wood forest products” (formulated as necessary to realise the full benefits of non-wood forest products (NWFPs) for individual, community and national well-being; decision makers, forest managers and resource users alike who lack information about economic, ecological and social characteristics of NWFPs.” The same declaration recommended that “government efforts be strengthened to conduct research, and to compile and disseminate information and statistics to key stakeholders on NWFP resources and their socio-economic and ecological values” (Quebec Declaration 2003 in Shackleton, 2005). It is the dearth of information on socio-economic importance of species that has been implicated for non-sustainable utilisation of many species (Ogunjinmi *et al*, 2009). Such a fundamental knowledge gap is however not new. The need for further quantitative research on:

a) the role of NTFPs in household livelihoods including their safety net function, and b) on the potential of small, natural resource-based enterprises has long been underscored by many (Angelsen and Wunder, 2003a; Lawrence, 2003; Sunderlin and Thubau, 2004; Shackleton, 2005).

Some studies have looked at the collection, processing and marketing of mopane worms (Hobane, 1994, 1995 Gondo, 2001), but little is known on the spatiotemporal changes on the contribution of these activities to rural household livelihoods and the variability of involvement in MW activities between different communities or between different socio-economic groups. Much of the work done to date on MWs is vulnerable to the criticism that the results are ‘just case studies’ that do very little to provide knowledge rather than hearsay about the wider population of users of this forestry resource at one given moment (Kozanayi and Frost, 2001; Stack *et al*, 2003; Hope *et al*, 2009).

The need to recognise the potential role that the NTFP sector poses in rural development programmes has not to date been considered using an LED lens or using in other terms a local and regional development perspective - yet the popularity of LED and NTFP centered approaches to development has risen significantly over the last two decades (Rodríguez-Pose & Palavicini-Corona, 2013; Shackleton & Pandey, 2014). Two main reasons account for the increased recognition. The first has to do with the failure of top-down development strategies to deliver (Boisier, 1999; Puga, 2002; Crescenzi and Rodríguez-Pose, 2012) and secondly the relative decline of the share the traditional sectors of agriculture and manufacturing in stimulating growth (Shackleton *et al.*, 2001; Hogarth *et al.*, 2013; Rodríguez-Pose & Palavicini-

Corona, 2013). It has been observed for instance that incomes from NTFPs in local rural livelihoods of households living in arid and semi-arid regions of the world is typically larger than those accruing from arable agriculture and livestock husbandry combined (Shackleton *et al.*, 2001; Hogarth *et al.*, 2013). Yet the development debate at various scales (urban and rural) has not positioned the NTFP sector on the LED agenda. Little is therefore known about the potential implication of promoting a NTFP – based LED strategies. It becomes therefore imperative that research on local economic development implications of implementing a NTFP-led growth initiative in general and in particular a MW-led growth initiative be conducted.

Such a study should however not take the cue from previous rural development approaches and strategies that according to Rodríguez-Pose & Hardy (2015) have adopted a much more traditional place-neutral stance that is devoid of spatial and other territorial issues that are crucial to

addressing spatial and interpersonal disparities that characterise most rural landscapes of the developing world.

This study seeks to fill in the knowledge gap by analysing the spatio-temporal changes in socioeconomic structures for mopane worm utilisation

1.3 The problem statement

Rural areas of developing countries such as Zimbabwe and other emerging economies have in recent years become a source of several pertinent international concerns (Rodríguez-Pose & Hardy, 2015). Major areas of concern include extreme poverty and hunger, and rising spatial and interpersonal disparities, challenges that the concerned national governments and the wider international community have failed to make meaningful headway in addressing. In the past decades, rural development approaches to addressing the challenges in Zimbabwe have overemphasized the importance of traditional sectors of agriculture and manufacturing – sectors whose contribution and share to the local economy has arguably been on the decline (Schejtman & Berdegue, 2008; Ambrosio-Albala & Bastiaensen, 2010). Despite their rising share and potential contribution to the rural economy, NTFPs such as mopane worms have not dominated the local and regional development agenda (Millennium Ecosystem Assessment, 2005; Steinfeld et al., 2006; Rodríguez-Pose & Palavicini-Corona, 2013; Shackleton & Pandey, 2014). Many studies that have been conducted on environmental resources and other non-agrarian sector resources acknowledge that NTFPs provide multiple livelihood benefits to local communities and regional and national economies (Shackleton and Pandey, 2014) and may play a significant role in addressing rural poverty, interpersonal and regional disparities (see Reardon., 2007; Dirven, 2011; Ambrosio-Albalá & Bastiaensen, 2010). As noted by Rodríguez-Pose and Hardy (2015) failure to develop a viable non- agricultural sector such as that dependent on NTFPs is liable to consigning the remote rural poor into deep and perpetual poverty. The central problem is that potential benefits likely to accrue from NTFPs are rarely drawn upon in the debates around and design of poverty alleviation or land use policies, LED strategies and / or projects (Millennium Ecosystem Assessment, 2005; Steinfeld et al., 2006; Shackleton and Pandey, 2014). There are several reasons to this.

While there is substantial knowledge about the local economic development implications of

harnessing the capabilities of an agricultural and / or manufacturing led growth initiative, the same cannot be said about the new and emerging NTFP sector. This is so because rural development in most developing countries such as Zimbabwe is continually being practiced with a single emphasis on agricultural development, and on productivity and modernisation in particular – attributes that have seen the two sectors of agriculture and manufacturing stealing the rural development and associated LED agendas (OECD, 2010; Akpan, 2012).

There is a general paucity of research scholarship on the local economic development implications of a NTFP-led growth initiative - issues that concerned local and national governments can base (champion and / or justify) their rural development efforts. Such dearth in research scholarship has been worsened by lack of explicit theoretical propositions that are designed to guide rural development and / or local economic development initiatives seeking to tap on the capabilities of utilising NTFPs such as mopane worms. What we currently have are numerous local economic development initiatives that have benefited from a multiplicity and diversity of models developed in host countries – a situation that has often made it difficult to replicate success stories in other lagging rural economies of the developing world. The existence of a multitude of small and generally poorly documented attempts to try to implement LED strategies across the world and that make the bulk of the NTFP sector such as mopane worms (Rodríguez-Pose & Rodríguez-Pose, 2013: 303) has not helped either.

It is also argued that most local and regional economic development initiatives that characterise the rural landscape of many developing countries (Zimbabwe inclusive) have in the past taken a more traditional place-neutral stance, in which the important role played by space and other related territorial issues has no room (Rodríguez-Pose & Hardy, 2015). Other scholars such as Markusen and Schrock (2006) have also noted that most LED strategies in developing and emerging economies are dominated by single-case inductive approaches that ignore spatial attributes of resource extraction. Such dominance of single-case inductive approaches to the study of LED strategies and their potential to transform the rural economy has been criticized by many.

Markusen and Schrock (2006: 1319) for instance have dismissed such an approach as an “often mindless groping for ‘best practice.’” Crescenzi and Rodríguez-Pose (2011) have also shared the same pessimism by questioning the extent to which such approaches help in informing development policy that (as argued by Rodríguez-Pose & Hardy, 2015) is targeted at winnowing

spatial and interpersonal disparities that characterise many rural regions of the developing world Zimbabwe inclusive.

Rural development studies that seek to predict the potential role of the NTFP sector and has been carried out in Zimbabwe and other parts of Africa and the rest of the developing countries have been accused of taking a much more spatially blind, sector led and people centred approach at the expense of a much more progressive integrated, territorial and placed based approach (see Kraybill & Kilkenny, 2003; Barca, 2009; Rodríguez-Pose, 2010: 2012; Barca et al., 2012). It is increasingly accepted that NTFP-led LED studies and other related non-agrarian sector studies conducted in the past have not escaped the risk of pursuing what have been termed ‘zero and negative-sum’ initiatives based on redistribution rather than ‘sustainable positive-sum’ forms of development, centred on equitable growth and employment generation (Bebbington et al., 2008; Rodríguez-Pose & Hardy, 2015).

Rural development strategies in the developing world have to date not properly conceptualised the problems characterising rural decline or what other scholars have referred to as ‘rural shrinkage’ (see Teitejen & Jørgensen (2016). Despite the increasing realisation that addressing rural decline requires approaches that define rural challenges using a ‘wicked problem’ actor network theory and a strategic planning lens, NTFP–LED efforts have not been analysed using precepts from such a perspective (Teitejen & Jørgensen, 2016). It is generally argued that approaches that take this perspective are ideal in the sense that they allow LED actors to recognise the fact that ‘knowing what distinguishes an observed (rural) condition from a desired (rural) condition’, is much more difficult (Rittel & Webber, 1973:153). This is because each “local situation is unique, socially contested and constantly changing due to many factors that occur at multiple scales.” (Teitejen & Jørgensen, 2016: 30). Accepting this therefore requires that we recognise that formulating a planning problem is interconnected with the process of its solution (Skaburskis, 2008) and that such interconnectedness varies both in time and space. Evaluating the potential role of the NTF sector in general and the extent to which it can contribute to sustainable solutions to the problems of rural decline will definitely require a general appreciation of the concept of wicked problems, strategic planning theory and Actor-Network-Theory. In local and regional development discourse, such a perspective has lacked and as a result we know less about the extent to which NTF sector interacts with other non-NTF sectors and the actors and non-actors thereof involved at least at the

local and regional scales.

Virtually all previous LED studies that seek to harness the potential of an existing local resourcebase have revealed that innovation is central to the economic growth and development of any rural territory (Hall *et al.*, 2003; Spielman, 2005; Pires *et al.*, 2014; Singh & Bhowmick, 2015; Provenzano *et al.*, 2016). Within the rural context, Singh and Bhowmick (2015) have for instance argued that innovation provides new ways to solve the problems of rural people and to create new opportunities for entrepreneurship development. Despite this general observation, the two authors argue that this concept has remained largely under-researched. Existing literature on rural innovation has also largely remained biased to the over researched traditional sectors of agriculture, manufacturing, mining and to some extent tourism. From a local and regional planning perspective it can be argued that there is limited knowledge on how innovation can stimulate NTFP-led growth. Despite a realisation that the conceptualisation of rural innovation should be handled with great care as it varies from one rural context to the next (see Zeng *et al.*, 2010), we do not know how such spatial and even temporal dynamics as they relate to the MW industry affect local growth.

Related to the above, it has been observed that the diffusion processes of technologic innovation have a strong impetus on the innovating economic entity and the economic system within which that entity is situated. Several technological innovations for the MW industry have been proposed ranging from those that seek to improve harvesting practices, processing, product development to those that seek to add value to the worm through innovative marketing channels. Understanding the ways in which innovative ideas and practices are diffused within the MW business entities and the associated spillover effects to the local economy has grossly remained an under-researched area. This is because past and current studies relating to adoption and diffusion of innovation have been biased largely to agricultural, manufacturing, mining and tourism sector as compared to other sectors (Tola & Contini, 2014). The adoption and diffusion of specific innovations in the NTFP sector in general and the implications thereof for local and regional development has as a result remained an under-researched area. This thesis posits that understanding the processes that shape the adoption and diffusion of specific innovative trajectories within the NTFP sector in general and the MW industry in particular, and how such trajectories vary both in time and space is crucial for mapping effective LED strategies. Within the MW industry there is limited systematic knowledge of how we can approach and assess the role of innovation in terms of how the focus and the scope of

innovation processes are understood and managed to inform analysis and action.

In general, lack of spatio-temporal data on the utilisation of NTFPs such as MWs, and the continued reliance by national governments of developing countries on the ailing traditional sectors of agriculture and manufacturing has stifled our understanding of what NTFP related local economic development scenario works best for the lagging rural regions of the developing world. Specifically, the following important research questions need to be answered:

- To what extent is rural household dependency on MWs affected by spatio-temporal attributes? What are the associated local economic development implications?
- What spatio-temporal attributes (factors) define successful territorial dynamics that lead to situations of growth in the MW industry and the local economy at large?
- What is the nature and strength of MW farm household interactions with the local economy?
- To what extent is the MW territorial space (and the rural households that occupy it) resilient to external changes and shocks in the local environment and beyond?
- What are the most appropriate mechanisms and policies (local economic development scenarios) that foster improvements in the MW industry and its subsequent contribution to the local economy?

This study therefore sought to bridge the existing knowledge gap by evaluating the local economic development implications of spatio-temporal changes in MW utilisation in selected rural territories of Southwestern Zimbabwe.

1.4 Objectives of the study

1.4.1 Broad objective

The study seeks to analyse Local Economic Development (LED) implications of spatial and temporal changes in Mopane Worm utilisation in selected communities of south-western Zimbabwe.

1.4.2 Specific objectives

The study is premised on the following specific research objectives.

1. To estimate spatial and temporal changes in rural household dependency on the MW industry.

2. To analyse spatio-temporal changes in factors explaining successful territorial dynamics that lead to situations of growth in the MW industry and the local economy at large.
3. To evaluate the nature and strength of MW farm household interactions with the local economy.
4. To analyse the resistance of MW territorial space to external changes and shocks in the local environment and beyond.
5. To develop the most appropriate mechanisms and policies that foster improvements in the MW industry and its subsequent contribution to the local economy.

1.5 Hypothesis

This study is premised on several hypotheses or propositions listed below. The hypotheses emanate from observations and commentary presented above and personal experience from working in this sector over several years, coupled with dialogue with other researchers. They are key in guiding the approach, design and methods adopted in this study and they underlie much of the discussion that follow.

- H1: There are intercommunity and temporal variations in levels of involvement of different socio-economic groupings in mopane worm harvesting.
- H2: Economic returns from mopane worm harvesting vary over space but such returns diminish in *real terms* with time.
- H3: The degree of MW farm household interactions with the local economy is higher in MW territories characterised by distant and a spatially concentrated pattern of trade transactions.
- H4: The degree of MW farm household interactions with the local economy is lower in MW territories characterised by trade transactions that are much closer to the MW farming household unit and that are more spatially dispersed.
- H5: LED interventions in the MW industry that seek to valorise given territorial potentialities are more likely to lead to situations of growth.
- H6: Successful territorial dynamics in MW territories are significantly influenced by the socioeconomic, institutional, physical / engineering, and ecological context of the households.

H7: Idiosyncratic health, severe weather, and economic shocks have resulted in distinct clusters of livelihood adaptation and / or resilience trajectories that significantly undermine the growth potential of MW territories.

H8: Idiosyncratic health, severe weather, and economic shocks tend to diminish important linkages between MW trading activities and markets within and beyond the boundaries of the rural economy.

1.6 Expected outcomes

The following is a list of the expected deliverables from this study.

- Estimation of spatial and temporal changes in rural household dependency on the MW industry.
- Definition and profiling of successful territorial dynamics that leads to situations of growth in the MW industry and the local economy at large.
- Determination of spatio-temporal attributes defining the nature and strength of MW farm household interactions with the local economy.
- Dynamics of MW territorial resistance to external shocks.
- Development of mechanisms and policies to foster improvements in the MW industry and its subsequent contribution to the local economy.

1.7 Policy significance

The widespread utilisation of MWs in south-western parts of Zimbabwe has been identified as one potential area of intervention that could make up for the gap left by the ailing traditional economic sectors of industry and agriculture. The potential role of this sector in the rural economy of Zimbabwe has attracted the attention of RDCs, development agencies such as DFID, the GEF, SAFIRE and others in recent times. SAFIRE and the Rural District councils have recently been involved in the setting up of Mopane Worm Marketing Associations and the mopane worm marketing warehouses across the mopane worm producing regions. The DFID, The Zimbabwe Forestry Commission, Institute of Environmental Studies (IES) and the University of Zimbabwe have been involved in several scientific studies that culminated in the setting up of two mopane worm farming projects in Bulilil Mamangwe and Matobo districts of Zimbabwe. Increased research scholarship on mopane worms would certainly guide development efforts of such key stakeholders.

Research findings would also give an invaluable insight of spatiotemporal trends in mopane worm utilisation in other countries such as South Africa, Namibia and Botswana where mopane worm outbreaks are also reported. Such knowledge is indispensable in local and regional economic planning as interest in these interrelated disciplines is steadily shifting focus from the ailing traditional sectors of agriculture and manufacturing to emerging forest resource- based industries.

In addition to influencing local and regional economic policy, the study will also inform the NTFPs agenda at different scales and platforms as interest in NTFPs has pervaded many areas ranging from the conservation agenda, sustainable development agenda, rural development agenda, to the global concern for poverty (refer to figure 1.1).

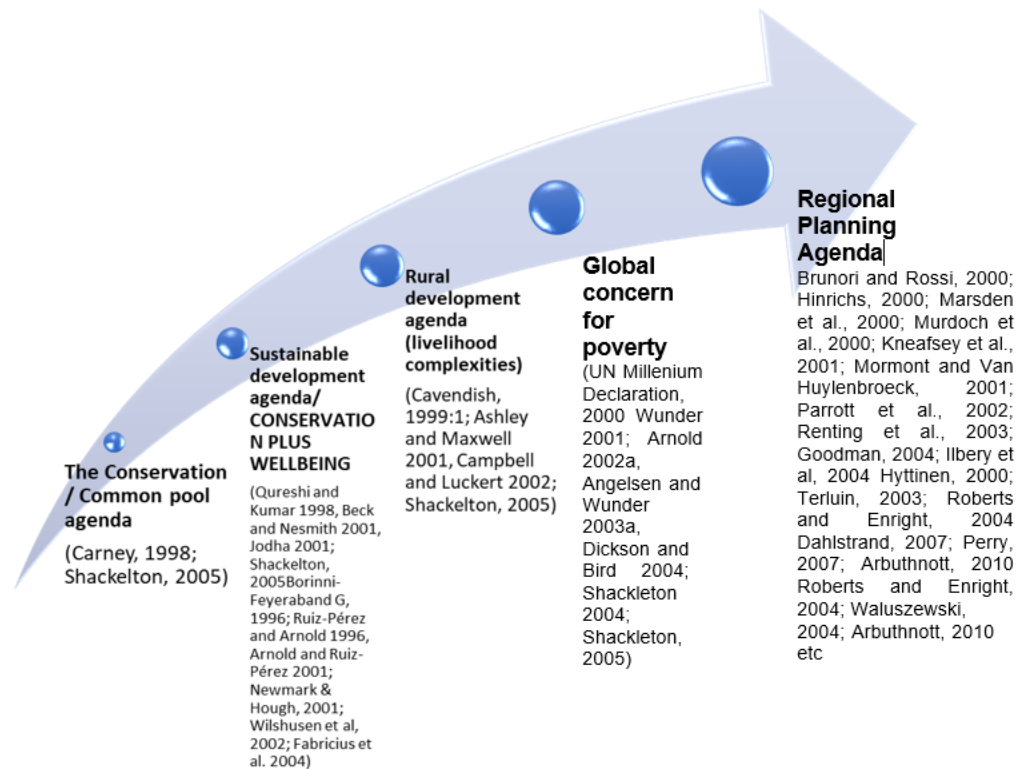


Figure 1.1 Tracing the interest in NTFPs: a paradigm shift

The global concern for poverty reduction has certainly seen rural regions of developing and other emerging countries becoming a source of several pertinent concerns. Such concerns among others include chronic poverty and hunger, and rising spatial and interpersonal disparities – issues that have seen concerned national governments and the wider international community failing to make headway in addressing (Rodríguez-Pose & Hardy, 2015). Such concerns have gained credence in

recent time given that the Millennium Development Goals are reaching their expiry date, and that the formulation of a post-2015 development agenda is well underway. Since the inception of the MDGs, there has been a general understanding and acceptance that global challenges of poverty, inequality and food security are “won and lost in rural areas of developing countries” (Anríquez & Stamoulis, 2007: 6) where there is an overwhelming concentration of the poor. This position is unlikely to change since it has become clearer that progress on rural issues has been underwhelming and that going forward more attention need to be directed to rural areas.

It is estimated that 1.2 billion poor people living on \$1.25 or less each day live in rural areas (World Development Indicators, 2013). These statistics represent 75% of those in living extreme poverty globally (World Development Indicators, 2013). In terms of food security, a staggering 805 million people, according to the FAO (FAO, 2014), or 870 million people, according to the UN (UN, 2013), reportedly go hungry each day. This bleak food security picture is again defined largely as a rural phenomenon (Rodríguez-Pose & Hardy, 2015). An analysis that focuses on local economic development implications of utilising NTFPs such as the MW in a rural setting will certainly inform policies those are targeted at addressing poverty, inequality and food security.

A study that puts more emphasis on rural areas is certainly not misplaced. The World Bank (2007) has reiterated the need to review and understand rural challenges by making a concerted effort to evaluate what works, where it works, and why (cited in Rodríguez-Pose & Hardy, 2015).

1.8. Scope of the study

Chang et al (2008) observes that spatiotemporal data analysis has recently gained considerable attention from both the research and practitioner communities because of the increasing availability of datasets with prominent spatial and temporal data elements. This study is therefore limited to four case study areas of Ndiweni, Kapeni, Maphisa and Sasane villages in the Matobo District of Zimbabwe where considerable amount of spatial and temporal data are available. A series of data points between the periods 1999 and 2013 will be used. While interest in NTFPs such as MWs has been of interest to many sectors and disciplines, the study will adopt a local economic development perspective that seeks to understand how interests in NTFPs in general and interest in MWs in particular has shaped the current thinking and practice in regional planning efforts.

CHAPTER TWO: *NTFP resource dependency and associated dynamics: The need for spatiotemporal and Local Economic Development studies*

2.0 Introduction

This chapter reviews three strands of literature associated within NTFP resource use in general and specifically MW use. First it situates the NTFP sector debate within the wider context of the LED agenda by reviewing existing deficiencies in the current literature. Secondly, it pays special attention to issues relating to resource dependency dynamics and associated spatial and temporal shortcomings. It also reviews important literature gaps in understanding successful territorial dynamics and associated resilience issues as they relate to NTFP extraction. It concludes by giving a final thought on why it has been difficult to measure resource exploitation and its impact on local communities.

2.1 NTFPs and the rural economy: A local and Economic Development perspective

MWs are one of several NTFPs that households across Southern Africa rely on. In order to have a clear picture of what knowledge deficiencies we currently have, and how they are limiting researchers and rural development practitioners from developing a MW oriented LED strategy, it is important that we first understand issues surrounding its wider NTFP context. The thesis holds that, in addition to exposing existing knowledge gaps, tapping on the knowledge from the NTFPs may assist in drawing important lessons that may inform the development of a MW oriented LED strategy. This section reviews existing literature on NTFPs. It situates such literature and associated research scholarship within the context of the rural economy and more specifically within the context of Local Economic Development (LED).

2.2.1 Establishing the need for spatiotemporal research in NTFP and Local Economic Development studies

There is consensus among researchers that the interaction and dynamic aspects of NTF resource extraction by local people is crucial in informing LED policies. Ignoring the variability in spatial

and temporal aspects of NTF resources extraction and use could result in inappropriate policies (Robinson et al, 2008; Bach, 2023; Nghonda et al, 2023; Sikuzani et al., 2023). Robinson et al, (2008) further argues that spatial links in NTF extraction (and use) decisions imply that policies imposed in one area can have unintended consequences in other areas.

Taking an explicitly temporal and spatial approach to analysing NTF resource extraction and use provides useful insights for LED related policies that are unlikely to come from the traditional aspatial strands of research that have for decades characterized the bulk of the developing countries. Interest in the spatial and temporal aspects of land-use and / or resource use decisions and their implication for policy is recent and encouraging (Vance & Geoghegan, 2002; Osseni, et al., 2022; Sikuzani et al., 2023). Vance and Geoghegan (2002:317) have for instance argued that efforts that seek to ignore spatial and temporal dimensions of resource extraction and use “compromises the implementation of appropriate policy response.” Sanchirico and Wilen, (2005) have also made a similar argument by maintaining that NTF resource extraction and use are not necessarily even variables across space and time. Sikuzani, et al., (2023) has more recently underscored the need understand the spatiotemporal dynamics and stability of NTF ecosystems as they have important implication of local development.

A more convincing perspective on the need to incorporate spatiotemporal trends in local economic development initiatives has come from literature and a spurt of research in **Successful Territorial Dynamics** (STD) and their important implications for local economic development and subsequently for rural development policy (Sánchez-Zamora et al, 2014; Calvo-Palomares, et al., 2023). The STD perspective acknowledges the existence of numerous and important territorial imbalances characterizing many rural regions and that understanding such imbalances are key to rural development programmes that seek to achieve socio-economic cohesion and environmental sustainability in rural territories (EC, 2010; Sánchez-Zamora & Gallardo-Cobos, 2020). The need to achieve territorial cohesion in rural areas that are increasingly suffering from spatial disparities has been underscored by Sánchez-Zamora & Gallardo-Cobos, (2020). In the context of the MW and the wider sector of NTFP, the context of territorial imbalances would imply that associated local economic gains do not evolve homogeneously. This confirms the existence of diverse

territorial dynamics whose implication on NTFP-centred local economic development initiatives is not yet known. Putting NTFPs such as MWs on a local economic growth path requires that such diverse territorial dynamics, including their impact on the productive capability of the NTFP sector are analyzed and understood. Many scholars who hold a similar development perspective believe that NTFP territories are likely to benefit from research grounded on territorial dynamics as such research would promote development of the territory that aligns well with major challenges affecting it (Sánchez-Zamora & Gallardo-Cobos, 2020; Calvo-Palomares, et al., 2023). This study is inspired by concept of rural territorial dynamics which in its beginnings referred to processes of development in the socioeconomic structure, institutional framework and environmental capital of rural areas, and the changes that accompany the effects of development (RIMISP, 2007; Hamdouch, 2010; Sánchez-Zamora et al, 2014). More recently the concept has been stretched to include a territory's competences in terms of its social, economic, environmental, institutional, and spatial planning attributes (Calvo-Palomares, et al., 2023). In the case of the MW industry and the wider NTFP sector, this study holds the view that dynamics of development that can respond to inherent obstacles to growth and that can lead to situations of economic growth, social cohesion and environmental sustainability, should be viewed as successful territorial dynamics (RIMISP, 2007). While Europe as a continent has taken a lead, making territorial cohesion as a major regional economic goal supported by promulgation of cohesion policy for the period 2014-2020 (EC, 2011), Africa and the SADC region have lagged on such matters. Recent interest in spatio-temporal studies associated with the NTFP sector and the wider forest sector have been overly biased towards ecosystem dynamics and more specifically how anthropogenic practices influence such (Taghouti et al., 2021; Osseni, et al., 2022; Sikuzani, et al., 2023). We dismiss such and other related studies as incomplete, as their only take a partial stance on successful territorial dynamics that only recognizes one competence dimension of the environment.

Approaches such as these that have focused on one dimension of territorial competences, are however not new. A substantial number of studies have in the past approached territorial development dynamics from a single perspective such as the economic perspective (Terluin, 2003; Bryden et al., 2004; Agarwal et al., 2009). Other studies have taken only taken a social perspective (Kahila et al., 2009; Hamdouch, 2010) and others an environmental perspective (Courtney et al.,

2006; Langlais and Tepecik Dis, 2009). Unfortunately, these studies have not been helpful in looking at a territory as a holistic system driven by multiple interactions that take place between its many competence dimensions. Such multiple interactions would then yield territorial outcomes that may or may not define success.

The thesis posits that understanding important factors that influence the dynamics of territorial development and consequently their impact on the growth potential of NTFP sector is important to developing a progressive local economic development strategy in rural regions of developing countries. Such thinking has gained momentum and credence in recent years – a development that has substantiated a stance taken by the present study. Such momentum is evidenced by a sprout of new buzz words and phrases associated with territorial dynamics such as ‘territorial capacity’ (Calvo-Palomares et al., 2023), ‘territorial structure dynamics’ (Isaeva et al., 2022), ‘territorial competences’ (Calvo-Palomares et al., 2021; Fric et al., 2023), ‘territorial cohesion’ (SánchezZamora, et al., 2020; Gospodarowicz & Chmieliński, et al., 2022), ‘territorial adaptation’ ‘spatiotemporal land used dynamics’ (Alves et al., (2022), and ‘territorial knowledge dynamics’ (Wang, 2022) among others.

Despite all these studies, there is however lack of knowledge of the underlying factors that defines successful territorial dynamics across rural regions of developing countries, and of the most appropriate mechanisms and policies to foster improvements. Such dearth of knowledge is even sharper, in semi-arid regions of Africa where household dependency on NTFPs is reportedly high. In addition, most studies have tended to approach the subject of territorial development dynamics by defining territoriality at either municipal and /or district levels and with less regard of the very local level where resource extraction by rural households usually take place. It is the submission of this study that issues of territorial dynamics need to be taken to the smallest smallest territories or smallest Decision-Making Units (DMUs) as they also qualify to be treated as ‘rural production spaces’ where important decisions concerning their growth and development are to be made (Chen et al., 2023).

Some of the most important projects that have defined space and / or territoriality at a much more aggregated higher level have been reported in European literature around the subject. These

include among others the European Development Opportunities for Rural Areas – EDORA project (Copus et al., 2011) and Dynamics of Rural Areas – DORAS project (Bryden and Hart, 2001). In Latin America, the much-cited example is the Rural Territorial Dynamics Project (RIMISP, 2007). There is therefore need of research scholarship on territorial development dynamics that is ‘rural household centric’ and therefore reflecting the household circumstances that surrounds households and their interactions with NTF resources such as MWs.

While interest in territorial development dynamics offers a plausible justification of taking a spatio-temporal dimension in NTFP and LED studies, there are other authorities who believe that this is important but not adequate. Understanding territorial development dynamics in NTFP and local economic development studies would under this perspective focus exclusively on growth matters (Hill et al., 2008; Sánchez-Zamora et al., 2014: 12). It is argued that understanding *territorial resistance* is as important as focusing exclusively on growth-centred approaches (Hill et al., 2008; Brunetta et al., 2019). This analysis defines territorial resistance as the ability of a territory to respond to external changes or ‘shocks’ – a definition that is shared by many scholars in the subject (Wells, 2009; Batty and Cole, 2010; Pilone et al., 2019). It is therefore imperative that research is conducted on how rural territories with households that heavily depend on NTFPs are prepared to resist or adapt to situations of shock. The major assumption is that shocks of varied nature, including economic, financial, social or political crises; natural, ecological, industrial or epidemiological disasters; climate change; and technological change among others affect the core elements of the territory, people and their activities (Hamdouch et al., 2012). Activities that may be affected in the case of the MW industry and the wider NTFP sector may include harvesting, trading and / or marketing dynamics with obvious implications on the growth of the industry itself and the wider local economy.

Studies on resilience in the rural context are however not new. Previous studies have approached the concept of resilience from the perspective of complex socio-ecological systems and sustainable development to address several specific issues in rural areas (Wilson, 2010; McManus et al., 2012; Schouten et al., 2012). An integrated and territorial perspective that considers social, economic, and environmental has however not been widely applied according to Sánchez-Zamora et al., (2014). In addition, studies that exist on spatial and / or territorial resilience have largely been confined to very large territorial areas and / or regions. Pike et al., (2010) maintains that very few

existing studies on territorial resilience have focused on other types of territories. Since environmental resources such as MWs and the wider NTFP sector are very much susceptible to external change and ‘shocks’, it is more appropriate to use a conceptual framework of resilience to analyse territorial dynamics affecting the sector given the potential impact that such changes might bring to the resource users and their local economy at large. Sánchez-Zamora et al., (2014) have argued that studies that focus on territorial resistance play an important role in the design of subsequent policies. Analysing the resilience and / or stability of MW territories during periods of rapid external change and / or shocks provide useful information for policymakers to design LED policies, which, in turn, could allow MW territories to respond more favourably in times of crises (Ulloa-Espíndola et al., 2023).

2.2.2 Why place based territorial studies have gained credence in LED research.

There are several major arguments that can be put forward to justify the reason why place based territorial studies have gained prominence in LED discourse over the years. This are presented and discussed below.

Argument 1: The governance / institutional / support perspective

Top-down approaches to rural development have largely failed to address and account for spatial anomalies in economic development that have characterized many rural regions of developing countries. It is strongly believed that interpersonal and territorial inequalities characterizing most rural households in developing and middle-income countries are because of deficiencies associated with conventional top down – state cantered approaches (Bebbington et al., 2008; Rodríguez-Pose & Ezcurra, 2010; Yoo & Choi, 2022). A top-down balanced development strategy adopted in Korea for instance to foster regional balance resulted in disproportionate growth between regions in respect to quality of life (Yoo & Choi, 2022).

While government and other forms of institutional support are critical to rural growth, several scholars now concur that such support is usually “uneven and incomplete” (Bebbington et al., 2008:3-4). Consequently, such variations lead to divergent performance across territories, which has seen some local actors in some rural regions better able to negotiate with central governments

and/or raise revenues locally to fund development efforts (Rodríguez-Pose & Hardy, 2015; Yang et al., 2020).

Argument 2: Capacity building and connectivity argument

It is argued that a territory-based paradigm offers plausible opportunity to addressing the needs of rural economies which are often diverse and complex (Ambrosio-Albala & Bastiaensen, 2010; Rodríguez-Pose & Hardy, 2015). Meeting such needs according to Ambrosio-Albala and Bastiaensen, (2010) will require that local resource potential is unlocked and that broader and deeper linkages with activities and agents within and beyond the boundaries of the local rural system are created. More recently, Calvo-Palomares et al., (2023) have observed that a territory-based paradigm shift offers an invaluable opportunity of addressing greater difficulties faced by rural territories in generating opportunities for job creation and local development. It is also accepted that the endogenous potential of a region can only be activated through the adoption of place-based, territorially integrated policies (Rodríguez-Pose & Hardy, 2015) Growing interpersonal and regional disparities are a sign that spatially blind and sector led approaches (particularly those based on agriculture and manufacturing) have failed in the past and that location and place based approaches are there in our view to offer more promise (Rodríguez-Pose & Hardy, 2015).

Argument 3: The regional heterogeneity argument

As argued by Kraybill and Kilkenny, (2003) additional justification of location tailored and territorially based studies comes from what this thesis has termed a ‘regional heterogeneity’ argument. This is premised in the understanding the development is not an even variable across space. Many regional development scholars have acknowledged the existence of spatial differences in the performance of different territories in terms of development (Stanny et al., 2021). Existence of such territorial differences have been characterised in almost every literature as ‘undesirable’ and often responsible for stifling local economic growth (OECD, 2020;) In other literatures such territorial imbalances have often called for economic and spatial restructuring strategies that are aimed at giving an uplift to spaces that are seen as low production units (Jafarzadeh & Feng, 2023). Where sector led and or people-based approaches exist, interventions seeking to ensure that available opportunities are availed equally to rural enterprises and individuals in different localities have been encouraged (Rodríguez-Pose & Hardy, 2015; 2018). In essence, this is a call that requires spatially blind development strategies that do not recognize

the spatial distribution heterogeneity of rural spaces to re align their strategies with location sensitive development approaches (Wu & Chen, 2023).

Argument 4: The economic efficiency and aggregate growth argument

The importance attached to spatially blind approaches to stimulating economic efficiency and national growth by the 2009 World Development Report (World Bank, 2008), can be viewed as an important step towards justifying the need for territorial based approaches. The report rightfully identifies the so called three Ds (Density, Distance and Division) as the three major obstacles to regional development and identifies the three Is (Institutions, Infrastructure, Integration) as solutions to winnowing such challenges. Its major drawback is the amount of emphasis it puts on economic efficiency which it defines from a national point of view (Rodríguez-Pose, 2010). According to this report, dividends accruing from the implementation of strategies based on the three Is are expected to be felt at the local level through what has been referred to by many as ‘trickle-down effect’ (Jiang et al., 2023; Feng et al., 2023). In other words, it downplays a focus on rural development and unwittingly promotes an urban development agenda where rural development prospects are thought to rely more on the extent to which trickle-down effects can be generated (Rodríguez-Pose & Hardy, 2015; 2018). Such benefits as argued as early as 2010 by Peck and Sheppard, (2010) are usually offset by other powerful forces to the extent that a singular focus on economic efficiency and aggregate growth is not helpful to the prospects of realizing rural growth.

The outcome is worry some as reports later commissioned by OECD, (2009) and the European Commission indicate that that increasing territorial disparities, and impact on inequalities in general, can eventually undermine economic growth (Barca, 2009; Barca et al., 2012; RodríguezPose, 2012). Based on this shared perspective, there is now widespread recognition of the need to “look at the real world and try and understand things from local perspectives” (Scoones, 2009:172) and that such recognition can only be accommodated by integrated territorial approaches to rural development (Barca et al., 2012; Rodríguez-Pose, 2012).

2.2.3 Distinguishing attributes of people and place-based approaches

Since the previous sections have dealt more with the need to incorporate placed based and place sensitive studies in understanding of the potential role that NTFPs play in promoting local

development, a conceptual clarity may be required on people centred studies and their implication for NTFP centred development initiatives. The tenancy of such have over the years argued that such approaches to research are premised on two development hypothesis namely “Putting the Last First” and “Working with People” Cazorla-Montero & De los Ríos-Carmenado, (2023). People based approaches essentially refer to approaches that are sensitive to peoples nees and aspirations. They require the adoption of what Cazorla-Montero & De los Ríos-Carmenado, (2023) has referred to as the Working with People (WWP) model. Theree is widespread manifestation of the WWP model within the NTFP sector where many studies have essentially taken underscored the need to nurture positive people-environment relationship (figure 2.1)



Figure 2.1. Characterization of people-based approaches though the WWP model

Source. Carzola et al., (2013) in Cazorla-Montero & De los Ríos-Carmenado, (2023)

According to this model, three important dimensions are worth paying attention too if rural development through the NTFP sector is to be fostered in such a way that it is sustainable. These include the (i) ethical-social, (ii) technical-entrepreneurial and (iii) the political-contextual. The ability of development practitioners and researchers to listen, interact and engage with the people through social learning is what drives the interaction between the 3 dimensions. When exploiting the NTFPs, the ethical-social dimension would at least require an understanding of people’s behaviours, values, and attitudes and how all these influence successful rural development outcomes (Danquah et al., 2024). Technical–entrepreneurial component in our understanding will require participatory approaches increase access to capital / investments, inculcates an

entrepreneurial mindset to the exploitation of NTFPs. Existing studies have often explored how factors constraining NTFP users as economic agents of change to achieve potential contribution to rural development (Meinhold & Darr, 2019) and how to increase resource user's access to markets (Bachi et al., 2023). The political–contextual component in NTFP extraction has always focused on institutional support services and resource governance regimes that are likely to yield positive rural development outcomes (Peerzada et al., 2021; Nemec et al., 2023)

While people-based approaches remain relevant in the NTFP research scholarship as evidenced by a spurt of recent studies presented, this study maintains that such efforts will ultimately lead to unbalanced development in rural regions unless if space dynamics are infused in their analysis.

Incorporating space in development discourses of NTFPs is crucial in avoiding the adoption of spatially blind, people-based approach that has characterized the bulk of previous rural development efforts whose outcome has not helped in tackling persistent poverty, interpersonal and territorial inequality of most rural regions of developing countries. It is therefore imperative that we have an informed comparison of the distinguishing attributes of people centered as opposed to place-based studies if we are to avoid reinventing the wheel. Based on the review of literature on spatially blind, sector-led and people-based approaches and integrated, territorial, place-based approaches (Pisani and Fraceschelli, 2011) it is possible to draw such a distinction around four main areas of focus including.

- Conceptual / theoretical grounding
- Economic goals and / or objectives
- Social goals and / or objectives
- Policy and / or institutional setting(s)

A sniper of such distinguishing traits is depicted in table 2.1.

Table 2.1: Distinguishing attributes of people and place-based approaches

Distinguishing attribute	Spatially-blind, and people-based approach	Integrated, territorial, place-based approaches
Conceptual / theoretical grounding	Largely premised on notions of New Economic Geography (NEG), trade theory, and urban economics	Notions of NEG also evident. Premised on endogenous growth theory, institutional and evolutionary economic geography. Increased emphasis and thrust on Community Development (CD), Sustainable Livelihoods (SL) concept and framework, Rural Territorial Development, Collaborative Planning (CL) with much emphasis on participation by local actors in bottom-up initiatives that pervade all other approaches.
Economic goals and / objectives	Primary focus on economic efficiency, productivity and aggregate growth (all viewed as part of a national growth strategy). Rural regions targeted at the sector level (with either an agrarian focus or manufacturing bias / focus). More emphasis on better connected regions.	Emphasis extends beyond economic efficiency, to encompass other economic objectives such as promotion of employment and incomes at the local level. Emphasis also put on unlocking the potential of regions through the optimum use of endogenous resource capabilities of a region
Social goals and / or objectives	Social goals and / or objectives are met indirectly through the ‘trickle down effects. Costless mobility of capital and labour from urban core to rural regions is also assumed to contribute positively towards meeting social goals and / or objectives.	Efficiency and equity concerns make social goals and / or objectives central to the approach. Economic development policies systematically target employment opportunities by harnessing the competitive advantage and capacities of the territory through targeting of opportunities and constraints in an informal institutional setting.
Policy and / or institutional setting (s)	The private sector is at the center stage of growth and development initiatives. The public sector on the other hand plays a facilitator role by supplying the necessary infrastructure and services to boost production and exchange activity.	Both the private and the public sector has a role to play with collaboration between the two taking place at multiple scales. Such collaboration is targeted at fostering common strategies for the development of a region / territory. The approach acknowledges the existence of resource asymmetries that inhibit growth and that social, political and economic costs that

Distinguishing attribute	Spatially-blind, and people-based approach	Integrated, territorial, place-based approaches
	An emphasis on regulation and formal institutions, as a potential source of barriers to regional convergence. A centralized government model that is principally top-down determines the course of development	constrain the mobility of resources further dent a strain on the growth potential of a territory. A decentralized government modes, that is primarily based on administrative, fiscal power transfers determines the course of development.

27

Source. Pisani and Fraceschelli, (2011)

28

2.2.4 People and place-based approaches: LED implications.

Just as it is possible to distinguish spatially blind, sector led and people-based approaches from integrated, territorial and place based approaches, it is possible to discern the difference between what can be termed ‘zero and negative sum’ LED initiatives and ‘sustainable and positive sum’ LED initiatives (Rodríguez-Pose & Gill, 2005; Bardhan & Mookherjee, 2006). It is argued that the bulk of the documented LED initiatives have tended to assume ‘zero and negative sum’ initiatives that are based on redistribution rather than growth. Such a welfare approach to local development has been an attribute of LED initiatives run primarily on the basis of spatially blind, sector led and people-based approaches that characteristically have not been sensitive to intricate territorial inequalities of most developing countries. They are very few cases if any of LED initiatives that have been pursued along a ‘sustainable and positive sum’ growth principle – a principle that is primarily built around the notions of promoting equitable growth and employment generation (Bebbington et al., 2008). A substantive review of each approach that also draws reference to case material from developing countries is given in the next two sections.

2.2.4.1 Zero and negative sum LED initiatives

Used the term place neutral approaches (Barca et al., 2012).

Local economic development in South Africa is explicitly formulated as a “pro-poor” strategy that is geared towards creating more equitable economic growth (Republic of South Africa (RSA), 2000; Ramukumba et al., 2012). Rogerson, (2000: 2006) for instance has observed that a range of localities in South Africa are designing LED programmes that have a have a community/pro-poor focus.

2.2.4.2 Sustainable and positive sum LED initiatives

This approach has been characteristic of LED initiatives that seek to explore alternative development options that are based on rural development policies that are deemed to be sound and progressive. Progressive LED, or to use Tang et al., (2013: 22) characterization - placebased strategies can only be realized by local governments who are ready to implement “sound and progressive rural development policies.” Abouleinein et al., (2010) has also observed that sustainable forms of development that are both pro-poor and inequality reducing can be achieved at least in agriculturally based LED initiatives when local tailoring is teamed

up with appropriate resource governance practices. Kraybill and Kilkenny, (2003) talks about the economic rationales for and against place-based policies.

2.2.5 Key LED related features worth analysing if the growth potential of NTFPs to be properly explored: In search of a methodological framework.

Despite their popularity in stimulating growth in lagging rural regions, the impact of bottomup LED strategies has remained insufficiently assessed in both the developed and the developing world (Gordon and Low, 1998). If the lack of rigorous evaluation is a gap in the LED literature relating to the impact of the ailing traditional sectors of agriculture and manufacturing, then lacunae is far larger when one tries to analyze the possibility of the NTFP sector in transforming the rural economies (Barberia & Biderman, 2010). Such evaluative deficiencies has been worsened by lack of explicit theoretical propositions that are designed to guide rural development initiatives seeking to tap on the capabilities of utilizing NTFPs such as mopane worms. Several knowledge realities account for such a methodological deficiency including.

- Existence of diverse and multiple LED models
- Definitional difficulties associated with what really constitute LED.
- Multiplicity of disciplines that inform the LED discourse.
- Multiplicity of LED objectives and associated evaluation challenges These are discussed in turn below.

2.2.5.1 Existence of diverse and multiple LED models and theoretical postulations

What we currently have are numerous local economic development initiatives that have benefited from a multiplicity and diversity of models developed in host countries – a situation that has often made it difficult to replicate success stories in other lagging rural economies of the developing world (Rodríguez-Pose & Rodríguez-Pose, 2013: 303). Valdes & Foster, (2010) have observed that we generally know far more about the promotion of agricultural growth in rural areas than about the promotion of non-agricultural activities – a situation which this thesis argued has created a methodological vacuum that is not helpful if we wish to assess the LED implications of rural household use of NTFPs.

Perhaps this in part explains why NTFPs and other natural resources are largely neglected in the decision-making process at individual, corporate or government levels despite their perceived contribution to the rural economy, (Millennium Ecosystem Assessment, 2005;

Steinfeld et al., 2006). While this observation holds true for a variety of other non-agricultural sectors, it is particularly significant to forest resources which in most literatures has been characterized as a complex entity. This thesis argues that NTFP extraction is a complex system whose economic principles of production (i.e resource extraction, processing and selling) are directly intertwined with its biological, ecological characteristics in addition to obvious sustainability concerns, social and political issues surrounding their exploitation. Because of these unique attributes and absence of a generic LED framework that can holistically define the implications associated with their use, it has become difficult to replicate the multitude of LED models that have been designed to deal with complexity in the agrarian and other nonagrarian sectors – including the manufacturing, mining and the tourism sectors.

2.2.5.2 Definitional difficulties associated with what really constitute LED

Definitional difficulties associated with what really constitute LED have not helped either. Taxonomy of definitions currently exists (table 2.2)

The related rural development field has not made life easier either. The field of rural development also has multiple definitions of what constitutes rural development. A sample of such definitions is given in the Table 2.2.

Table 2.2: A taxonomy of LED definitions

Definition	Supporting authority
Rural development is a strategy to enable a specific group of people, including poor rural women and men to gain for themselves and children more of what they want and need. The specific group of people referred to in this definition also “includes small scale farmers, tenants and the landless”.	Chambers, (2013: 147)
Rural development is also defined as “sustained and sustainable process of economic, social, cultural and environmental change designed to enhance long term well-being of the whole community.”	Moseley, (2003: 4)
The US Department of Agriculture (USDA) has defined rural development as “improvement in the overall rural community conditions including economic and other	USDA, (2006: 1)
quality of life considerations such as environment, health, infrastructure and housing”.	

Rural development is also defined as a process which should improve all aspects of human life.	Madu, (2007)
Rural development is “development that benefits rural populations, where development is understood as sustained improvement of the population’s standards of living or welfare”.	Anriquez & Stamoulis, (2007: 2).

Source. Author construct, (2023)

The process approach (essentially the bottom-up process) implied in the variety of definitions of what constitute LED (refer to table 2.2) has limitations in the sense that it does not give development experts a step-by-step process of what should be done to appraise LED implications of promoting a NTFP led growth strategy. The terrain gets messy when one decides to bring together the twin fields of local and regional economic development and rural development. Associated literature in rural development studies reveals additional complications. Hewings, (2004) has for instance argued that rural development has in the past emerged as a field offering many fads and a few satisfying economic evaluations. To scholars such as van der Ploeg et al., (2000) and to some extent Akpan, (2012) and OECD, (2010) this is partly a reflection of lack of a clear and common understanding of what ‘rural development’ precisely means – a characterization that has not spared the LED arena of definitions that have been presented before.

2.2.5.3 Multiplicity of LED objectives and associated evaluation challenges

The taxonomy of definitions of LED presented earlier on certainly implies that LED initiatives are designed to deal with a multiplicity of development objectives. In LED and other related literature, LED is characterized as a discipline and approach that plays an important role in achieving numerous development objectives relating to institutional efficiency and resource governance related issues (see Ellis and Biggs, 2001; OECD, 2006; Bebbington et al., 2008; Rodríguez-Pose & Ezcurra, 2010); capacity building including partnerships and support services (see Njeru, 2003; Ambrosio-Albala and Bastiaensen, 2010; Dirven, 2011, Twala, 2012), innovations and other advances (see Mukherjee & Kuroda, 2003; Morgan, 2004; Barberia & Biderman, 2010); connectivity efficiencies (see Gutman, 1999; Faigenbaum et al., 2002; Escobal & Ponce, (2003); Attanasio et al., 2004; De Ferranti, (2005); Reardon & Timmer,

2007; Lohmann & Leinfner, 2009; Topalova, 2010; Christiaensen et al., 2013); economic efficiency (see Storper & Venables, 2004; Frenken et al., 2007; World Bank, 2008); equity / distributive efficiency (see Rogerson, 2000: 2006; Tijmstra, 2007; Barberia & Biderman, 2010; Ramukumba et al., 2012); interpersonal and regional / territorial disparities (see Barca et al, 2012; Rodríguez-Pose and Hardy, 2018); sustained economic growth (see Kraybill & Killkenny; Abouleinein et al., 2010; Tang et al, 2013); territorial resilience to external shocks (McManus et al., 2012; Schouten et al., 2012; Abdullah et al., 2015) among others.

On this basis of such multiplicity (in objectives), this thesis argues that decision making processes relating to NTFP led LED initiatives should be built on diverse range of information, evaluation methods and decision support techniques. Such a requirement as noted by Jaklic et al., (2014) can only be realized by the adoption of multiple perspective evaluation approach – a methodological paradigm that recognizes the multiplicity of issues and objectives associated with the exploitation of a local resource base.

At a more conceptual level, this approach is based on methodological pluralism – a perspective which many scholars argue is at odds with mono-dimensional approaches that are reductionist in nature and may be biased as they tend to favour one performance objective over others (Funtowicz and Ravetz, 1994; Patterson, 1998; Gasparatos and Scolobig, 2012). Evaluating spatio-temporal changes in MW use and alternative decision options there-off solely from a single perspective will not provide satisfactory information for integrated and sustainable planning of MW led LED initiatives in particular and in general the wider NTFP led LED strategies. Such a view has been supported (both in principle and in practice) by many who believe that growth initiatives that have traditionally defined performance in economic terms alone are insufficient in making proper evaluations of dividends accruing from exploitation of natural resources and as a consequent, they grossly under-estimate their potential contribution to the growth and sustainability of local economies (Willson and Howarth, 2002; Christie et al., 2006; Brown and Ulgiati, 2011; Ulgiati et al., 2011). Empirical evidence from the agriculture sector has certainly shown us that several criteria and evaluation approaches need to be considered simultaneously (Conway, 1987; Pannell and Schilizzi, 1999; Kropff et al., 2001; Gomiero et al., 2006; Dumont et al., 2012) if we are to integrate different aspects that define factors that lead to situations of growth in NTFP sector in general the the MW industry in particular. Exploring the LED implication of promoting a MW led LED strategy would

certainly require a methodological framework that is amenable to a multiple perspective evaluation approach.

2.2.6 MW resource dependence dynamics: To harvest or not harvest MWs.

We posit that understanding determinants of MW resource dependency is a crucial step towards the development of a MW oriented development strategy. A review of existing studies in MW shows several attempts towards understanding MW resource dependency exist (Baiyegunhi, and Oppong, 2016; Baiyegunhi et al., 2016; Sekonya, J. G., et al., 2020; Manditsera et al., 2022). While some studies such as that of Baiyegunhi et al., (2016) and of Manditsera et al., (2022) have attempted to incorporate the much-needed spatial dimension to the analysis, they and other related studies fail to give a comprehensive and statistically convincing case for the spatial and temporal dimension. The study by for instance Baiyegunhi et al., (2016) attempted to incorporate only one spatial dimension in relation to distance of households from markets where MWs are traded. We argue that there are a host of other spatial dimensions that need to be considered when assessing MW dependency. A much more recent study by Manditsera et al., (2022) who have looked at the contribution of MWs in the rural town of Gwanda in Zimbabwe made a concerted attempt to look at MW resource dependency using the wards as a spatial unit of analysis. While other studies fail to question the dynamic interaction of households with the output marks, this study is encouraging as it touches on a variate of markets that MW traders depend on. Unfortunately, this variable and the ward as a spatial unit of analysis, remain the only two spatial variables whose results are difficult to replicate in other environments owing to the restrictive nature of sample sizes used in each ward (6 – 15 participants in each ward). No single study to the best of own knowledge has attempted to incorporate a comprehensive list of both temporal and spatial variables that are adequate to inform the crafting of a MW oriented LED strategy.

The quired statistical rigour in understanding MW resource dependency is arguable present in the studies by (Baiyegunhi, and Oppong, 2016; Baiyegunhi et al., 2016) were statistical models such as the use of Logistic, Tobit and Probit regression models is evident. Unfortunately, the number of restrictive spatial variables, absence of a temporal dimension and the use of single case and single dependent variable is limiting. Baiyegunhi et al., (2016) has for instance used food security as the only dependent variable, making observations shared there to be limited to

food security matters. We cannot say with a high degree of accuracy if the pattern of resource dependency portrayed will be the same if another dependent variable such as quantity of MWs traded on the market or the intensity of involvement in outside markets as measured by the Household commercialization Index (HCI). While a study by Baiyegunhi, and Oppong, (2016) successfully uses the HCI as the only dependent variable, it does not go further in the analysis to bring in the quality of markets involved by incorporating such indices as market efficiency among other out-put measures. It is the contention of this study, that current MW oriented interventions based on such studies cannot be trusted to inform the development of an objective MW oriented LED strategy as we currently don't know the following.

- How are a mosaic of spatial and temporal variables shaping the MW resource dependency discourse?
- How, other variables often mentioned in other literatures (NTFPs) as rural access, economic diversification and market efficiency are altering the current development dynamics?
- What new dynamics are brought in by the inclusion of multiple dependent variables depicting MW resource dependency? And subsequently
- How some of the identified determinants of MW resource are being converted into a plausible LED output using such methods as the Data Envelope Analysis (DEA) approach.

2.2.6.1 What we currently know about determinants of MW resource dependency.

To accurately trace the value addition capabilities of the present study, it is advisable that we review what existing literature says about the major determinants resource dependency in the MW sector and the wider NTFP sector. To harvest or 'not to' is considered in current MW literature and the wider NTFP as a binary choice (Pattanayak et al., 2002; Amacher et al., 2003; Cubbage et al., 2003; Beach et al., 2005; Stordal et al., 2008; Baiyegunhi, and Oppong, 2016; Baiyegunhi et al., 2016). A number of studies have shown that non-forest income tend to have a negative impact on harvesting (Kuuluvainen and Tahvonen, 1999; Conway et al., 2003). Such studies are an attempt to incorporate a livelihood diversification index a step closer to understanding how a structure of a local economy may affect resource dependents. This aspect unfortunately has yet to permeate the MW resource dependency studies.

Within the MW sector we expect to see households who have more access to non-forest income being involved more in MW harvesting. Conversely, the propensity to harvest the resource is expected to be high for those households who have limited non- forest income options (Stordal et al., 2008). Resource owner characteristics are also said to play a decisive role in determining

the decision to harvest (Bolkesjø and Solberg, 2003; Vokoun et al., 2006). MW reliance is also viewed as a function of labour availability. Labour resources are commonly measured in terms of the number of hours households are committed to be involved in the harvesting process. It also extends to include such variables as the number of family members involved including whether there is hired labour or not (Eid and Hoen, 2005). Closely related to labour is human capital influence on harvesting behaviours. Specific human capital influence variables commonly cited in related literature include age of the resource owner, and the education level (Fina et al., 2001; Conway et al., 2003; Lien et al., 2007). In a timbers extraction study, Lien et al., (2007) for instance found out that increasing age decreased the owners' technical efficiency in timber production.

A number of other socio-economic variables have been found to be linked to harvester's propensity to harvest. One important socio-economic variable has been the poverty status of households involved in the harvesting and trading of the resource. Evidence of the link between wealth status and resource dependency in the MW sector is widespread. It is generally argued that such dependence (on MWs) is more pronounced within rural communities where poor households collect, process and trade natural resources from forests, woodlands, grasslands and rivers (Shackleton, *et al.*, 2007; Heubach, *et al.*, 2011).

Income generation has been considered to be one of the several other key livelihood indicators that can be used as proxy measure to depict resource dependency (Loaiza et al., 2015).

It is generally argued that MW communities that occupy geographical locations that are vulnerable to external risks and or shocks as a result of extreme changes in weather patterns, and environmental degradation among other factors are likely to be more dependent on MW harvesting than those who occupy localities that have unfavourable conditions. This is because non-timber forest products such as MWs can serve as 'savings' for localities characterised by such 'austere' conditions (Godoy et al., 2000; Sheil & Wunder, 2002; Loaiza et al., 2015). Another stream of research has singled out distance to markets and market integration as two other drivers of resource dependency. Although research on MW use has not (explicitly) touched on this aspect, empirical evidence in the wider forest sector has revealed diverse outcomes regarding the effects of the distance to the markets and market integration on resource dependency (Godoy et al., 2002; McSweeney, 2002). Godoy et al., (2002) have for instance observed that higher income and proximity to markets can reduce forest dependency. The same

study and also supported by empirical evidence presented by McSweeney, (2002) revealed that higher income and market penetration can also lead to higher extraction and higher revenues from forests products.

CHAPTER THREE: *MWs and the rural economy: A conceptual note on household interactions with local economy*

3.0 Introduction

This chapter reviews existing MW literature and research scholarship and by identifying important knowledge gaps and methodological challenges in measuring the impact of MW use on the local economy. Specific knowledge gaps compared to what we already know are exposed in relation to the contribution of MW resources to the local rural economy. The chapter concludes by presenting a series of what the research considers to be plausible approaches to understanding MW household interaction with the local economy and beyond. The whole review constantly reflects on what an MW oriented LED strategy would require. The 3rd and final part of the chapter presents the MW use situation in Zimbabwe, prevailing LED context.

3.1 What are mopane worms?

Mopane worms colloquially known as *Imbrasia belina* are caterpillars or larvae of the *mopane* moth which is commonly found in the warmer parts of southern Africa including Botswana, Namibia, South Africa and Zimbabwe (Chiripasi et al., 2013). The larvae are known by different names in different parts of Southern Africa. In Botswana, they are referred to as *phane*. In northern Zimbabwe, they are referred to as *madora*, while in southern Zimbabwe they are referred to as *macimbi* (Gardiner and Niyemeyer, 1998). *Anomalous Emperor Moth* is the English name commonly used for adult while Mopane Worms is used for the larvae. The caterpillars feed on leaves of the *mopane* trees (*Colophospermum mopane*) which are abundant in these areas in general (Gondo et al., 2010) and specifically in the hot, dry, valley bottoms and adjacent plains of southern Angola and northern Namibia, across Botswana and Zimbabwe to central and southern Mozambique, and from the Luangwa valley in Zambia and central Malawi to northern South Africa (Porter 1968; Werger & Coetzee 1978; White 1983; Mapaire 1994; Timberlake, Chidumayo & Sawadogo 2010; Siebert 2012; Makhado et al., 2014). The moth can also survive on other indigenous trees found in the *mopane* woodlands including leaves of a mango tree (Chiripasi et al., 2013).

Available estimates show that mopane woodland accounts for about 30% -35% of the 1.5 million km² of savannas in southern Africa (White 1983; Mapaire 1994;), which represents

more than a quarter of land area in the region. It is estimated that mopane woodlands in southern Africa cover a total area of 555 000 km² (see table 3.1) with the largest stretch in terms of proportion of country area being situated in Zimbabwe (Mapaure 1994 cited in Makhado et al., 2014). A visual impression of the spatial distribution of mopane woodlands in southern Africa is shown in Figure 3.1.

Table 2.3. Total area covered by mopane-dominated woodland in southern Africa.

Country	Area (km ²)	Proportion of country area (%)	Proportion of total mopane area (%)
Angola	112 500	9	20
Zimbabwe	101 500	26	18
Mozambique	98 000	13	18
Botswana	85 000	15	15
Namibia	77 000	9	14
Zambia	43 500	6	8
South Africa	23 000	2	4
Malawi	10 000	9	2
Total	550 500	89	100

Source: Data are taken from Mapaure, I., (1994), 'The distribution of *Colophospermum mopane* (Leguminosae-Caesalpinioideae) in Africa', *Kirkia* 15, 1-5.

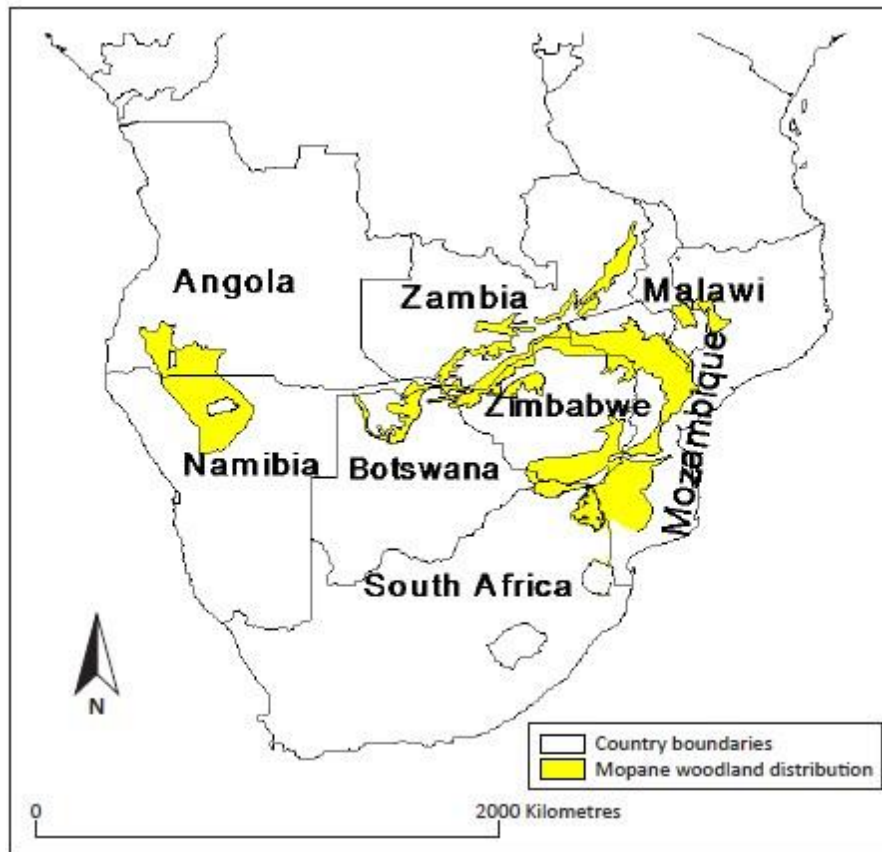


Figure 3.1. Spatial distribution of mopane-dominated woodlands in southern Africa.

Source: Makhado et al, (2014:2).

3.2 Mopane worms and the local economy: General importance

Existing literature on MWs and the wide edible insect sector reveals that many rural households derive many benefits from MW harvesting. To have an in-depth understanding of such benefits, we borrow insights from Shackelton and Pandey, (2014) have noted that existing literature NTFP extraction is awash with the multiplicity of functions that NTFPs fulfil in supporting human wellbeing. They argue that NTFPs fulfil such a function via five mechanisms as portrayed in figure 3.2.

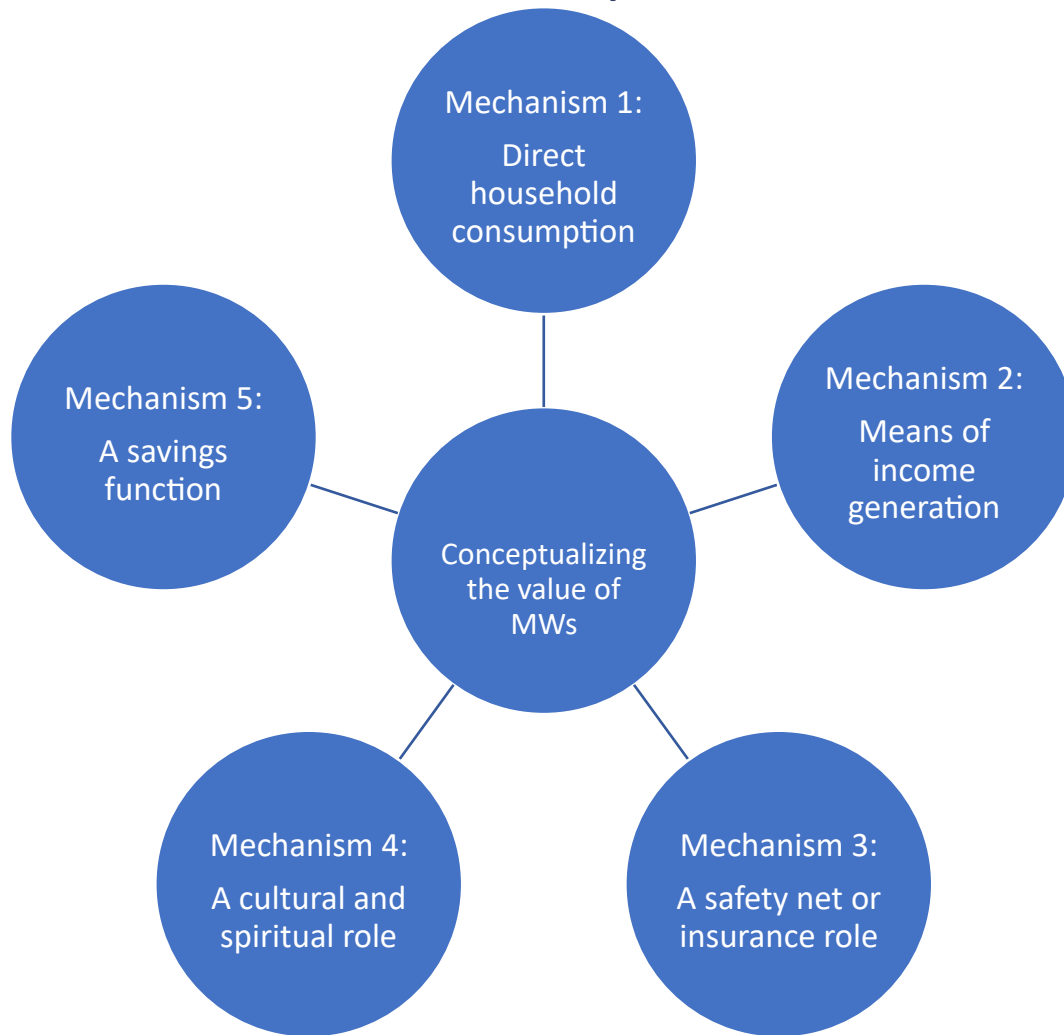


Figure 3.2. A framework for conceptualizing the value of MWs

Source: Author construct, 2023

Mechanism 1: Direct household consumption

A review of research scholarship on NTFPs in general and MWs in particular reveals that households stand to benefit from MWS through direct household consumption (Hegde and Enters, 2000; Kaimowitz, 2003; Stack et al., 2003; Akpalu et al., 2007; Hope et al., 2009; Madibela et al., 2009; Gondo et al., 2010; Saha and Sundriyal, 2012; Chiripasi et al., 2013).

The nutritional values of the MW, that is larvae of the moth *Imbrasia belina*, has seen its widespread consumption by both rural and urban communities (Voorthuizen 1976; Dreyer & Wehmeyer 1982) The nutritive significance of MWs as feed for livestock including guinea fowl in Botswana as well as other neighbouring countries such as South Africa and Namibia has been underscored by many (Madibela et al., 2009; Chiripasi et al., 2013). Chiripasi et al., (2013: 19) for instance has argued that the *Mopane* meal – which is essentially MWs harvested at larval stage, sun dried

and then milled is usually incorporated in animal diets as animal feed. The nutritive significance of MWs to rural households owing to high protein content has been noted in Zimbabwe by Stack et al., (2003) who have seen as a traditional delicacy to many.

While the precise contribution of these daily net resources to livelihoods is still debatable, some studies estimate that such contribution ranges from 10 to 60 % of total household income (Qureshi and Kumar, 1998; Babulo et al., 2009; Asfaw et al., 2013). Styles (1994) data estimated an annual population of 9,500m mopane worms in South Africa's 20,000 km² of mopane veld to be worth £57m. Approximately 40% of this worth was argued in the same study to go to producers who at that time were seen as an activity primarily for poor rural women. It is argued that diverse agro-ecological, social, cultural, economic, and political contexts in which NTFPs are found explain such a wide range in contribution (Belcher et al., 2005; Shackleton et al., 2007). Such benefits, however, vary according to the wealth status of households. NTFPs constitute a larger proportion of household incomes of poor families than they do of the relatively wealthy families in the same communities (Cavendish, 2000; Shackleton and Shackleton, 2006; Asfaw et al., 2013).

Mechanism 2: A means of income generation.

Many households rely on MWs as a source of income - either as supplementary income to other livelihood activities, or as the primary means of cash generation (Styles, 1993: 1996; Shackleton et al., 2008; Areki and Cunningham, 2010). MWs are usually traded to generate income (Styles 1996). It is estimated that NTFP trade's contribution to household cash income varies between 5% to over 90% (Bista and Webb, 2006; Shackleton et al., 2008; Moresello et al., 2012). The variability in contribution depends essentially on the degree of involvement and specialization, extent of value addition and seasonality of the resource (Shackleton and Pandey, 2014). The role of MW in come generation for rural people living in or near mopane woodlands of South Africa has been widely reviewed in recent times by Baiyegunhi and Oppong, (2016). In their study, the two researchers argued that income generation was one of the major drivers that has seen widespread commercialization of MWs through trade with obvious consequences on exploitation and management of the resource.

Mechanism 3: A safety net / insurance role

Several studies concur that NTFPs provide a safety-net, or insurance, for use in times of misfortune, such as death of a breadwinner in the household, loss of crops or livestock due to drought, disease or flooding, unexpected financial commitments, retrenchment, among other causes (McSweeney, 2005; Shackleton and Shackleton, 2004; Shackleton and Pandey, 2014). It is argued that MW are usually managed by rural households as part of a diversified livelihood portfolio to ensure availability of alternative resources in times of need as a buffer against uncertainty of natural resource availability and as a coping strategy (Kamanga, *et al.*, 2009). Shackleton, *et al.*, (2007) has also underscored the important role played by MWs in reducing household vulnerability. It is also argued that the insurance value is commonly realized by poorer households than wealthier ones (McSweeney, 2004; Paumgarten and Shackleton, 2011). It is typically employed by households directly affected as well as other households who provide support to the afflicted households (Takasaki, 2011).

Mechanism 4: A cultural and spiritual role

Posey, (1999) and Cocks *et al.*, (2011) believe that NTFPs play extensive and important roles in local cultures and spirituality. The widely cited example is that of Cocks and Wiersum (2003) who recorded the use of 103 plant species by households in a rural Eastern Cape (South Africa) village, of which almost one-third were used for cultural rather than directly utilitarian purposes. Other examples are also cited in literature. Kim *et al.*, (2012) for instance has described the use of a variety of NTFPs by the Sts'ailes people of Canada for ceremonial rites and making clothes and basketry, and resurgence of NTFP use as part of their identity. Areki and Cunningham (2010) have also described tensions between cultural uses of *Intsia bijuga* and growing ecotourism demand for cultural artifacts and handicrafts in Fiji. In Southern Africa, where it is widely harvested, Shackleton, *et al.*, (2007) has reiterated that MWs have other intangible benefits which include among others perpetuating traditions, improved quality of life, independence, and psychological wellbeing. Several other studies have also acknowledged the cultural and spiritual role played by MWs and other NTFP products in the wider sector. Such products are in these research efforts valued for their biological diversity for medicinal, local aesthetic use, cultural, recreational and spiritual values (Cocksedge, 2006; Muzayen, 2009; Areki and Cunningham, 2010; Cocks *et al.*, 2011; Kim *et al.*, 2012).

Mechanism 5: A savings function

Shackleton et al., (2007) maintain that the use of NTFPs by local households represents a cash saving to those households as well as the State. They believe that the use of such ‘free resources’ allows poor households to invest otherwise scarce cash resources in other livelihood needs, such as school fees, agricultural implements, fertilizers and many more.

3.3 MW use and its interactions with the rural economy

The ‘five mechanisms’ approach by Shackleton and Pandey, (2014) and supported by many other MW studies (Stack et al., 2003; Gondo et al., 2010) provides a novel entry point to understanding the importance of the MW to the rural economy.

Despite such studies in the MW sector and the wider NTFP sector, there is little field based knowledge on how to situate MW used based activities within a much broader rural economy. Previous and current approaches have certainly failed to address this knowledge gap. Past research has unsuccessfully tried to address this daunting challenge by analysing income generation as a key livelihood indicator. While income generation considerations are at least at the community and / or household scales a plausible entry point to understanding important interactions between MW use and the wider rural economy, this thesis posits that the approach is deficient. In the MW sector, there are few studies both in southern Africa and other regions that have attempted to evaluate MW harvesting for income generation at community and household scales.

Where such few evaluations exist, the thesis further posits that such evaluations have failed on three major fronts. First, data from such studies has failed to convince development practitioners as methodologies employed are multiple, varied and not accumulating and converging on the precise value of the resource to the rural economy. Some studies have focused only on direct income generated by MW harvesting and trade related activities (Stack et al., 2003; Dovie et al., 2005; Gondo et al., 2010; Shackleton and Gumbo, 2010) and others have considered subsistence income and indirect values accruing to the MWs and the wider NTFP sector (see Cavendish, 2002; Uberhuaga et al., 2012). Valuing income from the MW trade and other NTFPs has been problematic owing to several critical decisions that have to be made in terms of which income component to value and how to value it. Cavendish (2002:34) defined household income as the “total income: ... cash income plus value of all non-purchased

goods and services consumed or used by the household during the accounting period of time”. The length of accounting period in the MW sector has obviously been a subject of debate that has seen many researchers using different time metrics that suit their own study needs (See Cavendish, 2002; Uberhuaga et al., 2012; Loaiza et al., 2015).

One stream of research argues that total household income should be made up of the sum of all the economic value of products from a household in a year minus the farm inputs such as seeds, and feed among others (Cavendish, 2002). The other stream has attempted to incorporate indirect values accruing from a resource (Uberhuaga and Smith Olsen, 2008). The unit of measurement for income realised has been another contentious area. The estimation process involved is usually left to the discretion of researchers regarding which commodity prices to use in the valuation process. Whether to use farm-gate prices (value at the farm), barter values (value derived from exchange of product with market commodity), substitute values (value derived from local market price of close substitute), willingness to pay, and distant market prices (price on distant market minus transportation costs to market) has created a mosaic of decisions that often vary from one researcher to the next (Loaiza et al., 2015). This attribute has made comparability of LED initiatives that are informed by different income valuating methods difficult to compare.

Second, the income generation approaches employed have not gone beyond the subsistencebased production system view of individual harvesting households to look at how the net gains from this sector share important links with other major sectors of the economy such as agriculture and manufacturing among others. They have adopted a narrow focus on one product (i.e. MWs) as they have failed to look at MWs as part of a diversified livelihood strategy that considers important linkages between the mopane worm sector and other sectors of the wider rural economy. This overwhelming dominance of single-case inductive approaches to the study of LED strategies and their potential to transform the rural economy has been criticized by many (Markusen and Schrock, 2006; Crescenzi and Rodríguez-Pose, 2011; Rodríguez-Pose & Rodríguez-Pose, 2013). Such scholars have from the local and regional economic perspective dismissed single case induced approaches as inadequate in informing development policy. A few exceptions exist though. While a few exceptions such as a study by Stack et al., (2003) and other related efforts might be singled out, such studies have largely

remained informed by a variety of household and community level-based livelihood theories that are of little relevance to local and regional economic development studies.

Stack et al., (2003) has for instance looked at how income from MWs in southwestern Zimbabwe has been used by a sample of households to boost other sectors of the local economy such as agriculture, education and construction among others. Such a study benefited largely from the sustainable livelihood framework approach that generated ‘hear say’ study results not backed by robust statistical methods. Lack of robustness and lack of using extant local and regional development theories as a reference point has rendered such and related efforts obsolete, since it is difficult to establish the extent to which such supposedly links with other sectors of economy are statistically significant. Such inadequacies as has been noted earlier have been compounded by methodological flaws. It has been argued earlier on that the bulk of single case-based MW studies have largely borrowed research design insights from much broader sectors of forest and non-forest resources where different and often conflicting methodologies have been used to assess rural income sources.

This aspect alone then brings us to the third deficiency. It is currently difficult to discuss local economic development implications of MW use since no study to date has reviewed the contribution of this sector from a local and regional economic perspective. Using a local and regional economic perspective would require studies in MWs to be grounded on local and regional economic theories.

The major hurdle is how to make the MW sector – an activity that has been characterized in most literatures as a largely subsistence-based production system go along with other livelihood bearing sectors in the local rural economy.

3.2.1 MWs versus the local economy: The required shift

Although multiple researchers have studied the link between rural livelihoods and MWs, no study yet and to the best of our knowledge has attempted to assess the impact that MW harvesting has on LED or local rural development. There is need to develop or construct a transformation evaluation index system that can be used to evaluate the extent to which the MW sector is resulting in spill-over effects to the other sectors of the local economy. Most local and regional economic studies that have sought to analyze possible spill-over effects from one industry to other sectors of the local economy, begin by assuming that positive local economic effects will take place only if the industry concerned shows signs of transforming (Sun, 2014;

Hou et al., 2019, Yang et al., 2019). Put in a different way, industrial transformation is a prerequisite for registering of improvements in the local economy. It therefore follows that one of the intelligent ways of assessing the potential impact of the MW sector on the local economy is to begin by assessing the extent to which the whole sector or rather has transformed. It becomes imperative that we identify and explore those elements that are a critical impetus to industrial transformation. Once the elements are identified we then need to discern if an association between such and the local economy has been taking shape.

3.2.2 Why current MW studies have failed to shape the LED agenda.

The thesis posits that a multitude of existing studies that have attempted to discuss the important role that MWs has on the local economy have however failed to provide a convincing methodological framework that allows us to quantify such contribution both in time and space. While the widespread utilization of NTFPs such as MWs and their important contribution to rural livelihoods have been noted by several studies (Makhado et al. 2009; Paumgarten and Shackleton 2009; Makhado et al. 2012), the present study shares the same sentiments held by Baiyegunhi et al., (2016) who dismisses them as overly biased towards the ecological aspects of MWs and their contribution to rural livelihoods with less focus on their impact on the local economy using such LED indicator variables such as food security among other indicators.

3.4 MW household Interaction with the local economy and beyond

Building a NTFP based rural economy in general and more specifically a MW based will undoubtedly require that we have an in-depth understanding of how the key players in the sector are constantly interacting with several important attributes of the local economy and beyond. We will however need to restructure our current understanding of such household to local economy interactions, if we are to build a sustainable LED framework that should give a strategic direction the policy makers and other development practitioners should follow when implementing a MW led development strategy. The current spectrum of research efforts carried out to date has been overly limited to what happens to the household economy because of households' engagement with MW resource extraction and trade. Several attempts currently exist, that have taken mostly the livelihood capitals approach to understanding benefits likely to accrue to households because of their engagement with MW related activities. Despite challenges that exist in measuring the precise value of MW to the household economy, most

studies have adopted an income-based approach that attempts to look at the contribution of the resource to household income. Kwiri et al., (2014:61) has reported that “...in South Africa alone, the commercial value of Mopane worm harvests can reach \$3,000 per ha, amounting to annual sales of \$1.6m. Also in Botswana, the Mopane worm harvest in a good year is estimated to be worth \$3.3m, providing employment and income to 10,000 people (Shackleton & Gumbo, 2010). It has been argued that MW based rural and urban trade in Southern Africa can garner rural household’s financial returns comparable to remuneration earned from local agriculture (Dovie et al. 2002; Sekonya et al., 2020). The regional trade of MWs has become a common activity in recent times. Available estimates show that cross-border trade between Botswana, South Africa and Zimbabwe is valued between R422 million and R638 million per year (Makhado et al. 2014).

We argue in this thesis however that a MW based local economy would require us to go beyond the household economy and look at the likelihood of any overspill effects that are likely to accrue to the local economy and beyond.

Determining the transformative economic capacity associated with MW farm household interactions with the local economy and how such interaction varies with several local LED variables both in time and space is critical. The thesis recommends that the following approaches may help to shed light on household interaction with the local economy.

- A ‘territorial / regional dynamism in marketing strategies’ approach
- An LED index development approach
- A ‘resource to other sectors linkage’ approach.
- An infrastructure and services approach.
- A ‘development as hanging in, stepping up and stepping out’ perspective.
- A ‘MW households as agents of change’ perspective.
- A food security perspective

3.4.1 A territorial / regional dynamism in marketing strategies approach

The study takes its cue from Lobley et al. (2009), whose study on farm household interactions with the local economy in EU rural regions focused exclusively on direct economic transactions. This makes sense as rural household economic transactions involving monetary exchange values (either through expenditures or receipts), have been used extensively in local

and regional economic studies as a valuable starting point to understanding how NTFPs and other resources can or have been exploited to achieve positive and sustainable economic growth in the local economy. Markets for commodities are an integral part of the local economy and as such that understanding how LED players such as MW traders interact with which markets becomes very crucial in defining whether that interaction points to local integration or diversification. This approach requires that we take a closer look at how MW traders interact with the output markets. It is assumed that the degree of MW farm household interactions with the local economy is higher in MW territories characterized by distant and a spatially concentrated pattern of trade transactions. The thesis holds that development will take shape where there is a large concentration of trade in distant markets that are in relative terms more efficient in terms of the process of MWs fetched.

The two terms ‘distant’ and ‘closer’ are used in this study to denote how far from the MW farming household unit the actual transactions took place. A transaction platform near and around the MW farming household unit (eg nearby water-point, roadside) is defined in this study as closer, while those transactions taking place in a formal market such as a rural town or city were defined as distant.

Knowing where MW trade transactions take place is crucial of promoting growth. The concentration of MW trade was hypothesized to vary from one community to the next owing to several factors such as proximity to major rural markets and prices that traders would receive for the stocks. We expect proximal communities to be characterised by spatial dispersion of MW trade where most households in addition to selling some of their stock in the backyard or near roadside market, also sell in higher order and higher paying markets such as a rural centre markets, town or major city market. In distal communities we expect MW trade to be concentrated near the dwelling unit, where trade is spatially concentrated around the dwelling unit, trading households often sell their stock in what we have referred to as the back yard market and the nearby road-side market (Figure 3.3).

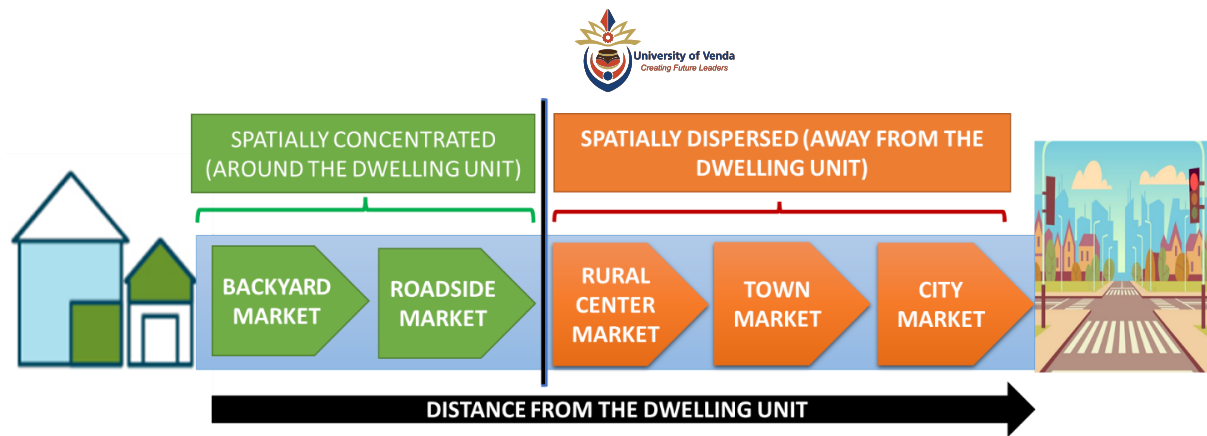


Figure 3.3 *Charactering MW trade as a binary variable – spatially dispersed versus spatially concentrated.*

A high concentration of such trading transaction near the dwelling unit is problematic for LED as such markets are often characterised as weak and paying less. Export markets are in LED literature characterised as lucrative as their offer higher income to the traders. A statistical analysis and characterization of places where MW trade takes place is a crucial indicator of the potential role that MWs play in the local economy. Existing MW research do appreciate the role that output markets play in promoting growth although many of such studies have not taken a much more rigorous statistical analysis approach.

Several authors for instance have observed that MWs in southern Africa support an increasing rural and urban-based trade (Illgner & Nel 2000, Kozanayi & Frost 2002; Sekonya et al., 2020). The livelihoods and income profiles of MW dependent households are significantly linked to household interactions with rural and urban-based trade of the worm (Heubach et al. 2011, Shackleton and Pandey 2014, Pandey et al. 2016). Sekonya et al., (2020), recently acknowledged the importance of MW income derived primarily from rural and urban based trade in supporting what they referred to as ‘regional livelihoods.’ This is because MW harvesters are estimated to be (currently) trading over 80% of their yield (Sekonya, 2020). Looking at the concentration of trade without question the quality of the product entering that market is not adequate. Adoption of product quality stretching innovations may increase the market value of that product.

3.4.2 A food security perspective

Kwiri et al., (2014) has observed that MW can play an important role in meeting one of the SDG goals of alleviating hunger. Their observations in Zimbabwe, reveal that MWs form a major part of the most consumed and highly nutritious insect with protein content averaging 55.41%. They further observe that MWs are a potential source of protein that could be capitalized on to alleviate diet deficiencies diseases among most vulnerable categories of rural

and urban communities. Such sentiments are also shared by several other scholars who have observed that edible insects in general are nutritious food that provide proteins (amino acids including methionine, cysteine, lysine, and threonine), carbohydrates, fats, a variety of minerals and vitamins, and have high energy value (Capinera, 2004; Johnson, 2010; Xiaoming et al., 2010). Increasing the uptake of such nutrition from insects has been viewed by others as requisite step towards alleviating food security challenge that is faced by many developing countries (Kent, 2002; Rowe et al., 2008; Gahukar, 2009; Kumar, 2010). Other scholars such as Moreki et al., (2012) also believe that MWs contain higher quantities of protein, fat, carbohydrate valuable minerals more than other substitutes foods such as beef and chicken. The increase in roughage intake that is associated with eating of MWs plays an important role in reducing some gastro-intestinal diseases – an attribute that has been dubbed a nutritious balanced meal functional perspective by some (Illgner & Nel, 2000; Mpuchane et al., 2000; Mohapatra et al., 2002). Table. Shows important statistics that has seen MWs being utilized as an important source of good nutrition in southern African countries of Zimbabwe, South Africa, Botswana and Namibia where the majority of stocks are harvested. Table 3.2 shows the nutritional composition of MWs.

Table 3.2. Nutritional composition of the MW.

Nutritional Composition	*Mean Value
Crude protein (%)	55.41
Digestible protein (%)	53.3
Carbohydrate (%)	8.16
Ash (%)	8.26
Neutral detergent Fibre (%)	27.8
Acid Detergent fibre (%)	16
Acid detergent Lignin (5.2)	5.2
Acid Detergent Insoluble Nitrogen (%)	0.9
Fat (%)	16.37
Potassium (mg/g)	35.2
Calcium (mg/g)	16.0
Phosphorus (mg/g)	14.7
Magnesium (mg/g)	4.1
Iron (mg/g)	12.7
Zinc (mg/g)	1.9
Sodium (mg/g)	33.3

*Mean value calculated from various sources including Dreyer and Wehmeyer, 1982; Illgner and Nel, 2000; Gardiner, 2003; Gardiner, 2005; Madibela et al., 2009; Moreki et al., 2012; Simone et al., 2013)

Source: Adapted from Kwiri et al., (2014: 60)

Several other scholars have also noted the important role played by MWs as an important source of protein. They argue that such role has seen the consumption of MWs contributing significantly to food security for poor households across Southern Africa (Dovie et al. 2002, Stack et al. 2003, Madibela et al. 2009; Sekonya et al., 2020).

Situating the MW-food security nexus within the local and regional development agenda.

Of interest to LED practitioners is the extent to which MW consumption will complement the dual role that the traditional sector of agriculture has always played. That of providing food and helping people to escape poverty (Gassner et al., 2019). Drawing parallels from other sectors such as agriculture and the wider Forest sector, this thesis argues that the potential role of MWs in meeting food security objectives of MW dependent rural communities need to be revisited. It is not enough to rely on anecdotal data to map out MW based food security interventions. Experiences from the agriculture reveal that important strides need to be made by rural development officials in closing the gap between actual and potential MW yields. A host of interventions that can close the gap between actual and potential MW yields exists and yet no study to date have explored how adoption of such may help achieve food security objectives in MW dependent communities. Following the cue from Gassner et al., (2019), we argue in this thesis that closing the gap between actual and potential MW yields will allow MW producers to harvest sufficient MWs to feed their families, and remain with a surplus to sell, thus meeting food security needs and bringing in an income to move them out of poverty. In addition to the promise brought by prospects of MW farming, a host of technological and institutional innovations exists that can raise MW yields per rural household substantially. Such innovations are however characterised by asymmetries depicting that MW households are heterogeneous and therefore follow different food security typologies that are associated with specific investment decisions made by each individual household. Increasing MW yield (farm productivity) is therefore largely a function of large differences between individual farming households themselves in terms of their investment incentives and capability to benefit from field-level technologies and their exposure to other innovations. The LED implications of this is that there is an urgent need to engage in ‘resource use analysis’ initiatives that lead to more differentiated MW based development policies and that will require policymakers to be much more aware of the heterogeneity of MW dependent households and the need for targeted interventions in addressing the food security challenges. Such analysis currently does not exist.

A MW – food security perspective is required so that we understand where and for whom MW harvests will have the main purpose of ensuring food and nutritional security and where and for whom there is the potential for significant increases in incomes and a contribution to wider economic growth. Such a stance is also acknowledged by other scholars who believe that such focus may help winnow the food security and undernutrition challenge that has remained one of the biggest problems that authorities in less developed parts of the world have been grappling with over the last few decades (HLPE, 2017; Gassner et al., 2019). Such concerns become particularly more significant in Sub-Saharan Africa (SSA) as the region has been singled out as the world's most food-insecure region, with almost one-fourth of people – over 230 million – being categorized as undernourished (FAO et al., 2019). Since it is acknowledged in literature that food security is about (1) access to safe, (2) nutritious and (3) sufficient food all year round, it becomes imperative that we interrogate the extent to which MW consumption is contributing towards these three main areas of focus within the context of what we earlier own termed actual versus potential MW yield. We envisage that such interrogation may go a long way in contributing to the debate about the effectiveness of food security interventions for rural development in general and the effectiveness of MW interventions for food security and subsequently for poverty reduction. It is also important to infuse in this analysis a categorization of MW dependent households into a categorization that enables LED practitioners to make a distinction between households who have limited incentives and resources and those with the potential and incentives to effectively invest in increased production. Gassner et al., (2019) believe that such a distinction has important implication for the natural resource dependent rural development policies. In the case of agriculture, the researchers believed that farming households who are characterized as having limited resources and incentives to boost productivity, need interventions that help to achieve food security and increase resilience while those with the potential and incentives to effectively invest in increased production. Would require help to maximize economic growth. While some MW studies such as that of Baiyegunhi and Oppong, (2016) have attempted to make such a categorization, we argue that such studies have been more biased towards an income-based resource commercialization and less on productivity-based classification. Such a MW commercialization study and other related efforts (Makhado et al., 2014) have done little to help us gain knowledge on actual versus potential MW yield within the context of food security.

3.4.3 A ‘resource to other sectors’ linkage perspective

This perspective looks at resource use and how such use is linked to other sectors of the rural economy and beyond. There is widespread acknowledgement in MW literature of the positive influence that resource use may have on other sectors of the economy including agriculture (Mpuchane et al., 2000; Kozanayi and Frost, 2002; Stack et al. 2003; Thomas 2013; Kwiri et al., 2014; Sekonya et al., 2020); The health sector (Illgner & Nel, 2000; Mpuchane et al., 2000; Mohapatra et al., 2002), the education sector (Kozanayi and Frost 2002; Stack et al. 2003; Thomas 2013), and the the forest sector (Hobane, 1995; Roberts, 1998; FAO 2010), the manufacturing sector , the construction industry and the food industry among other sectors. Most of the experiences presented in such literatures are however not helpful if we are promoting a MW based LED strategy. They are mostly isolated anecdotal experiences depicting household interactions with various sectors of the economy. We still lack an objective assessment of such interaction as it is currently difficult to tell the statistical significance of such interactions. An objective assessment of household interactions with various sectors of the economy may go a long way indicating which sectors are likely to benefit most is a MW based LED strategy was to be pursued. The development of what this thesis calls ‘a MW household based ‘resource to sector interaction index’ (R-SII) may go a long way in ranking the various sectors of the local economy per associated weights of interaction. It may also shed light in understanding spatial and temporal disparities associated with such interactions and subsequently LED implications. Such a micro-level analysis that looks at resource users at a household scale and how their activities are linked to the various sectors of the economy has important implications to the understanding of relationships between wider economic growth and poverty reduction, and to some extent of institutions and policies that might affect both economic growth and its impacts on poverty reduction (Dollar and Kraay, 2000; Dorward et al., 2003; Rodrik et al., 2004; Dorward et al., 2005; Ostrom, 2005). The following sections give details of how interaction between resource use and the various sectors of the local economy is currently perceived in MW literature and to some extent how such perceptions are reflected in extant LED literature.

Resource to sector linkage 1: The agricultural sector

Evidence in literature that links MW income to the agricultural sector exists. Several scholars have observed that MW produce and / or income has been invested by some households to support agricultural activities. One of the notable examples depicting such links has been the

positive role that MWs can play as a supplement to livestock feed. In semi-arid landscapes of Botswana, Namibia, South Africa and Zimbabwe Mpuchane et al., (2000) have reiterated that MWs could also be used in animal feed formulations. Due to its excellent nutritional content, interest in MWs as livestock feed has grown in recent times (Kwiri et al, 2014).

Evidence of MW traders using profit earned from the commercialization of trade to buying farm inputs such as, seed, fertilizers, ploughing utensils and livestock among others is widespread in literature (Stack et al. 2003; Thomas 2013). More recently, and building on observations shared by Kozanayi and Frost, 2002), Sekonya et al., (2020) has observed that the commercialization of trade has seen MWs not only providing a valuable source of income realised through formal or informal trade, but also as a key industry that contributes significantly in the purchase of farm inputs.

Resource to sector linkage 2: The health sector

The health sector is considered in LED literature as one of the major drivers of the local economy. A health labour force for instance is critical in steering productivity in major other sectors of the economy.

Several scholars believe that protein intake as well as intake of other important nutrients from MWs by both humans and livestock results in positive health outcomes (Sikwira et al., 2014). As observed by Moreki et al., (2012), this is because MWs contain higher quantities of protein, fat, carbohydrate valuable minerals in quantities that are more in quantities when compared to other foods such as beef and chicken. The increase in roughage intake that is associated with eating of MWs arguably plays an important role in reducing some gastro-intestinal diseases – an attribute that has been dubbed a nutritious balanced meal functional perspective by some (Illgner & Nel, 2000; Mpuchane et al., 2000; Mohapatra et al., 2002).

There is however a negative health effect associated with MW harvesting. MWs as observed by Kwiri et al., (2014: 59), have a tough skin that “... is protected by black or dark reddish brown spines which can be painful and cause lacerations...” The same authors also argue that the spines and associated hairs that characterize the worm have a slight rusticating effect. In addition to this, Gardner, (2005) also observed that when the larvae are handled, they often exude a slimy green fluid from the mouth, which may cause skin irritation to any scratches on the hands of harvesters (figure 3.4). Considering this health challenge some scholars have recommended the use of protective clothing such as gloves when harvesting or degutting the worm (Kozanayi and Frost, 2002; Taylor, 2003).



(a) Harvester collecting the worm using bare hands



(b) Harvester degutting the worm using bare hands

Figure 3.4. Image showing harvester collecting and degutting MWs using bare hands.

Source: Images from Brown, L (2013) <https://medium.com/the-best-of-zambia/the-mopaneworm-a-popular-african-delicacy-2aa2c20ec630> (Date accessed, 24 September, 2020).

As a key rural industry, mopane worm commercialization provides an important income source for households that has been used at times to support the health care needs of household members (Stack et al. 2003; Thomas 2013). Stack et al., (2003) for instance noted that some rural households have used part of the profit generated from trade to pay for health expenses incurred by family members.

Resource to sector linkage 3: The Forest sector

The link between MW utilization and then forest resource sector largely takes an ecosystem management perspective. Harvesting practices are said to either have a negative or positive effects on the Forest sector. FAO, (2010) has for noted that, reducing caterpillar populations through responsible or ecological harvesting practices is beneficial to host trees. However, nonresponsible harvesting practices such as cutting of branches or felling trees result in nonbeneficial outcomes such as forest degradation and deforestation. Such observation complements early observations made by Hobane, (1995) and Roberts (1998), who observed that a decline in the abundance and distribution of MWs was mainly due to increasing exploitation of the host mopane tree, a general increase in pressure on Mopane woodlands, and increased incidence and / or frequency of drought. A complementary view was also shared by Bartlett (1996), who concluded that heavy and irresponsible harvesting practices by households

in rural Botswana was largely responsible for the widespread disappearance Mopane moths in some areas.

Resource to sector linkage 4: The education sector

With more than 80 % of the yield traded on the market, MW commercialization has emerged as a key industry that has seen harvesters and traders using part of their profits to pay for school fees and buy school items including books and uniforms (Kozanayi and Frost 2002; Stack et al. 2003; Thomas 2013). Harvesting largely occurs during what Sekonya et al., (2020) calls the ‘hungry season’- between agricultural harvests and just before the school year begins when demand for cash to pay for school fees, buy uniforms and other school items is high.

Resource to sector linkage 5: The manufacturing sector

The inputs to the MW production system such as 20 litre buckets, gloves among others are purchased from the manufacturing sector. If such purchasing is happening locally, then there is strong interaction between MWs and that sector of the local economy. Where inputs are purchased from elsewhere, then the MW related activities will result in positive spill over effects into those outside economies.

Resource to sector linkage 6: The food industry

MWs play an important role in the food industry as consumers consider them as an important source of nutrient. With a little support to MW producers, we argue that investments in this sector may help MW dependent households realise potential yields that may help them have increased access to safe, nutritious and sufficient food. The contribution of the MWs to the local food and industry and beyond will go a long way in resolving the food security challenge that confront many families in Sub Saharan Africa.

3.4.4 Household Infrastructure and Services Index (HISI) approach

Based on observed dynamics associated with how MW income is used to acquire food, assets and foster certain improvements in the immediate environs of own dwelling unit there is a need to develop a much more localized development index that measures the impact of some income on the daily lives of rural households. While GDP related measures are a fair indication of the level of a region’s prosperity, the study argues that development progress at the regional scale may not be the development that households at village level experience. The trickle-down development hypothesis has not worked well for many communities in developing countries

mainly due to corruption and institutional bottlenecks that favour certain categories of individuals at the expense of others. Measuring progress towards the achievement of such aggregate top-down indicators of progress may not reflect accurately the contribution of MWs to the local economy. The closest well-popularized approach is to look at the Sustainable Livelihood Capital framework approach and quantify the values of the 5 capitals, including, Physical, Social, Human, Financial and Natural. This approach has been effectively used in analysis of household livelihood strategies and is not ideal to act as an indicator of LED. This study partially borrows insights from this approach and other insights from well-established indicators of LED to develop a much simple indicator system focusing on commonly discussed infrastructure assets and services impacting on the daily lives of households.

The connection between LED and infrastructure and services is acknowledged by multiple that have studied the link mostly at the national and / or regional level. (Hashimzade & Myles, 2010; Mizutani, & Tanaka, 2010). However only a few if any studies have attempted to treat investments in local infrastructure as an indicator of LED or local rural development as observed by Pavel and Moldovan, (2019). This study has adopted an innovative approach commonly referred to in inequality studies as an innovative ‘learn-as-you-go’ or sequential procedure to single out developments in infrastructure and services at household level as indicators of LED (Bilson et al., 2023). This study posits that rural infrastructure assets and services at the household level constitute a small part of a larger system of the local economy’s infrastructure assets and services at the regional and national levels. The thesis proposes that ‘improvements’ registered at the household level should be viewed as progress in development, since the construction of regional scale indices accounts for such. We call this thinking and approach as ‘development in small increments approach’.

Rationale behind the development of the infrastructure and services index

The development in ‘small increments concept’ requires that we split variables of development into smaller components. For instance, the total value of construction industry (one of the commonly used indicators of development) should in a rural set up incorporate improvements made at the household level such as the construction of a new building, or mere up-grades in terms of repainting of building structures including face uplifts in roofing materials among other improvements. Construction of a new source of water supply system is a ‘small’ achievement that may lead to the overall improvement in the quality of lives of all is many

households are continuously registering improvements in this regard. Positive changes in the amount of land cultivated when later combined with production statistics may increase the agricultural output of the whole village. We currently don't have an index that captures such incremental development activities. Based on the selection of several infrastructure assets and services that households normally invest in this study proposes the adoption of an indicator system such as the one shown in Table to compute the HSI index as presented in the indicator system in Table 3.3. The selection of such an indicator system is largely informed by data generated during focused discussions where participants were asked to identify areas of aspect in their lives that were being impacted positively by participation in MW trading activities.

Table 3.3 The HSI indicator variables

Variable	Theoretical assumptions	
Changes in dwelling unit	Number of dwelling units and associated improvements is a significant component of the overall value of the construction industry.	Pavel & Moldovan, (2019)
Changes in roofing material	Housing improvements are a significant component of the overall value of the construction industry	
Changes in water source	Access to clean water supply has direct impact on of quality of life and long-term economic impacts	Janeski & Whitacre, 2014
Changes in access to own Information and Communication Infrastructure (ICT)	Access to own Information and Communication Infrastructure (ICT) is one among many other predictors of quality of life	Wong, 2002.
Changes in transportation services (including new ownership of own vehicle, scotch cart, wheelbarrow, bicycle)	Changes in ownership of transportation services at household impact local development as a result of improved access.	Hashimzade & Myles, 2010; Mizutani, & Tanaka, 2010
Changes in area under cultivation	MW income may be invested to support cropping activities by expanding the portion of land normally cultivated under a scenario of no MW income.	

3.4.5 A ‘development as hanging in, stepping up and stepping out’ perspective

While the ‘resources to other sectors’ perspective provides, a valuable entry point to understanding how MW resource users interact with a multitude of sectors in the local economy and beyond, it does little to help understand the broader LED implications of such interaction on development goals as poverty reduction and a host of what this thesis terms ‘development trajectories’ that may see resource users and resource depended communities transition from a state of poverty to that of prosperity. An ideal approach would require us to adopt what other scholars have referred to as a ‘development as hanging in, stepping up and stepping out approach’ (Dorward et al., 2009). Understanding of poverty and of ways in which people escape from or fall into poverty is an integral part of any LED policy. The transition by MW resource users and / or MW depended on communities from a state of poverty to an aspired state of wealth and prosperity is not automatic. We posit in this thesis that putting MW dependent communities on such aspiration trajectories is a mammoth task that need to be addressed by developing and nurturing a positive relationship between what is aspired and the new and attractive LED realities to be achieved. The complexities associated with doing this are a major hindrance, since poverty as a concept is complex and therefore requiring approaches that integrate multi-dimensional, multi-level, and dynamic understandings of it, of livelihoods associated with resource use, and of changing roles of resource exploitation systems (Dorward et al., 2009). While such an approach is well documented in and has permeated the agricultural systems, the same cannot be said about the MW sector.

The usual practice in the agricultural systems sector has been to investigate the relationship between farmers and other sectors of the rural economy. Such investigations make use of a schema or theoretical framework that analyze the extent to which livelihood strategies employed by small scale farmers constitute what is commonly referred to in development circles as hanging in, stepping up and stepping out (Dorward et al., 2009; Pritchard et al., 2017; Masunungure et al., 2018; Gassner et al., 2019). Such an approach as argued by Dorward et al., (2009), allows policy analysts and other development experts to have an in-depth understanding of poverty, including the ways in which people escape from it or fall into or are locked in. The understanding here is that the exploitation of natural assets such as MWs can be used as a useful barometer in determining people's abilities to move out of poverty as well as consideration of the dynamics of chronic and transient poverty, including the processes by

which people escape from and fall into poverty (Carter and Barrett, 2005; Krishna, 2004; Kristjanson et al., 2004).

Existing theoretical frameworks

Investigating the relationship between MW farmers and the other sectors of the local economy and how that interactions plays out in placing MW farmers of a development trajectory require the use of an appropriate analytical framework. A multitude of theoretical frameworks which are largely an extension and / or variant of Dorward's middle-ground theory. According to Pritchard et al., (2017), Dorward's middle-ground theory is one among several other schemas that provides an appropriate analytical vehicle for capturing the vagaries and situated complexities of the land-livelihoods nexus. The theory can equally be used to have an in-depth understanding of the vagaries and complexities associated with MW-livelihoods nexus and how variations in LED factors may affect such in both time and space. An initial appreciation of how Dorward's schema may shed light to the extent to which household engagement in MW trade activities may help households escape out of poverty is extensively reviewed in Stack et al., (2003). In their work, Stack et al., (2003) make an attempt to employ the model by Dorward and Anderson (2002) to categorise different livelihood strategies employed by MW farmers. Such work significant as the model presented allows us to determining if investing in MW is associated with development opportunities that may see MW territories being transformed into spaces of wealth and prosperity. Dorward and Anderson (2002) initially identified four livelihood strategies that normally confront livestock farmers, that can equally be applied to the NTFS. They distinguished four livelihood strategies, including 'hanging on', 'stepping up' and 'stepping out'. Figure 3.5 depicts the envisaged relationships between the livelihood strategies and the associated pathways that according to Stack et al., (2003) may eventually see MWs users escaping poverty.

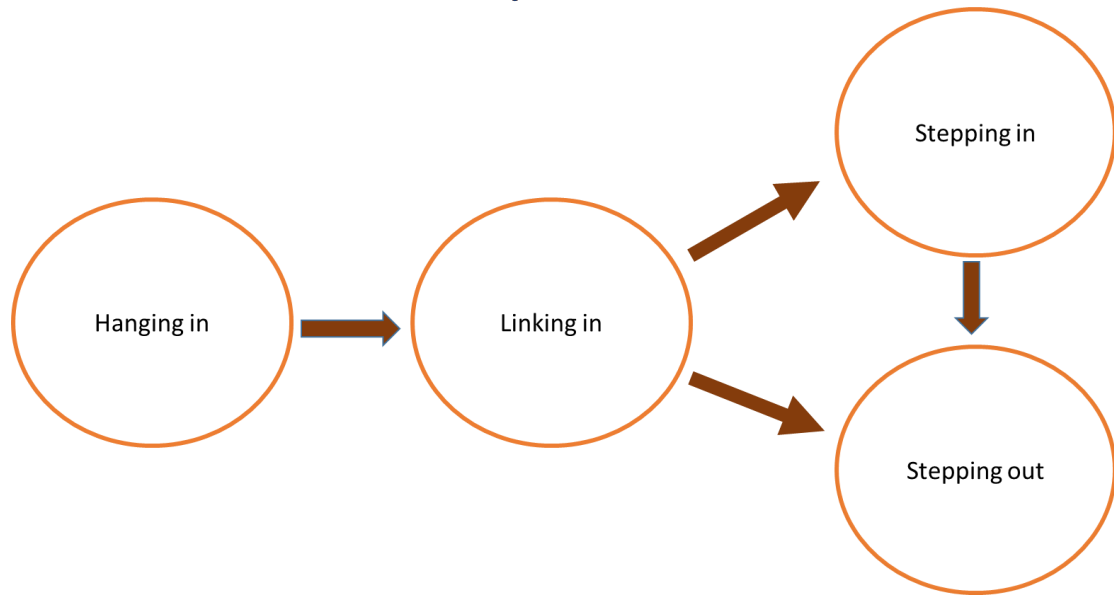


Figure 3.5. Schema depicting livelihood pathways that confront MW users

NB: Initial characterization inferred from Dorward and Anderson (2002), Stack et al., (2003) and Dorward, (2009).

Source: Author's construct, (2023)

By extension LED implications associated with the utilization of the MW resource may be clear if we look at development as ‘hanging on’, ‘stepping up’ and ‘stepping out’. In this schema, the ‘hanging on’ development scenario is described as activities that enable households to maintain their current livelihood. The main objective here is survival and this thesis posits that MW territories dominated by such a strategy have little chance of developing. By contrast, the latter two livelihood strategies represent different pathways for livelihood improvement and subsequently development. The first allows MW users to accumulate (through purchasing or bartering) productive resources that can be employed to expand current activities and income. The second strategy would then allow use of accumulated resources as a developmental springboard from which MW users can shift to different, more desirable livelihood outcomes. While this simplified version of schema is a valuable entry point in understanding LED implications associated with the use of MWs, we found it to have many shortcomings and as such we have introduced an expanded view of livelihood strategies that capture the diversity of livelihood pathways often followed by MW harvesting households. Our observations are consistent with views shared by Prichardt et al., (2017), who observed the initial model shared by Dorward, (2009) was too restrictive to account for the diversity of livelihood starting points and the multidimensionality of livelihood pathways that according to current literature characterize MW dependent households. We have introduced two more categories (‘dropping

out’ and ‘one foot sideways’) and stretched the characterization of the stepping out strategy to include what Pritchard has referred to as the ‘getting ahead’ strategy. Table 3.4 is an attempt to link the expanded livelihood strategies with LED implications.

As depicted in the table, we posit that MW territories that are significantly dominated by households whose main livelihood strategy is ‘Hanging in’ do not contribute much to LED as the primary motive is sustenance. As argued by Dorwad, (2009), this is because households perform this strategy to maintain the status quo. Economic growth may be triggered by MW territories where a significant number of MW dependent households are pursuing either the ‘stepping’ up or ‘stepping out’ livelihood strategies. Conditions amenable for development take-off are characteristic of MW territories that are dominated by households pursuing a ‘linking in’ livelihood strategy. The schema presented is an extension of the framework used by Stack et al., (2003). As reiterated earlier on, our schema is a stretched framework that attempts to show how livelihood strategies can be valorised by rural development practitioners to foster LED. It helps to look at LED from the development drivers and development opportunities perspective.

Table 3.4. Link between livelihood strategies, MW use and drivers of LED.

Zero/Slow growth Accelerated growth	Livelihood strategy	MW use scenario	LED drivers	LED implications
	'Going backwards'	Non-use of MWs Food insecure households	None	Food insecurity
	'Hanging in'	Subsistence Buffering	None	Livelihood sustenance Development assuming a welfare function Food security
	'one-foot sideways'	Buffering MW households who are also highly and increasingly active in the nonfarm economy	Income diversification	Livelihood diversification and sustenance Food and Income security
	'Linking in'	Market production/ income for small cash purchases Income to initiate some lower order 'stepping up' activities Income to initiate some lower order 'stepping out' activities Accumulation of primarily social capital	-Income -Social capital - Investments in lower order stepping out activities	MW led Development takes off
	'Stepping up'	Accumulation of all types of capital assets Complementary production Market production/income	-accumulated capital assets -Accelerated production -Income growth	Wealth and/or asset accumulation.
	'Stepping out'	Accumulation of capital assets	-Investments in other sectors of the local economy (education, agriculture, construction, etc).	Development and growth

Source: Author's construct, (2023)

Following the cue from Pritchard et al., (2017) who have experienced problems in applying Dorward's (2009) schema, we have added three missing livelihood strategies that capture resource use behaviours of MW users when faced with adversity and prosperity. We have added the category 'dropping out' for households under greater states of distress.

The alternative terminology used by Pritchard et al., (2017: 52) to characterize such a livelihood category is 'going backwards or muddling through'. Dorward, (2014) later acknowledges the existence of such a strategy when presenting what he terms four livelihoods transitions. The 'livelihoods framework' presented take cognisance of what he calls 'falling down and out'. In his framework, this strategy depicts households failing to maintain the status quo and

subsequently falling to a livelihood system with lower attainment of sets or subsets of activities and/or assets and asset functions. The end result is failure to maintain the livelihood system and to survive (Dorward, 2014: We define such MW dependent households as households who have limited access to land, ecosystem goods and services and who in the past have enjoyed access to large stocks of MWs. However intermittent disruption in resource supply owing to weather changes and long-term environmental degradation, has left a permanent food security void. The other category we introduced, is a borrowed and modified strategy labelled by Pritchard et al., as ‘one-foot sideways’. We define this as cases where MW households continue to rely on MW proceeds but are also highly and increasingly active in the nonfarm economy. Participation in the non-economy is main priority while MW use is secondary priority. We have also stretched Dorward’s initial characterization of the ‘stepping out’ strategy to introduce related attributes of what Pritchard et al., (2017) has referred to as getting ahead. These are Households who have decided to use MW income to venture into new investments in land and / agriculture, expenditure on education of children, and construction among other important sectors of the local economy. Since the ultimate objective is stepping out of the current livelihood portfolio, we decided to retain the label ‘stepping out’.

Despite an attempt by Stack et al., (2003) to apply the framework presented by Dorward and Anderson (2002), we still found important knowledge gaps. The approach adopted falls short in the following areas.

- It fails to link MW user livelihood pathways, to LED in general and more specifically to LED drivers.
- It fails to situate identified opportunities and constraints within a broader village and / rural economy.
- The approach fails to define and account how Implied development pathways and opportunities vary both in space and time.
- It also fails to take account of the diversity of livelihood strategies that often confront MW users. Examples of such omissions include but may not be limited to what Pritchard et al., (2017) have referred to as ‘dropping out’, ‘one foot sideways’, and ‘getting ahead’.
- The analysis presented is limited to application of a microscale- household-scale framework of sustainable livelihoods analysis (SLA) and does little to connect largescale LED theory with what Pritchard et al., (2017:42) has referred to as the messy realities of household decision making.

- Its greatest flaws lie in the lack of statistics that indicates which of the four livelihood is dominant and associated development implications thereof. It limits the discussion of such strategies to an anecdotal account of observed livelihood pathways.

We argue in this thesis that only approaches that objectively define the dominant livelihood strategies and associated livelihood pathways both in space and time may shed light about LED implications of investing in MWs. A conscious effort to link household livelihood strategies with broader developmental issues characterizing rural economies is not only required but is possible. One conscious effort is that presented by Dorward in 2014 when he developed a conceptual framework integrating social, ecosystem, and development. Such a conceptual framework which he dubbed the Livelisystems framework is depicted in Figure 3.6.

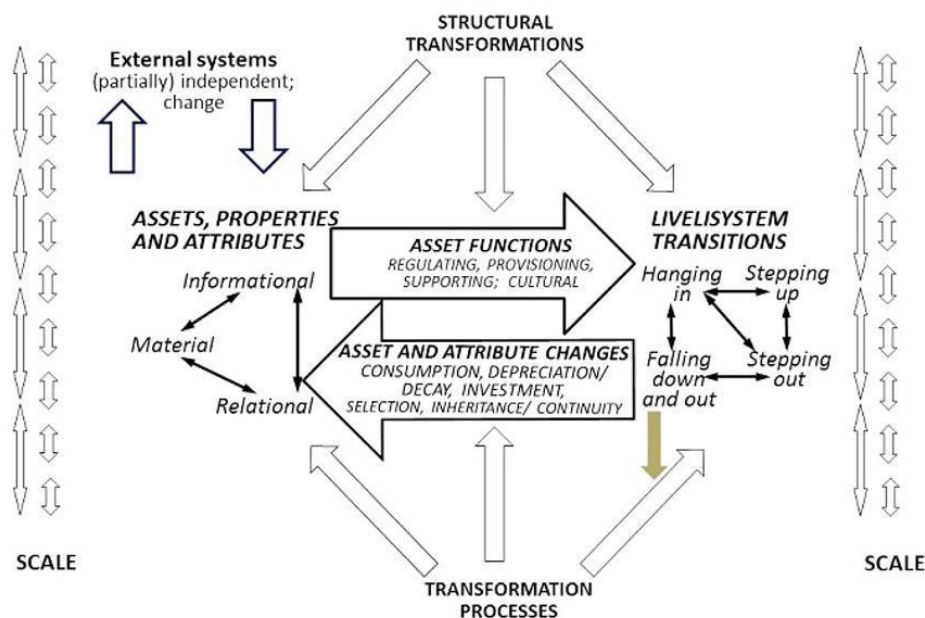


Figure 3.6. Broad processes and elements of the livelisystems framework

Source: Dorward, (2014).

As depicted in the figure, there are broader developmental processes and elements associated with different livelihood pathways that confront rural households. Understanding the breadth and depth of such processes and elements and how they are intricately linked to livelihood strategies and pathways is an important step toward development constraints, opportunities and aspirations associated with utilization of natural assets such as MWs. Such understanding was grossly limited by the framework applied by Stack et al., (2003) in a number of MW producing districts in Southern Zimbabwe.

Adopting a ‘development as hanging in, stepping up and stepping out’ perspective is deemed to be ideal for understanding how involvement in MW harvesting may potentially help households escape or remain trapped in poverty. Other related approaches have often failed to provide a schema that overcomes the challenges associated with satisfactory indicators of poverty reduction. Past efforts in measuring the impact of Investments on poverty in related sectors of agriculture for instance have been dismissed as inadequate as analysts have often often failed to generate sufficient positive measurable impacts on poverty reduction (Kelley et al., 2008; Renkow and Byerlee, 2010). More recently, Gassner et al., (2019) has implicitly acknowledged that Dorward’s schema may offer a plausible approach in overcoming such a measurement crisis. Such a schema was also deemed ideal as it resonates well with the multidimensionality of poverty as a concept. By looking at how MW proceeds are spent in various sectors of the local economy, the proposed framework fits well with word bank’s conceptualization of poverty as a multidimensional concept encompassing low income and consumption, low educational achievement, poor health and nutritional outcomes, lack of access to basic services, and a hazardous living environment (World Bank, 2018).

3.4.6 A ‘MW households as agents of change’ perspective.

Following the cue from agriculture-based LED policies, understanding the interaction between MW use and the local sectors of the economy will require that we place heavy emphasis on MW households as agents of change. This perspective allows us to view MW resource-based communities as development change catalysts that will help transform respective MW territories into situations of economic growth. It is a pro-growth-oriented LED perspective that seeks to create an enabling environment that will see MW territories being dominated by households as development actors that have potential and incentives to effectively invest in increased production and / or value creation. According to this view, increased interaction between resource users and the local economy is registered when the concerned communities are dominated by individuals or groups that have potential and incentives to effectively invest in increased production and or value creation (Gassner et al., 2019). Based on their experiences on investment outcomes associated with small scale farming operations in Sub-Saharan Africa (SSA), Gassner et al., (2019) reached the conclusion that investment efforts by small holder farmers were meaningless where the sector was dominated by farming household characterised as having limited incentives and resources.

This perspective builds on a persistent paradigm in the development debate on SSA that has seen over the years productivity, and potential earnings of resource-based communities as the key to achieving development goals such as alleviating poverty, ensuring food security, and fostering economic growth (Godfray and Garnett, 2014; Gassner et al., 2019). The bulk of MW literature has been biased towards a pro-poor LED stance that has looked at the ‘actual’ contribution of the resource to the local economy at the expense of looking at potential earnings and associated implications on the various sectors of the local economy should investing in the resource pays.

There are several pieces of evidence from existing LED literature and MW literature that points to the need to look at MW dependent households as agents of change. This includes the following.

- Rural-urban interdependences
- Entrepreneurship and entrepreneurial dynamism
- Research and Development (R&D)
- Social innovations

Associated pillars of change and specific building blocks associated with such are shown in Table 3.5.

Table 3.5. ‘Agents of Change’ model attributes at assumptions

Pillars of change	Specific Building block	Assumptions	Supporting references
Rural-urban interdependences	Beneficial Rural and urban networks / partnerships	Rural entrepreneurs with linkages to urban areas can bridge the rural–urban divide by accessing some of the urban features, such as knowledge and markets, while at the same time profiting from the advantages of their peripheral location Rural entrepreneurs are economic agents of change that may act as an opposing force to polarizing concentration of economic activities in cities	Freire-Gibb, & Nielsen, 2013; Faggio & Silva, 2014; Mayer et al., 2016;

	Sustainable economic relationships between urban and rural areas	Rural entrepreneurs are critical in building crucial rural–urban linkages which in turn might give rural economies development opportunities and might reduce the onesided dependency from urban dynamics Rural entrepreneurs with urban linkages might contribute to sustainable economic relationships between urban and rural areas	
Entrepreneurship and entrepreneurial dynamism	Enterprise development	The growth of a region is positively associated with the number of enterprise establishments in that space.	Spigel, 2016
	Density of entrepreneurship in the region	Rural households who occupy regions where the density of entrepreneurial activities is high	Staber, 2007; Isenberg, 2010; Autio, 2014; Spigel, 2016; Audretsch, & Belitski, 2017.
		have a higher likelihood of establishing enterprises compare to those who occupy low density regions.	2014; Spigel, 2016; Audretsch, & Belitski, 2017.
	Vibrancy and supportiveness of existing entrepreneurial ecosystem	A vibrant and supportive entrepreneurial ecosystem in a region may help and encourage the development of successful entrepreneurship.	Isenberg, 2010; Autio, 2014; Spigel, 2016; Audretsch, & Belitski, 2017
Creation of sustainable entrepreneurial ecosystems	Density of social networks and connections	Mature and stable EEs that are critical for economic growth are associated with a high density of intra-system connections.	Cohen, 2006; Isenberg, 2011; Spigel, 2016; 2017; Feldman, 2014; Malecki, 2018
	Level of interaction with social networks and institutions	The level of interaction between MW enterprising households and social networks and / or institutions is critical in defining the efficiency of connections that exist.	Alvedalen & Boschma, 2017.
	Entrepreneurial culture in the region.	Enterprising households occupying regional settings with a history of, and are characterized by active and successful entrepreneurship are likely to create the conditions and culture that ignite further entrepreneurial development and success.	Staber, 2007; Isenberg, 2010; Autio, 2014; Spigel, 2016; Audretsch, & Belitski, 2017.

Source. Author construct, 2024.

Rural - urban interdependences

This pillar of change builds on interdependences that exists between rural areas and urban areas and holds that enterprising communities that access urban markets may bring back development to lagging rural regions through backwash effects (Faggio & Silva, 2014; Mayer et al., 2016). Mayer et al., (2016) has for instance observed that rural entrepreneurs with linkages to urban areas can bridge the rural - urban divide, which is often an obstacle in efforts targeted at bridging the gap between widening gap that characterise most developing countries. They argue that rural entrepreneurs play a critical role in rural development as they can access some of the urban features, such as knowledge and markets, while at the same time profiting from the advantages of their peripheral location. In addition to this, it is argued that they have additional positive attributes that have seen them being able to develop sensibility for core market demands and trends, valuating rural assets, and combining rural and urban sources of knowledge for innovation and development.

Entrepreneurship and entrepreneurial dynamism

Another pillar of change comes from what others have termed entrepreneurship (Mayer et al., 2016). Entrepreneurship and / or entrepreneurial dynamism according to the ‘agents of change’ perspective would require MW territories to be dominated by enterprising households if positive socio-economic spill over development effects can be felt in the local economy and beyond. Several pieces of local and regional development literature acknowledge the role that enterprising communities play in boosting local and regional economic development.

It is believed that one of the major building blocks of entrepreneurship and entrepreneurial dynamism is the density of entrepreneurial activities found in the region. The understanding is that such density uniquely defines the entrepreneurial culture of that region that in turn determine whether positive spirals may be realized through any form of investment. By extension, investing in MW related entrepreneurial activities may not yield returns if the entrepreneurial culture of that region as defined by a low density of entrepreneurial activities is inhibitive. This is because the entrepreneurial mentalities, traditions, beliefs and other specifics of a place are an important determinant in defining the entrepreneurial capabilities of that place (Autio, 2014; Spigel, 2016; Audretsch, & Belitski, 2017). Sigel, (2016) has for instance observed that regions that have a history of and are characterized by successful entrepreneurship are likely to create the conditions and culture that ignite further entrepreneurial development. On the other hand, regions characterised by entrepreneurial

failure tend to be inhibitive. In such regions, the societal contribution of entrepreneurs as observed by Isenberg, (2010) is rarely valued. The risk associated with innovative entrepreneurship is often stigmatized by the prevailing inhibitive local culture (Staber, 2007).

Creation of sustainable entrepreneurial ecosystems

A more recent and more aggressive entrepreneurship perspective holds that rural households that are seen to be part of what Ana-Maria Grigore and Irina-Maria Dragan, (2020) has termed entrepreneurial ecosystems (EE) have a higher drive to establish enterprises that are critical to steering economic development. EE are defined in literature as sets of interdependent actors connected through complex interactions within a specific locality to foster entrepreneurship and new business creation (Theodoraki, 2019). Despite the wider application of this concept in regions of developed and more recently in transitional economies, this thesis posits that enterprising MW dependent households that through public policy interventions are embedded within EEs, are key to driving local and / or regional economic growth.

Existing perspectives shared by different authors who see MW enterprising households and traders as part of a larger network of actors and how that embeddedness helps to foster value creation falls short of adopting an EE perspective and how that can be valorised to boost interactions between MW households and the local economy. First, most analysis, do not explicitly view MW enterprising households and traders as entrepreneurs. Secondly the analysis presented does not benefit from explicit EE theoretical perspectives that are widely reviewed in sustainable EE literature including the ecosystems approach (Cohen 2006; Isenberg, 2011; Mason and Brown, 2014; World Economic Forum, n.d.), the systems approach (Stam, 2015) and the configurational approach (Spigel, 2017). MW research that is targeted at fostering economic growth can benefit from incorporating in many ways and by building on several specific pillars of change as reflected by the sustainable EEs perspective. We argue in this thesis that a perspective that looks at MW enterprising households as agents of change that are embedded within a multitude of other development actors, institutions, and processes, and when combined with the sustainable development concept may shed light in identifying factor conditions that are critical in developing a favourable environment for sustainable firms creation (Stam, 2015; Theodoraki et al., 2018). is critical and it is driven by complex and systemic interactions.

The underlying elements of a sustainable EE in which enterprising MW households and traders be important agents of change and how the whole system may be connected to growth in the local or regional economy is shown in figure 3.7.

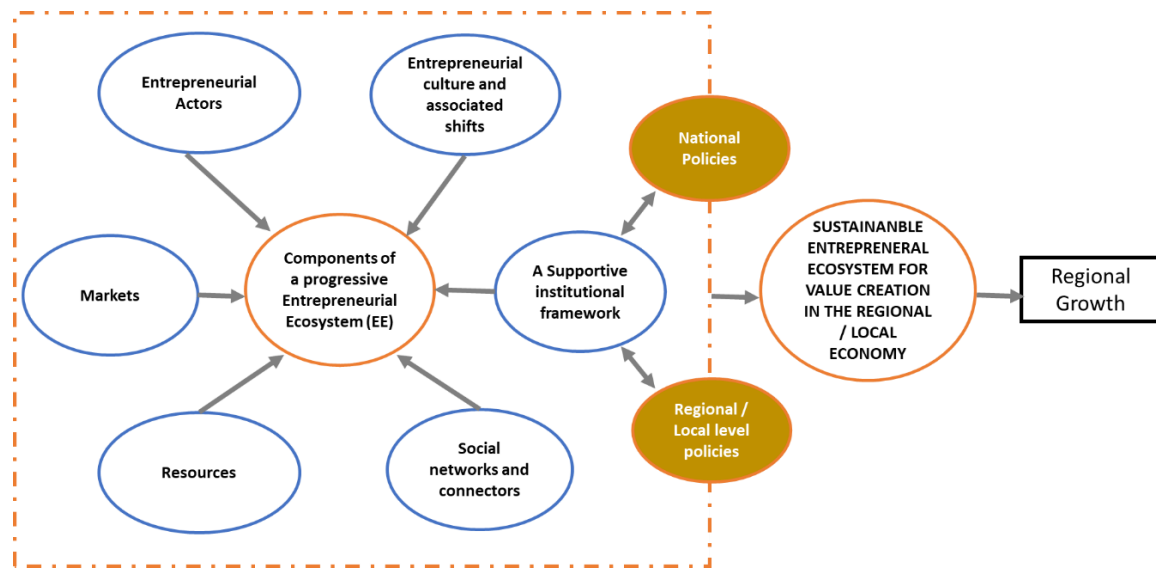


Figure 3.7 Components of a Sustainable and dynamic EE for value creation.

(Based on the works of Cohen, 2006; Isenberg, 2011; Feldman, 2014; Staber, 2007; Isenberg, 2010; Autio, 2014; Spiegel, 2016; 2017; Audretsch, & Belitski, 2017; Malecki, 2018).

Source: Author construct, 2023

Central to this perspective is the existence of what Mason and Brown, (2014) refers to as connectors. It is critical for development to analyse the extent to which MW enterprising households are linked or connectors in a EE. It is believed that the density of the intra-system connections in EEs will govern the amount of associated economic spinoffs. This in a sense mean that MW enterprising households that are situated in high densities of intra-system connections are likely to steer local growth as opposed those that are situated in low density intra-system connections. At a much higher regional scale, Mason and Brown have identified specific examples of connectors as professional associations, entrepreneurship clubs and startup communities, investor-investee matching services among others. At a much localised rural scale and in the case of MW dependent communities, social capital in the form of networks of friends and commercial contacts are critical for MW entrepreneurs to have access to necessary information, resources, and support (Spiegel, 2016). All regions are likely to benefit from the presence of dense social networks and connections (Feldman, 2014; Malecki, 2018). This thesis posits that connectors are so critical in the sense that they can link MW entrepreneurs with the resources they need for commercialization of innovative MW products

or linking them to important financing institutions (Mason and Brown, 2014). We further argue that MW enterprising households as members of a well-connected EEs are likely to benefit from sharing of knowledge, complementary competences, infrastructure, and even financial and human capital – attributes that may be critical in their quest to satisfy the market. Apart from the density of existing connections, it is also believed that the efficiency of the type of EEs that MW enterprising households are part of will depend on the level of interaction that exists between them and other actors in the system (Alvedalen & Boschma, 2017).

Another important building block that will ensure the presence of sustainable EEs is entrepreneurial culture in the region. As observed by many scholars, the appetite of a particular region to foster entrepreneurs is strongly associated with the density of entrepreneurship and culture of entrepreneurship in that region (Autio, 2014; Spigel, 2016; Audretsch, & Belitski, 2017).

3.4.7 MW innovation landscape as key to unlocking LED

Most LED studies at the local regional scales always assume that interactions between economic activities and the local economies can easily be measured by looking at how innovations and other type of investments in the activities are linked to the local economy as measured by some form of LED index. Put in other ways, investments associated with exploitation of resources are a precondition to fostering any meaningful gains in the local economy. Pavel et al., (2018) for instance has argued that investment programs and / or projects have a potential to act as a magic wand that can boost the local economies of lagging rural regions. By extension, it becomes imperative that if we are to fully comprehend, MW household interactions with the local economy, we need to begin quantifying all innovations and efforts associated with resource extraction and later correlate such with some form of LED evaluation index that gives us a picture of how the local economy is. This will however require the existence of panel data, a feature that is often lacking in the MW industry and the wider NTFP sector.

This thesis argues that no MW study to date has attempted to decipher such an association. The situation is also dire if one considers the overall NTFP sector in which the MW resource is situated. Two main reasons exist. There is a general lack of a conceptual clarification of what constitute an investment effort in the NTFP sector in general and the MW industry. This situation has been compounded by the fact regional planners have often viewed investment as catalyst to development using a ‘formal’ lens – i.e that which comes through formal programs

promoted by government, the private sector and / or non-state sector organizations. This stance is an unfortunate one given that the bulk of investment efforts in the MW industry are initiated by the farmers themselves through a wide variety of formal and informal networks. Consequently, it has been difficult to generate some form of Investment Index (II) so that its association with a proxy measure of LED can be measured.

Secondly, how to derive an LED index, particularly at the local scale such as the village level where there is general paucity of data is a vexing challenge. Despite the existence of a wide range of indices that can be employed to measure LED at least at the national and regional scales where considerable amount of data exists, their application at the smallest regional scales or rather glocalizing them has never been attempted owing to serious data deficiencies.

A conceptual note on MW innovation practices that have a bearing on the local economy.

We expect investment efforts targeted at improving MW institutions to have a positive impact on the local economy. There is enough empirical evidence in local and regional economic literature to suggest that efficient institutions contribute positively towards the regional growth (Arbolino & Boffardi, 2017). Many scholars believe that the quality of institutions is a decisive indicator of regional economic imbalances (Rodríguez-Pose & Fratesi, 2007; Baudner & Bull, 2013; Crescenzi et al., 2016). The argument is that institutions play a crucial role in shaping administrative and political capabilities of actors and / or stakeholders towards effective implementation of development policies (Milio, 2007; Rodriguez-Pose & Garcilazo, 2013; Bruinshoofd, 2016). There is dearth of research scholarship on how various efforts targeted at strengthening MW institutions (both formal and informal) may help boost local economies that are dependent on the resource. Having an in-depth understanding of such may inform LED practitioners about which policies aimed at building better MW institutions may result in growth in the local economy.

The number of resources injected by local government in support of exploitation of local resources such as MWs is also critical in boosting regional growth. Such investment represents some form of localized fiscal policies, which at national and regional levels as reported in some literatures has been an important factor in steering economic growth (Srithongrungs and Sánchez-Juaréz, 2015; Coetzee and Kleynhans, 2017). Such impact has been in recent times hypothesized and / or also observed on sub national economic growth (Lago-Penas and Ventelou, 2006; Mitze and Matz, 2015). Some reports indicate that most Rural District Councils

(RDCs) in MW producing regions are charging a levy on outsiders who come to buy or fetch MWs in their territories. Such a levy in the current study has been referred to as the *Macimbi* levy. A portion of the levy generated is usually reinvested back to the producer communities so that it further boosts the management of the MW resource. The other portion is reserved as part of public funds which is usually invested in the development of infrastructure in the RDC's territories.

Evidence of MW producers and other key players in the industry using Information Communication Technologies (ICT) such as mobile phones to analyse the workings of MW markets exists (Kozanayi, 2003). Some LED studies have shown that investments in ICT and related networks, are critical in the local economy as they reduce cost of doing business (Kretschmer & Woessmann, 2011; Thadaboina, 2009; Sahin et al., 2014). The net effect of this is increased productivity in the sector concerned and the overall quality of life. Apart from the widespread use of ICT technologies in the MW sector, numerous other innovations have been employed to try and create value addition to the MW producers. Evidence of harvesters using such simple technologies as gloves and empty bottles to degut the worms exist (Stack et al., 2003).

Resource exploitation when linked with innovative capacity is likely to boost the local economy. Some LED studies such as that of Crescenzi et al., (2012) have observed a positive relationship between regional growth and innovation capacity.

3.5 Spatial distribution of mopane worm producing areas in Zimbabwe.

Mopane worms are widely utilized in Zimbabwe. The main areas of mopane worm outbreaks are in districts in the south of the country (refer to figure 3.8 below) that lie in the natural regions 1V and V (in the Zimbabwe classification). Since 1990, these districts have been struck by six a series of serious food crises with notable ones in 1991, 1992 1997, 2000, 2002, 2003 and more recently during the Covid 19 pandemic.

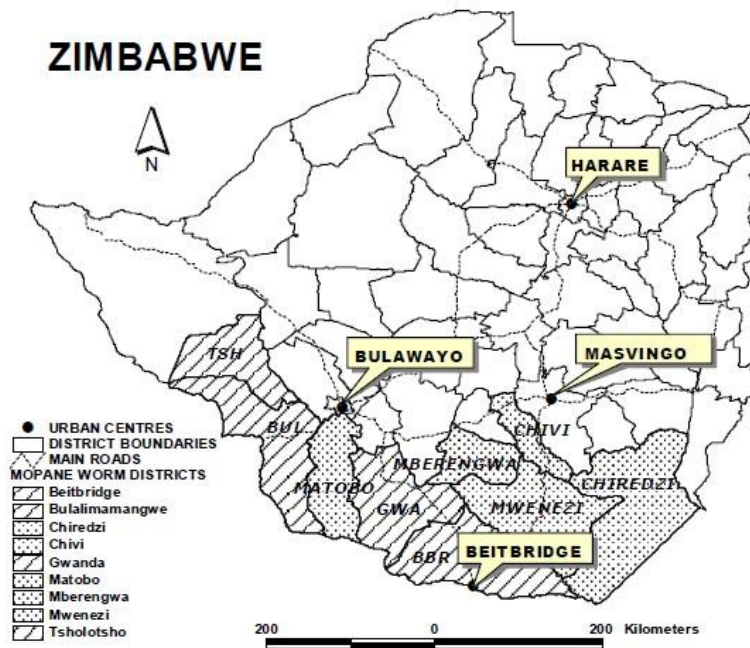


Figure 3.8. Mopane worm producing districts in Zimbabwe.

It is the existence of limited livelihood options in the stressed rural communities have seen many households turning to forest products for livelihood. In the semi-arid regions of the MW producing regions shown in the map, Cavendish (1999a) made a systematic valuation of the economic contribution environmental resources generate to rural household welfare, based on household data . The study shows environmental resources generating as much as 35% of the average per capita income. More evidence on the importance of wild foods and wild products to Zimbabwean rural households is also given in Campbell et al (1991; 1998). They used various methods to estimate the contribution of a wide range of woodland products to rural households and they suggest that these might generate around US\$50 per household per annum. Bringham et al (1996) reported a small number of traders in Zimbabwe and South Africa earning cash incomes from wood and wood-based products.

3.5.1 State of innovation in the MW industry

While the NTFP sector is considered less innovative than other sectors, the MW industry in Zimbabwe is arguably characterized by wide varieties of innovations that seek to;

- The sustainable utilization of the host *cholospERPum* mopane tree
- Promote better harvesting practices

- Promote efficiency in the processing of the worm and
- Product development and associated efficiencies in the marketing of the product. The level and extent of innovativeness and how that level translates to the overall MW industry performance and subsequently to the local economy is however not known.

3.5.2 Mopane worm farming innovations

The potential contribution of the MW to rural livelihoods was first recognized by Gondo, (2001) and Frost, (2003) who under the University of Zimbabwe, Institute of Environmental Studies, carried out a series of economic studies in the southwestern rural district of Matobo. Such studies inspired the DFID to use two of the sites in the district to implement MW farming. Specific villages chosen were Ndiweni (part of the Madwaleni Ward in Tshatshani Communal area) 5 km south of the town Kezi and Kapeni (part of the Beula Ward in Mambali Communal Area) approximately 40 km south of the rural town of Maphisa. A number of social and technical innovations related to the MW project were implemented. One such included the development of three MW farming booklets (see figure 3.9) (including the English, Ndebele and shona versions).



Figure 3.9. MW farming booklets to guide prospective MW farmers on how to implement farming the worm.

Source. DFID technical project report (2001).

Figure 3.10 shows sample pictures of women involved in DFID's MW farming project in Kapnei village of Matobo District.



Figure 3.10 Women in Kapeni village involved in DFID's MW farming project.

Source. DFID technical project report (2001).

Sample pupal pits for MW farming are shown in Figure 3.11



Figure 3.11 Sample pupal pits for MW farming project.

Source. DFID technical project report (2001).

Other technical innovations have involved encouraging harvesters to use gloves when processing (degutting) the worm as use of bare-hands often cause injury and infections to the bare hand (Figure 3.12)



Figure 3.12. Use of Kitchen gloves in degutting MWs

A sample of drying innovations share with communities, including a MW drying tower are shown in figure 3.13



Figure 3.13. Samples of MW drying innovations shared with communities under the DFID project.

3.5.3 MW research scholarship gaps

Many studies on MWs have been conducted in the country dating as far back as studies by Hobane in 1995, who observed that harvesting was mostly done by women and children. This is one of the earliest attempts that was made to try and characterize MW resource dependency alongside many other subsequent studies, including Gondo (2001); Gondo et al., (2010), Stack et al., (2003); Hope et al., (2009) As revealed in the previous literature sections, such studies have failed to address the following important knowledge gaps; • Modelling spatio-temporal changes in MW resource dependent

- Identifying what drives successful territorial dynamics.
- How various territorial capabilities are promoting the development of a MW or intended LED strategy
- How territorial resilience dynamics are preparing MW communities to deal with adversity.
- Mapping out the current impact of MW trade on the growth of the MW industry and the economy at large.

3.6 The rural development Policy Landscape in Zimbabwe

There is no clear co-ordinated rural development strategy for Zimbabwe. There are four strands of policy: decentralisation; land reform; poverty alleviation; and environment. A review of all policies reveal deficiencies in development provisions and targets that may influence our understanding how existing policies have shaped spatio-temporal dynamics in MW utilization. The only exception in the land reform policy that opened access to rural communities to access MW in some of the commercial farms redistributed. This did not only increase the supply of the worms but also created problems of managing the host tree – the mopane tree.

3.6.1 The local Economic Development Context in Zimbabwe

Understanding the spatial and temporal information on MW use and associated implications on the local economy requires us to review the LED context in Zimbabwe, by particularly focusing on specific LED variables that the sector may impact on. The rationale behind reviewing the LED context in Zimbabwe stems from an understanding that MW use has both direct and indirect impacts on several of the sectors of any local economy as argued in the preceding literature review. Zimbabwe like any other sub-Saharan country is characterized by unprecedented population growth, concomitant with limited industrialisation and job creation (Mercandalli, et al., 2023). Cities as major sources of employment for rural people have according to Mercandalli, et al., (2023) not always remained as strong engines of economic growth. They have over the years mutated through a series of local economic and financial crises that have seen many rural people relying on urban income suffer from sudden unemployment as a result of the economy shrinking and squeezing out the already limited job opportunities available to both urban and rural economies.

Overview of spatial disparities in poverty: The rural-urban divide

If intervention in the form of MW is to address the poverty situation in Zimbabwe, it is important that we have a shared understanding of the poverty situation in that country. In rural Zimbabwe, drastic measures are required where unemployment rates have in the past through to the present reached catastrophic levels of over 80%. The socio-economic conditions of households have worsened since the adoption of the Economic Structural Adjustment Programme in 1991 (Masuko, 1998) and the emergence of the political impasse. In addition, globalization has brought suffering to many, and the impact has been hard felt in communal areas (UNDP, 1999).

The globalization trend has increased stress on households, such as borrowing from friends, support from informal networks, use of savings, sale of assets, remittances from family members and other forms of community support. Rural- Urban support networks have also been weakened by high public transport costs, recurrent droughts, inflation and price instability of rural produce and basic household goods (Mutangadura and Makaudze, 1999). Informal support networks have been undermined by economic hardships across all households due to inflation (Loewenson, 1999; Sibanda, 1999). A further study by CSO (1998), suggest that the incidence of poverty in Zimbabwe has increased from 40,4% in 1990/91 to 63,3% by 1995/96. Such a desperate historical trend in poverty has persisted over time, with the situation worsening in rural areas as compared to urban areas. Available statistics on the percent poverty prevalence by province for households in Zimbabwe are pointing to a gloomy situation (figure 3.14).

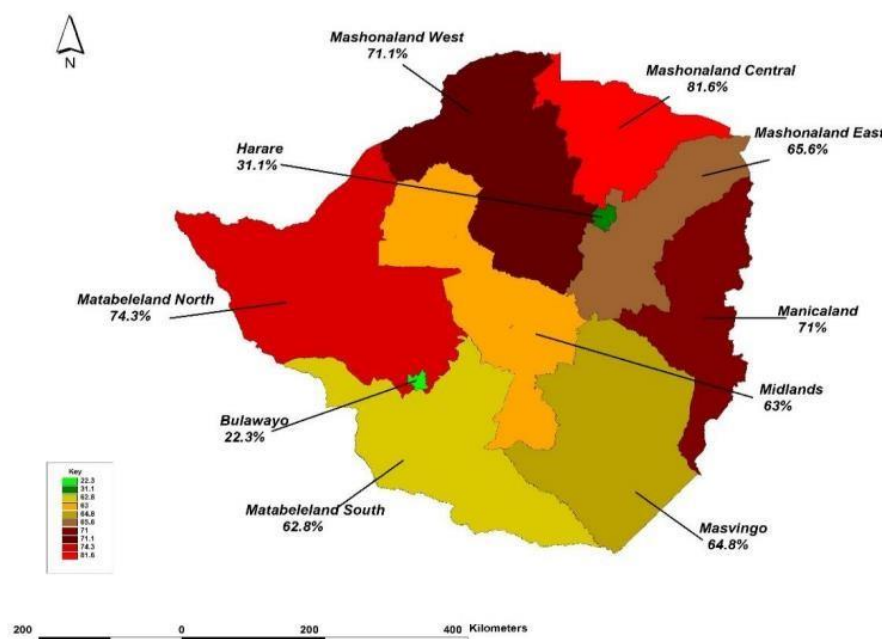


Figure 3.14 Percent Poverty Prevalence by Province for Households in Zimbabwe (PICES 2017)

Extreme poverty prevalence statistics, by province range from 31.1% in Harare to as high as 81.6% in Manicaland Central province (PICES, 2017). Such statistics remain high in mopane worm producing districts such as Matebeleland South, (62.8%), Matebeleland North (74.3%), Midlands, (63%) and Masvingo (64.8%). The reflected spatial disparities in poverty levels between urban and rural regions are also sharply reflected when one considers extreme poverty levels by district (Figure 3.15).

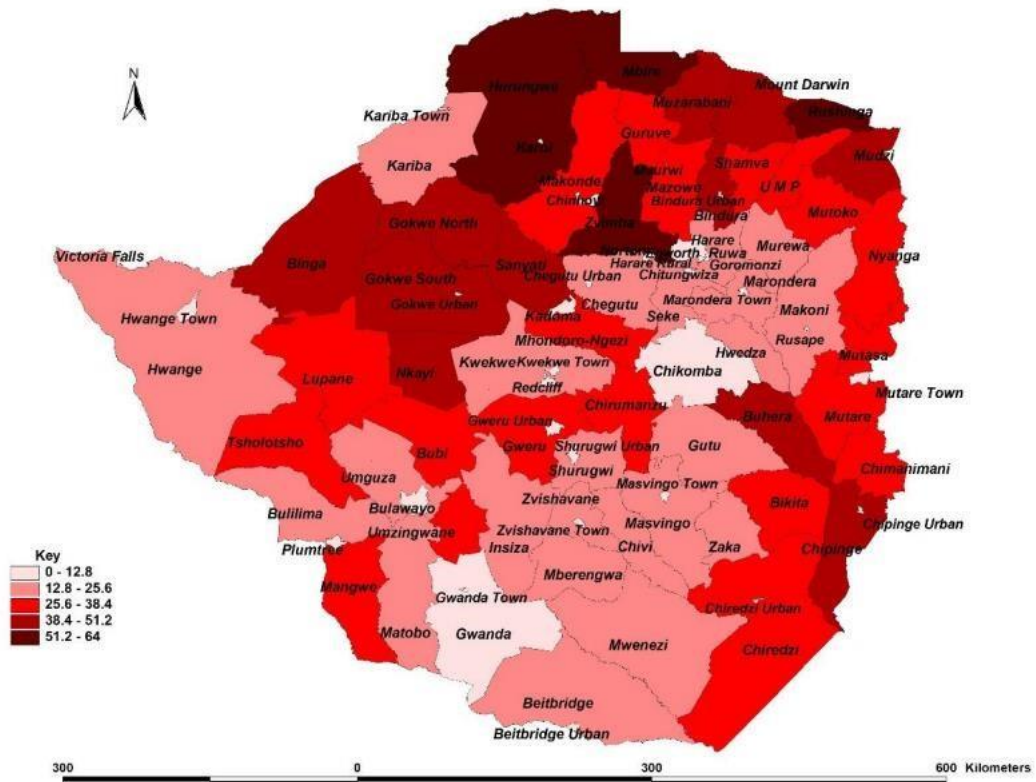


Figure 3.15 Percent Extreme Poverty Prevalence by District for Households in Zimbabwe, (PICES 2017).

Rural regions in Matobo district in which the present study is situated have percent extreme poverty levels ranging from 12.8% to 25.6%.

This current picture is an extension of a similar pattern of poverty statistics witnessed in the mid 90s. According to the 1995 Poverty Assessment Study (PASS) carried out by the Ministry of Public Service, Labour and Social Welfare, poverty in Zimbabwe was reported to be very high. Sixty one percent of the population was reported at the time to be failing to raise sufficient income to meet basic needs. About 45% of the households were reported to be living below the Food Poverty Line. That is, they seen as not able to meet basic nutritional needs. Poverty was unsurprisingly reported to be more prevalent in rural areas with 75% of the households reported to be in the total poor category, as compared with 39% of the urban households.

Spatial disparities in poverty: the consumption poverty line perspective

Disparities in poverty, (both in time and space) between urban and rural regions are also reflected when one looks at consumption poverty line statistics. As per the most recent poverty

assessment statistics, the value of the mean food poverty line, in the year 2017 was US\$31.2 per person per month while the Total Consumption Poverty Line (upper line) for Zimbabwe was set US\$70.36 per person per month. The national mean consumption per person per month was US\$85.2, with worrying disparities between urban and rural areas. The national mean consumption per person per month for urban areas was US\$133.4 while similar statistics for rural areas were US\$59.2.

Latest per capita consumption patterns also reveal a similar trend in spatial disparities. It is reported that 60.6 percent of all Zimbabwean households had per capita consumption expenditures below the upper poverty line. Related statistics showed that 76.9 % of rural and 30.4 % of urban households were deemed poor (PICES, 2017). The PICES 2017 data also revealed that the majority of Zimbabwe's households (69.2 percent) lived in rural areas where prevalence, depth, and severity of rural poverty were observed to be much higher than those of urban poverty.

Prevalence of poverty: A spatial and temporal perspective

Empirical poverty data from PICES (2017), PICES (2011), ICES (2001) and ICES (1995) reveals persistent spatial disparities in the prevalence of poverty, pointing the rural urban divide that has been demonstrated earlier on other dimensions of poverty. Data on such selected data points is summarized in table 3.6.

Table 3.6 Individual Measured Prevalence of Poverty, for Selected Years

Residence	Measured prevalence of		Poverty Indices	
	Poverty	Extreme poverty	Poverty gap index	Poverty severity Index
PICES 2017				
Rural	86.0	40.9	43.5	25.4
Urban	37.0	4.4	11.3	4.8
All Zimbabwe	70.5	29.3	33.3	18.9
PICES 2011/12				
Rural	84.3	30.4	42.8	25.4
Urban	46.5	5.6	15.5	7.2
All Zimbabwe	72.3	22.5	34.1	19.6
ICES 2001				
Rural	82.4	52.4	43.4	27.0
Urban	42.3	14.5	15.5	7.6
All Zimbabwe	70.9	41.5	35.4	21.4
ICES 1995				
Rural	86.4	62.8	47.1	29.6
Urban	53.4	15.0	20.2	10.0
All Zimbabwe	75.6	47.2	38.3	23.2

Source: PICES 2017, PICES 2011, ICES 2001 and ICES 1995.

While the poverty situation has been deteriorating since 1995, it appears to have improved marginally in 2017, which is not the case since the presented poverty lines were not recalibrated to 2017 prices (PICES, 2017).

An interesting trend in income inequalities can be observed when one looks at inequalities as measured by the Gini coefficient. Since the 90's, the Gini coefficient statistics have been steadily increasing until the year 2011/12 where the country saw a jump in such statistics from 0.42 to 0.44 in 2017.

3.6.2 Forest products as a potential solution to the poverty challenge

Given the poverty trends that have characterized most communal areas since the 90's, many scholars have always held the belief that forest such as MWs among other resources have potential to play a meaningful role in alleviating poverty. Early studies in this field (forest resources) have revealed that limited livelihood options in the stressed rural communities saw many households turning to forest products for livelihood. In the semi-arid regions of Zimbabwe example, Cavendish (1999a) made, a systematic valuation of the economic contribution environmental resources generate to rural household welfare, based on household data. The study shows environmental resources generating as much as 35% of the average per capita income. More evidence on the importance of wild foods and wild products to Zimbabwean rural households is given in Campbell et al (1991; 1998). They used various methods to estimate the contribution of a wide range of woodland products to rural households and they suggest that these might generate around US\$50 per household per annum. Bringham et al (1996) reported a small number of traders in Zimbabwe and South Africa earning cash incomes from wood and wood-based products.

3.6.2.1 The vulnerability context

Understanding the vulnerability context of rural regions of Zimbabwe is very critical in two may ways, including;

1. In defining the likelihood of communities engaging in NTFPs such as MWs.
 2. In defining successful territorial dynamics.
- Literature on NTFPs has shown that households occupying territories that are defined as vulnerable and lagging in terms of many development parameters, are faced with few

livelihood options. In such ‘livelihood - constrained environment’s, there tends to be high dependents or reliance on harvesting NTFPs. By extension, we therefore expect MWs to play a crucial role in making up for the development deficits associated with livelihood constrained environments. Understanding the major drivers of vulnerability in rural regions will not only help us map the contribution of MWs to the rural economy, but will also present us with an opportunity to analyze how MW use varies in regions with different vulnerability contexts. By contrast, rural territories that are less vulnerable when contrasted with vulnerable ones will help us understand factors defining successful territorial dynamics and how these can be valorized in developing LED strategies that seek to enhance earnings from MW use. This section seeks to review the rural vulnerability context by reviewing data already available from government sources. Since the study is situated in Matobo district of Zimbabwe located in Matabeleland South Province, understanding the vulnerability context at district level as well as at provincial level will help us interrogate the behavior of many LED variables in response to major stressors that characterize the Zimbabwean economy at large.

Case study 1: Mopane worm (*Imbrasia belina*) and rural household food security in Limpopo province, South Africa

An interesting study is that of Baiyegunhi et al., (2016) who brings us one step closer to understanding the contribution of MWs to addressing food and income adversity. This study conceptualizes the role of MWs using a schema portrayed in figure 3.16.

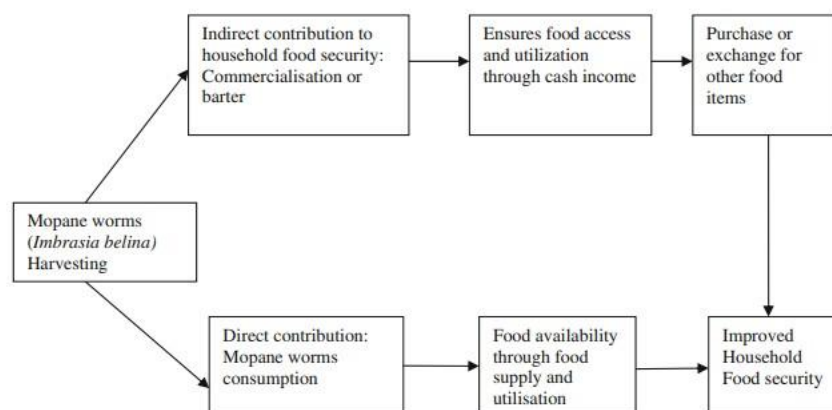


Figure 3.16: Linkages between Mopane worm consumption/ commercialization and food security

Source: Baiyegunhi et al., (2016)

The study developed a food insecurity score that acted as a dependent variable in measuring the extent to which MWs were addressing the food insecurity challenge. The main assumption in this study was that MW income from MW trade had either a direct and indirect effect on household food security. The direct contribution was seen as a function of households directly consuming the MW and its indirect contribution was via income generated from sales that could be used to access other food sources.

The study confirmed an important link between the intensity of involvement in MW trade as measured by the Household Commercialization Index (HCI). It also attempted to include a spatial variable in the analysis, that of distance from markets where the MW was traded. The major shortcomings of this study however are as follows.

- It does not tell us the food security situation of households that are not involved in trade. In other words, there is need for an LED focused study that go beyond trading circumstances of harvesting households and look at the situation that characterizes those not involved in the harvesting business at all. Only then can we have a convincing impact on food security if the situation of harvesters and non-harvesters is compared.
- The number of spatial variables involved is very limited and therefore results do not portray an accurate picture of spatial dynamics in food-security that can inform the development of MW oriented LED strategy.
- The study also lacks repeated observation over time. Such repeated observations bring in the much important temporal dimension towards understanding the role of MWs in the local economy.

Regardless of such shortcomings, the study does shed light on determinants of resource dependents at least using the stated socio-demographic variables as predictor variables.

CHAPTER FOUR: MW use and territorial dynamism: *Conceptualizing territorial success and resiliency in MW dependent communities*

4.0 Introduction

The contribution of MWs to the rural economy requires a comprehensive understand of the spatial inequalities that exists between different territories with differing capabilities and or potentialities. Such a comprehensive understanding is crucial as it allows LED practitioners to single out territorial capabilities that may define territorial success in terms of creating situations that lead to growth in the rural economy and beyond. This chapter gives a conceptual clarification on what constitutes territorial success in MW territories. It also discusses a plausible theoretical framework that can be employed to identify factors that define territorial success. It also goes beyond an understanding of territorial success to review existing literature on territorial resilience by examining different reliance capacities that require building if MW communities are to overcome or cope with adversity.

4.1 Mopane Worm Resource Extraction, External Shocks and livelihoods implications

Understanding Local economic development implications of spatio-temporal changes in mopane worm use will not be complete if we neglect how some aspects of the resource interacts with the external social, physical and economic environment. Several studies of NTFPs and the wider natural resource's sector in semi-arid regions of the world often ignore such interaction (Addison and Brown, 2014; Addison et al, 2013). Understanding and where possible estimating the relationship between the external environment and resource user response, within any local context, may assist in the design of policies targeted at improving livelihoods and in dealing with environmental implications thereof (Addison and Brown, 2014). In local and regional development circles, it becomes imperative that such relationship is explored not at any one fixed point, but at different points through time and space. Such understanding will subsequently highlight where interventions are best placed to improve livelihoods, resource conditions and the local economic circumstances of resource users.

We currently know with an acceptable level of certainty that poor rural households who depend primarily on common pool resources such as MWs are highly vulnerable to external risks such as weather extremes, diseases and pests, and market price fluctuations of inputs and final product (Campbell & Luckert, 2002; Loaiza et al., 2015). Environmental and climatic conditions such as rainfall and phenological cycles have a negative impact on production and collection patterns of NTFPs such as MWs (McSweeney, 2002; Godoy et al., 2002; Coomes et al., 2004). Owing to this and a host of other factors, we would therefore expect high levels of MW income heterogeneity to occur within one year or during subsequent years at different spatial locations characterised by different contextual conditions. Measuring such income heterogeneity and deciphering the contextual conditions explaining associated spatial disparities in MW income is indispensable in mapping out appropriate LED policies that seek to harness the potential of the MW sector. Currently there is dearth of scholarship in this area. We currently have a spurt of people centred MW studies that only help us in understanding how individual MW producers have been responding to specific categories of shocks. What can be termed as current external shocks in the sector is summarised in Table.

4.1.1 MWs and territorial resilience scholarship gaps

The study assumed that developing an effective MW- led development strategy would require an initial understanding of a set of capacities that enable households and MW dependent communities to effectively function in the face of shocks and stresses and still meet a set of well-being outcomes. Such understanding will help develop a territorial based resilience strategy that will ensure that MW dependent communities will not collapse when faced with adversity. Despite a growing body of local economic development studies that is increasingly realising the need to approach resilience of communities from a territorial perspective (Tan, 2020; Wang, 2022), this analysis has seen that such sentiments have not been echoed in current MW research studies. Existing studies have tended to be overly biased the concept of community resilience, that does little to show how resilience dynamics vary across space and time. Sekonya's, 2016 study on MW use, livelihoods and environmental change in Limpopo Province, South Africa is one among a few studies that has tried to incorporate resilience. Unfortunately, his study is overly biased towards looking and how MW territories behave in in face of environmental changer as a stressor. The study successfully manages to look at how different environmental regimes may affect the resilience capabilities of MW communities. The challenge with the approach employed is that it exclusively defines resilience from a

resource governance perspective. We expect that any study on resilience should consider resilience of MW communities as the outcome of the dynamic interaction between three strands of resilience capacity that more than often are interwoven as shown in figure 4.1.

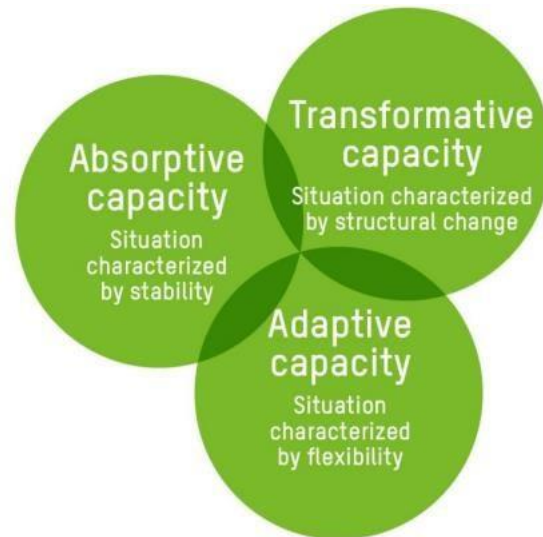


Figure 4.1. Overarching nature of resilience capacities

Source, Oxfam International, January 2017

We assume in this thesis that MW territories and households possess different capacities that enables them to behave differently when faced with adversity. In regional resilience or territorial resilience literature, such differences are assumed to be a function of the interplay between various territorial attributes that define different resilience trajectories for each household and MW territory in terms of.

- Absorptive capacity
- Adaptive capacity and
- Transformative capacity

An effective MW led development strategy is likely to yield positive results in the local economy if these three capacities are strengthened. One of the goals of an LED strategy that seeks to harness the potential of MWS should be to strengthen these three capacities as their strengthening can help achieve the realization of acceptable wellbeing outcomes when communities are confronted by shocks, stresses, and uncertainty. It is therefore imperative that we first identify and categorise MW territories according to these three major resilience categories. Secondly there is a need that we develop some indices to gauge the level of resilience capacities possessed by each unique territory. Following the works of Ramezani and

Camarinha-Matos, (2020); Blečić and Cecchini (2020); Hillmann and Guenther (2021) and Nieuwborg et al., (2023) four categories that define the state of resilience for any territory can be discerned. These are illustrated in figure 4.2.

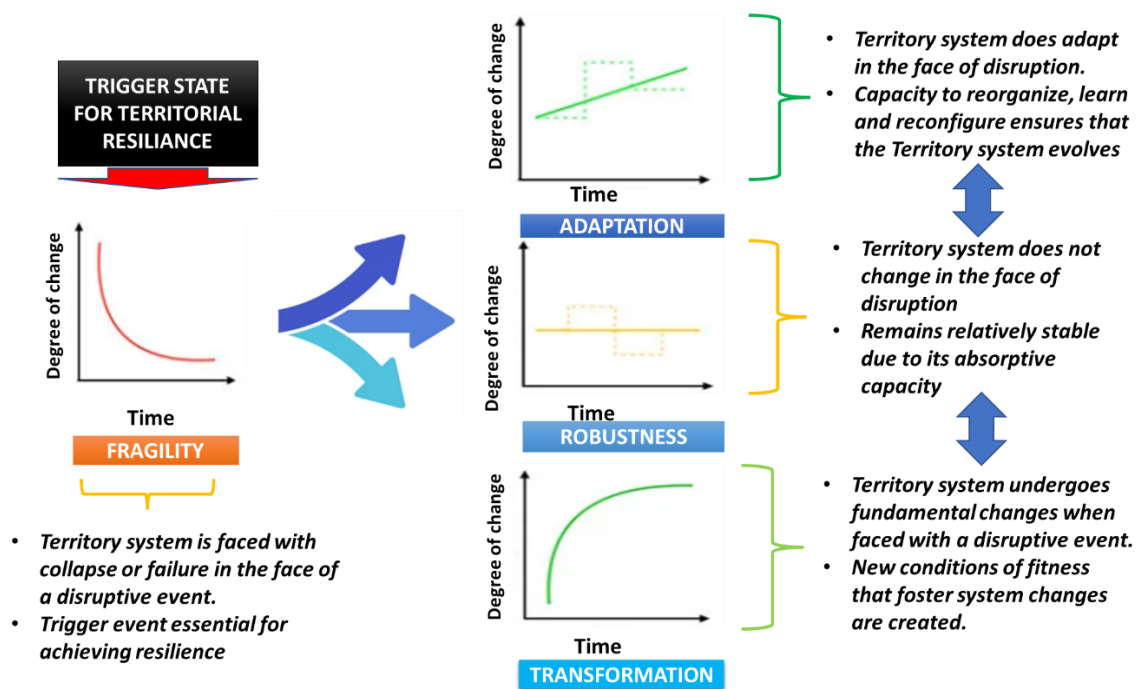


Figure 4.2. Hypothetical typologies of resilience characterising different Territorial systems

Source. Author construct, (2023).

The thesis recommends that any study that seeks to understand resilience dynamics associated with MWs territories should adopt the above to aid resilience decision making and resilience strategy formulation in MW territories. Wese this a valuable entry point in getting answers to some of the following central questions.

- Should MW territories aspire to be more robust, adaptive, transformative, or antifragile when confronted by a disruptive event?
- What are the main determinants of MW territorial resistance to adversity?

Since the concept of territorial resilience has not permeated MW research scholarship to date, we currently do not have ready answers to such questions. The three stance of resilience capacities that we recommend should be incorporated in MW resilience research are defined as follows.

Absorptive capacity

Understanding territorial resilience will require that we explore the absorptive capacity of each MW territory by assessing the extent to which a territory is able to minimize exposure to shocks

and stresses. We posit that this ability (of a MW territory) to minimize exposure to shocks and stresses can be analysed by evaluating the extent to which existing preventative measures and coping strategies are better placed to avoid permanent and / or negative impacts on the wellbeing of communities. As interpreted by different scholars, absorptive capacity may help shed light on the following specific and often overlapping questions about MW territorial resilience.

- To what an extent can a MW territory absorb a disruption without changing? (Manca et al. (2017)
- How robust or tolerant is a MW territory against a predefined disruption? (Chroust and Aumayr (2017)
- Can MW territories survive changes within pre-designed parameters? Can they survive the onslaught of unforeseen circumstances? (Ruiz-Martin et al., 2018)
- To what extent can MW territories experience no significant changes when exposed to disruptions? (de Bruijn et al., 2020)
- To what extent can MW territories sustain shocks while remaining relatively unchanged? (Ramezani and Camarinha-Matos, 2020).
- Do MW territories possess ability to maintain; to resist; and to cope when faced with disruptions? (Munoz et al., 2022).

Finding answers to these or some of the questions would require that we calculate an Absorptive Capacity Index (AbCI) using different measurement variables that either relate to existing preventative measures or copying strategies both at household and territorial levels.

Adaptive capacity

Understanding territorial resilience will also require that we assess the extent to which a MW territory is able to make proactive and informed choices about alternative livelihood strategies when faced with adversity. Such an assessment will allow us to assess whether communities occupying different territories can adapt well in the face of adversity. As re-iterated by different scholars, adaptive capacity may help shed light on the following specific and often overlapping questions about MW territorial resilience.

- Are MW territories able to learn from disruptions and improve? Do they have
(Chroust and Aumayr, 2017)
- Are MW territories able to foster incremental changes while being flexible
when faced with a disruption? (Manca et al., 2017)

- Are MW territories able to adapt; to renew, reconfigure and/or reinvent when faced with disruptive events? (Hillmann and Guenther, 2021).

Finding answers to these questions would require that we calculate an Adaptive Capacity Index (AdCI) that we can use to compare different MW territories in terms of their ability to make proactive and informed choices about alternative survival strategies when faced with adversity.

Transformative capacity

We also posit that a resilient MW territory should be able to transform or change for the better when faced with adversity. For this systemic change to happen, certain territorial attributes that favour such transformation should exist. The existence of such attributes would naturally create an enabling environment that will permit system changes as the territory evolves in response to a disruptive event (Ramezani and Camarinha-Matos 2020). These attributes would include (but not limited to) existing governance mechanisms, policies or regulations, infrastructure, and community networks as well as other mechanisms providing social protection from adversity. Transformative capacity is on a new concept and over the years different scholars have often argued that it helps answer the following resilience questions that can equally be applicable to assessing the transformative capacity of MW territories.

- Can MW territories create new conditions of fitness in response to a disruption? (Chroust and Aumayr, 2017)
- To what extent do MW territories offer an enabling environment that will permit system changes as the territory evolves in response to a disruptive event? (Ramezani and Camarinha-Matos 2020).
- Are MW territories able to thrive, grow and flourish when faced with a disruptive event (Munoz et al., 2022).

It is therefore also possible to calculate a Transformative Capacity Index (TCI) that will enable us to compare and contrast MW territories on the basis of the extent to which respective territories offer an enabling environment that permits systemic changes. It may also go a long way in shedding light on whether targeted MW interventions may strengthen or weaken existing resilience capacities of MWs. If any intervention results in increase in resilience capacity and achievement of the LED objectives, then it will provide a case of investing in MW business.

4.2 MW use and Successful Territorial Dynamics.

No MW study to date has attempted to take a holistic stance on how various territorial system attributes such as the social, economic, institutional / governance, ecological and physical engineering attributes interact and influence successful outcomes such as MW income, intensity of involvement in trade, addressing poverty and inequality among others. Current scholarship on successful territorial dynamics acknowledges that each territory such as a MW territory, possess certain capabilities and potentialities that can be converted (through appropriate production processes) into a territorial success outcome variable. At the national and provincial scales GDP is always used as an outcome variable, although in many other resource sectors other variables can be used (Sánchez-Zamora, & Gallardo-Cobos, 2020). Within the MW territorial system, we see a number of useful indicators emerging, including the Household Commercialization Index (HCI) (Baiyegunhi & Oppong, 2016; Baiyegunhi et al., 2016), interaction with output markets (Manditsera et al., 2022), Food security, resilience (Sekonya, 2020) and the traditional MW income variable (Stack et al., 2003, Gondo et al., 2010; Makhado et al., 2012). Despite this growing interest in such outcome variables, we still lack a single study that attempts to interrogate how the existing territorial capabilities are efficiently converted to optimize success as measured by any of these outcome variables.

Many scholars in recent territorial approach have taken interest in calculating such measures as technical efficiency to analyse how a territory's capabilities are converted into situations that promote growth in output. The most used method to do so has been the employment of Data Envelop Analysis (DEA) method (Sánchez-Zamora, & Gallardo-Cobos, 2020; Gospodarowicz & Chmieliński, 2022). A study by Sánchez-Zamora, & Gallardo-Cobos, (2020) for instance used a system of territorial dynamic system variables such as economic, social, environmental, institutional, and integrated spatial development (see figure 4.3)

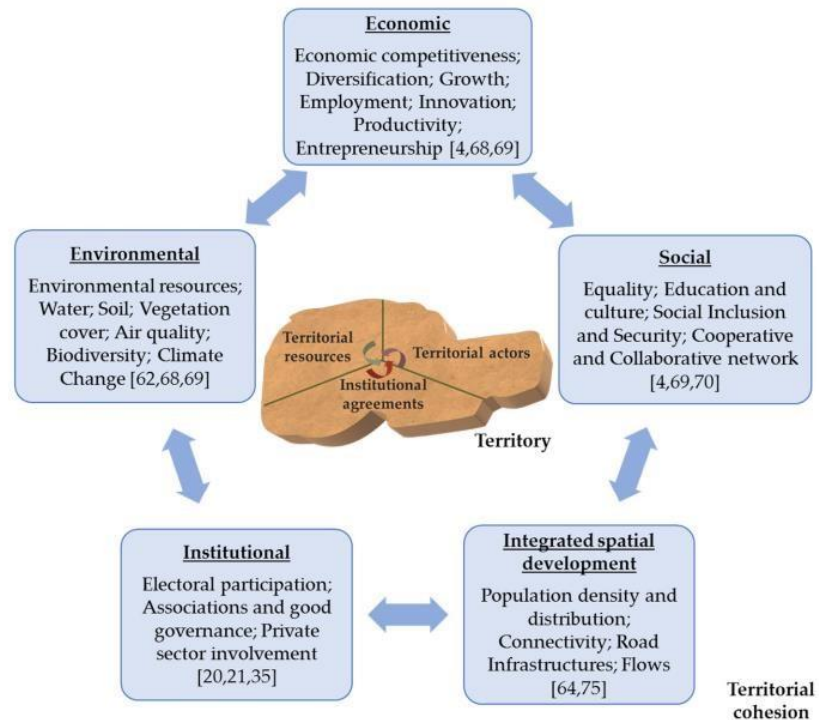


Figure 4.3. Dimensions and variables associated with territorial dynamics.

Source. Sánchez-Zamora, & Gallardo-Cobos, (2020).

The study employed the DEA method to analyse how the territorial system capabilities were been converted into GDP as an outcome measure in rural areas of Spain. Such kind of studies are needed in MW research if we are to intelligently craft a place sensitive MW oriented LED strategy. We currently have a piecemeal idea of how certain territorial system attributes may influence MW work outcome variables mentioned earlier on. We call it piecemeal because there exists a multitude of isolated studies that often focus on one dimension of a territorial system. Such isolated cases which overlook the importance of interactions that exist between system attributes are presented below by highlighting important features that are worth investigating under each territorial system attribute.

4.2.1 The social system

Commonly cited social attributes include population density and its effect on over exploitation of resources. Others include the effect of such variables as underpopulation owing to emigration among other factors.

4.2.2 Ecological system

How the ecological system of MW landscapes work has important repercussions in understanding the economic importance of the resource. In the late 90s, several research

scholars, reiterated that the precise economic value of Mopane woodlands in general can only be understood if more ecological studies are done on the tree species (Ditlhogo et al., 1997; Flower et al., 1999). Understanding such ecological dynamics and their presumed effect on the economic importance of the worm, would as argued by Flower et al., (1999) and much later by go a long-way in unlocking the potential to MW farming.

Many scholars concur that there is a positive relationship between the ecological integrity of MW ecosystems and the amount of harvest that rural households are likely to realise (Kwiri et al., 2014). MW territories that are characterised by ecological harvesting practices are deemed to be ideal as they ensure that there will be a good crop for the following season. The bigger the size of the area where ecological harvesting is being practiced, the bigger the harvest. Dube and Dube (2010) for instance have observed that a woodlot of 4000 hectares would naturally support 19 million worms, which would translate to 193 tonnes of Mopane worms. What this means is that sustainable harvesting practices would ensure the availability of future MW stocks. Sustainability in harvesting practices requires that the host mopane tree is managed properly since young MWs or larvae feed on the leaves of the mopane trees where they hatch and as they grow and molt four times before they reach their maximum size (Timberlake, 1996; Toms, 2001; FAO, 2010). It is believed that MW populations are generally on the decrease owing to several factors that are mostly anthropogenic in nature. Most identified factors include increase in their exploitation, declining selective harvesting practices (Hobane, 1995) and general decrease on the Mopani woodlands due to deforestation and wildfires (Kwiri et al., 2014). Variations in the extent of depletion of the resource has been noted by Ghazoul, (2006) who observed the existence of geographical variability in outbreak occurrence which had dire consequences to social cohesion as such spatial variability were in most cases leading to conflicts between community members. Table 4.1 presents a sample of ecological system indicators emerging from MW scholarship.

Table 4.1 Select ecological system indicators emerging from existing MW scholarship.

Study variable	Research assumption	Supporting references
Evidence of selective harvesting of Mws	MW territories that are characterised by selective harvesting practices are deemed to be ideal as they ensure that there will be a good crop for the following season.	

Study variable	Research assumption	Supporting references
Evidence of ecologically friendly harvesting practices	Ecologically friendly harvesting practices that	Timberlake, 1996; Toms, 2001; FAO, 2010
	seek to protect the host mopane tree on which young MWs or larvae feed on its leaves (where they hatch, and molt before they reach their maximum size) ensure the availability of good stocks.	
Woodlot size	Mopane woodlot sizes that are bigger are likely to support a larger population of MWs and other related ecosystem products.	Dube and Dube, 2010; Kwiri et al., 2014.

Source. Author construct, (2023)

4.2.3 The governance system

Despite the significant role played by MW income in supporting regional livelihoods, Sekonya et al., (2020) acknowledges that little is known about the governance systems in play and presumable how associated dynamism arrangements in such systems will result in positive and / or negative (regional) livelihood outcomes. It is the unprecedented decline in resource and associated implications on regional livelihoods that have underscored the importance of having an in-depth understanding of governance systems of MW territories (Gondo et al., 2019; Sekonya et al., 2020). With a successful territorial dynamic lens several governance variables are worth reviewing. One of the key governance variables likely to drive territorial dynamism is existing governance regimes that may influence resource access and use (Gondo, 2001; Thomas 2013). This is largely because the institutions, rules, and norms that embody governance systems favour certain mechanisms of access over others (Ribot and Peluso, 2003). Following studies made in Botswana, Namibia, South Africa and Zimbabwe, three common property management regimes are discernible. These include communal, private and public management property regimes (Sekonya et al., 2020). Communal property regimes are said to be susceptible to over-exploitation of MW resource as they are characterised by a loose regulatory climate (Stack et al. 2003, Lucas 2011, Thomas 2013). A comparison of these property management regimes in terms of resource access conditions, harvesting rules, enforcement and resource management issues is given in Table 4.2. The summary clearly characterise communal property regimes as inferior as will be explained in paragraphs to follow.

Table 4.2. A categorisation of widely applied rules across three property management rules.

	Communal	Private	State
Resource access Conditions	Access open for locals. Nonlocals require permission from the traditional leadership Harvesters discouraged from camping	Access fee required per person per harvesting session / season. Camping may be allowed in designated areas	Access limited only to selected authorised harvesters Overnight camping is not allowed.
Harvesting rules	No limitation on harvest quantities Harvesters discouraged from harvesting juvenile caterpillars. Digging pupae is considered a taboo No harvesting till chief declares the commencement of harvesting season No harvesting till mopane worm reaches maturity Harvesters encouraged to not to break branches or trees	There is no limit on harvest quantities No harvesting of juvenile caterpillars or digging pupae allowed No harvesting till landowners declare the commencement Harvesting only permitted in instar V No tree climbing or breaking branches allowed	No harvesting of juvenile caterpillars or digging pupae allowed No harvesting till park managers declare the commencement Harvesting only permitted in instar V Harvesters not allowed to break branches or climb trees
Resource management practices	Fires discouraged Tribal police and ordinary villagers constantly monitor any unauthorised harvesting	Fires are only permitted at the camps or provided accommodation areas Patrols conducted for security enforcement	All fires strictly prohibited Inspection of all harvesters on entering and exiting the park
Enforcement mechanisms	Fines and confiscation of harvest	Immediate confiscation of harvest. Expulsion and blacklisting	Immediate expulsion. In the case of poaching, prosecution

Source: Adapted from Sekonya et al., (2020:143).

Another significant governance variable is the strength of existing regulatory system in place. MW territories where the ability to access and benefit from a resource is weak, are seen in most literatures as susceptible to over exploitation (Stack et al. 2003, Lucas 2011, Thomas 2013). Enforcement of existing resource access mechanisms are expected to be effective in deterring transgressors (Sekonya et al., 2020). Of all three regimes identified above, Sekonya et al., (2020:147) noted that "...access to mopane worms in the communal areas was least controlled, with evidence suggesting that the enforcement of existing access mechanisms was ineffective to deter transgressors." This dire situation is also compounded by the fact that most harvesters prefer to harvest in communal areas where access restrictions are minimal. Sekonya et al., (2020) for instance noted that harvesting within the community is seen by harvesters as more convenient and cost-effective than accessing MWs on private or public property. They argued

that more effective access mechanisms such as strict sanctioning of harvesters; use of access fees; harvester patrols and inspections that usually characterise private and publicly managed areas in South Africa guarded against overexploitation of MW resources. The prevailing level of resource access restrictions is worth noting. This is because uncontrolled access, coupled with habitat destruction from harvesters can lead to resource degradation and reduced availability of MWs (Wynberg and Laird, 2007; Shackleton 2009; Sekonya et al., 2020).

Where there is uncontrolled access to MW resources, this thesis posits that existing traditional ecological knowledge likely ensure the sustainable use of mopane worms. Such a traditional resource management system has been historically found to be effective in protecting common pool resources such as MWs (Mbata et al. 2002; Ndlovu et al., 2019). Mbata et al., (2002) have for instance observed that traditional resource management systems have been effective in ensuring strict monitoring of the resource, protecting early life stages, conserving habitat, and applying harvesting restrictions through socially embedded customary practices, rules, and beliefs (Mbata et al., 2002 cited in Sekonya et al., 2020: 148). Such restrictive harvesting practices primarily designed to restrict early instar harvesting has not been limited to the South African case study presented by Sekonya et al., (2020) alone but have been reported in Zambia (Mbata et al. 2002), in other parts of South Africa (Egan, 2013) and in Zimbabwe (Mawere, 2014).

The level of resource commercialization versus the resilience of existing customary laws in communal lands where most of the stock is harvested is a main source of worry. It is argued that in some MW territories resource may have increased to the point that customary approaches are no longer appropriate to match the level of commercialisation (Wynberg and Laird, 2007). Such poor adherence to and / or bursting of established customary norms is largely due to unprecedented social change and urban influx that have not only tainted the legacy of traditional leaders but also undermined their authority as the custodians of the resource (Mashele, 2004; Wynberg and Laird, 2007). Such institutional isolation tendencies, which have created what has been referred to in some literatures as ‘institutional vacuum have also been acknowledged in the wider forest resource sector (Bromley, 2008; Shackleton 2009). It has also been observed that where the ability of resource users to respond to impending resource degradation is severely diminished the incidence of (resource) exploitation tends to be high (Vetter 2013; Sekonya et al., 2020).

MW governance studies from Namibia have however revealed that some of the challenges discussed in the preceding sections can be overcome through strengthening of institutional coordination mechanisms. A series of studies in communal areas of Namibia have concurred that institutional coordination and stricter controls on access and monitoring are critical for MW population sustainability (Thomas 2013, Ndeinoma and Wiersum 2016). Similar experiences drawn from Zimbabwe are also shared by Ndlovu et al., (2019) who observed that diminished coordination, in communal areas, led to widespread deforestation and habitat destruction in mopane woodlands. Putting MW resources on a resilience trajectory against adverse external pressures however requires what has been referred to in some other literatures as ‘fit-for-purpose state interventions’ (Ndeinoma & Wiersum, 2016). Ndeinoma and Wiersum, (2016) observed that state led legal protection of species should be promoted in communal areas as it ensures high adherence to statutory and customary rules by resource users.

Investing in management initiatives, such as policing, fencing woodlots, annexing MW trees and controlled defoliation of the MW tree through controlled grazing practices among others have been found to be other effective ways of ensuring sustainability in MW resources (Cloete et al. 2007; Ostrom 2009; Hartnett et al. 2012). Investing in monitoring and enforcement activities that restricts open access to MW by outsiders has been touted as one of the effective ways of sustainably managing the resource (Akpalu et al. 2009, Thomas 2013). Table 4.3 show types of regulatory regimes and associated MW related theoretical assumptions that may be pursued to explore resource governance dynamics in MW use.

Table. 4.3. Regulatory regimes and associated MW related theoretical assumptions

Regulatory	Research assumption	Supporting references
Resource regulatory climate	A loose regulatory climate leads to overexploitation of MW resources and other environmental resources	Stack et al. 2003; Lucas 2011; Thomas 2013; Kwiri et al., 2014; Sekonya et al., 2020
Existing resource governance regime	Strong governance regimes influence resource access and use in a positive way while weak ones will result in negative resource management outcomes.	Gondo, 2001; Thomas 2013.
(Level of) Resource access restrictions.	Uncontrolled access and habitat destruction from local and nonlocal harvesters will lead to resource degradation and reduced availability of Mws.	Wynberg and Laird, 2007; Shackleton 2009; Sekonya et al., 2020.

Level of resource commercialization	Unsuccessful resource management outcomes are expected where resource use may have increased to the point that customary approaches are no longer appropriate to match the level of commercialisation.	Mashele, 2004; Wynberg and Laird, 2007.
Ability to respond to impending resource degradation	Where the ability of resource users to respond to impending resource degradation is severely diminished the incidence of (resource) exploitation is high.	Vetter 2013; Sekonya et al., 2020.
State of traditional ecological knowledge	Traditional ecological knowledge encourages restrictive customary harvesting approaches that have resulted in sustainable resource outcomes in MW territories. Such knowledge will ensure effective monitoring of the resource, protection of early life stages, conserving habitat, and will allow harvesters to apply harvesting restrictions through socially embedded customary practices, rules, and beliefs	Mbata et al., 2002; Egan, 2013; Mawere, 2014; Ndlovu et al., 2019.
Level of institutional coordination	Institutional coordination and stricter controls on access and monitoring are critical for MW population sustainability	Thomas, 2013; Ndeinoma & Wiersum, 2016; Ndlovu et al., 2019.
Fit for purpose state interventions	State led legal protection of MW resources is effective in ensuring high adherence to statutory and customary rules by resource users.	Ndeinoma and Wiersum, 2016.
Evidence of investments in (resource) management initiatives	Investing in management initiatives, such as policing, fencing woodlots and annexing MW trees have been found to be other effective ways of ensuring sustainability in MW resources	Cloete et al. 2007; Akpalu et al. 2009; Ostrom 2009; Hartnett et al. 2012; Thomas 2013.

Source. Author construct, (2023)

4.2.4 The physical / engineering system

One of the most important physical / engineering variables that drives successful territorial dynamics has been spatial proximity of the resource to urban influx. The relative distance of communities to urban centres is therefore worth taking note of from an ecological point of view. Social change and urban influx are singled out as two major drivers of environmental change with communities located near urban centres being hardest hit in terms of resource exploitation (Mashele, 2004; Wynberg and Laird, 2007). This is because urban centres are characterized by high demand of environmental resources – an attribute that has seen an unprecedented rise in MW resource use in most communal areas. Such spatial dynamism in communal regions and associated resource management implications is well documented in other literature (Beinart 2000, King 2011, Palmer and Bennett 2013, Vetter 2013).

CHAPTER FIVE: *Research Methodology*

5.0 Introduction

This chapter gives a connotation and measurement of spatial and temporal changes in MW use and associated LED implications. It specifically presents the various research instruments that were employed to achieve research objectives and test the various research propositions outlined in previous sections. It also sheds light on specific research variables that were measured during fieldwork.

5.1 The research design philosophy

To avoid what Maxwell and Miller (2008) refer to as ‘analytic blinders’, an alternative way of understanding the LED implications of spatiotemporal changes in MW use that goes beyond the quantitative approach was required.

On one hand are questions that are much suited to *process theory* as the study sought to understand the meanings and processes that lead to MW-led vibrancy, dynamism and growth in the local economy and the influence of the territorial and / or spatial circumstances to such growth. On the other hand, an *open-ended deductive approach* that borrowed from *or rather the quantitative research paradigm* was employed to decipher or understand the transformative effect MW utilisation on the local economy by paying special attention to significant spatiotemporal attributes and their associated LED implications. Such an approach adopted by the study lends itself on to comparison and control issues that *variance theory* requires.

5.1.1 Participatory Rural Appraisal (PRA) design philosophy for selected LED insights

To understand and situate the role of MW harvesting in the local economy, there is need to employ participatory planning methods that allow MW harvesting households to map their own resources and have a say on the perceived value of MW resources in their local economy. Participatory Rural Appraisal (PRA) methods that were adopted in this study are defined as “a family of approaches and methods to enable rural people to share, enhance, and analyse their knowledge of life and conditions, to plan and to act” (Chambers; 1994:953). While the original scope of PRA studies has been limited to rural environments, this thesis has adopted a stretched concept that allows PRA approaches to be employed in urban settings as well to understand MW marketing dynamics and in the analysis of associated value chains. We found

this stretched application to be consistent with the views shared by Sandham et al. (2019). While the questionnaire survey method was the main data collection instrument used to statistically understand local economic development implications of spatial and temporal changes in MW use, there was an added need to triangulate such an approach with methodologies that are less prescriptive in nature and are allowing community voices about LED to be heard. The questionnaire survey method is often accused of being a top-down, and technoscientific approach to development Sandham et al. (2019). yet most LED studies rely heavily on people centred approaches that can only be supported by PRA studies. Use of PRA studies in this thesis is not misplaced for three main reasons.

Reason 1: The need to tap on local knowledge in crafting a MW based LED strategy.

We envisage that the development of a MW based LED strategy would require to bring on board the participation of and amplification of voices MW resource users. PRA studies are touted in literature for using highly participatory methodologies that actively integrated local values and knowledge for decentralised planning and democratic decision making (Cavestro; 2003; Chambers, 2007). This is because PRA approaches embody “. . . participatory ways to empower local and subordinate people, enabling them to express and enhance their knowledge and take action” (Chambers, 2007:3).

Reason 2: The need to move away an LED perspective that is state led to a people centred one.

While the state, remains significant on LED strategy crafting, this thesis holds that successful LED initiatives need to be grounded on people centred approaches. This view we have advanced tallies well with the conceptual roots of PRA approaches. PRA approaches are said to be rooted in neo-populist ideologies of development that require community members to be the primary agents of change in development (Sandham et al., 2019).

Reason 3: Building Local capacities for citizen led development.

In this study, we posit that MW-led development strategies can only be understood through the lens of citizen driven development initiatives. PRA approaches will not only guarantee the participation of communities but will also ensure that they have a voice that is backed by sustained capacity building measures that are so critical in harnessing local resources such as

MWs. Such ideals are embodied in the people centeredness nature associated with PRA studies. It is argued that PRA approaches will allow communities to “... increase their personal and institutional capacities to mobilize and manage resources to produce sustainable and justly distributed improvements in their quality of life, consistent with their own aspirations” (Korten 1990: 67, Sandham et al., 2019).

The study employed PRA studies to gather and analyse information in relation to the following:

- 5.1.1.1 ***Carrying out transect walks*** with sample community members to map significant socioeconomic activities associated with the bio-geophysical characteristics of the prevailing landscape. *Here, participatory generated village / resource map was divided into equal sized quadrants (20x20metres). Quadrants occupying the village margins were randomly selected. The central points of the first two randomly selected quadrants formed the start and finishing points for the transect walk.*
- 5.1.1.2 ***A historical time series analysis*** to understand resource use trends and any discernible association with major events.
- 5.1.1.3 ***A resource mapping exercise*** to understand resource use and impacts of human interventions on the MW ecosystem.
- 5.1.1.4 ***Pairwise ranking and matrix scoring exercises*** to assess the importance of MW resources to the local economy against other resources options as perceived by communities.
- 5.1.1.5 ***Understanding of MW marketing dynamics*** and assessment of the sustainability of associated value chains. Building on ranking and scoring exercises, PRA studies were used to rank the various output markets of MWs based on efficiency by identifying a plausible indicator of market efficiency.
- 5.1.1.6 ***An infrastructure asset inventory*** was carried out at rural centre nodal points to understand the dynamics of rural markets.
- 5.1.1.7 ***Confirming results from road infrastructure audit*** was done on major roads leading to output markets by the researcher. This was done to have a comprehensive understanding of rural access dynamics and how they influence the development of a MW-oriented LED strategy.

5.1.2 Research Design

The study adopted an experimental research design to test a series of propositions (hypotheses) that were put forward. Such a research design was deemed to be the most appropriate as it sought to quantify the statistical significance and direction of relationships between select MW utilisation variables – including amount of mopane worms harvested, traded, exchanged, consumed and how these vary according to household characteristics (including wealth status, headship and size), harvester characteristics (including gender and age), location (of resource, harvester / household, markets), networks, external shocks / stressors (weather, economic and health). This design was further triangulated by PRA studies, that were conducted in each of the five villages as justified in the preceding section.

5.2 Research and Sampling design

At the community level data was gathered from 5 communities situated in four wards including Zamanyoni, Sigangatsha, Beula, and Madwaleni wards. The study defined a community as an aggregate of households juridically constituted according to the Zimbabwean legislation. The five communities included in this study were selected according to (1) their relative distance to the markets (2) abundance and or availability of MWs (3) availability of previous research findings on which to build credible temporal data and (4) differing land tenure arrangements in terms of the ownership status of mopane woodlands where MWs were sourced.

At the household level, a total of 443 households that were targeted. Such a number was statistically determined using a 5% level of significance. Accurate sample frames in Zimbabwe are difficult to obtain at village level and the study had to rely on estimates provided by respective councillors and the chief and headmen where applicable. The resulting sample was seen as ideal in permitting certain statistical analysis and to capture wide variation in sample size and avoid the dangers of using smaller samples that might mask important spatial and temporal changes in resource use (Bremner & Lu, 2006). The five villages selected and their respective wards, including sample frame and targeted sample size are shown in Table 5.1. In the end and owing to the quality of responses received in some villages, a total sample size of 412 households was reached.

Table 5.1 Sample frame and sample size

Name of Ward	Name of targetvillage	Estimated population	Desired sample (# of households)

Sigangatsha	Sasane	165	84
Beula	Kapeni	203	55
Zamanyoni	Mahetshe	211	89
Madwaleni	Mangala	220	146
Madwaleni	Ndiweni	203	69
TOTAL		1002	443

The spatial distribution of selected villages is shown in Figure 5.1.

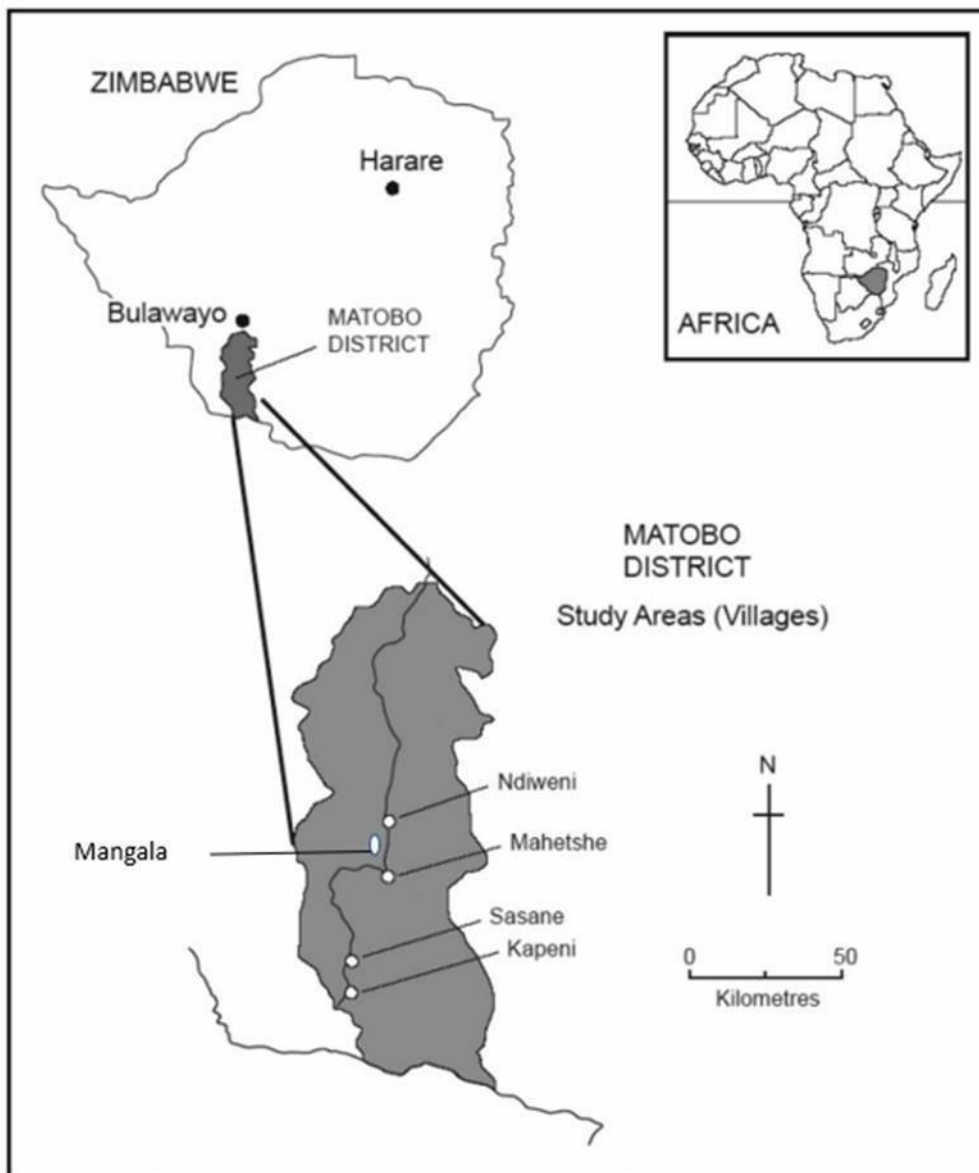


Figure 5.1 Spatial distribution of selected villages.

The questionnaire survey (see annexure 1 for an extract) was conducted mainly with the household heads and their spouses. Where these were not present, elderly children were interviewed. A child who qualified to be interviewed was of minimum age 16 years. The study

defines a household according to Babigumira et al. (2014: 11) who defines it as a “group of people (normally family members) living under the same roof, and pooling resources (income and labour) for their livelihood”.

A mopane worm substitute and price survey (see annexure 2) to get an appreciation of the urban marketing dynamics.

5.2.1 Spatial sampling unit of analysis.

The selection of the spatial unit of analysis in this study is largely inspired by the work of Behrens and Thisse (2007: 458) who have argued that “when there is a single region, the economy is a-spatial and there is nothing interesting to be said in terms of spatial analysis.” It then follows that “...any meaningful discussion of regional issues requires at least two regions in which economic decisions are made.” (Behrens & Thisse, 2007: 458). This need for systematic evaluations of LED initiatives that are based on multiple cases (or rather multiple regions) was already noted three decades ago by Hughes (1991) and Teitz (1994), who recognised the necessity to undertake better analysis and evaluations of the processes and outcomes of the diversity of LED strategies. OECD (2003, 2004) later reiterated this demand. Multiplicity of cases and regions in this study has been achieved in three main ways. As discussed below.

5.2.1.1 *Accounting for spatial disparities in MW use*

This study used three levels of spatial unit of analysis. The main spatial unit of analysis that has been used and is comparable to other LED studies carried out elsewhere is the village. The village was used in some analysis as a spatial entity with relatively homogenous LED and MW utilisation attributes. Certain type of analysis particularly those that required understanding links between harvesting households and output markets and the impact of MW income on inequality required us to formulate another spatial level of analysis requiring a distinction between **proximal** and **distal** communities. We defined proximal communities in this study as villages that are near or in ‘proximity’ to the major rural urban centres of Maphisa and Kezi. Those that were located further away from these two major centres were defined as distal communities. This classification system was largely inspired by studies in the field of rural-urban linkages. The study therefore assumed that rural areas cannot be homogenous in terms of social, and economic conditions and other dynamics that are considered in regional economics to vary according to distance away from major centres (Ucieklak-Jeż & Bem, 2020). While scholars such as Ucieklak-Jeż & Bem (2020) have used the terms such as ‘suburban

rural areas' to characterise rural communities surrounding large urban centres that chose to use proximal rural communities to define rural communities surrounding major rural urban centres. Three such communities in this study fit this characterisation, including Mahetshe (nearest to Maphisa rural centre), Ndiweni and Mangala (both nearer to Kezi and Maphisa rural centres). All three communities are also relatively well connected to the major urban centres of Bulawayo by a paved road network system (see Figure 3.1).

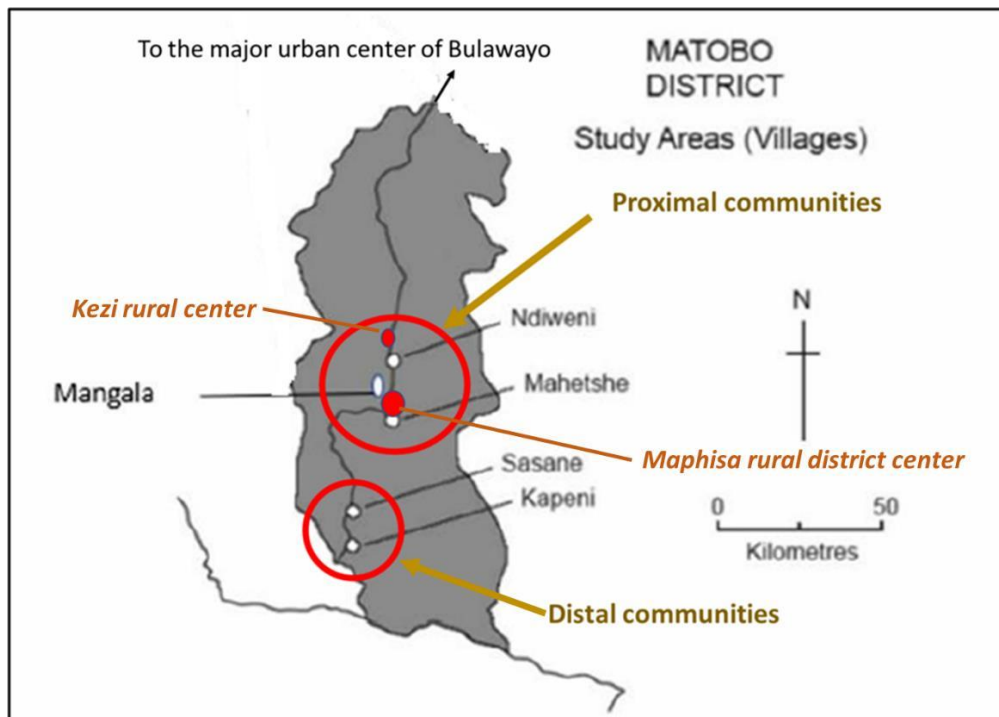


Figure 3.1 Location of proximal and distal communities in relation to major markets.

The study also employed unique MW territories created using a clustering algorithm as another spatial unit of analysis. These were particularly chosen in instances where optimum LED solutions and statistically significant territorial dynamics were sought. They complemented proximal and distal communities and the 5 villages that were clustered according to administrative boundaries.

5.2.1.2 Accounting for temporal changes in MW use

Most studies on forest dependence usually distinguish between two resource states to account for temporal variations in resource use. Such two resource states include the Wet Resource State (WRS) and the Dry resource State (DRS). The study incorporated the temporal dimension, by employing a proxy measure that we found to be ideal in depicting the influence of variations in precipitation on availability on the availability of MWs and other Ecosystem Services (ES) provisioning goods. We followed the cue from Gondo (2019) by borrowing

5.3 Study timelines and activities undertaken.

The following is a profile of field work activities that were carried out and their respective time frames (Table 5.2). Data for the 2000-2014 was collected in retrospect in year 2015. Every other period it was collected during and collated at the end of each period to give a complete reflection of harvesting and marketing dynamics.

Table 5.2. Study time frames and activities undertaken.

Study time frame	Activities undertaken	Responsible person
2000 – 2014	Training of research assistance Negotiating entry into the communities with Rural, District Council Officials, The Zimbabwe Republic Police (ZRP), the political leadership (Councillors) and the traditional leadership. Piloting the Household questionnaire survey Identification of the panel for PRA studies in each targeted village. First household survey conducted in April 2015.	Researcher Research assistants
2014 – 2018	Household survey continued Focused group discussion in each village (Data relating to 2000 – 2014 period obtained retrospectively). Participatory historical time series analysis with selected participants in each village. Participatory resource mapping exercises. Interviews with key Rural District officials to obtain data on the profile of the district and updated local maps showing the location of targeted communities. Road Infrastructure audits carried out. Market efficient analysis study carried out. Urban markets surveys carried out. Several visits to Matobo Rural district Offices to obtain maps and secondary information of the District profile. A visit to the Surveyor General's office in Harare to obtain satellite image and remote sensing data for the study sites. Rural and Urban Market Surveys. A minimum of 3 transect walks conducted in each village	Researcher Research assistants
2018 – 2022	Household survey continued A continuation of focused group discussion in each village. Participatory historical time series analysis with selected participants in each village. Continued informal interviews with key Rural District officials to obtain data on the profile of the district and updated local maps showing the location of targeted communities. Road Infrastructure audits carried out. Market efficient analysis study carried out. Urban markets surveys carried out. Rural and Urban Market Surveys continued. Transect walks concluded.	Researcher Research assistants.

Source. Author construct (2023).

5.4 Analysis of research Objectives

A detailed description of how each research objective was achieved is given in this section.

5.4.1 Objective 1: To estimate spatial and temporal changes in rural household dependency on the MW industry.

This objective is largely inspired by the attendant need to develop methodologies that are designed to capture fine-scaled patterns of resource dependency and associated development patterns over significant periods of time and across geographic boundaries. A plethora of methodologies both at landscape and regional levels exist (Kirk et al., 2012). These methods include using aggregated and disaggregated census data to map trends in resource use by rural households; evaluating spatial characteristics of resource exploitation behaviours using satellite image derived classifications and spatial indices; interpreting current and historic aerial photography to map trends in resource use; extracting data from government sources, international agencies, and NGOs; and / or analysing the socio-economic and demographic characteristics of resource users participating in the extraction process (Mujawamariya and Karimov, 2014; Liu et al., 2014).

The decision to use a specific approach is often governed by the data availability and the geographic scale of analysis required (Kirk et al., 2012). National scale studies would usually rely on aggregated data provided by sources such as national censuses or satellite while localised studies such as this study would rely on fine scaled data that is readily available through surveys at ecosystem, resource user or household level. The approach taken by this study was to analyse the socio-economic, socio-spatial and demographic characteristics of resource users.

5.4.1.1 Econometric procedures in estimating spatial and temporal changes in MW resource dependency.

In local and regional economic planning and other related fields of study, most studies that seek to quantify resource dependency begin by identifying unique household characteristics that determine the decision by a household to participate in the resource extraction process (Vokoun et al., 2006; Stordal et al, 2008; Mujawamariya and Karimov, 2014; Liu et al., 2014). They then proceed to look at the impact of such household characteristics on either the income derived from the resource, or the quantities extracted (Beach et al., 2005; Stordal, 2008). Modelling

such participation and resource extraction behaviours requires an appropriate theoretical framework that defines explicitly the processes that are involved. To quantitatively depict the impact of certain household characteristics on the decision to participate or not participate in the MW harvesting and the product marketing process, regional econometrics requires that an ‘identification’ problem is first articulated (Liu et al., 2014).

Identification and measurement of resource dependency

As in many LED projects that seek to tap on the NTFP extraction, participation in MW activities such as harvesting and marketing is characterised by two potential outcomes. One outcome that this study defines as Y_1 is when the rural household participates in the harvesting and / or marketing process. The other potential outcome is Y_0 when the rural household is not participating in the harvesting and / or marketing process. Assessing resource dependency would require us to specify the impact of participating in the harvesting and / or the marketing process, by specifically determining if there are any unique household and other related attributes that makes certain categories of rural households more dependent on MWs than others both in time and space. Mathematically such impact of participating in the MW harvesting and / or marketing can be represented by the following equation.

$$= Y_1 - Y_0$$



Estimating such impact would always require information on both Y_1 and Y_0 for each rural household being investigated. As in this case, empirical evidence from elsewhere suggests that such information is not readily obtainable as one cannot observe the outcome of participation for non-participants or the outcome of non-participation for participants (Liu et al., 2014). Several studies on rural household involvement in NTFP extraction have often underplayed this aspect by employing discrete regression techniques that do not allow the identification of relevant impacts in the absence of the data (Heckman and Robb, 1985; Heckman et al., 1997). This has tended to create a void in efforts targeted at assessing resource dependency. In the case of MW utilisation, it is imperative that we know the difference between the level of household income when a household is participating in the resource extraction process and when they are not (i.e. a zero-sample scenario case). Since not all households in our study are participating in the harvesting and / or the marketing process, we only have data on one situation or the other.

Modelling resource dependency: Which econometric model to use?

The study employed the Binary logistic regression model to estimate factors affecting MW resource dependency using two models with two different but related dependent variables. The first model, Model I used the amount of 20 litre buckets of MWs harvested, since most studies on resource dependency use quantities extracted as a dependent variable (Mertler & Reinhart, 2017; Mendako et al., 2022). Model II employed the HCI as the dependent variable as it can be easily used as a predictor of expected returns from MW trade. These dependent variables were recorded in binary variables, since it was considered worthwhile to develop LED interventions or plans that divide household status into “high resource dependency” and “low resource dependency” categories. Both dependent variables were divided into two using the median values. Like many other related studies, the median as a better indicator of central tendency than the mean since high-value cases can significantly impact the mean but have little or no impact on the median (Mertler & Reinhart, 2017; Mendako et al., 2022). The median was calculated for both the WRS and the DRS to account for temporal variations in resource dependency.

5.4.1.2 Determination of intensity of (MW resource) commercialisation: the HCI

Resource commercialisation in the mopane worm industry is an important determinant of household resource dependency. Related studies in the field have often identified intensity of commercialisation as an important resource commercialisation variable that needs to be quantified objectively (Baiyegunhi & Oppong, 2016). Such a variable is important to analyse as it helps map why some MW territories and MW households show high intensity of participation in the output market than others. We expect high intensity of participation in the output market to be an objective indicator of high resource dependency and vice-versa. Such intensity as observed by Baiyegunhi & Oppong (2016) can be measured using the Household Commercialisation Index (HCI). In this study, the HCI is defined as the ratio of the gross value of all crop sales (i.e MW sales) to gross value of all production (i.e. MW harvested). Mathematically the HCI can take any value from zero to one and can be expressed using the following formula.

$$HCI = \frac{GCS}{GCP}$$

Where: GCS = Gross value of Crop Sale

 GCP = Gross value of Crop Produced

This formula will apply in instances where this study uses MW harvesting households as the

spatial unit of analysis. Unlike in the study by Baiyegunhi & Oppong (2016), this study further stretched this formula to calculate a Village Scale Commercialisation Index (VSCI) to estimate direct spatial variations in the intensity to participate in the output market by all harvesting households belonging to that village. This to some extent helps shed light on spatial and temporal variation in resource dependency at village level. By extension, the VSCI is expressed mathematically as follows.

$$VSCI = \frac{GCS}{GCP}$$

Where: GCS = Gross value of Crop Sale by all households in the village
 GCP = Gross value of Crop Produced all households in the village

5.4.1.3 Measuring Road pavement distress conditions and associated impact on household participation in the output market.

The ability of harvesting MW households trading large volumes of MWs in intermediate rural-urban markets rely to a larger extent to the number of buyers willing to travel and fetch stocks from those markets. Since most harvesters are restricted by huge transportation and other upkeep costs to enter distal markets, bringing the market to the rural centres becomes an ideal LED intervention. The study assumed that the number of buyers willing to access any rural market for MWs is largely a function of road pavement distress conditions. There is ample evidence to suggest that poor road infrastructure quality is not only a deterrent to rural traders willing to enter high value distal markets, but also a major problem in limiting the number of buyers able to access rural markets. It is a major limitation on the intensity of local traders to participate in the output market. This aspect has been widely accepted in some MW studies that have sought to understand trading behaviours of harvesting households who have commercialised the trading of the worm (Baiyegunhi & Oppong, 2016). Unfortunately, such and other studies have often used accessibility and / or transportation challenges as a determinant of resource dependency. Such studies have failed to acknowledge that rural market accessibility is a complex interaction of many road pavement distress parameters that deter actual and potential buyers to access rural markets. Measuring road pavement distress and its impact on household participation in the output market.

Due to constrained access to automated pavement defect detection methods in the university and in the case study region, we opted to use manual pavement condition assessment. While such an approach is usually criticised on relying on the observer's subjectivity, we tried to minimise bias by using a carefully structured distress detection template largely informed by the works of Ragnoli et al. (2018). Subjectivity was also minimised by developing a comprehensive indicator system for each distress condition that later allowed us to calculate an average rating value based on the severity scores given to each of the observable indicators. Study variables and measurement criteria used are shown in Table 5.3.

Table 5.3 Road pavement distress variables and measurement

Pavement distress variable	Observable pavement distress attributes	Expected impact on:							Supporting references	LED
		Willingness of buyers to access the rural market			Ability of local traders to access output markets.					
		Severity	L	M	H	L	M	H		
		Impact	L	M	H	H	M	L		
Pavement integrity (PI)	degree of pavement surface maintenance and deterioration (surface defects, plastic deformations, and cracking)	1	2	3	3	2	1	Miller and Bellinger, 2003; Ragnoli et al., 2018; Qiao et al., 2021;		
Pavement surface (PS)	Type, severity, amount of distress	1	2	3	3	2	1	Chan et al., 2010;		
Ride quality (RQ)	Riding comfort rating or roughness.	1	2	3	3	2	1	Wiradnyana et al., 2021		
Road safety Measures and Facilities (RS)	Safety warning signs; safety protection facilities, side parking, road safety reserves, storm water management	1	1	2	2	2	1	Wiradnyana et al., 2021		
Pothole intensity(PIN)	Number and distribution of potholes	1	2	3	3	2	1	Bello-Salau et al., 2019; Du et al., 2020; Khahro et al., 2021;		
Comprehensibility of road signage (CR)	Incomprehensible versus comprehensible terms, symbols, and colours. Detectability by automated vehicles, availability and adequacy	1	2	3	3	2	1	Carlson and Lupes, 2007; Euro RAP & Euro NCAP, 2015; Babic et al., 2022		
Visibility of Pavement Surface Features(VP)	Pavement surface colour and reflectivity; lane markings and signings; visibility at night and in bad weather conditions	1	2	3	3	2	1	Bennett et al.,2006; Carlson and Lupes, 2007; Babic et al., 2022.		

Individual distress ratings along major roads leading to, and out of the rural market were calculated using severity scores generated for each pavement distress variable using a 3-point rating system as shown in Table 5.3. Observing road distress conditions was aided by a series of PRA transect walks that were conducted along carefully selected points major roads leading to the local markets. Observed road defects and associated distress conditions was guided by a carefully structured ‘template for recording and interpreting pavement distress severity and extent.’ Shown in Table 5.4.

Table 5.4. Template for recording and interpreting Pavement Distress Severity and Extent

Severity score	Descriptor	Extent (percent of surface affected):	
		Severity scale: 0-100%	Equivalent. 0-10 scale
1 = LOW	Very slight	0 – 10 Occasional	0-1
	Slight	10 – 20 Intermittent	1-2
2 = MEDIUM	Moderate	20 -50 Frequent	2-5
3 = HIGH	Severe	50 – 80 Extensive	5-8
	Very severe	> 80 Throughout	> 8

According to such a template, is therefore possible to express the Pavement Distress Index (PDI) as percentage that defines percent of surface affected. The PDI therefore ranges from 0 to 100%, values that can be rescaled to a 3-point rating scale the method of interpolation as implied in Table.

To estimate the impact of prevailing road distress conditions on the willingness of buyers to visit a rural market and / or the ability of local traders to access output markets, the study employed the concept of inherent risk that allowed the construction of 3x3 road distress heatmaps for each village market (s). Inherent risk was computed using the following formular.

$$\text{Inherent risk} = \text{risk} \times \text{impact}.$$

Where ‘risk’ defined the likelihood of a road pavement system restricting buyers and sellers to access rural markets and output markets respectively. The ‘impact’ component defining what would happen if indeed the prevailing pavement distress was to have an impact on buyers and sellers in accessing rural markets and output markets respectively. Both parameters were captured using a 3-point rating scale where 1 = less likely, 2 = somewhat likely and 3 = likely in the case of risk. The study defined the impact scale as follows; 1 = low, 2 = moderate and 3 = high. The village was used as a spatial unit of analysis to compare spatial differences in the inherent risk values via the construction of 3x3 heat maps.

5.4.1.4 Measuring economic complexity.

Evidence of connections between resource dependency and a regions economic complexity index exists at least at country and subnational levels (Aerni, 2018; Cakir et al., 2021). An attempt was made to measure the spatial variation in the economic capabilities of each village by looking at how well diversified and complex the village economy is. The normal procedure is to calculate the economic complexity index. Because rural economies in Zimbabwe are less sophisticated and diversified and that export and import behaviours of economic agents are not systematically captured, there was a need to calculate a simple proxy measure to capture the spatial variations economic complexity. The main assumption here is that ‘villages are rural villages are not homogenous economic entities. Instead, there exists a mosaic of them that offer diverse and unique range of economic capabilities and sophistications.’ Such spatial heterogeneity will have a direct bearing on MW resource dependency. We expect households who occupy MW-based village territories whose economies are in relative terms highly diversified and sophisticated to be highly dependent on MW resources. This is because, such economies are usually associated with supportive institutions, responsive education and responsive research systems, supportive physical infrastructure, and highly sophisticated product value chains among other factors (Aerni, 2018; Cakir et al., 2021). Such positive factor conditions are likely to incentivise MW harvesting households to expand their reliance on MWs. We expect resource extraction in such environments to be high subject to supply to resource dynamics.

To measure such complexity, mainstream LED literature required us to look at the diverserange of products exported by a village (diversification) and how broadly they are supplied intoother markets (that is expressed by a function of ubiquity) by various other villages (Hidalgo & Hausmann, 2009). This is possible to execute at country or subnational levels where such data is readily available and where the level of economic sophistication allows. In such instances an Economic Diversity Index can be calculated to compare different nations and regions. At village level we argue that a simple index can be developed that captures the extentand diversity of human capabilities in their respective Wards by quantifying the number of unique products and / or services (P_S) that the concerned Ward produces or offers and dividing this by the total number of unique products and / or services (P_S) that all Wards combined (from that the sampled villages are drawn) produce or offer. Mathematically thatcan be presented as follows.

$$VECI = \frac{\sum (P\_S \text{ offered by all villages in Ward } i)}{\sum (P\_S \text{ offered by all villages in ALL sampled Wards})}$$

Where: VECI = Village Economic Complexity Index
P_S = Unique Products and / or Services

Data on unique products and or services offered was primarily captured from the Matobo District profile handbook and supplemented by participants in focused group discussions during the PRA studies.

5.4.1.5 Measuring peak market efficiency

Guided by preceding literature review, the study assumed that the willingness of households to enter certain rural-urban markets is an important predictor of resource dependency. We expected trading households to increase their trading activities in markets that are more efficient as opposed to the less efficient ones. The efficient operation of rural markets is a complex interaction between many variables, including road pavement distress conditions leading into such markets, the (demographic) size of the market, availability, and cost of transportation to access the market, anticipated produce price, availability of quality market infrastructure, the likelihood of realising a sale upon arrival is another factor. Since modelling the complex interaction between these is often a complex task, a participatory ranking exercise was carried out in each village to determine the most simple and preferred indicator of market efficiency. At the PRA stage participants in all villages, agreed that what attract them to the rural and urban markets the most is the speed at that they get their stocks sold.

To calculate market efficiency the study used the likelihood of realising faster sales as a proxy measure that can be calculated using the queuing model approach since observed arrival of MW produce tends to follow a queuing pattern. The model of stock arrivals and sales (the queuing discipline) depends largely on the negotiation skills of the seller. Where sellers are good bargainers, we expect the MW stock arrivals to follow the First-In-First-Out (FIFO) queuing discipline. The analysis considered each rural market centre to be one giant server where traders would come and buy stock from. An important quantity to estimate was the following *service utilisation*.

Service utilisation (P) = λ/μ .

Where; (λ) = Average number of 50kg bags of MWs arriving at the market (i.e. server) per seller per day

(μ) = Average number of 50kg bags of MWs completing a sale per seller perday

P = (Peak) Market efficiency

The study used such quantity as a proxy measure of market efficiency. P denotes the proportion of time that a server (in this case a rural -urban market) spends with the MW stockbefore they are finally bought by a potential customer.

5.4.2 Objective 2: To analyse spatiotemporal changes in factors explaining successful territorial dynamics that lead to situations of growth in the MW industry and the local economy at large.

This objective was achieved by adopting a two levels of analysis approach as follows.

- Measuring territorial dynamics and associated determinants
- Measuring territorial resilience and associated dynamics

3.4.2.1 Measuring territorial dynamics and associated determinants

A multiple perspective evaluation approach that tapped onto territorial vulnerability, territorial imbalance, territorial cohesion and territorial capability literature was employed for obvious reasons. At a more conceptual level, this approach is based on methodological pluralism – a perspective that many scholars argue is at odds with mono-dimensional approaches that are reductionist in nature and may be biased as they tend to favour one performance objective over others (Gasparatos and Scolobig, 2012). Evaluating spatio-temporal changes in factors explaining successful territorial dynamics and alternative decision options there-off solely from a single perspective would not provide satisfactory information for integrated and sustainable planning of MW-oriented LED initiatives.

The study took the position that identifying a territory's shortcomings and potentialities is key to meeting its LED goals. To achieve such goals, we take the cue from Calvo-Palomares et al. (2021) who has argued that different territorial units require a sufficient level of competence to be able to undertake successful development processes that are “sustainable, responsible, appropriate, and adapted to their particular needs and characteristics” (Calvo-Palomares et al., 2021:1). According to this shared understanding, successful territorial dynamics therefore becomes a function of the extent to which existing competences of a territory can promote local development processes that may lead to situations of growth in the local economy. Within MW-

dependent communities, an understanding of each community's territorial competences. This objective was achieved by adopting a two levels of analysis approach as follows.

- Measuring territorial dynamics and associated determinants
- Measuring territorial resilience and associated dynamics

5.4.2.1 Measuring territorial dynamics and associated determinants

A multiple perspective evaluation approach that tapped onto territorial vulnerability, territorial imbalance, territorial cohesion and territorial capability literature was employed for obvious reasons. At a more conceptual level, this approach is based on methodological pluralism – a perspective that many scholars argue is at odds with mono-dimensional approaches that are reductionist in nature and may be biased as they tend to favour one performance objective over others (Gasparatos and Scolobig, 2012). Evaluating spatio-temporal changes in factors explaining successful territorial dynamics and alternative decision options there-off solely from a single perspective would not provide satisfactory information for integrated and sustainable planning of MW-oriented LED initiatives.

The study took the position that identifying a territory's shortcomings and potentialities is key to meeting its LED goals. To achieve such goals, we take the cue from Calvo-Palomares et al. (2021) who has argued that different territorial units require a sufficient level of competence to be able to undertake successful development processes that are “sustainable, responsible, appropriate, and adapted to their particular needs and characteristics” (Calvo-Palomares et al., 2021:1). According to this shared understanding, successful territorial dynamics therefore becomes a function of the extent to which existing competences of a territory can promote local development processes that may lead to situations of growth in the local economy. Within MW-dependent communities, an understanding of each community's territorial competences or

attributes will help shed light on each MW territory's prospects of triggering LED. It helps in pinpointing that elements exist and have potential that can be valorised to generate local development processes.

Five categories of study variables were identified through literature review and were hypothesised in this study to be important depictees of successful territorial dynamics. These include the Environmental / Ecological System, the Social System, the Economic System, the Institutional / Governance System and the Physical / Engineering System (Osipov et al., 2016; Brunetta et al., 2019; Stanganelli et al., 2020)

The study sought to analyse the dynamic interactions among these five systems according to how they perform in each territorial space and their ultimate influence on the MW business and the local economy. Ultimately Successful Territorial dynamics (STD) becomes the sum of the performance metrics associated with such four territorial systems and can be expressed mathematically as follows.

$$STD = f(ESP+SSP+ISP+EcSP+PESP)$$

Where; STD = Successful Territorial Dynamics

ESP = Ecological/ Environmental System Performance
SSP = Social System Performance

ISP = Institutional System Performance
ESP = Economic System Performance

PESP= Physical or Engineering System Performance.

For each MW territory as defined by the village, several territorial system performance study variables were identified and analysed.

Indicators of successful territorial dynamics: rationale and study variables.

A review of literature relating to integrated, territorial, and place-based studies (see Kraybill & Kilkenny, 2003; Justino et al., 2004; Barca, 2009; Jonasson & Helfund, 2010; Kumar et al., 2011; Barca et al, 2012; Rodríguez-Pose and Hardy, 2015, successful territorial dynamics (see RIMISP, 2007; EC, 2010; Sanchez-Zamora et al., 2014) and territorial resistance (see Hill et al., 2008; Ashby et al., 2009; Wells, 2009; Batty and Cole, 2010; Hamdouch et al., 2012) reveals several dimensions of territorial performance that are worth pursuing if we are to have a

comprehensive understanding of development dynamics of the MW industry that according to RMISP (2007) can respond to inherent obstacles to growth and that lead to situations of economic growth, social and territorial cohesion and environmental sustainability. Taking the cue from RIMISP's and several other recent studies on territorial dynamics the study identified a system of variables that define successful territorial dynamics. These are given in Figure 5.3.



Figure 5.3 Study variables adopted to define successful territorial dynamics.

The theoretical assumptions that link each of these variables are given in Annexure 2. Each variable defined a territory's capability or potential that can be valorised to foster successful outcome in the MW business. As such the study proposed the following hypothesis.

Hypothesis 3: LED interventions in the MW industry that seek to valorise given territorial potentialities are more likely to lead to situations of growth.

To test this hypothesis, the study first used a clustering algorithm to create a unique system of MW territories that possessed different capabilities and potentialities. After such a system was generated, the Data Envelop Approach (DEA) was used to assess how such unique capabilities were being converted by each unique territorial cluster into a territorial success outcome variable such as MW income among others. Other successful outcome variables used included quantity of MWs harvested, Amount of MWs sold to the market and the intensity of

involvement in MW commercialisation as measured by the Household Commercialisation Index (HCI).

Cluster analytical creation of successful MW territories: The procedure

The study adopted a cluster analytical procedure similar (but not entirely so) to that of Bacher et al. (2010). HCA alternatively known as hierarchical modelling refers to a class of multivariate statistical techniques developed for the analysis of data collected from dependent groups or clusters. HCA allowed us to consider the relationship between MW territorial predictor variables and associated outcomes as defined by their effect on territory dynamics. Conceptually, the analysis denotes associated territorial outcomes for predictor variable i in spatial locality j in which the household is located as Y_{ij} . This outcome is represented in equation one as a function of the individual MW territory characteristics, X_{qij} , and a model error r_{ij} (Bryk & Raudenbush, 1992).

$$Y_{ij} = \beta_{0j} + \beta_{1j}X_{1ij} + \beta_{2j}X_{2ij} + \dots + \beta_{nj}X_{nij} + r_{ij}$$

where $r_{ij} \sim N(0, \sigma^2)$.

The HCA approach adopted is essentially bottom-up process, where objects and then clusters of objects are progressively combined on the basis of a linkage algorithm that uses the distance measures to determine the proximity of objects and then clusters to each other (Legendre and Legendre, 1998). The standard metric for distance calculation used for continuous variables is 'Euclidean distance.' (Olden et al., 2012). The analysis adopted 'Euclidean distance', as a standard metric to calculate distances (interpreted as the similarity) between all objects in a data matrix. This was done on the basis that those objects (i.e. spatial localities in which households were located) closer together are more alike than those objects further apart. To promote a more rigorous analytical approach, testing of alternative linkage and distance measures is advocated for (Mouchet et al., 2008; Hennig et al., 2015). For this reason, linkage algorithm options were explored, including comparison of distance based (e.g. single, average and complete) and variance-based algorithms- (e.g. Ward) and evaluated (see Saraçlı et al., 2013). An acceptable solution was achieved using Ward (minimum variance) distances. The basic Euclidean distance formula was used as there were no theoretical reasons to prefer a more complex formula, and other formulas did not produce substantially different or more interesting results. The adopted Ward's minimum variance method (that essentially minimises the squared Euclidean distance) led to a decrease in variance for the cluster being merged. At each

step, the pair of clusters merged was based on the optimal value of the error sum of squares as defined in the following equation.

$$d_{ij} = d(\{X_i\}, \{X_j\}) = \|X_i - X_j\|^2.$$

where d_{ij} is the squared Euclidean distance between x_i and x_j .

Testing of the significance of the resulting cluster was done using Kruskal-Wallis one-way analysis of variance tests (Kruskal and Wallis, 1952).

Measuring territorial success: The Data Envelop Analysis (DEA) Method.

Several studies on successful territorial dynamics have employed this approach to measure the extent to which a territory's capability and / or potential is converted into a success outcome variable (Sánchez-Zamora & Gallardo-Cobos, 2020; Cordini et al., 2021). The DEA approach was employed to assess how efficient each generated territorial cluster was, in converting its capabilities or potentialities defined by five capabilities including the Ecological System Capabilities (ESC), the Social System Capabilities (SSC), the Institutional System Capabilities (ISP), the Economic System Capabilities (EcSC) and the Physical, Engineering System Capability (PESC). The main outcome variable used was the amount of MW income received by households. DEA uses the technical efficiency criteria to measure territorial performance.

It allowed us to identify territories otherwise known as Decision Making Units (DMUs) whose technical efficiency is 1 (or 100%) and therefore occupying the Probability Production Frontier (PPF) otherwise known as the Efficient Frontier (EF). Such technical efficiency value would mean that a territory is 100% efficient in converting its capabilities and potential in an outcome variable (in this study MW income). Such territory or territories would then form a benchmark upon which other lagging territories would strive to achieve. DEA has an advantage in the it allows decision makers to decide that of the input-oriented or output-oriented LED strategy would lead into territorial success. Two indices were calculated to define territorial success under this method. These included.

5.4.2.1.1 The Partial Territorial Dynamic Index (PTDI) and

5.4.2.1.2 The Global Territorial Dynamic Index (GTDI)

The DEA model employed was applied dynamics, once for each five dimensions (or capabilities) of territorial dynamics to obtain five partial indices. This as in the study by Sánchez-Zamora & Gallardo-Cobos (2020) made it possible rank MW territories according to

their levels of relative performance in each of the five dimensions. To obtain the GTDI, associated with each MW territory the five partial indices were aggregated by adding them. The aggregation procedure was done using the DEA model using STATA version 18.

The Pearson's correlation coefficient (r) is one of the correlation indices that has widely been accepted as a measure that can help identify major determinants of successful territorial dynamics (Sánchez-Zamora & Gallardo-Cobos, 2020). Given the nature the data collected, it was used in this study to discern if there was any meaningful connection between study variables and the outcome variable.

5.4.2.2 Measuring territorial resilience and associated dynamics

This approach is employed to analyse the resistance of MW territorial space to external changes and shocks in the local environment and beyond. Understanding such behaviours was deemed critical to understanding factors explaining successful territorial dynamics under different shock scenarios associated with Mopane worm utilisation.

Three important hypotheses guided the achievement of this sub- objective. These include.

Hypothesis 6: Idiosyncratic health, severe weather, and economic shocks have resulted in distinct clusters of livelihood adaptation and / or resilience trajectories that significantly impact the growth potential of MW territories.

Hypothesis 7: Idiosyncratic health, severe weather, and economic shocks tend to diminish important linkages between MW trading activities and markets within and beyond the boundaries of the rural economy.

Hypothesis 8: The ecological, socio-economic, engineering and institutional vulnerability status of the MW territories significantly shape their adaptive capacity to withstand external shocks.

To achieve all three hypotheses (H6) (H7) and (H8), the thesis borrowed insights from concepts of livelihood adaptation and determinants of coping strategies that are well framed in the literature on environmental disturbances and disasters (Pelling, 2011; Below et al. 2012; Kurukulasuriya and Rosenthal, 2013). These insights were deemed to be very useful in that they provided appropriate data input metrics and a framework for analysis on the vulnerability and adaptive capacity of populations affected by unforeseen events in different territorial spaces. The main task was to find out that typology of households in which territorial spaces and time scales were more likely to absorb shocks and cope with changes in MW livelihood

dependent territories. The most used methods for profiling a typology of such households to use a joint factor and cluster analysis similar to those in the studies of Kura et al. (2017) and Weltin et al. (2017). A three-level approach was adopted in this study including.

- ***Level1: Use of a classification decision tree model.***
- ***Level 2. Measuring resilience and***
- ***Level 3: Segmenting households according to various reliance capacities***

Level 1: The classification decision tree model explained.

The study employed the decision tree model as a structural analysis tool that allowed us to develop a profile of households according to their behaviours when faced with adversity such as health, severe weather (leading into reduced harvests), and economic shocks (as a result of sudden unemployment leading into unforeseen loss of income) and other forms of stressors such as sudden emigration of family member (leading into loss of labour) and sudden death. A profiling of such behaviours permitted a classification of households according to their resilient. This approach increasingly used in many similar rural studies (Huang & Xia, 2023; Pathak & Deshkar, 2023) has an advantage of generating probabilities that can be used to correctly predict group that a household would belong to according to a reliant attribute of interest. To measure the significance of any association among the dependent and independent variables, the adopted model used the Chi-square Automatic Interaction Detector (CHAID) method.

Level 2: Measuring resilience.

The study assumed that developing an effective MW- led development strategy would require an initial understanding of a set of capacities that enable households and MW dependent communities to effectively function in the face of shocks and stresses and still meet a set of well-being outcomes. Such understanding will help develop a territorial based resilience strategy that will ensure that MW dependent communities will not collapse when faced with adversity. Three resilient capacities were assessed including.

- Absorptive capacity
- Adaptive capacity and
- Transformative capacity

An effective MW-led development strategy is likely to yield positive results in the local economy if these three capacities are strengthened. Calculating partial resilience indices based on these three strands of resilient capacity would allow a classification of different MW territorial units using the hypothetical framework in Figure 5.4.

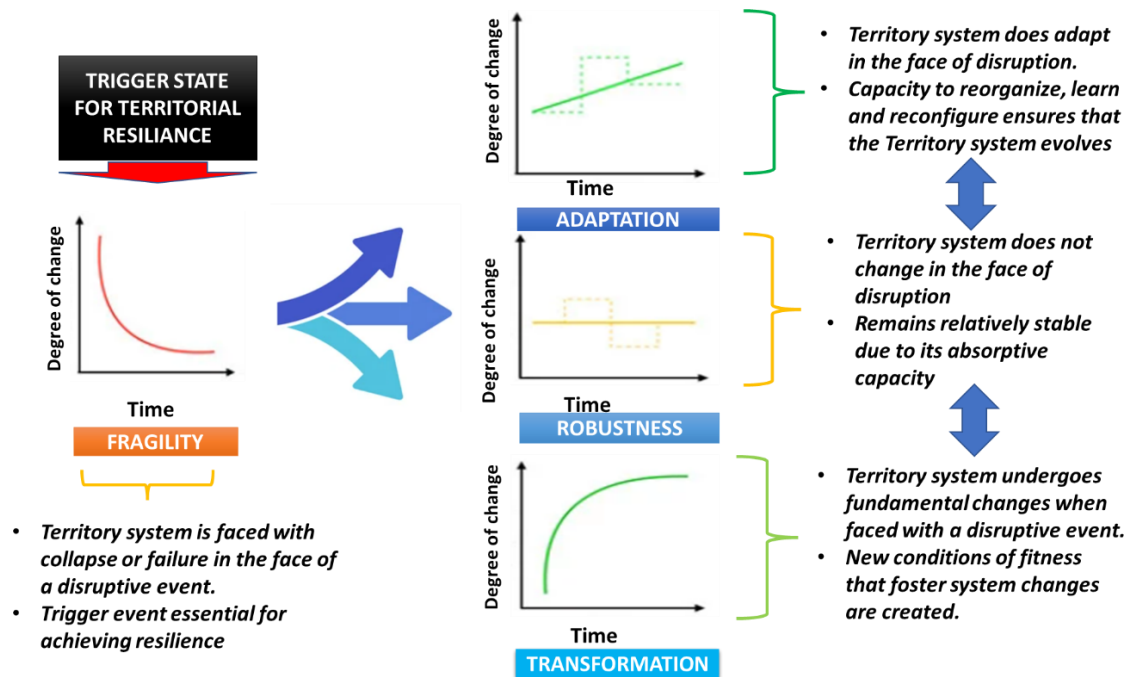


Figure 5.4 Hypothetical typologies of resilience characterising different Territorial systems

Source. Author construct (2023).

Detailed Calculations

Data to calculate resilience capacities has been collected using different measurement instruments at household level and in some instances at village level using perceptions shared by households during PRA studies. Ultimately all data is captured at household level to denote the various resilience capacity contexts that surrounds each household. Since data captured on each resilient capacity relate to different types of measurement scales, it is first numerically converted to standardised z score value. The standardised z score value then allows the initial computation of a resilience score for equally weighted average of the identified resilience capacity variables for each of the three resilience capacities (i.e. Absorptive, Adaptive and Transformative).

The resilience z score values are further standardised by minmax normalization formula similar to that used in resilience index calculations by Jones (2019) and the World Food Program's (WFP's) Climate Resilience Capacity Score (CRCS).

Minmax normalization formula: $X_{\text{normal}} = \frac{(X - \min(X))}{\max(X) - \min(X)}$

This procedure allows us to transform the results into a single index score value that ranges from 0 (not at all resilient) to 1 (fully resilient).

Interpretation of the Resilience Capacity Index score values

The Resilience Capacity Score (RCS) value ranges from 0 (not at all resilient) to 1 (fully resilient). Once the RCS is calculated, we follow a categorisation of such scores given by the World Food Program's Climate Resilience Capacity Score classification scale to divide households occupying different MW territories into terciles (low-medium-high) to show the spatial differences in resilient capacities of such territories. Therefore, if,

- RCS is less than 33 the household is categorised as residing in MW territories with a low RCS,
- RCS greater or equal to 33 and less than 66 the household is categorised as residing in MW territories with a medium RCS and
- RCS is greater or equal to 66 then the household is categorised as residing in MW territories with a high RCS.

The three partial resilience capacity indices were later aggregated using the *entropy method* to generate a Global Resilience Index (GRI) for various MW territories.

Level 3: Segmenting households according to various reliance capacities

Unique territories posing similar resilience capacities were identified and analysed using a combination of the 2-step and K-means clustering algorithms.

5.4.3 Objective 3: To evaluate the nature and strength of MW farm household interactions with the local economy.

In the absence of a clear methodological framework that can be applied at village scale level, this study adopted five main approaches to evaluate the nature and strength of MW farm household interactions with the local economy. These include.

- A 'regional / territorial dynamism in marketing' approach
- A 'resource to other sectors linkage' approach.

- A ‘development as hanging in, stepping up and stepping out’ perspective.
- A ‘MW households as agents of change’ perspective.
- An LED index development approach

5.4.3.1 A regional / territorial dynamism in marketing strategies approach

The study takes its cue from Lobley et al. (2009), whose study on farm household interactions with the local economy in EU rural regions focused exclusively on direct economic transactions. This makes sense as rural household economic transactions involving monetary exchange values (either through expenditures or receipts), have been used extensively in local and regional economic studies as a valuable starting point to understanding how NTFPs and other resources can or have been exploited to achieve positive and sustainable economic growth in the local economy. Markets for commodities are an integral part of the local economy and as such that understanding how LED players interact with which markets becomes very crucial in defining whether that interaction points to local integration or diversification. As guided by discussions in the literature section, it is assumed that the degree of MW farm household interactions with the local economy is higher in MW territories characterised by distant and a spatially concentrated pattern of trade transactions. The thesis sought to test the following two hypotheses.

First hypothesis: *The degree of MW farm household interactions with the local economy is higher in MW territories characterised by distant and a spatially concentrated pattern of trade transactions.*

Second hypothesis: *The degree of MW farm household interactions with the local economy is lower in MW territories characterised by tradetransactions that are much closer to the MW farming household unit and that are more spatially dispersed.*

The two terms ‘distant’ and ‘closer’ are used in this study to denote how far from the MW farming household unit the actual transactions took place. A transaction platform near and around the MW farming household unit (e.g. nearby water-point, roadside) was defined as closer, while those transactions taking place in a formal market such as a rural town or city were defined as distant.

Knowing where MW trade transactions take place is crucial of promoting growth. The concentration of MW trade was hypothesized to vary from one community to the next owing

to several factors such as proximity to major rural markets and prices that traders would receive for the stocks. We expect proximal communities to be characterised by spatial dispersion of MW trade where most households in addition to selling some of their stock in the backyard or near roadside market, also sell in higher order and higher paying markets such as a rural centre markets, town or major city market. In distal communities we expect MW trade to be concentrated near the dwelling unit, where trade is spatially concentrated around the dwelling unit, trading households often sell their stock in what we have referred to as the back yard market and the nearby road-side market (Figure 5.5).

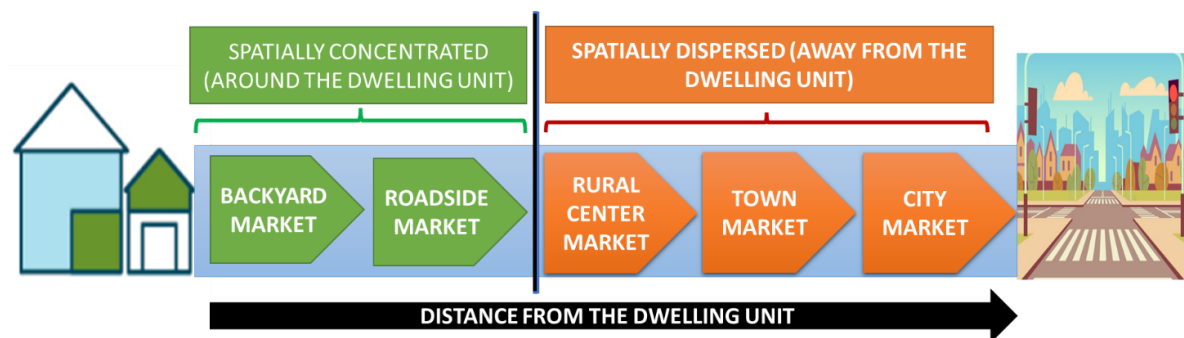


Figure 5.5: Characterizing MW trade as a binary variable – spatially dispersed versus spatially concentrated.

Source. Author construct (2023)

A high concentration of such trading transaction near the dwelling unit is problematic for LED as such markets are often characterised as weak and paying less. Export markets are in LED literature characterised as lucrative as their offer higher income to the traders. It was possible in this analysis to characterise places where MW household sold their stock a binary variable depicting spatially concentrated trade as opposed to spatially dispersed trade (Figure) The marketing behaviours were profiled using the decision tree model.

5.4.3.2 ‘Resource to other sectors’ linkage perspective

The value of MW production and marketing systems to the household and wider local economy is widely acknowledge in literature. There is widespread acknowledgement in MW literature of the positive influence that resource use may have on other sectors of the economy including agriculture (Mpuchane et al., 2000; Kozanayi and Frost, 2002; Stack et al. 2003; Thomas 2013; Kwiri et al., 2014; Sekonya et al., 2020); The health sector (Illgner & Nel, 2000; Mpuchane et al., 2000; Mohapatra et al., 2002), the education sector (Kozanayi and Frost 2002; Stack et al. 2003; Thomas 2013), and the forest sector (Hobane, 1995; Roberts, 1998; FAO 2010), the manufacturing sector, the construction industry and the food industry, among other sectors. It is acknowledged in literature that the production system (i.e., harvesting, processing and

storage) and marketing systems (i.e., transportation, communication and trade) share important links with the household economy and the wider local economy via several development sectors. For example, studies that have observed MW harvesters buying inputs for the harvesting, processing and marketing and use of hired labour and transportation exist (Stack et al., 2003). Other have also witnessed the use of mopane worm income to buy agricultural implements, pay school fees, pay medical expenses, assist other vulnerable households among other use areas also exist (Stack et al., 2003; Gondo et al., 2010;) Understanding such important links and establishing spread and depth of such association is crucial for mapping future LED strategies. An input-output schematic diagram depicting how important the MW business is to other sectors of the household and local economy is presented in Figure 5.6.

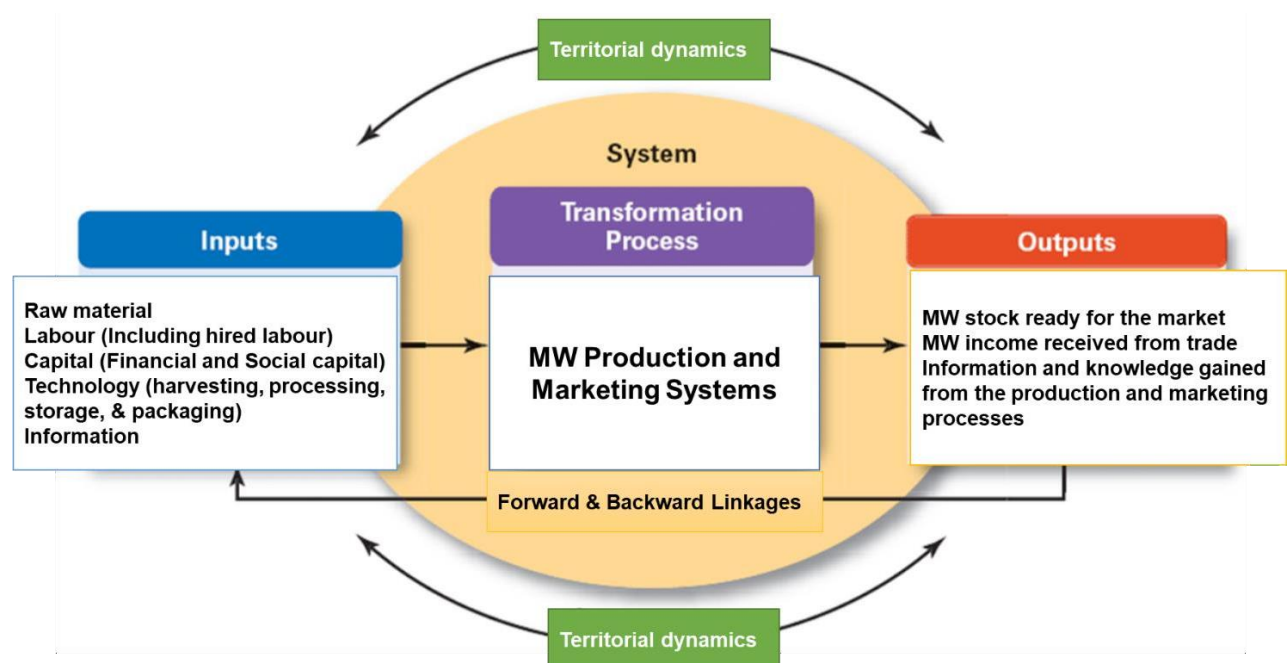


Figure 5.6: Schematic modelling of the MW production and marketing system.

Source, Author construct (2023)

The inputs that are required in the production and marketing processes are obtained from mostly from the manufacturing sector, government support systems, and from social networking. The output that is the final mopane worm stock is traded on the market and the proceeds are used for various purposes. Such purposeful expenditure is important as it becomes and important input into other development sectors of the economy. For example, meeting educational expenses through MW proceeds of learners is an important input variable that can

impact positively the education system of the local economy. Knowledge gained through involvement in the MW production and marketing processes can be an invaluable input into other sectors of development. Extension services rendered by institutions such as the Forest Commission of Zimbabwe will become an invaluable input into maintaining the environmental integrity of the community. The whole production and marketing system is invariably governed by territorial dynamics. We expect variations in terms of where the inputs are obtained, what type of production and marketing processes are adopted, as well the preferred areas of expenditure by the trading household.

Current MW research scholarship is however overly biased to hear say insights into how harvesting communities use proceeds from mopane worm trade and where they obtain various inputs. We currently do not have a study that has attempted to do an in-depth analysis of how such derived income is intricately connected to hypothesized areas of influence. While the direction of influence can almost be inferred from such say studies, it is the spread and depth of association that has been difficult to discern.

Measurement of the spread and depth of sectoral influences

The study used the Pearson's correlation coefficient to estimate the direction and strength of association between MWs income use and selected expenditure items associated with a specific a development sector that we hypothesised to have a connection with the MW income expenditure behaviours of harvesting households. We did not follow mainstream local and regional economic literature to try and discern connections between MW income and each sector. Rather we focused more on plausible connections between MW income and expenditure items within established development sectors to get a sense of what sectors of development may be impacted positively by any future investments into the MW business. Mainstream LED literature maintains that an understanding of the interaction between income and household expenditures is a crucial macro-economic indicator of living standards and well-being (Piekut & Piekut, 2022). Piekut & Piekut (2022) have observed that changes in household spending may act as an important indicator that corresponds to the level of development of the economic system. Taking the cure form other LED studies, we posit in this study that an analysis of differences in household spending of MW income, both in space and time may aid the understanding and establishment of variations in the standards of living of individual communities (Scholliers & Schwarz, 2003; Vojnovic, 2014).

The choice of expenditure items to assess was guided by a critical review of MW literature. Commonly cited expenditure items were therefore identified and stacked according to the sectoral classification system used in Table 3.5.

Table 5.5 MW income-expenditure items and sectoral areas of influence

Applicable sector	Expenditure items (study variable)
Agriculture	Buying livestock
	Buying farming implements
Manufacturing	Buying food stuffs
	Buying, clothes and household assets
Education	Paying school fees
Health	Paying medical bills
Social / Services sector	Funeral expenses
	Contribution to savings clubs
	Helping the needy
Research and development	Investment into other establishments
Manufacturing	
Construction industry	Building new structures
	Housing infrastructure improvements
	Uplift on roofing materials

Source, Author construct (2023)

Profiling of households and MW territories with similar consumption-expenditure structures.

To decipher common patterns and disparities in MW usage patterns, households were grouped according to their expenditure structures using a combination of Hierarchical Cluster Analysis (HCA) and K-means clustering methods. We followed a similar approach by Piekut & Piekut (2022) who applied the hierarchical Ward method and the non-hierarchical k-means method to combine households into group of clusters most similar to each other and, at the same time, most dissimilar from others in terms MW income usage characteristics.

A ‘development as hanging in, stepping up and stepping out’ perspective.

While the ‘resources to other sectors’ perspective provides, a valuable entry point to understanding how MW resource users interact with a multitude of sectors in the local economy and beyond, it does little to help understand the broader LED implications of such interaction on development goals as poverty reduction and a host of what this thesis terms ‘development trajectories’ that may see resource users and resource depended communities transition from a state of poverty to that of prosperity. An ideal approach would require us to adopt what other scholars have referred to as a ‘development as hanging in, stepping up and stepping out approach’ (Dorward et al., 2009).

Understanding of poverty and of ways in which people escape from or fall into poverty is an integral part of any LED policy. The transition by MW resource users and / or MW dependent communities from a state of poverty to an aspired state of wealth and prosperity is not automatic. We posit in this thesis that putting MW dependent communities on such aspiration trajectories is a mammoth task that need to be addressed by developing and nurturing a positive relationship between what is aspired and the new and attractive LED realities to be achieved. Borrowing insights from the agricultural sect, we note that it is imperative that to investigate the relationship between MW producers and other sectors of the rural economy. Such investigations should make use of a schema or theoretical framework that analyses the extent to which livelihood strategies employed by MW producers constitute what is commonly referred to in development circles as hanging in, stepping up and stepping out (Dorward et al., 2009; Pritchard et al., 2017; Masunungure et al., 2018; Gassner et al., 2019).

Adopted methodological (theoretical) framework.

This study builds upon the schema proposed by Dorward and Anderson in 2002. Dorward and Anderson (2002) initially identified four livelihood strategies that normally confront livestock farmers, that can equally be applied to the NTFS. They distinguished four livelihood strategies, including ‘hanging on’, ‘stepping up’ and ‘stepping out’. Figure 5.7 depicts the envisaged relationships between the livelihood strategies and the associated pathways that according to Stack et al. (2003) may eventually see MWs users escaping poverty.

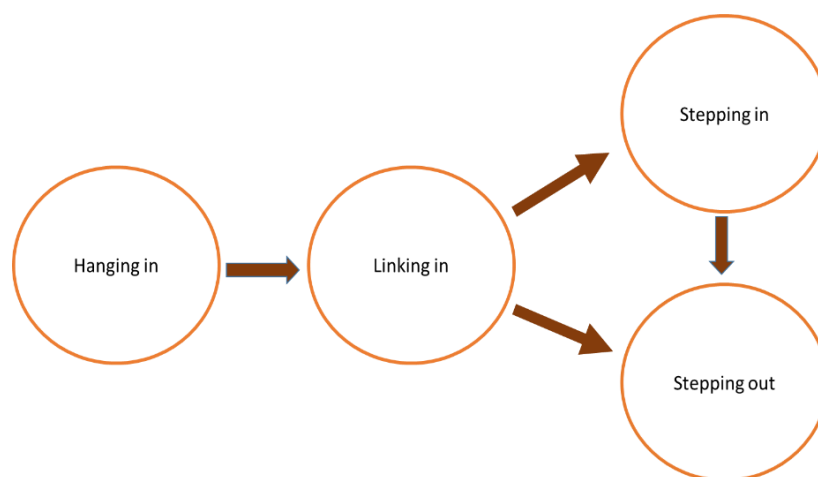


Figure 5.7: Schema depicting livelihood pathways that confront MW users

NB: Initial characterisation inferred from Dorward and Anderson (2002), Stack et al. (2003) and Dorward (2009).

Source: Author's construct (2024)

Assessing LED implications using the proposed schema

The theoretical realm provided by ‘development as hanging in, stepping up and stepping out’ perspective, will be compared with the case study realm that allows us to inspect the extent to which the livelihood strategies adopted by MW users are matching with theory. To do this the study used the qualitative methodology of pattern matching as recommended by Yin (2009). The interpretation of LED implications and associated spatial differences across all villages was aided by the framework proposed in Table 5.6.

Table 5.6: Link between livelihood strategies, MW use and drivers of LED

Livelihood strategy	MW use scenario	LED drivers	LED implications
‘Going backwards’	Non-use of MWs Food insecure households	None	Food insecurity
‘Hanging in’	Subsistence Buffering	None	Livelihood sustenance Development assuming a welfarefunction Food security
‘one-foot sideways’	Buffering MW households who are alsohighly and increasingly activein the nonfarm economy	Income diversification	Livelihood diversification and sustenance Food and Income security
‘Linking in’	Market production/ income for small cash purchases Income to initiate some lower order ‘stepping up’ activities Income to initiate some lowerorder ‘stepping out’ activities accumulation of primarily social capital	-Income -Social capital -Investments in lower order stepping out activities	MW-led -Development takesoff
‘Stepping up’	accumulation of all types of capital assets Complementary production Market production / income	-accumulated capitalassets -accelerated production Income growth	Wealth and / or asset accumulation.
‘Stepping out’	Accumulation of capital assets	-Investments on other sectors of the local economy (education, agriculture, construction etc).	Development and growth

Source: Author’s construct (2024)

Zero/Slow growth

Accelerated growth

As depicted in the table, we posit that MW territories that are significantly dominated by households whose main livelihood strategy is ‘Hanging in’ do not contribute much to LED as the primary motive is sustenance. As argued by Dorwad (2009), this is because households perform this strategy to maintain the status quo. Economic growth may be triggered by MW territories where a significant number of MW dependent households are pursuing either the ‘stepping’ up or ‘stepping out’ livelihood strategies. Conditions amenable for development take-off are characteristic of MW territories that are dominated by households pursuing a ‘linking in’ livelihood strategy.

A ‘MW households as agents of change’ perspective.

Following the cue from agriculture-based LED policies, understanding the interaction between MW use and the local sectors of the economy will require that we place heavy emphasis on MW households as agents of change. This perspective allows us to view MW resource-based communities as development change catalysts that will help transform respective MW territories into situations of economic growth. It is a pro-growth-oriented LED perspective that seeks to create an enabling environment that will see MW territories being dominated by households as development actors that have potential and incentives to effectively invest in increased production and / or value creation. According to this view, increased interaction between resource users and the local economy is registered when the concerned communities are dominated by individuals or groups that have potential and incentives to effectively invest in increased production and or value creation (Gassner et al., 2019).

Based on their experiences on investment outcomes associated with small scale farming operations in Sub-Saharan Africa (SSA), Gassner et al. (2019) reached the conclusion that investment efforts by small holder farmers were meaningless where the sector was dominated by farming household characterised as having limited incentives and resources. In this study, we profiled the concentration of rural households according to their innovation behaviours using the decision tree diagram technique. The assumption was that MW territories where there was a high number of households exhibiting innovation behaviours, development was likely to take place.

An LED index development approach

Most LED studies at national and / regional level employ GDP statistics as an important measure of growth and development. It also follows that if we are to assess the potential contribution of MW utilisation to the village economy, we also need to use some LED measure to express the level of economic prosperity of that village. Once we are able to develop that measure at least at the village level, it becomes plausible that we may check if there is any

difference in movements in *that statistic* between two typologies of villages (i.e. villages where the intensity of exploitation of the MW resource is high versus villages where the intensity of exploitation of the resource is MW resource is low) both over time and in space. Figure 5.8 is a simple proposed graphical expression of how the possible effect of MW utilisation on the local economy may be measured and interpreted.

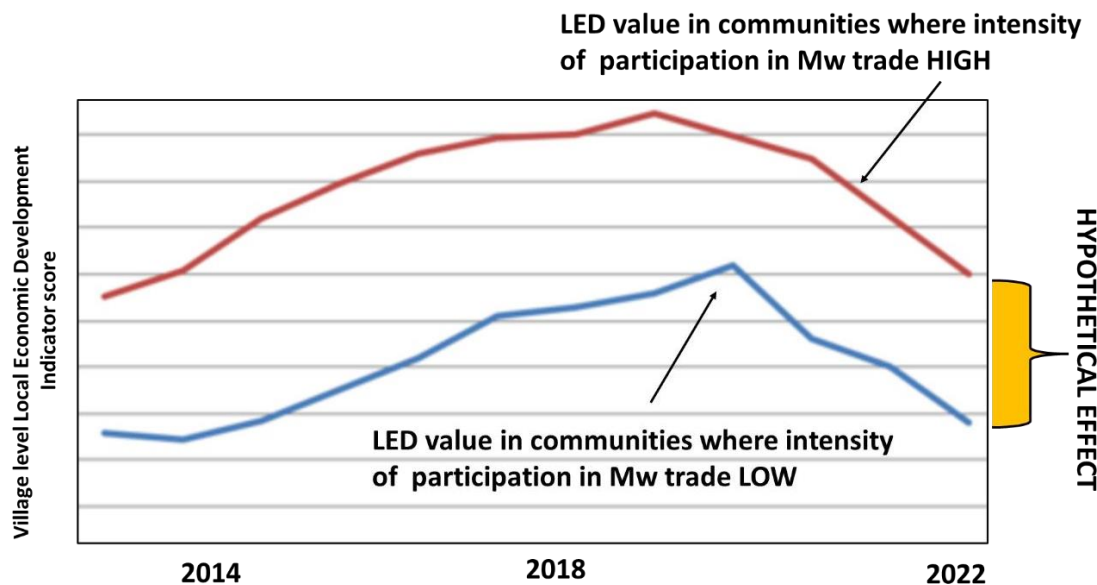


Figure 5.8. A schema to measure the impact of MW harvesting on the local economy.

Because of lack of publicly accessible statistics at that spatial unit of analysis (i.e the village level), it is therefore difficult to generate any meaningful measure of prosperity that may replicate the GDP measure. Many recent studies have however acknowledged the need to use alternative measures of growth to measure growth and development (Wang and Chen 2022). Other studies have taken an extreme stance on GDP by dismissing it as an LED measure overlooks other development progress factors, such as subjective well-being, equity, and environmental sustainability – attributes that may be easily observed and measured at the village level (Bleys, 2011). This thesis also posits that there are a variety of partial LED measures that can be employed to measure development at the local level and whose justification share with many other partial LED indices that have been used in other LED studies. This analysis recommends we use of the following partial LED indices as measures that can measure development and progress at the local level.

- Economic complexity index
- Inequality Index as measured by a localised Gini coefficient.
- Household Infrastructure and Services Index

- Rural access as measured by road pavement distress index.
- Successful Territorial Dynamic Index
- Resilience Capacity Index

This study has adopted a multiple LED indicator system, since using only one measure such as the GDP is considered inappropriate in other literatures as it does not take into consideration the three main dimensions of development that include the economic, social and environmental dimensions (Michalek & Zarnekow, 2011). A series of Partial LED indices were calculated on the basis the above to measures LED. The indices were compared two scenarios

– one where the intensity of involvement in MW trade was high and where such intensity was low as discussed in the above schema. Where data permitted, a comparison of the partial LED indices was made based on nature of involvement in harvesting. Two scenarios of harvesting versus non harvesting were compared. Any positive differences between the partial LED indices were tested for statistical significance using various statistic measures appropriate to the nature of data acquired.

Calculation of Partial LED indices

The calculation of such partial LED such as the Economic Complexity Index (ECI), the Pavement Distress Index (PDI), the Successful Territorial Dynamic Index (STDI) and Resilience Capacity Index (RCI) have already been explained in the previous sections. To calculate partial LED indices based on household data and the PRA study the study employed the commonly used extreme value method as the initial step towards calculating such indices as.

- Household Infrastructure and Services Index (HISI)
- Successful Territorial Dynamics Index (TDI)
- Resilience Capacity Index (RCI)

This is because when constructing an index, it is basic requirement that we homogenize the heterogeneous indicators and standardise the indicators, to solve the problem of the

$$Z_{ij} = (X_{ij} - X_{jmin}) / (X_{jmax} - X_{jmin})$$

homogenization of the values of various heterogeneous indicators (He & Ahmed, 2019, Su et al, 2019). We borrowed insights from a related study by Zhang (2029) and used the extreme value method to standardise the data. The following is the formula that was used,

where i represents the number of households, j represents the number of indicator variables

used, X_{ij} is the original value of the j th indicator of the i th household, X_{jmax} is the maximum value of the j th indicator, X_{jmin} is the minimum value of the j th indicator, and Z_{ij} is the standardised value of the j th indicator of the i th household. The closer the normalized value is to 1, the higher the relative level of the indicator. The aggregation of indicator system variables used different weighting systems depending on the index of interest. For instance, the STDI used the **DEA approach** as an aggregation method that employed weights for each input variable. The RCI employed the **entropy method** to calculate weights on each of the input variables. Further details on the measurement of the HISI and the income inequality index are given below.

Household Infrastructure and Services Index (HISI)

There was a need to develop a much more localised development index that impacts on the daily lives of rural households. While GDP related measures are a fair indication of the level of a region's prosperity, the study argues that development progress at the regional scale may not be the development that households at village level experience. The trickle-down development hypothesis has not worked well for many communities in developing countries mainly due to corruption and institutional bottlenecks that favour certain categories of individuals at the expense of others. Measuring progress towards the achievement of such aggregate top-down indicators of progress may not reflect accurately the contribution of MWs to the local economy.

Measuring the impact of MW income on income inequality

We employ the Gini Coefficient technique to assess changes in income inequality by comparing two scenarios that include WITH MW income and the WITHOUT MW income for all sampled 5 villages. The study chose the Gini coefficient over other measures of inequality as it is commonly applied to studies such as this that seek to compare spatial variations in incomes (Mastronardi & Cavallo, 2023). To account for temporal changes over time we compare the income profiles of households during a common WRS (i.e. one good MW season they remember) and common DRS (one bad MW harvesting season).

The Gini Coefficient and Lorenz curve explained.

In LED studies the Gini coefficient is defined as an objective measure of income inequality. For any income distribution the Gini coefficient will assume a value that ranges between

0 and **1**. The value **0** depicts an income distribution where wealth is most equally distributed (with every individual owning the same sized share). The value **1** on the other hand points to an income distribution where wealth is most unequally distributed (one individual owns everything). We would therefore expect movement in the Gini coefficient if a certain category of income is removed from the analysis. If the removal of MW income from the analysis (i.e. the WITHOUT scenario) results in an increase in the Gini coefficient value, then we can assume that MR resource use has a meaningful contribution to reducing income inequality. The bigger the movement the more significant is its contribution. If alternatively, the Gini coefficient stays the same the resulting interpretation would mean MW income is not making a meaningful difference in reducing income inequalities. This study employed the following formula to calculate the Gini coefficient.

$$G = \frac{n+1}{n} - \frac{2 \sum_{i=1}^n (n+1-i)x_i}{n \sum_{i=1}^n x_i}$$

with X_i are incomes in the data set ordered from smallest to largest.

The Gini coefficient can also be represented graphically by the Lorenz curve (see Figure 5.9). The difference between the line of equality and the Lorenz curve is an indicator of income inequality. This is represented as area A in the graph. The larger the area the more unequal is that income distribution.

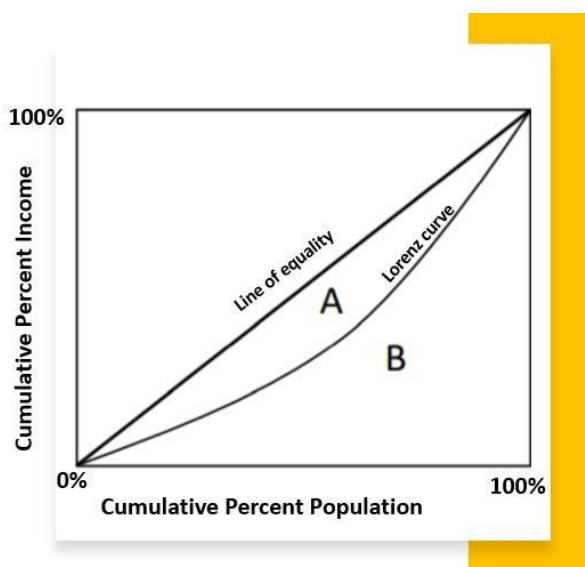


Figure 5.9 Lorenz curve illustration

It is therefore possible to compute two Lorenz curves, one representing an income distribution where MW income is included and the other an income distribution where MW income is

excluded (see Figure 5.10). The gap created because of the Lorenz curve shifting to the left would depict the contribution of MW income to addressing the problem of income inequality.

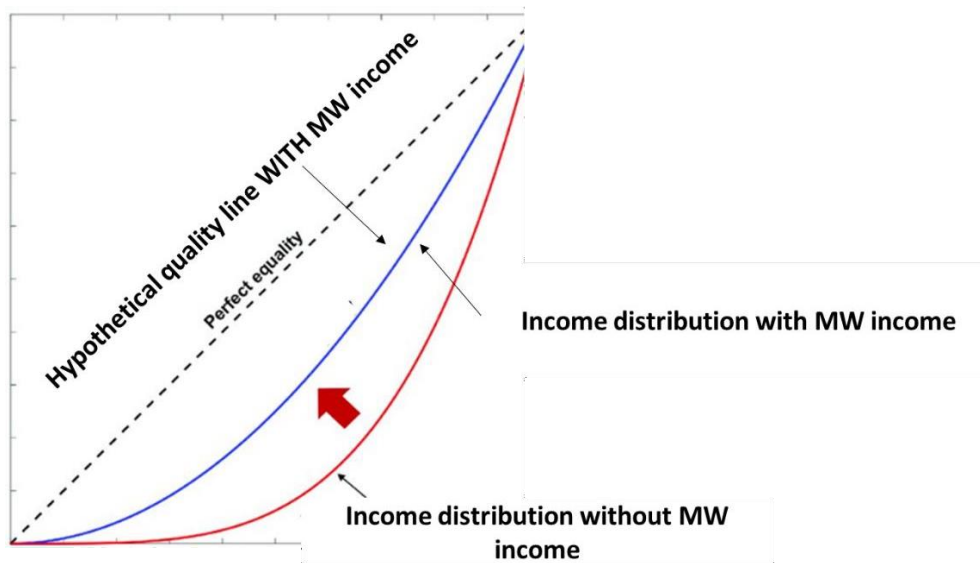


Figure 5.10 With and Without MW income scenario and its effect on equality

5.5 Research Ethics

An ethical clearance certificate was requested from the University of Venda to conduct the present study (see Annexure 3). The following key research ethics were paid attention to.

1. Honesty

- The researcher strived for honesty in all scientific communications. Honesty will be reflected in reporting data, results, methods and procedures, and publication status. No fabrication, falsification, or misrepresentation data will be allowed.

2. Objectivity

- The researcher strived to avoid bias in experimental design, data analysis, data interpretation, peer review, and other aspects of research where objectivity is expected or required.

3. Integrity

- The researcher kept promises and agreements, will act with sincerity and strive for consistency of thought and action.

4. Carefulness

- The researcher strived to avoid careless errors and negligence. Carefulness will also be maintained by keeping good records of research activities, such as data collection, research design, and correspondence with agencies or journals.

5. Openness

- The researcher is open to sharing data, results, ideas, tools, resources. He will also be open to criticism and new ideas.

6. Confidentiality

- The researcher ensured confidentiality of sensitive information that may be supplied by participants.

7. Seeking consent

- Consent was sought before research was conducted.
- Entrance to the communities required seeking permission at the Rural District Council Offices first and informing the Zimbabwe Republic Police about the reasons for carrying out research. Such permission was solicited. A list of Councillors and traditional leaders was generated and used to negotiate access to villages. Permission to enter the villages was then be solicited via the councillors and village chiefs and or headmen on the basis of the names supplied at the Rural District Council offices.

Chapter 6: *Estimating spatial and temporal changes in rural household dependency on the MWs.*

6.0 Introduction

One of the main objectives of this study is to estimate spatial and temporal changes in household dependency on MWs. Understanding resource dependency is seen as crucial in mapping LED interventions. LED interventions are expected to be aligned to the resource dependency needs of harvesting households. To understand such resource dependency the following data is presented in this chapter.

- Spatial and temporal in demographics of harvesting households
- Spatial and temporal variations in the number of households and harvesters involved in harvesting.
- Spatial and temporal changes in the type of harvesters involved in MW harvesting
- Spatial and temporal changes in places where most MWs are harvested from.
- Spatial and temporal changes in quantity of MWs harvested, sold, and bartered
- Spatial and temporal variations in nutritional value derived from consuming MWs
- Type of markets accessed by trading households.
- Statistical estimation of factors that explain household dependency on MW resource.

6.1 Spatial and temporal variation in demographics of harvesting households

6.1.1 Household headship and harvesting behaviours.

Resource dependency is usually expected to vary according to household headship status. Household headship statistics per village are shown in Table 6.1

Table 6.1 Spatial variations in household headship.

Village	Statistic (Count/ % within village)	Household head				Total
		Male headed	Female headed	Female managed	Child headed	
Kapeni	Count	5	56	14	7	82
	%	6.1%	68.3%	17.1%	8.5%	100.0%
Sasane	Count	22	30	8	12	72
	%	30.6%	41.7%	11.1%	16.7%	100.0%
Ndiweni	Count	23	58	6	6	93
	%	24.7%	62.4%	6.5%	6.5%	100.0%
Mangala	Count	23	60	17	1	101

	%	22.8%	59.4%	16.8%	1.0%	100.0%
Mahetshe	Count	10	34	13	7	64
	%	15.6%	53.1%	20.3%	10.9%	100.0%
Total	Count	83	238	58	33	412
	%	20.1%	57.8%	14.1%	8.0%	100.0%

N = 412 households

Data collected revealed that, many sampled households are headed by females (57.8%), followed by male headed households (20.1%), female managed (14.1%) and child headed households (8%) in that order. A similar pattern is reflected when one looks at village statistics. The associated harvesting behaviours of such households is summarised in Table 6.2.

Table 6.2 Spatial variations in household harvesting behaviours

Village	Statistic (Count/ % within village)	Nature of household involvement in MW harvesting					Total
		Non harvesting	We have recently started harvesting and trading only	We have recently started harvesting, consuming, and trading	We have always been harvesting, and trading only	We have always been harvesting, consuming, and trading	
Kapeni	Count	18	8	6	9	41	82
	%	22.0%	9.8%	7.3%	11.0%	50.0%	100.0%
Sasane	Count	15	2	4	9	42	72
	%	20.8%	2.8%	5.6%	12.5%	58.3%	100.0%
Ndiweni	Count	52	1	0	26	14	93
	%	55.9%	1.1%	0.0%	28.0%	15.1%	100.0%
Mangala	Count	36	12	1	31	21	101
	%	35.6%	11.9%	1.0%	30.7%	20.8%	100.0%
Mahetshe	Count	16	4	3	13	28	64
	%	25.0%	6.3%	4.7%	20.3%	43.8%	100.0%
Total	Count	137	27	14	88	146	412
	%	33.3%	6.6%	3.4%	21.4%	35.4%	100.0%

N = 412 households

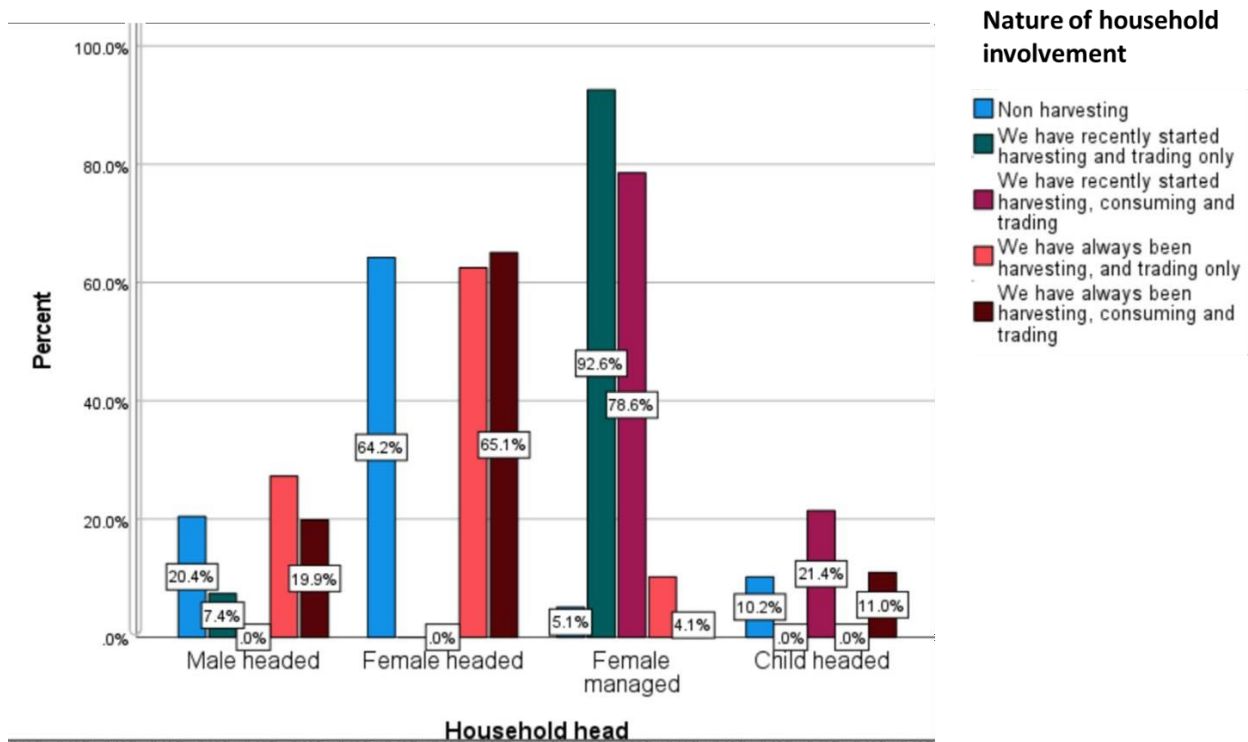


Figure 6.1 Household harvesting behaviours according to headship status.

While traditionally previous studies have often pointed to MW harvesting as activity largely dominated by female headed households and to some extent male headed households, a recent development shown by this study is the emergency of female managed households as another category of households who are increasing entering the harvesting business in recent times (see Figure 6.1). Most of the newcomers into MW harvesting are female managed households, who have in the past relied more on remittances coming from husbands working abroad. Data from participatory group discussions revealed that delayed remittances had seen more and more previously non harvesting households entering into harvesting activities.

6.1.1.1 Household wealth status and harvesting behaviours.

Household wealth status is another important depicter of MW resource dependency commonly cited in literature. Using indicator variables of wealth status (income and asset profiles) developed during focus group discussions, it was possible to distinguish high-income from low-income households Results depicting spatial variations in wealth status are shown in Table 6.3.

Table 6.3 Spatial variation in household wealth status

Village	Statistic (Count/ % within village)	Wealth status based on asset and income profile		Total	Statistical Test Results (Chi-Square and Cramer's V)			
		Low income	High income		Chi-Square Tests:			
Kapeni	Count	46	36	82		Value	df	Asymptotic Sign. (2-sided)
	%	56.1%	43.9%	100.0%	Pearson Chi-Square	10.628 ^a	4	.031
Sasane	Count	54	18	72	Likelihood Ratio	10.746	4	.030
	%	75.0%	25.0%	100.0%	N of Valid Cases	412		
Ndiweni	Count	52	41	93	a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 22.83.			
	%	55.9%	44.1%	100.0%	Symmetric Measures:			
Mangala	Count	67	34	101		Value		Approximate Significance
	%	66.3%	33.7%	100.0%	Nominal by Nominal	Phi Cramer's V	.161 .161	.031 .031
Mahetshe	Count	46	18	64	N of Valid Cases			
	%	71.9%	28.1%	100.0%			412	
Total	Count	265	147	412				
	%	64.3%	35.7%	100.0%				

N= 412 households

In all the five sampled villages, many households (64.3%) were classified as low-income as opposed to a few (35.7%) that were classified as high-income. A similar pattern is also reflected when one looks at the relative proportions of high and low-income households in each village. Highly significant differences were observed in villages such as Mahetshe ($\chi^2 = 12.25$; $df = 63$; $P\text{-value} < 0.05$) and Sasane ($\chi^2 = 18.00$; $df = 71$; $P\text{-value} < 0.05$). Both Chi-Square and Cramers' V results (see Table 4.3) depicted so significant relationship between wealth status and type of village. Space had no effect on the distribution of households according to wealth status. The relative involvement of households by wealth status in MW harvesting is presented in Table 6.4.

Table 6.4 Household involvement in MW harvesting according to wealth status

Wealth Status	Statistic (Count/%within wealth status category)	Nature of household involvement in MW harvesting					Total
		Non harvesting	We have recently started harvesting and trading only	We have recently started harvesting, consuming, and trading	We have always been harvesting, and trading only	We have always been harvesting, consuming and Trading	
Low- income	Count	110	27	14	48	66	265
	%	41.5%	10.2%	5.3%	18.1%	24.9%	100.0%
High-	Count	27	0	0	40	80	147

income	%	18.4%	0.0%	0.0%	27.2%	54.4%	100.0%
Total	Count	137	27	14	88	146	412
	%	33.3%	6.6%	3.4%	21.4%	35.4%	100.0%

N = 412 households.

Results reveal that the many high-income households (54.4%) compared to low-income households (24.9%) have in recent times been involved harvesting, consuming and trading of MWs. A chi-squared test for equality of proportions revealed statistically significant differences between the two proportions ($\chi^2 = 1.3425$; df = 145; P-value < 0.05). These results suggests that contrary to the traditional belief that MW harvesting, consuming, and trading is largely the activity pursued by low-income families, high-income families are increasingly being involved. LED interventions should cater for both, the needs of high-income and low-income households. The high proportion of non-harvesting low-income households (41.5%) is largely a reflection in part of the relative size sampled low-income households and in part a high concentration of the poor who attend the Seventh day Adventist church that restricts harvesting, consuming or trading the MW. Despite interesting intra differences, overall village statistics revealed no significant association between household wealth status and the nature of involvement in harvesting ($\chi^2 = 64.880$; df = 4; P-value < 0.001).

6.2 Spatial and temporal variations in the number of households and harvesters involved in harvesting.

6.2.1 Spatial and temporal variations in household size per village

Spatial and temporal variations in household size are shown in Table 6.5

Table 6.5 Spatial and temporal variations in household size

Village	Sample size	Statistic	Household size*			
			1996-2000	2000-2014	2014-2018	2018-2022
Kapeni	82	Mean	8.01	6.11	4.79	4.29
		Std. Dev.	2.028	1.556	1.152	1.105
		Skewness	.976	-.147	1.114	.797
Sasane	72	Mean	8.38	6.47	5.19	4.68
		Std. Dev.	1.740	1.384	1.285	1.276
		Skewness	-.040	.108	1.058	.378
Ndiweni	93	Mean	6.46	5.68	4.82	3.99
		N	93	93	93	93

		Std. Dev.	2.165	2.856	2.202	1.632
		Skewness	.788	1.146	1.705	1.828
Mangala	101	Mean	6.00	4.28	3.58	3.26
		Std. Dev.	2.970	1.632	1.125	1.074
		Skewness	1.421	.626	.194	.603
Mahetshe	64	Mean	7.95	5.84	4.83	4.47
		Std. Dev.	1.872	1.504	1.363	1.195
		Skewness	-.364	-.101	-.532	-.298
Total	412	Mean	7.22	5.58	4.58	4.07
		Std. Dev.	2.450	2.062	1.602	1.372
		Skewness	.431	.671	1.256	.871

* Average household size statistics refer to the period ending 2000, 2014, 2018 and 2022. The period ending 2000 statistics are based on household recall, while the rest are based on actual information obtained from the households via a series of household surveys.
N = 412 households.

Combined statistics reveal that the average family size in all 5 villages is 7 for the period ending 2000, 6 for the period ending 2014, 5 for the period ending 2018, and 4 for the period ending 2022. This general decline in household size is presented graphically in Figure 6.2.

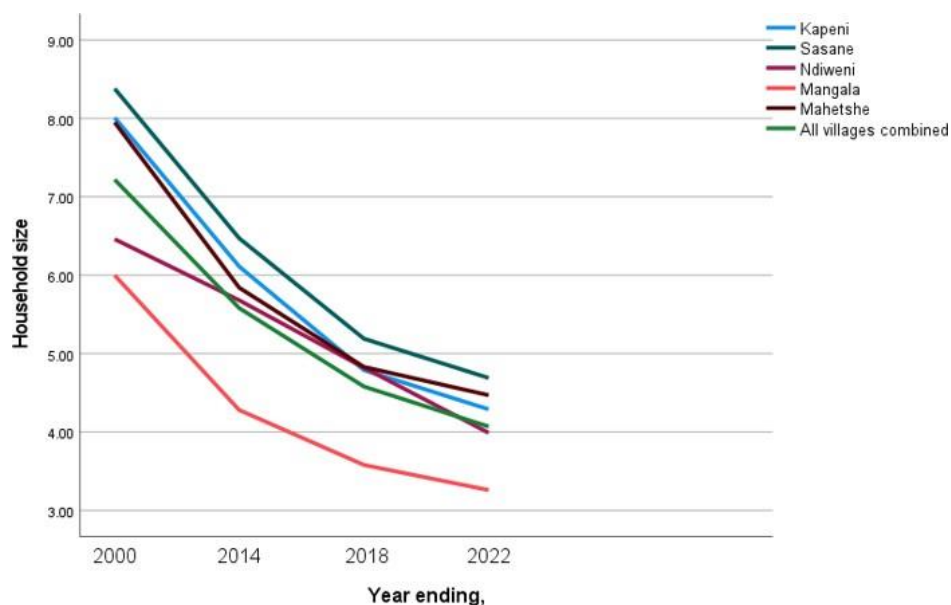


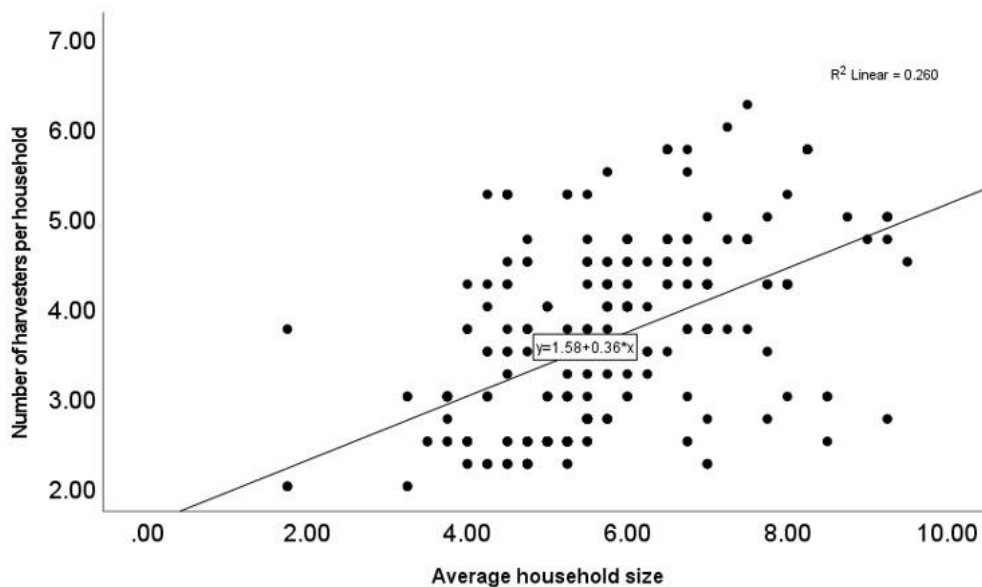
Figure 6.2 Spatial and temporal trends in household size.

N= 412 households

Household size is an important variable that defines labour input in MW harvesting, processing, and trading. We expect harvesting households with larger families to invest more labour into harvesting, processing, and the trading of the worm. In the Wet Resource State (WRS) that defines a good MW harvest, results indicate a positive correlation between Household size and

the number of family members involved in harvesting (figure 6.3). Although the association is relatively weak because of a large proportion of children and the elderly, such a positive correlation is further weakened during the Dry Resource State (DRS) that defines a poor harvesting season with less incentives for involvement.

(a) The Wet Resource State (WRS)



(b) The Dry Resource State (DRS)

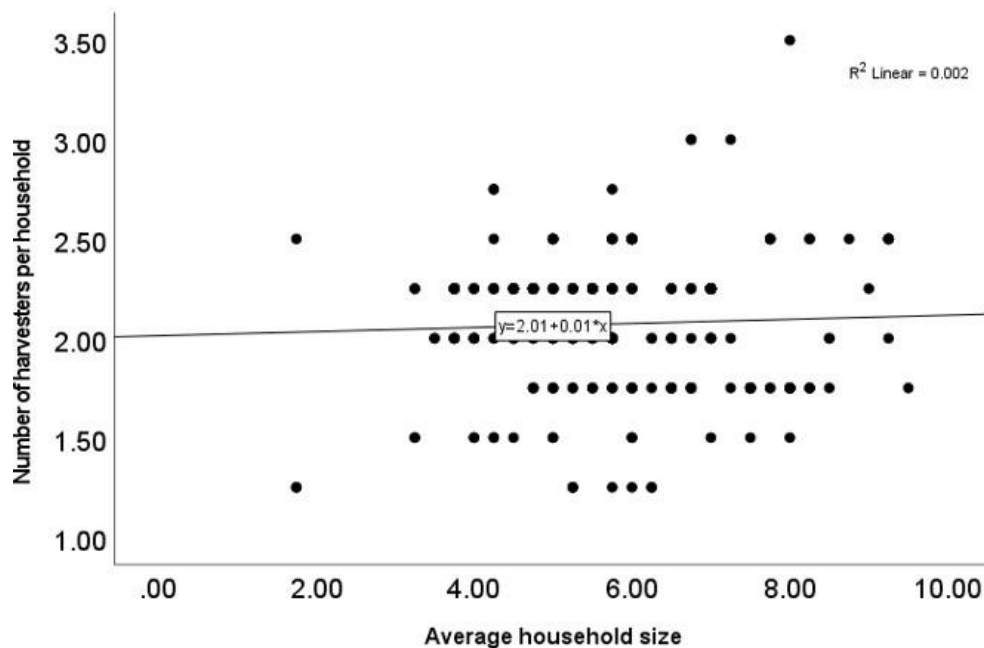


Figure 6.3. A temporal perspective on the relationship between household size and number of harvesters per family during (a) the WRS and (b) the DRS.

6.3 Spatial and temporal changes in quantity of MWs harvested and sold.

Understanding the dynamics of household involvement in the harvesting, trade and intensity of involvement in the output markets for MWs was seen as crucial in understanding resource dependency. This section presents descriptive statistics relating to the following.

- 6.3.1 Spatial and temporal changes in quantity of MW harvested.
- 6.3.2 Spatial and temporal changes in quantity of MW sold and bartered.
- 6.3.3 Measuring spatial and temporal changes in intensity of MW resource commercialisation

6.3.1 Spatial and temporal changes in quantity of MW harvested.

Data on quantities of MWs harvested by households in all 5 villages in both the Wet Resource State (WRS) and the Dry Resource State (DRS) is shown in Table 6.6.

Table 6.6. Temporal changes in quantity of MW harvested*

Period	Resource State	Range	Mean Quantity harvested	Std. Dev.	Skewness	
					Statistic	Std. Error
2000-2014	WRS	142.00	21.0995	26.42636	2.534	.120
	DRS	71.00	9.0097	13.30770	3.066	.120
2014-2018	WRS	92.00	16.7864	18.95822	1.881	.120
	DRS	55.00	6.8641	8.88099	2.767	.120
2018-2022	WRS	164.00	20.0437	26.85018	3.369	.120
	DRS	94.00	8.1942	15.92657	4.201	.120

* Refers to number of 20 litre containers of MWs harvested by each household. N = 412 households

As expected, the average quantity harvested per household in each period is consistently higher for the WRS as compared to the DRS. During the period 2000 to 2014, households on average harvested 21, 20 litre buckets of MWs in the WRS compared to 9, 20 litre buckets during the DRS. An almost similar pattern is reflected in the 2018 – 2022 statistics where households

average harvested 20, 20 litre buckets of MWs in the WRS compared to 8, 20 litre buckets during the DRS. A deep in quantities harvested was however experienced during the 2014 – 2018 period. During this period households on average harvested 17, 20 litre buckets of MWs in the WRS compared to 7, 20 litre buckets during the DRS. This similar harvesting pattern is reflected when one looks at village level statistics (Table 6.7).

Table 6.7 Spatial and temporal changes in quantity of MW harvested*

Village	Statistic	2000-2014		2014-2018		2018-2022	
		WRS	DRS	WRS	DRS	WRS	DRS
Kapeni	Mean	21.8675	8.8675	18.1084	7.0964	20.3614	7.6386
	Std. Dev	19.39120	7.97063	13.98083	5.61925	19.22307	10.62507
	Range	142.00	54.00	92.00	39.00	164.00	94.00
	Kurtosis	18.427	14.706	10.324	11.540	38.105	54.272
Sasane	Mean	20.7917	7.7778	17.6806	6.8889	20.0139	7.1944
	Std. Dev	12.68684	5.03291	10.83009	4.21451	11.49096	5.47115
	Range	48.00	18.00	35.00	14.00	43.00	22.00
	Kurtosis	-.646	-.920	-.994	-.822	-.553	.306
Ndiweni	Mean	8.2717	2.6630	7.4891	2.6087	9.1739	2.6087
	Std. Dev	12.27174	3.62918	11.85303	3.85722	14.79502	3.32806
	Range	54.00	12.00	48.00	15.00	64.00	10.00
	Kurtosis	3.640	.325	5.101	3.417	6.054	-.760
Mangala	Mean	25.5644	12.5842	18.7723	8.2475	23.1386	11.3663
	Std. Dev	37.9232	19.9726	26.5081	13.0869	38.3359	24.4322
	Range	138.00	68.00	87.00	55.00	164.00	94.00
	Kurtosis	2.576	2.547	1.694	4.273	7.113	6.230
Mahetshe	Mean	31.8438	14.0625	24.2969	10.4687	30.4063	13.0625
	Std. Dev	31.5334	16.8785	21.1373	10.8305	33.5766	20.5742
	Range	132.00	71.00	85.00	49.00	155.00	89.00
	Kurtosis	3.267	4.503	.982	3.438	6.265	7.529
Total	Mean	21.0995	9.0097	16.7864	6.8641	20.0437	8.1942
	Std. Dev	26.42636	13.30770	18.95822	8.88099	26.85018	15.92657
	Range	142.00	71.00	92.00	55.00	164.00	94.00
	Kurtosis	7.657	10.107	4.173	9.791	14.463	18.580

* Refers to number of 20 litre containers of MWs harvested by each household. N = 412 households
Quantities harvested are systematically lower in the DRS when compared to the WRS in all villages. In addition, it can be clearly seen that the average number of 20 litre buckets harvested per household is systematically higher for proximal communities of Mahetshe and Mangala than the distal communities of Kapeni and Ndiweni villages. The only exception is Ndiweni

village where previous analysis has shown that less households are involved in MW harvesting because of religion. Number of harvesters per family involved in harvesting also shows a similar pattern of variation between the WRS and the DRS (Table 6.8).

Table 6.8 Temporal changes in amount of MW harvested per harvester.

Period	Resource State	Average Quantity harvested	Number of harvesters	Average quantity harvested per harvester
2000-2014	WRS	21.0995	2.67	7.9024
	DRS	9.0097	1.35	6.6739
2014-2018	WRS	16.7864	2.17	7.7357
	DRS	6.8641	1.41	4.8682
2018-2022	WRS	20.0437	1.93	10.3853
	DRS	8.1942	1.19	6.8859

N = 412 households

Involvement statistics are consistently lower for the DRS owing to poor harvests that disincentivises harvester to participate in the collection of the worm. Those who participate often travel longer distances to fetch the stock as it is normally not readily available around their homesteads. The average number of 20 litre buckets of MWs harvested during the WRS per family member ranges from 7.74 to 10.39 for the period 2014 to 2018 to the period of 2018 to 2022 respectively. Lower harvesting statistics for the period 2014 to 2018 are systematically lower due to number of family members in the active age group who left the household in search of employment elsewhere.

Table 6.9 Spatial and temporal changes in amount of MWs harvested per harvester*

Village	Statistic	2000-2014		2014-2018		2018-2022	
		WRS	DRS	WRS	DRS	WRS	DRS
Kapeni	Mean	21.8675	8.8675	18.1084	7.0964	20.3614	7.6386
	# Of Harv	3.42	1.49	2.84	1.52	2.59	1.31
	Aver/Harv	6.39	5.96	6.38	4.67	7.86	5.83
Sasane	Mean	20.7917	7.7778	17.6806	6.8889	20.0139	7.1944
	# Of Harv	3.51	1.61	2.79	1.79	2.46	1.26
	Aver/Harv	5.92	4.83	6.34	3.85	8.14	5.71
Manga Ndiweni	Mean	8.2717	2.6630	7.4891	2.6087	9.1739	2.6087
	# Of Harv	1.58	.98	1.32	.91	1.15	1.01
	Aver/Harv	5.24	2.72	5.67	2.87	7.98	2.58
Manga Ndiweni	Mean	25.5644	12.5842	18.7723	8.2475	23.1386	11.3663
	# Of Harv	2.04	1.26	1.50	1.35	1.39	1.22

	Aver/Harv	12,53	9.99	12,51	6,11	16.65	9.32	
Mahetshe	Mean	31.8438	14.0625	24.2969	10.4687	30.4063	13.0625	
	# Of Harv	3.34	1.58	2.84	1.62	2.47	1.17	
	Aver/Harv	9.53	8.90	8.56	6.46	12,31	11,16	
Total	Mean	21.0995	9.0097	16.7864	6.8641	20.0437	8.1942	
	# Of Harv	2.67	1.35	2.17	1.41	1.93	1.19	
	Aver/Harv	7,90	6.67	7.74	4.87	10,39	6.89	

* Refers to number of 20 litre containers of MWs harvested by each harvester. N = 412 households

Temporal changes in the quantity of MWs harvested by wealth status.

It has been argued in the literature section that resource dependency often varies according to wealth status. It was possible to gather such statistics. Table 6.10 show temporal variation in the amount of 20 litre container bucket of MWs harvested by both low-income and high-income households.

Table 6.10 Temporal variation in the amount MWs harvested by both low-income and high-income households.

Wealth status based on income and asset profile		2000-2014		2014-2018		2018-2022	
		WRS	DRS	WRS	DRS	WRS	DRS
Low-income	Mean	15.3623	6.2792	12.3245	4.9811	13.9925	4.9208
	Std. Dev	18.63091	8.98512	14.10943	5.97942	16.28859	7.90170
	Range	129.00	67.00	79.00	49.00	155.00	88.00
	Kurtosis	8.356	18.029	4.233	11.054	20.956	48.824
High-income	Mean	31.4422	13.9320	24.8299	10.2585	30.9524	14.0952
	Std. Dev	34.21710	17.73769	23.46328	11.80439	36.92483	23.38051
	Range	142.00	71.00	92.00	55.00	164.00	94.00
	Kurtosis	3.378	3.846	1.579	4.310	6.078	6.129
Total	Mean	21.0995	9.0097	16.7864	6.8641	20.0437	8.1942
	Std. Dev	26.42636	13.30770	18.95822	8.88099	26.85018	15.92657
	Range	142.00	71.00	92.00	55.00	164.00	94.00
	Kurtosis	7.657	10.107	4.173	9.791	14.463	18.580

N = 412 households

Temporal changes in the quantity of MW harvested by headship status.

Resource dependency has also been hypothesized in literature to vary according to wealth status. It was possible to gather such statistics. Table 6.11 show temporal variation in the amount of 20 litre container bucket of MWs harvested by male headed, female headed, female managed, and child headed families.

Table 6.11 Temporal variation in the amount MWs harvested according to headship status.

Headshipstatus		2000-2014		2014-2018		2018-2022	
		WRS	DRS	WRS	DRS	WRS	DRS
Male headed	Mean	23.5301	9.6145	18.2169	6.6747	19.8675	7.6265
	Std. Dev.	27.60936	11.96930	20.24186	7.23829	21.87591	11.69815
	Range	122.00	53.00	78.00	35.00	143.00	76.00
	Kurtosis	3.474	3.312	1.762	4.402	11.423	16.490
Female	Mean	20.1513	9.0042	15.9496	6.3655	20.4958	8.8908
	Std. Dev.	28.64246	14.50811	19.95368	9.07568	31.39832	19.12662
	Range	142.00	71.00	92.00	55.00	164.00	94.00
	Kurtosis	8.394	9.829	5.132	9.930	11.854	13.571
Female	Mean	23.6207	10.1897	18.8103	9.1207	21.5862	7.3621
	Std. Dev.	18.80353	13.01343	14.73087	10.86775	16.93438	8.99064
	Range	98.00	67.00	72.00	55.00	86.00	48.00
	Kurtosis	5.047	11.975	3.891	9.581	5.097	11.957
Child headed	Mean	17.3939	5.4545	15.6667	6.9697	14.5152	6.0606
	Std. Dev.	16.20559	5.51187	14.55092	6.86697	13.54419	6.59043
	Range	50.00	23.00	45.00	26.00	46.00	28.00
	Kurtosis	-1.254	1.398	-1.472	-.013	-1.037	1.981
Total	Mean	21.0995	9.0097	16.7864	6.8641	20.0437	8.1942
	Std. Dev.	26.42636	13.30770	18.95822	8.88099	26.85018	15.92657
	Range	142.00	71.00	92.00	55.00	164.00	94.00
	Kurtosis	7.657	10.107	4.173	9.791	14.463	18.580

5.3.1 Spatial and temporal changes in quantity of MW consumed.

MW consumption statistics are important to understand as they have a direct impact on food security. They may go a long way in distinguishing between food secure and food insecure communities. Knowing how much quantities of MWs are retained for household consumption is important, as it brings us a step closer to knowing the amount of nutrition that households are getting from eating MWs. Results are shown in Table 6.12.

Table 6.12 Temporal changes in MWs consumed.

Period	Resource State	Range	Quantity arvested (Mean)	Std. Dev.	Skewness	
					Statistic	Std. Error
2000-2014	WRS	21	4.00	5.437	1.106	.120
	DRS	12	1.39	1.916	1.778	.120
2014-2018	WRS	15	3.70	4.446	.869	.120

2018-2022	DRS	8	1.09	1.461	1.602	.120
	WRS	16	3.25	4.034	1.213	.120
	DRS	8	1.09	1.532	1.920	.120

During the period 2000-2014, sampled households on overage consumed 4 buckets (20 Litre) of MWs and 1.39 buckets for the WRS and DRS respectively. These quantities declined gradually over the years. The decrease in the amount of MWs retained for consumption can largely be explained by the pressure to trade and get cash. Economic hardships have forced most households with limited cash options to rely more of cash proceeds from the sale of the worm. Combined Spatial and Temporal variations in the amount of MW stock retained for household consumption are presented in Table 6.13.

Table 6.13 Spatial and temporal variations in the amount of MWs consumed by households.

Village	Statistic	2000-2014		2014-2018		2018-2022	
		WRS	DRS	WRS	DRS	WRS	DRS
Kapeni	Mean	6.17	1.83	5.57	1.48	4.69	1.55
	Std. Dev	5.757	1.710	4.562	1.517	4.403	1.677
	Range	16	6	14	6	13	6
	Kurtosis	-1.278	-.761	-1.490	.069	-.890	.507
Sasane	Mean	8.10	2.22	7.08	1.71	6.01	1.99
	Std. Dev	6.219	2.071	5.153	1.477	4.886	2.010
	Range	18	8	15	6	15	8
	Kurtosis	-1.623	-.478	-1.458	-.177	-1.496	.299
Ndiweni	Mean	.51	.36	.96	.36	1.12	.30
	Std. Dev	1.153	.750	1.766	.750	1.809	.569
	Range	4	3	6	3	6	2
	Kurtosis	3.259	6.091	1.239	6.091	.424	2.060
Mangala	Mean	1.45	.95	1.66	.77	1.82	.59
	Std. Dev	3.517	2.027	2.547	1.378	2.948	.874
	Range	21	12	13	6	16	3
	Kurtosis	18.146	16.541	5.998	5.868	9.598	.894
Mahetshe	Mean	5.59	2.06	4.61	1.44	3.61	1.38
	Std. Dev	5.327	2.145	4.580	1.717	3.749	1.686
	Range	16	8	14	8	16	8
	Kurtosis	-1.299	-.575	-1.038	3.510	.694	4.399
Total	Mean	4.00	1.39	3.70	1.09	3.25	1.09
	Std. Dev	5.437	1.916	4.446	1.461	4.034	1.532
	Range	21	12	15	8	16	8
	Kurtosis	-.154	4.281	-.618	2.518	.523	3.750

In distal communities of Kapeni and Sasane villages, we see a similar pattern of decline in the amount of MWs retained for household consumption. Such a pattern is also reflected in one proximal community of Mahetshe. An irregular consumption pattern is reflected for proximal

communities of Ndiweni and Mangala (see Figure 6.4) is largely a function of the high number of households whose religious inclination does not allow households to eat the worm.

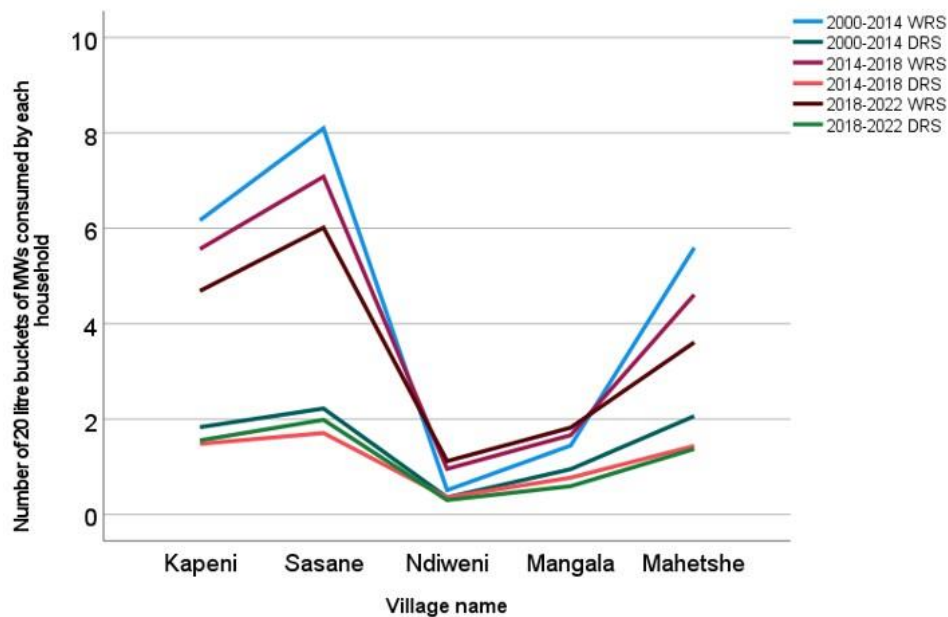


Figure 6.4 Spatial and temporal changes in amount of MWs consumed by households.

We also see high consumption statistics for Distal communities as opposed to proximal communities in both the WRS and the DRS. For instance, households in Kapeni and Sasane retained high quantities of MWs (6.17 and 8.10 buckets) for consumption in the WRS in the period 2000 to 2014 when compared to a similar group in the distal communities of Ndiweni and Mangala, who retained 0.51 and 1.45 buckets respectively.

Temporal changes in the quantity of MWs consumed by wealth status.

Data on temporal changes in the amount of MWs consumed by high-income and low-income households was gathered, and results are summarised in Table 6.14.

Table 6.14 Temporal variation in the amount MWs consumed by low-income and high-income households.

Wealth status based on income and asset profile		2000-2014		2014-2018		2018-2022	
		WRS	DRS	WRS	DRS	WRS	DRS
Low-income	Mean	3.40	1.30	3.14	.95	2.80	.94
	Std. Dev	5.291	1.916	4.432	1.479	3.960	1.493
	Range	18	8	15	7	14	6
	Kurtosis	.209	.189	-.338	2.798	.145	3.408

High-income	Mean	5.07	1.56	4.70	1.33	4.07	1.35
	Std. Dev	5.548	1.909	4.306	1.401	4.051	1.573
	Range	21	12	14	8	16	8
	Kurtosis	-.488	11.657	-.739	2.702	1.120	4.438
Total	Mean	4.00	1.39	3.70	1.09	3.25	1.09
	Std. Dev	5.437	1.916	4.446	1.461	4.034	1.532
	Range	21	12	15	8	16	8
	Kurtosis	-.154	4.281	-.618	2.518	.523	3.750

N = 412 households

Results indicate that high-income households have retained large quantities of MWs worms for consumption when compared to low-income households in both the WRS and the DRS.

Temporal changes in the quantity of MWs consumed by headship status.

The temporal variations in consumption pattern associated with different households stacked according to headship status is shown in Figure 6.5.

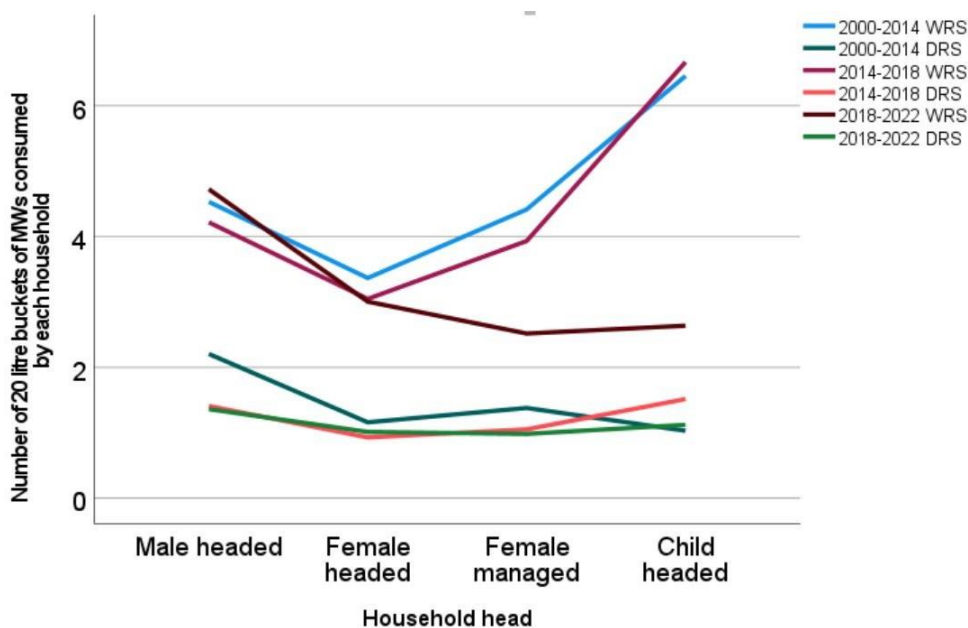


Figure 6.5 Temporal changes in the quantity of MWs consumed by household headship status

Results reveal that for the period 2000 to 2014, both male-headed, and child headed households consumed retained more MW for consumption compared to the other type of households. In all time periods, male headed households tend to retain more stock for consumption than other households. No significant differences were discerned in the consumption patterns of female headed and female managed except for the 2018-2022 WRS that saw more female headed

households consuming more. The amount consumed by all categories has been declining since the 2000 – 2014 season except for child headed families that consumed relatively more MW than other categories in the 2000-2014 period. In all cases consumption statistics are subdued for the DRS where harvests are reported to be poor.

6.3.2 Spatial and temporal changes in quantity of MW sold.

The amount of mopane worms traded on the local and external markets is an important dependent variable that can measure resource dependency. It is expected that that high intensity of participation in the output markets by household can be used as a proxy measure of high dependency on the resource. This section presents findings in relation to the following.

6.3.2.1 Temporal changes in MWs traded by households.

6.3.2.2 Temporary variations in quantity of MWs sold per trader.

6.3.2.1 Temporal changes in MWs traded by households.

It was possible to get a sense of how MW trade has evolved over time since the base year period of 2000 to 2014. Results are given in Table 6.15.

Table 6.15 Temporal changes in MWs traded by households.

Period	Resource State	Range	Quantity harvested Mean	Std. Dev.	Skewness	
					Statistic	Std. Error
2000-2014	WRS	138	15.75	24.118	3.262	.120
	DRS	67	6.70	12.246	3.611	.120
2014-2018	WRS	87	12.48	17.054	2.680	.120
	DRS	55	5.14	8.169	3.627	.120
2018-2022	WRS	160	15.86	25.466	3.955	.120
	DRS	90	6.18	15.225	4.645	.120

N = 412 households

In the period 2000-2014, households traded an average of 15.75 and 6.7 buckets of MWs (20 litre) during the WRS and the DRS respectively. This pattern of high trade and low traded in WRS and DRS is consistently reflected during the 2014 to 2018 and the 2018 to 2022 periods. The dip in the number of households trading MWs on the market during the 2014 to 2018 period is associated large with a similar dip in the quantity of MWs harvested. The study revealed a strong positive correlation between quantities harvested and quantities traded on the market during the WRS and the DRS (Figure 6.6).

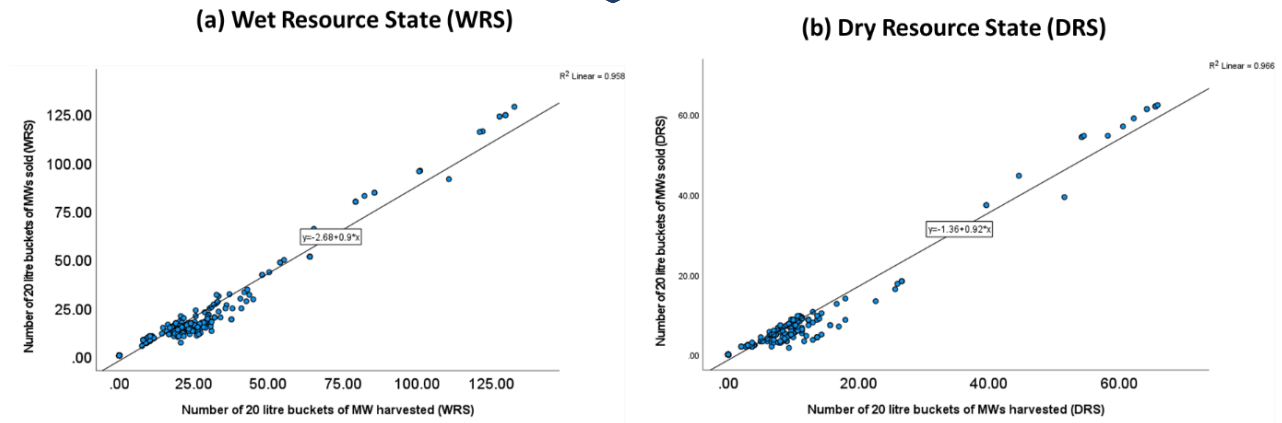


Figure 6.6 Correlation between quantity of mopane worms harvested and traded during (a) the WRS and (b) DRS

Such a strong positive correlation is also discernible when one considers variations by village and wealth status (figure 6.7)).

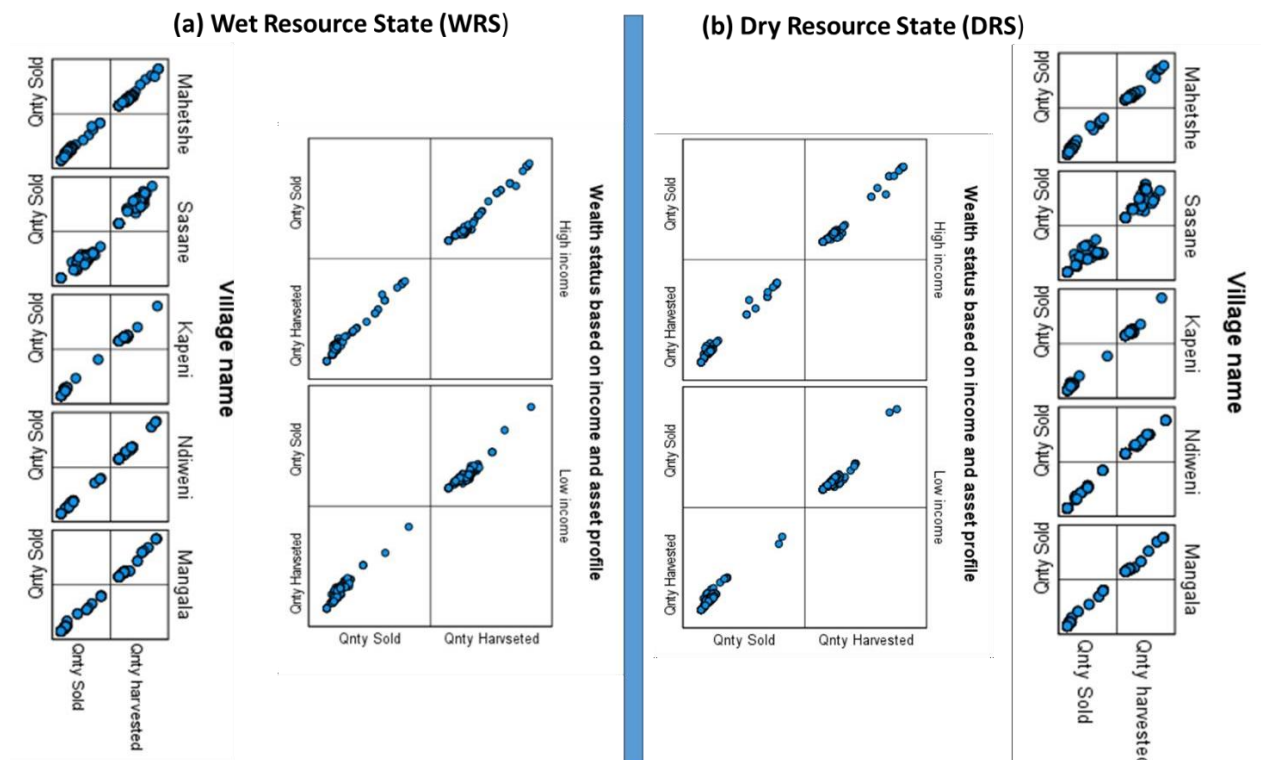


Figure 6.7 Correlation between quantity of mopane worms harvested and sold by location and wealth status during (a) the WRS and (b) DRS

has huge implications for the advancement of technical and social innovations that seek to boost MW supplies. Innovations such as MW farming will certainly boost quantities harvested and eventually sold to the market.

6.3.2.1 Temporary variations in quantity of MWs sold per trader.

Data on quantity of MWs sold to the market and the number of traders involved in the selling process permitted the calculation of quantities sold by each trader at different time intervals. Results are shown in Table 6.15

Table 6.15. Temporal changes in MWs sold per trader.

Period	Resource State	Range	Quantity harvested (Mean)	Number of traders	Average quantity sold per trader
2000-2014	WRS	138	15.75	1.67	9.43
	DRS	67	6.70	1.59	4.21
2014-2018	WRS	87	12.48	1.57	7.95
	DRS	55	5.14	1.47	3.50
2018-2022	WRS	160	15.86	1.58	10.04
	DRS	90	6.18	1.06	5.83

N = 412 households

6.4 Spatial and temporal changes in the intensity of MW resource commercialisation

Knowing how many traders or trading households are involved in trade and how much is being traded is a step closer to understanding the intensity of participation in the market by traders and / or households. If we are to understand resource dependency, it is important that we get a sense of the level of commercialisation of the MW. Commonly used approaches include the calculation of the proportion of stock harvested and sold to the market.

4.4.1 Temporal variations in the HCI

The study calculated the Household Commercialisation Index (HCI) to measure the intensity of commercialisation both in space and in time. Temporal variations in the HCI for both the WRS and the DRS of the three periods under analysis is shown in Table 6.16.

Table 6.16 Temporal variations in the HCI

Period	Resource State	HCI	Std. Dev.	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
2000-2014	WRS	.7214	.20523	-.211	.146	-1.164	.292
	DRS	.6959	.23147	-.553	.146	-.296	.292

2014-2018	WRS	.7193	.17329	-.474	.146	-.687	.292
	DRS	.6847	.20397	-.500	.146	-.977	.292
2018-2022	WRS	.7552	.18126	-.611	.146	-.300	.292
	DRS	.6722	.24324	-.706	.146	.309	.292
TOTAL*	WRS	.7320	.15914	-.118	.146	-.901	.292
TOTAL*	DRS	.6843	.16824	-.474	.146	-.220	.292

*Refers to the combined average HCI indices during the WRS and the DRS. N = 277 harvesting and selling households.

Study findings revealed that the intensity of involvement in MW trade is consistently higher for the WRS in all time scales under analysis. The low HCI statistics for the DRS are largely because of reduced supplies of MWs leading to low harvest.

6.4.2 Spatial and temporal changes in HCI

Data on spatial and temporal changes in HCI was compiled and summarised in Table 6.17

Table 6.17 Spatial and temporal changes in HCI

Village name	Statistic	2000-2014		2014-2018		2018-2022	
		WRS	DRS	WRS	DRS	WRS	DRS
Kapeni	HCI	.6362	.6316	.6514	.6942	.7009	.6426
	N	65	65	65	65	65	65
	Std. Dev.	.19145	.22869	.14231	.18185	.18647	.19724
Sasane	HCI	.5457	.5740	.5614	.6298	.6483	.6014
	N	57	57	57	57	57	57
	Std. Dev.	.17249	.26255	.17134	.18011	.18826	.22831
Ndiweni	Mean	.8191	.7384	.7984	.6333	.7723	.6558
	HCI	40	40	40	40	40	40
	Std. Dev.	.10503	.18260	.08391	.20946	.15753	.19132
Mangala	HCI	.8818	.8193	.8442	.6928	.8485	.7361
	N	67	67	67	67	67	67
	Std. Dev.	.15230	.19122	.10132	.23852	.13927	.29799
Mahetsi	HCI	.7402	.7202	.7586	.7686	.8111	.7208
	N	48	48	48	48	48	48
	Std. Dev.	.16616	.18622	.16666	.17612	.14746	.24808
Total	HCI	.7214	.6959	.7193	.6847	.7552	.6722
	N	277	277	277	277	277	277
	Std. Dev.	.20523	.23147	.17329	.20397	.18126	.24324

During the WRS of the year 2000-2024, we see the proximal communities of Mangala (HCI = 0.8818), Ndiweni (HCI = 0.8191) emerge as top three communities where the intensity of involvement in MW trade is very high. In comparison the two distal communities of Kapeni (HCI=0.6362) and Sasane (HCI=5.4.7) in relative terms are characterised by low intensity of involvement in trade. This pattern is consistently replicated for the years 2014-2028 and 2018-2022. The DRS show subdued HCI statistics for all villages. This indicates low intensity of

involvement in MW trade due to suppressed harvests. The relative rankings of villages however show variations depending on the extent to which harvests have been suppressed in those contexts.

6.5 A cluster analytical creation of consumption and trading activities

While there is clear evidence of spatial variations in consumption and selling patterns of households coming from distal and opposed to proximal communities, we hypothesize that such analysis should be taken down to the household as a spatial unit of analysis. This is because proximal and distal communities should not be treated as homogenous entities in all aspects of MW utilisation as there are bound to be overlaps in terms of consumption and trading behaviours. It was therefore necessary to identify unique clusters of households based on consumption and selling behaviours. We employed a two-step clustering algorithm to identify such unique clusters.

6.5.1 Number of emerging unique clusters

The analysis revealed three unique clusters of MW consumption and selling behaviours during the WRS (Figure 6.8)

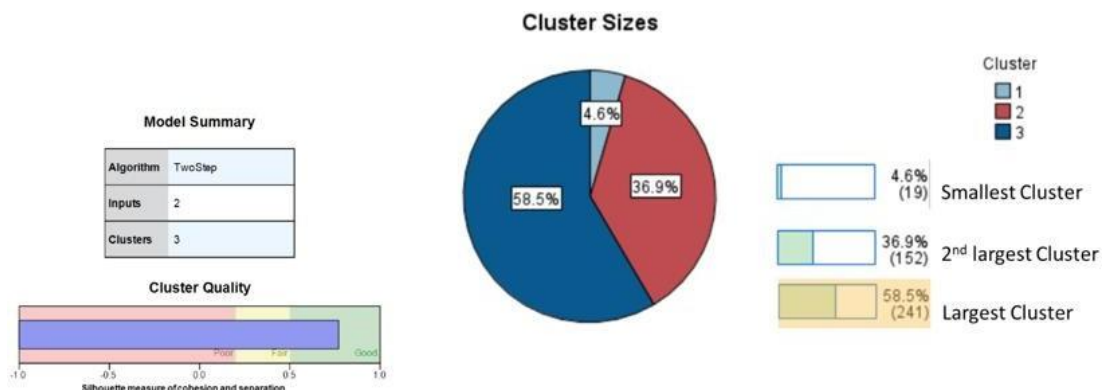


Figure 6.8 Number and size of emerging unique clusters (WRS)

The analysis reveals 3 unique clusters of households who have unique consumption and selling behaviours. The average Silhouette of cohesion and separation of 0.8 reveals no overlap between the generated cluster solution. The smallest cluster (4.6%) is composed of 19 households (Cluster 1). The second largest cluster (36.9%) is composed of 152 sampled households (Cluster 2). The largest of all three clusters (58.5%) is composed of 241 households (Cluster 3).

3). The unique consumption and trading behaviours are explained in the next section.

6.5.2 Description of unique clusters of consumption and trading behaviours.

Figure 6.9 shows differences on the generated 3-cluster solution on the bases of computed median values and cell distribution visuals.

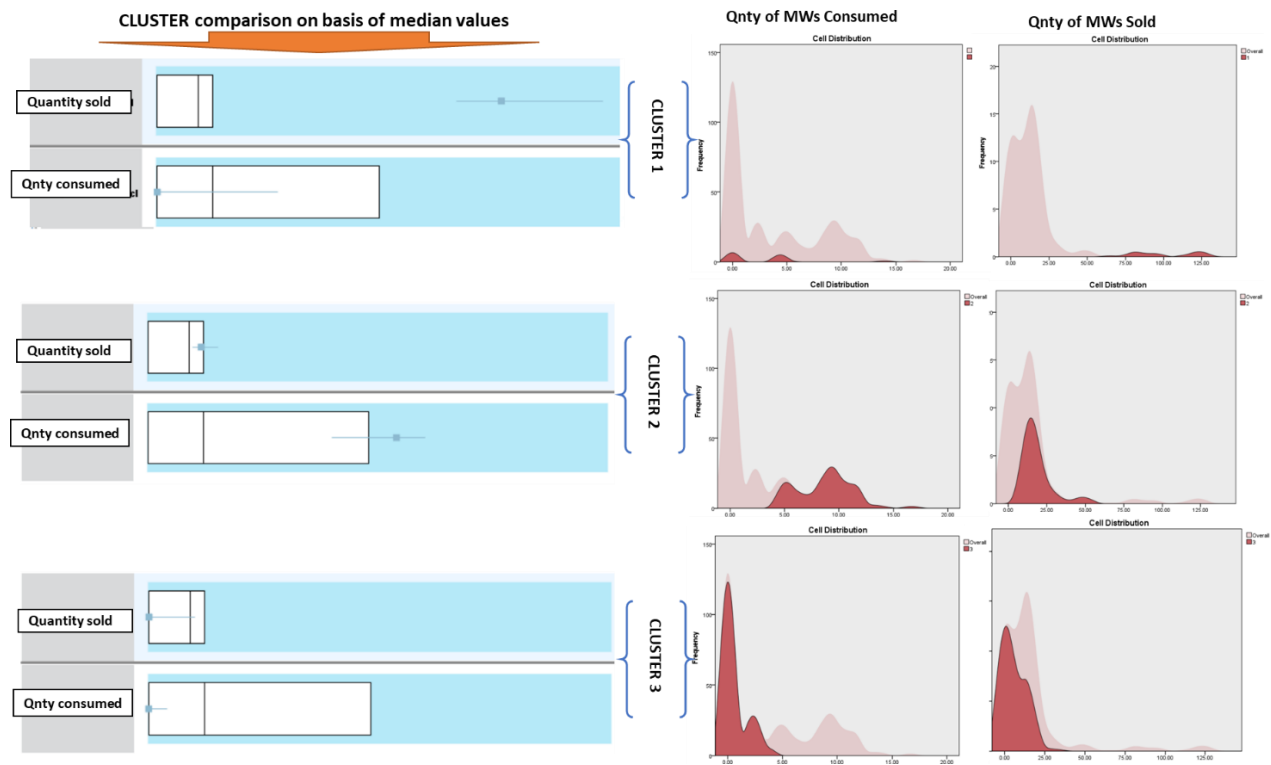


Figure 6.9 Comparison of clusters by median values and cell distribution characteristics.

As shown in the figure, the smallest cluster of households (Cluster 1) are low consuming and low selling households. Owing to low consumption levels, such households are not benefiting from the nutritional value that is associated with the chemistry of the worm. Their interaction with the output market and subsequently their ability to reap benefits from MW trade is limited. In comparison, cluster 2 households consume relatively high amount of MWs and are also trading a sizable share to the market. While their level of consumption and selling is encouraging from a food security and interaction with the output market perspective, cluster 3 households are performing better than them in all these aspects. They are characteristically consuming the highest quantity of worms and are also trading the largest portion on the market. From a developmental perspective, these statistics are encouraging as the highest number of all sampled households fall into this category where the intensity to participate in the output market is very high.

6.6 Type of markets accessed by trading households.

The type of markets most accessed by is an important variable as markets can vary in terms of their performance and the prices offered for MW sold. Rural development literature holds that major markets such as city markets, town markets or major rural markets offer a much higher price for MW stocks when compared to localised markets. The nature of markets accessed by households is presented as follows.

6.6.1 Spatial and temporal changes in the type of markets mostly accessed by households.

6.6.2 Spatial and temporal changes in the prices of MWs according to type of markets mostly accessed by households.

6.6.1 Spatial and temporal changes in the type of markets mostly accessed by households.

Table 6.18 presents data on the spatial differences in the type of markets mostly accessed by households in each village.

Table 6.18 Spatial and temporal changes in the type of markets* mostly accessed by households in each village.

Village name		WRS			DRS		
		2000-2014	2014-2018	2018-2022	2000-2014	2014-2018	2018-2022
Kapeni	*Mean	2,70	2,52	2,52	2,33	1,22	1,89
	Std. Dev.	1,101	1,108	1,004	,813	,827	1,059
Sasane	Mean	2,78	2,49	2,50	2,24	1,06	1,81
	Std. Dev.	1,247	1,311	1,233	,942	,669	1,121
Ndiweni	Mean	2,15	1,87	1,85	1,88	1,46	1,64
	Std. Dev.	1,644	1,762	1,437	1,421	1,370	1,280
Mangala	Mean	2,31	2,00	2,03	1,95	1,68	1,72
	Std. Dev.	1,754	1,822	1,621	1,424	1,503	1,320
Mahetshe	Mean	2,62	2,56	2,56	2,16	1,78	1,94
	Std. Dev.	1,351	1,511	1,367	1,130	1,374	1,180
Total	Mean	2,48	2,25	2,25	2,09	1,44	1,79
	Std. Dev.	1,482	1,573	1,391	1,205	1,240	1,205

*Based on the following scale: 0 = N/A; 1= Backyard market;2=Nearby road; 3=nearby shops; 4 = nearby city;5 Other city(ies).

It can be seen from the analysis that households in all villages are struggling to access the lucrative urban markets. During the WRS of the three periods under analysis, we see most households in Kapeni village selling their stocks to nearby shops (mean >2.5). Such access

dynamics however change as households transition into the DRS. During this resource state most, households sell their stocks at a nearby road (mean < 2.5) where buyers come to fetch the MWs. From PRA studies conducted in all villages, it emerged that prices fetched at nearby shops are generally higher compared to those fetched at the roadside market and the backyard market. It is argued that the seller negotiating power declines as one moves from City markets down to the backyard markets where prices are seen as extremely low. This makes the year 2014-2018 a problematic one since many households in Kapeni sold their stocks to the backyard market.

A similar pattern is also portrayed in Sasane and Mahetshe villages for both WRS and the DRS. In the villages of Ndiweni and Mangala, we see a completely different picture where many households sell their stocks at nearby roadside markets. This is partly because the two villages are very much accessible to the main road that links the bigger city market of Bulawayo and the major rural markets of Kezi and Maphisa.

6.6.2 Spatial and temporal changes in the prices of MWs according to type of markets mostly accessed by households.

Existing MW literature on how rural markets for MWs works is currently marred by here-say observations on variations in the prices of MWs fetched by traders in different markets. In this section, a spatial and temporal perspective on the workings of such markets is based on actual statistics collected from the trading households. Table 6.19 gives such results.

Table 6.19 Spatial and temporal changes in the prices of MWs according to type of markets mostly accessed by households.

Type of market mostly accessed		Price of MWs fetched by each trader in US\$					
		WRS			DRS		
		2000-2014	2014-2018	2018-2022	2000-2014	2014-2018	2018-2022
Backyard Market	*Mean	8,08	13,91	N/A	9,51	11,81	14,69
	Std. Dev.	1,084	2,852	N/A	2,921	2,236	2,748
Nearby road	Mean	9,09	10,34	14,50	9,79	15,67	16,06
	Std. Dev.	1,663	2,444	3,011	1,526	3,615	3,510
Nearby shops	Mean	11,58	12,25	17,09	10,59	13,76	17,31
	Std. Dev.	12,955	2,358	4,917	1,832	2,024	11,118
Nearby city	Mean	10,19	13,63	17,11	N/A	13,84	16,43
	Std. Dev.	1,769	3,578	3,541	N/A	2,343	8,720
Other City (ies)	Mean	12,37	12,00	20,00	N/A	N/A	N/A
	Std. Dev.	1,500	0	0	N/A	N/A	N/A

Total	Mean	11,00	12,75	16,15	10,36	12,62	16,43
	Std. Dev.	10,037	3,321	4,029	1,864	2,452	8,720

Combined price statistics show that the prices of MWs received by trading households have been increasing in nominal over the years for both the WRS and DRS. Statistics on prices disaggregated by type of market are indeed collaborating with views shares in the PRA study. They consistently confirmed that backyard markets are the least attractive markets in terms of Prices. The most attractive markets are city markets, followed by rural centre markets (i.e nearby shops), followed by roadside markets and lastly backyard markets. These statistics are consistently true for all time periods under study, except for the DRS period of year 2014 to 2018 where roadside markets appear to fetch mor prices than the nearby shop markets. This only anomaly is caused by outlier statistics associated with some households who manage to hold on to their stocks until supply is limited and prices increase owing to the supply-demand dynamics.

6.7 Statistical estimation of factors that explain household dependency on MW resource.

One of the main objectives of this study was to estimate spatial and temporal changes in household dependency on MWs. Identifying that MW households are dependent on MWs helps to more effectively and accurately locate households who may need assistants the most. Spatial and temporal changes in factors shaping such dependency will certainly inform what kind of interventions are required. Understanding such will enhance the effectiveness of capacity building and realising the sustainability of resource protection. The study employed the Binary logistic regression model to estimate factors affecting MW resource dependency using two models with two different but related dependent variables. The first model, Model I used the amount of 20 litre buckets of MWs harvested, since most studies on forest dependency use such a variable. Model II employed the HCI as the dependent variable as it can be easily used as a predictor of expected returns from MW trade. These dependent variables were recorded in binary variables since it considered worthwhile to develop LED interventions or plans that divide household status into “high resource dependency” and “low resource dependency” categories. Both dependent variables were divided into two using the median values. Like many other related studies, the median as a better indicator of central tendency than the mean since high-value cases can significantly impact the mean but have little or no impact on the median (Mertler & Reinhart, 2017; Mendako et al., 2022). The median values were calculated for both

the WRS, and the DRS as shown in Table 6.20.

Table 6.20 Median cut-off values for the dependent variables.

Dependent variable	Resource State	
	WRS	DRS
Quantity harvested*	17.6667	6.6667
Household Commercialisation Index (HCI)	0.7340	0.7286

*Refers to number of 20 lite buckets of MWs harvested.

Households below the cut-off median valued were categorised as “lowly dependent on MWs” and those above the median and “highly dependent on MWs. The variable MW resource dependency was measured as a dichotomous response occupying the value of 1 or 0, where 1 denotes high resource dependency and 0 meant low resource dependency. Incorporating the temporal dimension ultimately generated a total of two models associated with each dependent variable. A preliminary assumption analyses to test for multicollinearity was conducted. Only explanatory variables whose tolerance values were above the conventional cut-off point for tolerance (not less than 0.10), indicating that the multicollinearity assumption is not violated were accepted. This data screening procedure is also supported by the Variance Inflation Factor (VIF) values of each independent variable that was expected to be well below the cut-off value of 10 (i.e. not greater than 10). Complementary analysis by inspecting the correlation matrix revealed no serious correlation issues among the independent variables (see Table 6.22 for the WRS and Table 6.24 for the DRS). Table 6.23 shows associated determinants of household dependency on MWs using quantity of MW harvested as a dependent variable for both the WRS and DRS.

Table 6.22 Correlation matrix_ WRS (Dependent variable: Quantity of MWs harvested)

	Market efficiency	Road Pavement Condition	Change in area cultivated	Average age of harvesters	Proportion of MW income	Economic Complexity Index	Household Commercialisation	Number of harvesters	Wealth status	Nature of involvement in harvesting.
Market efficiency	1.000									
Road Pavement Condition Index (PCI)	.558	1.000								
Change in area cultivated	.012	.251	1.000							
Average age of harvesters	-.112	-.199	-.262	1.000						
Proportion of MW income	.042	-.006	-.196	.435	1.000					
Economic Complexity Index	-.549	.288	.273	-.119	-.087	1.000				
Household Commercialisation Index (HCI)	.091	-.049	-.221	.573	-.016	-.235	1.000			
Number of harvesters	-.112	-.554	-.287	.187	.085	-.405	.055	1.000		
Wealth status	.017	.458	.780	-.307	-.053	.454	-.317	-.407	1.000	
Nature of involvement in harvesting	.000	.000	.000	.000	.000	.000	.000	.000	.000	1.000

Table 6.23 Determinants of household dependency on MWs (Dependent variable: quantity of MW harvested)

Determinants	WRS				DRS			
	B	Wald	P-value	Exp(B)	B	Wald	P-value	Exp(B)
Market efficiency	-1.343	3.756	.053	.261	.070	.014	.906	1.072
Road Pavement Condition Index (PCI)	1.565	7.019	.008	4.783	2.519	30.953	<.001	12.418
Change in area cultivated	1.650	6.795	.009	5.206	.375	1.327	.249	1.456
Average age of harvesters	-1.545	15.542	<.001	.213	-1.270	27.946	<.001	.281
Proportion of MW income	9.884	2.002	.157	19609.798	19.473	1.608	.205	286372875
Economic Complexity Index	25.660	28.484	<.001	139368895162	22.279	32.005	<.001	4740765696
Household Commercialisation Index	-12.428	25.646	<.001	.000	-4.942	11.995	<.001	.007
Number of harvesters	.076	.072	.788	1.079	.104	.034	.853	1.109
Wealth status	4.334	27.541	<.001	76.276	2.365	22.976	<.001	10.641
Nature of involvement in harv.	.467	.071	.789	1.596	-.632	.118	.731	.532
Model Evaluation:					Model Evaluation:			
-2 Log likelihood: 130.922					-2 Log likelihood: 188.093			
Cox & Snell R Square: .599					Cox & Snell R Square: .507			
Nagelkerke R Square: .799					Nagelkerke R Square: .676			
Hosmer and Lemeshow Test: Chi-square=14.902; df =8; P-value = .061					Hosmer and Lemeshow Test: Chi-square=2.715; df =8; P-value = .951			

Model fit statistics for the WRS and DRS shows a good fit of data to the model employed. The Hosmer and Lemeshow Test for both scenarios attracted chi square tests statistics and P-values ($P\text{-value} > 0.05$ in each case) showing the Goodness of Fit of the models used. Both the Cox & Snell R Square and Nagelkerke R Square statistics are above the thresholds normally cited in related studies as acceptable. An analysis of the residual graphs of the dependent variable also showed no issues of heteroscedasticity.

Resource dependency in this case is significantly defined by the variables that are consistently showing significant results as households transition from the WRS to the DRS. These at least for the WRS include spatial and aspatial variables such as road pavement conditions ($\beta = 1.565$; $P\text{-value} = 0.008$), average age of harvester ($\beta = -1.545$; $P\text{-value} < 0.001$), economic complexity index ($\beta = 25.66$; $P\text{-value} < 0.001$), household commercialisation index ($\beta = -12.428$; $P\text{-value} < 0.001$), and wealth status ($\beta = 4.334$; $P\text{-value} < 0.001$).

Road pavement condition as a variable defining rural access in this analysis emerged as a significant predictor of MW resource dependents during the WRS and the DRS ($\beta = 2.519$; $P\text{-value} < 0.001$). Because the beta coefficients are positive in both cases, the analysis concludes that household occupying communities where there is restricted access owing to poor pavement conditions depend more on MWs than those that occupy spaces where pavement conditions are better.

Average age of harvester emerged as another variable that is a significant predictor of MW dependency for the two scenarios of WRS and DRS ($\beta = -1.27$; $P\text{-value} < 0.001$). Because of the negative beta values, the analysis concludes that it is mostly the young generation of harvesters that is very much involved in the harvesting business than the older generation whose labour productivity capacities are low due to ageing.

Economic Complexity Index (ECI) emerged as another significant determinant of dependency in MW resources for the WRS and the DRS ($\beta = 22.279$; $P\text{-value} < 0.001$). Because of positive beta coefficients, the analysis concludes that households that occupy more diverse and less concentrated economies are systematically harvesting more quantities of MWs than those that occupy economies that are much more concentrated and less diverse. This is largely because such economies at least in this analysis are located closer to major markets where higher prices of the MW are a major incentive to harvesting more quantities.

Wealth status was found to be another major predictor for both the WRS and the DRS ($\beta = 2.365$; $P\text{-value} < 0.001$). The positive beta coefficients show that it is households from wealthier communities that tend to harvest more quantities of the worm than those from the low-income bracket.

Table 6.24 and table 6.25 show correlation statistics and determinants of MW household dependency respectively, using the Household Commercialisation Index (HCI) as the dependent dichotomous variable. Model fit statistics for both the WRS and DRS shows a good fit of data to the model employed. The Hosmer and Lemeshow Test for both scenarios attracted chi square tests statistics and P-values ($P\text{-value} > 0.05$ in each case) showing the Goodness of Fit of the models used. Both the Cox & Snell R Square and Nagelkerke R Square statistics are above the thresholds normally cited in related studies as acceptable. An analysis of the residual graphs of the dependent variable also showed no issues of heteroscedasticity.

Resource dependency in this model case is significantly defined by a sample of variables that are consistently showing significant results as households transition from the WRS to the DRS. These at least for the WRS include spatial and aspatial variables such as Sale competition rate of MW stocks ($\beta = 0.4976$; $P\text{-value} = -.003$), and number of harvesters involved in harvesting ($\beta = -7.98$; $P\text{-value} < 0.001$).

Sale completion rate of MW as a proxy measure of market efficiency emerged in this analysis as a significant depicter of MW resource dependency during the WRS and the DRS ($\beta = 3.369$; $P\text{-value} = 0.022$). Because the beta coefficients are positive in both cases, the analysis concludes that household residing in near markets where mopane worms sale father are heavily involved in the trading business as measured by the HCI. Where the sale completion rate is low the intensity of involvement in the trading business is low.

Number of harvesters involved emerged as another variable that is a significant depicter of MW dependency for the two scenarios of WRS and DRS ($\beta = -0.533$; $P\text{-value} < 0.001$). Because of the negative beta values, the analysis concludes that it is mostly households with less number of harvesters that are heavily involved in trade. Further analysis revealed that such is a characteristic of wealthier households who at times engage hired labour in the harvesting and selling activities on their behalf.

Table 6.24 Correlation matrix_DRS (Dependent variable: (Household Commercialisation index))

	Market efficiency	completion rate of MW stocks	Economic complexity	anges in areacultivated	Age of harvester	Quantity of MWs sold	Number of harvesters	Proximity to MaphisaMarket	Wealth status
Market efficiency	1.000								
Sale completion rate of MW stocks	-.056	1.000							
Economic complexity	-.313	-.593	1.000						
Changes in area cultivated	.481	-.660	.212	1.000					
Age of harvester	.008	-.269	.320	-.003	1.000				
Quantity of MWs sold	-.062	.227	-.100	-.158	.149	1.000			
Number of harvesters	.107	.033	-.251	-.122	-.419	-.482	1.000		
Proximity to major market	-.407	.038	-.487	-.228	-.261	-.087	.203	1.000	
Wealth status	.494	-.592	.166	.589	-.205	-.279	.025	-.206	1.000

Removed: Road pavement, quantity harvested

Table 6.25 Determinants of household dependency on MWs (Dependent variable: Household Commercialisation Index)

Determinants	WRS				DRS			
	B	Wald	P-value	Exp(B)	B	Wald	P-value	Exp(B)
Market efficiency	-.012	.002	.968	.988	-.951	12.068	<.001	.386
Sale completion rate of MW stocks	4.976	8.535	.003	144.941	3.369	5.264	.022	29.056
Economic complexity	-14.323	22.239	<.001	.000	-3.945	2.586	.108	.019
Changes in area cultivated	.031	.010	.922	1.031	-.450	2.938	.087	.638
Age of harvester	-.130	.749	.387	.878	1.037	31.907	<.001	2.821
Quantity of MWs sold	.035	6.110	.013	1.035	.614	3.149	.076	1.848
Number of harvesters	-.798	37.875	<.001	.450	-.533	15.689	<.001	.587
Proximity to major market	1.200	26.686	<.001	3.322	.027	2.215	.137	1.027
Wealth status	-.411	1.123	.289	.663	-1.281	27.792	<.001	.278
Model Evaluation:					Model Evaluation:			
-2 Log likelihood: 313.061					-2 Log likelihood: 376.508			
Cox & Snell R Square: .466					Cox & Snell R Square: .377			
Nagelkerke R Square: .621					Nagelkerke R Square: .502			
Hosmer and Lemeshow Test: Chi-square=14.490; df =8; P-value = .070					Hosmer and Lemeshow Test: Chi-square=4.962; df =8; P-value = .762			

6.8 Spatial variations in economic complexity and quantities of MWs harvested and traded.

The previous analysis has seen several spatial planning variables emerge as major determinants of MW resource dependency. This section zooms into such variables and investigates the associated implications for resource dependency at the village scale. It is structured as follows.

- 6.8.1 Spatial differences in the Village Economic Complexity Indices
- 6.8.2 Spatial variation in road pavement distress conditions and participation of local traders into the output market.
- 6.8.3 Spatial variations in peak market efficiency

6.8.1 Spatial differences in the Village Economic Complexity Indices

Logistic regression analysis results revealed economic complexity as one of the major determinants of MW resource dependency. The study had hypothesized the existence of a positive correlation between resource dependency and the level of economic diversification and sophistication of the respective Ward in which the village is located. This section takes a closer look at the ECI dynamics in each village and how such dynamics translate to changes in quantity of MWs harvested and traded. Guided by the previous logistic model results the analysis expects households who occupy MW-based village territories whose economies are in relative terms highly diversified and sophisticated to be highly dependent on MW resources. Table 6.26 shows spatial differences in the village economic complexity Indices (VECI) calculated for each village.

Table 6.26 Spatial differences in the Village Economic Complexity Indices (VECI)

Village	Number of unique product and / services produced in respective Ward*	Commonly cited sectors from that identified products and services belong to in the respective ward*	VECI***
Kapeni	3	Livestock farming Forestry and Fisheries Wood industry	0.0968
Sasane	5	Mining Retail Industry Forestry Transportation	0.1613
Ndiweni	7	Food and Beverages Manufacturing	0.2258

		Retail industryForestry Tourism	
Mangala	7	Food and Beverages Manufacturing Retail industryTourism	0.2258
Mahetshe	16	Tourism Food and BeveragesMining ICT servicesHealth Agricultural Extension Services Manufacturing Construction Urban Infrastructure andservices Retail IndustryArt and Crafts	0.5161
TOTAL	31**		1.00**

*Based on data obtained from Matobo rural district profile handbook and data generated in focused group discussions during PRA studies.

**Totals not adding up to 38 and 1.2258 respectively because the number of unique products and / or services from Ndiweni and Mangala villages were counted once since both villages belong to the same Ward (i.e Madwaleni ward).

$$***VECI = \frac{\sum (P\_S \text{ offered by all villages in Ward } i)}{\sum (P\_S \text{ offered by all villages in ALL sampled Wards})}$$

The analysis revealed that villages that occupy wards whose economic agents produce a relatively larger number unique products and services such as Mahetshe near the capital rural centre of Maphisa offer a much more diverse and complex economy than villages that occupy remotely located wards such as Kapeni.

Results also revealed significant positive correlations (P-value<0.01) between the VECI and quantity of MWs harvested and traded by households (see Table 6.27). Such a pattern of association is consistently reflected both during the Wet based Resource State (WRS) and the Dry Based Resource State (DRS).

Table 6.27 Relationship between VECI and quantities of MWs* harvested and traded

Variables	PEARSONS CORRELATION COEFFICIENT						
	VECI	Qty harvested_WRS	Qty harvested_DRS	Qty sold_WRS	Qty sold_DRS	# of hhld Inv in Harv_WRS	# of hhld Inv in Harv_DRS
VECI	--						
	412						
Qty harvested_WRS	.132**	--					
Qty harvested_DRS	.135**	.963**	--				
Qty sold_WRS	.160**	.979**	.967**	--			
Qty sold_DRS	.147**	.927**	.983**	.962**	--		
# of hhld Inv in Harv_WRS	.013	.521**	.404**	.416**	.319**	--	
# of hhld Inv in Harv_DRS	.004	.527**	.434**	.452**	.357**	.835**	--

* Quantities based on number of 20 litre buckets of mopane worms harvested.

** . Correlation is significant at the 0.01 level (2-tailed).

Although the number of households involved in harvesting is positively correlated with VECI, such results are however insignificant (P-value > 0.05).

6.8.1 Spatial variation in road pavement distress conditions and participation of local traders into the output market

An important assumption in this study is that the ability of harvesting MW households trading large volumes of MWs in intermediate and distal rural-urban markets rely to a larger extent on road pavement distress conditions that may either enhance or limit travel by both buyers of stock and trading households. The study assumed that the complex interaction of such road pavement conditions such as road pavement integrity, pavement surface features, pothole intensity, ride quality, road safety measures and facilities, visibility of pavement features, and comprehensibility of road signage will either limit or enhance accessibility to output markets by local traders. When road distress conditions are favourable, we expect to see many buyers accessing the local markets – a situation that may boost returns to local harvesters. We also expect more local traders willing to access distal markets via private or public transportation.

Logistic regression analysis from the previous section has already revealed this to be one of the significant predictors of MW resource dependency.

It was possible to calculate the Pavement Distress Index (PDI) for each village. The index scale employed depicted extent of road surface affected. Such extent was initially estimated in percentage form and later rescaled to a 0 to 10 and finally to a -1 to +1 scale to aid the visual analysis of spatial differences in pavement among the sampled villages. Spatial variations in the calculated PDIs are presented in Table 6.28.

Table 6.28 Spatial variation Road Pavement Distress

Village name	(Relative) Proximity to major MW markets**	PDI score*	Severity***	Extent of road pavement affected***
Kapeni	Distal	8.1429	High.	Extensive.
Sasane	Distal	6.8571	High.	Extensive.
Ndiweni	Proximal	2.7143	Moderate.	Frequent.
Mangala	Proximal	3.2857	Moderate.	Frequent.
Mahetshe	Proximal	1.7143	Low.	Intermittent.
Average (All Villages)		4.5429	Moderate	Frequent

*PDI = Pavement Distress Index. Index Defined as a function of Individual Distress Parameters including, *road pavement integrity, pavement surface features, pothole intensity, ride quality, road safety measures and facilities, visibility of pavement features, and comprehensibility of road signage*

**PDI induced unique cluster generated using a Two-step clustering algorithm

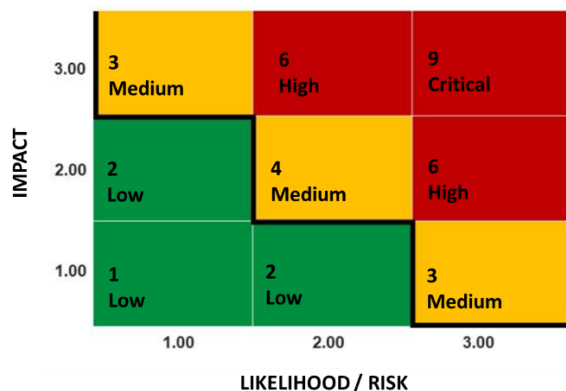
***Severity scale: 0-100%	Equivalent. 0-10 scale
0 – 10 Occasional	0-1
10 – 20 Intermittent	1-2
20 -50 Frequent	2-5
50 – 80 Extensive	5-8
> 80 Throughout	> 8

Results generally reveal that distal communities primarily located away from major rural and city markets are characterised critical road pavement distress conditions. This has rendered such markets in accessible to potential buyers who prefer to access proximal markets such as those found in Ndiweni, Mangala and Mahetshe, where the road pavement distress conditions are in relative terms favourable. Data generated at focused group discussions confirmed that the distal communities of Kapeni and Ndiweni have an inherent high risk that is limiting the participation of local trading households from the output markets (see Table 6.29).

Table 6.29 Extent to which Inherent Road pavement distress conditions are limiting local trader participation in output markets.

Road pavement Distress segment	Number of local traders participating in the rating exercise	Statistical measure	Pavement distress parameter		
			Risk	Impact	Inherentrisk
Kapeni	11	Rating	3	2.9091	8.7273
		Std. Deviation	.000	.30151	.90453
Ndiweni	22	Rating	2.1364	1.3636	2.9545
		Std. Deviation	.56023	.49237	1.39650
Sasane	9	Rating	2.8889	2.7778	8.0000
		Std. Deviation	.33333	.44096	1.50000
Mangala	10	Rating	2.2000	1.6000	3.5000
		Std. Deviation	.63246	.51640	1.35401
Mahetshe	28	Rating	1.6071	1.3929	2.2500
		Std. Deviation	.56695	.49735	1.14261

KEY:



Inheritance = risk x Impact

NB: Heat map colours based on rounded off (discrete) mean scores values

6.8.2 Spatial variations in peak market efficiency

It was possible to assess peak market efficiency. Guided by preceding literature review, the study assumed that the willingness of households to enter certain rural-urban markets is an important predictor of resource dependency. We expected trading households to increase their trading activities in markets that are more efficient as opposed to the less efficient ones.

Logistic regression results in the previous sections have already confirmed the importance of this variable in depicting resource dependency. It was calculated based on the queuing model explained in the methods section. Results of the queuing model showing spatial variations in peak market efficiency according to each village are shown in Table 6.30.

Table 6.30 Application of queuing model concept to measuring spatial differences in rural market efficiency.

Village	Number of accessible rural urban markets observed	Number of observed sellers	Total number of 50 kg bags of MW stock arriving on day of observation	Total number of 50 kg bags of MW stock observed to have been sold by end of day	Average number of 50kg bags of MWs arriving per seller per day (λ)	Predominant queuing discipline observed 5 = Almost always FIFO 4. Mostly FIFO 3 = Occasionally FIFO and LIFO 2 = Mostly LIFO 1 = Almost always LIFO	Average number of 50kg bags of MWs completing a sale per seller per day (μ)	Market efficiency/ service utilisation (P = λ/μ)
Kapeni	5	16	31	15	1.9375	Mostly LIFO	0.4839	4.0039
Sasane	2	9	22	13	2.4444	Occasionally FIFO and LIFO	0.5909	4.1367
Ndiweni	2	8	40	33	5.0000	Mostly FIFO	0.8250	6.0606
Mangala	3	11	34	21	3.0909	Mostly FIFO	0.6176	5.0047
Mahetshe	2	9	58	52	6.4444	Almost always FIFO	0.8966	7.1876

Both market efficiency statistics and the sale completion rate of MW stocks show that markets of proximal communities that include Mahetshe, Ndiweni and Mangala are more efficient in that order when compared to the markets of distal communities such as Sasane and Kapeni.

CHAPTER 7: *Spatiotemporal changes in factors explaining success and resilience of MW Territories.*

7.0 Introduction

This chapter seeks to provide study results in relation to two study objectives. First, the study will determine spatial and temporal changes in factors explaining successful territorial dynamics that lead to situations of growth in the MW industry and the local economy at large. Secondly it will analyse the resistance of MW territorial space to external changes and shocks in the local environment and beyond.

7.1 Spatial and temporal changes in factors explaining successful territorial dynamics that lead to situations of growth in the MW industry and the local economy at large.

The study assumed that there are certain territorial dynamics that leads to situations of growth and subsequently territorial resistance in the face of adversity. Such territorial dynamics as argued in the literature section are a function of a territories economic system performance, social system performance, environmental system performance and physical engineering system performance. Each MW household was assumed to occupy a MW territory with unique traits that may result in situations of growth or failure in the MW business and the local economy at large. The study assumed that successful territorial dynamics are associated with territories that are defined as less vulnerable and therefore more capable and with a lot of potentialities to drive success. By extension, it is possible to locate every household on a continuum scale that distinguishes between those that occupy successful and less vulnerable territories from unsuccessful and vulnerable territories (Figure 7.1).

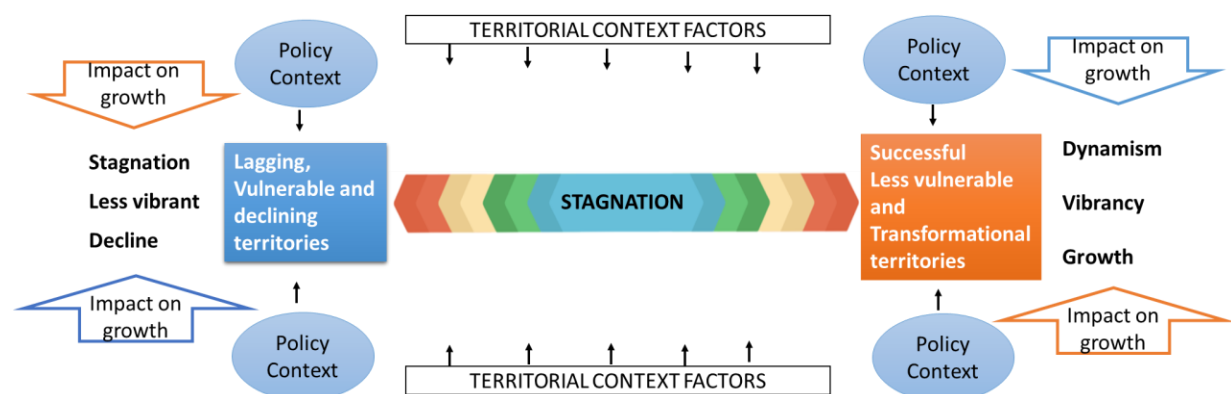


Figure. 7.1 *Defining territorial success.*

As depicted in Figure, this section seeks to identify territorial factors that explain why some households are in spatial territories that are defined as growing, stagnant or in a state of decline. It first seeks to perform a cluster analytical creation of unique categories households in similar spatial territories according to a multitude of territorial attributes identified earlier on in the literature section. Using generated LED indicators of growth as a dependent variable, it then proceeds to identify that factors significantly explain situations of growth in the MW industry and the local economy at large.

7.1.1 Descriptive statistics on territorial attributes that define territorial success.

Five categories of study variables were hypothesised in this study to be important depictees of successful territorial dynamics. These include the Environmental / Ecological System Performance (ESP), the Social System Performance (SSP), the Economic System Performance (EcSP), the Institutional / Governance System Performance (ISP) and the Physical / Engineering System Performance (PESP). The study sought to analyse the dynamic interactions among these four systems according to how they perform in each territorial space and their ultimate influence on the MW business and the local economy.

For each MW territory as defined by the village, several territorial system performance study variables were identified and analysed. Table statistics in Appendix 2 show descriptive statistics associated the level of skewness and kurtosis of the five main study constructs and study variables used in this analysis. Normality test measures were calculated since performing cluster analysis to identify unique territorial clusters portraying unique capabilities and potentialities requires that data follows a normal distribution.

Following the cue from Hair et al (2010) only values for skewness and kurtosis between -2 and +2 were considered acceptable to prove a normal univariate distribution. Those variables not meeting such criteria were removed from further analysis as shown in the Appendix. Further data screening was performed by subjecting all territorial variables to scale reliability analysis using the Cronbach Alpha statistic. Results are shown in Table 7.1.

Table 7.1 Scale reliability Analysis

Study Construct	# of variables before screening	# of variables after screening*	Cronbach Alpha Statistic	Remark
Ecological System Performance (ESP)	14	11	0.724	Good
Institutional System Performance (ISP)	12	8	0.727	Good
Social System Performance (SSP)	13	13	0.786	Good
Economic System Performance (EcSP)	17	13	0.725	Good
Physical/Engineering System Performance (PESP)	16	13	0.727	Good

Territorial variables removed from further statistical analysis include. (ESP2;ESP3;ESP8):(ISP2;ISP3;ISP9;ISP12):(EcSP16;EcSP17;EcSP20;EcSP22):(PESP2;PESP15;PESP16)

7.1.2 Territorial cluster size and composition

A closer inspection at the Scree plot results generated using the method of Hierarchical Cluster Analysis (HCA) revealed 5 unique clusters with different territorial capabilities and potentialities that could promote situations of growth through relevant production processes both in the MW business and the local economy at large through income generated from trading the worm. The relative size of such clusters and its composition in terms of where each household resides is shown in Table 7.2 and table 7.3.

Table 7.2 Size of each Territorial Cluster

Cluster	Frequency	Percent	Cumulative Percent	Bootstrap for Percent ^a			
				Bias	Std. Error	Confidence Interval	
						Lower	Upper
1	72	26,2	26,2	,1	2,7	21,1	31,9
2	64	23,3	49,5	-,1	2,5	18,4	28,0
3	66	24,0	73,5	-,1	2,6	18,9	29,1
4	26	9,5	82,9	,1	1,7	6,2	12,8
5	47	17,1	100,0	,1	2,3	12,7	21,9
Total	275	100,0		,0	,0	100,0	100,0

a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

The largest of all Territorial clusters is cluster 1 that is composed of 26.2% of all 275 harvesting households that were sampled. Such cluster analytical creation was done on the basis of harvesting households since it is the expectation of this study that we generate a MW-oriented LED strategy. Other analysis however does include all households as unique capabilities for each territory needed to be contrasted with those of non-harvesting households to get a fairer indication of whether interventions in MW utilisation would make any meaningful difference in boosting the local economy. The second largest cluster Territory 3 (24%) followed by Territory 2 (23.3%), followed by Territory 5 (17.1%) and the smallest Territory 4 with 9.5% of harvesting households. Statistics relating to where each household resides stacked against each cluster are shown in Table 7.3.

Table 7.3 Size and composition of each territorial cluster according to village

		Territorial cluster					Total
		1	2	3	4	5	
Kapeni	Count	11	6	33	15	0	65
	% within Village	16,9%	9,2%	50,8%	23,1%	0,0%	100,0%
Sasane	Count	14	2	30	11	0	57
	% within Village	24,6%	3,5%	52,6%	19,3%	0,0%	100,0%
Ndiweni	Count	12	28	0	0	0	40
	% within Village	30,0%	70,0%	0,0%	0,0%	0,0%	100,0%
Mangala	Count	35	28	3	0	0	66
	% within Village	53,0%	42,4%	4,5%	0,0%	0,0%	100,0%
Mahetshe	Count	0	0	0	0	47	47
	% within Village	0,0%	0,0%	0,0%	0,0%	100,0%	100,0%
	Count	72	64	66	26	47	275
	% within Village	26,2%	23,3%	24,0%	9,5%	17,1%	100,0%

Results indicate that there are overlaps between clusters generated using a clustering algorithm and those generated by government using administrative boundaries. This is because no cluster is composed of households belonging to one village. Cluster 3 for instance is mostly made up of households residing in Kapeni and Sasane villages (mostly making up what has been referred to as distal communities in this analysis). Households residing in the three proximal communities of Mahetshe, Mangala and Ndiweni mostly make up cluster 1 territory. We also see households residing in the two proximal communities of Ndiweni and Mangala mostly occupying Territory 2. Only Territory 5 is made up entirely of households residing in Mahetshe village. Such findings also reflected in Figure 7.2 underscores the need to go beyond administrative boundaries when making optimum LED decisions that seek to harness the unique capabilities and potentialities of each territorial space.

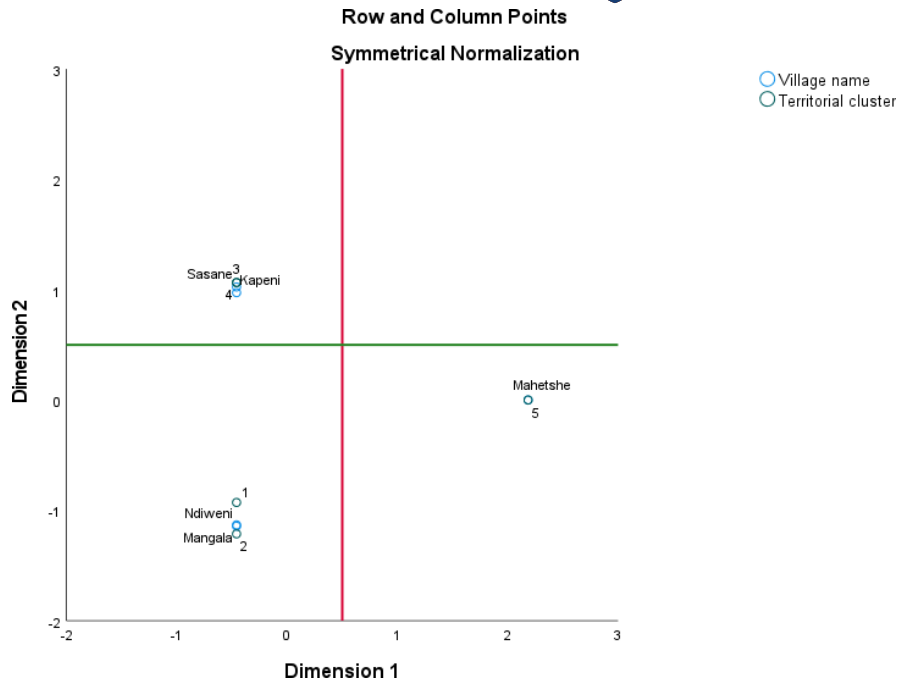


Figure 7.2 Territorial cluster uniqueness according to admirative villages boundaries.

Such uniqueness certainly crosses administrative boundaries. Nevertheless, territorial dynamics relating to each village are be analysed in other sections as this will enable to promote quick decisions that government can implement withing the confines of current administrative boundaries.

This analysis assumed that optimal decisions can only be generated on clusters that have been statistically generated using a clustering algorithm. Until the present study no such study has attempted to define what an optimal MW-oriented LED strategy would look like. The uniqueness of each territory was objectively tested using the Kruskal Wallis Test (see Table 7.4).

Table 7.4 Kruskal Wallis Test results: Statistical differences between territorial clusters

Sample 1-Sample 2	Test Statistic	Std. Error	Std. TestStatistic	Sig.	Adj.Sig. ^a
1-2	-57.500	14.717	-3.907	<,001	.001
1-3	-108.000	14.799	-7.298	<,001	.000
1-4	-165.000	13.861	-11.904	.000	.000
1-5	-221.000	14.971	-14.762	.000	.000
2-3	-50.500	15.604	-3.236	.001	.012
2-4	-107.500	14.717	-7.304	<,001	.000
2-5	-163.500	15.768	-10.369	.000	.000
3-4	-57.000	14.799	-3.852	<,001	.001

3-5	-113.000	15.844	-7.132	<,001	.000
4-5	-56.000	14.971	-3.741	<,001	.002

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is .050.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Test results reveal that each territorial cluster generated is uniquely (P -values < 0.05) different from the other. Such statistical differences are also evident when one looks at the mean ranks as a territorial performance metric of each cluster (see Figure .3).

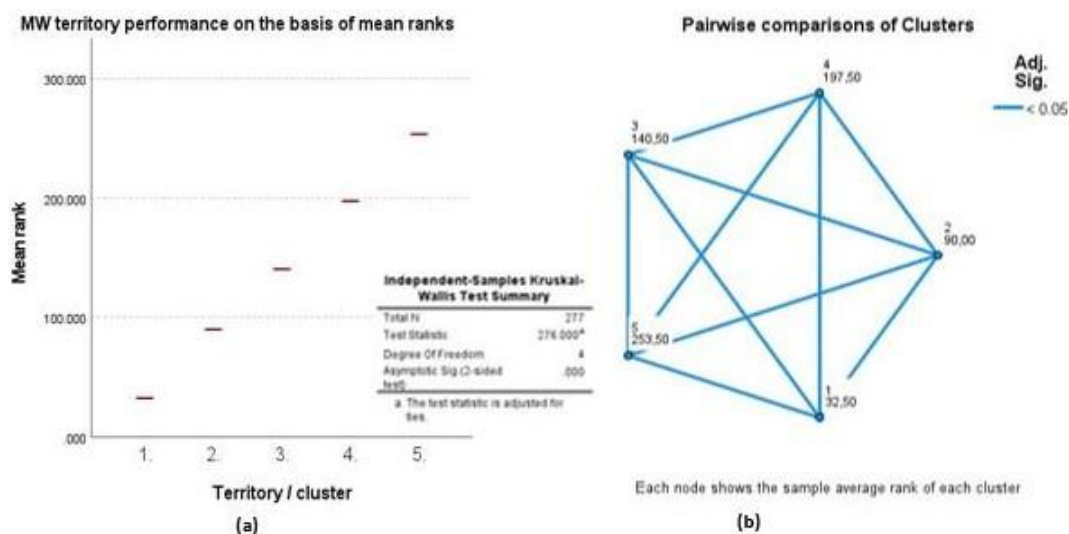


Figure 7.3 Territorial performance based on mean ranks.

7.2 Defining successful territorial dynamics.

The first step to conducting territorial dynamic analysis is to identify capabilities and / or potentialities that are associated with each unique territory. The second step is to analyse these capabilities or potentialities to determine which are being efficiently converted into a success variable such as MW income, quantities of MWs harvested, sold, consumed among others. The first part of this section deals with identifying such Territorial capabilities and potentialities. The second part focuses on how such capabilities are efficiently converted into territorial success using selected MW output measures.

7.2.1 Detailed description of MW territories according to capability defining attributes.

The study assumed that quantifying successful territorial dynamics would go a long way in informing policy makers about what type of LED strategies would work to achieve territorial equality in terms of success. Specifically, this would indicate where territorial strategies such as ‘input-oriented’ and ‘output-oriented’ LED strategies would work. Following the method described in the methodology section, the study employed Data Envelop Analysis (DEA) to calculate partial and global territorial dynamic indices. A successful territory in this analysis was defined as a territory able to convert its territorial capabilities and potentialities (i.e. its inputs) into a success output variable in an efficient manner. The most successful territory in this case and under DEA would score an efficient score of 1 (or 100%), indicating that such a territory is 100% efficient in converting its capabilities or potentialities into a specified output variable. The chosen output variable in this analysis is MW income generated from MW trade by households. We expect existing territorial capabilities and potentialities to assist MW harvesting households to reap the-most of the benefits through increased income earning. Territories whose territorial dynamic index scores are equal to one would then form benchmark for other lagging territories to catch up via the implementation of appropriate input or output-oriented LED strategies. Twelve types of territories were identified in this study including 5 territorial clusters generated during cluster analysis, the 5 administrative clusters made up of the five villages under analysis and the two clusters’ segments (proximal versus distal communities) generated according to the location of households relative to distance from major markets. In DEA, such territories are defined as Decision Making Units (DMUs). The relative performance of each DMU prior to DEA was conducted by calculating standardised Z score values for each of the 5 Territorial System Performance factors. Since various indicators for each of the 5 Territorial System Performance factors used different scales, it was necessary to standardise them and get an initial appreciation of how each DMU based on existing capabilities and potentialities.

7.2.1.1 *PTDI and GTDI values for each territorial cluster based on Standardised Z values.*

It was possible to calculate Partial Territorial Dynamic Indices (PTDIs) and a Global Territorial Dynamic Index (GTDI) based on standardised Z score values for each DMU generated based on a clustering algorithm. Figure 7.4 shows the PDTI for each territory. Detailed PDTI statistics and the GTDI are shown in Table 7.5.

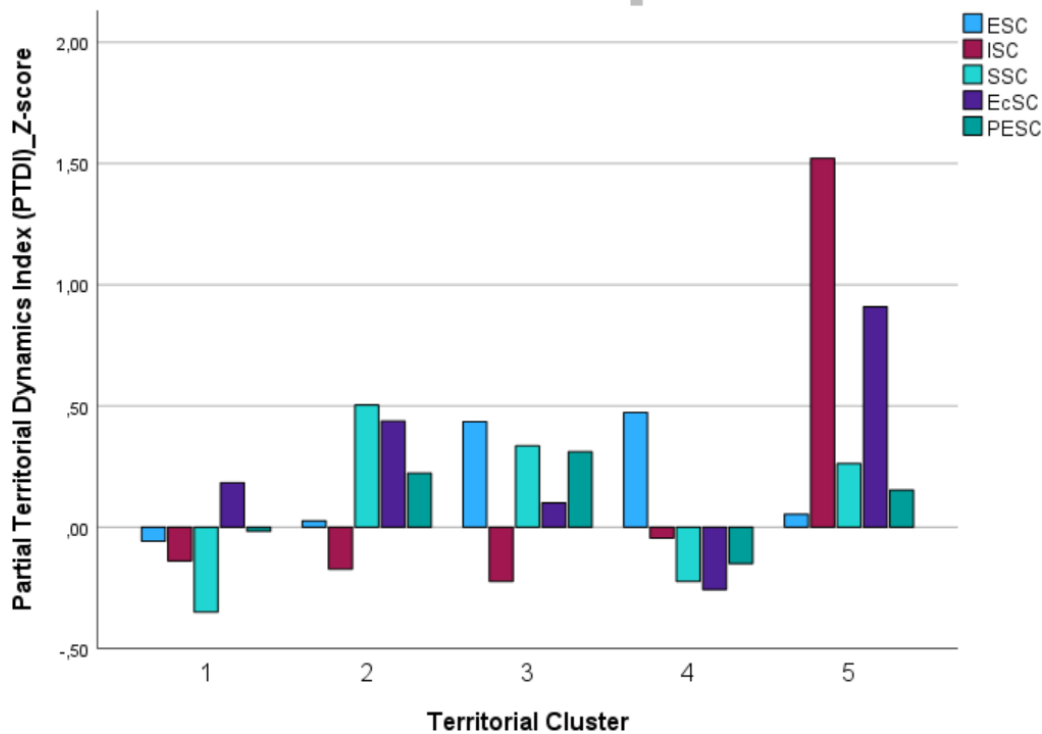


Figure 7.4 Territorial performance according to territorial system capabilities.

Table 7.5 PTDI and GTDI values for each territorial cluster based on Standardised Z values.

Cluster		Standardised Z score values					
		ESP	ISP	SSP	EcSP	PESP	GTDI
1	Index	-,0494	-,1391	-,3512	,1832	-,0222	-,0757
	Std. Dev.	,28156	,12692	,20496	,27481	,28499	,08707
2	Index	,0262	-,1729	,5035	,4376	,2229	,2035
	Std. Dev.	,28030	,19146	,25158	,18801	,28799	,10518
3	Index	,4353	-,2234	,3353	,1004	,3110	,1917
	Std. Dev.	,24202	,15231	,24685	,13736	,15579	,08825
4	Index	,4732	-,0451	-,2236	-,2572	-,1498	-,0405
	Std. Dev.	,16833	,11258	,16627	,11562	,02865	,05829
5	Index	,0582	1,5222	,2546	,9060	,1521	,5786
	Std. Dev.	,35749	,15732	,36818	,17844	,24472	,14377
Total	Index	,1513	,1297	,1268	,3062	,1321	,1692
	Std. Dev.	,34868	,65851	,42835	,38660	,28200	,24438

Based on all 5 factor conditions, the initial analysis reveals Territorial Cluster 5 (TC5) as the best territory that possesses high potential in terms of existing territorial capabilities and potentialities to yield successful outcomes associated with exploiting MWs. This is because it

attracted a high Z-score value of 0.5786. The second based performing territory is TC2 with $z = 0.2035$, followed by TC3 with $z = 0.1917$, followed by two worst performing clusters TC4 and TC1 with associated Z score values of -0.0405 and -0.0757 respectively. TC5 is the only territory that is performing above average ($z > 0$) on all system factors. Its greatest strength and/or potential that raises it above all other territories lies in its institutional system potential ($z = 1.5222$) and its economic system potential ($z = 0.9060$). The second most placed territory (TC2) is also performing above average in all system factors, except on institutional system integrity where it attracted a below average Z-score value of -1.729. Its greatest potential lies in its social system abilities where it attained a highest Z-score value of 0.5035. The 3rd placed territory has unique capabilities and potential in its physical and / or engineering attributes where it obtained a high z-score value of 0.3110.

While TC4 performs below average in almost all system factors, its unique and greatest potential lies in ecological system abilities where it attained a high Z-score value of 0.4732. TC1 is performing poorly in all system factors except on its economic system potential where it received an above average Z-score value of 0.1832. Unfortunately, this does not represent its unique capability as two other clusters performed better. This renders it the worst cluster relative to others with no unique capabilities that stand above the rest.

An Independent-Samples Kruskal-Wallis Test was conducted to test if there was any meaningful difference between the GTD Z-score indices (Figure 7.5).

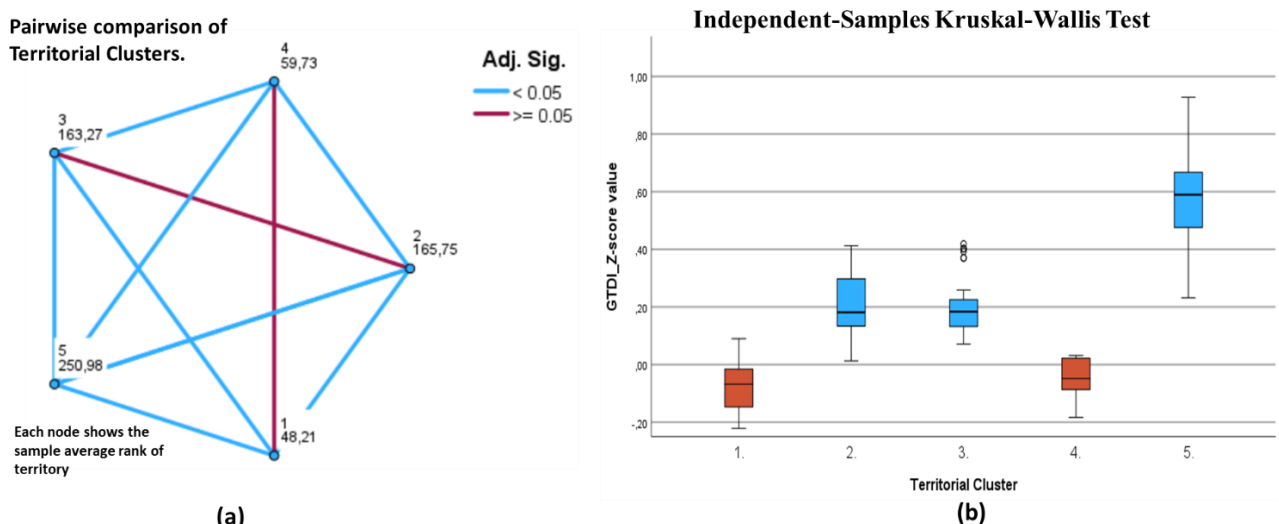


Figure 7.5 Independent-Samples Kruskal-Wallis Test results: global index differences between territories.

Results showed significant ($P\text{-value} < 0.05$) differences and similarities ($P\text{-value} > 0.05$) between territories. Despite statistically significant differences in the GTDIs for all other territories, we did not find any significant differences between territories 4 and 1 and territories

3 and 2. An Independent-Samples Kruskal-Wallis Test was conducted to test if there was any meaningful difference between the PTD Z-score indices (Figure 7.6).

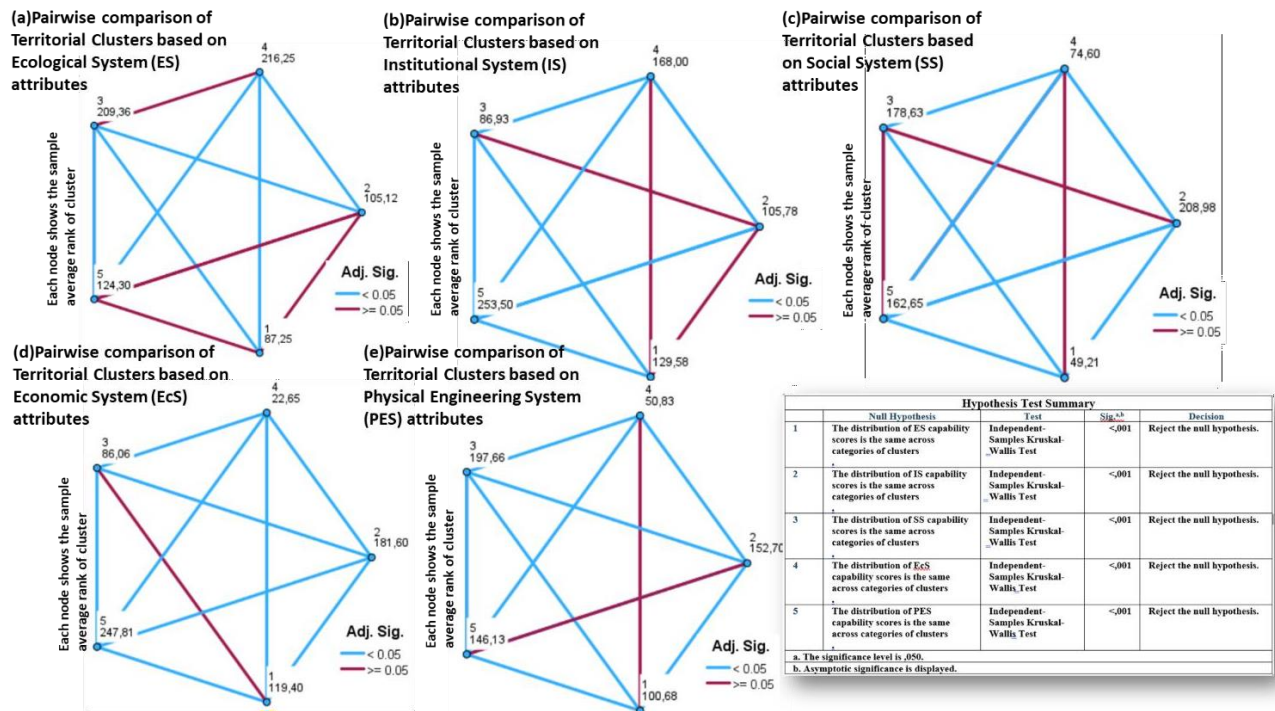


Figure 7.6 Independent-Samples Kruskal-Wallis Test results: partial index differences between territories.

7.2.1.2 PTDI and GTDI values for each village based on Standardised Z values.

It was also possible to calculate the PTDI and the GTDI based on standardised Z score values for each DMU generated based on administrative boundaries. Such administrative boundaries define the 5 villages under investigation. Table 7.6 shows such indices for each of the 5 villages under analysis.

GTDI statistics reveal that Mahetshe is the only village that has greatest potential to yield successful outcomes through MWs. This is because it attracted a relatively high Z-score index value of 0.4463. All other villages attracted below average GTDI – Z-score values. The second placed village is Kapeni that attracted a Z-score value of -0.0127, followed by Sasane (z=-0.1628). The two worst performing villages include Ndiweni (z=-0.1220) and Mangala (z= -1.496). Mahetshe stands out above the rest as it has registered above average potential in its institutional (z=1.4217), economic (0.6622), social (z=0.1558) and physical engineering (z=0.0777) system attributes. It is however one of the potentially worst performers on its ecological system abilities alongside two other villages of Mangala and Ndiweni. Its standout

out territorial performance lies in three system attributes, that include the institutional, economic, and social system capabilities where it registered the Z-score values of 1.4217, 0.6622 and 0.1558 respectively.

Table 7.6 PTDI and GTDI values for each village based on Standardised Z values.

Village		Standardised Z score values					
		ESP	ISP	SSP	EcSP	PESP	GTDI
Kapeni	Index	,2630	-,2566	,0162	-,2116	,1256	-,0127
	Std. Dev.	,40359	,18679	,46484	,37942	,27211	,24597
Sasane	Index	,1400	-,2188	,0019	-,1675	,1628	-,0163
	Std. Dev.	,42029	,19357	,36683	,43219	,25339	,24214
Ndiweni	Index	-,2818	-,2473	,0739	,0280	-,1827	-,1220
	Std. Dev.	,41027	,24826	,43982	,57355	,30153	,28145
Mangala	Index	-,0048	-,3087	-,1807	-,1519	-,1021	-,1496
	Std. Dev.	,25425	,19312	,49071	,60975	,35646	,29495
Mahets	Index	-,0860	1,4217	,1558	,6622	,0777	,4463
	Std. Dev.	,45036	,23890	,41486	,48035	,26896	,26977

Even though the GTD Z-score value for Kapeni points to below average performance ($z = -0,0127$), the village emerged as the second-best performer. Partial index scores reveal that the village is performing above average in its ecological ($z = 0,2630$), physical engineering ($z = 0,1256$) and social system attributes ($z = 0,0162$). Its unique abilities lie in its ecological system performance where it stands out with a highest score above the rest of the villages. Sasane Village the 3rd placed territory has its unique strength in the physical engineering ($z = 0,1628$) and social system attributes ($z = 0,0019$). Mangala has emerged as the worst performing village as it is performing below average ($z < 0$) in all territorial system attributes.

An independent Kruskal Wallis Test showed significant differences and similarities in the GTD Z score indices between the 5 villages (Figure 7.7).

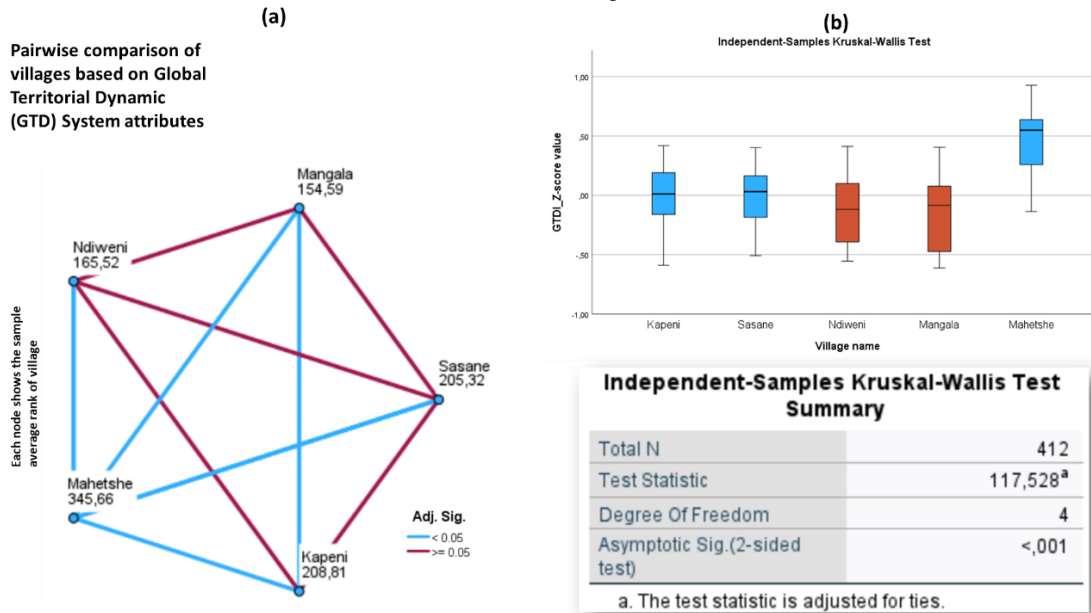


Figure 7.7 Independent-Samples Kruskal-Wallis Test results: global index differences between villages.

Despite statistically significant ($P\text{-value} < 0.05$) differences in the GTDIs of Mahetshe village and all other villages, the analysis did not find any significant differences ($P\text{-value} > 0.05$) between the rest of the villages. Such results suggesting that in terms of territorial system capabilities, all other villages are the same except for Mahetshe village.

7.2.1.3 PTDI and GTDI values based on distance to major markets and Standardised Z values.

PTDI and the GTDI based on standardised Z score values were calculated for each DMU generated based on proximity to major rural markets. Such criteria based on distance from major markets allowed the study to distinguish between proximal and distal communities. Table 7.7 shows such indices for each of these 2 types of communities.

Table 7.7 PTDI and GTDI values based on distance to major markets and Standardised Z values.

Proximity to majormarkets		Standardised Z score values					
		ESP	ISP	SSP	EcSP	PESP	GTDI
Distal	Index	,2217	-,2438	,0055	-,1962	,1382	-,0149
	Std. Dev	,40511	,19003	,42380	,39845	,26111	,24318
Proxim.	Index	-,1270	,1396	-,0032	,1123	-,0791	,0085
	Std. Dev.	,38825	,76458	,47304	,64975	,33466	,37733

A comparison of the 2 communities based on GTD Z-score values shows that proximal communities in general have in relative terms better territorial system abilities. They registered just above average performance ($z=0.0085$) while distal communities registered just below average performance ($z=-0.0149$). Their standout abilities are associated with institutional ($z=0.1396$) and economic ($z=0.1123$) system attributes. Despite their overall performance below average, distal communities' capabilities lie in their ecological ($z=0.2217$) and physical and / or engineering (0.1382) system attributes.

7.3 Measuring territorial success: The Data Envelop Analysis (DEA) approach.

Table 7.8 presents findings in relation to the partial and global territorial dynamic indices calculated via the DEA using the STATA package version 18. The efficiency indices were calculated for 12 DMUs.

Table 7.8. Partial and global territorial dynamic indices: the DEA method

Cluster criteria	Territorial cluster DMUs	Partial Territorial Dynamics Indices (PTDIs)					GTDI
		/ESC	ISC	SSC	EcSC	PESC	
Clustering algorithm	C1	0.2941	0.3563	0.2941	0.2941	0.2941	0.3563
	C2	1	1.2115	1	1	1	1.2115
	C3	0.3180	0.3852	0.3180	0.3180	0.3180	0.3852
	C4	0.2853	0.3456	0.2853	0.2853	0.2853	0.3456
	C5	0.8255	1	0.8255	0.8255	0.8255	1
Administrative boundaries	Kapeni	0.3152	0.3818	0.3152	0.3152	0.3152	0.3818
	Sasane	0.2148	0.2602	0.2148	0.2148	0.2148	0.2602
	Ndiweni	0.1883	0.2282	0.1883	0.1883	0.1883	0.2282
	Mangala	0.5542	0.6714	0.5542	0.5542	0.5542	0.6714
	Mahetshe	0.6191	0.7500	0.6191	0.6191	0.6191	0.7500
Distance to major markets	Distal	0.2709	0.3282	0.2709	0.2709	0.2709	0.3282
	Proximal	0.4348	0.5267	0.4348	0.4348	0.4348	0.5267

Results show that cluster 2 territories are best territories in terms of converting existing territorial capabilities in MW income as the chosen output variable. For instance, such a territory is according to the developed DEA model 100% efficient in converting its Ecological System Capabilities (ESC), Social System Capabilities (SSP), Economic System Capabilities (EcSC), Physical Engineering System Capabilities (PESC) into income from MW trade. It is also 121,15% efficient in converting its Institutional System Capabilities (ISC) into MW

proceeds. The calculated GTDI also shows that the territory is also 121,15% efficient in converting all its territorial system capabilities into MW income earnings. Cluster 5 territory emerges as the second placed benchmark territory that is also highly efficient in harnessing its territorial system capabilities for successful outcomes in the MW business. It is 100% efficient in converting all territorial capabilities into MW earning as evidenced by the final GTDI score of 1. As far as partial indices are concerned, the analysis revealed that it is also 100 efficient in converting its ISCs. With regards to the rest of the system capabilities it was found to be 82.55%. efficient.

Among the 5 villages under analysis, results shows that Mahetshe village is 75% efficient in converting is territorial system capabilities. Related statistics for other villages are 67.14% efficiency for Mangala village, 38.18% for Kapeni village, 26.02% efficiency for Sasane, and 22.82% efficiency for Ndiweni village. An almost similar pattern of efficiency is reflected when one looks at partial indices with Mahetshe village.

7.4 Spatial and temporal changes in MW territorial performance

The previous section has used the technical efficiency criteria to assess how territorial capabilities are converted into a MW outcome variable that defines success. While MW income is certainly an important success outcome variable, there are many other variables that existing territorial abilities and potentialities seek to influence. This section looks at how existing territorial clusters compare in performance. A detailed look at these is given in the next sections.

7.4.1 Territorial performance based on quantity of MWs harvested.

The study assumed that territorial attributes that are favourable will naturally permit increased use of the MW resource in terms of quantities harvested by households and / or individual harvesters. Two dichotomous outcomes in terms of harvesting behaviours are possible. Existing territorial conditions will either result in ‘suppressed MW harvesting behaviours’ or in ‘encouraged MW harvesting behaviours.’ Quantities of MWs harvested therefore is an important evaluation field that can be used to gauge how successful a rural territory is. The analysis was done for both the WRS and the DRS. The analysis revealed that the distribution of quantities of MWs harvested by households was not the same across all clusters and across different time periods. A Kruskal Wallis H test revealed sharp differences in quantities of MWs harvested both space and time during the WRS (Chi square = 112.995; df = 4; P-value

<0.0001), and the DRS (Chi square = 103.561; df = 4; P-value <0.0001) (Table 7.9)

Table 7.9 Kruskal Wallis H test summary: Evaluation field – Quantity of MWs harvested.

Test	Null Hypothesis	Test	Sig. ^{a,b}	Decision
1	The distribution of quantity of MWs harvested during the WRS is the same across categories of clusters	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
2	The distribution of quantity of MWs harvested during the DRS is the same across categories of clusters	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
a. The significance level is .050.				
b. Asymptotic significance is displayed.				

Computed figures revealed that five clusters performed differently in relation to the average number of 20 litre buckets of MWs harvested by each household during the WRS. Territory 5 ranked the highest followed by territory, 4, 3, 1, and 2 in that order.

A pairwise comparison using the Kruskal Wallis Test was conducted to check if there were significant differences between the average quantity of 20 litre buckets of MWs harvested by each household (Table 7.10)

Table 7.10 Pairwise comparison of Territorial clusters based on amount of MW harvested (WRS).

Sample 1-Sample 2	Test Statistic	Std. Error	Std. TestStatistic	Sig.	Adj.Sig. ^a
2-3	-102.514	15.936	-6.433	<.001	.000
2-1	115.226	15.030	7.666	<.001	.000
2-4	-124.827	15.030	-8.305	.000	.000
2-5	-157.752	16.103	-9.797	.000	.000
3-1	12.712	15.113	.841	.400	1.000
3-4	-22.313	15.113	-1.476	.140	1.000
3-5	-55.238	16.180	-3.414	<.001	.006
1-4	-9.602	14.155	-.678	.498	1.000
1-5	-42.526	15.289	-2.781	.005	.054
4-5	-32.924	15.289	-2.153	.031	.313
Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is .050.					
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.					

While the majority of clusters share statistically significant differences (P -values < 0.05) in terms of quantities of MWs harvested during the WRS, the analysis further revealed statistical similarities (P -values > 0.05) between Territory 3 and 1; Territory 3 and 4; Territory 1 and 4; Territory 1 and 5 and Territory 4 and 5. Although the amount of MWs harvested by each household is low for the DRS, the analysis revealed a similar pattern of ranking in terms of territorial performance with Territory 5 ranked the highest and territory 2 ranked the least (see Figure 7.8).

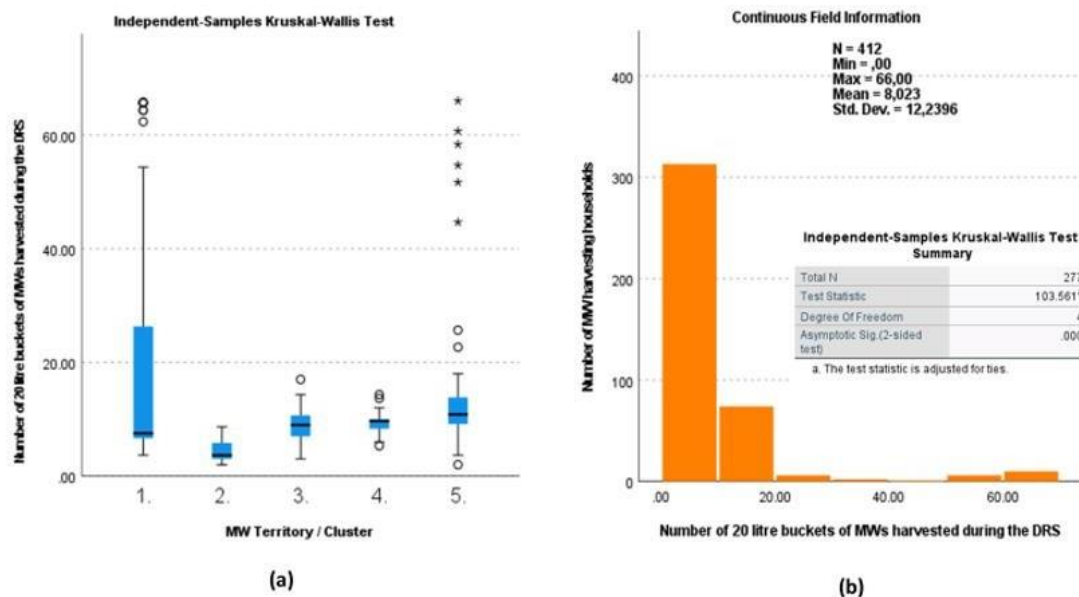


Figure 7.8 Quantity of MWs harvested in each territorial cluster (DRS).

A pairwise comparison of each territorial cluster revealed a similar pattern of cluster differences and similarities except for territory 1 and 5 where this time a statistical difference in the mean quantities harvested was discerned (Table 7.11).

Table 7.11 Pairwise comparison of Territorial clusters based on the amount of MW harvested (WRS).

Sample 1-Sample 2	Test Statistic	Std. Error	Std. TestStatistic	Sig.	Adj.Sig. ^a
2-3	-107.191	15.920	-6.733	<,.001	.000
2-1	108.654	15.015	7.236	<,.001	.000
2-4	-114.928	15.015	-7.654	<,.001	.000
2-5	-152.607	16.087	-9.487	.000	.000
3-1	1.463	15.098	.097	.923	1.000
3-4	-7.737	15.098	-.512	.608	1.000
3-5	-45.416	16.164	-2.810	.005	.050
1-4	-6.273	14.141	-.444	.657	1.000
1-5	-43.953	15.274	-2.878	.004	.040
4-5	-37.680	15.274	-2.467	.014	.136

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is .050.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

The analysis revealed statistically significant differences between all cluster except for the pairs cluster 3 and 2; cluster 3 and 1; 3 and 4; 1 and 4, and 4 and 5.

7.4.2 Territorial performance based on quantity of MWs sold to the market.

The amount of income derived by households from selling MW produce to the market is a good indicator of successful territorial dynamics. We expect households selling more quantities of MWs stocks to the market to generate more revenue than those selling less assuming no significant differences in prices offered by different markets.

The study assumed that territorial attributes that are favourable to success will naturally permit households to sell large quantities of MW stocks to the market. Two dichotomous outcomes in terms of nature of sales are possible. Existing territorial conditions will either result in 'limited sales' or in 'increased sales.' Quantities of MWs sold to the market is therefore another important evaluation field that can be used to gauge how successful MW territory is. The analysis revealed that the distribution of quantities of MWs sales of harvesting households was not the same across all clusters and across different time periods. A Kruskal Wallis H test revealed sharp differences in quantities of MWs sold to the market **by each household** both in space and time during the WRS (Chi square = 98.699; df = 4; P-value <0.0001), and the DRS (Chi square = 68.609; df = 4; P-value <0.0001). Similar observations can also be made when one looks at individual harvester diaries. A Kruskal Wallis H test revealed significant disparities in quantities of MWs sold to the market **by each harvester** both in space and time during the WRS (Chi square = 98.699; df = 4; P-value <0.0001), and the DRS (Chi square = 67.127; df = 4; P-value <0.0001). (Table 7.12).

Table 7.12 Hypothesis Test Summary

Test	Null Hypothesis	Test	Sig. ^{a,b}	Decision
1	The distribution of quantities of MWs sold by each household to the market during the WRS is the same across categories of MW territories / clusters	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
2	The distribution of quantities of MWs sold by each household to the market during the DRS is the same across categories of MW territories / clusters	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
a. The significance level is .050.				
b. Asymptotic significance is displayed.				

During the WRS, we see all clusters performing differently in relation to the amount of MWs each household is selling on the market (Figure 7.9).

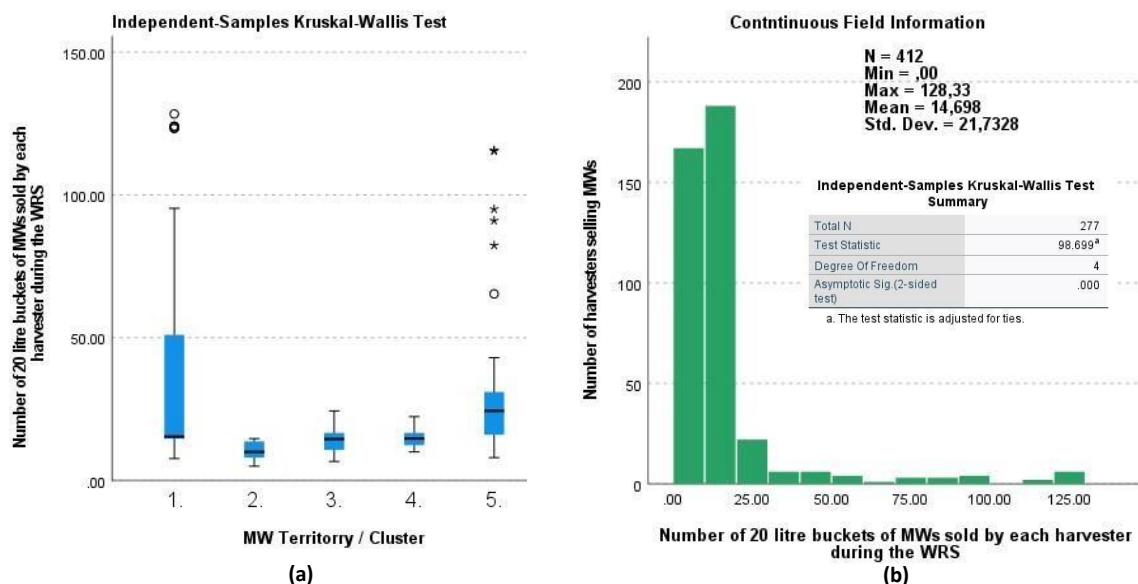


Figure 7.9. Territorial differences in the amount of MWs sold to the market (WRS)

Territory 5 again emerges as the territory where most households are selling more MW stocks to the market when compared with others. Territory 2 emerges as the poorly performing territory in terms of the number of 20 litre buckets of MWs sold to the market. Such differences are statistically different across all clusters (P-value <0.05) except for cluster3 and 4; cluster4 and 1, and cluster 1 and 5 where the P-value is greater than 0.05 (see Table 7.13)

Table 7.13. Pairwise comparison of Territorial clusters based on the amount of MW sold (WRS).

Sample 1-Sample 2	Test Statistic	Std. Error	Std. TestStatistic	Sig.	Adj.Sig. ^a
2-3	-59.153	15.914	-3.717	<,.001	.002
2-1	-80.078	15.010	-5.335	<,.001	.000
2-4	119.179	15.010	7.940	<,.001	.000
2-5	-142.124	16.081	-8.838	.000	.000
3-1	-20.924	15.093	-1.386	.166	1.000
3-4	60.026	15.093	3.977	<,.001	.001
3-5	-82.971	16.159	-5.135	<,.001	.000
1-4	39.102	14.136	2.766	.006	.057
1-5	-62.047	15.269	-4.064	<,.001	.000
4-5	-22.945	15.269	-1.503	.133	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is .050.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

A similar pattern of territorial differences is also portrayed for the DRS with the number of 20 litre buckets of MWs sold by each household somewhat reduced (figure 7.10).

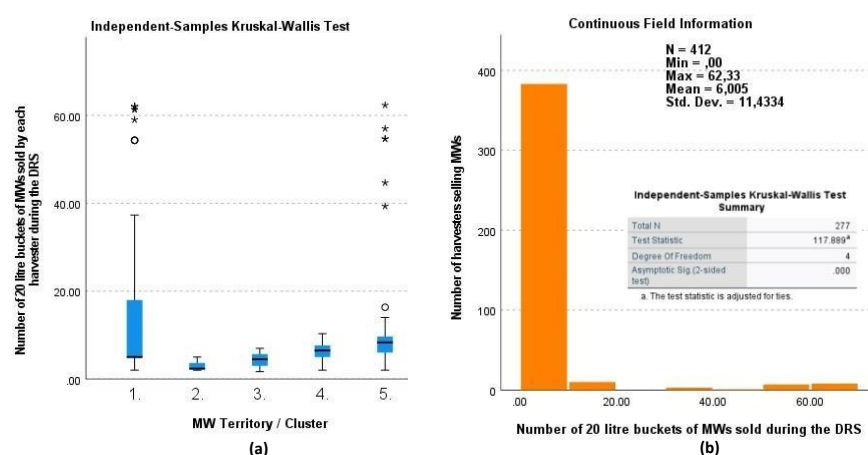


Figure 7.10. Territorial differences in the amount of MWs sold to the market (DRS)

We see the number of 20 litre buckets of MWs sold by each household drop from 15 to a low

of 6.

7.4.3 Territorial performance based on the Household Commercialisation Index (HCI).

The study also assumed that territorial attributes that are favourable will naturally permit high level of commercialisation of the MW resource in terms of the ratio of the quantity of MWs sold to the market, relative to the quantity harvested by households and / or individual harvesters. In this case two dichotomous territorial outcomes in terms of commercialisation behaviours are possible. Existing territorial conditions will either result in ‘low level of commercialisation’ or in ‘high level of commercialisation.’ The Household Commercialisation Index (HCI) therefore is an important evaluation field that can be used to gauge how successful a rural territory is. The analysis revealed that the HCI was not the same across all clusters and across different time periods. A Kruskal Wallis H test revealed sharp differences in quantities of MWs harvested both space and time during the WRS (Chi square = 105.336; df = 4; P-value <0.0001), and the DRS (Chi square = 44.420; df = 4; P-value <0.001),

During the WRS, the analysis observes high HCIs for all clusters. These however vary significantly from one cluster to the next. The intensity of household involvement in the output market higher for Territory 1 and 2 followed by territory 5,3 and 4 in that order (figure 7.11).

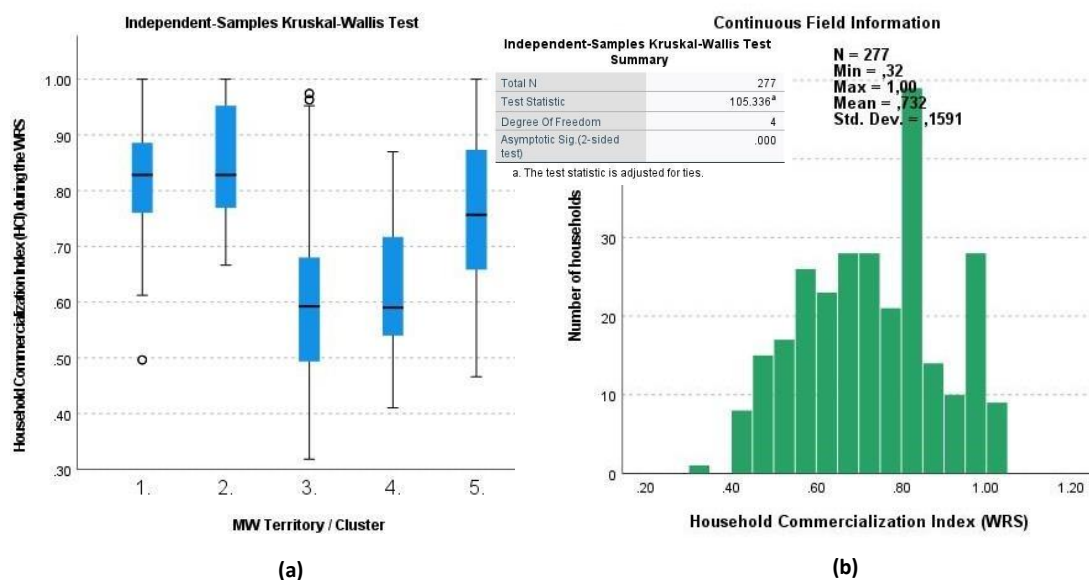


Figure 7.11 Territorial performance based on the HCI (WRS).

While all territorial clusters attracted an HCI score of 0.732 indicating high intensity of involvement on commercialisation of the worm, we see statistically significant differences between all territorial clusters (Table 7.14).

Table 7.14 Pairwise comparison of Territorial clusters based on the HCI (WRS).

Sample 1-Sample 2	Test Statistic	Std. Error	Std. TestStatistic	Sig.	Adj.Sig. ^a
4-3	8.558	15.116	.566	.571	1.000
4-5	-78.396	15.291	-5.127	<.001	.000
4-1	104.188	14.157	7.359	<.001	.000
4-2	118.055	15.032	7.854	<.001	.000
3-5	-69.838	16.183	-4.316	<.001	.000
3-1	95.630	15.116	6.327	<.001	.000
3-2	109.498	15.938	6.870	<.001	.000
5-1	25.792	15.291	1.687	.092	.917
5-2	39.659	16.105	2.463	.014	.138
1-2	-13.868	15.032	-.923	.356	1.000
Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is .050.					
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.					

A few exceptions however exist between the HCIs of territorial cluster 4 and 3, cluster 5 and 1, cluster 5 and 2, and cluster 1 and 2 where the differences are not statistically significant (P-values > 0.05).

As households transition to the DRS, we see the average HCI for all territorial clusters drop to 0.684 due to low harvests. Territorial cluster 2, 1 and 5 portray a high intensity of involvement in the commercialisation of the worm when compared to Territory 4 and 3 where such intensity is low.

The distribution of differences and similarities between the HCIs of territories during the DRS exhibited the same pattern as that of the WRS.

7.4.4 Territorial performance based on selected livelihood pathways.

The study also assumed that territorial attributes that are favourable will propel households to adopt more progressive livelihood pathway strategies such as ‘stepping in’ and ‘stepping out’ as opposed to more conservative and regressive livelihood pathway strategies such as ‘hanging in’ and ‘linking in’. In this case two dichotomous territorial outcomes in terms of livelihood

pathway strategies are possible. Existing territorial conditions will either result in households adopting livelihood pathway strategies that are ‘progressive’ or conservative’. Livelihood pathway strategies adopted by the households can therefore be used as an important evaluation field that can be used to measure how successful a rural territory is. The analysis revealed that adopted livelihood pathway strategies were not the same across all territorial clusters and across different time periods. A Kruskal Wallis H test revealed significant differences in the type of livelihood strategies adopted by harvesting households both space and time during the WRS (Chi square = 72.596; df = 4; P-value <0.001), and the DRS (Chi square = 162.263; df = 4; P-value <0.0001).

During the WRS we see interesting differences between the clusters in terms of the livelihood pathway strategies adopted. Territory 5 emerges as the best cluster where many households are adopting more progressive livelihood pathways strategies such as stepping in and stepping out in addition to linking in (figure 7.12).

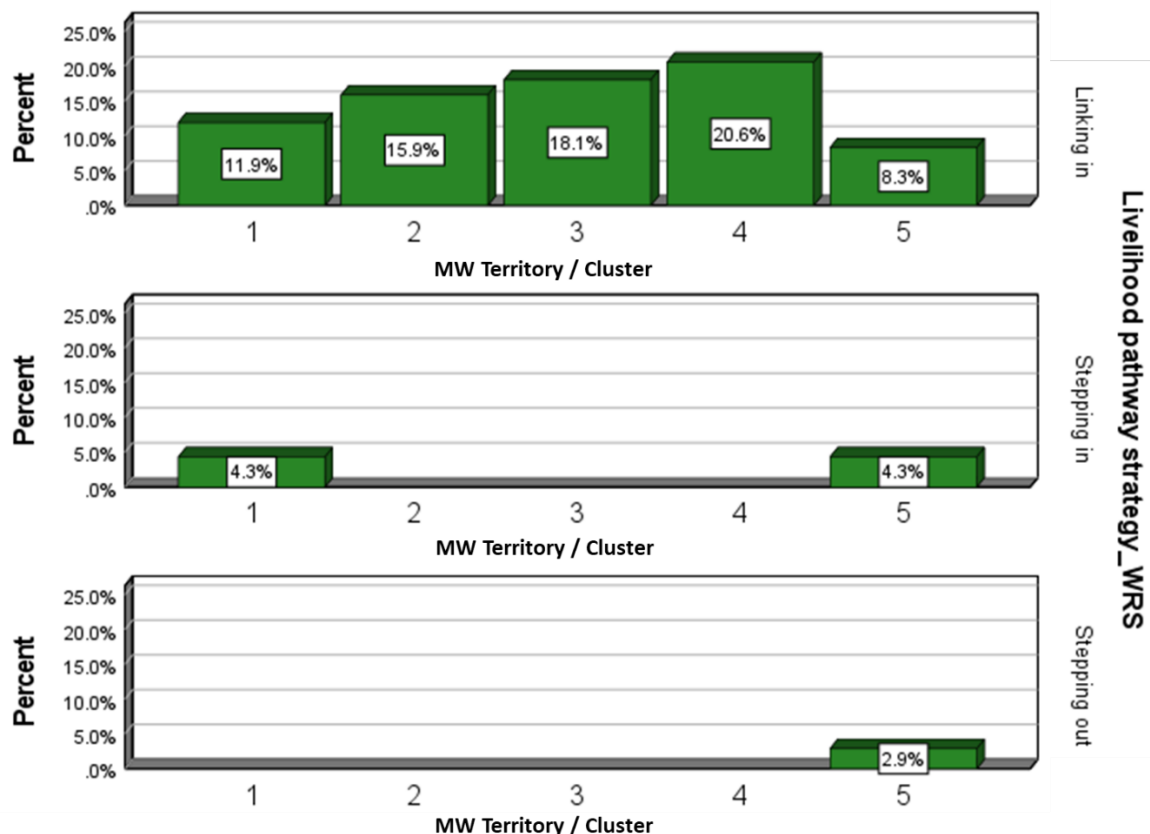


Figure 7.12 Territorial performance based on livelihood pathway strategy adopted (WRS).

The second placed territory is cluster 1 where 4.3% of the households have also adopted the stepping in strategy in addition to the 11.9% who have adopted the linking in strategy. The rest

of the ordering is cluster 4, followed by cluster 3 and 2 where households have only adopted the linking in strategy. This analysis is encouraging as it reveals that when MW supplies are high as in the WRS, households tend to adopt more progressive livelihood strategies that may help spread the risks by using MW proceeds to diversify into other sectors of the local economy.

As households transition into the DRS, we see a significant proportion of households engaging in a retrogressive livelihood pathway strategy of hanging in (figure 7.13). These findings have significant LED implications. Interventions seeking to encourage households to adopt life changing livelihood strategies should focus of finding ways to boost MWs as we have seen that work with the WRS scenario.

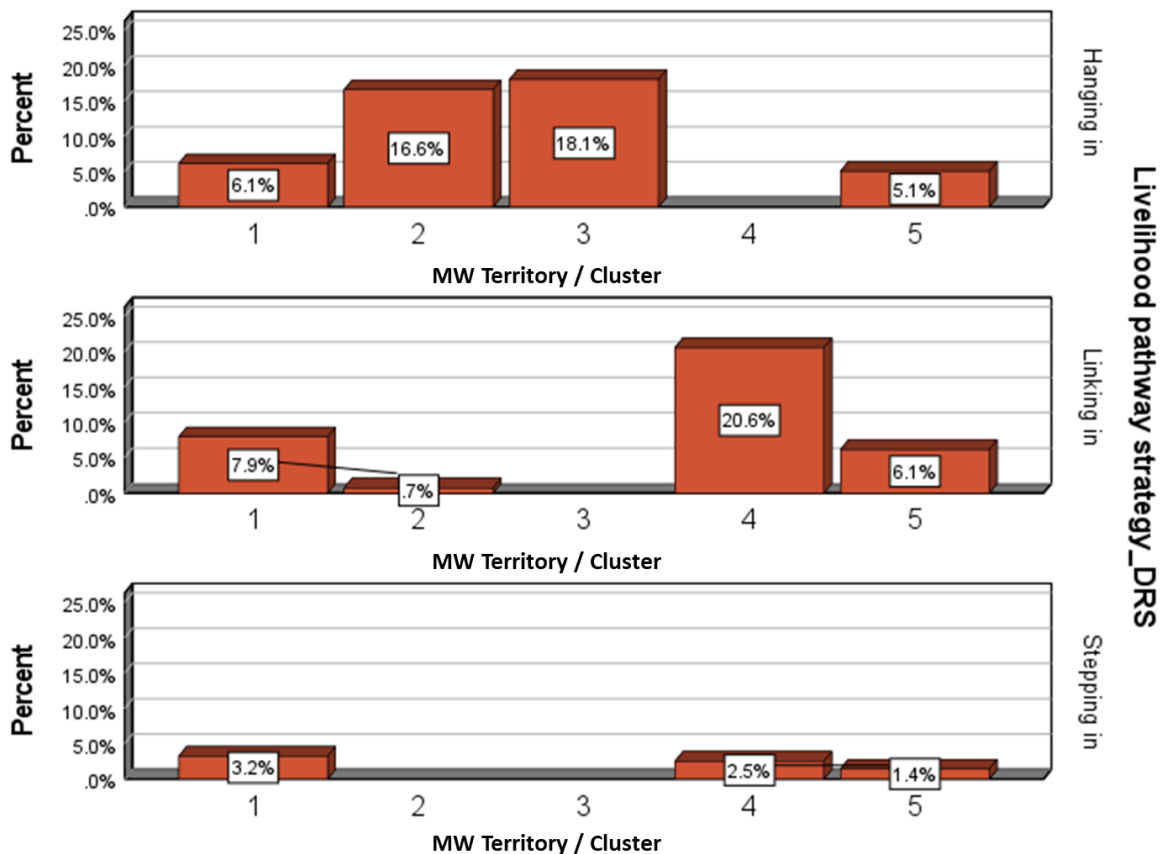


Figure 7.13 Territorial performance based on livelihood pathway strategy adopted (DRS).

7.5 Factors affecting territorial success.

To identify factors associated with territorial success, correlation analysis was performed between the factors of each territorial system capability dimension and the output variable used in the calculation of the GTDI. While only one out-put variable was used in DEA relating to

the WRS, two output variables were used in correlation analysis for both resource states to get a temporal dimension to the analysis. MW income per household was therefore used as a proxy measure of successful territorial outcomes. The Pearsons coefficients depicting association between ESC and MW income are shown in Table 7.15.

Table 7.15 Pearson's coefficient depicting association between ESC and MW income.

Code / Variable name	Pearson's Correlation Coefficient (r)	
	WRS	DRS
ESP1 Level of degradation around the homestead (100 m radius)	,138**	,089
ESP4 Drainage Density	,143**	,137**
ESP5 Ecosystem service provisioning goods	,050	,000
ESP6 Flood water characteristics	-,156**	-,154**
ESP7 Stream order characteristics	,320**	,252**
ESP9 Soil Moisture storage abilities	,043	,023
ESP10 Type of plant community	-,054	-,081
ESP11 MW resource supplies	,122*	,070
ESP12 Households from constrained ecohydrological systems	-,155**	-,127**

* Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

Although the correlation coefficients are pointing towards a either a weak positive or weak negative association between ESCs and MW income, such correlation was found to be statistically significant for such variables as level of land degradation around the homestead ($P < 0,001$) drainage density ($P < 0.001$), flood water characteristics ($P < 0.001$), stream order characteristics ($P < 0.001$), MW resource supplies ($P < 0.05$), and households from constrained ecohydrological systems ($P < 0.001$) at least during the WRS. The significance of these factors is consistently reflected during the DRS apart from the level of degradation and MW resource supplies where the correlation statistics are not statistically significant.

The Pearsons correlation coefficients depicting association between ISC and MW income are shown in Table 7.16.

Table 7.16. Pearson's coefficient depicting association between ISC and MW income.

Code / Variable name	Pearson's Correlation Coefficient (r)	
	WRS	DRS
ISP1 Presence of degrading land use practices	-,129**	-,110*
ISP4 Importance Institutional importance	,167**	,170**

ISP5 Institutional Influence	,167**	,170**
ISP6 Institutional Attitude	,167**	,170**
ISP7 Institutional resourcefulness	,167**	,170**
ISP8 Institutional Support	,167**	,170**
ISP10 Social capital accumulation (WRS)	,197**	-
ISP11 Social capital accumulation (DRS)	-	,302**

* Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

The Pearsons correlation coefficients depicting association between SSC and MW income are shown in Table 7.17.

Table 7.17 Pearson's coefficient depicting association between SSC and MW income

Code / Variable name	Pearson's Correlation Coefficient (r)	
	WRS	DRS
SSP1 Wealth status based on income and asset profile	,310**	,295**
SSP2 Household size (moving average)	,084	,041
SSP3 Average age of harvester (WRS)	,113*	-
SSP4 Average age of harvester (DRS)	-	,101
SSP5 Type of livelihood strategies adopted (WRS)	,228**	-
SSP6 Type of livelihood strategies adopted (DRS)	-	,181**
SSP7 Households losing family member(s) due to emigration.	,076	,056
SSP8 Households whose family members have lost jobs	,168**	,165**
SSP9 Households affected by sickness and death	,232**	,234**
SSP10 Number of harvesters involved (WRS)	,427**	-
SSP11 Number of harvesters involved (DRS)	-	,311**
SS12 Dominant livelihood pathway strategy (WRS)	,237**	-
SS13 Dominant livelihood pathway strategy (DRS)	-	,187**

* Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

The study revealed significant positive correlation between ISC attributes such as social capital accumulation ($P < 0.001$), institutional influence, attitude, resourcefulness, and support (P -value < 0.001). The significant negative correlation associated with presence of degrading land-use practices indicates the negative relationship that exist between MW income as a successful outcome variable and that attribute. This means that an increase in the number of degrading land use practices will significantly ($P < 0.001$) limit the amount of MW income that a household will get through trade.

The Pearsons correlation coefficients depicting association between EcSC and MW income are

shown in Table 7.18.

Table 7.18 Pearson's coefficient depicting association between EcSC and MW income.

Code / Variable name	Pearson's Correlation Coefficient (r)	
	WRS	DRS
EcSP3 Household Commercialisation Index (DRS)	,435**	,445**
EcSP5 Market efficiency	,106*	,099*
EcSP6 Sale completion rate (of MW stocks)	,046	,043
EcSP7 Investment / innovation drive	,409**	,329**
EcSP9 Interaction with outside markets (WRS)	,300**	-
EcSP10 Interaction with outside markets (DRS)	-	,273**
EcSP14 Level of economic complexity	,167	,170
EcSP15 Behavioural intention to adopt new innovations.	,409**	,329**
EcSP18 Distribution channel (WRS)	,444**	-
EcSP19 Distribution channel during (DRS)	-	,359**
EcSP23 Resource markets mostly used	,094	,074

* Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation coefficients depicting association between PESC and MW income are shown in Table 7.19.

Table 7.19 Pearson's correlation coefficient depicting association between PESC and MW income.

Code / Variable name	Pearson's Correlation Coefficient (r)	
	WRS	DRS
PESP1 Proximity to major rural market.	,207**	,199**
PESP3 Road Pavement Condition	-,127**	-,119**
PESP4 Economic complexity	,175**	,176**
PESP5 Inherent risk to market infrastructure	-,128**	-,118**
PESP6 Road pavement surface conditions	-,132**	-,119**
PESP7 Improvements in housing infrastructure (structural)	,394**	,365**
PESP8 Improvements in housing infrastructure (roofing material)	,160**	,171**
PESP9 Changes in water source (Water access)	,159**	,149**
PESP10 Changes on telephone ownership (access to ICT)	,350**	,320**
PESP11 Improvements in own transportation means	,517**	,470**
PESP12 Resource markets mostly used	-,094	-,074
PESP13 Location of major harvest (place where most harvest is obtained)-(WRS)	,434**	,363**

PESP14 Location of major harvest (place where most harvest is obtained)-(DRS)	,324**	,261**

* Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

7.6 MW territorial space resistance to external changes and shocks in the local environment and beyond.

The study assumed that MW territories that are resistant to external shocks are characterised by vulnerable households who adopt more progressive and more resilient strategies to counter the challenges paused by adversity. We would expect significant positive correlations between the vulnerability status of households exposed to external shocks (such as loss of employment, sickness and death in the family, sudden emigration, and adverse weather conditions) and the adoption of resilient and other mitigatory strategies in the harvesting, processing and marketing of the MW. We would expect the harvesting, processing, and resource marketing behaviours to be adjusted to deal with the effects of external shocks. We also expect the vulnerable households to increase their innovation drive in the face of adversity. This section seeks to:

1. Ascertain if households most affected by external shocks are systematically deciding to employ more adaptive, and resilient strategies. The main assumption here is that MW territories that are non-resistant to external shocks will conversely be associated with risk averse households who are less willing to adopt more progressive and more resilient livelihood strategies.
2. Categorise and rank MW territories according to three main resilience capacities commonly mentioned in territorial / regional resilience literature including Absorptive Capacity (AbC), Adaptive Capacity (AdC) and Transformative capacity (TC).
3. To identify the main determinants of resilience of territorial resilience that can be valorised in developing MW based LED strategy.

7.6.1 Effect of external shocks on resilience strategy adoption

To understand the effect of external shocks on the type of resilient strategies adopted by households, the study first segmented all households according to external stressors. Two categories of households were created in each external stressor situation (the most affected versus the least affected). We employed a supervised segmentation approach in which median values were used to define cut off points resulting in least affected as opposed to most affected

households. We then question the extent to which such two categories of households are willing to adopt more progressive and resilient strategies given their external shock circumstances. A decision tree diagram approach was used in this case measure the likelihood of vulnerable households adopting progressive and more resilient strategies. This section reviews the following.

7.6.1.1 External shocks versus reliance on risk limiting livelihood strategies.

7.6.1.2 External shocks versus interaction with outside markets.

7.6.1.1 External shocks versus reliance on risk limiting livelihood strategies.

The study assumed that households that occupy more resistant MW territories will have a high appetite for adopting risk limiting livelihood strategies such as ‘stepping in’ and ‘stepping out’ strategies as opposed to ‘hanging in’ and ‘linking in’ Strategies. A multivariate statistical analysis using decision tree diagrams was generated to check the behaviour of vulnerable household during the WRS. The significance of the results was tested using the Chi Square Automatic Detection Algorithm (CHAID) method. The appropriateness of the model in assessing predicted behaviours was done by inspecting the resulting classification table that yielded an acceptable value of 70.1%. Results are shown in Figure 7.14.

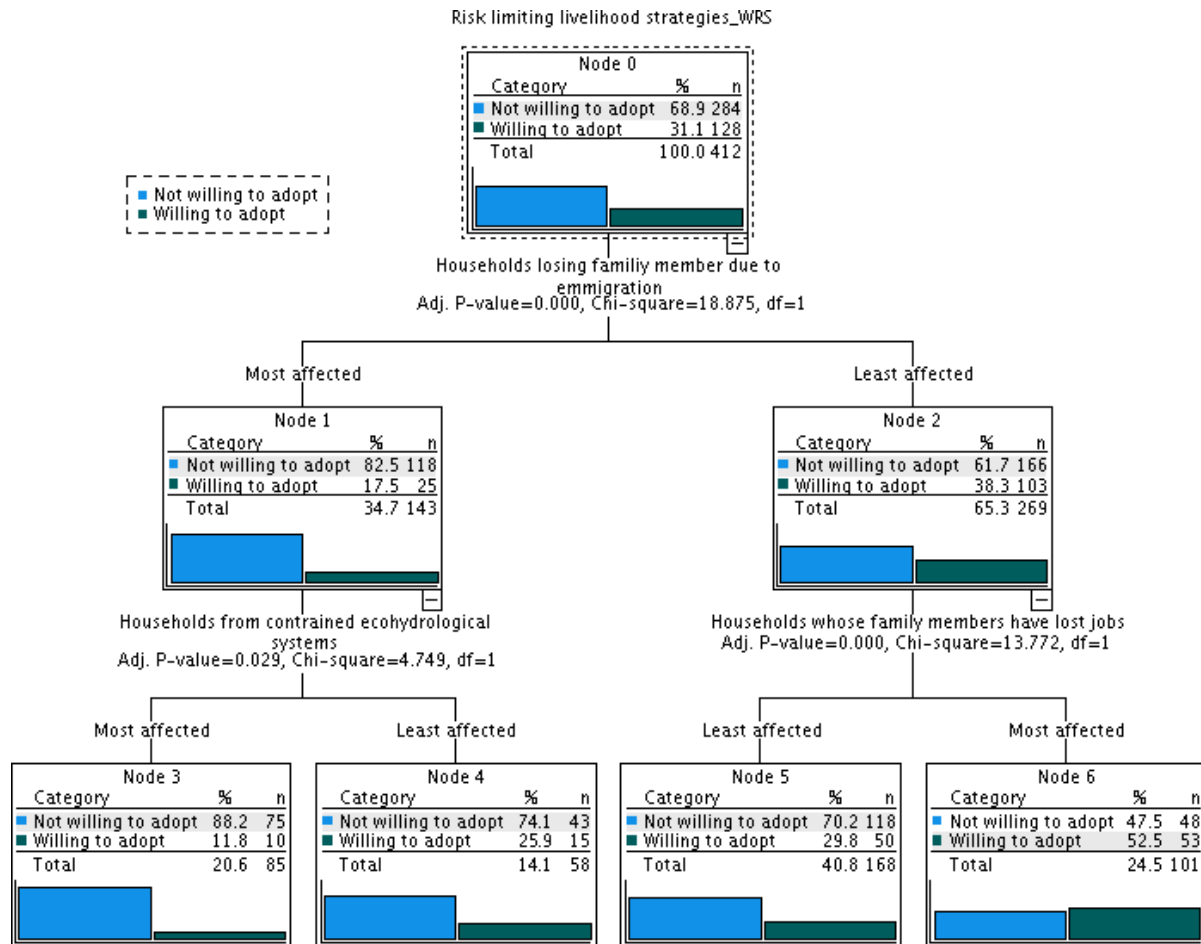


Figure 7.14. Effect of external shocks on reliance on risk limiting strategies (WRS).

Results reveal that many households (82.5%) mostly affected by losing family members due to sudden emigration are less willing to rely on risk limiting livelihood strategies such as ‘stepping in’ and ‘stepping out’. Only a small proportion (17.5%) are willing to invest in risk limiting livelihood strategies. These results are statistically very significant (Chi-square = 18.875; df= 1; P-value <0.0001). Such findings reveal that a lack of willingness to escape their current vulnerabilities. The same pattern of results is reflected when one looks at least affected households in this category where many (61.7%) are not willing to adopt risk limiting livelihood strategies compared to those willing (38.3%). Interesting though is a significant proportion (38.3%) of those that are willing to invest in such strategies in this category. While a similar behavioural pattern is also depicted by households located in ecohydrologically constrained environments; a significantly different finding is that portrayed by households who have family members that have lost jobs. To compensate for lost income, many of them (52.5%) have taken a progressive and sustainable step of adopting risk limiting livelihood strategies. Such a finding is statistically significant (Chi-square = 13.772; df= 1; P-value < 0.0001). Results

in relation to households affected by sickness and death are not shown as they were not statistically significant.

The models predictive capabilities for the DRS stood at 61.9%. The same statistical procedures were employed to observe the behavioural intentions of the same categories of households in adopting risk limiting resilience strategies in the face of adversity during the DRS. The resulting tree diagram is shown in Figure 7.15.

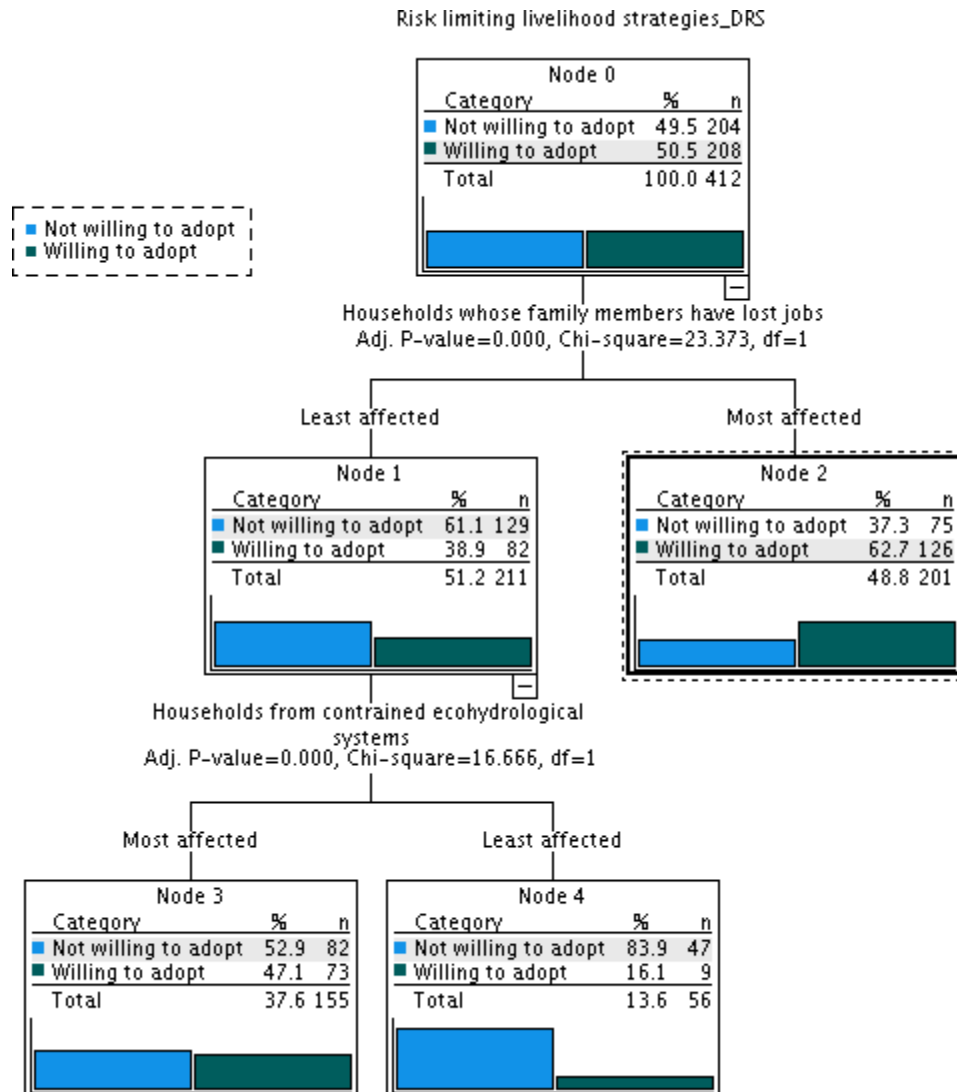


Figure 7.15. Effect of external shocks on reliance on risk limiting strategies (DRS).

Results in the DRS were only significant for households whose members lost jobs and those who come from severely constrained ecohydrological ecosystems. We also see a significantly larger proportion of households (62.7%) from families most affected by job losses having a high appetite for adopting risk limiting livelihood strategies.

7.6.1.2 External shocks versus interaction with outside markets.

The study assumed that *idiosyncratic health, severe weather, and economic shocks tend to diminish important linkages between MW trading activities and markets within and beyond the boundaries of the rural economy*. A decision tree diagram was constructed to test this assumption during the WRS. The significance of the results tested using the Chi Square Automatic Detection Algorithm (CHAID) method. The appropriateness of the model in assessing predicted behaviours was done by inspecting the resulting classification table that yielded an acceptable value of 69.3%. Using extent of interaction with outside markets as a dependent variable, the analysis expected to see such interaction diminish as households get constrained by existing shocks. Mixed results were discerned as shown in Figure 7.16.

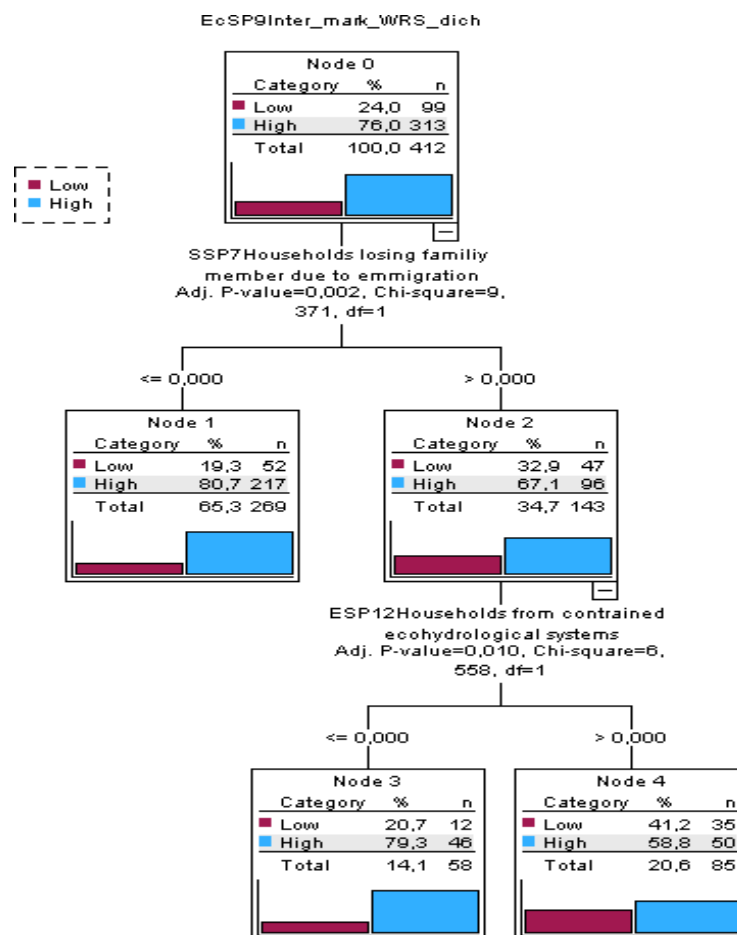


Figure 7.16. Effect of external shocks on households' interaction with outside markets.

Despite using households losing family members (due to sudden emigration), losing jobs, affected by sickness and death, and those affected by severe weather conditions as input variables into the analysis, the assessment yielded significant results on two input variables as shown in Figure. We see many households (80.7%) least affected by loss of family members (<0.00) significantly interacting with outside markets that in the previous analysis were characterised as more efficient. The same pattern of interaction is also portrayed when one looks at households most affected by loss of family members (>0.00). Although the proportion is in relative terms lower (67.1%), these results come as a surprise. Probably reflecting a compensatory behaviour by households left in the household. A similar picture is also true for household residing in strained ecohydrological conditions. No significant associations were discerned during the DRS.

7.6.2 A cluster analytical creation of MW communities according to Territorial Resilience attributes.

The study sought to calculate the Resilience Capacity Index (RCI) to summarise a MW territory's status on several factors hypothesized to influence the ability of a region to bounce back from a future unknown stress. Such a single statistic would permit comparisons across MW regions / territories and the subsequent identification of strong and weak conditions relative to other MW regions. Such analysis is critical in LED studies as it will allow us to assess how future investments in the MW business would help increase the resilience capacities of households so that they are better prepared to deal with adversity.

Resilience as one of the variables that defines successful territorial dynamics was in this analysis assumed to be a function of three overarching capacities that include (i) Absorptive Capacity (AbC) (ii) Adsorptive Capacity (AdC) and (iii) Transformative Capacity (TC). A series of capacity indicator variables under each territorial capacity were identified and defined according to data shared in the methods section. This section focuses on creating unique clusters of communities based on these three resilient capacity attributes using a k-means clustering algorithm. Once that is done it gives a detailed description of how various communities compare and contrast on the basis of such resilient capacities. In the end a weighted Resilient Capacity Index using the entropy method is calculated. Based on such the analysis then employs the logistic regression equation to identify and rank the resilience capacity indicators according to their extent of influence on the resilience of MW communities

should they be subjected to external shocks or any form of adversity. The section is structured as follows.

- Data screening procedures
- Segmentation of MW territories according to Resilience Capacity Indicators
- Resilience structure matrices for each resilience capacity
- Segmentation of households according to village and ‘Resilience Capacity’ context
- Segmentation of households according to distance from major markets and ‘Resilience Capacity’ context
- A global perspective territorial resilience and factors affecting it.

7.6.2.1 Data screening procedures

Data on resilient capacity indicators was first screened using normality test measures of skewness and kurtosis. Indicator variables that did not meet the ± 2 cut off value were removed from further statistical analysis. Appendix 3 gives detailed information of variables under each resilient capacity that were retained or removed for further statistical analysis. All resilient capacity indicator variables met the cut off value requirements. They were then further subjected to scale reliability analysis using the Cronbach Alpha statistic. Results are shown in Table 7.20.

Table 7.20 Screening resiliency capacity indicators via scale reliability analysis

Resilience Study Construct	# of variables before screening	# of variables after screening*	Cronbach Alpha Statistic	Remark
1. Absorptive Capacity (AbC)	14	14	0.809	Very good
Adaptive Capacity (AdC)	11	6	0.632	Acceptable
Transformative Capacity	16	11	0.608	Acceptable

*Refers to variables that were eliminated including. (AdC1; AdC5; AdC7; AdC8; AdC9) and (TC7; TC13; TC14 TC2; TC9)

7.6.2.2 Segmentation of MW territories according to Resilience Capacity Indicators

A combination of the 2 -step and K-means clustering algorithm was used to identify and group common MW territories exhibiting similar resilience attributes based on 41 resilience variables relating to three main territorial abilities, including Absorptive Capacity (AbC), Adaptive Capacity (AdC) and Transformative Capacity (TC). First the Two-step clustering algorithm was employed to identify the number of such unique clusters (see Figure 7.17).

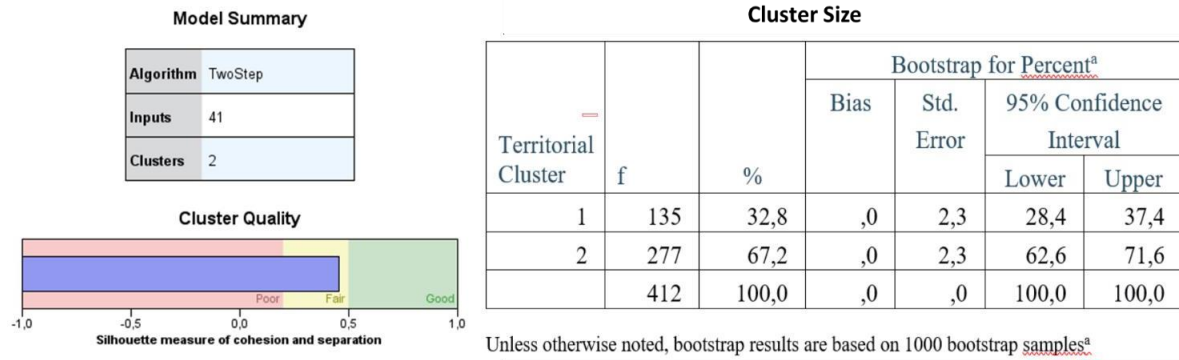


Figure 7.17. Two-step clustering solution depicting two unique MW territories.

The Two-Step clustering process generated two distinct clusters of MW territories occupied by households possessing two distinct type of resilience abilities. The clustering process generated an acceptable value (0.5) of the Silhouette measure of cohesion and separation. Based on the computed standardised z score values of each of the three resilient capacities, including AbC, AdC and TC, cluster 2 type of MW territories were in relative terms found to be more resilient when compared to Cluster 1 type of MW territories that were found to be fragile (see Figure 7.18). Type 2 MW territories registered positive resilient scores on all three resilient capacities while Type 1 MW territories registered negative resiliency scores. These statistics are in principle encouraging given that the majority (67.2%) of sampled households are residing in in relatively resilient MW territories compared to 32.8% residing in relatively fragile MW territories.

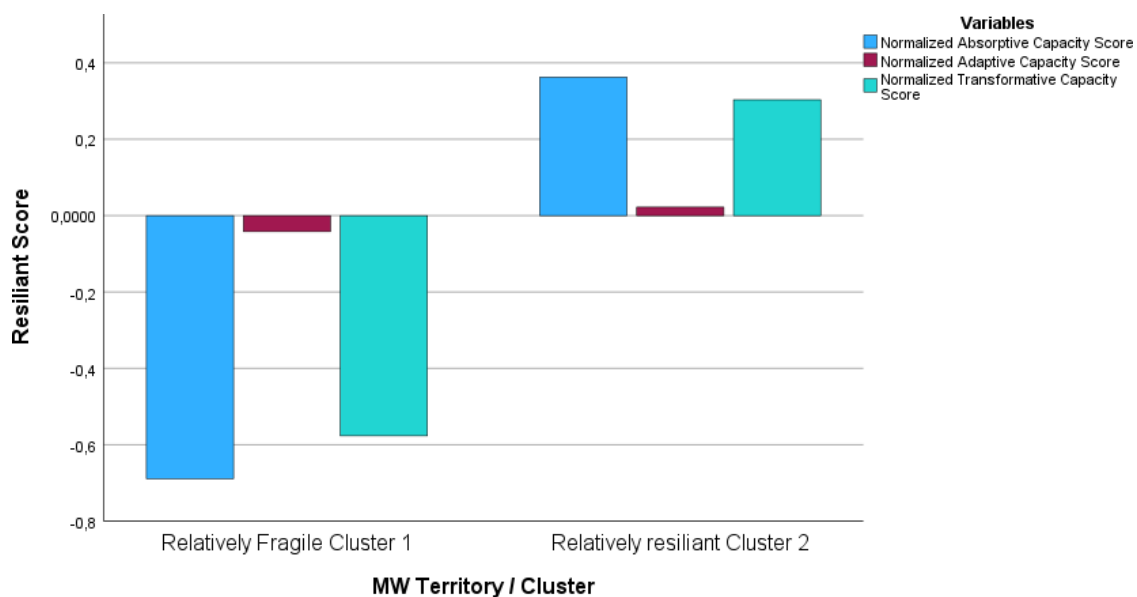


Figure 7.18. Resilience structure matrix based on standardised z-score values of resilient capacity study constructs.

Further statistical analysis through the ‘Independent Samples Mann-Whitney U test and the Wilcoxon W test revealed that such differences are statistically significant for all three resilient capacities (Figure 7.19).

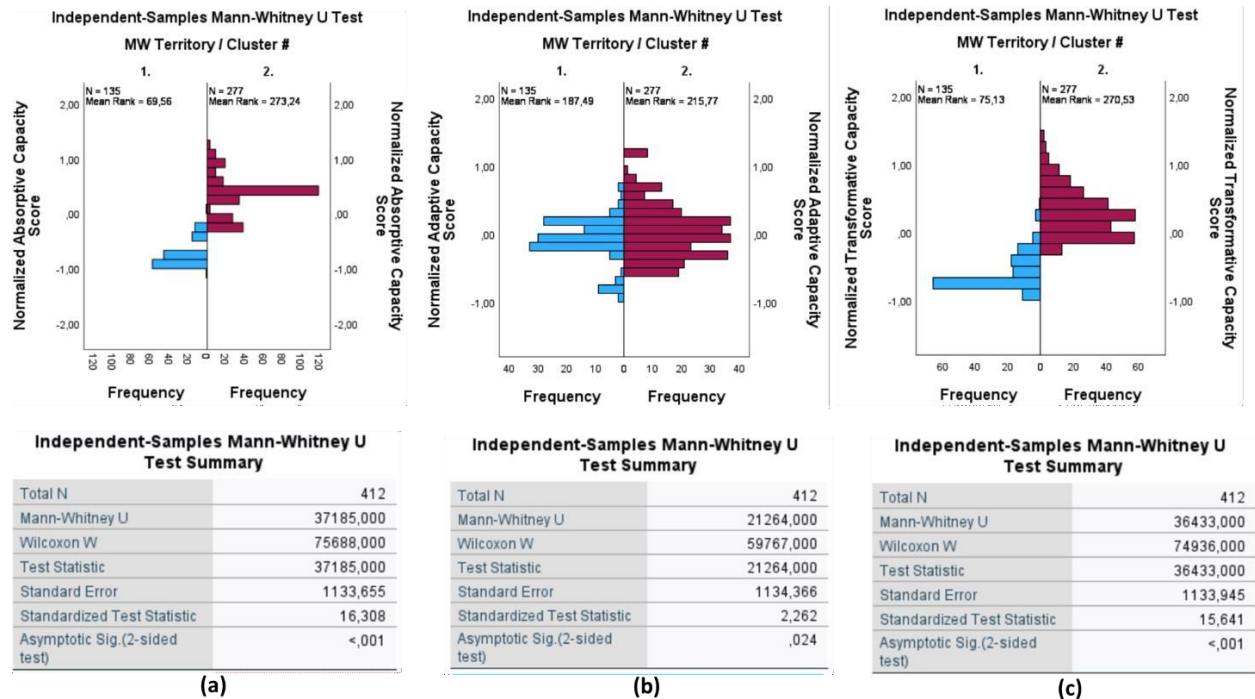


Figure 7.19 Mann-Whitney U test results on territorial performance based on (a) Absorptive Capacity (b) Adsorptive Capacity and (c) Transformative Capacity.

The study tested if the distribution of normalized resilient capacity scores were the same across all clusters. Results showed statistically significant differences across all three resilient capacities including absorptive capacity (P-value <0.01), adaptive capacity (P-value = 0.024) and transformative capacity (P-value <0.01). Since some of the resilience capacity variables are MW use related variables, these results have important policy implications if removal of such variables from such analysis would result in the reduction of resilience scores. Such analysis is later conducted in the next chapter. Fragility reflected by Type 1 MW territories calls for interventions to build absorptive, adsorptive, and transformative resilience capacities.

7.6.2.3 Resilience structure matrices for each resilience capacity

A disaggregation of resilient capacity statistics according to specific indicator variables however revealed that Type 1 territorial cluster does perform relatively better in certain resilience capacity indicators despite its fragility. In relation to absorptive capacity, the study revealed that Type 1 fragile MW territories were performing relatively better in such resilience

capacity indicators such as preparedness to deal with shock and ability to mitigate and in the existence of institutional support systems (figure 7.20).

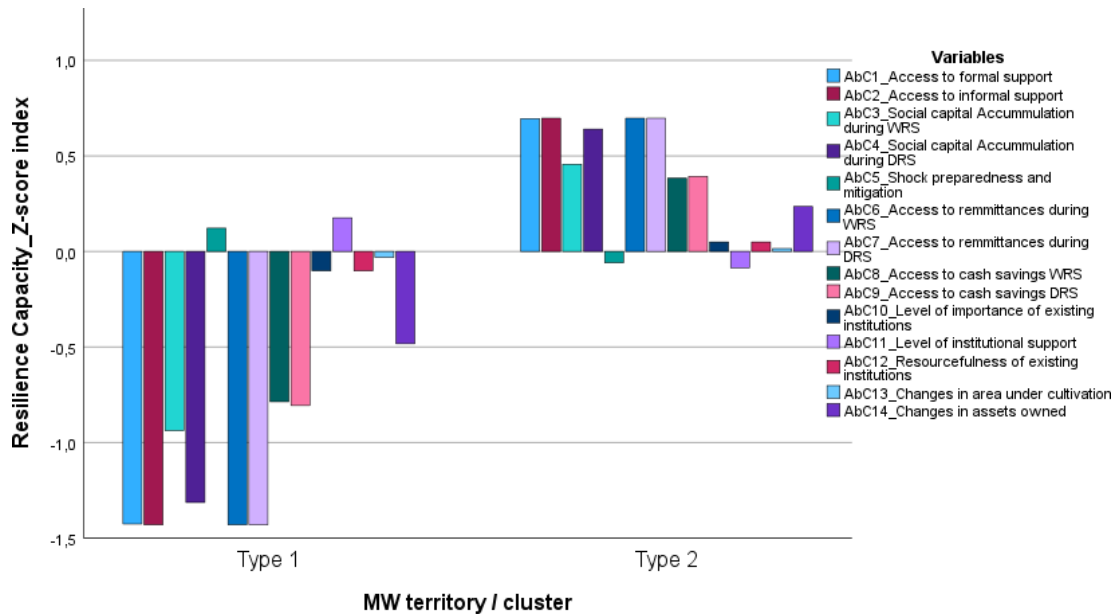


Figure 7.20. Resilience structure matrix showing territorial performance according to Absorptive Capacity (AbC).

Type 2 resilient MW territories were on the other hand found lacking in these capacity areas. In terms of adaptive capacity, Type 1 fragile MW territories were found to be relatively better in the existence of non-degrading land use practices (figure 7.21).

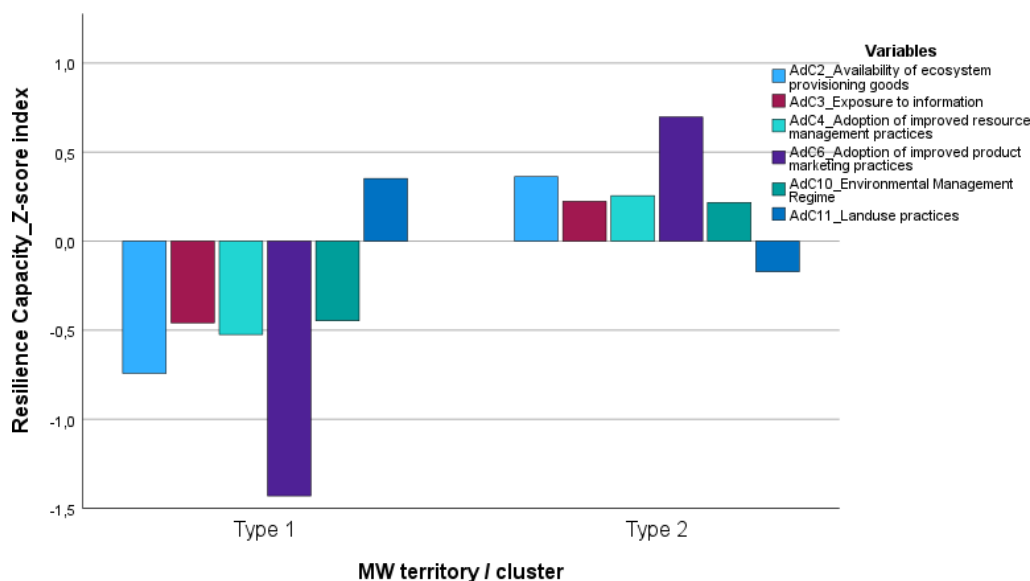


Figure 7.21. Resilience structure matrix showing territorial performance according to Adaptive Capacity (AdC).

While still considered fragile from a transformative capacity perspective, Type 2 fragile MW territories were found to be performing better in 4 main capacity areas as shown in Figure (7.22).

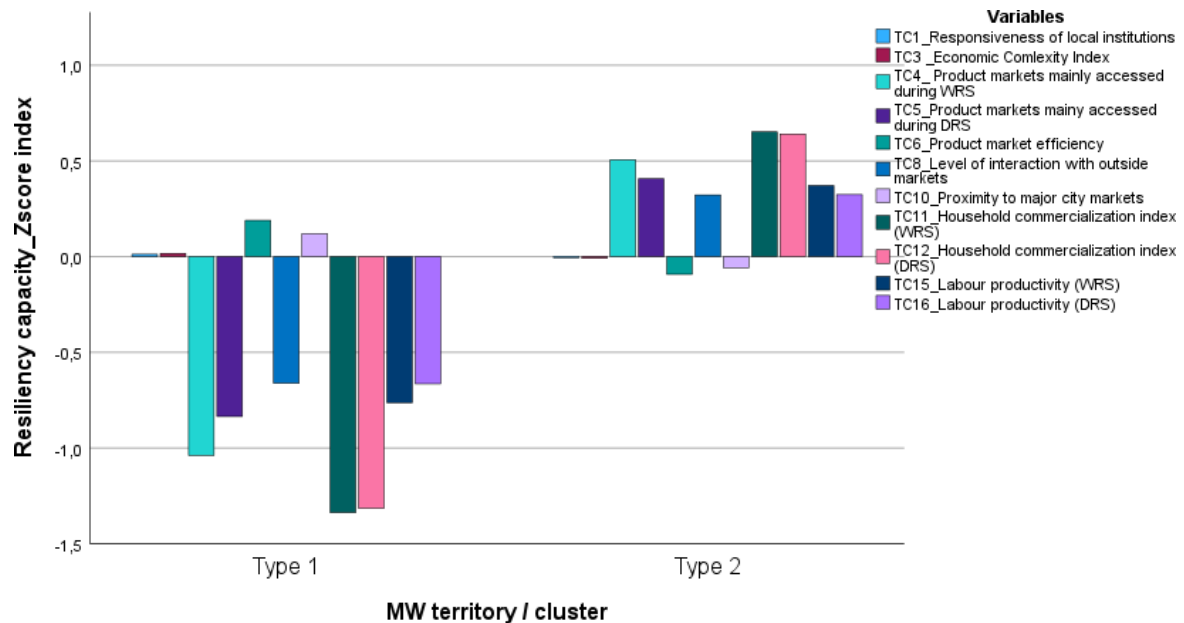


Figure 7.22. Resilience structure matrix showing territorial performance according to Transformative Capacity (TC).

The analysis found type 2 territories excelling in relative terms in such variables as responsiveness of local institutions, economic diversification (measured by economic complexity index), product market efficiency and proximity to major city markets.

7.6.2.4 Segmentation of households according to village and 'Resilience Capacity' context

At the village scale, the analysis revealed that many households reside in environments that can be classified as relatively resilient (i.e. Cluster 2 type of MW territories) as opposed to relatively fragile environs largely characterising type 1 type of MW territories (see Figure 7.23). The only exception is Ndiweni village where most sampled households were found to be situated in fragile environments. A statistically significant relationship between number of households in each village and the resilience cluster was discerned (Chi-square = 34.634; df =4; P-value<0.001) although the effect size of such an association was found to be significantly moderate (Cramer's V = 0.29).

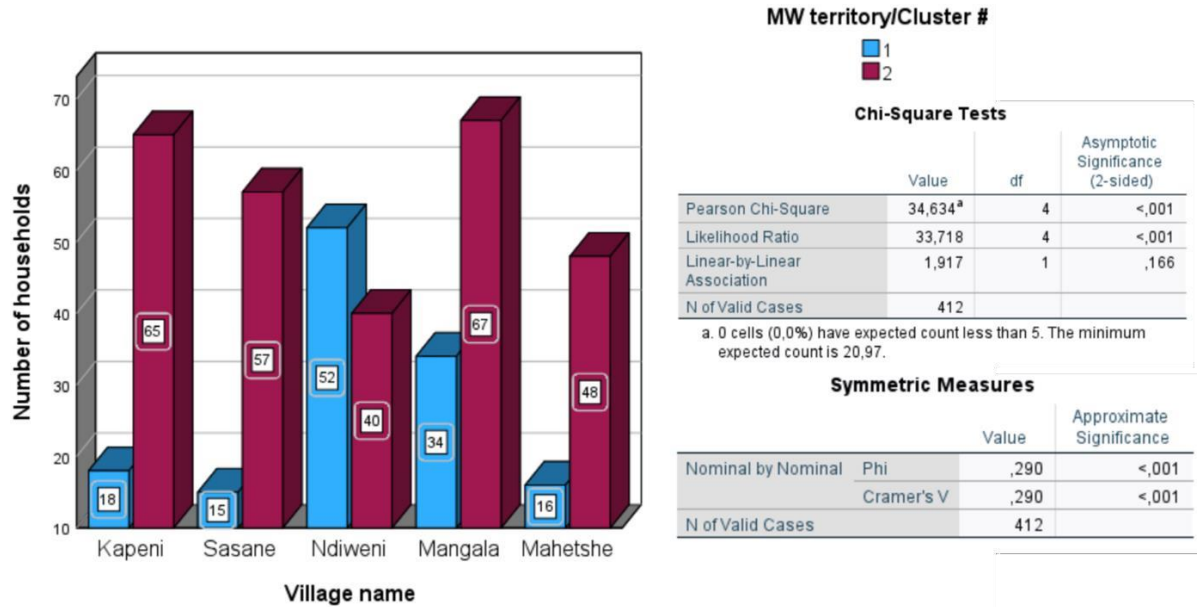


Figure 7.23 Resiliency capacity for each village stacked against unique clusters of resiliencies.

7.6.2.5 Segmentation of households according to distance from major markets and 'Resilience Capacity' context

The analysis attempted to compare the resilience capabilities of both proximal and distal communities. It sought to understand of distance from major markets as a spatial variable would affect resilience capacities of communities. Results stacked against unique clusters of resilience are shown in Figure 7.24.

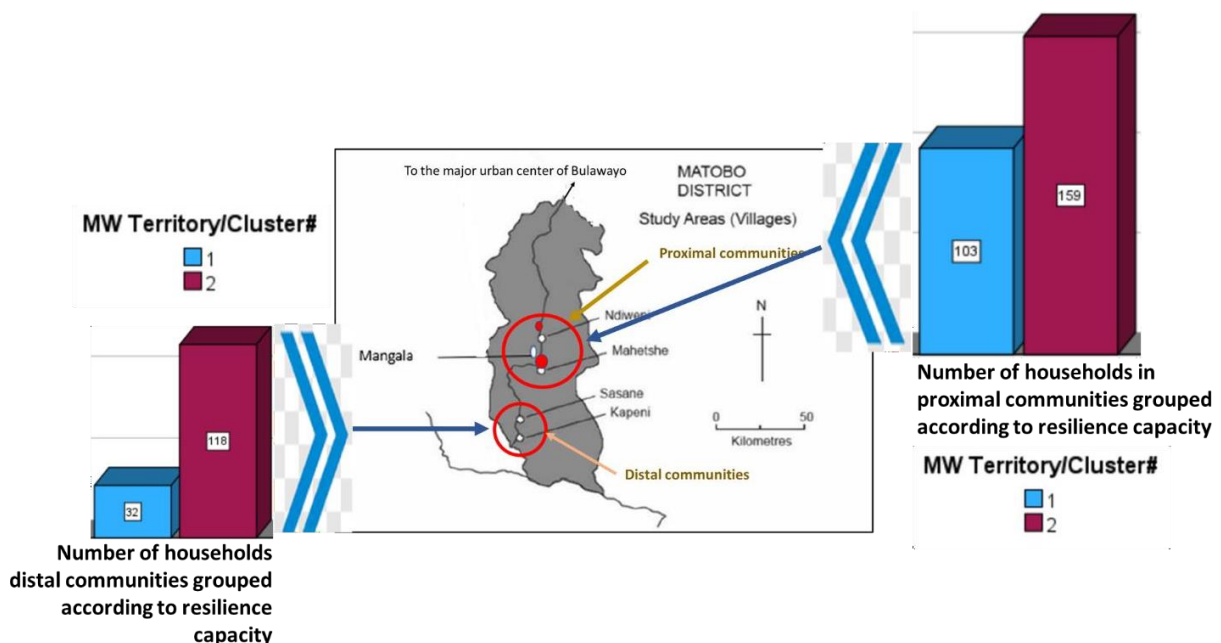


Figure 7.24 Resiliency capacity of proximal and distal communities stacked against unique clusters of resiliencies.

In distal communities, we observe that many households (79%) occupy territorial contexts that have been classified as resilient. We however still see about 21% occupying fragile territories. This similar picture is also observed when one looks at proximal communities where 61 % of households belong to resilient territories while 39% belong to fragile territories. Such findings reveal that territorial resilience is not a constant variable as one moves away from major markets.

7.6.2.6 A global perspective territorial resilience and factors affecting it.

While in the previous session resilient capacity was largely treated as an unweighted dummy variable that has been generated by a clustering algorithm, this section calculates a weighted resilience index that combines all the three resilient capabilities analysed in previous sections using the entropy method. The calculated weighted Partial Resilient Capacity Indices (PRCIs) are shown in Table 7.21.

Table 7.21. Unweighted and weighted Partial Resilient Capacity Indices (PRCIs)

MW Territory / Cluster	Partial Resilient Capacity Index		
	Absorptive Capacity Index (X_{ij})	Adaptive Capacity Index (X_{ij})	Transformative Capacity Index (X_{ij})
Type 1 (unweighted)	0.1473	0.3999	0.1336
Type 2 (unweighted)	0.6250	0.4615	0.5070
W_j	0.578256	0.00715	0.414597
Type 1 (Weighted)	,1469	,2860	,1351
Standard Deviation	,11489	,10738	,12056
Type 2 (Weighted)	,6231	,3300	,5127
Standard Deviation	,15603	,13274	,14780
Combined capacity (Weighted)	,4671	,3155	,3889
Standard Deviation	,26597	,12657	,22560

Data portrayed shows that type 1 Mopane worm territories are categorised as territories with low resilience in all three capacities as the associated Resilience Capacity Scores (RCS) are less than 0.33. Type 2 territories on the other hand are in relative terms more resilient although the RCSs are classified as moderate resilience since they lie between the scores of 0.33 and 0.66 (i.e. $0.33 < RCS < 0.66$). The GRI for Type 1 territories yielded a score of 0,1893 (standard

dev.= 0,07627; $RCS < 0.33$) while that of Type 2 territories yielded a score of 0,4886 (standard dev.= ,09657; $0.33 < RCS < 0.66$). An ANOVA test analysis revealed a statistically significant ($P\text{-value} < 0.001$) difference between the two RCSs (Table 7.22)

Table 7.22. ANOVA test results: difference between GRIs of Type 1 and Type 2 MW territories.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8,130	1	8,130	993,991	<,001
Within Groups	3,353	410	,008		
Total	11,483	411			

The effect size as measured by Eta squared attracted a value of 0.708. since it is closer to 1, this is considered as strong effect.

Global Resilience Indices for each village

Global Resilience Indices were also calculated for each village. Results are summarised in Figure 7.25. Results reveal that four villages of Mahetshe, Sasane, Kapeni and Mangala have RCS values lying between 0.33 and 0.66 indicating that such territories are moderately resilient. Ndiweni village however emerged as fragile community since its RCS was less than 0.33.

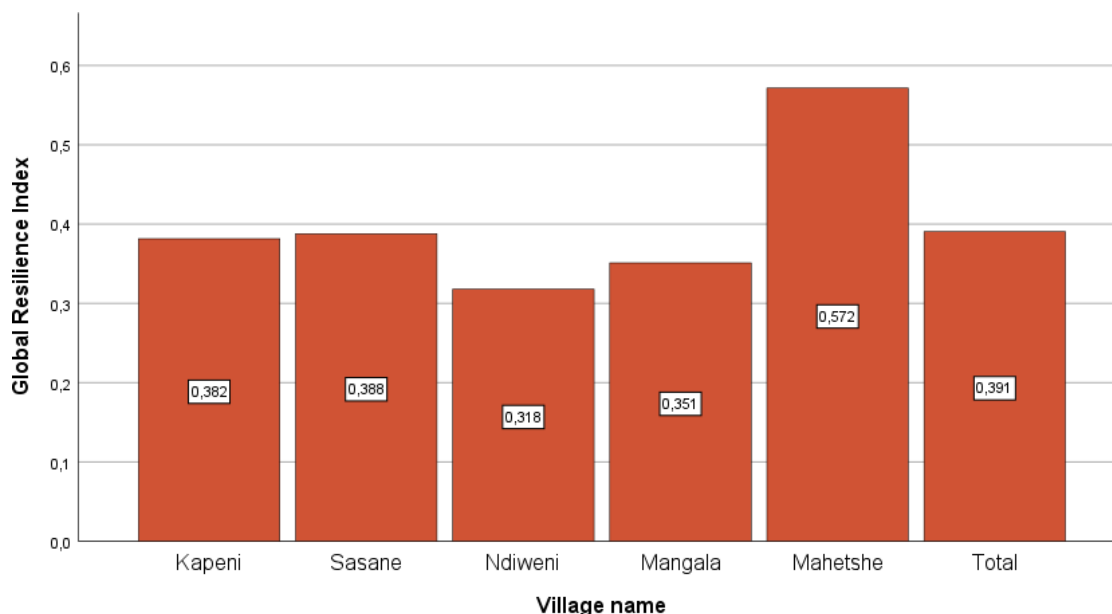


Figure 7.25. Global Resilience Indices for each village.

The GRIs of each village were compared to check if there were any significant differences using the Kruskal Wallis test. Results are summarised in Table 7.23. Each row tested the null hypothesis that the GRIs of village *a* and village *b* are the same.

Table 7.23 Pairwise comparison of GRIs of villages through the Kruskal Wallis Test

Villag a-Village b	Test Statistic	Std. Error	Std. TestStatistic	Sig.	Adj.Sig. ^a
Ndiweni-Mangala	-21,782	17,161	-1,269	,204	1,000
Ndiweni-Kapeni	33,180	18,027	1,841	,066	,657
Ndiweni-Sasane	37,239	18,737	1,987	,047	,469
Ndiweni-Mahetshe	-160,032	19,382	-8,257	<,001	,000
Mangala-Kapeni	11,398	17,642	,646	,518	1,000
Mangala-Sasane	15,456	18,366	,842	,400	1,000
Mangala-Mahetshe	-138,250	19,025	-7,267	<,001	,000
Kapeni-Sasane	-4,058	19,177	-,212	,832	1,000
Kapeni-Mahetshe	-126,851	19,809	-6,404	<,001	,000
Sasane-Mahetshe	-122,793	20,457	-6,003	<,001	,000

Each row tests the null hypothesis that the Village a and Village b distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is ,050.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

The GRI of the moderately resilient village of Mahetshe was found out to be statistically different from that of all other villages (P-value = 0.000). Results also revealed statistically significant differences (P-value = 0.047) between the GRIs of the fragile community of Ndiweni and that of the moderately resilient community of Sasane. No statistically significant differences (P-values>0.05) were discerned between the GRIs of the rest of the villages.

The GRIs of proximal and distal communities are shown in Figure 7.24.

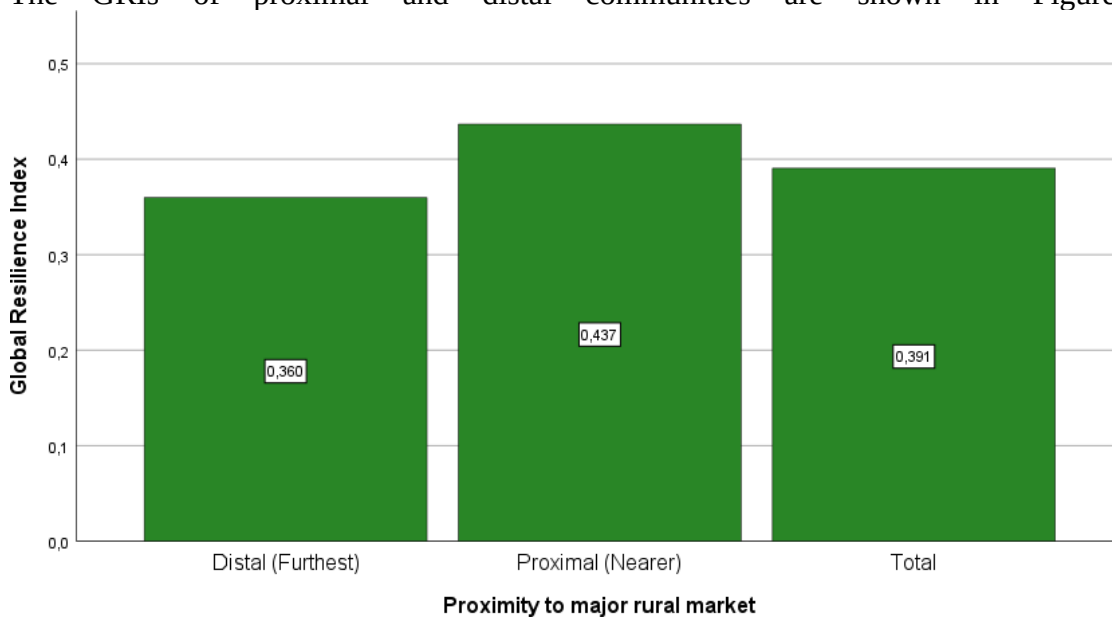


Figure 7.24. The GRIs of proximal and distal communities

Proximal communities GRI of 0.437 was found to be relatively higher than that of distal

communities (GRI = 0.360) and the combined average of both communities (GRI = 0.391). Even though both communities can be classified as moderately resilient, we found statistically significant differences between the two with regards to their GRIs (Table 7.24).

Table 7.24. ANOVA test results: difference between GRIs of proximal and distal communities.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8,130	1	8,130	993,991	<,001
Within Groups	3,353	410	,008		
Total	11,483	411			

The two GRIs were found to be statistically different (P-value<0.01) although the effect size was found to be low (Eta squared = ,051).

Major determinants of resilience in MW territories

One of the intentions of this study was to determine what spatial and temporal variables are critical in defining resilience. The study used the binary logistic regression analysis to make such a statistical assessment, with variables of P-value < 0.05 and higher odds ratios considered to be major determinants. The odds ratios were used as a proxy measure of sensitivity analysis where capacity variables with higher odds were the most sensitive. Not all resilience capacity variables were used as input variables in the model. Further screen was done through correlation analysis where several variables whose correlation was strong ($r > 0.60$) and significant were eliminated (see Appendix 3). The final model, table used 13 input variables. In terms of its predictive capabilities, it correctly classified 98 percent of the low GRIs and 77.9% of the high GRIs (see Table 7.25).

Table 7.25. Classification table^a

Observed		Predicted		
		GRI		Percentage Correct
		Low	High	
GRI	Low	302	6	98,1
	High	23	81	77,9
Overall Percentage				93,0
a. The cut value is ,500				

Hosmer and Lane show statistics revealed an acceptable Goodness of Fit (Chi-squared = 13,322; df = 8; P-value = 0.101). Both the Cox & Snell R Square (R = 0.620) and the Nagelkerke R Square (R = 0,827) are high and acceptable. Results are shown in Table 7.26.

Table 7.26. Binary logistic results: determinants of resilience in MW territories

	B	Wald	df	P-value	Odds ratio
AbC2 Access to informal support	16,685	,000	1	,994	17634442
AbC5 Shock preparedness and mitigation	-,184	,131	1	,717	,832
AbC6 Access to remittances during WRS	-50,813	,000	1	,992	,000
AbC8 Access to cash savings WRS(proxy entre Drive)	2,816	1,955	1	,162	16,713
AbC9 Access to cash savings DRS(proxy entre Drive)	1,662	,632	1	,427	5,270
AbC13 Changes in area under cultivation	-,821	1,450	1	,228	,440
AdC3 Exposure to information	5,363	16,021	1	<,001	213,311
AdC4 Adoption of improved resource management practices	-,966	8,197	1	,004	,381
AdC10 Environmental Management Regime	-,426	2,127	1	,145	,653
AdC11 Land use practices	1,060	4,918	1	,027	2,886
TC8 Level of interaction with outside markets	-,088	,023	1	,880	,916
TC16 Labour productivity (DRS)	,473	25,243	1	<,001	1,605

The most significant determinants of resilience ranked according to the odds ratios are land use practices (P-value = 0.027), labour productivity during the DRS (P-value < 0.001), exposure to information (P-value < 0.001) and adoption of improved resource management practices (P-value = 0,004).

CHAPTER 8: *An evaluation of the nature and strength of MW farm household interactions with the local economy.*

8.0 Introduction

This chapter attempts to evaluate the nature and strength of MW farm household interaction with the local economy. Knowing the extent to which MW farming households are interacting with the local economy is important as it sheds light on the precise contribution of the MW to the local economy. A review of existing LED literature in other related sectors has revealed that this can be done by 6 main approaches including.

- A ‘regional / territorial dynamism in marketing’ approach
- A ‘resource to other sectors linkage’ approach.
- A ‘development as hanging in, stepping up and stepping out’ perspective.
- The impact of MW income on inequality approach.
- A ‘MW households as agents of change’ perspective.
- Resilience Index approach
- An LED index development approach

8.1 A ‘regional / territorial dynamism in marketing’ approach

Existing LED studies maintain that participation of rural households in the output markets holds a significant potential for economic growth, poverty reduction, and advancing the food security situation of rural households (Sher et al., 2021; Zondi et al., 2022). An in-depth understanding of the individual decisions taken by MW harvesting households in terms of which output markets to access and what type of marketing strategies to pursue is very critical in understanding the LED implications of MW trade. Building on the rational choice theory advanced by Sher et al. (2021), we expect the impact of MW use on the local economy to be higher where MW farming households choose to enter lucrative or high paying markets for their harvested MW stocks. Increased participation in distant markets such as major rural and urban centres can be used as a proxy measure for prosperity since such markets are not only efficient but offer a higher price for MW stocks. Increased participation in localised markets such as the back yard, and roadside markets in the rural context markets has negative effect on

rural development since such markets always offer low bargaining power and lower prices for the selling households. In this section, we look at the marketing behaviours of MW farming households. We do this by examining the type of markets often accessed, the type of marketing strategies adopted. Ultimately, we draw inferences on such behaviours.

- 8.1.1 Decision mapping of the likelihood of interaction with the output market
- 8.1.2 Distribution channel choice versus spatial concentration of MW trade
- 8.1.3 Household interaction with the local economy versus spatial concentration of MWtrade

8.1.1 Decision mapping of household's likelihood to interact with output markets.

The study assumed that local economic growth would take place in MW territories where many trading households are interacting with the output markets. In the preceding sections, the Household Commercialisation index (HCI) has been identified as a measure that gauges the intensity of involvement in the selling of the worm by trading households. The higher the HCI the higher is rural household interaction with the local economy via output markets. Our earlier analysis revealed relatively high HCI values for both the WRS and DRS. Although statistics were relatively subdued for the DRS, the overall statistics indicated a higher drive towards resource commercialisation by households. Since such data is based on a sample of 277 trading households, it is possible to draw inferences about the whole population by estimating the household's likelihood to interact with output markets. Such a statistical estimation process is crucial in LED studies as it allows us to estimate the risk associated with households deciding not to commercialise. We employ the decision tree diagram technique in which our variable of interest is HCI to segment, profile and predict household choices made in relation to their intensity of involvement with output markets. We first transform the variable of interest into a dichotomous variable. We do this by considering HCI that are greater than the mean-score value of 0.7320 as 'high intensity of involvement in output markets' and those less than as 'low intensity of involvement in output markets' for the WRS. For the DRS the mean-score cut off value used is 0.6843.

8.1.1.1 Decision tree analysis results for the WRS

The decision tree model adopted for the WRS was evaluated for accuracy using the gains plot and the classification table results. Results revealed that 84.7% of the cases analysed were correctly classified by the model. The accuracy of classification was found to be much higher

for correctly classifying high intensity of involvement (93.4%) than low intensity of involvement in output markets (67.4%). Such differences in predictive capabilities for the two scenarios are also significantly portrayed in the Gains plots in Figure 8.1

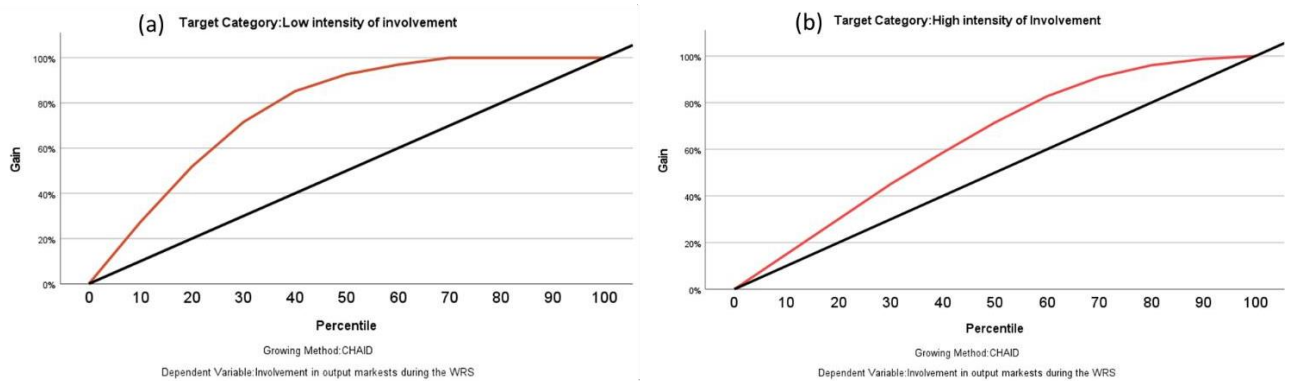


Figure 8.1. Gains plot: intensity of involvement (WRS)

The relative distance of the model graph (in red) from the random model graph (in black) show that the model performed relatively better in correctly classifying high intensity of involvement cases as opposed to low intensity of involvement cases. Decision tree results for the WRS model are shown in Figure 8.2.

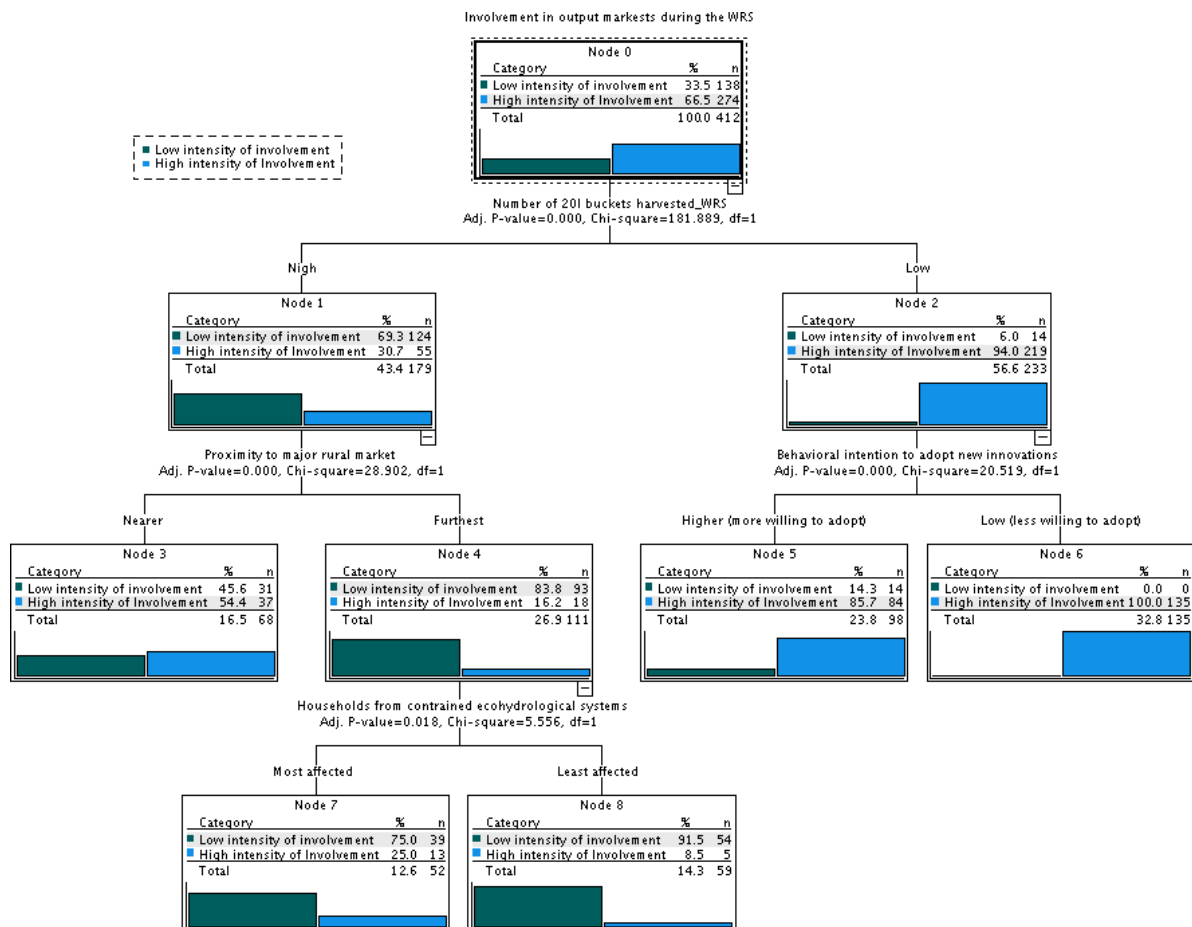


Figure 8.2. household's likelihood to interact with output markets (WRS).

Results show that many sampled households (66.5%) are highly interacting with output markets as opposed to a small proportion (33.5%) that is lowly interacting with output markets for MWs. As expected, the quantity of MWs harvested as measured by the number of 20 litre buckets collected per household is a major predictor of the intensity of involvement in the output markets. The intensity of involvement in the output market was found to be significantly (Chi-square = 181.889; df = 1; P-value<0.0001) low among many households (69.3%) who harvested more than the mean- score value of 19.3 - 20 litre buckets of MWs. On the other hand, the intensity of involvement in the output markets was found to be significantly higher for households harvesting less than the mean- score value of 19.3 - 20 litre buckets of MWs. These results suggest that MW resource commercialisation is common among many households that harvest relatively less quantities of MWs as compared to popular belief that households harvesting larger quantities are more likely to commercialise trade.

Proximity to major rural markets emerged as the second major predictor of household interaction with the output-market. The analysis further revealed that the level and intensity of interaction with the output markets was higher for households located near major rural markets (i.e., for proximal communities) than in those residing in distant locations (i.e., for distal communities). Statistics in Figure show a higher intensity of involvement in output markets for many households (54.4%) located near major rural markets. Similar statistics for households located further away (distal households) are significantly lower at 16.2% (Chi-square = 28.902; df = 1; P-value<0.0001).

The next major predictor is the innovation stretching choice measured by the behavioural intent to innovate. Households were asked about their willingness to stretch their harvesting, processing, storage, and MW resource marketing behaviours by adopting a host of known innovations. Results reveal a high intensity of involvement in in output markets associated with both a high willingness and a low willingness to adopt innovation stretching technologies. All households (100%) that had expressed a lower willingness to stretch their harvesting, processing, storage, and MW resource marketing behaviours were significantly (Chi-square = 20.519; df = 1; P-value<0.0001) associated with higher likelihood to commercialise the resource, when compared to a similar proportion who expressed a higher willingness to stretch (85.7%).

Statistically significant variations in the intensity of involvement in output markets were also found in households located further away from major rural markets according to the

ecohydrological stress characteristics of their MW territories. A high proportion of households (25%) mostly affected by ecohydrological distress conditions in their communities portray a high intensity of involvement with output markets as compared to a relatively low proportion of households (8.5%) least affected by ecohydrological distress conditions. These results suggest that households residing in highly stressed ecohydrological environments are highly motivated to intensify their involvement in MW trade. The likelihood to intensify trade is high in such households probably because they must compensate for lost income opportunities from existing ecosystem provision goods that are limited in breadth and scope. A much broader statistical analysis shown in Table 6.1 show that households mostly affected by stressed ecohydrological conditions are on average access 2.23 ecosystem service provisioning goods as compared to those least affected who are accessing an average of 3.83 ecosystem service provisioning goods.

Table 8.1. Effect of ecohydrological conditions on number of ecosystem service provisioning goods accessed by households.

Type of households affected by ecohydrological stress	Statistical measure	Statistic	Bootstrap ^a			
			Bias	Std. Error	Confidence Interval	
					Lower	Upper
Least affected	Mean	3.83	.00	.16	3.54	4.15
	N	130	0	10	111	149
	Std. Deviation	1.864	-.009	.104	1.642	2.047
Most affected	Mean	2.23	.00	.08	2.07	2.41
	N	282	0	10	263	301
	Std. Deviation	1.465	-.004	.054	1.360	1.570
Total	Mean	2.73	.00	.09	2.57	2.91
	N	412	0	0	412	412
	Std. Deviation	1.765	-.003	.067	1.633	1.899

a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Statistically significant differences in the number of ecosystem provisioning goods accessed by households mostly affected by constrained ecohydrological systems and those least affected were discerned (Chi-square = 93.821; df = 8; P-value < 0.001).

8.1.1.2 Decision tree analysis results for the DRS

The decision tree model adopted for the DRS was evaluated for accuracy using the gains plot and results from the classification table. Results revealed that 83.3% of the cases analysed were

correctly classified by the model. The accuracy of classification was found to be much higher for correctly classifying high intensity of involvement (90.8%) than low intensity of involvement in output markets (62.4%). Such differences in predictive capabilities for the two scenarios are also significantly portrayed in the Gains plots in Figure 8.3.

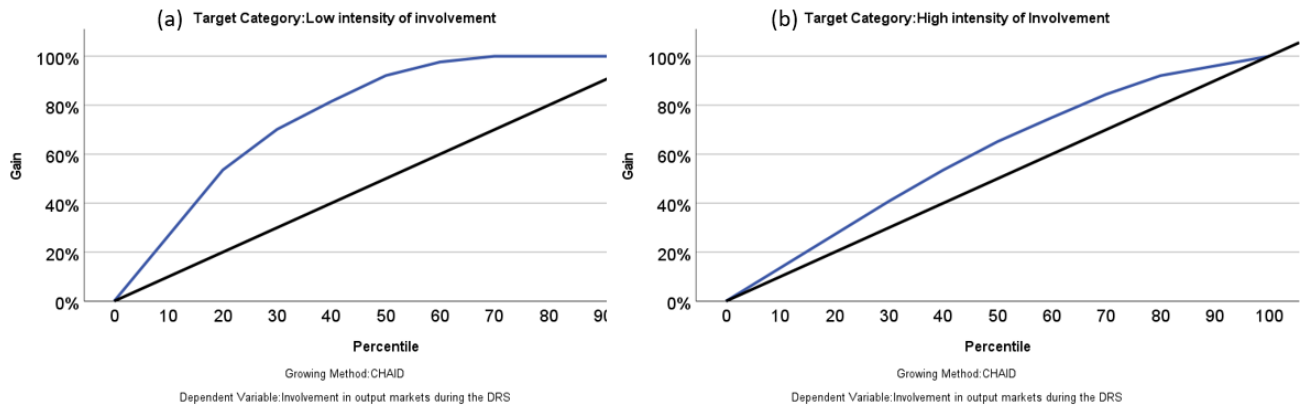


Figure 8.3. Gains plot: Intensity of involvement (DRS)

The Gains plot graph in this case shows the power of the classification model against a random model. The relative distance of the model graph (in blue) from the random model graph (in black) show that the model performed relatively better in correctly classifying high intensity of involvement in in output market cases as opposed to low intensity of involvement in output market cases. Decision tree results for the resultant DRS model are shown in Figure 8.4

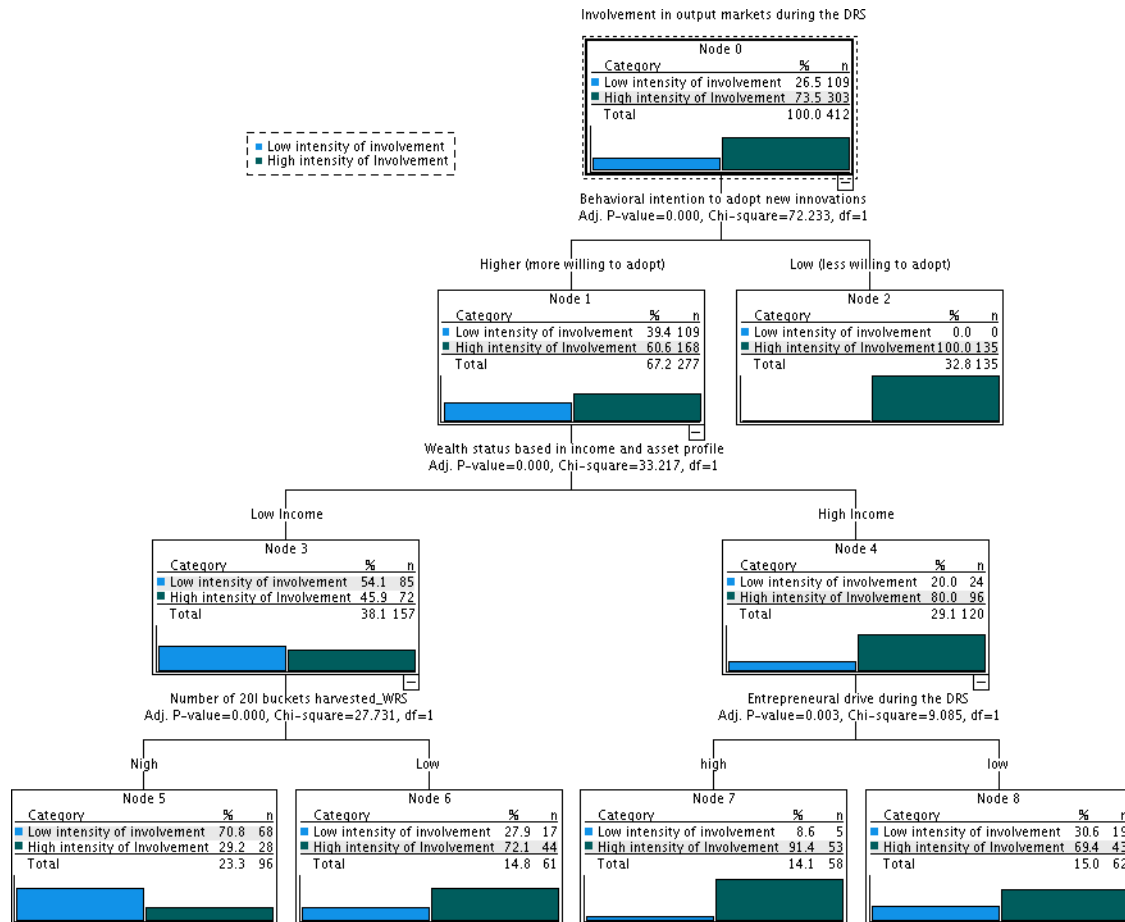


Figure 8.4. household's likelihood to interact with output markets (DRS).

8.1.2 Distribution channel choice versus spatial concentration of MW trade

Knowing where MW trade transactions take place is crucial of promoting growth. The concentration of MW trade was hypothesized to vary from one community to the next owing to several factors such as proximity to major rural markets. We expect proximal communities to be characterised by spatial dispersion of MW trade where most households in addition to selling some of their stock in the backyard or near roadside market, also sell in higher order and higher paying markets such as a rural centre markets, town or major city market. In distal communities we expect MW trade to be centred near the dwelling unit,

where trade is spatially concentrated around the dwelling unit, trading households often sell their stock in what we have referred to as the back yard market and the nearby road-side market (Figure 6.5). A high concentration of such trading transaction near the dwelling unit is problematic for LED as such markets are often characterised as weak and paying less. Export markets are in LED literature characterised as lucrative as they offer higher income to the traders. It was possible in this analysis to characterise places where MW household sold their stock a binary variable depicting spatially concentrated trade as opposed to spatially dispersed trade (Figure 8.5)

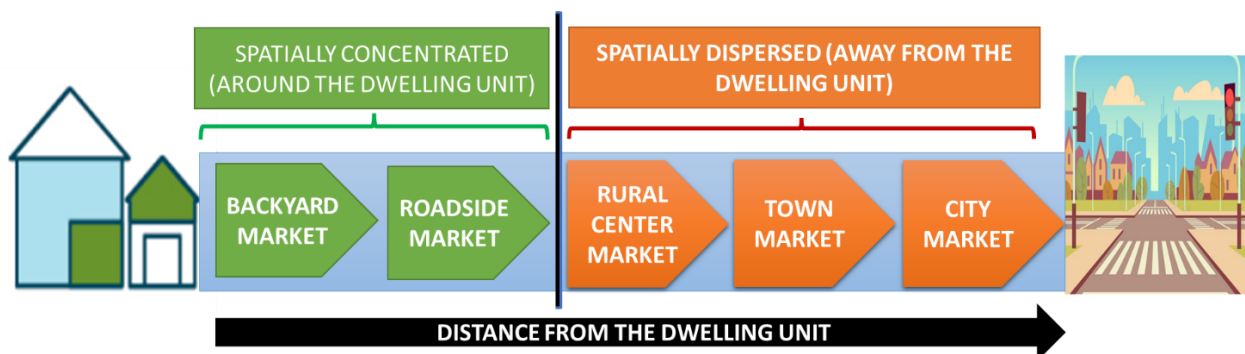


Figure 8.5 *Charactering MW trade as a binary variable – spatially dispersed versus spatially concentrated.*

8.1.2.1 Distribution choice by Village during the WRS and DRS

Figure 8.6 show the distribution channel most used by the MW users by village during the WRS. Distal communities of Kapane and Sasane villages are mostly selling their MW stocks to the nearby roadside market. As such households' transition into the DRS (figure 8.7), we see a higher number selling in backyard markets. Markets that have been revealed in earlier analysis as inefficient and therefore contributing less to the local economy. A similar pattern of observation is made when one looks at the effect of distance from major markets on distribution channel choice (see Figure 8.8 and 8.9).

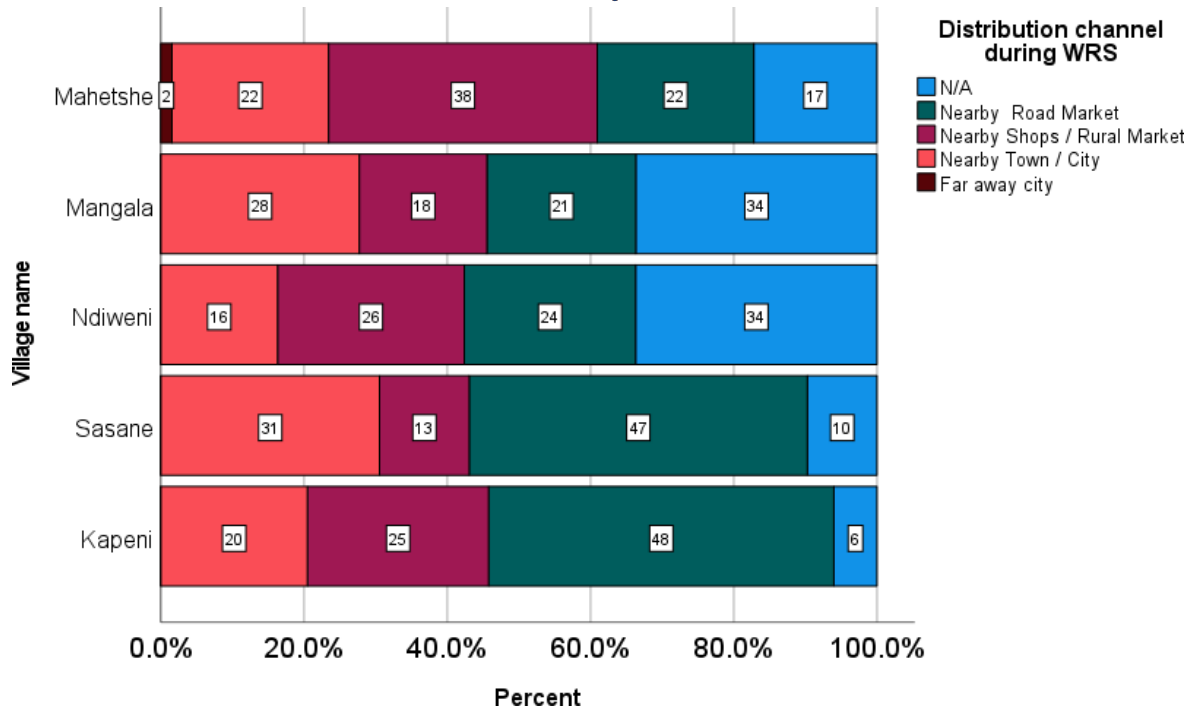


Figure 8.6. Distribution choice by Village during the WRS

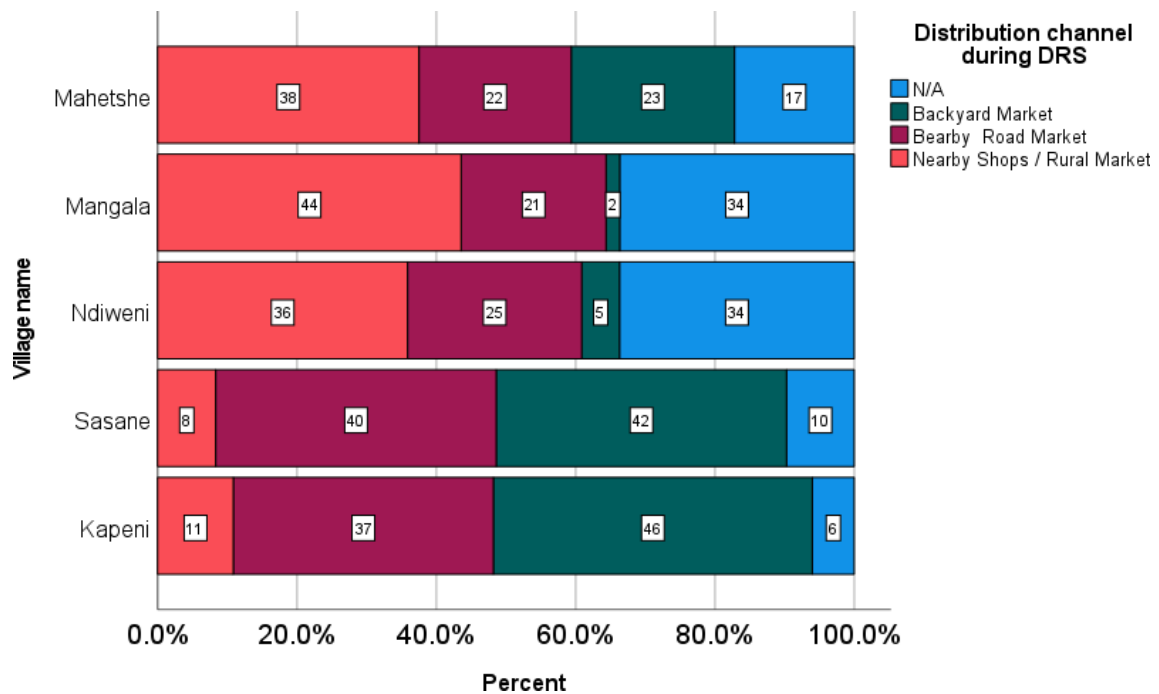


Figure 8.7 Distribution choice by Village during the DRS

8.1.2.2 Distribution channel choice by distance from major city markets

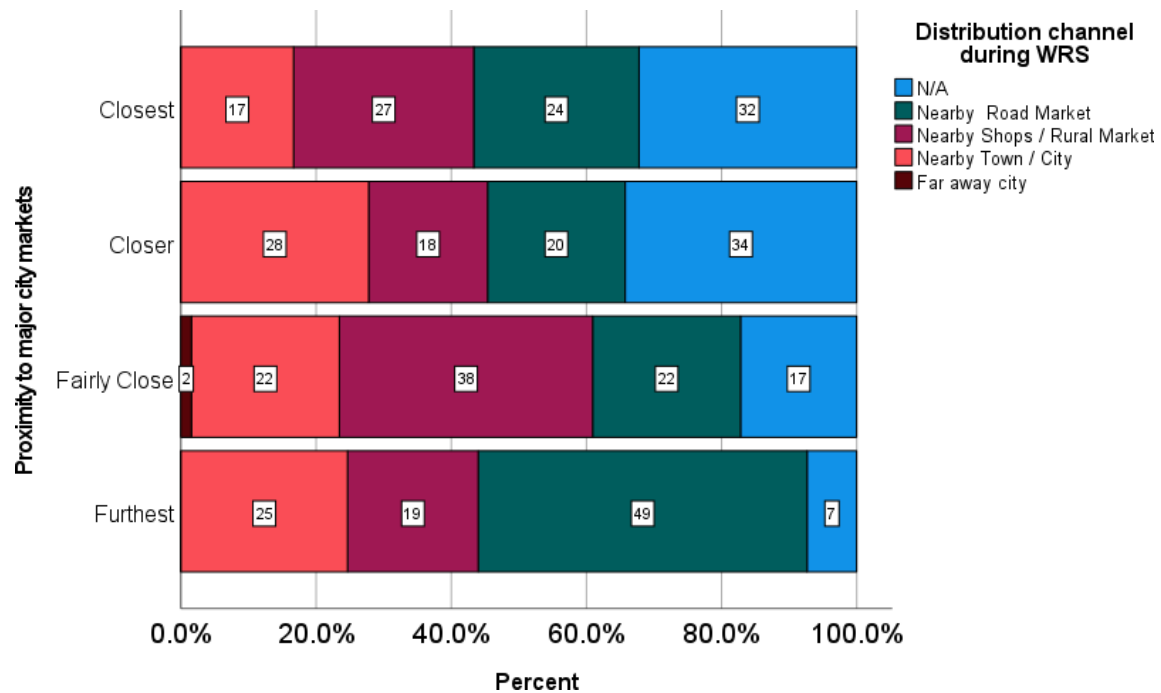


Figure 8.8. Distribution channel choice by distance from major city markets

A chi-square test for independence of association was conducted to find out if the choice of distribution channels during the WRS was significantly varying according to distance of the household from major city markets. Results revealed a statistically significant association between distribution choice and distance to major markets (Chi square = 65.837; df = 12; P-value < 0.001). These results suggest that proximal communities that are relatively closer to major city markets tend to engage in spatially dispersed MW trade transactions, while those located further away (i.e., distal communities are characterised by largely spatially concentrated trade.

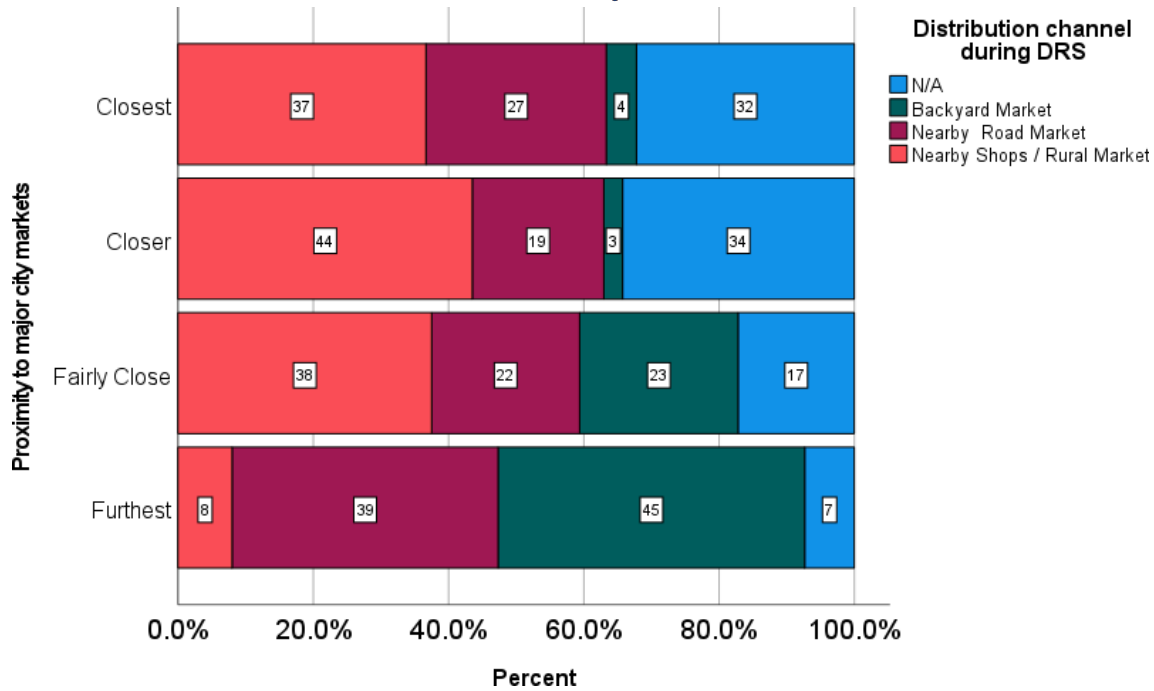


Figure 8.9 Distribution channel choice by distance from major city markets - DRS

A chi-square test for independence of association was conducted to find out if the choice of distribution channels during the DRS was significantly varying according to distance of the household from major city markets. Results revealed a statistically significant association between distribution choice and distance to major markets (Chi square = 141.450; df = 12; P-value < 0.001). These results like in the DRS suggest that proximal communities that are relatively closer to major city markets tend to engage in spatially dispersed MW trade transactions, while those located further away (i.e., distal communities are characterised by largely spatially concentrated trade. The strength of association was however found to be much higher for the DRS as compared to the WRS as measured by Cramer's V. The Cramer's V statistic significantly increased from 0.231 during to WRS to 0.338 during the DRS (P-value < 0.001).

8.1.3 Household interaction with the local economy versus spatial concentration of MW trade

One of the major hypotheses that the study sought to test was to establish the relationship between the spatial concentration of MW trade and the degree of household interaction with the local economy. The degree of household interaction with the local economy was measured by analysing how MW farming households were spending proceeds from MW sales. Two

proxy measures were used including where MW income was invested or used and the Livelihood pathways that the individuals chose.

8.1.3.1 Household interaction with the local economy versus spatial concentration of MWtrade -WRS

The decision tree model adopted for the WRS was evaluated for accuracy using the gains plot and the classification table results. Results revealed that 77.2% of the cases analysed were correctly classified by the model. The accuracy of classification was found to be much higher for correctly classifying spatial concentration of MW trade (89%) than spatial dispersion in MW trade (63.7%). Such differences in predictive capabilities for the two scenarios are also significantly portrayed in the Gains plots in Figure 8.10.

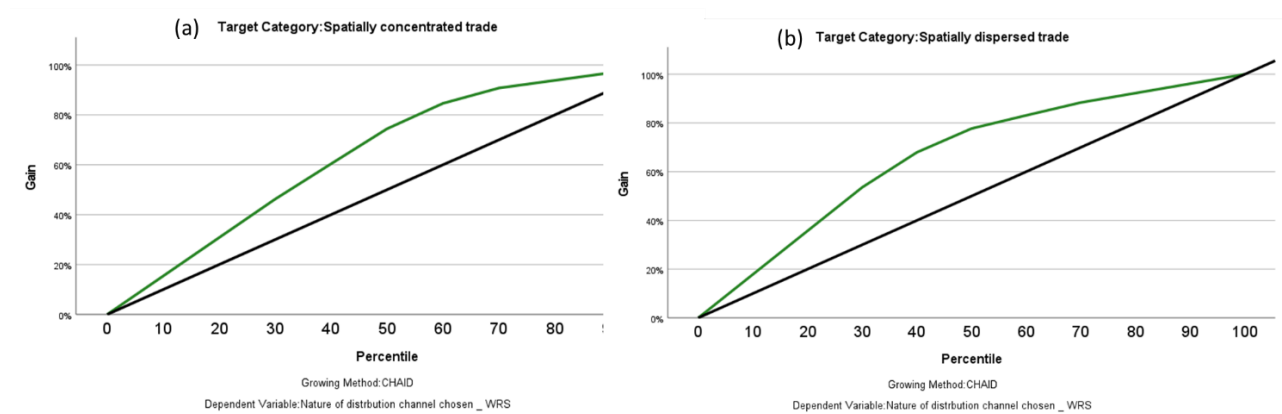


Figure 8.10. Gains plot: spatial concentration of MW trade (WRS)

Results of the analysis are shown in Figure 8.11.

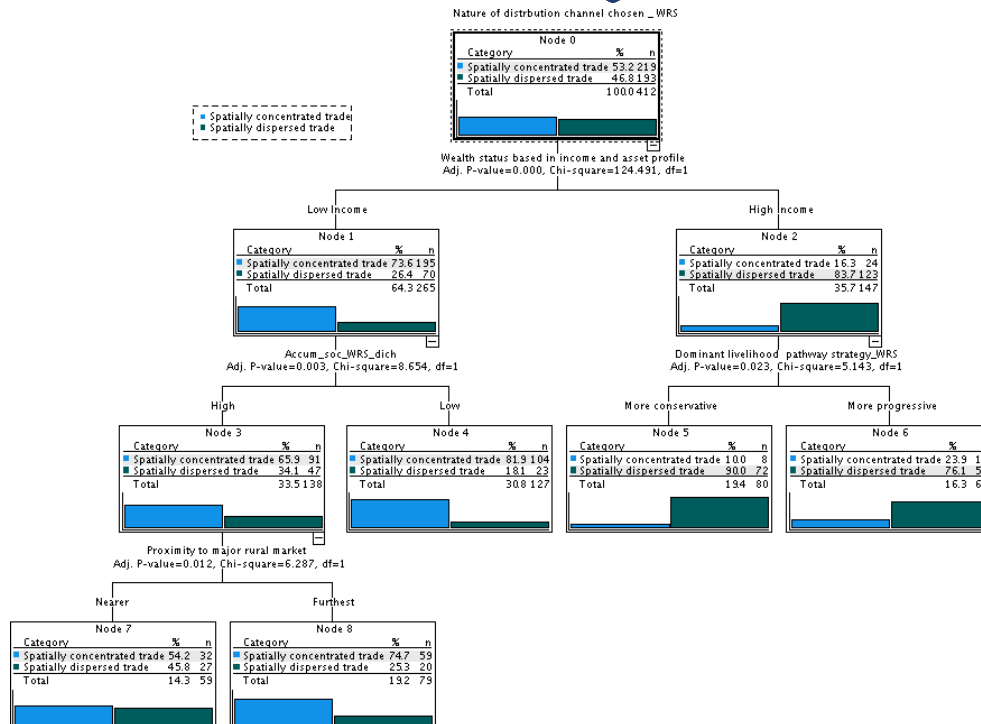


Figure 8.11. Household interaction with the local economy versus spatial concentration of MW trade -WRS

8.1.3.2 Household interaction with the local economy versus spatial concentration of MW trade -DRS

The decision tree model adopted for the DRS was evaluated for accuracy using the gains plot and the classification table results. Results revealed that 79.1% of the cases analysed were correctly classified by the model. The accuracy of classification was found to be much higher for correctly classifying spatial concentration of MW trade (96.3%) than spatial dispersion in MW trade (35.3%). Such differences in predictive capabilities for the two scenarios are also significantly portrayed in the Gains plots in Figure 8.12.

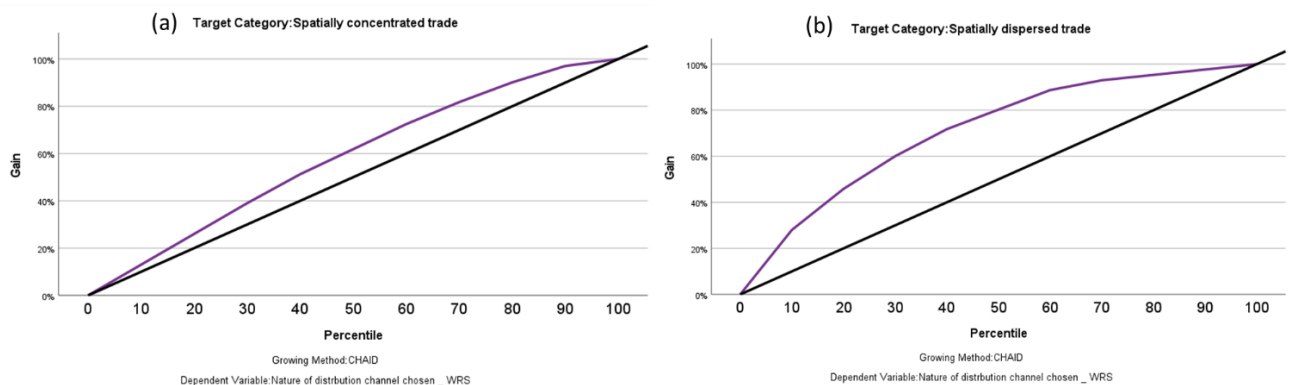


Figure 8.12 Gains plot: spatial concentration of MW trade (DRS)

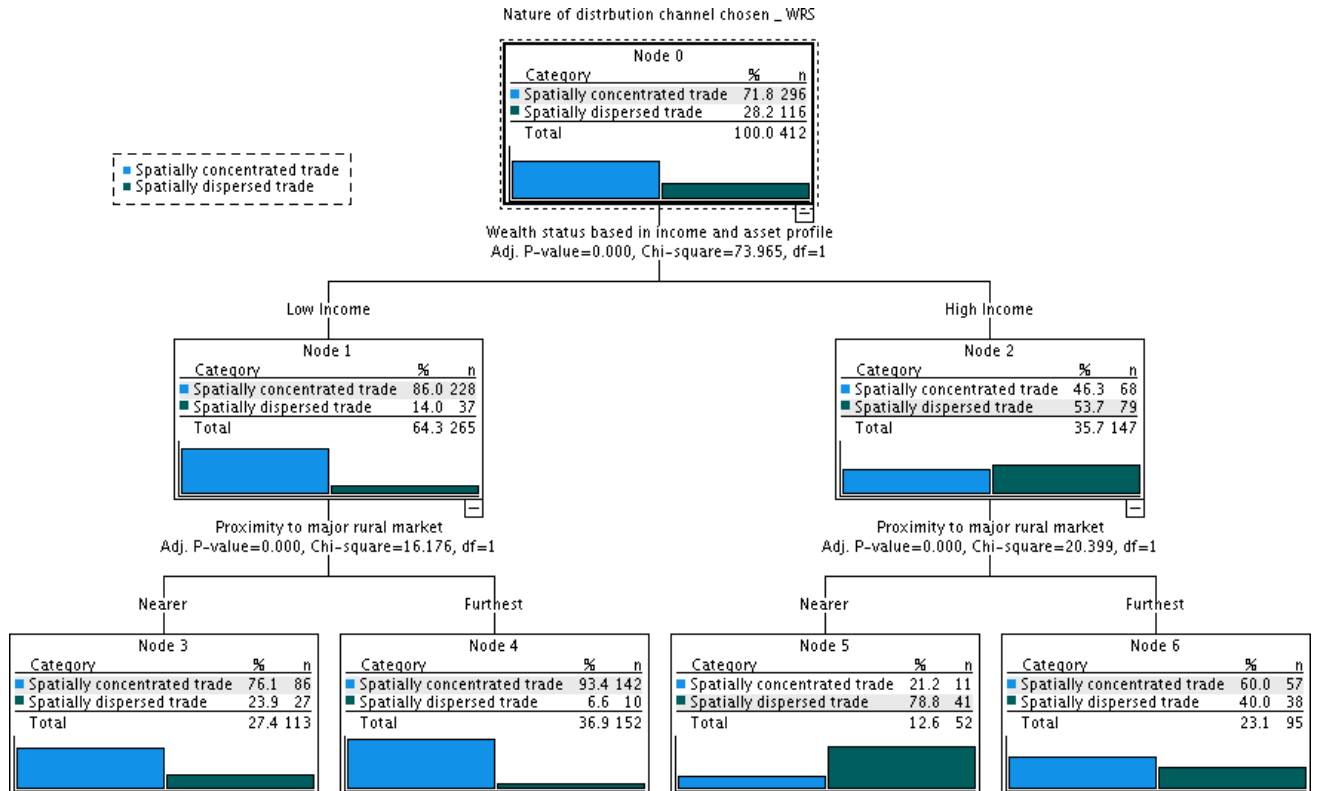


Figure 8.13 Household interaction with the local economy versus spatial concentration of MW trade -DRS.

8.2 A ‘resource to other sectors linkage’ approach

One approach to understanding household interaction with the local economy is to look at how proceeds from MW trade are used. The main assumption is that MW proceeds are intricately linked with various sectors of the local economy, including primary, secondary, and tertiary sectors. Understanding spatial and temporal variations in such linkages has important implications for crafting a MW-oriented LED strategy. This section has been conveniently divided into the following subsection.

- 8.2.1 Spatial and temporal changes in the MW income realised by households.
- 8.2.2 Temporal changes in the use of MW income
- 8.2.3 Nominal versus real MW income
- 8.2.4 A temporal perspective on MW income and its significance to various sectors of the local economy (WRS)
- 8.2.5 A temporal perspective on MW income and its significance to various sectors of the local economy (DRS)

8.2.1 Spatial and temporal changes in the MW income realised by households.

Virtually all local economic studies assume that the amount income realised from resource trade plays an important role in determining whether development takes place or not. The starting point in understanding how MW trade are linked to other sectors of the local economy is to have an appreciation of how much income has been received from MW trade. It was possible to get both a spatial and temporal perspective on variation in such income statistics. Such a spatial and temporal perspective is important as it allows us to gauge income variations (or dispersions) both in time and space.

8.2.1.1 Combined statistics on the shape and distribution of MW income realised over time.

Combined statistics on MW income per household during the WRS and the DRS show two contrasting results (refer to figure 8.13).

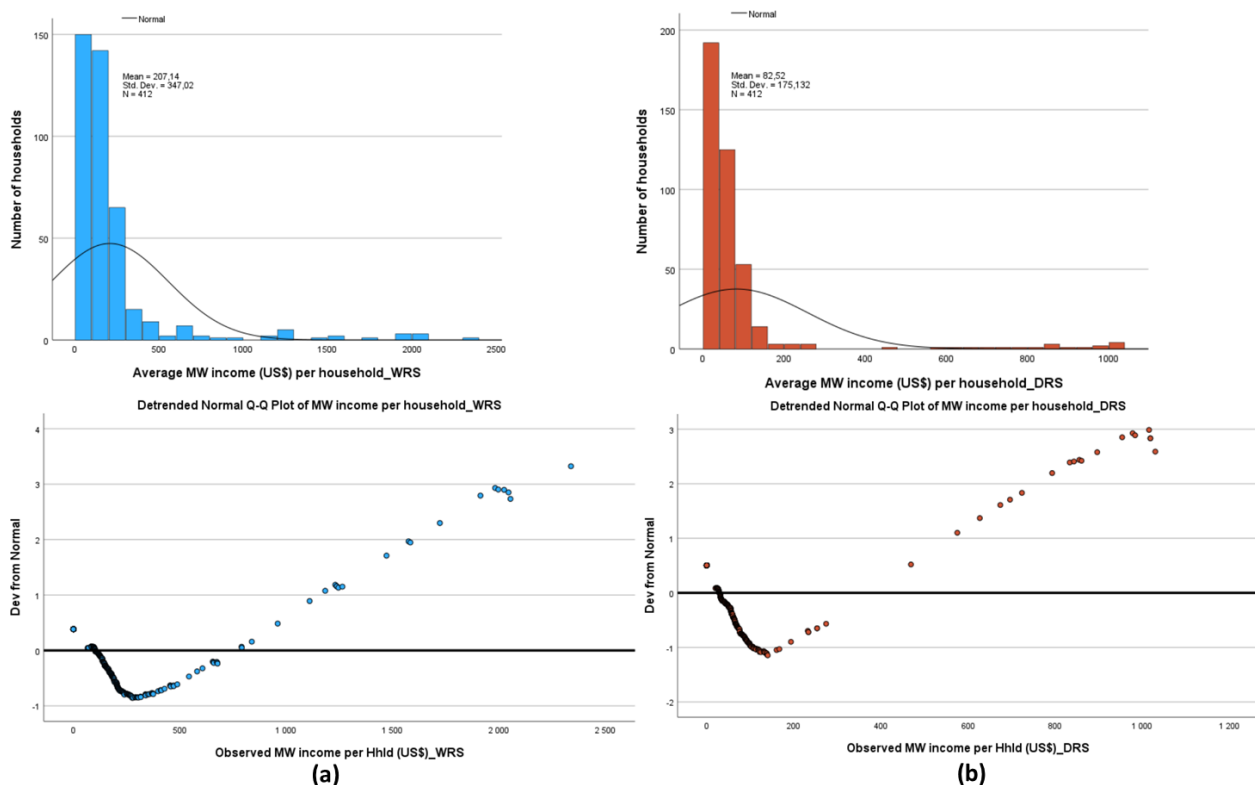


Figure 8.13. Shape and distribution of MW income per household during (a) the WRS and (a) the DRS

Both distributions are skewed to the left indicating a high proportion of households having received less income in relative terms when compared to high-income earners. The WRS however shows a highly peaked distribution of MW income when compared to the DRS

indicating that households generally received higher incomes from MW trade during this state. On average each household on average received US\$207.14 during the WRS compared to US\$82.52 during the DRS. Such difference in income received from MW are also evident when one looks at the median income values of the two resource states. The median income value from MW trade during the WRS is US\$138 while that of the DRS is as low as US\$46.33. A paired sample test showed a significant decrease in MW income by households (see Table 6.2) as they transitioned from a WRS to a DRS ($t = 13,238$; $df = 411$; $P\text{-Value} < 0.001$: two sided). The mean increase in MW income was US\$124,62 with a 95% confidence interval ranging from US\$106,12 to US\$143.13. The Cohen's d point estimate (0.652) indicated a relatively high effect size of such a transition. The subdued nature of income realised by households through MW trade is also consistently reflected when one looks at percentile distribution of such (see Table 8.2). Sharp differences are also visible when one looks at outlier or extreme income value statistics depicted in the box plots in Figure 8.14. Results revealed that extreme MW income value earners during the WRS earning almost twice as big when compared to similar statistics for the DRS.

Table 8.2. Paired samples t - test results

Resource State	MW income (US\$)		Paired Differences					T	df	P-value	
			Mean difference	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				One-Sided	Two-Sided
	Mean	Std. Deviation				Lower	Upper				
WRS	207,14	347,020	124,62	191,080	9,414	106,116	143,127	13,238	411	<,001	<,001
DRS	82,52	175,132									

Table 8.3 Percentile distribution of MW income per household

Measure	Resource State	Percentiles						
		5	10	25	50	75	90	95
Weighted Average	MW Income_WRS	,00	,00	,00	138,00	208,83	391,20	807,78
	MW Income_DRS	,00	,00	,00	46,33	75,67	121,33	260,57
Tukey's Hinges	MW Income_WRS			,00	138,00	208,67		

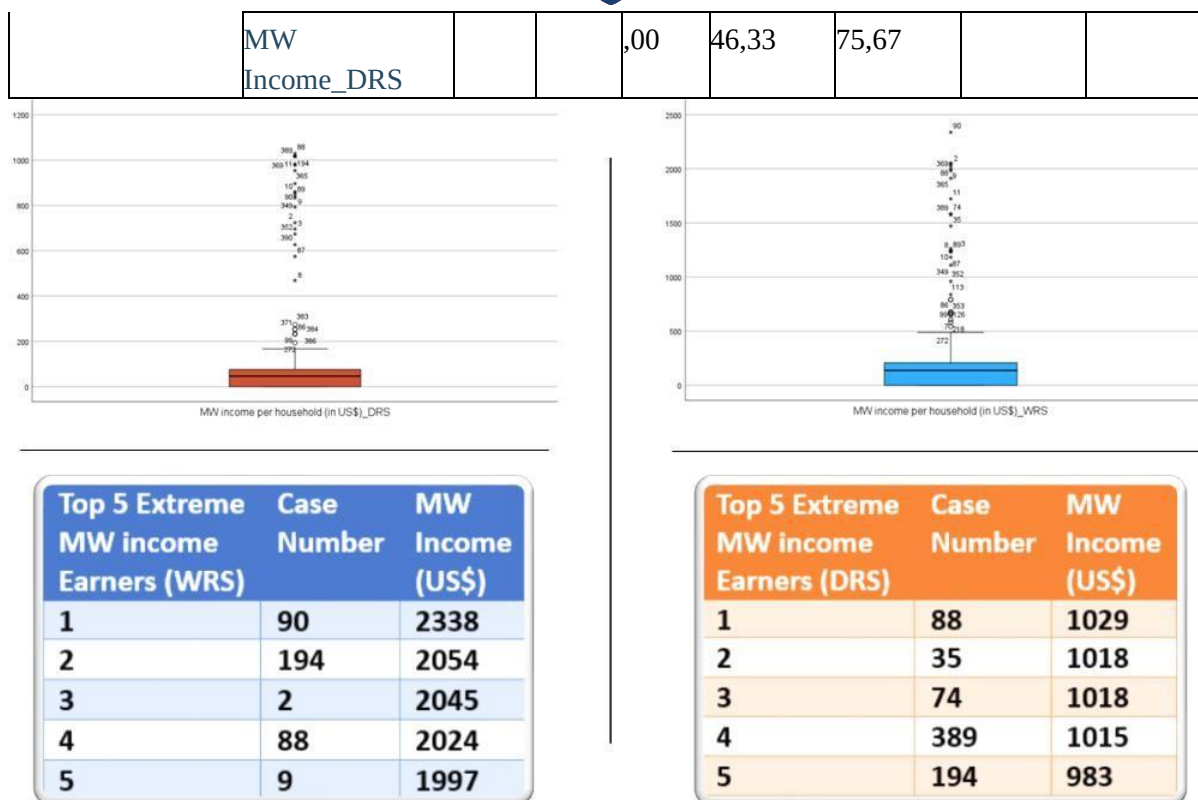


Figure 8.14 Temporal differences in extreme MW income earners

Such statistics have huge LED implications for the development of a MW-oriented LED strategy. Boosting MW supplies thorough interventions such as MW farming or assisted harvesting where rural households migrate to where supplies are better during the DRS may help such households to transition to higher incomes similar or close to those received during the WRS.

8.2.1.2 Disaggregated statistics on the shape and distribution of MW income received over time.

Disaggregated data by year on temporal changes in MW received by each household show interesting patterns for both the WRS and the DRS.

MW income dynamics during the WRS

The shape and distribution of WRS MW income and associated shifts in the years 2000-2014; 2014-2018; and 2018-2022 is shown in Figure 8.15. While distribution of MW income received is uniformly skewed to the right in all time periods under observations, there are obvious differences in terms of mean income values and the variability of such earnings as defined by the standard deviation. During the period 2000-2014, the average earning received by each household from MW trade was US\$180.66. This figure dropped in absolute terms to a figure of US\$164.81 earnings per household. We also observe a sharp increase in average MW

earnings per household to a figure of US\$275.97 for the period 2018-2022. A similar pattern is also reflected in the median MW income statistics. Respective median MW income earnings were US\$118.50 (for the period 2000-2014); US\$120.00 (for the period 2014-2018) and US\$188.00 (for the period 2018-2022).

A related -Samples Friedman's Two-Way Analysis of Variance (ANOVA) by Ranks was conducted to test if the distributions of MW income received by each household in the WRS of years 2000-2014; 2014-2018 and 2018-2022 are the same. The derived test statistics

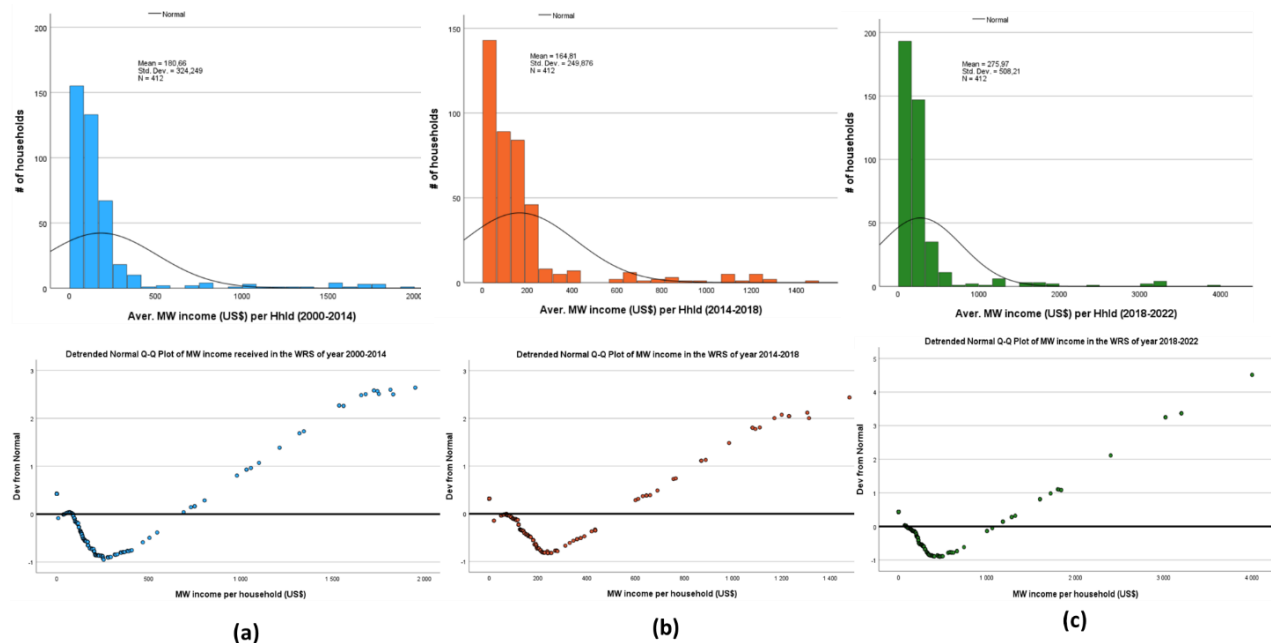
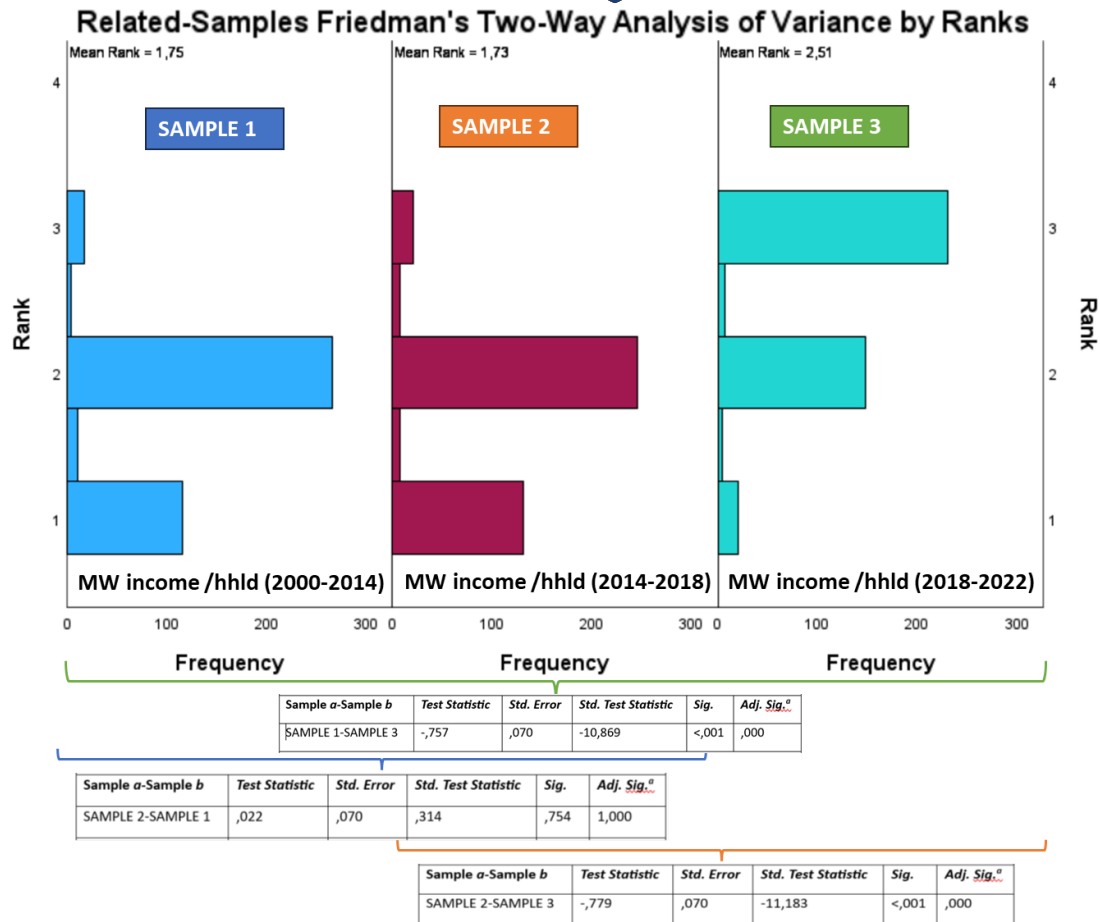


Figure 8.15 Shape and distribution patterns of MW income during the WRS of years (a) 2000-2014; (b) 2014-2018 and (c) 2018-2022.

indicated the need to reject the null hypothesis as there are statistically significant differences between the 3 distributions ($\chi^2=244,769$; $df=2$; $P\text{-value} < 0.001$). This global picture, however, is not consistently reflected on a season-to-season basis. Figure 6.16 statistics show statistically significant differences observable between MW income received between years 2000-2014 and 2018-2022 ($\chi^2=-0,757$; $P\text{-value} < 0.001$) and between the years 2014-2018 and 2018-2022 ($\chi^2 = -,779$; $P\text{-value} < 0.001$). This trend certainly shows that MW incomes have significantly increased since the season 2000-2014 up to the current season of 2018-2022 at least in nominal terms. The same test, however, revealed that there were no statistically significant changes in MW incomes between the period 2000-2014 and period 2014-2018 ($\chi^2 = 0.022$; $P\text{-value} > 0.05$). A similar pattern is also reflected when one looks at the percentile distribution of incomes (figure 8.16).



The study also observed statistically significant dynamics between extreme MW income earners over the years (figure 6.17). The highest income being associated with the period 2018 – 2022 and the least earners with the period 2014-2018.

Figure 8.16 Related -Samples Friedman's Two-Way Analysis of Variance (ANOVA) by Ranks test results.

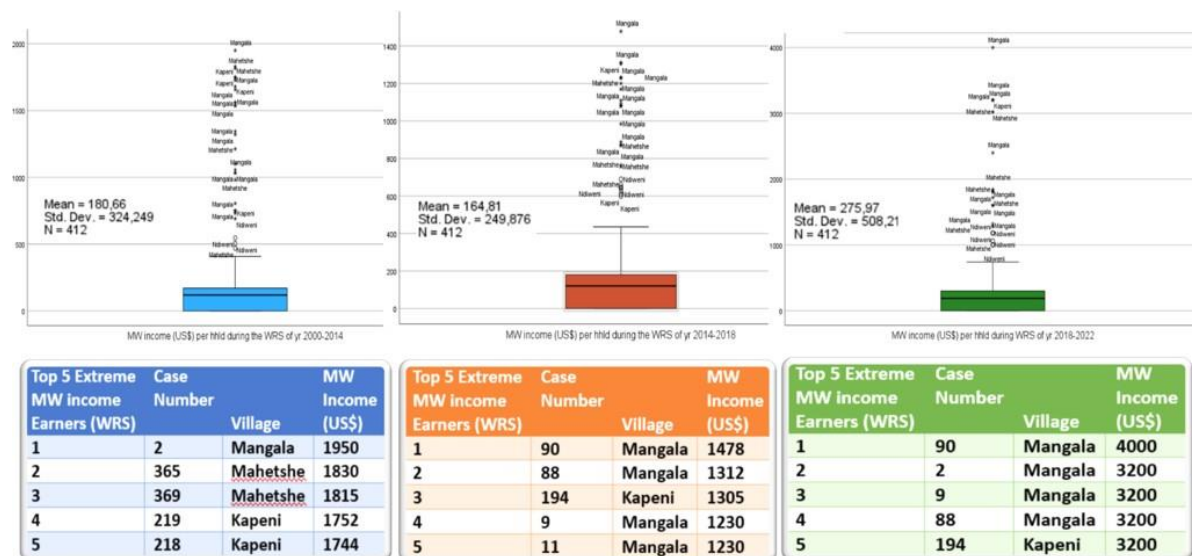


Figure 8.17 Extreme MW income dynamics during the WRS of years 2000-2014; 2014-2018 and 2018-2022.

Percentile distribution of MW income earnings over time are shown in Figure 8.18.

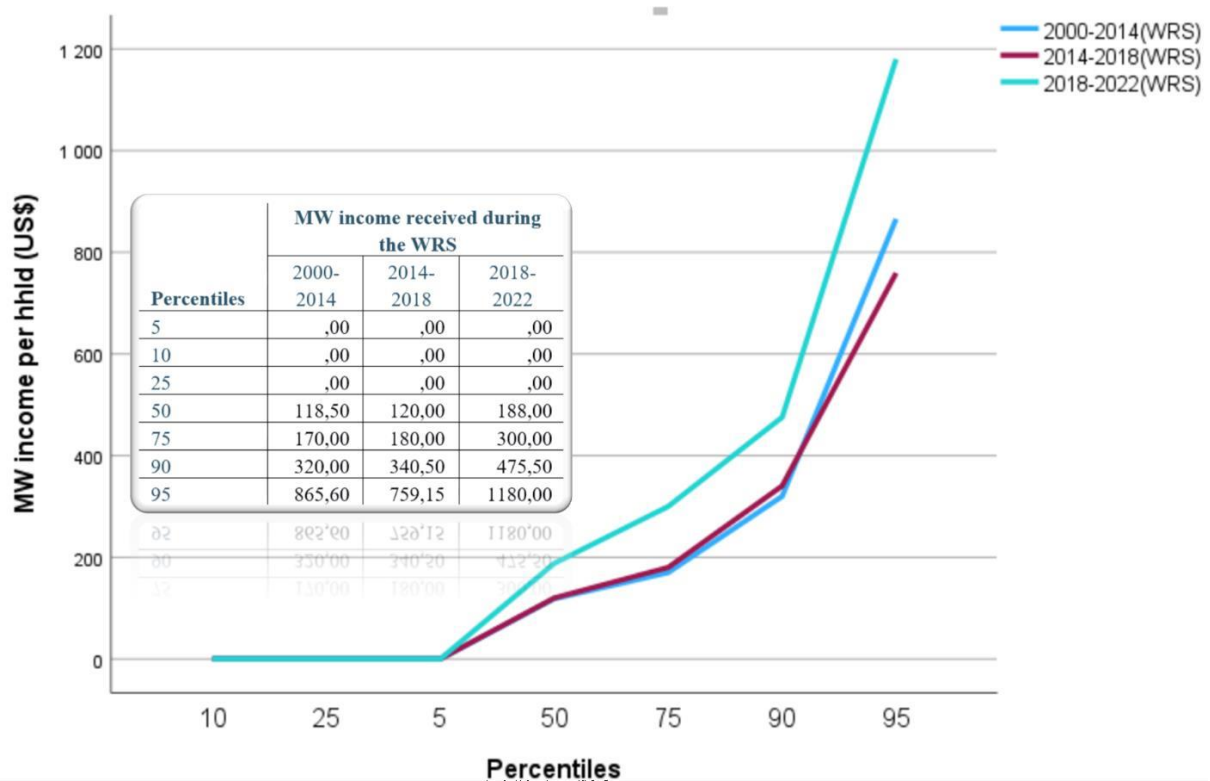


Figure 8.18 Percentile distribution of MW income for the WRS of years 2000-2014; 2014-2018 and 2018-2022.

Interesting income dynamics are however interesting to take note of in relation to the 75th (Q3) and 90th percentiles. Results show that 75 % of households on average earned US\$170 or less for the period 2000-2014. Similar statistics show that 90% of households earned US\$320 or less. Such percental MW income contrary to the picture portrayed in other percentiles has been increasing in absolute or nominal terms over time. Similar MW income statistics for the year 2014-2018 are US\$180 and US\$340 respectively. We see a big jump (at least in absolute terms) in year 2018-2022 where the 75th and 9th percentile incomes were US\$300 and US\$475.50 respectively.

8.2.2 Spatial and temporal changes MW income by village during the WRS

MW incomes per household are not only varying over time but also between villages. Table 8.4. Depicts such income variations both in space and in time, For the 2000-2014 season,

average income earnings from MW trade ranged from low average US\$78.99 per household for Ndiweni village to a high average of US\$ 295.17 per household for Mahetshe village. For the period 2014 – 2018 we observe low average MW earnings of Ndiweni village of US\$ 92.80, while Mahetshe village continues topping the list with an high average of US\$ 252.00. Average earnings from MW trade per household are extremely high for the period 2018-2022. The highest recipient households with an average MW income earnings of US\$478,44 per household again belong to Mahetshe village.

Table 8.4 Spatial and temporal changes in MW income per household and per village

	WRS period	household and per villagers inUS\$					
		<i>Kapeni</i>	<i>Sasane</i>	<i>Ndiweni</i>	<i>Mangala</i>	<i>Mahetsh</i>	Total
Mean (US\$)	2000-2014	170,95	94,71	78,99	269,94	295,17	180,66
	2014-2018	135,22	97,00	92,80	247,79	252,00	164,81
	2018-2022	215,98	164,06	140,23	400,40	478,44	275,97
Std. Dev.	2000-2014	315,73	64,00	126,73	447,454	400,96	324,25
	2014-2018	165,27	66,37	156,62	380,711	261,88	249,88
	2018-2022	352,85	109,04	260,63	760,746	616,71	508,21

Ndiweni village still emerges as the lowest recipient village with average MW earnings of US\$140. 23. In all three time periods, the ranking of villages according to average MW income earnings from top recipients to least recipients follow the order Mahetshe, Mangala, Kapeni, Sasane and Ndiweni respectively. An independent samples Kruskal-Wallis H test revealed significant similarities and differences along the 3-time period cycle as shown in Figure 8.19

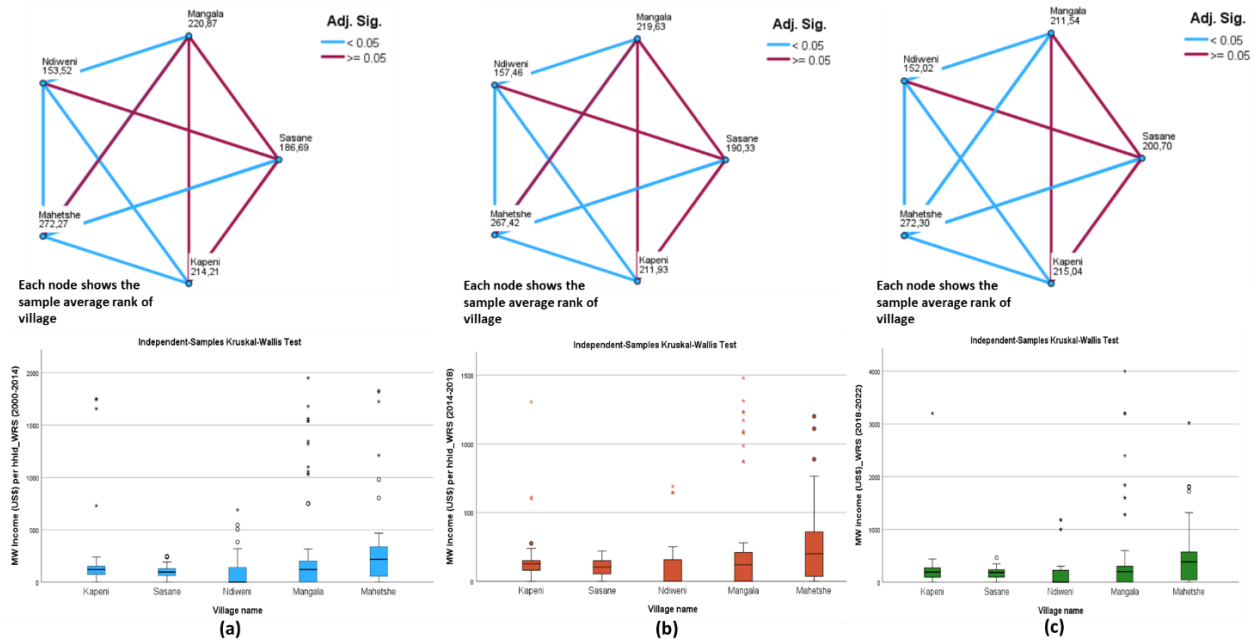


Figure 8.19 Independent samples Kruskal-Wallis H

Since the WRS of year 2000-2014, MW earnings per household has been increasing in nominal terms in all villages except in Kapeni where we see a dip in 2014-2018 season. A closer look at per capita MW income statistics, however, reveals a slightly different income distribution pattern. Ranking of villages according to the amount of MW income received by each family member (per capita income) varies from one time period to the next. In year 2000-2014, the ranking of per capita income statistics follows the order Mangala, Mahetshe, Kapeni, Ndiweni and Sasane. During the period 2014-2018, we see a slight shift in the rankings with Mahetshe leading the rankings followed by Mangala, Kapeni, Sasane and Ndiweni in that order. This latest pattern of rankings is also replicated in year 2018-2022 (Figure 8.20).

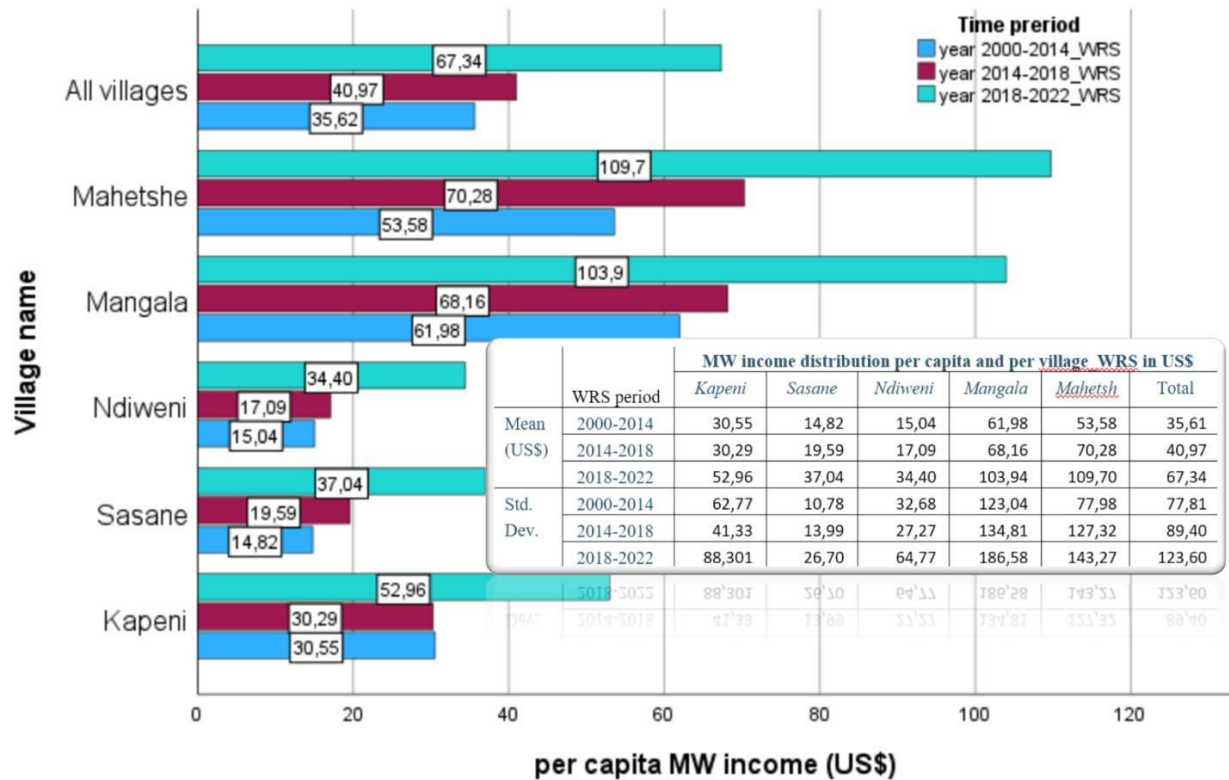


Figure 8.20 Spatial and temporal changes in MW income per capita and per village

Spatial and temporal changes in MW income per household and proximity to major markets-WRS.

The study revealed MW income per household differences during the three-time period under investigation (Figure 8.21)

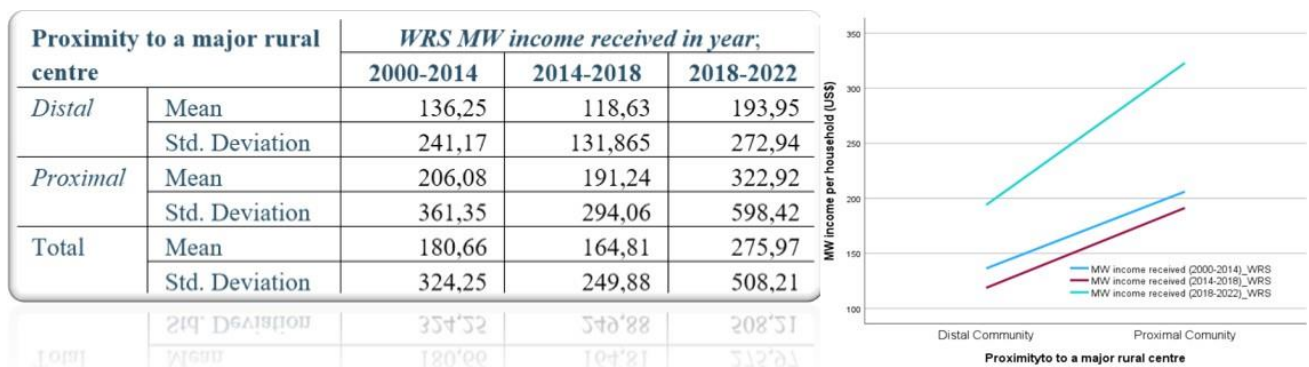


Figure 8.21 Spatial and temporal changes on MW income per household and proximity to major markets_WRS

Households located near major rural markets in general received higher MW income when compared to those located further away (i.e. distal communities). During the period 2000-2014

alone, proximal communities received an average MW income of US\$206,08 per household. Such income was in relative terms higher than the US\$136.25 per household MW income received by distal communities. Such a pattern continues, with households from proximal communities receiving an average MW income of US\$322.92 per household when compared to US\$193.95 per household for distal communities during the period 2018-2022. Despite a dip in MW income statistics experienced during the period 2000 to 2014, these latest income statistics reveal that in general MW earnings have been increasing over time at least in absolute terms. An assessment of the concentration of extreme MW income earners across all three time periods reveals that such concentration is biased towards proximal communities (Figure 8.22)

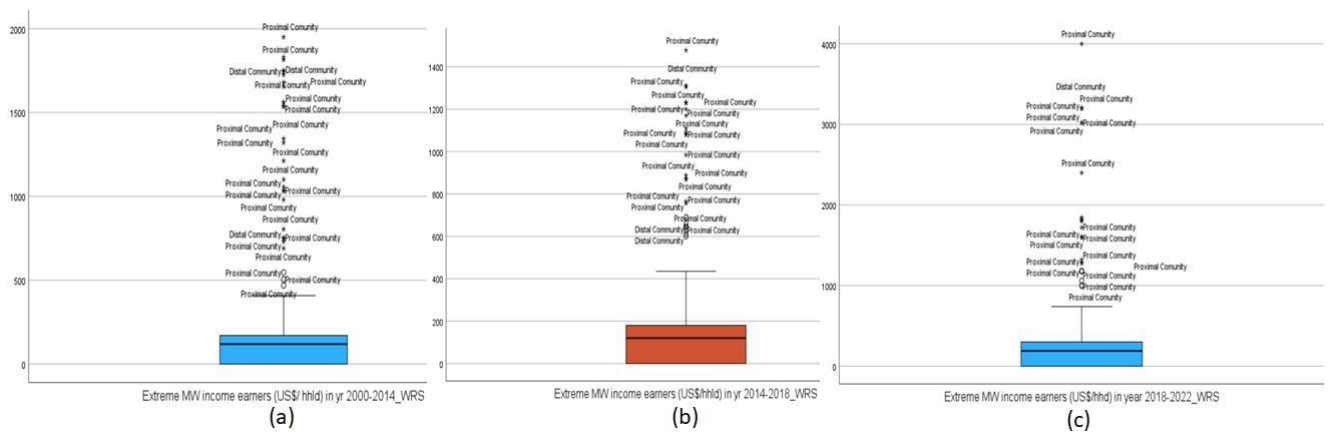


Figure 8.22 Temporal variations MW incomes per household and distance to major markets

We observe the highest number households earning extreme incomes from MW trade living closer to major rural markets as compared to those located further away. For example, among the top 5 MW income earning households 3 are from proximal communities for the period 2000 to 2014. Similar statistics for the period 2014 to 2018 and 2018 to 2022 are 5 and 4 respectively. Such variations are further substantiated by an ANOVA test carried out to test whether there were any statistically significant differences between mean MW incomes received by households near major rural markets as opposed to those living in distal communities (Table 8.5). Since the analysis yielded P-values of less than the cutoff value of 0.05, results reveal statistically significant differences in the average MW earnings between proximal and distal communities for all three time periods. These results suggests that MW-oriented LED strategies that seek to raise income earnings of distal communities, should focus more on bringing such communities closer to major markets, where prices of MW stocks are reportedly higher in relative terms.

Table 8.5 ANOVA test results depicting significant MW income differences between proximal and distal communities - WRS.

Period	Comparisons	Sum of Squares	df	Mean Square	F	Sig.
2000-2014	Between Groups	465042,212	1	465042,212	4,460	,035
	Within Groups	42746348,847	410	104259,387		
	Total	43211391,058	411			
2014-2018	Between Groups	502867,782	1	502867,782	8,195	,004
	Within Groups	25159190,684	410	61363,880		
	Total	25662058,466	411			
2018-2022	Between Groups	1586627,443	1	1586627,443	6,221	,013
	Within Groups	104565489,147	410	255037,778		
	Total	106152116,590	411			

8.2.3 Nominal versus real MW income

The study assumed that MW income received by households has been increasing over the years at least in nominal terms but has been decreasing in real terms. Table 8.6 shows nominal and real MW incomes using the period 2000-2014 as the base year.

Table 8.6 Nominal versus real MW income for WRS and DRS.

Village name		WRS			DRS		
		14G	Inc 18G	Inc 22G	Inc14B	Inc18B	Inc22B
Kapeni	Nomin	170,95	135,22	215,98	57,05	55,76	76,96
	Real	170,95	130,94	160,10	57,05	51,38	51,38
Sasane	Nomin	94,71	97,00	164,06	43,42	45,58	52,54
	Real	94,71	105,26	139,49	43,42	44,42	40,25
Ndiweni	Nomin	78,99	92,80	140,23	20,52	26,00	33,21
	Real	78,99	67,20	81,90	20,52	18,90	17,55
Mangala	Nomin	269,94	247,79	400,40	121,06	93,59	176,78
	Real	269,94	182,86	227,19	121,06	70,61	105,55
Mahetsh	Nomi	295,17	252,00	478,44	122,95	123,84	209,22
	Real	295,17	210,37	282,39	122,95	87,33	109,81
Total	Nomin	180,66	164,81	275,97	72,44	67,19	107,94
	Real	180,66	137,29	174,48	72,44	53,21	64,24

The study sought to test the hypothesis that economic returns from mopane worm harvesting vary over space but such returns diminish in *real terms* with time.

Temporal changes in MW income per household and per wealth status-WRS.

The analysis also revealed major differences in the MW incomes received by households by wealth status (Table 8.7)

Table 8.7 Temporal changes in MW income per household and per wealth status-WRS

Wealth status based on income and asset profile		received (US\$) per household during the WRS		
		2000-2014	2014-2018	2018-2022
Low-income	Mean	116,06	104,72	160,45
	Std. Deviation	221,276	146,577	253,850
High-income	Mean	297,10	273,13	484,22
	Std. Deviation	431,519	344,311	736,655
Total	Mean	180,66	164,81	275,97
	Std. Deviation	324,249	249,876	508,210

In all the three time periods under enumeration, we see MW incomes received by high-income households to be consistently higher than that received by low-income households. During the WRS period of 2000-2014, 2014-2018 and 2018-2022 each household from high-income families received an average of US\$ 297.10, US\$104.72, and US\$160,45 respectively from MW trade. These MW income statistics were consistently greater than average returns received by households classified as low-income at least in nominal terms. Related MW income statistics are US\$116.06, US\$104.72, and US\$160.45 for the WRS period of years 2000-2014, 2014-2018 and 2018-2022 respectively.

Such variations are further substantiated by an ANOVA test carried out to test whether there were any statistically significant differences between mean MW incomes received by high-income households as opposed to low-income households (Table 8.8).

Table 8.8 ANOVA test results depicting significant MW income differences between high-income and low-income households - WRS.

Period	Comparisons	Sum of Squares	df	Mean Square	F	Sig.
2000-2014	Between Groups	3098648,482	1	3098648,482	31,672	<,001
	Within Groups	40112742,576	410	97835,958		
	Total	43211391,058	411			
2014-2018	Between Groups	2681720,148	1	2681720,148	47,845	<,001
	Within Groups	22980338,318	410	56049,606		
	Total	25662058,466	411			
2018-2022	Between Groups	9911411,994	1	9911411,994	42,224	<,001

	Within Groups	96240704,596	410	234733,426		
	Total	106152116,590	411			

Since the analysis yielded P-values of less than the cutoff value of 0.001, results reveal statistically significant differences in the average MW earnings between high- and low-income households for all three time periods. These results suggest that MW-oriented LED strategies that seek to raise income earnings of poor communities should strive to close rather than expand the existing income inequalities.

As shown in Table 8.9, female headed households are in absolute terms receiving higher incomes from trade in year 2000-2014 and year 2018-2022. The least receivers are families headed by children.

Table 8.9 Temporal changes in MW income per household and per headship status-WRS

		d (US\$ per household) during the WRS		
Household head		2000-2014	2014- 2018	2018-2022
Male headed	Mean	178,45	176,11	231,69
	Std. Deviation	268,276	259,834	327,874
Female headed	Mean	194,16	168,20	301,40
	Std. Deviation	380,826	273,747	614,711
Female managed	Mean	177,90	178,28	296,50
	Std. Deviation	202,740	179,124	328,969
Child headed	Mean	93,64	88,24	167,82
	Std. Deviation	96,963	99,926	166,416
Total	Mean	180,66	164,81	275,97
	Std. Deviation	324,249	249,876	508,210

8.2.4 Temporal changes in the use of MW income

It was possible to gather information on how households have been using cash income from MW trade. This was done to understand how MW proceeds can impact positively other sectors of the local economy. Data was gathered for both the Wet Resource State (WRS) and the Dry Resource State (DRS) during the harvesting seasons of years 2000 - 2014, 2014 - 2018 and year 2018 – 2022 (Figure 8.23).

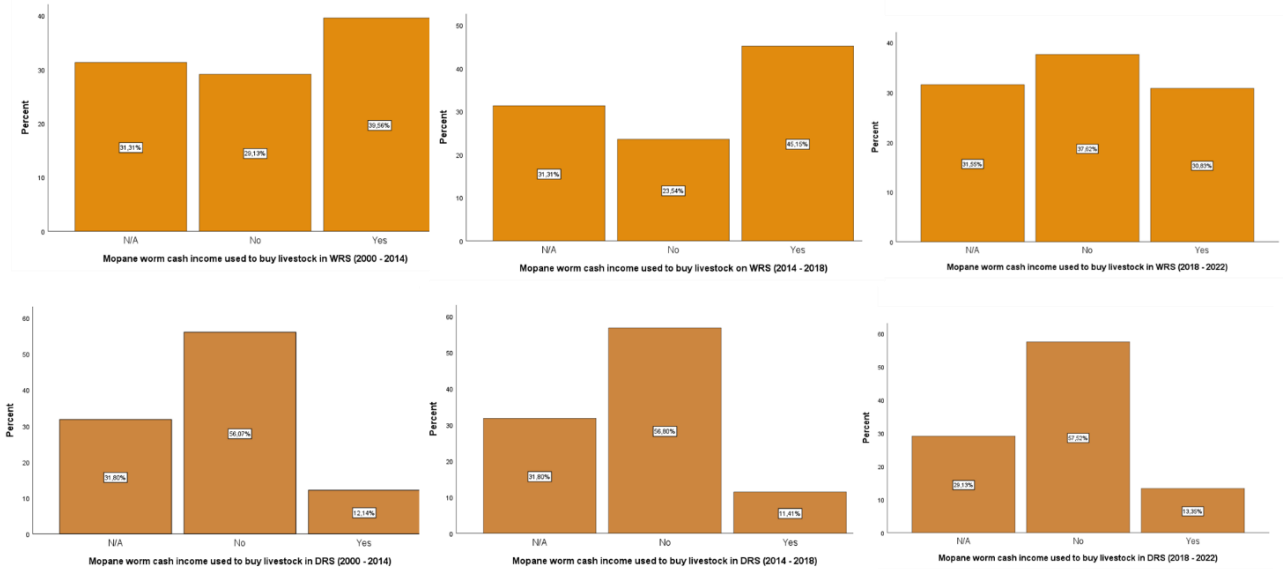


Figure 8.23. Temporal changes in the use of MW income to buy livestock.

The distribution of number of people who reported buying livestock during the WRS and DRS is largely a reflection of trader preferences. no unique pattern was discerned.

8.2.4 A temporal perspective on MW income and its significance to various sectors of the local economy (WRS)

It was possible to gauge that sector is significantly impacted the most by MW income earnings based on a predictor importance index calculated using a two-step clustering algorithm. The significance of the results was assessed using the Silhouette measure of cohesion and separation. The most important depictees of unique clusters that are also shown on figure 8.24, are a reflection of where MW traders would like to spend their income most. The study generated a steady 3 cluster solution over the period.

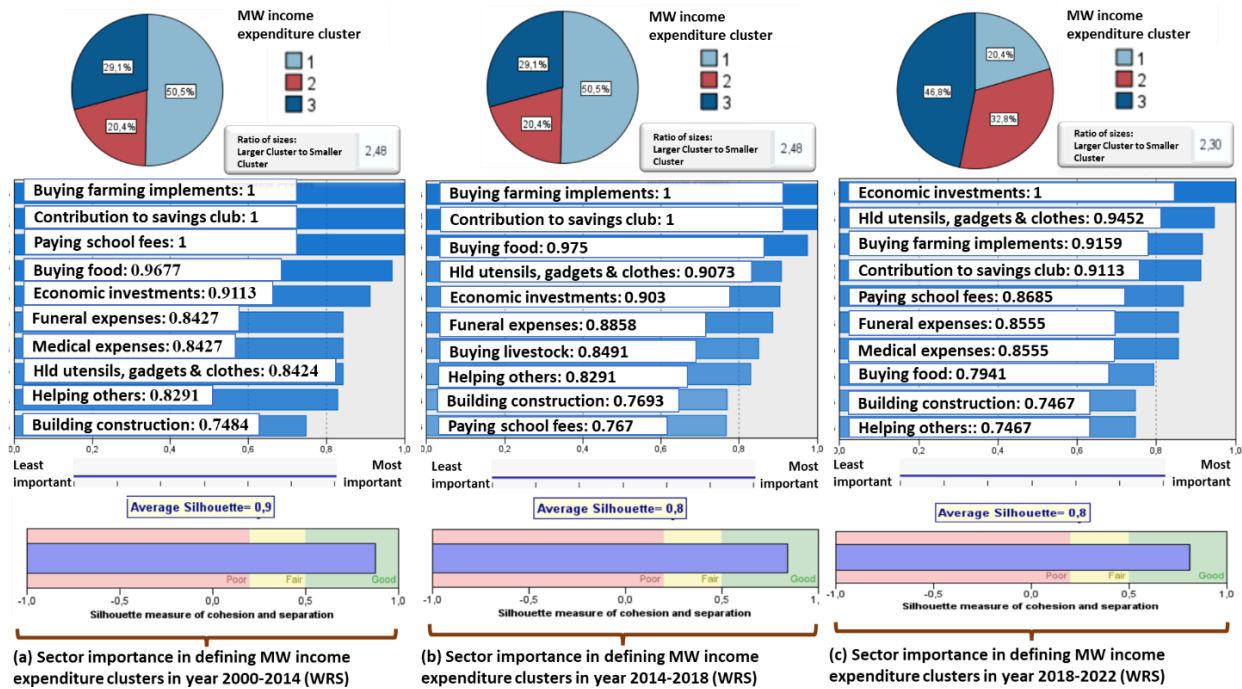


Figure 8.24 Temporal variations in the importance and size of MW income expenditure clusters during the WRS.

Buying farming implements is consistently showing in the years 2000-2014 and year 2014-2018, economic investments emerge as the highest expenditure item in year 2018 – 2022. Since investing in other sectors of the local economy is the dominant deciding factor in separating clusters, one can argue that MWs are indeed making an impact in other sector of the local economy. Significant differences in the expenditure profiles of the 3 type of clusters are shown in Figures, 8.25 to 8.27.

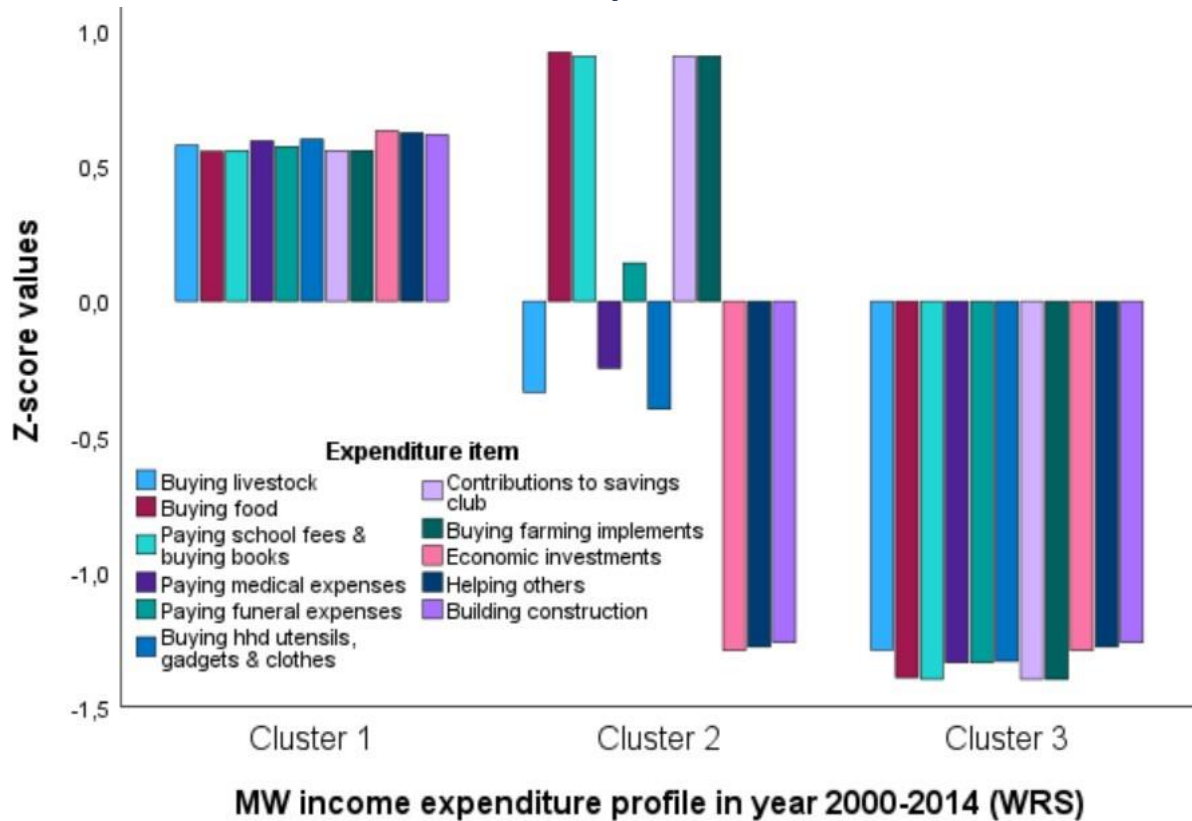


Figure 8.25 Expenditure profile of each MW cluster in year 2000-2014 during the WRS

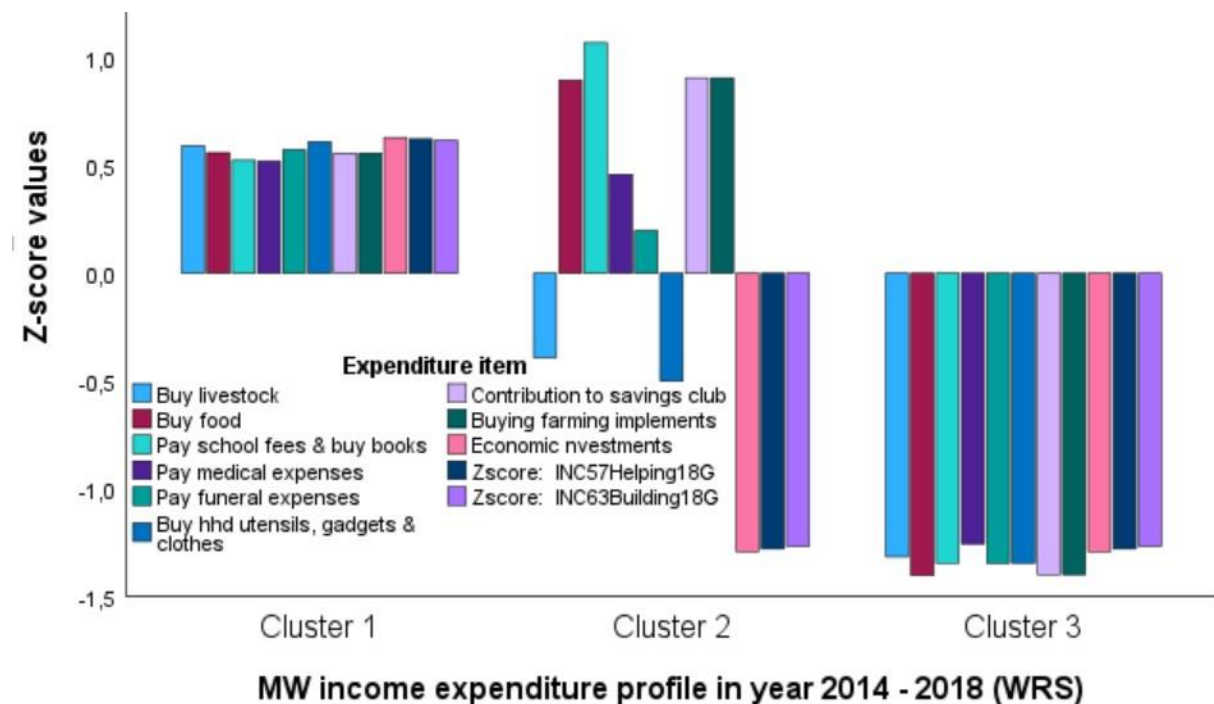


Figure 8.26 Expenditure profile of each MW cluster in year 2014-2018 during the WRS

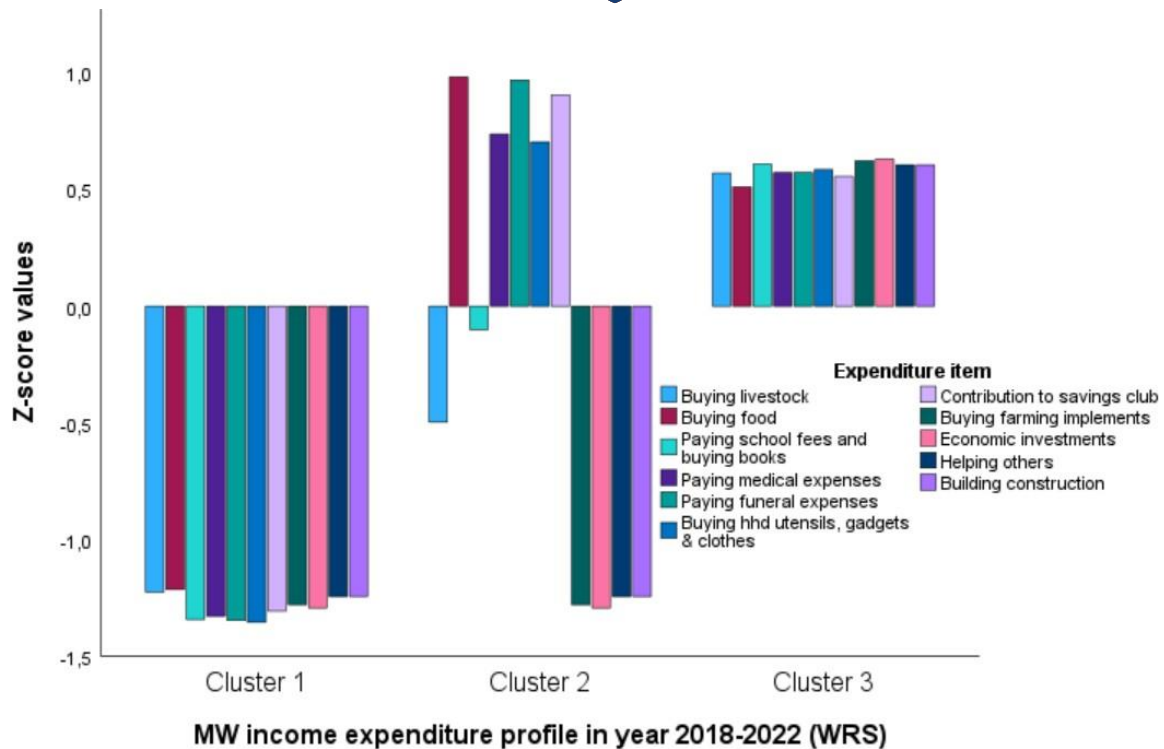


Figure 8.27 Expenditure profile of each MW cluster in year 2018-2022 during the WRS

We can clearly see that cluster 3 households are consistently the highest spenders, followed by cluster 2. Cluster 1 type of households are generally the non-spenders. A more objective approach was adopted to assess the strength of association between the amount of MWs traded on the market and the income realised (Table 8.10).

Table 8.10 Direction and strength of association between quantity of MWs traded and MW income use area (WRS)

MW income expenditure item;	Pearson's Correlation coefficient		
	2000-2014	2014-2018	2018-2022
Pay school fees and buy books	,339**	,311**	,391**
Pay medical expenses	,374**		,324**
Pay funeral expenses	,314**	,407**	,324**
Buy hhld utensils, gadgets and clothes	,376**	,426**	,325**
Contributions to savings club	,339**	,387**	,306**
Buying farming implements	,339**	,387**	,356**
Economic investments	,388**	,442**	,353**
Helping the needy	,393**	,445**	,288**
Building construction	,410**	,463**	,288**
Buying food	,346**	,418**	,319**
Buying livestock		,425**	

Independent variable: Quantity of 20 litre buckets of MWs sold to the market.

* Sig. (2-tailed) P-value < 0,001

Results revealed positive and statistically significant association with regards to all expenditure in terms listed in Table.

8.2.5 A temporal perspective on MW income and its significance to various sectors of the local economy (DRS)

During the DRS we see more non-investment expenditure items uniquely separating the 3-cluster solutions (figure 8.28)

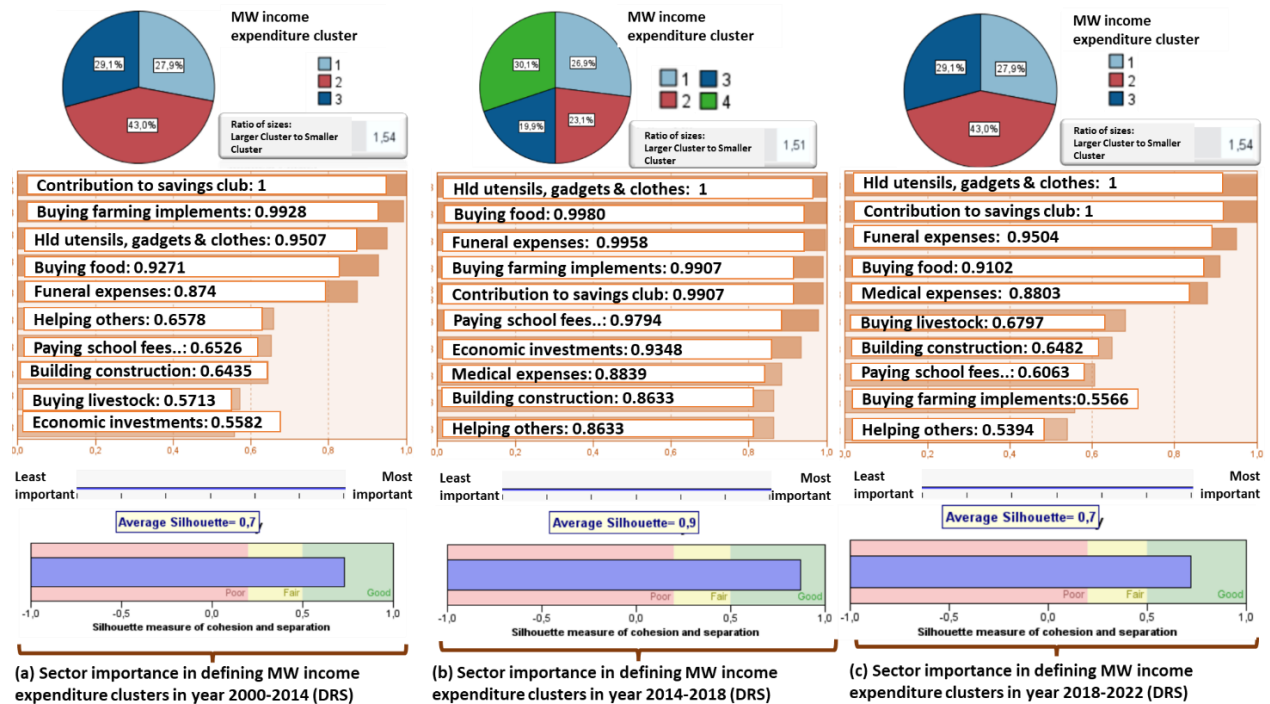


Figure 8.28 A temporal perspective on MW income and its significance to various sectors of the local economy (DRS)

The pattern of expenditure over the years is very divers with year 2014 – 2018 generating 4 unique expenditure profiles. Reduced supplies of MW during the DRS have huge LED implications since reorient their investments into social capital. The expenditure pattern provided by each cluster is consistently depicting the same picture. The big spender, average spender and least spender dynamics portrayed by each cluster over time is not consistent and therefore no inferences could be made. (see Figures 8.29, 8.30, and 8.31).

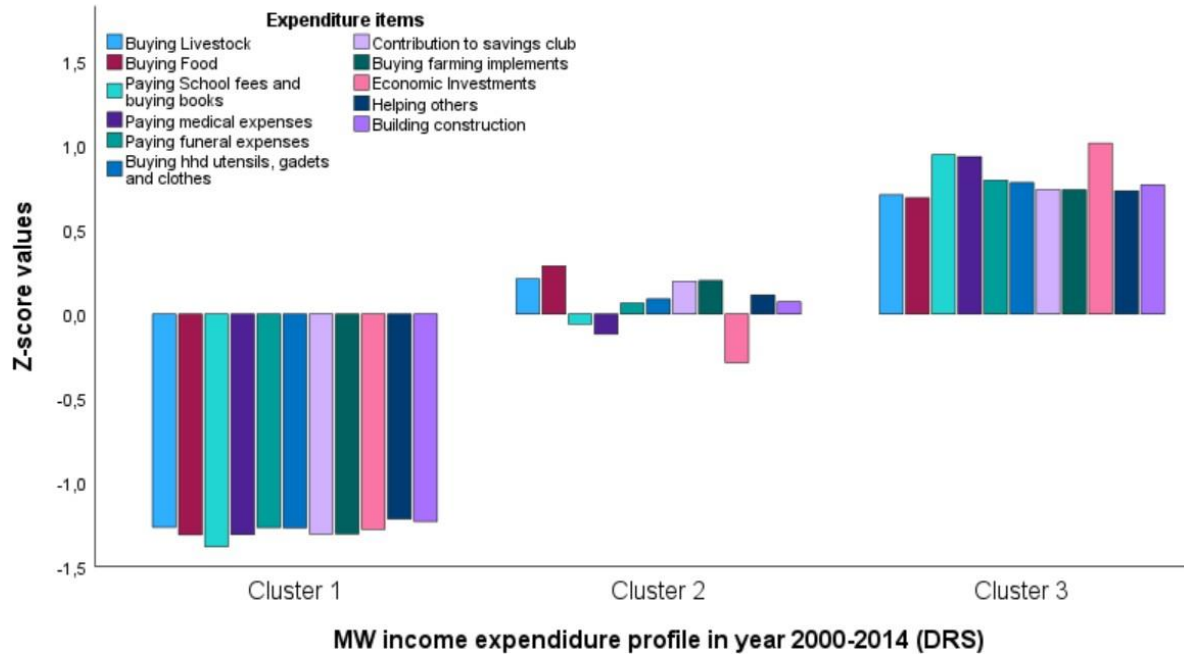


Figure 8.29 Expenditure profile of each MW cluster in year 2000-2014 during the DRS

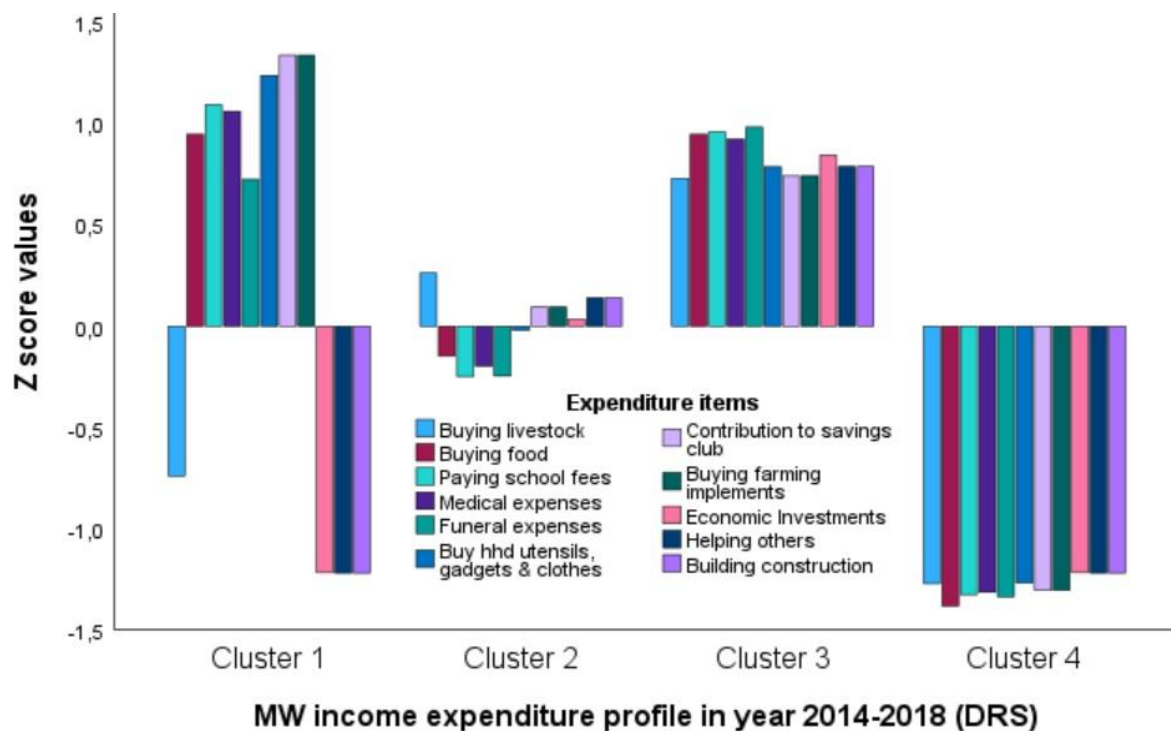


Figure 8.30 Expenditure profile of each MW cluster in year 2014-2018 during the DRS

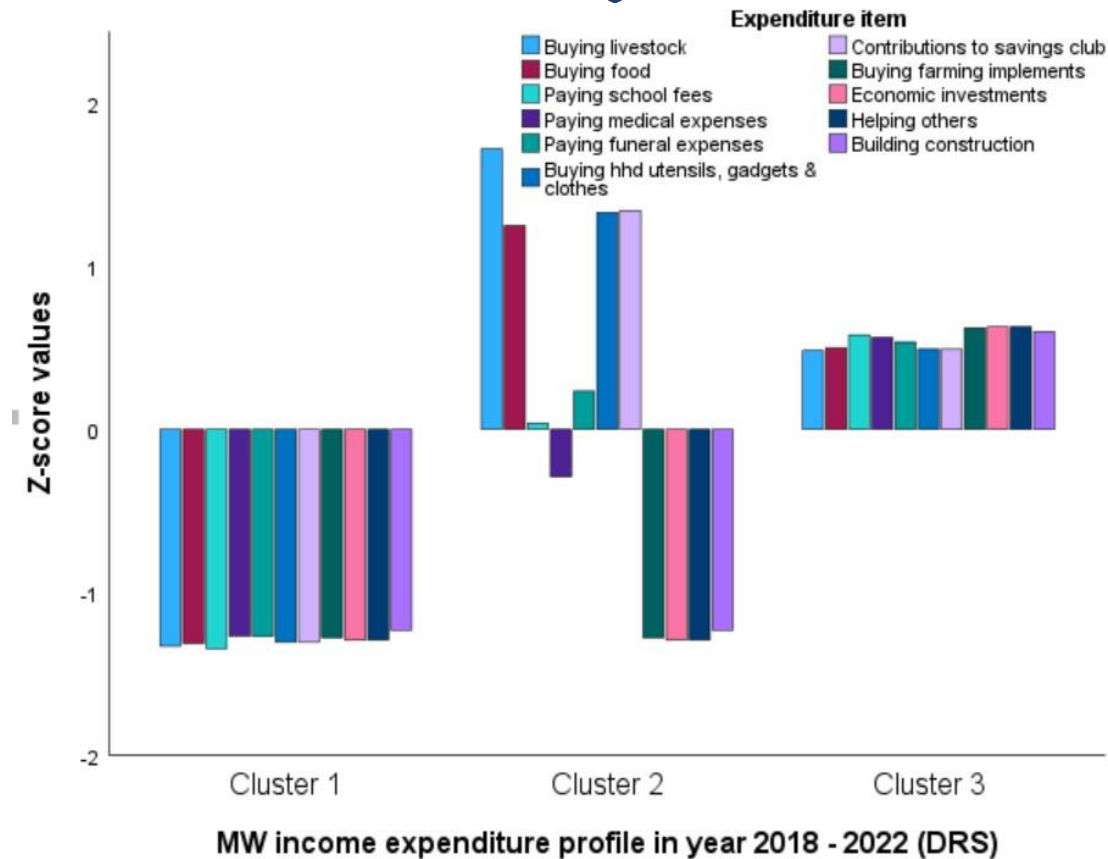


Figure 8.31 Expenditure profile of each MW cluster in year 2018-2022 during the DRS

8.3 A ‘development as hanging in, stepping up and stepping out’ perspective.

This section analysis MW farm household interactions with the local economy via the proposed ‘development as hanging in, stepping in and stepping out perspective.

8.3.1 Typology of livelihood strategies adopted by households during the WRS.

The study assumed that households who use MW proceeds to adopt higher order livelihood strategies such as ‘stepping up’ and ‘stepping out’ are more likely to escape poverty and to be on developmental livelihood trajectories. A decision tree approach was employed to objectively analyse the most dominant livelihood strategies employed in each village. Results are given in Figure 8.32. The associated classification table yielded a value of 78.2%, indicating that the resulting decision tree model has 78.2% predictive capabilities. Four independent variables were considered in the analysis, including the village, its proximity to major rural

markets, wealth status, and headship status. Only significant relationships have been portrayed in Figure 8.32.

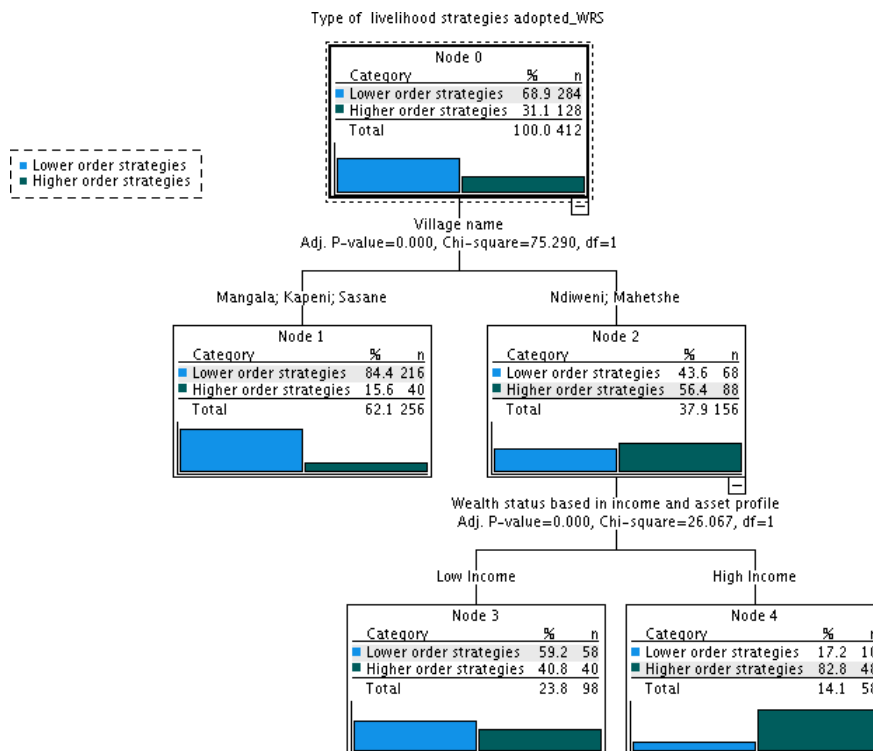


Figure 8.32 Nature of Livelihood strategies adopted by MW farming households during the WRS

Results reveal that, in general many MW farming households (84.4%) have adopted lower order livelihood strategies as compared to a few (15.6%) who have adopted high order livelihood strategies. The most dominant lower order livelihood strategy adopted is ‘linking in’ and ‘hanging on.’ These results have been tested using the CHAID method and are statistically significant. These statistics are worrisome given that there is ample opportunity for households to escape the poverty trap by adopting more progressive livelihood strategies. Results also reveal that the most affected villages are distal communities of Kapeni and Ndiweni that has been grouped together with the proximal community of Mangala. A significantly larger proportion (84.4 %) of households in this cluster of three communities are using MW income to adopt lower order livelihood strategies (chi-square = 78.290; df = 1; P-value<0.0001). The most dominant livelihood strategies among these are the least appealing ‘hanging in’ strategy. An interesting finding relates to the two proximal communities of Ndiweni and Mahetshe where many households (56.4%) are adopting high order livelihood strategies. Season specific differences in terms of which specific livelihood strategy has been adopted by households in

each village. Figure 8.33 for instance shows the livelihood pathway followed by households during the WRS of 2000-2014.

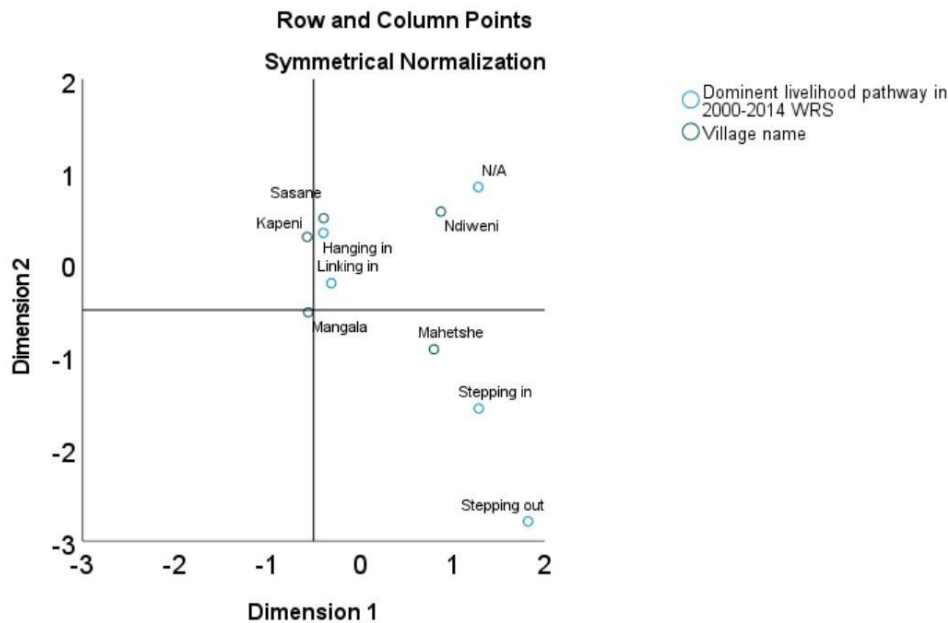


Figure 8.33 Dominant livelihood pathway followed by household from each village (2000-2014 -WRS).

It can be clearly seen that the most dominant livelihood pathways chosen by the distal communities of Kapeni and Sasane is hanging in followed by linking in. Households in Mangala are more leaning towards linking in livelihood pathways. Mahetshe households are more leaning towards stepping in lively pathways. Stepping out livelihood pathways are a strategy that has not been explored by households during this season. The 2014-2018 WRS however portray a totally different picture (figure 8.34).

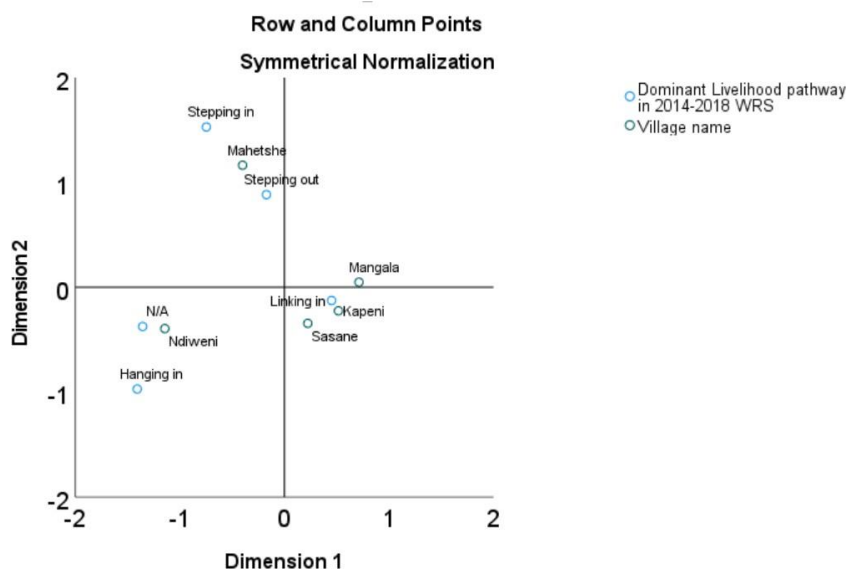


Figure 8.34 Dominant livelihood pathway followed by household from each village (2014-2018-WRS).

The type of strategy adopted was also found to significantly vary with wealth status of households (chi-square = 26.067; df = 1; P-value<0.0001). A highly significant large proportion (82.8%) of high-income households are characteristically adopting higher order livelihood strategies. A large proportion (59.2%) of poor households on the other hand are associated with adopting lower order livelihood strategies.

8.3.2 Typology of livelihood strategies adopted by households during the DRS.

The tree diagram was also used to profile the type of strategies adopted by households during the DRS. The classification table resulted a predictive capability of 77.4%. Results are shown in Figure 8.35.

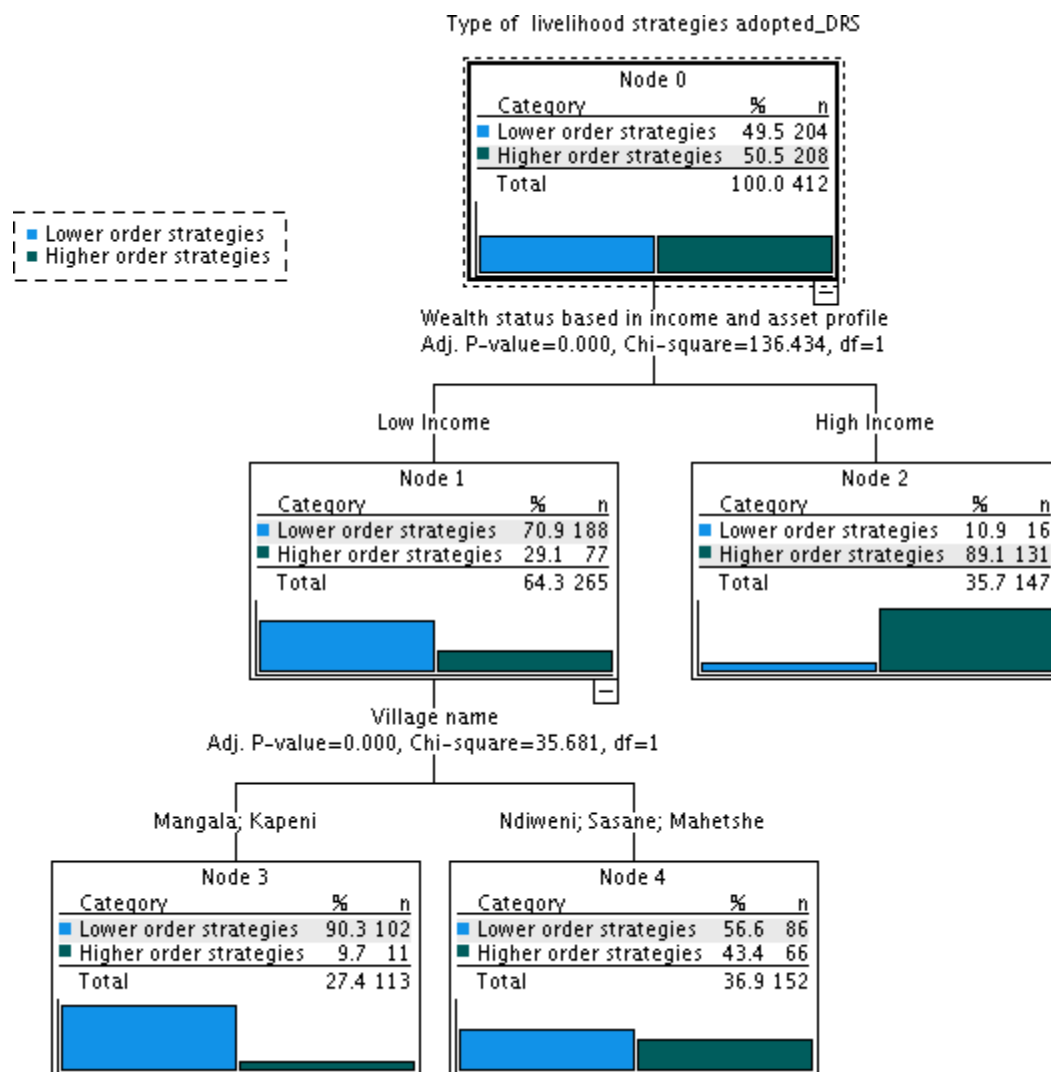


Figure 8.35 livelihood strategies adopted by households during the DRS.

During the DRS the decision tree diagram flips in-favour of wealth status as the most important

variable influencing the type of livelihood strategy adopted. During the WRS, the type of village was the most important predictor. The DRS has seen the same variable becoming the second major predictor.

8.4 A ‘MW households as agents of change’ perspective

Another approach to understanding the potential impact of MW use on the local economy is to look at MW harvesters and / or traders as development change agents. This approach assumes that achieving social and economic transformation that is sustainable and inclusive in rural areas requires capacitating or rather the presents of a high concentration of development agents who are eager to innovate or have a high willingness to adopt innovations that will expand returns on investments associated with the exploitation of the resource. Innovations in the study refer to a wide range of issues, including ideas, practices, products, services, processes, technologies, policies, structures, and administrative systems—that that are perceived as new (Rogers 2003; Damanpour and Schneider 2006). In the context of MW used, innovations may be defined as anything successfully incorporated into the harvesting, processing, storage and marketing of the worm. It refers to both technical and social innovations. Social innovations such as coppicing or annexing of mopane tree may in the long-term boosts the number of harvests and the quantity of other ecosystem service provisioning goods obtained from the Mopane tree. Technical innovations in harvesting, processing and storage and other product marketing innovations such as change of place, change of form, packaging and delayed sales are all targeted at increasing economic returns to investments. This analysis therefore considers both pro-poor innovations (mostly targeted at protecting the host tree for future harvests) and pro- growth innovations targeted at increasing the economic value of the worm. Inclusive and progressive development may therefore be associated with MW territories where many households are participating in such innovations or have a high willingness to embrace innovations. Knowing where participation levels are low or where the willingness to adopt innovations is low is also important for redirecting capacity development programmes so that lagging MW territories are no left behind.

We therefore make a distinction between two groups of households in this section. On one hand we can look at the number of MW harvesting households who have adopted innovations and contrast them with those that have not adopted innovations or whose appetite for adopting innovations is very low. This will allow us to distinguish households according to their appetite

to embrace innovations when exploiting the MW resource. We check that territories have a high concentration of households with a high appetite as opposed to those with a low appetite. The other distinction is between those households whose intent of adopted new innovations is higher as compared to those that are less intent to adopt. This section is therefore structured as follows.

8.4.1 LED implications of households' appetite for MW innovations.

8.4.2 LED implications of household's 'behavioural intent' to innovate.

8.4.1 LED implications of households' appetite for MW innovations.

The study measured household's appetite for innovation adoption by looking at actual innovations (both technical and social) adopted by households during harvesting, processing, storage, and marketing of the worm. Social innovations in this case referred to household efforts to engage in environmental management behaviours targeted at protecting the host tree. Among the list of variables defined as innovations included the use of gloves (for collecting the worm), use of hired labour, use of hired transportation means, improved packaging, selling in smaller quantities, use of won marketing shelters, use of alternative innovative source of energy for processing the worm, use of spices and salt to improve product quality and use of innovating marketing warehouses among others. Frequency of use of such innovations was used as a proxy measure to gauge the household's appetite to embrace innovations. Because data was collected using different scales, data was first standardised and aggregated to create one common innovation index for each household. Using a standardised mean score Z value of 0, a distinction was made between high innovation appetite and low innovation appetite. Since this is a binary choice made by households, a decision tree approach was therefore used to compare different MW territories, according to place and demographic variables such as wealth status, headship status and other spatial variables such as proximity to major markets, economic complexity index and level of environmental degradation. Results are shown in Figure. 8.36.

Appetite for innovations

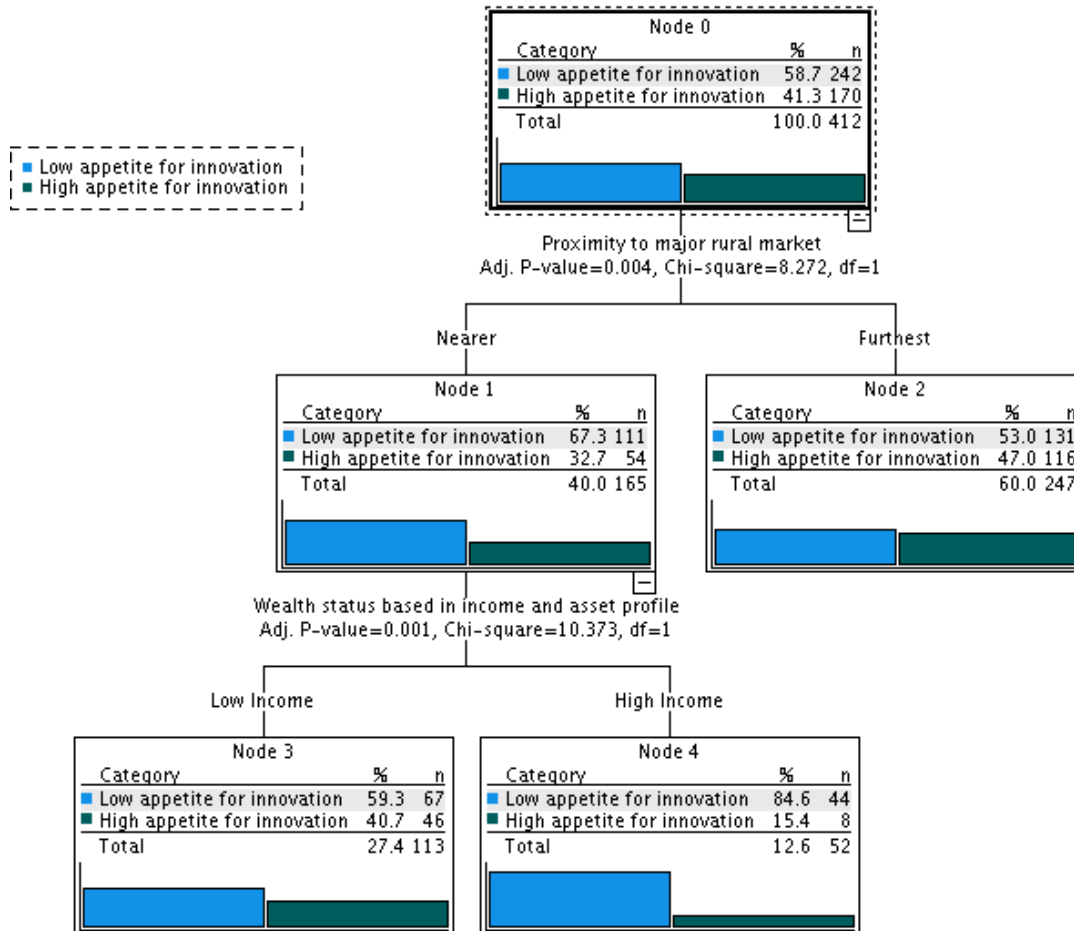


Figure 8.36 households' appetite for MW innovations

Among all independent variables considered only two were found to be statistically significant predictors. These included proximity to major rural market of Maphisa (chi-square = 8.272; df = 1; P-value<0.005), and the wealth status of the household (chi-square = 10.373;df = 1; P-value<0.005).

Variations in appetite for innovations is also shown by village in Figures 8.37 and figure 8.38. We see households coming from Ndiweni and Kapeni have a high appetite for adopting innovations in their MW related activities. Such willingness largely reflects the important value that the MW plays in their livelihoods.

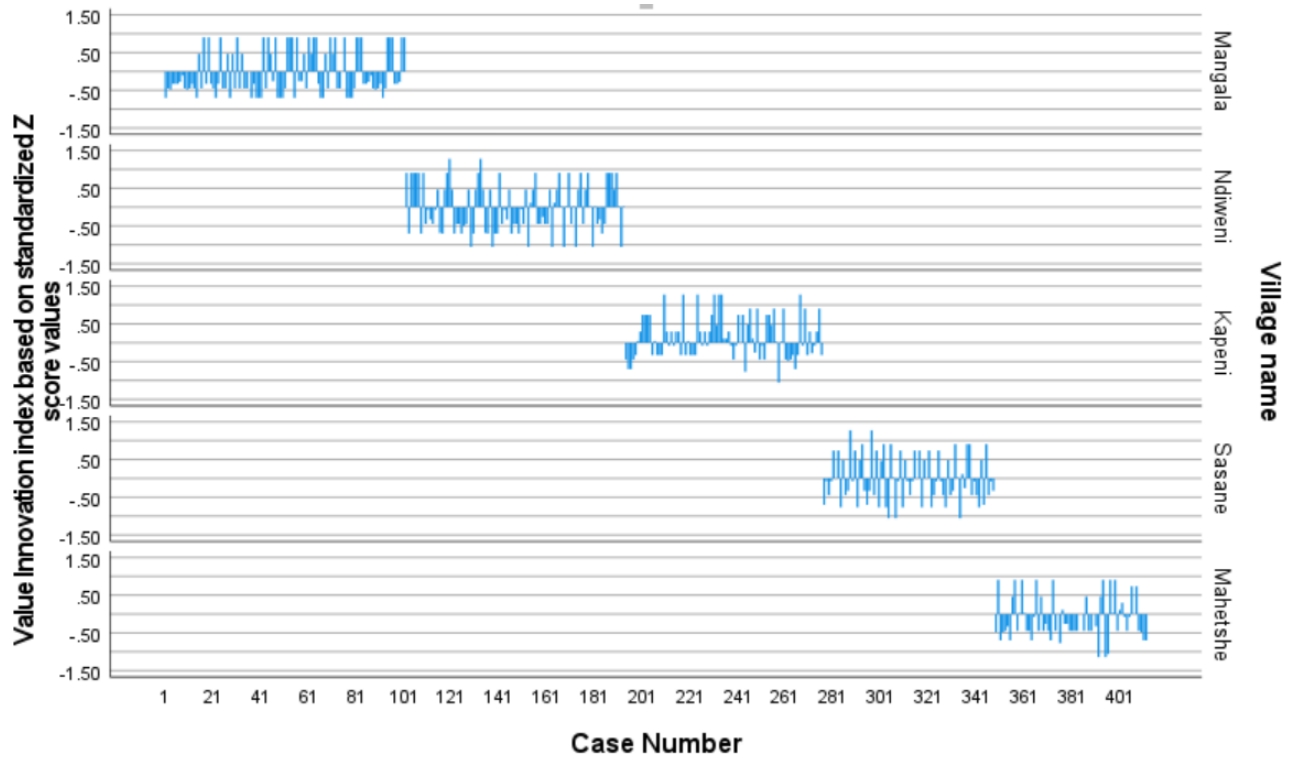


Figure 8.38 households' appetite for MW innovations by village

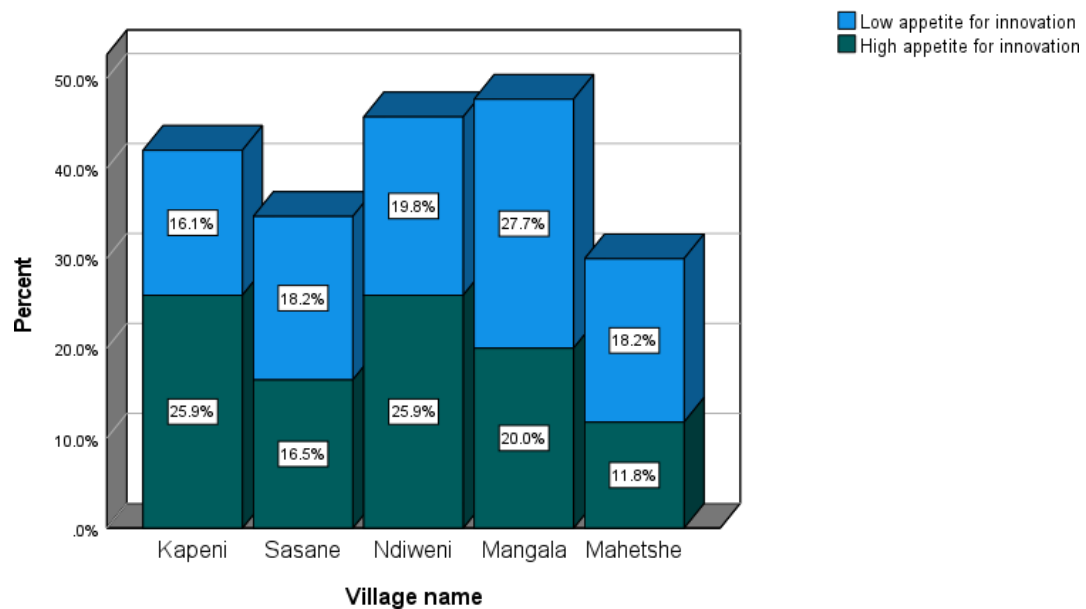


Figure 8.38 households' appetite for MW innovations

8.4.2 LED implications of households' 'behavioural intent' to innovate.

It was possible to map the actual behaviours of MW households in terms of the innovations that they were adopting and to link this to the various possible causes. Possible causes are mapped using the decision tree technique in Figure 8.39. The classification table generated an acceptable figure of 87.6 %.

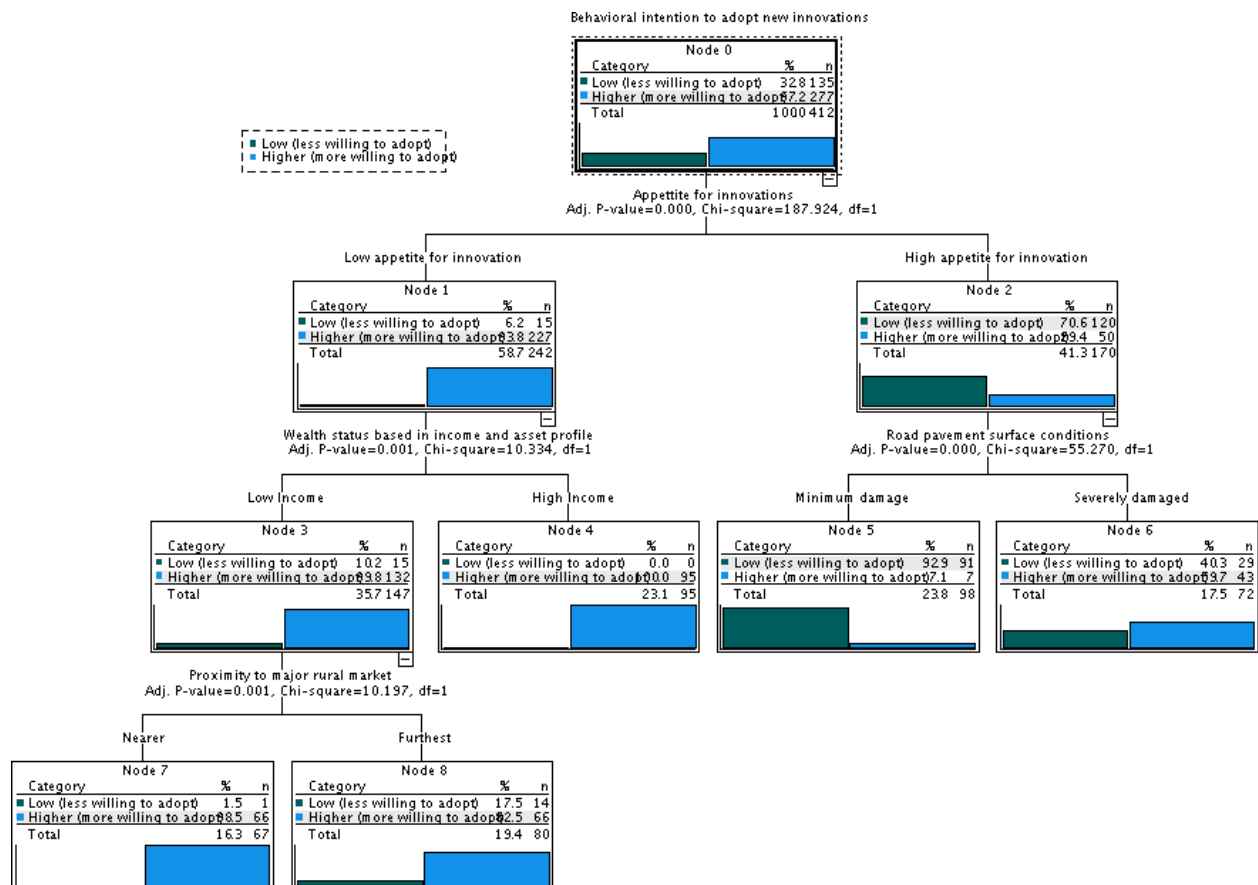


Figure 8.39 Profiling actual innovation behaviours.

Despite higher appetite for innovations portrayed previously in such villages and Ndiweni and Kapeni, households are not adopting many current innovations on offer. Higher-income families were constantly using innovation - mostly marketing innovations. Households from restricted access due to damaged road infrastructure are involved in severe innovative practices as opposed to those from better road conditions.

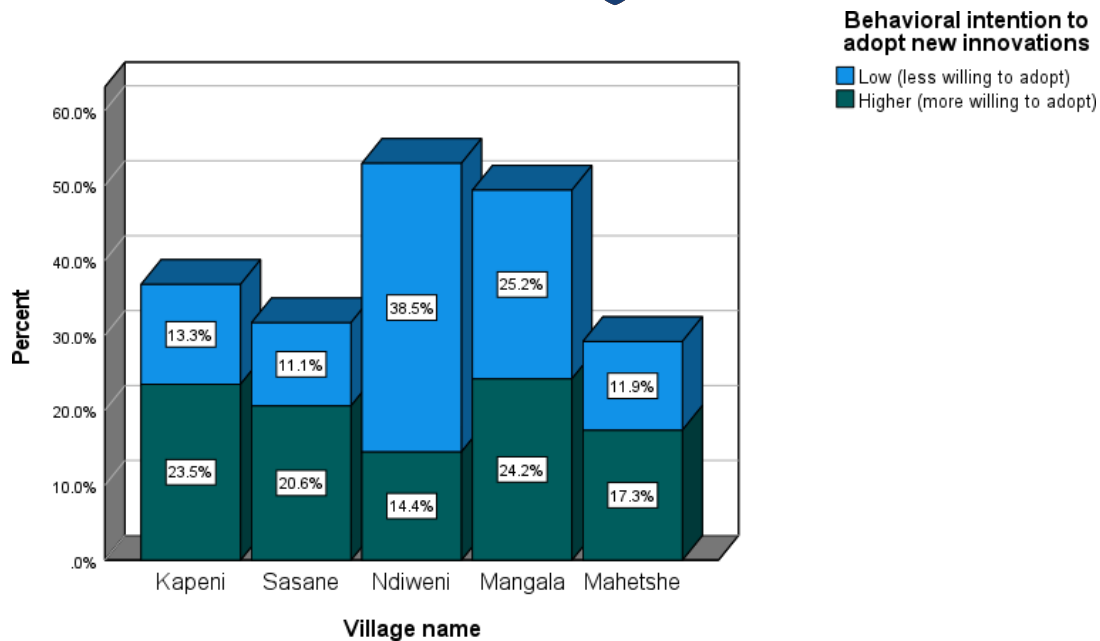


Figure 8.40 profiling actual innovation behaviours

The biggest adopters of innovations in MW utilisation are households from Kapeni and Mangala (Figure 8.40) In Mangala it is mostly the marketing innovations while in Kapeni it is mostly the harvesting innovations.

8.5 Spatial and temporal changes in the impact of MW income on inequality

One other way of measuring the impact of resource use on the local economy is to assess the relationship between resource income and inequality. It has already been argued in the method section that situations of growth in the local economy as measured by an inequality index will happen if there is a registered movement in inequality statistics. The study calculated the most employed measure of inequality, the Gini coefficient and the associated Lorenz graphics to demonstrate if MW income was having any meaningful impact of the lives of harvesting households. Temporal variations are analysed by computing the Gini coefficient for the combined income statistics of the WRS and DRS and associated disaggregation based on the three time periods 2000-2014, 2014-2018 and 2018-2022. Spatial differences are analysed by comparing the Gini coefficient statistics between villages, territorial clusters, proximal communities, and distal communities. Because of well documented challenges of estimating household income, data from the household survey was restricted to cash income statistics. The assumption here was that households recall more cash income that they received rather than

the complications associated with recalling all economic transactions and reducing them to monetary values. Nevertheless, complimentary analysis that involved a recall of all monetary transactions was conducted with a few samples of participants during the group discussions held in each village.

8.5.1 Temporal changes in income inequality during the WRS and DRS

Based on household survey data, the study calculated and compared Gini coefficient index for the situations ‘with’ and ‘without’ MW incomes to gauge the impact of MW income during the WRS and DRS. Such analysis was only restricted to income statistics of harvesting households only. Percentile income statistics associated with such analysis are shown in Table 6.11.

Table 8.11 Percental income distribution of harvesting households under combined income statistics of the WRS and DRS.

	Combined income statistics per harvesting household (US\$)			
	WITH MW INCOME		WITHOUT MW INCOME	
Percentiles Resource State	WRS	DRS	WRS	DRS
5	1183,56	1793,33	740,13	1682,93
10	1478,67	2016,67	1118,00	1924,47
25	2155,56	3100,00	1703,67	2949,67
50	3945,00	5000,00	3126,00	4820,00
75	5763,89	7466,67	4854,00	7098,00
90	9523,67	12500,00	7649,20	11450,07
95	15526,67	27266,67	12430,09	25020,00
Tukey's Hinges				
25 (Q1)	2158,61	3100,00	1705,33	2951,83
50 (Q2)	3945,00	5000,00	3126,00	4820,00
75 (Q3)	5759,72	7433,33	4848,89	7087,67

The Tukey's hinges statistics are consistently displaying higher DRS median income values (Q2) for harvesting households in both income scenarios (i.e. the with versus the without MW income). To assess the meaningful contribution of MW income in addressing inequality, Gini coefficient indices and associated Lorenz curves were computed. The resulting Gini coefficient and associated Lorenz curves are shown in Figure 8.41.

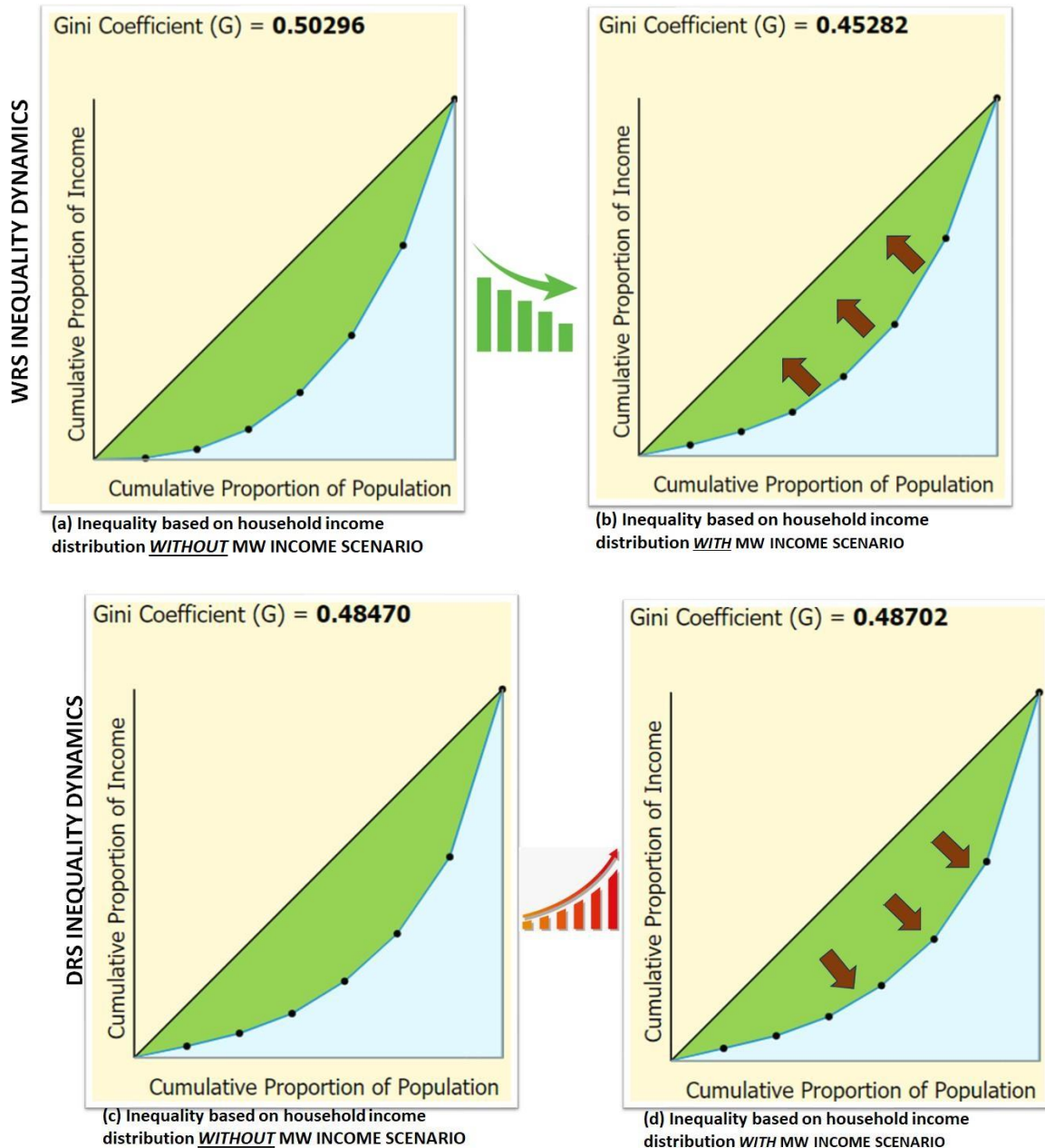


Figure 8.41 Income inequality shifts under the ‘with’ and ‘without’ MW income scenarios of the WRS and DRS.

Results during the WRS revealed a drop in the Gini coefficient from 0.50296 of the without MW income scenario (a) to 0.45282 of the with MW income scenario (b). The associated shift in the Lorenz curve towards the line of equality indicates that the inclusion of MW income in the calculation of the Gini coefficient resulted in a decrease in income inequality during the WRS. The LED implications associated with this is how authorities should intervene to increase the magnitude of such a shift so that MW harvesting as an income generating activity has a meaningful impact in reducing income inequalities among harvesting households.

A contrasting picture is however displayed when one looks at similar statistics for the DRS. Results during the DRS revealed an increase in the Gini coefficient from 0.48470 of the without MW income scenario (c) to 0.48702 of the with MW income scenario (b). The associated shift in the Lorenz curve away from the line of equality indicates that the inclusion of MW income in the calculation of the Gini coefficient resulted increase in income inequality during the DRS. We can conclude from this observation that subdued harvests and decreased returns from MW trade has resulted in increased income inequalities among households in the study area as they transition from the WRS to the DRS. Implementing MW-oriented LED strategies targeted at boosting supplies and returns from trade will go a long way in overcoming income inequalities. This global picture however conceals interesting variation over time if one looks at disaggregated inequality statistics by year. Figure 8.42 show such disaggregation by year in relation to the DRS.

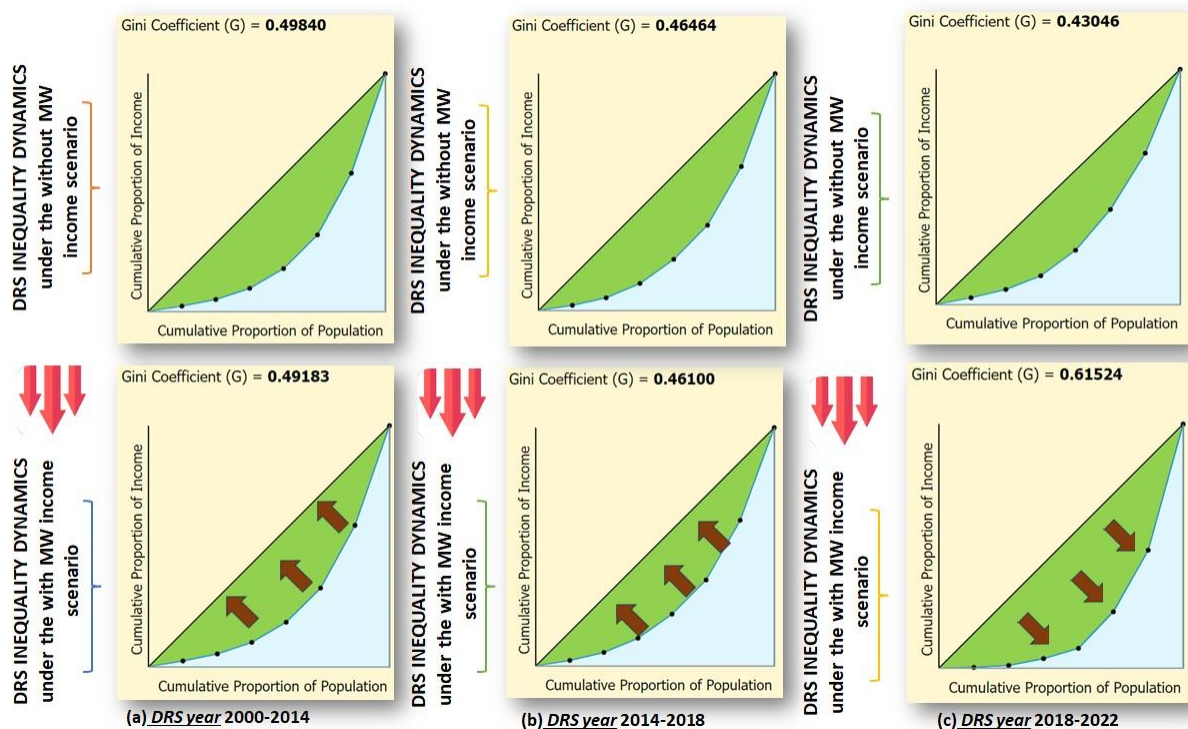


Figure 8.42 Disaggregated income inequality shifts under the ‘with’ and ‘without’ MW income scenarios of the WRS and DRS.

Further analysis from disaggregated income statistics by resource state and year of harvesting yielded interesting differences in Gini coefficients as shown in Figure... Shifts in income inequality show a similar trend for the DRS of years 2000-2014 and 2014-2018. We observe a drop in Gini coefficient indices, signalling the important role that MW income plays in

reducing income inequalities. We however see households transition to the period increased inequalities in year 2018-2022. This is because the Gini coefficient dropped from a low value of 0.43046 to a high value of 0.61524.

8.5.1 Spatial and temporal changes in income inequality during the WRS and DRS

Village dynamics versus impact of MW income on inequality

Based on household survey data, the study also calculated and compared Gini coefficient index for the situations ‘with’ and ‘without’ MW incomes to gauge the impact of MW income on inequality for each of the 5 villages during the WRS and DRS. Resulting Gini coefficients are shown in Table 8.12.

During the WRS of year 2000-2014, MW income was critical in reducing income inequalities among households in three villages of Sasane, Ndiweni and Mangala. Positive shifts in the Gini coefficient indices for Kapeni and Mahetshe villages meant that earnings from MW trade resulted in increased income inequalities.

Table 8.12 Spatial and temporal changes in Gini coefficients between villages during the WRS and DRS

Village	MW income Scenario	Changes in Gini coefficients between villages					
		2000-2014		2014-2018		2018-2022	
		WRS	DRS	WRS	DRS	WRS	DRS
Kapeni	<i>Without</i>	0.42996	0.43299	0.40171	0.36998	0.38422	0.39209
	<i>With</i>	0.43522	0.37542	0.39579	0.36815	0.36714	0.39054
	Change*	+ve	-ve	-ve	-ve	-ve	-ve
Sasane	<i>Without</i>	0.36285	0.39563	0.36285	0.35623	0.42109	0.45596
	<i>With</i>	0.35232	0.42109	0.35232	0.33843	0.39524	0.45440
	Change	-ve	+ve	-ve	-ve	-ve	-ve
Ndiweni	<i>Without</i>	0.41152	0.41090	0.40840	0.43967	0.41011	0.40742
	<i>With</i>	0.40845	0.28144	0.40883	0.43981	0.41618	0.40570
	Change	-ve	-ve	+ve	+ve	+ve	-ve
Mangala	<i>Without</i>	0.55674	0.55470	0.56319	0.65838	0.48434	0.68537
	<i>With</i>	0.55302	0.52797	0.55559	0.65686	0.47784	0.68317
	Change	-ve	-ve	-ve	-ve	-ve	-ve
Mahetshe	<i>Without</i>	0.45800	0.45969	0.45800	0.50451	0.37351	0.54955
	<i>With</i>	0.45974	0.56015	0.45974	0.50295	0.37261	0.55022
	Change	+ve	+ve	+ve	+ve	-ve	+ve

* Refers to either an increase (+ve movement) or a decrease (-ve movement) in the Gini coefficient index.

A similar pattern of inequality movements is also reflected for the DRS of the year, 2000-2014, the WRS of year 2000-2018 and the DRS of year 2014-2018, where we see the inequality

indices of three village being reduced because of MW income earnings. The year 2018-2022 is characterised by 4 villages where MW income earnings has made some difference in terms of reducing income inequalities. During this time it has only resulted in increased income inequalities for the two villages of Kapeni during the WRS and Mahetshe during the DRS. Looking at the global picture, we see MW income earnings consistently making a meaningful contribution to reducing income inequalities to villages such as Mangala, Kapeni and Sasane where we see a drop in at least 5 out of the 6 Gini coefficient indices calculated for the three time period and 6 resource states under analysis. We however see an increase in 5 out of 6 Gini-coefficient indices calculated for Mahetshe village. This makes Mahetshe village a unique case where MW income has resulted in increased income inequalities among households.

Proximity to major markets versus impact of MW income on inequality

The study also calculated and stacked Gini coefficients according to the level of access that households had to major markets. Distance to major rural markets such as Maphisa was used as a proxy indicator of physical access to major markets. The assumption here was that income inequalities and associated impact of MW income earnings would vary according to distance from major markets. Combined percentile income statistics for harvesting households under the WRS and DRS are shown in Table 8.13. The percentile incomes have been stacked for the two income scenarios, 'with' and 'without' income.

Table 8.13 Percental income distribution of harvesting households under combined income statistics of the WRS and DRS.

Percentiles / Resource State	Combined income statistics per harvesting household (US\$)							
	WITH MW INCOME				WITHOUT MW INCOME			
	WRS		DRS		WRS		DRS	
	Distal	Prox.	Distal	Prox.	Distal	Prox.	Distal	Prox.
5	900,21	1328,89	1832,50	1696,67	296,07	806,94	1727,90	1611,27
10	1309,71	1628,79	2026,67	2000,00	1033,82	1222,86	1945,47	1896,60
25	1943,79	2281,15	3462,50	2816,67	1512,79	1795,83	3258,17	2699,83
50	3262,50	4361,90	4650,00	5400,00	2871,00	3656,67	4495,50	5116,00
75	4910,56	7096,67	6408,33	9020,83	4398,17	5265,78	6198,50	8330,06
90	6255,83	14357,44	8135,00	20640,00	5706,93	11151,93	7865,63	19940,80
95	7380,00	17652,67	9341,67	42703,33	6723,20	13927,37	9058,42	39979,63
Tukey's Hinges								
25 (Q1)	1946,67	2286,11	3466,67	2833,33	1518,67	1865,56	3279,00	2716,00
50 (Q2)	3262,50	4361,90	4650,00	5400,00	2871,00	3656,67	4495,50	5116,00
75 (Q3)	4906,67	6966,67	6400,00	8708,33	4389,78	5248,89	6195,33	8297,78

Based on median income statistics (Q2 statistics), data shows that proximal communities are

consistently receiving higher incomes for both scenarios (with and without MW income) under both resources' states (WRS and DRS). To understand variability in income earnings shown in the table, the study calculated the Gini coefficients. The resulting Gini coefficients and associated Lorenz curves for the WRS are shown in Figure 8.43.

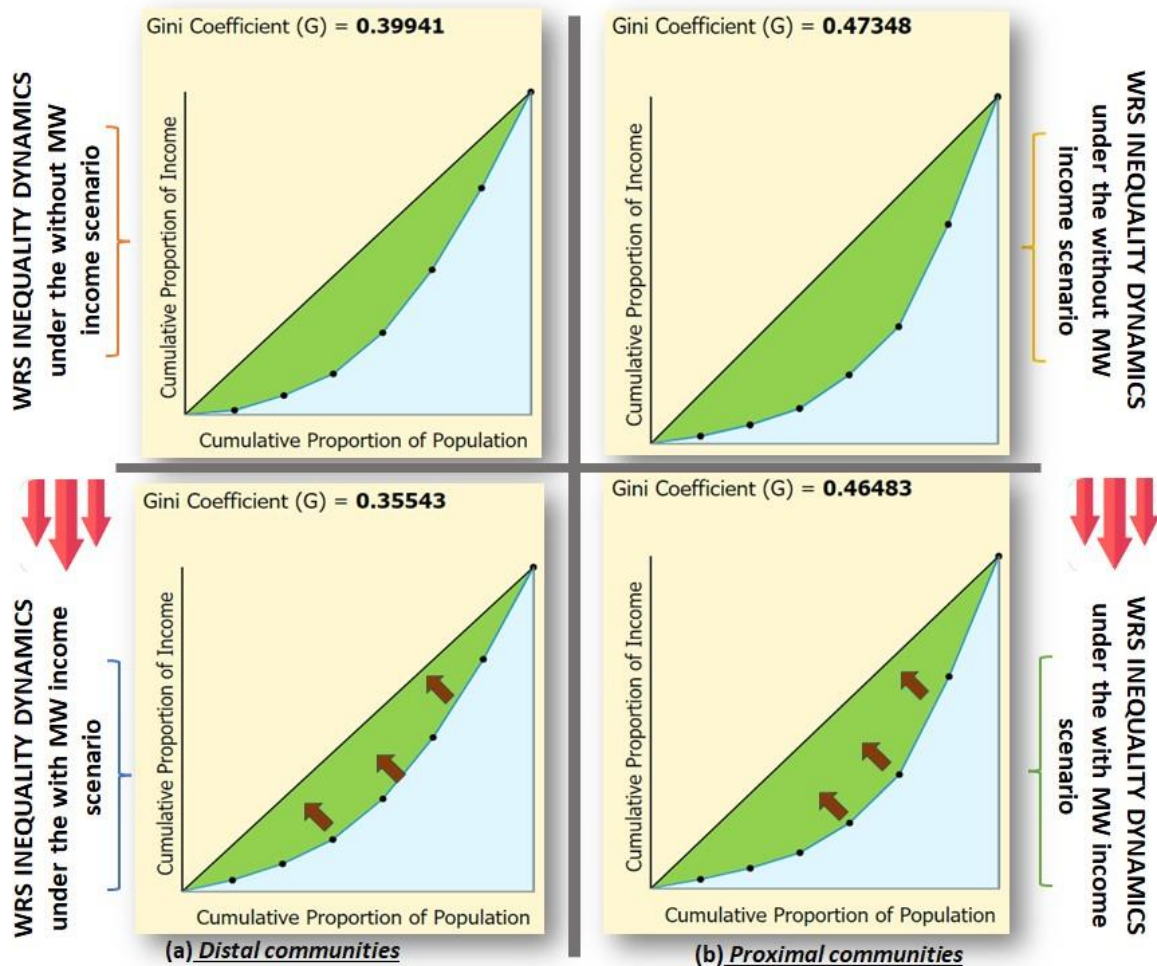


Figure 8.43 Proximity to major markets versus impact of MW income on inequality during the WRS

As shown by relatively higher the Gini coefficient statistics, proximal communities are generally characterised by high-income inequality when compared to distal communities. Both type of communities received a boost in the reduction of inequality as we transition from a without MW income to a with MW income scenario. This is because we see a drop in Gini coefficient statistics and associated movements of the Lorenz curves towards the line of income equality. The DRS inequality situation with and without MW income is shown in Figure 8.44 for both distal and proximal communities.

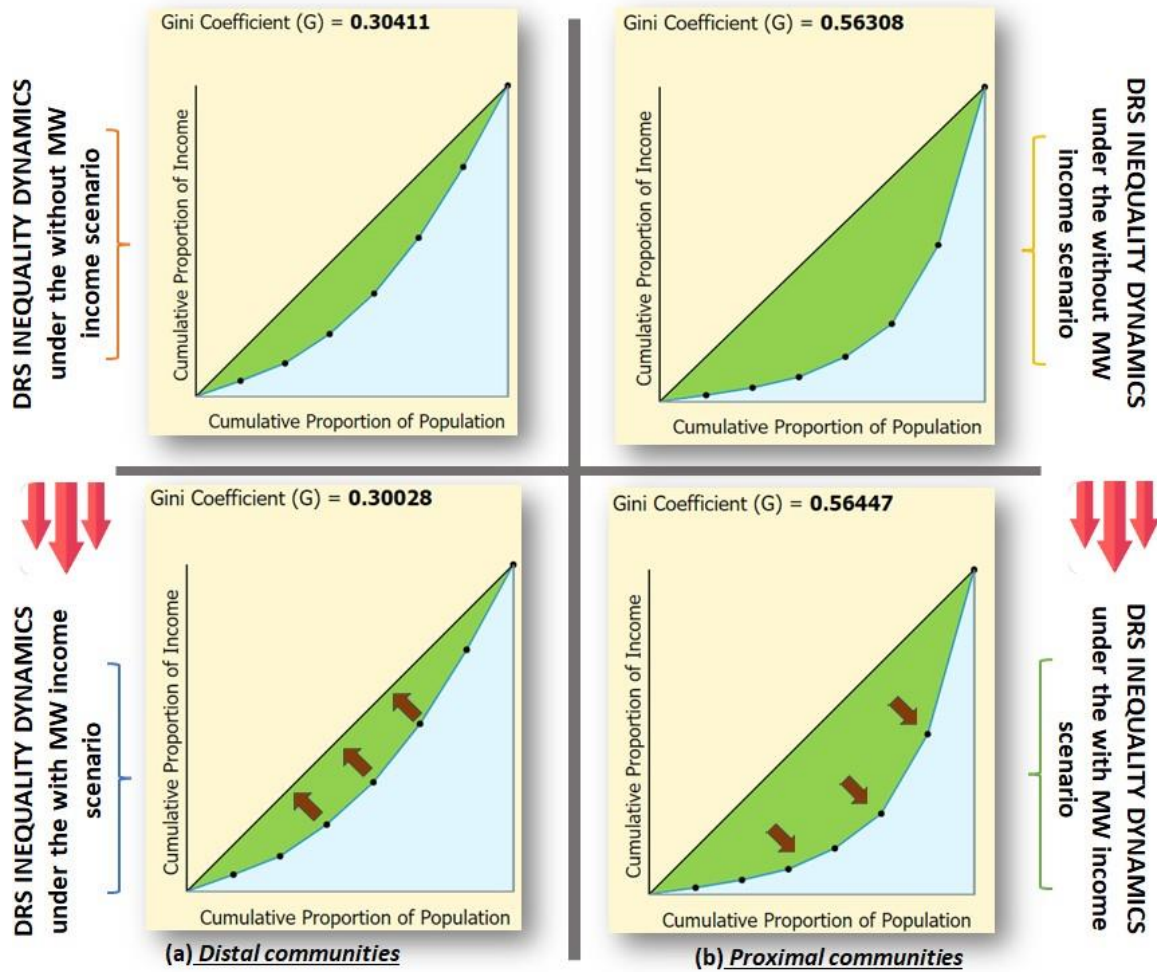


Figure 8.44 Proximity to major markets versus impact of MW income on inequality during the DRS

Results depict a similar pattern of income inequality that sees high-income variability in households residing in proximal communities as opposed to those who reside in distal communities during the DRS. While MW income is making a difference in reducing income inequalities in distal communities, we see MW earnings being responsible for increasing income inequalities in proximal communities. We see the Lorenz curve moving away from the line of income inequality in response to an increase in the Gini coefficient from a value of 0.56308 (for the without MW income scenario) to a value of 0.56447 (for the with MW income scenario).

Year on year dynamic changes in income inequality as measured by the Gini coefficient are shown in Table 6.14. Results over the three-year period under review reveal that the inequality indices measured by the Gini coefficient are consistently higher for proximal communities compared to those of distal communities. When we factor in MW income earnings, we see the

Gini coefficients of distal communities dropping consistently in year 2000-2014 (the DRS being the exception), year 2014-2018 and year 2018-2022.

Table 8.14 Spatial and temporal changes in Gini coefficients between proximal and distal communities during the WRS and DRS

Distance from major markets	MW income Scenario	Gini coefficients between proximal and distal communities					
		2000-2014		2014-2018		2018-2022	
		WRS	DRS	WRS	DRS	WRS	DRS
Distal	<i>Without</i>	0.38478	0.38276	0.38253	0.32445	0.39805	0.42073
	<i>With</i>	0.38129	0.40742	0.36764	0.32251	0.37701	0.41860
	Change*	-ve	+ve	-ve	-ve	-ve	-ve
Proximal	<i>Without</i>	0.50957	0.51041	0.48019	0.59097	0.43712	0.56217
	<i>With</i>	0.51079	0.51463	0.47139	0.58952	0.44311	0.56297
	Change	+ve	+ve	-ve	+ve	-ve	+ve

* Refers to either an increase (+ve movement) or a decrease (-ve movement) in the Gini coefficient index.

Such results indicate that MW incomes are playing a decisive role in lowering income inequalities in distal communities more than they are doing for proximal communities. A mixed picture is portrayed when it comes to proximal communities. During the year 2000-2014, we see increase in the Gini coefficient in both the WRS and DRS. Such an upward trajectory indicates that MW income earning resulted in increased income inequalities. In the year 2014-2018 and year 2018-2022, we see MW income earnings playing an important role of reducing income inequalities during the WRS. In contrast, MW income earnings are exacerbating income inequalities during the DRS as evidenced by a positive change in Gini coefficient statistics.

8.6 An LED index development approach

The study employed multiple indices to measure LED. Such type of indices was then compared using two development scenarios. One scenario entailed looking the LED index value for communities where the intensity of involvement in MW trading was low. The other scenario was to look at the LED index value for communities where the intensity of involvement in trade was high. Intensity of involvement in MW trade was measured through the Household Commercialisation Index (HCI) calculated through the formula described in the method section. Here the main assumption was that LED index values from communities where the intensity of involvement in MW trade is higher will be relatively higher than the same obtained from communities where the intensity of involvement was low. A multiple indicator system

that looked beyond income as the only indicator of development was employed to measure development and progress at the local level. The partial indices that were developed to measure development at local level included.

8.6.1 Economic complexity index

8.6.2 Household Infrastructure and Services Index

8.6.3 Rural access as measured by road pavement distress index.

8.6.4 Inequality Index as measured by a localised Gini coefficient.

8.6.5 Territorial Cohesion measured by the Global Territorial Dynamic Index.

8.6.6 Resilience Index

8.6.1 Economic Complexity Index (ECI) and Intensity of Involvement in MW trade.

The study assumed that increased involvement in MW trade will allow enterprising households to invest part of their earned income into other new business establishment. Number of economic establishments is an important input variable in the calculation of the ECI. The study first distinguished two groups of rural households according to their intensity of involvement in MW trade based on the calculated Household Commercialisation Index (HCI). Using the mean as cut off point, one group whose HCI was above this value ($ECI > \text{mean}$) was characterised as ‘high intensity of involvement’ in MW trade. The other group whose HCI was less than the mean was characterised as ‘low intensity of involvement’ in MW trade. The study sought to test if the intensity of involvement in MW trade made any meaningful difference in the resulting ECIs. Two models were considered to check if the findings were consistently yielding the same results. One model related to HCI statistics during the WRS and the other during the DRS.

Associated ECIs for both types of rural households were calculated and results are presented in Table 6.15.

Table 8.15. Relationship between ECI and intensity of involvement in MW

HCI classification (Intensity of involvement in MW trade)	WRS		DRS	
	ECI	Std. Dev.	ECI	Std. Dev.
Low intensity	,208515	,1475832	,205687	,1295957
High intensity	,246287	,1200439	,243689	,1301980
Partial LED Index 1 (ECI)	,233635	,1309612	,233635	,1309612

Results reveal that ECIs for communities highly engaged in MW trade is consistently higher than that of those of communities less engaged for both the WRS and DRS. The study conducted an ANOVA analysis to test if there was any meaningful difference between the ECIs of the two types of HCI classifications for two model scenarios as shown in Table 8.16.

Table 8.16 ANOVA test results: Statistical difference between ECI and intensity of involvement in MW trade.

MODEL TYPE		Sum of Squares	Df	Mean Square	F	P-value
MODEL(WRS)	Between Groups	,131	1	,131	7,760	,006
	Within Groups	6,918	410	,017		
	Total	7,049	411			
MODEL 2(DRS)	Between Groups	,116	1	,116	6,846	,009
	Within Groups	6,933	410	,017		
	Total	7,049	411			

Both models revealed statistically significant ($P\text{-value} < 0.05$) differences in the ECIs communities where the intensity of involvement in MW trade was deemed high as opposed to where the intensity of involvement was characterised as low. The effect size of such association was however low since the Eta squared statistics of both models were low. Model1 yielded an Eta squared value of 0.019 while model 2 yielded a value of 0.016.

8.6.2 Household Infrastructure and Services Index (HISI)

Based on previous research results and own experiences working in the study communities in previous projects, the study assumed that MW income is critical in fostering major improvements in certain infrastructure facilities and services at least at the household level. It was possible to observe any improvements in this sector and analyse if there were any statistical differences between the two scenarios of high intensity of involvement in MW trade versus

low intensity of involvement. Since data was available for both the non- harvesting and the harvesting households, intensity of involvement was contrasted according to nature of involvement in MW related activities. Table 8.18 shows variations in the HISIs according to nature of involvement in MW related activities.

Table 8.17 Variation in HISI according to nature of involvement in MW harvesting

Nature of involvement	Measure	Statistic	Bootstrap ^a			
			Bias	Std. Error	ConfidenceInterval	
					Lower	Upper
Non harvesting	HISI	,4432	,0000	,0152	,4091	,4724
	Std. Dev.	,18427	-,00071	,00976	,16385	,20232
Harvesting	HISI	,5920	-,0001	,0121	,5669	,6156
	Std. Dev.	,20366	-,00051	,00778	,18771	,21846
Partial LED Index 3 (HISI)	Mean	,5425	,0001	,0101	,5221	,5621
	Std. Dev.	,20931	-,00033	,00699	,19539	,22255

a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

The resulting HISI statistics reveal that households involved in harvesting and trading of MWs have invested positively into improving own infrastructure facilities and services. This is because of the associated HISI value of 0.5920 that is above the cut-off point of 0.5 indicating positive changes in the improvements made to existing infrastructure facilities and services. On the contrary, own infrastructure and services for non-harvesting households has regressed as negative changes have been witnessed by such households as evidenced by a low HISI value of 0.4432 (i.e $HISI < 0.5$). An ANOVA analysis was conducted to test if there were statistically significant differences in the HISI statistics between the two groups (see Table 8.18)

Table 8.18 ANOVA test results: Statistical difference between HISI and nature of involvement in MW harvesting and trade

	Sum ofSquares	Df	Mean Square	F	P-value
Between Groups	2,025	1	2,025	51,939	<,001
Within Groups	15,982	410	,039		
Total	18,007	411			

Eta squared = 0.112

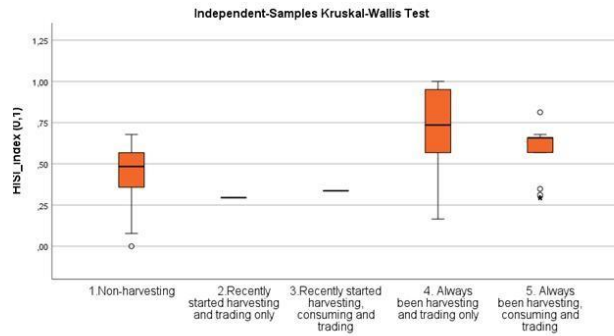
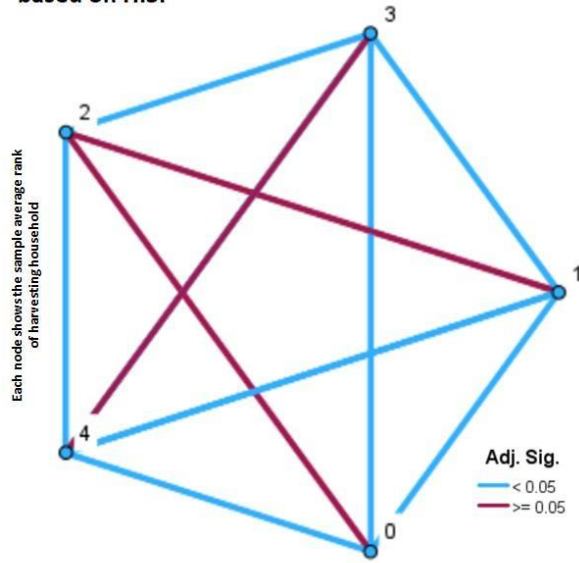
This analysis is also consistent with specific categories in involvement in MW harvesting and trading (Table 8.19).

Table 8.19. Variation in HISI according to specific categories of involvement in MW harvesting

Sample	Nature of Involvement	HISI	Bootstrap ^a			
			Bias	Std. Error	95% Confidence Interval	
					Lower	Upper
1	<i>Non harvesting</i>	,4432	,0000	,0152	,4091	,4724
2	<i>We have recently started harvesting and trading only</i>	,2943	,0000	,0000	,2943	,2943
3	<i>We have recently started harvesting, consuming, and trading</i>	,3362	,0000	,0000	,3362	,3362
4	<i>We have always been harvesting and trading only</i>	,7033	-,0009	,0254	,6534	,7515
5	<i>We have always been harvesting, consuming, and trading</i>	,6044	,0002	,0092	,5860	,6223
	Partial LED index 3 (HISI)	,5425	,0001	,0101	,5221	,5621

As shown in the table, the greatest impact on infrastructure and services has been associated with households with a long history of harvesting and trading the MW (HISI = 0.7033). such households because of religious beliefs don't consume the worm but harvest solely for the purposes of trading. This is followed by those who have always been harvesting, consuming, and trading (HISI = 0.6044). The least impact has been associated with those who have started harvesting and trading only (HISI = 0.2943). A Kruskal Wallis Test was conducted to investigate any differences and / or similarities between the generated HISI scores and the nature of household's involvement in MW harvesting and trading (see Figure 8.45). Statistically significant differences in HISI scores were discerned between household who have always been harvesting and trading only and non-harvesting households (P-value = <0.001). A similar conclusion can also be reached between the HISI scores of non-harvesting and that of households who have always been involved in harvesting, consuming and trading.

Pairwise comparison of harvesting households based on HISI



Nature of household involvement in MW harvesting

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig. ^a
2- 3	-31.500	38.959	-.809	.419	1.000
2- 1	107.978	24.908	4.335	<.001	.000
2- 5	-199.103	24.782	-8.034	<.001	.000
2- 4	-229.261	26.025	-8.809	<.001	.000
3- 1	76.478	33.192	2.304	.021	.212
3- 5	-167.603	33.097	-5.064	<.001	.000
3- 4	-197.761	34.038	-5.810	<.001	.000
1- 5	-91.125	14.071	-6.476	<.001	.000
1- 4	-121.283	16.161	-7.505	<.001	.000
5- 4	30.159	15.965	1.889	.059	.589

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Figure 8.45 Pairwise comparison of harvesting households based on the HISI.

8.6.3 Rural access as measured by road pavement distress index.

Inspired by evidence from the tourism sector where the quality of road infrastructure may be improved by tourism through what has been termed 'tourism led infrastructure development' hypothesis, this study made an important assumption about a plausible link between road pavement distress and the MW business. Since most of the buyers for the MW stock come from all over the country and sometimes beyond borders to come and fetch the stock, the study hypothesised that quality of road pavements in communities where the intensity to engagement in MW trade is high might be relatively better than that of communities where the intensity of involvement is low. Results are shown in Table 8.20.

Table 8.20 Relationship between PDI and intensity of involvement in MW

HCI classification (Intensity of involvement in MW trade)	WRS		DRS	
	PDI	Std. Dev.	PDI	Std. Dev.
Low intensity	,6562	,38808	,5859	,39283
High intensity	,3250	,32224	,3820	,35958
Partial LED Index 1 (PDI)	,4359	,37904	,4359	,37904

The analysis revealed that road rural access measured by road pavement condition was consistently and significantly higher in all instances where the intensity of involvement in trade was high for both the WRS and the DRS (Figure 8.21).

Table 8.21 ANOVA test results: Statistical difference between PDI and intensity of involvement in MW trade.

MODEL TYPE		Sum of Squares	Df	Mean Square	F	P-value
MODEL(WRS)	Between Groups	10,068	1	10,068	84,279	<,001
	Within Groups	48,981	410	,119		
	Total	59,049	411			
MODEL 2(DRS)	Between Groups	3,335	1	3,335	24,544	<,001
	Within Groups	55,714	410	,136		
	Total	59,049	411			

Both models revealed statistically significant ($P\text{-value} < 0.05$) differences in the PDIs

8.6.4 Inequality Index as measured by a localised Gini coefficient.

Such analysis has been done in the previous sessions by comparing the with and without MW Income scenarios. The analysis has shown that in almost all scenarios considered and stacked against the spatial and time variables, MW income is making a meaningful contribution to those involved in the harvesting business.

8.6.5 Territorial Cohesion measured by the Global Territorial Dynamic Index.

Such analysis has been done in the previous sessions by calculating the Global Territorial Dynamic Index via the DEA approach. The analysis identified territorial cluster 2 out of the 5 territorial cluster solution as the cluster that occupied the Production Possibility Frontier (PPF) as technical efficiency on all its 5 territorial capabilities equalled 1. Using the HCI as a measure of intensity of involvement in MW trade, the study has already revealed that high HCI indices were associated with Cluster 2. Statistically significant differences between cluster 2 HCIs and all other cluster has already been discerned using the Kruskal Wallis H Test. What these results imply is that a high intensity of involvement in MW trade is significantly associated with MW territories are efficiently converting their capabilities and potentialities into successful territorial outcomes measured by MW income received.

8.6.6 Resilience Index

The study assumed that MW interventions would make a difference in the local economy if related activities of harvesting households are making any meaningful impact to enhance the resilience capacities of their respective territories. The expectation is that they should be a difference between the resilience capacities of communities that are involved in harvesting the worm as opposed to those not involved. It was therefore possible to compare harvesting and non-harvesting households based on the calculated Global Reliance Indices (GRIs). Results of the analysis are shown in Figure. 8.46.

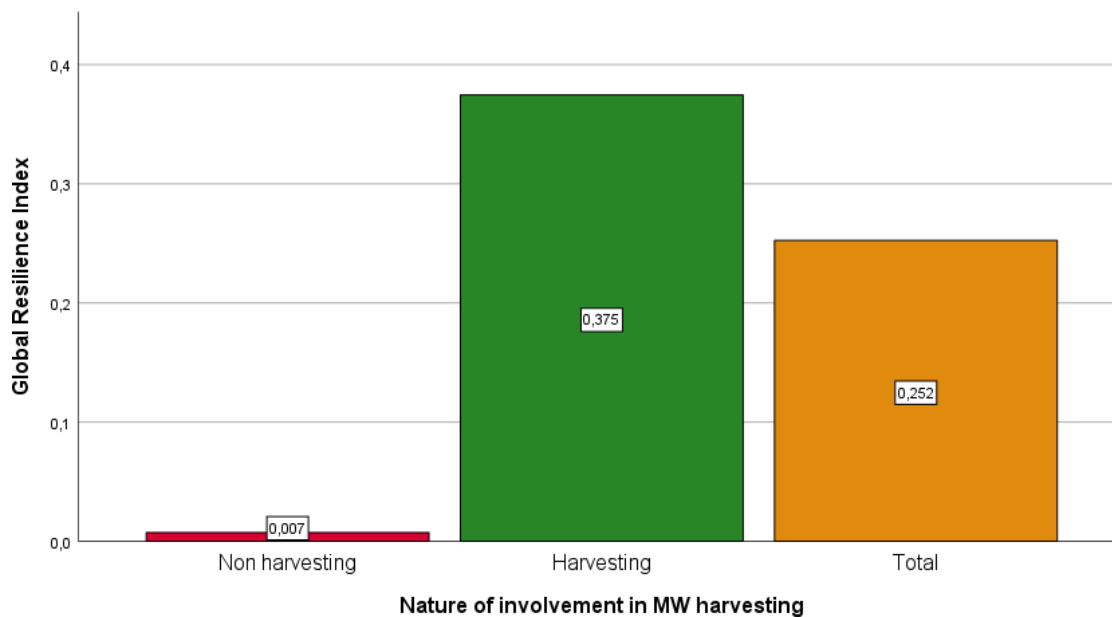


Figure 8.46. Difference between GRIs of harvesting and non-harvesting households

Results clearly reveal that being involved in MW harvesting and trading related activities is making an impactful difference in boosting the resilience capacities of households involved when compared to those than are not involved. The GRI for harvesting households was found to be 0.376 (a moderately high resilience score) with a standard deviation of 0,48489. This is much higher than that of non-harvesting household whose territories attained a score of 0,0073 (standard dev = 0,08544). Non harvesting communities according to these statistics are generally fragile, while harvesting communities are moderately resilient. An ANOVA test analysis showed significant differences ($P\text{-value} < 0.001$) in the GRIs of both types of communities (see Table 8.21).

Table 8.21 ANOVA test results: Statistical difference between GRIs of harvesting and non-harvesting communities.

	Sum ofSquares	Df	Mean Square	F	P-value
Between Groups	12,333	1	12,333	77,300	<,001
Within Groups	65,415	410	,160		
Total	77,748	411			

Eta squared = 0,159

CHAPTER 9: Conclusions and recommendations

9.0 Introduction

This study has argued from the onset that developing a MW-oriented LED strategy is currently not possible owing to lack of spatio-temporal analysis data that enables us to;

- Fully comprehend MW resource dynamics
- Understanding factors explaining successful dynamics that will lead to situations of growth in the MW industry and the local economy.
- Comprehend the nature and strength of MW farm household interactions with the local economy.
- Analyse the resistance of MW territorial space to external changes and shocks in the local environment and beyond.
- Develop the most appropriate mechanisms and policies that will foster improvements in the MW industry and its subsequent contribution to the local economy.

This final chapter seeks to first recall the important knowledge gaps identifies (in each of the above items) and demonstrate what ne knowledge this study has generated. A discussion of such new findings then informs the crafting of a MW-oriented LED through a series of recommendations that we envisage will foster improvements in the MW industry and its subsequent contribution to the local economy.

9.1 Spatial and temporal changes in rural household dependency on the MWs.

Research scholarship on MW resource dependency have recently gathered pace with a few studies employing statistical estimation methods to assess factors explaining reliance on MWs (Baiyegunhi, and Oppong, 2016; Baiyegunhi et al., 2016; Sekonya, J. G. et al., 2020; Manditsera et al., 2022). While this thesis sees this as a crucial step towards understanding resource dependency dynamics in the MW sector, the thesis has identified several flaws that may not be helpful, if we are to craft MW-oriented LED strategy. The development of a MW-oriented development strategy. The breadth and scope of factors involved in such assessments has been limited and overly biased towards socio-economic determinants with less attention placed on spatial variables that we envisage are critical in generating space sensitive LED strategies. Lack of repeated measures both in time and space has also diminished our

confidence in drawing any meaningful inferences that can be used as important benchmarks in crafting a MW-oriented LED strategy. Most of these used a single dependent variable to measure resource dependence, a practice that is currently at odds with the multifarious nature of LED as a discipline.

The present study has overcome such knowledge deficiencies by bringing in a spatial and temporal perspective to understanding MW resource dependency. The temporal perspective has entailed gathering data on repeated measures over three time periods including years 2000-2014, 2014-2018, and 2018-2022). Within each time-period two data points were generated to get a better understanding of MW utilisation dynamics between two resource states, including the Wet Resource State (WRS) and the Dry Resource State (DRS). Our analysis therefore is based on 6 data points whose statistics have been aggregated to the WRS and DRS to give the much-needed temporal dimension. The spatial dimension has been stretched to include other important spatial variables that include rural access (proxy measure: road pavement distress index), product market efficiency, and the complexity of the local economy measured by the economic complexity index (ECI). The analysis also used a multiple objective system to assess resource dependency by using the amount of harvest and the Household Commercialisation Index as two dependent variables. For each of these two dependent variables, resource dependency was modelled for both the WRS and the DRS to check if results were consistently reflecting in both resources states. A 4-model system was therefore used to assess MW resource dependency via the binary logistic regression analysis method. The main hypothesis (H1) that was tested reads.

H1. There are intercommunity and temporal variations in levels of involvement of different socio-economic groupings in mopane worm harvesting.

Using the amount of harvest as a depicter variable, the study revealed aspatial and spatial variables such as age of harvesters, wealth status, and economic complexity as the major factors (P-values <0.05) determining MW resource dependency. Such factors consistently emerged statistically significant for both the WRS and the DRS. Such consistency allows us to conclude that large harvests are positively associated with adult harvesters, wealthier families, economically diversified local economies and better rural access as measured by the road pavement distress index.

Using the HCI as a depicter variable, the analysis revealed statistical significance in such factors as market efficiency and the number of harvesters involved as the main determinants of

intensity of involvement in the trade. Where markets were efficient in allowing complete sales to happen within a short space of time, the study observed a high concentration of trading. The intensity of involvement in trade was also positively associated with the number of harvesters. This finding over emphasizes the importance of labour as an input variable into the trading business.

9.2. Spatio-temporal changes in factors explaining successful territorial dynamics that lead to situations of growth in the MW industry and the local economy at large.

Current scholarship on MW utilisation to the best of our knowledge has not benefited from successful territorial dynamics postulations from a new and fast-growing discipline of territorial dynamics. The thesis has underscored the need to incorporate such, as this new knowledge domain would shed light on which territorial dynamics in the study area would lead to situations of growth in the MW industry and the local economy at large. There is currently no single study, that has attempted to take a much more globalized stance to look at dynamic interaction between the various capabilities and potentialities of a given MW-dependent community and assess how that interaction translates into situations of growth. This study filled this knowledge gap by assessing the dynamic interaction between the most cited territorial system capability attributes that include the Ecological System Capabilities (ESCs), Social System Capabilities (SSCs), Institutional System Capabilities (SSCs), Institutional System Capabilities (ISCs), Economic System Capabilities (EcSCs) and the Physical or Engineering System Capabilities (PESCs). It sought to test the following hypotheses.

- H5. LED interventions in the MW industry that seek to valorise given territorial potentialities are more likely to lead to situations of growth.*
- H6. Successful territorial dynamics in MW territories are significantly influenced by the socioeconomic, institutional, physical / engineering, and ecological context of the households.*

Such dynamic interaction was discerned by creating unique clusters of territorial capabilities using the above five capabilities as input variables into a Hierarchical Cluster Analysis (HCA) model. A 5-cluster solution was generated. The study then employed the criteria of technical efficiency to assess the extent to which existing territorial capabilities and potentialities were being transformed into successful territorial outcomes such as MW income. The Data Envelop

Analysis (DEA) method was applied on these 5 clusters as Decision Making Units (DMUs). & additional clusters were added in the analysis as they constituted unique MW clusters segmented according to administrative boundaries (i.e. the five villages in the study) and distance from major markets (i.e. distal versus proximal markets). The DEA method was applied as machine learning tool with linear programming capabilities that allowed the analysis to check that of the 12 DMUs were generating optimal solutions in terms of harnessing own territorial system capabilities and / or potentialities.

Based on the calculated Partial Territorial Dynamic Indices (PTDIs) and the Global Territorial Dynamic Indices (GTDIs) for each DMU, our analysis observed that cluster 2 MW territories generated using the HCA method were the most efficient territories that generated optimal outcomes in terms of realising higher income from MW trade. Many other MW worm territories that were found to be grossly inefficient in terms of valorising (*H 5 tested*) own territorial system capacities were associated with less acceptable territorial outcomes in terms of MW income, amount of MWs harvested, Intensity of household involvement in trade (measured by the HCI) and type of livelihood strategies when compared to territory 2 (i.e. the benchmark).

The second most efficient cluster was MW territory. We observed that both cluster 2 and cluster 5 territories were associated with very high technical efficiency levels in all 5 territorial system attributes. Technical efficiency levels measured using the PTDI for cluster 2 type of territories for instance were constantly high for all system attributes including ESCs (100%), SSCs (100%), ISCs (121%), EcSCs (100%) and PESCs (100%). Related statistics for territory 5 included ESCs (83%), SSCs (100%), ISCs (83%), EcSCs (83%) and PESCs (83%). These high efficiency levels were intricately linked to high GTDIs that in this analysis represented an indicator successful territorial dynamic. This finding allows us to conclude that *‘successful territorial dynamics in MW territories are significantly influenced by the socioeconomic, institutional, physical / engineering, and ecological context of the households.’* (H 6 tested). The validity of this conclusion was validated by a series of Kruskal Wallis H tests that were carried out using different territorial outcome variables that included, MW income derived from trade, amount of harvest, amount of MW traded, the MW Household Commercialisation Index (HCI) and the different livelihood pathways strategies adopted.

The thesis followed the cue from related studies to calculate the Pearson’s correlation coefficients to determine that factors were significantly explain spatial and temporal variations

in territorial performance. In terms of ESCs territorial attributes such as land degradation around the homestead ($P < 0,001$) drainage density ($P < 0.001$), flood water characteristics ($P < 0.001$), stream order characteristics ($P < 0.001$), MW resource supplies ($P < 0.05$), and households from constrained ecohydrological systems ($P < 0.001$) were found to be significantly influencing territorial dynamics during both the WRS and the DRS. Two exceptions, that include level of degradation and MW resource supplies were however noted as associated correlation statistics were not statistically significant during the DRS.

In terms of ISCs, major predictors of successful territorial dynamics included such attributes such as social capital accumulation ($P < 0.001$), present of degrading land use practices ($P\text{-value} < 0.001$) institutional influence, attitude, resourcefulness, and support ($P\text{-values} < 0.001$). In terms of EcSC attributes significant predictors ($P < 0.001$) for both the WRS and DRS included the HCI, investment or innovation drive, interaction with outside markets, and the behavioural intention to adopt new innovations. For the DRS an additional important factor was distribution channel choice ($P\text{-value} < 0.001$).

In terms of SSCs, many factors were found to be significant determinants ($P\text{-value} < 0.001$) of territorial success during both the WRS and the DRS. These included, wealth status, type of livelihood strategies adopted, unemployment, sickness and death in family, number of harvesters involved and the dominant livelihood pathway strategy. The age of resource users was only found to be a significant factor during the DRS ($P\text{-value} < 0.05$).

Many PESC factors were also found to be significant determinants ($P\text{-value} < 0.001$) determinants of territorial success during both the WRS and the DRS. These included proximity to major rural markets, road pavement condition, economic complexity, inherent risk to marketing infrastructure, road pavement surface conditions, water access, access to ICT, transportation, location of major harvests and (physical) infrastructure improvements.

9.3 The nature and strength of MW farm household interactions with the local economy.

The nature and strength of MW farm household interaction with the local economy has been characterised in this thesis as a grey area, owing to a paucity of studies that have attempted to measure such as village scale level. The study sought to test the following hypotheses.

H2. Economic returns from mopane worm harvesting vary over space but such returns

diminish in real terms with time.

H.3 The degree of MW farm household interactions with the local economy is higher in MW territories characterised by distant and a spatially concentrated pattern of trade transactions.

H4. The degree of MW farm household interactions with the local economy is lower in MW territories characterised by trade transactions that are much closer to the MW farming household unit and that are more spatially dispersed.

Using Household income as household entry point to be interacting with the local economy, the study revealed that MW incomes have been increasing in nominal terms over the years in almost all of the five villages under study. The corresponding real MW income using the year 200-2014 as base year has been decreasing (H2 tested).

We have argued that LED as a multifarious discipline with multiple objectives would require that we develop multiple indicators to measure the impact of resource use on the local economy. To measure the impact, the study employed a multiplicity of approaches. One approach was to look at household interaction with the output markets. The assumption here was that development will only take place if there is high intensity of interaction with the output markets, particularly those that are distant and area permitting spatial concentration of trade. The analysis used the decision tree diagram technique to validate that the hypotheses that *The degree of MW farm household interactions with the local economy is higher in MW territories characterised by distant and a spatially concentrated pattern of trade transactions.* (H3 tested). The same approach also confirmed that: *The degree of MW farm household interactions with the local economy is lower in MW territories characterised by trade transactions that are much closer to the MW farming household unit and that are more spatially dispersed.* (H4 tested).

We have also used several Partial LED indices that we calculated to measure if involvement in MW utilisation made a meaningful difference. LED indices that we calculated include, the Household Infrastructure and Services Index (HISI), The Gini coefficient and associated Lorenz curve shifts, The successful Territorial Dynamic Index (STDI), the Resilience Capacity index (RCI) among other measures. Our results have demonstrated that communities characterised by high intensity of involvement in MW trade are consistently associated with better achievement in infrastructure and services, are characterised by reduced income inequalities, reduced territorial imbalances, improve rural access as measured by the Pavement Distress Index (PDI) and increased territorial resilient capacity.

9.4 To analyse the resistance of MW territorial space to external changes and shocks in the local environment and beyond.

Despite the existence of a handful of studies that have managed to look at MW use from a resilience perspective, the thesis observed several shortcomings that were limiting in terms of developing a progressive MW-oriented LED strategy. Firstly, we do not know how such shocks such as death of family members, severe weather (leading to suppressed harvests) and economic shocks triggered by loss of employment or sudden emigration) are affecting livelihood adaptation and resilient trajectories of affected communities and how such vary both in time and in space. The study was heavily premised on the assumption that resultant livelihood adaptation and resilient trajectories would either undermine or promote the growth potential of MW territories. For this reason, the present study sought to test the following two hypotheses.

H7 Idiosyncratic health, severe weather, and economic shocks have resulted in distinct clusters of livelihood adaptation and / or resilience trajectories that significantly undermine the growth potential of MW territories.

H8. Idiosyncratic health, severe weather, and economic shocks tend to diminish important linkages between MW trading activities and markets within and beyond the boundaries of the rural economy.

To achieve these, the study adopted a multivariate statistical analysis approach using decision tree diagrams to profile and explore the behaviour of households subjected to the stated stressors. Two decision tree diagrams were generated for both the WRS and the DRS to understand temporal variations in such behaviours. One of the theoretical assumptions underpinning H7 was that households who occupy more resistant MW territories will have a high appetite for adopting progressive and risk limiting livelihood strategies such as ‘stepping in’ and ‘stepping out’ strategies as opposed to ‘hanging in’ and ‘linking in’ strategies.

Using Chi Square Automatic Detection Algorithm (CHAID) method to test the statistical significance of the findings, results during the WRS on this aspect revealed that many households mostly affected by losing family members due to sudden death and emigration are less willing to rely on more progressive and risk limiting livelihood strategies such as ‘stepping in’ and ‘stepping out’ (P-value <0.0001). Such findings reveal that a lack of willingness to escape their current vulnerabilities. The analysis also observed an interesting behavioural pattern among households located in ecohydrologically constrained environments where the

major stressor is reduced harvests due to harsh weather conditions and high levels of environmental degradation and those families whose members had lost jobs. To compensate for lost income, many of them have taken a progressive and sustainable step of adopting risk limiting livelihood strategies such as stepping in and stepping out (Chi-square = 13.772; df= 1; P-value <0.0001).

As the households' transition from the WRS into the DRS, the analysis revealed a similar behavioural pattern for households whose members lost jobs and those who come from severely constrained ecohydrological ecosystems. We also see a significantly larger proportion of households (62.7%) from families most affected by job losses having a high appetite for adopting risk limiting livelihood strategies.

The study also assumed that (H8) *idiosyncratic health, severe weather, and economic shocks tend to diminish important linkages between MW trading activities and markets within and beyond the boundaries of the rural economy*. A decision tree diagram was constructed to test this assumption during the WRS. Despite using households losing family members (due to sudden emigration), losing jobs, affected by sickness and death, and those affected by severe weather conditions as input variables into the analysis, the assessment yielded significant results on two input variables. These included households losing family members due to sudden emigration and those residing in ecological deprived environments. We see many households (80.7%) least affected by loss of family members significantly interacting with outside markets have been characterised as more efficient. The same pattern of interaction is also portrayed when one looks at households most affected by loss of family members, although the proportion drastically drops when compared with the 'least affected' scenario.

Calculated resilience capacity revealed significant variations between communities, and MW territories uniquely created using a combination of the two step and k-means clustering algorithm. One cluster that attracted a low resilient score based on absorptive, adaptive, and transformative capacities was characterised as fragile. The other cluster attracted a moderate resilient index value and was therefore classified as moderately resilient. Resilience score statistics derived were found in principle encouraging given that the majority (67.2%) of sampled households are residing in relatively resilient MW territories compared to 32.8% residing in relatively fragile MW territories. Significant differences in resilient capacities were discerned between both territories using the resilience structure matrix approach and the Man Whitney U test. Statistically significant differences across all three resilient capacities including absorptive capacity (P-value <0.01), adaptive capacity (P-value = 0.024) and

transformative capacity ($P\text{-value} < 0.01$) were observed. While the relatively resilient cluster was performing relatively well in terms of absorptive capacity and transformative capacity, the resilient index score was not encouraging on adaptive capacity as it was below the acceptable threshold of 0.33.

Many households from the four villages of Mangala, Kapane, Sasane and Mahetshe, belonged to the moderately resilient cluster (cluster 2 type). Associated Global Resilience Index (GRI) score values were all higher than the acceptable threshold ($GRI > 0.33$). Ndiweni village with its largely degraded terrain was the only administrative territory classified as fragile since many households belonged to the fragile cluster two type. It attracted a low GRI score value of 0.318. Based on the GRIs generated proximal communities ($GRI = 0.437$) were in relative terms found to be more resilient than distal communities ($GRI = 0.360$). An ANOVA analysis revealed statistically significant results ($F=993,991$ $df = 1$; $P\text{-value} < 0.001$).

Major factors explain variations in the resilience capacities of various communities was conducted using the binary logistic regression model. The most significant determinants of resilience ranked according to the odds ratios were found to be land use practices ($P\text{-value} = 0.027$), labour productivity during the DRS ($P\text{-value} < 0.001$), exposure to information ($P\text{-value} < 0.001$) and adoption of improved resource management practices ($P\text{-value} = 0.004$). These results suggest that to improve the resilience capacities of communities in the study area authorities should promote less degrading land use practices, promote innovative harvesting practices to compensate for low labour during the DRS, and increase exposure to information.

9.5 Conclusions on hypotheses testing

One of the main hypotheses (H1) that was tested reads.

H1. There are intercommunity and temporal variations in levels of involvement of different socio-economic groupings in mopane worm harvesting.

Using the amount of harvest as a depicter variable, the study managed to validate this by identifying aspatial and spatial variables such as age of harvesters, wealth status, and economic complexity as the major factors ($P\text{-values} < 0.05$) determining MW resource dependency. Such factors consistently emerged statistically significant for both the WRS and the DRS. Such consistency allows us to conclude that large harvests are positively associated with adult harvesters, wealthier families, economically diversified local economies and better rural access as measured by the road pavement distress index.

The study also sought to test the following hypothesis.

H2. Economic returns from mopane worm harvesting vary over space but such returns diminish in real terms with time.

Such hypothesis was confirmed by comparing real versus nominal MW income received by households from trade. Study results revealed that MW incomes have been increasing in nominal terms over the years in almost all of the five villages under study. The corresponding **real** MW income using the year **200-2014 has base year** has however been decreasing (H2 tested). Such findings largely reflect the relative resistance to price increases by the market whose economic circumstances has been eroding their income over the years.

Another important study hypothesis that was tested read.

H.3 The degree of MW farm household interactions with the local economy is higher in MW territories characterised by distant and a spatially concentrated pattern of trade transactions.

This hypothesis was put forward on the assumption that development will only take places if there is high intensity of interaction with the output markets, particularly those that are distant and area permitting spatial concentration of trade. To validate this, the analysis used the decision tree diagram technique. Results significantly revealed that *the degree of MW farm household interactions with the local economy was higher in MW territories characterised by distant and a spatially concentrated pattern of trade transactions.* (H3 tested). In such communities by extension, market efficient interventions would result in notable and impactful gains to the lives of the MW traders.

Hypothesis four sought to test the claim that.

H4. The degree of MW farm household interactions with the local economy is lower in MW territories characterised by trade transactions that are much closer to the MW farming household unit and that are more spatially dispersed.

Using the same approach that was employed to test H3, the study confirmed a significantly lower degree of MW farm household interactions with the local economy in MW territories characterised by trading activities that were much closer to the MW farming household unit and that were much more spatially dispersed (H4 tested). Such research findings are crucial as

they reflected a general tendency of some traders sell their stock to much weaker markets where the prices are relatively low. Such traders are predominantly from low-income families who cannot afford to travel longer distances and access much more lucrative markets. An appropriate local economic development intervention would be to assist such traders to access better markets.

It also sought to test the following hypothesis.

H5. LED interventions in the MW industry that seek to valorise given territorial potentialities are more likely to lead to situations of growth.

To test this hypothesis the study first generated unique clusters that possessed unique growth and development capabilities using a clustering algorithm. The general performance of the generated cluster solution was assessed by calculating such as the Global Territorial Cohesion Index and a series of Partial Territorial Cohesion Indices to gauge the extent to which existing and potential capabilities have been converted efficiently to foster growth in each respective territory. Such an approach confirmed that LED interventions in the MW industry that seek to valorise given territorial potentialities were more likely to lead to situations of growth.

H6. Successful territorial dynamics in MW territories are significantly influenced by the socioeconomic, institutional, physical / engineering, and ecological context of the households.

The study then employed the criteria of technical efficiency to assess the extent to which existing territorial capabilities and potentialities were being transformed into successful territorial outcomes such as MW income. The Data Envelopment Analysis (DEA) method was applied on these 5 clusters as Decision Making Units (DMUs) and the five villages as additional clusters were added in the analysis as they constituted unique MW clusters segmented according to administrative boundaries (i.e. the five villages in the study) and distance from major markets (i.e. distal versus proximal markets). The DEA method was applied as machine learning tool with linear programming capabilities that allowed the analysis to check that of the 12 DMUs were generating optimal solutions in terms of harnessing own territorial system capabilities and / or potentialities. Optimality was used as a proxy measure to determine successful MW territory or DMU. Pearson's correlation coefficient was then calculated to determine with territorial capabilities were positively and significantly defining optimality. Study results confirmed that successful territorial dynamics in MW territories were

significantly influenced by socioeconomic, institutional, physical / engineering, and ecological context of the households (H6 tested). We conclude by arguing that realizing optimal growth and development outcomes in MW-dependent communities will requires harnessing a territories existing potential socioeconomic, institutional, physical / engineering, and ecological strengths and capabilities.

Another important assumption that was test was as follows.

H7 Idiosyncratic health, severe weather, and economic shocks have resulted in distinct clusters of livelihood adaptation and / or resilience trajectories that significantly undermine the growth potential of MW territories.

To test this assumption, the study adopted a multivariate statistical analysis approach using decision tree diagrams to profile and explore the behaviour of household subjected to the a stated stressors. Two decision tree diagrams were generated to for both the WRS and the DRS to understand temporal variations in such behaviours. One of the theoretical assumptions underpinning H7 was households who occupy more resistant MW territories will have a high appetite for adopting progressive and risk limiting livelihood strategies such as ‘stepping in’ and ‘stepping out’ strategies as opposed to ‘hanging in’ and ‘linking in’ strategies. Using Chi Square Automatic Detection Algorithm (CHAID) method to test the statistical significance of the findings, results several important observations. Many households mostly affected by losing family members due to sudden death and emigration were less willing to rely on more progressive and risk limiting livelihood strategies such as ‘stepping in’ and ‘stepping out’ (P-value <0.0001). The analysis also observed an interesting behavioural pattern among households located in ecohydrologically constrained environments where the major stressor was reduced harvests due to harsh weather conditions and high levels of environmental degradation and those families who members had lost jobs. To compensate for lost income, many of them have taken a progressive and sustainable step of adopting risk limiting livelihood strategies such as stepping in and stepping out (Chi-square = 13.772; df= 1; P-value <0.0001).

These results suggest that idiosyncratic health, severe weather, and economic shocks have resulted in distinct clusters of livelihood adaptation and / or resilience trajectories that significantly undermine the growth potential of MW territories (H7 tested). Such vulnerabilities need to be taken cognisance of in the implementation of any MW-oriented LED interventions.

The last important assumption that was tested was hypothesis eight stated as follows.

H8. Idiosyncratic health, severe weather, and economic shocks tend to diminish important linkages between MW trading activities and markets within and beyond the boundaries of the rural economy.

A similar statistical procedure (of H7) was adopted to test this assumption. Study results confirmed that idiosyncratic health, severe weather, and economic shocks were significantly threatening important linkages between MW trading activities and markets within and beyond the boundaries of the rural economy (H8 tested). Such findings have important LED implications since such stressors tend to undermine the growth potential of MW territories (H8 tested). Such vulnerabilities need to be taken cognisance of in any effort targeted at crafting a MW-oriented LED strategy.

9.6 Mechanisms and policies that foster improvements in the MW industry and its subsequent contribution to the local economy.

9.6.1 MW growth-oriented LED strategies versus Pro-poor LED Strategies

Our analysis has revealed a significant positive correlation between reliance on MWs (i.e. resource dependency) in mopane work territories that have a much diversified and relatively more sophisticated economy as measured by the ECI. The economic landscape in such environs is that of diversified portfolio of products offered on the market with high intensity of trade and associated high incomes from MW sales. In such communities, what is required are pro- growth LED strategies that seek to further accelerate growth by taking advantage of existing type of markets that were in this analysis found to be efficient. In distal communities where there is an almost balanced distribution of MW consumption and trading patterns, more peoplecentre strategies are encouraged.

- ***Increasing the intensity of participation of harvesting households into the outputmarkets.***

This is key to promoting widespread commercialisation of the trade. This strategy will work the most in distal communities whose participation levels in the output market are severely constrained by many factors, including limited transportation capabilities. In distal MW territories such as Kapeni and Sasane where road pavement distress conditions are critical as measured by the PCI and where the associated inherent risk is likely to limit access to markets

by MW buyers and the overall participation of local traders in the output market, addressing poor road infrastructure should be a priority. Effectively bringing local traders into the output market and increasing their intensity of involvement will require to addressing a host of road pavement distress conditions, including pavement surface integrity, pothole intensity among other variables. We reckon that such LED interventions may not only increase the intensity of participation in the output market but may also address the problem of market inefficiency that is characteristic of such communities. Computed market efficiency indices for all sampled villages have already shown that rural markets in distal communities are largely inefficient and are characterised by long waiting periods before the traded MW stocks are bought when compared to distal markets. In proximal MW territories such as Mahetshe, Ndiweni and Mangala where the road pavement distress condition is fairly acceptable, the goal is to increase the intensity of local traders' participation into distal output markets where MWs are likely to fetch a higher price. Targeted improvements in road pavement conditions may in the long term unlock the economic capabilities of distal MW communities. Unlocking such capabilities as often argued in other LED literatures may in the long-term increase diversification and sophistication of such lagging economies, a development that we have seen in this study may further increase rural household dependency on MW resources and the likelihood of local traders accessing high value chains for their MW stocks.

- ***Implementing progressive MW entrepreneurship ecosystem (EE)***

The thesis has in various pieces of analysis the significant role that innovation and entrepreneurship plays in creating successful and resilient MW territories that are significantly associated with high MW returns, low-income inequalities, improved infrastructure assets and services, more progressive livelihood pathways strategies (including linking in, stepping in and stepping out) among other territorial outcomes. Value creation in terms of increased MW returns, reduced income inequalities, and adoption of more progressive livelihood strategies would require the development of what this thesis terms a progressive entrepreneurial ecosystem. The proposed elements of such are shown in Figure. 9.1.

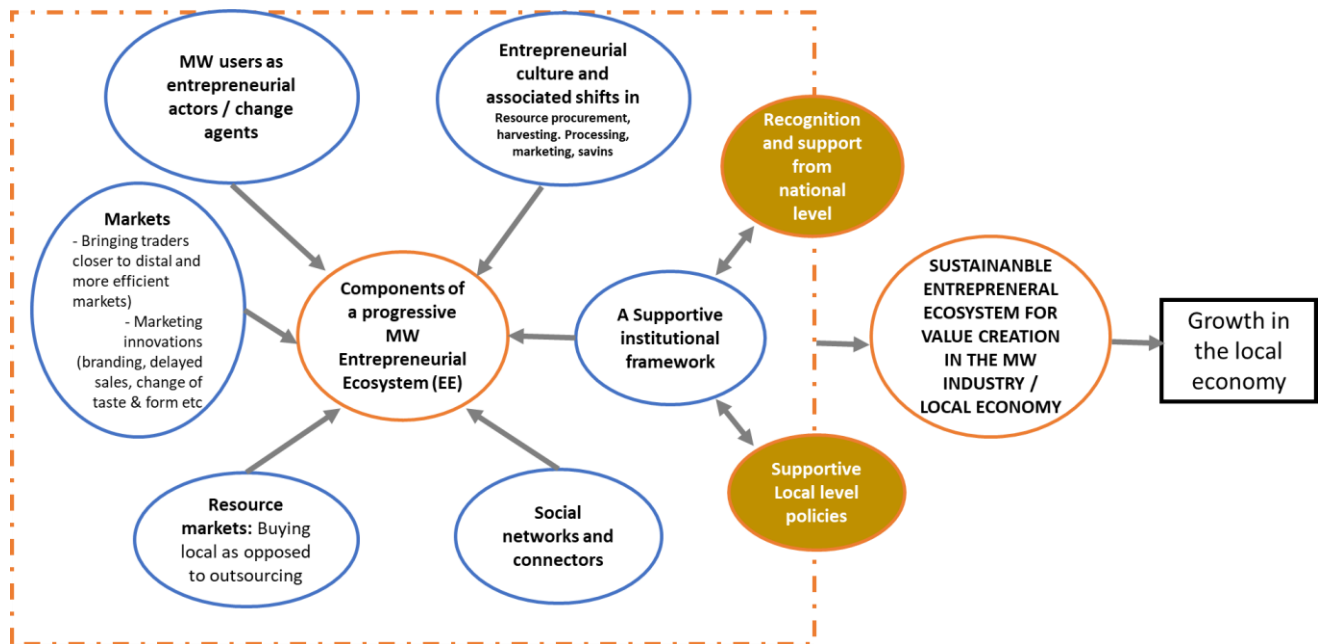


Figure 9.1 Proposed growth model for creating a progressive MW entrepreneurship ecosystem (EE).

We find such recommendations to be consistent with pro-growth LED strategies that seek to foster growth in the local and regional economy.

Once the EE value creation targets are met, we expect to see positive spillovers to the growth of not only the MW industry but the local economy as well. For this to happen, at the institutional level formal support systems should be availed by government as our analysis has revealed that these are crucial for boosting the adaptive resilience capacity of the actors involved. Other important resilient boosting strategies that need to be enhanced include strengthening existing social networks and connecting current traders to more efficient resource markets. A supportive local level policy aimed at promoting the interests of the traders should be in place. Current initiatives by the Rural District Council such as charging MW buyers a *macimbi* levy and developing warehouses where households would come and deposit their surplus stocks for delayed sales are welcome developments. More can however still be done by improving access to markets through road infrastructure development project and increasing the quality of existing marketing infrastructure (where present) and introducing marketing shelters where they are not available.

There is need to increasingly see MW actors as agents of change, who needs support in terms of adopting innovations in harvesting, processing, storage and marketing. This is because

evidence of development taking place where there is a large concentration of investments and innovations exist. In addition to adoption of marketing innovations, an effort should be made to bring traders closer to distant and more efficient markets where they are guaranteed of high prices. Encouraging traders to buy inputs may go a long way in supporting local business growth.

9.6.2 Towards place sensitive MW-oriented LED strategies: ‘Input-oriented’ versus ‘output-oriented’ LED strategies.

The analysis on successful territorial dynamics and territorial resilience in this study allows us to propose place- based strategies that build on the various capacities and potentials of each territory and associated territorial performance. Results from the DEA method have permitted to set a benchmark of territorial performance based on both the PTDIs and GTDIs. The benchmark or rather the best practise territory that other territories need to strive for or play catch up is Territory 2. If one looks at the GTDIs as indicator of territorial success, the benchmark efficiency value of at least 100% has been set by both territory 5 and territory 2. All other 10 remaining DMUs require the adoption of output-oriented LED strategies if they are to catch up in terms of optimising successful outcomes that are associated with high-income from MW sales. Among the 5 villages under analysis for instance, the highest performing village that attracted a GTDI value of 75% is Mahetshe. Such a technical efficiency value would mean that if Mahetshe were to achieve optimum output, it will require increase its technical performance by a further 25%. The required percentages would sharply increase when one goes to poorly performing villages of Ndiweni, Sasane and Kapeni whose GTDIs are 23%, 26%, and 38% respectively. Such villages, alongside distal communities that attracted a GTDI value of 33% would require the implementation of an output-oriented LED strategy that is slightly elevated compared to that of proximal communities and specifically the villages of Mahetshe and Mangala that. To optimise gains from MW utilisation, such a strategy as informed by this analysis should target increasing successful territorial outcomes in terms of:

- Increasing the MW income realised from trade.
- Addressing household income inequalities (measured by the Gini coefficient)
- Quantity of MWs traded on the market.
- Household’s intensity of involvement in MW trade (measured by the HCI)
- Adoption of more progressive livelihood pathway strategies likely to lead many households

out of poverty.

The analysis has also revealed that, to achieve the above output goals, there is need of a complementary input-oriented LED MW strategy that should strive at enhancing existing capabilities and potentialities. This is because the same territories did not attract PTDIs of 100% as in the benchmark territory 2. How much of each capability and / or potential needed should be guided by individual PTDIs for each community based on the PTDIs for all five system capabilities, including ESC, EcSC, ISC, SSC, and PESC. From a resilience perspective, all such communities should strive to adopt risk limiting resilient strategies such as adoption of progressive livelihood pathway strategies (stepping in and stepping out), resource harvesting and processing innovations, and marketing innovations.

9.7 Areas for future Research

Our study has been restricted to one rural district situated in Southwestern Zimbabwe and more specifically to five villages. Our findings may not be replicable in other rural districts in Zimbabwe and in the SADC region where MW harvesting is taking place. We encourage future researcher to expand such analysis to some districts and include more villages in Zimbabwe and the rest of the SADC region. The purpose at the SADC level would be to influence regional efforts towards the development of place-based MW-oriented LED strategy.

REFERENCES

- Acocks, J.P.H. 1988. *Veld types of South Africa*. 2nd Edition. Memoirs of the Botanical Survey of South Africa 57. Government Printer, Pretoria.
- Agar, M. (1991) The right brain strikes back . In N. G. Fielding, ed. & R. M. Lee (eds.), Using computers in qualitative research (pp. 181–194). Newbury Park, CA: Sage.
- Al-Izzi, M.A.J. & Al-Maliky, S.K. 1996. Action of tannic acid on consumption and utilisation of food by *Ectomyelois ceratoniae* Zeller (Lepidoptera: Pyralidae). J. Stored Prod. Res. 32: 195-199.
- Allotey, J, Mpuchane, S.F., Gashe, B.A., Siame, A.B. & Teferra, G. 1996. Insect Pests Associated with stored Mophane Worm, *Imbrasia belina* Westwood (Lepidoptera: Saturniidae) in Botswana. In: Proceedings of the First Multidisciplinary Symposium on Phane. Gaborone, Botswana, eds B.A. Gashe & S.F. Mpuchane. NORAD. 18 June 1996.
- Arbuthnott, A., Eriksson, J., Wincent, J., 2010. When a new industry meets traditional and declining ones: An integrative approach towards dialectics and social movement theory in a model of regional industry emergence processes. *Scandinavian Journal of Management* (2010) 26, 290-308
- Bonsma, J.C. 1942. Useful bushveld trees and shrubs their value to the stock farmer. *Farming in South Africa* Vol 17: 226-239.
- Brown, M.T., Ulgiati, S., 2011. Understanding the global economic crisis: a biophysical perspective. *Ecol. Model.* 223, 4-13.
- Brunori, G., Rossi, A. (2000). Synergy and coherence through collective action: some insights from wine routes in Tuscany. *Sociologia Ruralis* 40 (4), 409-423.
- Cannes, A. (2001). Tannins: Fascinating but sometimes dangerous molecules. [Http://ansci.cornell.edu/plants/toxicagents/tannin/](http://ansci.cornell.edu/plants/toxicagents/tannin/) Accessed 18 June 2024.
- Cooper, S.M. & Owen-Smith, N. (1985). Condensed tannins deter feeding by browsing

ruminants in a South African savanna. *Oecologia* 67: 142-146.

Christie, M., Hanley, N., Warren, J., Murphy, K., Wright, R., Hyde, T. (2006). Valuing the diversity of biodiversity. *Ecol. Econ.* 58, 304-317.

Creswell, J. W., Klassen, A. C., Plano Clark, V. L., and Smith, K. C. (2011). Best practices for mixed methods research in the health sciences. Washington, DC: National Institutes of Health.

Conway, G.R. (1987). The properties of agroecosystems. *Agric. Syst.* 95-117.

Cooke, P. 1996. The new wave of regional innovation networks: Analysis, characteristics and strategy. *Small Business Economics*, 8(2), 159—171.

Counsell, D & Houghton, G., 2009. Sustainable development in regional planning: The search for new tools and renewed legitimacy *Geoforum* 37 (2006) 921–931

Dahlstrand, A. L. 2007. Technology-based entrepreneurship and regional development: The case of Sweden. *European Business Review*, 19(5), 373—386.

de Jong, J & Spaans, M., 2009. Trade-offs at a regional level in spatial planning: Two case studies as a source of inspiration. *Land Use Policy* 26 (2009) 368–379

Dekker, B. 1996. *Ekologiese skeiding tussen groot herbivore van die Messina Proefplaas, Limpopovallei*. Unpublished MSc dissertation (Nature Conservation), University of Pretoria, Pretoria.

Dithlogo, M., 1996. The Ecology of *Imbrasia belina* (Westwood) in North Eastern Botswana. In: Proceedings of the First Multidisciplinary Symposium on Mopane. Gaborone, Botswana, eds B.A.

Dumont, B., Fortun-Lamothe, L., Jouven, M., Thomas, M., Tichit, M., 2012. Prospects from agroecology and industrial ecology for animal production in the 21st century. *Animal* 7, 1028-1043.

Escobal, J., & Ponce, C. (2003). The benefits of rural roads: enhancing income opportunities for the rural poor. Documento de Trabajo (40).

Gomiero, T., Giampietro, M., Mayumi, K. (2006). Facing complexity on agroecosystems: a new approach to farming system analysis. *Int. J. Agric. Resour. Gov. Ecol.* 5, 116–144.

Erkkila, A. & Siiskonen, H. 1992. *Silva Carelica* No. 20. University of Joensuu, Finland. 244 pp.

Faigenbaum, S., Berdegue, J. A., & Reardon, T. (2002). The rapid rise of supermarkets in Chile and its effects on the dairy, vegetable and beef chains. *Development Policy Review*, 20(4), 459-471.

Feeny, P. 1968. Effect of oak leaf tannin on larval growth of the winter moth *Operopthera brumata* L. *J. Econ. Entomol.* 71: 366-368.

Feeny, P. 1970. Seasonal changes in oak leaf tannins and nutrients as a cause of spring feeding by winter moth caterpillars. *Ecology* 51: 565-581.

Flower, C., Wardell-Johnson, G. & Jamieson, A. (Eds) 1999. *Management of mopane in southern Africa*. Proceedings of a conference held at Ogongo Agricultural College, Namibia, 26-29 November 1996. ODA/Directorate of Forestry, Windhoek.

Frears, S.L. Chown, S.L. & Webb, P.I. 1997. Behavioural thermoregulation in the mopane worm (Lepidoptera: Saturniidae). *Journal of Thermal Biology* 22, 325-330.

Frenken, K., Van Oort, F., & Verburg, T. (2007). Related variety, unrelated variety and regional economic growth. *Regional Studies*, 41(5), 685-697

Frost, P.G.H. 2003. Internal Annual Report 2002/2003: Mopane Woodlands and the Mopane Worm: Enhancing Rural Livelihoods and Resource Sustainability, DFID Project No. R7822 . University of Zimbabwe, Institute of Environmental Studies.

Frost, P.G.H. 2005. A Guide to the Sustainable Use of Mopane Worms. Institute of Environmental Studies, University of Zimbabwe, Harare.

Funtowicz, S., Ravetz, J. (1994). Emergent complex systems. *Futures* 26, 568–582.

Gardiner, A.J. 2003. Internal Final Report: Mopane Woodlands and the Mopane Worm: Enhancing Rural Livelihoods and Resource Sustainability, DFID Project No. R7822. The Domestication of Mopane Worms (*Imbrasia belina*). Veld Products Research & Development, Gaborone, Botswana.

Gardiner, A., 2005. Farming Mopane Worms – a household guide. English version. Unpublished manuscript, Harare.

Gasparatos, A., Scolobig, A. (2012). Choosing the most appropriate sustainability assessment tool. *Ecol. Econ.* 80, 1-7.

Gelens, M., 1999. Mopane shrubland management in northern Namibia. In: Gondo, T., 2001. Mopane Worm Utilisation and Rural Livelihoods: The case of Matobo District. Masters Thesis. Department of Rural and Urban Planning, University of Zimbabwe.

Hagerman, A.E. 2002. Tannin handbook. <http://www.users.muohio.edu/hagermae/>. Accessed: 28 June 2004.

Hassink, R., 2005. How to unlock regional economies from path dependency? From learning region to learning cluster. *European Planning Studies*, 13(4), 521-535.

Harms, D.A. & Mattson, W.J. 1992. The dilemma of plants: to grow or defend. *Quart. Rev. Biol.* 67: 283-335.

Hinrichs, C., 2000. Embeddedness and local food systems: notes on two types of direct agricultural market. *Journal of Rural Studies* 16, 295–303.

Hyttinen, P., Niskanen, A., Ottitsch, A., 2000. New challenges for the forest sector to contribute to rural development in Europe. *Land Use Policy* 17 (2000) 221}232

Jonasson, E., & Helfand, S. M. (2010). How important are locational characteristics for rural non-agricultural employment? Lessons from Brazil. *World Development*, 38(5), 727-741.

Justino, P., Litchfield, J., & Niimi, Y. (2004). Multidimensional inequality: An empirical application to Brazil. Poverty Research Unit at Sussex (PRUS) Working paper No. 24. Brighton, UK: University of Sussex.

Kneafsey, M., Ilbery, B., Jenkins, T., 2001. Exploring the dimensions of culture economies in rural west Wales. *Sociologia Ruralis* 41 (3), 296–310.

Kozanayi, W. & Frost, P. 2002. Marketing of Mopane Worm in Southern Zimbabwe. Internal Report: Mopane Woodlands and the Mopane Worm: Enhancing Rural Livelihoods and Resource Sustainability, DFID Project No. R7822. Institute of Environmental Studies, University of Zimbabwe.

118

Kreber, R.A. & Einhellig, F.A. 1977. Effects of tannic acid on *Drosophila* larval salivary gland cells. *J. Insect Physiol.* 18: 1089-1096.

Kropff, M.J., Bouma, J., Jones, J.W. (2001). Systems approaches for the design of sustainable agro-ecosystems. *Agric. Syst.* 70, 369-393.

Kumar, A., Kumar, S., Singh, D. K., & Shivjee. (2011). Rural employment diversification in India: trends, determinants and implications on poverty. *Agricultural Economics Research Review*, 24(2), 361-372.

Langley, A. (1999). Strategies for theorizing from process data. *Academy of Management Review*, 24, 691-713.

Lanjouw, P. (2001). Nonfarm employment and poverty in rural El Salvador. *World Development*, 29(3), 529-547.

Larcher, W. 1991. *Physiological Plant Ecology*. Springer-Verlag, Berlin.

Louviere, J.J., Hensher, D.A. and Swait, J.D. (2000) Stated Choice Methods. Analysis and

Application. Cambridge University Press, Cambridge.

Louw, A.J. 1970. 'n Ekologiese studie van die mopanieveld noord van die Soutpansberg. Unpublished D.Sc. (Agric) thesis, University of Pretoria, Pretoria.

Marsden, T., Banks, J., Bristow, G., 2000. Food supply chain approaches: exploring their role in rural development. *Sociologia Ruralis* 40 (4), 424–439.

Maskell, P., Eskelinen, H., Ingjaldur, H., Malmberg, A., & Vatne, E.. 1998. Competitiveness, localised learning and regional development: Specialisation and prosperity in small open economies. London: Routledge.

Maxwell, A.J. 2009. Designing a qualitative study. In: Bickman, L. and Rog, D.J. The Sage Handbook of applied social research methods. London: Sage.

Maxwell, J.A., & Miller, B.A. (2008). Categorising and connecting strategies in qualitative data analysis . In P. Leavy, ed. & S. Hesse-Biber (eds.), Handbook of emergent methods (pp. 461-477). New York: Guilford Press.

Murdoch, J., Marsden, T., Banks, J., 2000. Quality, nature and embeddedness: some theoretical considerations in the context of the food sector. *Economic Geography* 76 (2), 107–125.

Mushongahande, M. 2003. Mopane Worm Annual Project Report: Mopane Woodlands and the Mopane Worm: Enhancing Rural Livelihoods and Resource Sustainability, DFID Project No. R7822. Forestry Commission of Zimbabwe.

Mushove, P.T. 1992. Productivity from mopane stumps and seed. ForMat 4: 4.

Mushove, P.T. 1999. On-farm research in mopane woodland: a case study from Chivi, Zimbabwe. In: Flower, C., Wardell-Johnson, G. and Jamieson, A. (Eds) *Management of Mopane in Southern Africa*. Proceedings of a conference held at Ogongo Agricultural College, Namibia, 26-29 November 1996. ODA/Directorate of Forestry, Windhoek. Pp. 17-20.

Mushove, P.T. & Makoni, J.T. 1993. Coppicing ability of *Colophospermum mopane*. In: Pearce, G.D. and Gumbo, D.J. (Eds) *The ecology and management of indigenous forests of southern*

Africa. Forestry Commission, Zimbabwe. Pp. 226-230.

Nyakudya, T.T. 2004. Determination of the Nature and Level of Contamination of Dried Larvae of the moth, *Imbrasia belina* (Mopane Worms) by Microorganisms. Submitted in partial fulfillment of the requirements for the Bachelor of Science Honours Degree in Biological Sciences. Department of Biological Sciences, Faculty of Science, University of Zimbabwe.

Pacciani, A., Belletti, G., Marescotti, A., Scaramuzzi, S., 2001. The role of typical products in fostering rural development and the effects of Regulation (EEC) 2081/92. Paper presented at: Policy Experiences with Rural Development in a Diversified Europe. 73rd EAAE Seminar, Ancona, Italy, 28–30 June.

Pannell, D.J., Schilizzi, S. (1999). Sustainable agriculture: a question of ecology, equity, economic efficiency or expedience? *J. Sustain. Agric.* 13, 57-66.

Patterson, M. (1998). Commensuration and theories of value in ecological economics. *Ecol. Econ.* 25, 105–125.

Perry, M., 2007. Business environments and cluster attractiveness to managers. *Entrepreneurship and Regional Development*, 19, 1-24.

Pettigrew, A. M. (1985). Context and action in the transformation of the firm. *Journal of Management Studies*, 24(6), 649-670.

Pettigrew, A. M. (1997). What is a processual analysis? *Scandinavian Journal of Management*, 13(4), 337-348.

Porter, M. E., 1990. The competitive advantages of nations. London: Macmillan.

Roberts, B. H., & Enright, M. J., 2004. Industry clusters in Australia: Recent trends and prospects. *European Planning Studies*, 12(1), 99-121.

Salminen, J.-P. & Lempa, K. 2002. Effects of hydrolysable tannins on a herbivorous insect: fate of individual tannins in insect digestive tract. *Chemoecology* 12: 203-211.

Scholes, R.J. & Walker, B.H. 1993. An African Savanna. Cambridge University Press, Cambridge.

Smit, G.N. 1994. The influence of intensity of tree thinning on mopani veld. (Volumes I & II). Unpublished D. Phil thesis, University of Pretoria, Pretoria.

Stack, J., Dorward, A., Gondo, T., Frost, P., Taylor, F. & Kurebgaseka, N., 2003. Mopane Worm Utilisation and Rural Livelihoods in Southern Africa. Paper presented at International Conference on Rural Livelihoods, Forests and Biodiversity, 19-23 May, 2003, Bonn, Germany.

Strauss, A., & Corbin, J. (1990). Basics of qualitative research. Newbury Park: Sage. Styles, C.V. (1994) The big value in Mopane worms. Farmers Weekly, July 22, pp 20-22.

Styles, C.V., 1996. The Biological Ecology of *Imbrasia belina* (Saturnidae) with reference to its Behaviour, Physiology, Distribution, Population dynamics, Impact within Mopane Veld and Utilisation within South Africa. In: Proceedings of the First Multidisciplinary Symposium on Phane. Gaborone, Botswana, eds B.A. Gashe & S.F. Mpuchane. NORAD. 18 June 1996.

Styles, C.V & Skinner, J.D., 1996. Possible factors contributing to the exclusion of saturniid caterpillars (mopane worms) from a protected area in Botswana. *African Journal of Zoology*, **34**, 276-283.

Styles, C.V. & Skinner, J.D., 1996. Feeding preferences of goats, *Capra hircus* for different mopane plant parts. S. A. J. Sci. 92: 255.

Storper, M., & Venables, A. J. (2004). Buzz: face-to-face contact and the urban economy. *Journal of Economic Geography*, 4, 351-370.

Taylor, F.W. (2003). Internal Report: Mopane Woodlands and the Mopane Worm: Enhancing Rural Livelihoods and Resource Sustainability, DFID Project No. R7822. Some Aspects of Innovation and Traditional Processing, Storage and Marketing of Mopane Worms in Botswana. Veld Products Research & Development, Gaborone, Botswana.

Terluin, I., 2003. Differences in economic development in rural regions of advanced countries: an overview and critical analysis of theories. *Journal of Rural Studies* 19, 327–344.

Tietema, T., 1989. The possibility of management of mopane woodland. In *Report of Workshop on Management and Development of Indigenous Forests in the SADCC Region*. SADCC Forestry Sector. Lilongwe, Malawi. Pp. 263-282.

Tietema, T., Kgathi, D.L. & Merkesdal, E., 1988. *Wood production and consumption in Dukwe: A feasibility study for a woodland management and plantation scheme*.

NORAD/National Institute for Development Research and Documentation. Gaborone, Botswana. 86 pp. 119

Tietema, T., Tolsma, D.J., Veenendaal, E.M. & Schroten, J., 1991. Plant responses to human activities in the tropical savannah ecosystem of Botswana. In: *Ecological Responses to Environmental Stresses*. Netherlands, Kluwer. Pp. 262-276.

Timberlake, J.R., 1995. *Colophospermum mopane*. Annotated bibliography and review. Zimbabwe Bulletin of Forestry Research No.11. Forestry Commission, Zimbabwe. 49 pp.

Tregeara, A., Arfinib, F., Bellett, G., Marescotti, 2007. Regional foods and rural development: The role of product qualification. *Journal of Rural Studies* 23 (2007) 12–22.

Ulgiate, S., Brown, M.T., Zucaro, A., Franzese, P.P. (2011). Shared wealth or nobody's land? The worth of natural capital and ecosystem services. *Ecol. Econ.* 70, 778-787.

Van de Ven, A. H., 1993. The development of an infrastructure for entrepreneurship. *Journal of Business Venturing*, 8, 211-230.

Van de Ven, A. H., 2005. Running in packs to develop knowledge intensive technologies. *MIS Quarterly*, 29(2), 365-377.

Van de Ven, A. H., & Garud, R., 1989. A framework for understanding the emergence of new industries. *Research on Technological Innovation, Management and Policy*, 4: 195—225.

Van der Merwe, H., 1990. Boerbokke goeie benutters van Mopanieveld. *Landbouweekblad* 649: 44-46.

Van Maanen, J. (1979). The fact of fiction in organizational ethnography. *Administrative Science Quarterly*, 24, 539-550.

Ventura, F., Milone, P., 2000. Theory and practice of multi-product farms: farm butcheries in Umbria. *Sociologia Ruralis* 40 (4), 452–465.

Waiss, A.C. Jr., Chan, B.G., Elliger, C.A., Dreyer, D.L., Binder, R.G. & Gueldner, R.C. 1981. Insect growth inhibitors in crop plants. *Bull. Entomol. Soc. Amer.* 27: 217-221.

Waluszewski, A., 2004. A competing or co-operating cluster or seven decades of combinatory resources? What's behind a prospering biotech valley? *Scandinavian Journal of Management*, 20, 125-150.

Wiggins, D.A., 1997. Clutch size and oviposition site characteristics of a nocturnal African silk moth *Imbrasia belina* (Lepidoptera: Saturniidae). *Annales Zoologici Fennici*, **34**, 235-240.

Wild H. & Fernandes A., 1967. Vegetation map of the Flora Zambesiaca area. Flora Zambesiaca M.O. Collins (PVT.) LTD, Salisbury.

Willson, M.A., Howarth, R.B. (2002). Discourse-based valuation of ecosystem services: establishing fair outcomes through group deliberation. *Ecol. Econ.* 41, 431-443.

APPENDICES

Appendix 1. Amalgamated Questionnaire templated used to collate data from a series of surveys conducted.

Local economic development implications of spatio-temporal changes in mopane worm utilisation in south-western rural Zimbabwe (Matobo District)

HOUSEHOLD QUESTIONNAIRE

ADMINISTRATIVE

District name: Matobo District
(name).....

Ward

Village.....
#.....

Questionnaire

Date of interview.....
Interviewer.....

Household name (*Ngumuzi kabani?*)..... (OPTIONAL)

¹Interviewer perception of quality of responses (to be completed at the end of interview).....

General description of the mopane tree vegetation around the homestead

GPS coordinates.....

MOPANE WORM TERRITORY AND GENERAL HOUSEHOLD CHARACTERISTICS

1. Observable Mopane worm territory characteristics (data based on observation, and transect walks)

Criterion layer	Observable Indicators	Measurement	Score
Exposure indicators	Level of degradation around the homestead (100 m radius)	1 = Highly degraded 2 = Degraded 3 = (fairly) Vegetated 4 = Well vegetated	
	Number of MW tree stumps (100 m radius)	1 = Low (< 3 stumps); 2 = Medium (3-5 stumps); 3 = > 5 stumps).	
	Topography / Catena of place where harvesting happens the most	4 = upper; 3 = middle; 2 = bottom; 1 = floor 	
	Drainage density (proxy – extent of channelization)	3 = high (higher than the combined drainage density average for all sampled wards) 2 = average 1 = low (higher than the combined drainage density average for all wards)	

¹ Excellent = 5; Good = 4; Fair = 3; Poor = 2; Very Poor = 1.

	Ecosystem service provisioning goods	Number of ecosystem service provisioning goods(1 up to 9) - (Use given 9 types of service provisioning goods)	
Climate sensitive indicators	Flood water characteristics	2 = upstream 1 = downstream	
	Stream order characteristics	Based on stream order classification method by Strahler (1957)	
	Soil particle size	5 = coarse sand; 4 = sand; 3 = fine sand; 2 = very fine sand; 1 = silt and Clay 	
Adaptive capacity indicators	Soil moisture storage abilities	3 = good – better insulation (mostly vegetated, evidence of shrubs, crop residue) 2 = fair – fairly insulated (both extreme scenarios co-existing) 1 = poor – poor insulation (evidence of bare soils, herbaceous vegetation, highly degraded landscapes)	
	Type of plant communities	3 = mostly woody (i.e. trees and shrubs) 2 = partly woody and partly herbaceous vegetation 1 = mostly herbaceous (mainly grasses and herbs)	
	Land degradation	3 = land under non-degrading use 2 = land under degrading use 1 = degraded Based on observable land use practices (e.g. prevalence of stumps owing to tree cutting)	
	Evidence of coppicing or annexing	3 = Highly evident 2 = Somewhat evident 1 = No evidence	

2. Headship status (*tick*): Male headed ☐ Female headed ☐ Female managed ☐

Child headed ☐

3. Household Assets

Category of assets	Number	Status (circle where applicable)	Year of first acquisition is applicable) e.g. 2010
(Main) housing unit		2 = brick; 1 = mud	
Type of roofing material		3 = asbestos; 2 = corrugated iron; 1 =thatch	
Water point		1 = tap; 2 = protected well; 3 un- protected well; 4 = river 5 = Other (Specify.....)	
Telephone (landline)		1 = working; 2 = not working	
Telephone (mobile / Cell phone)		1 = working; 2 = not working	
Vehicle		1 = working; 2 = not working	
Scotch cart		1 = working; 2 = not working	
Bicycle		1 = working; 2 = not working	
Wheel barrow		1 = working; 2 = not working	
Television		1 = working; 2 = not working	
Radio		1 = working; 2 = not working	
LIVESTOCK			
Cattle		Number slaughtered in the preceding year.....	
Goats		Number slaughtered in the preceding year.....	
Donkeys		N/A	
Pigs		Number slaughtered in the preceding year.....	

Chicken		Number slaughtered in the preceding year.....	
Other (Specify... ..)		Number slaughtered in the preceding year.....	
LAND-HOLDINGS			
Size of land holding	Acres.....	Area under cultivation.....%	

4. How many family members have;

	Between 1996 and 2000	Between 2000 and 2014	Between 2014 and 2018	Between 2018 and 2022
Been living with the household				
Left the household in search of employment elsewhere				
Lost their jobs				
Passed away (died)				
Been chronically ill (sick)				

MOPANE WORM HARVESTING AND TRADING PRACTICES

5. How many family members have been involved in ;

	Between 1996 and 2000	Between 2000 and 2014	Between 2014 and 2018	Between 2018 and 2022
Harvesting of mopane worms				
Processing of mopane worms				
Selling of mopane worms locally				
Selling of mopane worms in other non-local markets				

6. Mopane worm harvesting and trading activities

Harvester (name optional)	Gender: 1 = Male 2 = Female	Age years	Highest educational qualification 1 = Tertiary (Degree / Diploma / Certificate) 2 = Secondary 3 = Primary; 4 = Less than primary.		d, consumed, sold and bartered in good and bad MW seasons						Indicate whether harvester was active in the specified years	
					2000 - 2014		2014 - 2018		2018 - 2022			
					Good	Bad	Good	Bad	Good	Bad	Year	Score
1.				Harvested								
				Sold						2018	.....	
				Consumed						2019	.....	
				Bartered						2020	.....	
				¹ Place harvested						2021	.....	
				² Place sold						2022	.....	
				Price per 20L	\$.....	\$.....	\$.....	\$.....	\$.....	\$.....		
2.				Harvested								
				Sold						2018	.....	
				Consumed						2019	.....	
				Bartered						2020	.....	
				¹ Place harvested						2021	.....	
				² Place sold						2022	.....	

Mopane worm harvesting and trading activities (contd.)

Harvester (name optional)	Gender: 1 = Male 2 = Female	Age years	Highest educational qualification 1 = Tertiary (Degree / Diploma / Certificate) 2 = Secondary 3 = Primary; 4 = Less than primary.		d, consumed, sold and bartered in good and badMW seasons						Indicate whether harvester was active in the specified years Score: 5 = very active 4 = active 3 = In active - poor2 = Completely Inactive – no harvest 1 = In active other reasons			
					Key: ¹ Place harvested: 1 = commercial farms; 2 = Around homestead 3 = communityforest; 4 = state land / grazing area ² Place sold: 1 = backyard market 2 = nearby road; 3 = at the nearby shops; 4 = At the nearby city 5 = at a far-away city; 6 = na		2000 - 2014		2014 - 2018				2018 - 2022	
					Good	Bad	Good	Bad	Good	Bad			Year	Score
3.				Harvested										
				Sold							2018	.....		
				Consumed							2019	.....		
				Bartered							2020	.....		
				¹ Place harvested							2021	.....		
				² Place sold							2022	.....		
				Price per 20L	\$.....	\$.....	\$.....	\$.....	\$.....	\$.....				
4.				Harvested										
				Sold							2018	.....		
				Consumed							2019	.....		
				Bartered							2020	.....		
				¹ Place harvested							2021	.....		
				² Place sold							2022	.....		

Mopane worm harvesting and trading activities (Contd.)

Harvester (name optional)	Gender: 1 = Male 2 = Female	Age years	Highest educational qualification 1 = Tertiary (Degree / Diploma / Certificate) 2 = Secondary 3 = Primary; 4 = Less than primary.		d, consumed, sold and bartered in good and badMW seasons						Indicate whether harvester was active in the specified years Score: 5 = very active 4 = active 3 = In active - poor2 = Completely Inactive – no harvest 1 = In active other reasons	
					Key: ¹ Place harvested: 1 = commercial farms; 2 = Around homestead 3 = communityforest; 4 = state land / grazing area ² Place sold: 1 = backyard market 2 = nearby road; 3 = at the nearby shops; 4 = Atthe nearby city 5 = at a far-away city; 6 = na							
					2000 - 2014		2014 – 2018		2018 - 2022			
					Good	Bad	Good	Bad	Good	Bad	Year	Score
5.				Harvested								
				Sold							2018	.....
				Consumed							2019	.....
				Bartered							2020	.....
				¹ Place harvested							2021	.....
				² Place sold							2022	.....
				Price per 20L	\$.....	\$.....	\$.....	\$.....	\$.....	\$.....		
6.				Harvested								
				Sold							2018	.....
				Consumed							2019	.....
				Bartered							2020	.....
				¹ Place harvested							2021	.....
				² Place sold							2022	.....

Additional harvester calendar sheets will be supplied in cases where households have more than six harvesters

7. How often do you use the following technologies in the harvesting and processing of the mopane worms.

	<i>Always</i>	<i>Very often</i>	<i>Sometimes</i>	<i>Never</i>	Indicate type of market mostly obtained (<i>tick</i>)	
					<i>local</i>	<i>Outside</i>
Bare hands						
Gloves						
Bottles						
Firewood						
Salt						
Spices (e.g. periperi)						
Plastic bags						
Other bags (90 kg, 50 kg etc)						
20 / 10 / 5 litre buckets						
Hired labour						
Electricity						
Gas						
Other (specify... ..)						

8. How often do you use the following in the marketing / selling of the mopane worms

	<i>Always</i>	<i>Sometimes</i>	<i>Never</i>	Indicate type of market mostly obtained (<i>tick</i>)	
				<i>local</i>	<i>Outside</i>
Hired labour					
Own wheel barrow					
Hired wheel barrow					
Own scotch cart					
Hired scotch cart					
Own bicycle					
Hired bicycle					
20 litre containers					
10 litre containers					
5 litre containers					
Shoe polish container					
Small plastic bags					
90 kg bags					
50 kg bags					
Telephone (land or mobile)					
Own private vehicle					
Hired private vehicle					
Public transport (Taxi or bus)					
Protected marketing shelter					
Marketing warehouse by municipality					
Support services from NGOs (Specify... ..)					

9. What is the relative distance of the household from the following marketing centres;
Walking distance Commuting distance

- (a) Nearby road.....km ☐ ☐
- (b) Nearby shops.....km ☐ ☐
- (c) Nearby rural centre.....km ☐ ☐

INTERACTIONs WITH THE LOCAL ECONOMY

10. Where have you as a household sold the bulk of your mopane worms the most? (NB: Do not aim for too high level of accuracy)

type of harv.season	2000 – 2014		2014 – 2018		2018 -2022	
	Good	Bad	Good	Bad	Good	Bad
Backyard market						
Nearby road						
Nearby shops						
Nearby center (Maphisa)						
Nearby city (Byo)						
Far away city						
Another country						
Elsewhere.....						

11. What proportion of mopane worm cash income has been used by the household for the following purposes: (NB: Use number of stones as trained to estimate proportions / don't aim for too high level of accuracy! *You may alternatively only tick option if estimating proportion is difficulty!*)

Type of harv. season	2000 – 2014		2014 – 2018		2018 -2022	
	Good	Bad	Good	Bad	Good	Bad
Buying livestock						
Buying other foodstuffs						
Paying school fees						
Paying medical expenses						
Covering of funeral costs						
Buying clothes						
Buying other household assets and / or accessories						
Contributions to savings clubs						
Investing in farming activities						
Investing in other cashgenerating business (Specify... ..)						
Helping the needy						
Building improvements (roofing, painting, extension etc.)						
TOTAL	100%	100%	100%	100%	100%	100%

12. In the last 10 years has the cash income you received from mopane worm sales been better than the following income sources? (If possible estimate the proportion of CASH income have you have received from each source).

Scale	1= N/A; 2 No, Not at all, 3 = Yes, sometimes; 4 = Yes always		
Income source	IN GOOD HARVEST	IN POOR HARVEST	Additional notes
Selling of mopane worms	%..... ONLY	%..... ONLY	(If any)
Selling of livestock	Score..... %.....	Score..... %.....	

Selling of agricultural foodstuffs	Score..... %.....	Score..... %.....	
Selling of wild fruits	Score..... %.....	Score..... %.....	
Selling of wild foods eg <i>ulude</i>	Score..... %.....	Score..... %.....	
Selling of other household assets	Score..... %.....	Score..... %.....	
Remittances	Score..... %.....	Score..... %.....	
Mining	Score..... %.....	Score..... %.....	
Formal employment	Score..... %.....	Score..... %.....	
Cash borrowings	Score..... %.....	Score..... %.....	
(Other specify... ..)	Score..... %.....	Score..... %.....	
TOTAL	100%	100%	

13. Do you agree that the following will boost own returns to mopane worms

	What is your level of awareness about the following;			Level of agreement					
	high	fair	low	Strongly agree	Agree	Disagree	Strongly disagree	Not sure	N/A
Exploiting outside markets									
Marketing warehouse									
MW farming									
Better processing technologies									
Improved storage facilities									
Improved transportation facilities									
Improved marketing infrastructure									
Improved harvesting techniques									
Eliminating the middleman									
Selling in smaller quantities									
Delayed sales									
Improved packaging									
Improved product quality									

14. In case of a poor mopane worm harvest what has the household done to make up of lost income?

	Strongly agree	Agree	Neither Agree / Disagree	Disagree	Strongly disagree	N/A
Sell livestock						
Sell other household assets						
Cut on meals						
Rely on government support						
Seek help from church and other well-wishers						
Seek help from relatives and friends						
Borrow from others						
Cut on school fees / expenses obligations						
Other (Specify... ..)						

15. Assuming support is available are you willing to invest / engage in the following MW business related areas;

	Strongly agree	Agree	Neither Agree / Disagree	Disagree	Strongly disagree	N/A
Better harvesting techniques						
Better processing techniques						
Improved drying technologies						
Better storage						
Delay sales until better prices						
Sell all stock to a warehouse and get immediate payment						
Transportation of produce to far away markets						
Processing of mopane worms into high value products (e.g. canned MWs)						
Improved packaging						
Hiring of additional labour to boost quantities harvested						
MW farming to ensure steady supplies.						
Apply for business funding						
Other (Specify.....)						

INSTITUTIONS AND INSTITUTIONAL SUPPORT SERVICES

16. On a scale of 1 to 5 (where 1 = lowest score and 5 = highest score) what can you say about the following institutions and their engagements with mopane worm matters (NB: Village level opinions may be imported from PRA study conducted with selected households)

	SCORE				
	Importance	Influence	Attitude	Resourcefulness	Level of support
The RDC					
The Forest Commission					
CAMPFIRE					
Government					
NGOs (e.g. SAFIRE)					
Universities (eg. UZ)					
Local Schools					
The local church					
The traditional leadership					
The police					
Neighbourhood watch committee					
The community					
Outside traders					
Public transport operators					
Other (Specify.....)					

17. Do you agree that your household has participated in the following mopane worm related activities

	Strongly agree	Agree	Disagree	Strongly disagree	Never
Mopane worm farming					
Mopane worm marketing warehouse					

Monitoring activities of outsiders					
MW meeting organized by the RDC					
MW meetings organized by the Forest Commission					
MW meetings organized by CAMPFIRE					
MW meetings organized by NGOs e.g.SAFIRE					
MW meetings organised by local schools					
MW meetings organized by the traditional leadership					
MW research activities organized by Universities (e.g. UZ)					
Awareness and / security meetings organized by the local police					
Other MW related meetings (Specify)					

18. Additional comments (if any?)

.....

.....

.....

.....

.....

THANK YOU!!!

Appendix 2. Descriptive statistics of attributes defining Territorial Dynamics

Table (a) Ecological System Performance: normality test statistics

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Ecological System Performance (ESP)	ESP1	Level of degradation	3.07	.848	-.896	.480	Retain
	ESP2	Number of tree stumps	1.67	.726	.584	-.913	Retain
	ESP3	Topography / Slope	2.10	1.067	.433	-1.146	Retain
	ESP4	Drainage	1.88	.790	.223	-1.366	Retain
	ESP5	Number of ecosystem provisioning goods	2.73	1.765	.704	.531	Retain
	ESP6	Presence of flood water	1.21	.407	1.439	.070	Retain
	ESP7	Stream order characteristics	1.82	.739	.299	-1.126	Retain
	ESP8	Soil particle size	1.80	1.323	1.054	-.884	Retain
	ESP9	Soil moisture conditions	1.74	.812	.503	-1.304	Retain
	ESP10	Type of plant community	2.34	.709	-.595	-.838	Retain
	ESP11	*Mopane worm resource supplies	3.07	.850	-.889	.443	Retain
	ESP12	MW supplies under wet weather conditions (WRS)	.4757	.50002	.098	-2.000	Retain
	ESP13	MW supplies under dry weather conditions (DRS)	.4587	.49890	.166	-1.982	Retain
	ESP14	Hhds most affected by ecohydrological system constraints.	.6845	.46529	-.797	-1.372	Retain

* Mopane worm resource characterization inspired by the works of Hope et al., (2009: 35). Although Hope et al used such characterization to depict desired scenarios of where rural households would prefer to access their supplies, the characterization used in this study has been stretched to depict places where most supplies are currently obtained.

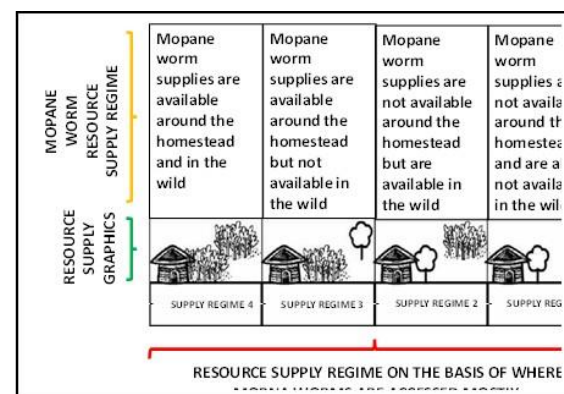


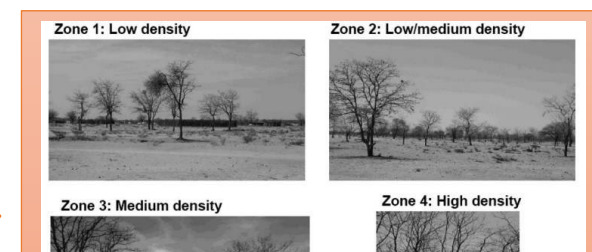
Table (b) Institutional System Performance: normality test statistics

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Institutional System Performance (ISP)	ISP1	Land use practices	2.25	.566	-.032	-.418	Retain
	ISP2	Annexing culture	1.45	.673	1.199	.154	Retain
	ISP3	*Environmental management regime	3.08	.847	-.905	.483	Retain
	ISP4	Level of importance attached to existing institutions	4.1553	.36267	1.910	1.656	Retain
	ISP5	Ability of existing institutions to influence change	3.1553	.36267	1.910	1.656	Retain
	ISP6	Attitude of existing institutions	2.1553	.36267	1.910	1.656	Retain
	ISP7	Resourcefulness of existing institutions	4.1553	.36267	1.910	1.656	Retain
	ISP8	Institutional support	1.5874	.74457	.835	-.725	Retain
	ISP9	Participation in MW related activities	3.6723	2.16742	-.165	-1.738	Retain
	ISP10	Social capital accumulation WRS	.4684	.49961	.127	-1.994	Retain
	ISP11	Social capital accumulation DRS	.7087	.45490	-.922	-1.155	Retain
	ISP12	Appetite for innovations	.41	.493	.356	-1.882	Retain

318

*Resource management regime based on tree densities by Hope et al. (2009: 36). The study assumed that the resource management is largely and interaction between the presence of degrading and non-degrading land use activities. Ultimately the resource management regime based on tree densities by Hope et al. (2009: 36)

Table (c) Social System Performance: normality test statistics



Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Social System Performance (SSP)	SSP1	Social well being	1.36	.480	.600	-1.648	Retain
	SSP2	Household size (moving average)	4.7427	1.50160	.629	1.022	Retain
	SSP3	Average age of harvester (WRS)	2.8115	1.29144	-.139	-1.053	Retain
	SSP4	Average age of harvester (DRS)	3.0089	1.42495	-.020	-.935	Retain
	SSP5	Type of livelihood strategies adopted (WRS)	.3107	.46333	.821	-1.332	Retain
	SSP6	Type of livelihood strategies adopted (DRS)	.5049	.50058	-.019	-2.009	Reject
	SSP7	Households most affected by emigration	.3471	.47662	.645	-1.592	Retain
	SSP8	Households most affected by job losses	.4879	.50046	.049	-2.007	Reject
	SSP9	Households most affected by sickness and death.	.3641	.48176	.567	-1.687	Retain
	SSP10	Number of harvesters per Hhd (WRS)	.55	.498	-.216	-1.963	Retain
	SSP11	Number of harvesters per Hhd (DRS)	.67	.473	-.702	-1.515	Retain
	SSP12	Dominant livelihood pathway (WRS)	.29	.455	.922	-1.155	Retain
	SSP13	Dominant livelihood pathway (DRS)	.44	.497	.235	-1.954	Retain
	SSP14	Gender mostly involved in harvesting (WRS)	2.34	1.059	.284	-1.160	Retain
	SSP15	Gender mostly involved in harvesting (DRS)	2.33	1.055	.318	-1.115	Retain

Table (d) Economic System Performance: normality test statistics

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Economic System Performance (EcSP)	EcSP1	% MW income (WRS)	6.94	8.057	2.413	7.070	reject
	EcSP2	% MW income (DRS)	1.51	2.057	4.004	21.914	reject
	EcSP3	Household Commercialisation Index (WRS)	.7320	.15914	-.118	-.901	Retain
	EcSP4	Household Commercialisation Index (DRS)	.6843	.16824	-.474	-.220	Retain
	EcSP5	Efficiency of MW market	5.2263	1.1299	.492	-1.085	Retain
	EcSP6	Sale completion rate of MW stocks	.675652	.14868	.259	-1.429	Retain
	EcSP7	Harvesting innovation drive	3.5212	1.76225	-.737	-1.464	Retain
	EcSP8	Marketing innovation drive	3.8014	1.95806	-.737	-1.464	Retain
	EcSP9	Level of interaction with outside markets (WRS)	.7597	.42778	-1.220	-.514	Retain
	EcSP10	Level of interaction with outside markets (DRS)	.5655	.49629	-.265	-1.939	Retain
	EcSP11	Entrepreneurial drive (WRS)	.50	.501	-.019	-2.009	reject
	EcSP12	Entrepreneurial drive (DRS)	.51	.500	-.058	-2.006	reject
	EcSP13	Efficiency of MW local markets	.38	.486	.502	-1.756	Retain
	EcSP14	Level of Economic Complexity	.16	.363	1.910	1.656	Retain
	EcSP15	Willingness to adopt new innovations	.67	.470	-.737	-1.464	Retain
	EcSP16	Labour productivity (WRS)	.43	.496	.265	-1.939	Retain
	EcSP17	Labour productivity (DRS)	.37	.482	.556	-1.699	Retain
	EcSP18	Preferred product market (WRS)	2.28	1.403	-.442	-.920	Retain
	EcSP19	Preferred product market (DRS)	1.64	1.107	-.195	-1.296	Retain
	EcSP20	MW income use coefficient (WRS)	.53	.500	-.107	-1.998	Retain
	EcSP21	MW income use coefficient (DRS)	.52	.500	-.068	-2.005	Reject
	EcSP22	Changes in area under cultivation	1.68	.565	.368	-.637	Retain

Table (e) Physical / Engineering System Performance: normality test statistics

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Physical Engineering System Performance (PESP)	PESP1	Proximity to major rural markets	2.83	1.513	-.069	-1.484	Retain
	PESP2	Proximity to major city markets	2.97	1.612	-.163	-1.591	Retain
	PESP3	Road pavement condition	4.5167	2.4367	.464	-1.505	Retain
	PESP4	Village level Economic Complexity Index (ECI)	.2336	.1310	1.309	.658	Retain
	PESP5	Inherent risk associated with road pavements	5.0235	2.6550	.468	-1.666	Retain
	PESP6	State of road pavement surface	.38	.485	.513	-1.745	Retain
	PESP7	Improvements in building units	2.28	.390	-.553	.548	Retain
	PESP8	Improvements in roofing material	2.63	.455	-1.143	-.192	Retain
	PESP9	Water supply changes	2.30	.214	-.023	-1.022	Retain
	PESP10	Access to ICT infrastructure	2.72	.175	-.696	.907	Retain
	PESP11	Changes in own transportation means	2.53	.264	.292	-.954	Retain
	PESP12	Resource markets mostly used	.98	.154	-6.205	36.683	Reject
	PESP13	Location of main MW supplies (WRS)	1.38	.969	.394	.396	Retain
	PESP14	Location of main MW supplies (DRS)	2.41	1.427	-.654	-.840	Retain
	PESP15	Product markets mainly accessed (WRS)	2.33	1.424	-.500	-.928	Retain
	PESP16	Product markets mainly accessed (DRS)	1.78	1.124	-.394	-1.083	Retain

Appendix 3 Data screening procedures associated with resilience capacity Indicator variables.

Table (a): Descriptive statistics for Absorptive Capacity study variables

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Absorptive Capacity (AbC)	AbC1	Access to formal support	3,99	2,174	-,761	-1,385	Retain
	AbC2	Access to informal support	3,69	1,880	-,737	-1,464	Retain
	AbC3	Social capital Accumulation during WRS	,47	,500	,127	-1,994	Retain
	AbC4	Social capital Accumulation during DRS	,71	,455	-,922	-1,155	Retain
	AbC5	Shock preparedness and mitigation	,52	,500	-,098	-2,000	Retain
	AbC6	Access to remittances during WRS	1,67	,470	-,737	-1,464	Retain
	AbC7	Access to remittances during DRS	1,67	,470	-,737	-1,464	Retain
	AbC8	Access to cash savings WRS (proxy entre Drive)	,50	,501	-,019	-2,009	Retain
	AbC9	Access to cash savings DRS (proxy entre Drive)	,51	,500	-,058	-2,006	Retain
	AbC10	Level of importance of existing institutions	4,16	,363	1,910	1,656	Retain
	AbC11	Level of institutional support	1,59	,745	,835	-,725	Retain
	AbC12	Resourcefulness of existing institutions	4,16	,363	1,910	1,656	Retain
	AbC13	Changes in area under cultivation	1,68	,565	,368	-,637	Retain
	AbC14	Changes in assets owned	2,49	,189	-,194	-,483	Retain

Table (b): Descriptive statistics for Adaptive Capacity study variables

Study	Study variables		Std.			

construct	Code	Name	Mean	Deviation	Skewness	Kurtosis	Remark
Adaptive Capacity(AdC)	AdC1	Availability of financial resources and services	4,155	,3627	1,910	1,656	Retain
	AdC2	Availability of ecosystem provisioning goods	2,73	1,765	,704	,531	Retain
	AdC3	Exposure to information	2,55097	,307023	,118	-1,559	Retain
	AdC4	Adoption of improved resource management practices	1,45	,673	1,199	,154	Retain
	AdC5	Adoption of improved resource extraction and processing practices	3,01	1,360	,535	-1,231	Retain
	AdC6	Adoption of improved product marketing practices	,67	,470	-,737	-1,464	Retain
	AdC7	Type of livelihood strategy commonly adopted during WRS	,29	,455	,922	-1,155	Retain
	AdC8	Type of livelihood strategy commonly adopted during DRS	,44	,497	,235	-1,954	Retain
	AdC9	Appetite for innovations	,41	,493	,356	-1,882	Retain
	AdC10	Environmental Management Regime	3,08	,847	-,905	,483	Retain
	AdC11	Land use practices	2,25	,566	-,032	-,418	Retain

Table (c): Descriptive statistics for Transformative Capacity study variables

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Transformative Capacity (TC)	TC1	Responsiveness of local institutions	2,76	,437	1,674	1,153	Retain
	TC2	Road pavement condition	4,52	2,437	,464	-1,505	Retain
	TC3	Economic Complexity Index	,23	,131	1,309	,658	Retain
	TC4	Product markets mainly accessed during WRS	2,28	1,403	-,442	-,920	Retain
	TC5	Product markets mainly accessed during DRS	1,64	1,107	-,195	-1,296	Retain
	TC6	Product market efficiency	5,23	1,130	,492	-1,085	Retain
	TC7	Level of interaction with outside markets	,76	,428	-1,220	-,514	Retain

	TC8	Level of interaction with outside markets	,57	,496	-,265	-1,939	Retain
	TC9	Resource markets mainly used	,98	,154	-6,205	36,683	Retain
	TC10	Proximity to major city markets	2,83	1,513	-,069	-1,484	Retain
	TC11	Household commercialisation index (WRS)	,73	,159	-,118	-,901	Retain
	TC12	Household commercialisation index (DRS)	,68	,168	-,474	-,220	Retain
	TC13	Entrepreneurial Drive (WRS)	,50	,501	-,019	-2,009	Retain

	TC14	Entrepreneurial Drive (DRS)	,51	,500	-,058	-2,006	Retain
	TC15	Labour productivity (WRS)	8,83	8,404	3,090	10,514	Retain
	TC16	Labour productivity (DRS)	5,85	6,982	3,164	1,153	Retain

Appendix 4 Correlation analysis between independent resilience variables

	AbC2	AbC5	AbC6	AbC7	AbC8	AbC9	AbC13	AdC3	AdC4	AdC10	AdC11	TC8	TC16
AbC2	--												
AbC5	-,085	--											
AbC6	1,000**	-,085	--										
AbC7	1,000**	-,085	1,000**	--									
AbC8	,550**	,311**	,550**	,550**	--								
AbC9	,564**	,290**	,564**	,564**	,981**	--							
AbC13	,022	,030	,022	,022	,422**	,468**	--						
AdC3	,321**	-,131**	,321**	,321**	-,221**	-,193**	-,560**	--					
AdC4	,367**	-,007	,367**	,367**	,192**	,179**	-,041	,054	--				
AdC10	,312**	-,229**	,312**	,312**	,142**	,164**	,026	-,036	,251**	--			
AdC11	-,246**	-,280**	-,246**	-,246**	-,245**	-,253**	-,044	-,247**	,098*	,256**	--		
TC8	,463**	,077	,463**	,463**	,180**	,197**	-,190**	,367**	-,077	-,013	-,301**	--	
TC16	,465**	-,220**	,465**	,465**	,174**	,213**	,211**	,368**	,095	,145**	-,103*	,283**	--

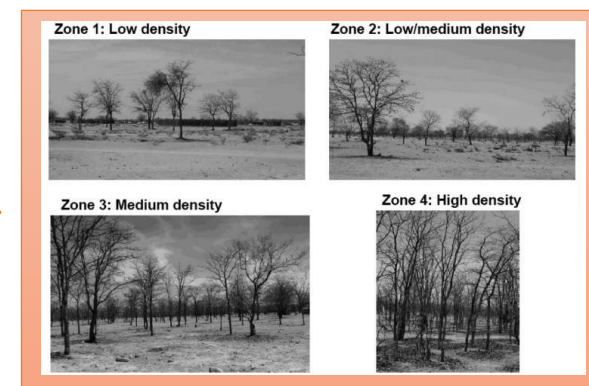
Variables with significant correlations above 0.60 were eliminated. These include AbC1,3,4,10,11,12,15; AdC 2,6, and TC 1,3,4,5,6,10,11,12,15.

Table 6.1.1.2 Institutional System Performance: normality test statistics

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Institutional System Performance (ISP)	ISP1	Land use practices	2.25	.566	-.032	-.418	Retain
	ISP2	Annexing culture	1.45	.673	1.199	.154	Retain
	ISP3	*Environmental management regime	3.08	.847	-.905	.483	Retain
	ISP4	Level of importance attached to existing institutions	4.1553	.36267	1.910	1.656	Retain
	ISP5	Ability of existing institutions to influence change	3.1553	.36267	1.910	1.656	Retain
	ISP6	Attitude of existing institutions	2.1553	.36267	1.910	1.656	Retain
	ISP7	Resourcefulness of existing institutions	4.1553	.36267	1.910	1.656	Retain

	ISP8	Institutional support	1.5874	.74457	.835	-.725	Retain
	ISP9	Participation in MW related activities	3.6723	2.16742	-.165	-1.738	Retain
	ISP10	Social capital accumulation WRS	.4684	.49961	.127	-1.994	Retain
	ISP11	Social capital accumulation DRS	.7087	.45490	-.922	-1.155	Retain
	ISP12	Appetite for innovations	.41	.493	.356	-1.882	Retain

*Resource management regime based on tree densities by Hope et al. (2009: 36). The study assumed that the resource management is largely and interaction between the presence of degrading and non-degrading land use activities. Ultimately the effectiveness of such resource management regimes can be measured by assessing the resultant regimes / zones of MW tree densities



Resource management regime based on tree densities by Hope et al. (2009: 36)

Table 6.1.1.3 Social System Performance: normality test statistics

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Social System Performance (SSP)	SSP1	Social well being	1.36	.480	.600	-1.648	Retain
	SSP2	Household size (moving average)	4.7427	1.50160	.629	1.022	Retain
	SSP3	Average age of harvester (WRS)	2.8115	1.29144	-.139	-1.053	Retain
	SSP4	Average age of harvester (DRS)	3.0089	1.42495	-.020	-.935	Retain
	SSP5	Type of livelihood strategies adopted (WRS)	.3107	.46333	.821	-1.332	Retain

SSP6	Type of livelihood strategies adopted (DRS)	.5049	.50058	-.019	-2.009	Reject
SSP7	Households most affected by emigration	.3471	.47662	.645	-1.592	Retain
SSP8	Households most affected by job losses	.4879	.50046	.049	-2.007	Reject
SSP9	Households most affected by sickness and death.	.3641	.48176	.567	-1.687	Retain
SSP10	Number of harvesters per Hhd (WRS)	.55	.498	-.216	-1.963	Retain
SSP11	Number of harvesters per Hhd (DRS)	.67	.473	-.702	-1.515	Retain
SSP12	Dominant livelihood pathway (WRS)	.29	.455	.922	-1.155	Retain
SSP13	Dominant livelihood pathway (DRS)	.44	.497	.235	-1.954	Retain
SSP14	Gender mostly involved in harvesting (WRS)	2.34	1.059	.284	-1.160	Retain
SSP15	Gender mostly involved in harvesting (DRS)	2.33	1.055	.318	-1.115	Retain

Table 6.1.1.4 Economic System Performance: normality test statistics

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Economic System Performance (EcSP)	EcSP1	% MW income (WRS)	6.94	8.057	2.413	7.070	reject
	EcSP2	% MW income (DRS)	1.51	2.057	4.004	21.914	reject
	EcSP3	Household Commercialisation Index (WRS)	.7320	.15914	-.118	-.901	Retain
	EcSP4	Household Commercialisation Index (DRS)	.6843	.16824	-.474	-.220	Retain
	EcSP5	Efficiency of MW market	5.2263	1.1299	.492	-1.085	Retain
	EcSP6	Sale completion rate of MW stocks	.675652	.14868	.259	-1.429	Retain
	EcSP7	Harvesting innovation drive	3.5212	1.76225	-.737	-1.464	Retain
	EcSP8	Marketing innovation drive	3.8014	1.95806	-.737	-1.464	Retain
	EcSP9	Level of interaction with outside markets (WRS)	.7597	.42778	-1.220	-.514	Retain

	EcSP10	Level of interaction with outside markets (DRS)	.5655	.49629	-.265	-1.939	Retain
	EcSP11	Entrepreneurial drive (WRS)	.50	.501	-.019	-2.009	reject
	EcSP12	Entrepreneurial drive (DRS)	.51	.500	-.058	-2.006	reject
	EcSP13	Efficiency of MW local markets	.38	.486	.502	-1.756	Retain
	EcSP14	Level of Economic Complexity	.16	.363	1.910	1.656	Retain
	EcSP15	Willingness to adopt new innovations	.67	.470	-.737	-1.464	Retain
	EcSP16	Labour productivity (WRS)	.43	.496	.265	-1.939	Retain
	EcSP17	Labour productivity (DRS)	.37	.482	.556	-1.699	Retain
	EcSP18	Preferred product market (WRS)	2.28	1.403	-.442	-.920	Retain
	EcSP19	Preferred product market (DRS)	1.64	1.107	-.195	-1.296	Retain
	EcSP20	MW income use coefficient (WRS)	.53	.500	-.107	-1.998	Retain
	EcSP21	MW income use coefficient (DRS)	.52	.500	-.068	-2.005	Reject
	EcSP22	Changes in area under cultivation	1.68	.565	.368	-.637	Retain

Table 6.1.1.5 Physical / Engineering System Performance: normality test statistics

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Physical Engineering System Performance (PESP)	PESP1	Proximity to major rural markets	2.83	1.513	-.069	-1.484	Retain
	PESP2	Proximity to major city markets	2.97	1.612	-.163	-1.591	Retain
	PESP3	Road pavement condition	4.5167	2.4367	.464	-1.505	Retain
	PESP4	Village level Economic Complexity Index (ECI)	.2336	.1310	1.309	.658	Retain
	PESP5	Inherent risk associated with road pavements	5.0235	2.6550	.468	-1.666	Retain
	PESP6	State of road pavement surface	.38	.485	.513	-1.745	Retain
	PESP7	Improvements in building units	2.28	.390	-.553	.548	Retain
	PESP8	Improvements in roofing material	2.63	.455	-1.143	-.192	Retain

	PESP9	Water supply changes	2.30	.214	-.023	-1.022	Retain
	PESP10	Access to ICT infrastructure	2.72	.175	-.696	.907	Retain
	PESP11	Changes in own transportation means	2.53	.264	.292	-.954	Retain
	PESP12	Resource markets mostly used	.98	.154	-6.205	36.683	Reject

	PESP13	Location of main MW supplies (WRS)	1.38	.969	.394	.396	Retain
	PESP14	Location of main MW supplies (DRS)	2.41	1.427	-.654	-.840	Retain
	PESP15	Product markets mainly accessed (WRS)	2.33	1.424	-.500	-.928	Retain
	PESP16	Product markets mainly accessed (DRS)	1.78	1.124	-.394	-1.083	Retain

Appendix 5 Data screening procedures associated with resilience capacity Indicator variables.

Table: Descriptive statistics for Absorptive Capacity study variables

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Absorptive Capacity (AbC)	AbC1	Access to formal support	3,99	2,174	-,761	-1,385	Retain
	AbC2	Access to informal support	3,69	1,880	-,737	-1,464	Retain
	AbC3	Social capital Accumulation during WRS	,47	,500	,127	-1,994	Retain
	AbC4	Social capital Accumulation during DRS	,71	,455	-,922	-1,155	Retain
	AbC5	Shock preparedness and mitigation	,52	,500	-,098	-2,000	Retain
	AbC6	Access to remittances during WRS	1,67	,470	-,737	-1,464	Retain
	AbC7	Access to remittances during DRS	1,67	,470	-,737	-1,464	Retain
	AbC8	Access to cash savings WRS (proxy entre Drive)	,50	,501	-,019	-2,009	Retain
	AbC9	Access to cash savings DRS (proxy entre Drive)	,51	,500	-,058	-2,006	Retain
	AbC10	Level of importance of existing institutions	4,16	,363	1,910	1,656	Retain
	AbC11	Level of institutional support	1,59	,745	,835	-,725	Retain
	AbC12	Resourcefulness of existing institutions	4,16	,363	1,910	1,656	Retain
	AbC13	Changes in area under cultivation	1,68	,565	,368	-,637	Retain
	AbC14	Changes in assets owned	2,49	,189	-,194	-,483	Retain

Table: Descriptive statistics for Adaptive Capacity study variables

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
	AdC1	Availability of financial resources and services	4,155	,3627	1,910	1,656	Retain
	AdC2	Availability of ecosystem provisioning goods	2,73	1,765	,704	,531	Retain
Adaptive Capacity(AdC)	AdC3	Exposure to information	2,55097	,307023	,118	-1,559	Retain
	AdC4	Adoption of improved resource management practices	1,45	,673	1,199	,154	Retain
	AdC5	Adoption of improved resource extraction and processing practices	3,01	1,360	,535	-1,231	Retain
	AdC6	Adoption of improved product marketing practices	,67	,470	-,737	-1,464	Retain
	AdC7	Type of livelihood strategy commonly adopted during WRS	,29	,455	,922	-1,155	Retain
	AdC8	Type of livelihood strategy commonly adopted during DRS	,44	,497	,235	-1,954	Retain
	AdC9	Appetite for innovations	,41	,493	,356	-1,882	Retain
	AdC10	Environmental Management Regime	3,08	,847	-,905	,483	Retain
	AdC11	Land use practices	2,25	,566	-,032	-,418	Retain

Table: Descriptive statistics for Transformative Capacity study variables

Study construct	Study variables		Mean	Std. Deviation	Skewness	Kurtosis	Remark
	Code	Name					
Transformative Capacity (TC)	TC1	Responsiveness of local institutions	2,76	,437	1,674	1,153	Retain
	TC2	Road pavement condition	4,52	2,437	,464	-1,505	Retain
	TC3	Economic Complexity Index	,23	,131	1,309	,658	Retain
	TC4	Product markets mainly accessed during WRS	2,28	1,403	-,442	-,920	Retain
	TC5	Product markets mainly accessed during DRS	1,64	1,107	-,195	-1,296	Retain
	TC6	Product market efficiency	5,23	1,130	,492	-1,085	Retain

	TC7	Level of interaction with outside markets	,76	,428	-1,220	-,514	Retain
	TC8	Level of interaction with outside markets	,57	,496	-,265	-1,939	Retain
	TC9	Resource markets mainly used	,98	,154	-6,205	36,683	Retain
	TC10	Proximity to major city markets	2,83	1,513	-,069	-1,484	Retain
	TC11	Household commercialisation index (WRS)	,73	,159	-,118	-,901	Retain
	TC12	Household commercialisation index (DRS)	,68	,168	-,474	-,220	Retain

	TC13	Entrepreneurial Drive (WRS)	,50	,501	-,019	-2,009	Retain
	TC14	Entrepreneurial Drive (DRS)	,51	,500	-,058	-2,006	Retain
	TC15	Labour productivity (WRS)	8,83	8,404	3,090	10,514	Retain
	TC16	Labour productivity (DRS)	5,85	6,982	3,164	1,153	Retain

Appendix 6 Correlation analysis between independent resilience variables

	AbC2	AbC5	AbC6	AbC7	AbC8	AbC9	AbC13	AdC3	AdC4	AdC10	AdC11	TC8	TC16
AbC2	--												
AbC5	-,085	--											
AbC6	1,000**	-,085	--										
AbC7	1,000**	-,085	1,000**	--									
AbC8	,550**	,311**	,550**	,550**	--								
AbC9	,564**	,290**	,564**	,564**	,981**	--							
AbC13	,022	,030	,022	,022	,422**	,468**	--						
AdC3	,321**	-,131**	,321**	,321**	-,221**	-,193**	-,560**	--					
AdC4	,367**	-,007	,367**	,367**	,192**	,179**	-,041	,054	--				
AdC10	,312**	-,229**	,312**	,312**	,142**	,164**	,026	-,036	,251**	--			
AdC11	-,246**	-,280**	-,246**	-,246**	-,245**	-,253**	-,044	-,247**	,098*	,256**	--		
TC8	,463**	,077	,463**	,463**	,180**	,197**	-,190**	,367**	-,077	-,013	-,301**	--	
TC16	,465**	-,220**	,465**	,465**	,174**	,213**	,211**	,368**	,095	,145**	-,103*	,283**	--

Variables with significant correlations above 0.60 were eliminated. These include AbC1,3,4,10,11,12,15; AdC 2,6, and TC 1,3,4,5,6,10,11,12,15.

Appendix 7 Language editing certificate



E-mail: patriciangundu83@gmail.com. CONTACT NO. +27 081 077 0336

PROOF-READING & EDITORIAL CERTIFICATE

DATE: 11 August 2024

DISSERTATION AUTHOR: GONDO TENDAYI OF STUDENT ID NO. 11635987

DISSERTATION TITLE: LOCAL ECONOMIC DEVELOPMENT IMPLICATIONS OF SPATIO-TEMPORAL CHANGES IN MOPANE WORM UTILISATION IN SELECTED COMMUNITIES OF SOUTH-WESTERN ZIMBABWE.

TO WHOM IT MAY CONCERN

This serves to confirm that the dissertation written by **GONDO TENDAYI** of student ID NO. 11635987, was proof-read and edited by an English-speaking professional editor at P&T Proof-reading & Editing Services.

We make no claims to the content of this dissertation drafted by the author.

The author may accept or reject any suggestions upon receipt of the document we edited. Should you have any questions or concerns, please contact Patricia Ngundu on 081 077 0336. Sincerely

P&T Proof-reading & Editing Services

At P&T Proof-reading & Editing Services, our mission is to assist students reach their full potential through clear communication. It is in our nature to deliver high quality professional services.

Signature



Managing Editor

Date: 19 AUGUST 2024

Appendix 8 Ethics Clearance Certificate

ETHICS APPROVAL CERTIFICATE

RESEARCH AND INNOVATION
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:

Mr T Gondo

STUDENT NO:

11606873

PROJECT TITLE: Local Economic Development (LED) implications of spatial and temporal changes in Mopane Worm utilization: Evidence from rural regions of Southwestern Zimbabwe.

ETHICAL CLEARANCE NO: FSEA/22/URP/13/1108

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Prof AT Adebayejo	Ladoke Akintola University of Technology (LAUTECH), Nigeria	Supervisor
Prof J Chakwizira	North-West University	Co - Supervisor
Mr T Gondo	UNIVEN,	Investigator – Student

Type: Doctoral Research

Risk: Minimal risk to humans, animals, or environment (Category 2)

Approval Period: August 2022 – August 2025

The Research Ethics Social Sciences Committee (RESSC) hereby approves your project as indicated above.

General Conditions

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following.

- The project leader (principal investigator) must report in the prescribed format to the REC:
 - Annually (or as otherwise requested) on the progress of the project, and upon completion of the project
 - Within 48hrs in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
 - Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the REC. Would there be deviation from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date; a new application must be made to the REC and new approval received before or on the expiry date.
- In the interest of ethical responsibility, the REC retains the right to:
 - Request access to any information or data at any time during the course or after completion of the project,
 - To ask further questions; Seek additional information; Require further modification or monitor the conduct of your research or the informed consent process.
 - withdraw or postpone approval if:
 - Any unethical principles or practices of the project are revealed or suspected.
 - It becomes apparent that any relevant information was withheld from the REC or that information has been false or misrepresented.
 - The required annual report and reporting of adverse events was not done timely and accurately,
 - New institutional rules, national legislation or international conventions A it necessary

ISSUED BY:

UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE

Date Considered: July 2022

Name of the RESSC Chairperson of the Committee: Prof TS Mashau

Signature




Appendix 9 Turnitin Report

Spatio-temporal Analysis of Mopane Utilization in South-Western Zimbabwe

ORIGINALITY REPORT

3%	2%	1%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	assets.publishing.service.gov.uk Internet Source	<1 %
2	eprints.lse.ac.uk Internet Source	<1 %
3	5dok.net Internet Source	<1 %
4	www.researchgate.net Internet Source	<1 %
5	vital.seals.ac.za:8080 Internet Source	<1 %
6	www.sarpn.org.za Internet Source	<1 %
7	hdl.handle.net Internet Source	<1 %
8	Roberts, Deborah, Edward Majewski, and Piotr Sulewski. "Farm household interactions with local economies: A comparison of two EU case study areas", Land Use Policy, 2013. Publication	<1 %

9	Submitted to University of Venda Student Paper	<1 %
10	coek.info Internet Source	<1 %
11	core.ac.uk Internet Source	<1 %
12	c.coek.info Internet Source	<1 %
13	econ.geo.uu.nl Internet Source	<1 %
14	univendspace.univen.ac.za Internet Source	<1 %
15	repository.nwu.ac.za Internet Source	<1 %
16	Andrés Rodríguez-Pose, Daniel Hardy. "Addressing poverty and inequality in the rural economy from a global perspective", Applied Geography, 2015 Publication	<1 %
17	"Proceedings of the International Conference on Radioscience, Equatorial Atmospheric Science and Environment and Humanosphere Science", Springer Science and Business Media LLC, 2023 Publication	<1 %

18	edocs.maseno.ac.ke Internet Source	<1 %
19	link.springer.com Internet Source	<1 %
20	fdocuments.in Internet Source	<1 %
21	ir.cuea.edu Internet Source	<1 %
22	"Chapter 300194 Distribute", Springer Science and Business Media LLC, 2022 Publication	<1 %
23	Pusceddu, A.. "Exergy, ecosystem functioning and efficiency in a coastal lagoon: The role of auxiliary energy", Estuarine, Coastal and Shelf Science, 20090910 Publication	<1 %
24	Jérôme Kabagerayo, Freddy Endelea Mwambusa, Marie Thérèse Uyambaje, Zela Bwija Olive et al. "Impact of Rural Female Entrepreneurs on Social and Economic Inclusion: Case of Giharo District", Modern Economy, 2022 Publication	<1 %
25	etheses.bham.ac.uk Internet Source	<1 %
	open.uct.ac.za	