AN EVALUATION OF ENVIRONMENTAL SUSTAINABILITY OF LAND REFORM IN ZIMBABWE: A CASE STUDY OF CHIRUMANZU DISTRICT, MIDLANDS PROVINCE

BY

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List of abbreviations

AGRITEX	Agricultural Research and Extension Services
BC	Biological capacity or biocapacity
DDF	District Development Fund
EF	Ecological Footprint
FTLRP	Fast track land reform programme
GFN	Global Footprint Network
gha	global hectare
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
WCED World	Commission on Environment and Development
ZERO	Zimbabwe Environmental Research Organisation
ZFU	Zimbabwe Farmers Union

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Declaration

I, **EDMORE KORI**, hereby declare that the dissertation for the Master of Environmental Science in Geography degree at the University of Venda, hereby submitted by me, has not been submitted previously for a degree at this or any other university, that it is my own work in design and execution, and that all reference material contained therein has been duly acknowledged.

Signature.....Date.....15/05/2012.....

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Abstract

Land reforms are carried out in different countries during different periods for various reasons. For the African countries, land reforms aim to address social and economic injustices of the colonial period. The economic, social and political dimensions of land reform usually overshadow the importance of environmental sustainability. For any land reform process to score economic and social points, it should deeply embrace environmental sustainability. The aim of this research was to evaluate the environmental sustainability of land reform in Zimbabwe through a case study of Chirumanzu district, in the Midlands province. Primary data was collected through the administration of household questionnaires to households sampled through multistage cluster sampling. Secondary data was collected from government offices in Mvuma and Kwekwe. The environmental sustainability was evaluated through the application of the Ecological Footprint accounting system. The Ecological Footprint accounting system calculates the human consumption of the ecological resources (Ecological Footprint) and compares it with the calculated available ecological resources (biocapacity). The data was processed through the five stages of the Ecological Footprint and biocapacity computation system. The Ecological Footprint system identified cropland, grazing land, built-up land and forestland uses as applicable in this research. An Ecological Footprint and biocapacity was calculated for each land use. The total for all the land uses gives the Ecological Footprint and biocapacity for Chirumanzu resettlement areas. The difference between biocapacity and Ecological Footprint determines the environmental sustainability status of the study area. The total Ecological Footprint results reveal that land reform in Zimbabwe is generally sustainable. However, the general situation masks the disparities found in the different land uses. The cropland and built-up land uses reveal ecological deficits. These are attributable to more than planned households settled in the area. The grazing land use reports a huge ecological reserve. This is attributable to very low livestock ownership in the resettlement areas of Chirumanzu. The huge ecological reserve in the grazing land use cushions the narrow ecological deficits in the cropland use and built-up land use to paint an overall ecological reserve. Compared to the national situation, the district environmental sustainability situation is very much different. The district largely reports environmental reserve while the nation reports an environmental deficit. This leads to a conclusion that land reform in Chirumanzu district is weakly environmentally sustainable. It is recommended that land reforms consider environmental sustainability as an important cornerstone for its success. An audit should be carried out to ascertain households on the ground against the planned numbers.

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CHAPTER 1: PROBLEM DEFINITION AND ITS SETTING

1.0 Introduction

Land reform has occurred throughout the world for different reasons including the need to change patterns of land ownership or land use. Land reforms, especially in Africa, aim to redress the discriminatory colonial land policies by providing the poor and disadvantaged with arable land (Gonese, *et al.*, 2002). It emphasizes direct redistribution, equity and land for crops, grazing and settlement. Land reform, hence, seeks to ensure food security and eradicate rural poverty.

Land reforms aim to promote food security, eradicate rural poverty and empower people suffering from land shortages or any other tenure inadequacies. However, there are questions about the environmental sustainability of these programmes. Musyoki (1999) and Mohamed-Katerere (2000) observe that to be successful, land use options within a land reform programme should incorporate not only social and economic viability, but environmental sustainability as well. In this context, environmental sustainability is considered in terms of the natural resources available to support life (biocapacity) against what humanity is extracting (Ecological Footprint) from nature. However, environmental considerations of land reform are generally conceptualised inadequately, despite being a central consideration of sustainable land use (Manjengwa, 2006). The challenge for land reform, therefore, is to redistribute land and at the same time ensure productivity and ecological sustainability.

1.1 Background to the research problem

Zimbabwe's land reforms commenced immediately after independence from Britain in 1980. Land Reform in Zimbabwe seeks to address three key issues: inequitable land distribution, insecurity of land tenure and unsustainable and sub-optimal use of land in communal areas and large-scale commercial farms, respectively (Ministry of Lands and Agriculture, 1999). Initially, the Government of Zimbabwe implemented the intensive package approach, which entailed the provision of adequate basic support services, such as access roads, water, and sanitation facilities, dipping tanks, clinics, schools and rural service centres, before or as soon as settlers

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had occupied the redistributed land (Moyo, 1995; Z.F.U., 1995; Clover and Eriksen, 2009). The associated comprehensive planning done before the settlers' relocation sought to ensure environmental sustainability.

This intensive package approach followed the policy of willing buyer-willing seller and lasted until 2000. By the mid 1990s, it was clear that this intensive package approach had failed to reach the set resettlement targets and a quicker approach had to replace it. A new approach was adopted that entailed the relocation of settlers to new settlement areas before basic social services and infrastructure had been established (Land Reform Task Force, 1999) and it became known as The Fast Track Land Reform Programme (FTLRP).

FTLRP was a radical and controversial exercise that sometimes included the forcible removal of existing landowners. Methods of land acquisition, beneficiary selection and resettlement support changed to a completely command-driven approach (Chiremba and Masters, 2003). This approach was totally different from the willing buyer willing seller method that was used during the first two decades of Zimbabwe's independence. Here, beneficiaries occupied farms before any provision of basic infrastructure and Government officials followed at a later stage to "demarcate" the land (Muyengwa and Sango, 2008). Such an approach is likely to have been leading to serious ramifications on the sustainability of the environment in resettled areas.

According to the Zanu (PF)'s National Congress Report (2000), one of the objectives of the FTLRP was to reduce pressure on land and enhance environmental sustainability. The Land Reform Task Force (1999: 3) identifies the intention to "promote environmentally sustainable utilization of land", as one of the objectives of the FTLR. Manjengwa (2009:17), however, observes that there was some "environmental degradation occurring as a result of accelerated resettlement causing conflicts over natural resource use... [and] no environmental audit or assessment [had been comprehensively] carried out." This is supported by Murombedzi's (2005: 4) observation that ''settlers are 'asset strippers', cutting down trees, hunting wild animals and exploiting other natural resources so as to open up new lands for agriculture, reduce competition and protect their livestock from predation, but also to source capital to invest in their new agriculture enterprise''. Furthermore, the Zimbabwe Environmental Research Organization

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(ZERO) (2005) argues that the post-colonial era in Zimbabwe has been characterised by growing levels of environmental degradation and to date, land reform has done little to improve the environmental sustainability of rural land use practices.

Zimbabwe has one of the worst environmental indicators in the world with its ecosystems either in decline or under severe threat. The Yale University's 2008 Environmental Performance Index (EPI), which ranks 149 countries according to a weighting of air pollution, water purity and conservation (ecosystem vitality) practices, ranks Zimbabwe at number 95 (Esty, *et al.*, 2008). Thus, despite the stated intention of addressing some of the problems of overcrowding and inequality, land reform in Zimbabwe has paradoxically failed to address overcrowding and resource scarcity on marginal lands, but instead precipitated new ecological, social and economic challenges (Clover and Eriksen, 2009).

Ironically, the pace of environmental degradation has nowhere been quicker than in resettlement areas (ZERO, 2005). Despite government rhetoric about environmental protection, environmental sustainability has not been mainstreamed in the land reform process (Manjengwa, 2006). This is illustrated in the way the Ministry of Lands, Land Reform and Resettlement's land audit exercise of 2005 failed to include neither officials from the Ministry of Environment and Tourism nor those from the Environmental Management Agency. Added to that, the questionnaire used did not cover fundamental environmental issues or compliance with the Integrated Conservation Plan (ICP).

1.3 Problem statement

Zimbabwe is a predominantly rural country where access to productive land resources is essential for social and economic development. However, between 1893 and 1980, the colonial government passed segregatory legislation such as the Land Husbandry Act of 1930, which deprived the majority of the Africans of the right to own productive land. This divided the country into prime land for Europeans and largely infertile and inhospitable land as "Native Reserves" for Africans. The result was that 3 per cent of the population got entitlement to about 39 per cent of the national total arable land (Chitsike, 2003; Moyo, 2005; Mushimbo, 2005).

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African economic and social development was, therefore, retarded. Thus, the new government implemented land reforms after independence from Britain in 1980 to address these anomalies. However, land reform in Zimbabwe has been piece-meal and reactive in approach (ZERO, 2005) culminating in environmental sustainability challenges.

Different studies point to environmental sustainability challenges in resettlement areas in Zimbabwe. Resettlement schemes have been implemented in some comparatively vulnerable and agro ecologically poorly endowed regions of the country (Harts-Broekhuis and Huisman, 2001). Demographic and economic changes have produced a semblance of communal areas in resettlement schemes, causing serious environmental degradation (Mukwada, 2007; Sikor and Muller, 2008). For instance, Chirumanzu, in Agro-ecological Regions III to IV, which receive low rainfall and suitable for cattle ranching or crops under irrigation, was turned into a resettlement area for rain fed crop cultivation. The government regulation for the area is 30 hectares and 50 hectares per household in Region III and IV, respectively. However, this regulation was not always observed thus compromising the ecological carrying capacity of the land. Estimates suggest that this resulted in deforestation ranging between 100,000 and 320,000 hectares per year (Ministry of Lands, Land Reform and Resettlement, 2004).

Gold panning along Zimbabwe's rivers also mushroomed since the beginning of the FTLRP. Panning is carried out unsustainably and unsystematically, usually in riverbeds, banks and flood plains with no concern for the environment (Manjengwa, 2009). The concern is the ability of such a scenario to sustain the ecosystem services which humanity will always need for survival. The panners and new settlers extract useful resources from the environment for survival. The same population pollutes the biophysical environment. Therefore, for a sustainable environmental situation to prevail, humanity should extract ecological resources from, and release waste to the environment in quantities that the biophysical environment has the capacity to supply and absorb, respectively. The research problem, thereof, concerns the equitable access to land while at the same time maintaining environmental sustainability in the resettled areas.

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1.4 Rationale and justification of the study

The rationale for this study emanates from the need to evaluate the sustainability of the environment in areas affected by Zimbabwe's land reform. This is important information for future planning seeking to achieve the principles of sustainable development.

When the human economic subsystem was small, the regenerative and assimilative capacities of the environment appeared infinite. Humanity now faces the painful reality that environmental resources and sinks are finite. Originally, the regenerative and assimilative capacities were very large, but the scale of the human development has exceeded them (Goodland, 2005). Source and sink capacities have now become limited. This is what environmental sustainability is concerned with.

Sustainability, in a broad sense, means meeting the needs of the present generation without compromising the ability of future generations to meet their needs (World Commission on Environment and Development, 1987). For humans, it is the potential for long-term maintenance of wellbeing, which in turn depends on the wellbeing of the natural environment and the responsible use of natural resources (Goodland, 2005). However, land reform, especially in southern Africa, tends to focus more on land administration than land management (Manjengwa, 2006). It is concerned with who occupies what land but not whether or not the land is capable of supporting the pressure exerted on it by the occupants. It is therefore, important to understand that environmental limits affect the economy and society. Thus, land reform has to be environmentally sustainable in order for it to score social and economic goals.

The issues of environmental sustainability, degradation and management are fundamental to land reform as agricultural production usually brings with it deforestation and soil erosion. Vast tracts of land are cleared for cultivation. Manjengwa (2009) picks out tree cutting, veld fires, gold panning, wetland and stream bank cultivation as common environmental problems that bring about changes in agriculture (and land use administration). Prince, *et al.* (2009) found out that 13% of the entire national potential loss in productivity in Zimbabwe is due to land degradation.

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Thus, this research seeks to make an evaluation of the environmental stress resulting from land reform in Zimbabwe.

Mukwada (2007) observes that there is a current debate on whether land resettlement in Zimbabwe has benefited the people or it is an expensive extension of the communal livelihoods (which have serious environmental challenges). Supporting this view, Manjengwa (2009) asserts that environmental issues are usually the last priority in land resettlement policy in Zimbabwe. High population density areas created by resettlement face problems of congestion and resource overuse. This is likely to create potential environmental destruction unless resource harvesting or use limits are devised and enforced. This, therefore, calls for an assessment of environmental sustainability challenges that land reforms bring.

1.5 Research assumption

Land use practices significantly influence the environmental sustainability of land reform in Zimbabwe.

1.6 Research aim and objectives

1.6.1 Aim

This study aims to evaluate the environmental sustainability of land reform in Zimbabwe.

1.6.2 Specific objectives

The specific objectives of this study are to:

- compute and evaluate the biocapacity of Chirumanzu resettlement areas;
- compute and analyse the Ecological Footprint of Chirumanzu resettlement areas;
- compute and evaluate the household biocapacity and ecological Footprint for Chirumanzu and compare them with Zimbabwe's biocapacity and ecological Footprint per household; and

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- evaluate the environmental sustainability of settled areas.

1.8 Delimitation of the research and study area

1.8.1 Scope of study

Land reform before the year 2000 was carried out under Models A to D resettlement system. From 2000 only Model A was followed. Model A1 and A2 are the two variants of the programme. Model A1 aims at decongesting the communal areas by settling as many households as possible, resulting in the reproduction of the communal areas settlement style of high population concentration (Mukwada, 2007; Sikor and Muller, 2008).

The focus of this study is on Model A and A1 resettlement system's biophysical and ecological aspects of environmental sustainability. Model A and A1 resettlement aimed to decongest the communal areas and provide subsistence farmers with arable land. In some resource poor regions of the country, a resemblance of the social and economic characteristics to those obtaining in the overcrowded communal areas is considered a strong possibility (Harts-Broekhuis and Huisman, 2001). Therefore the areas, that can be termed *recommunal* areas, present challenges to environmental sustainability, similar to those posed by the communal areas.

This study focuses on four land uses, as adapted from Ewing *et al.* (2008). The activities dominant in the resettlement models are cultivation of crops and rearing of animals mainly for domestic consumption. These activities' impacts affect the biophysical realm of land, water and vegetation. Thus, the research focuses on the environmental sustainability of cropland use, grazing land use, forestland use and built up land use.

Environmental sustainability seeks to improve human welfare by protecting natural capital, referred to in this work as biocapacity. Natural capital is both the source of inputs for human needs, a medium of recycling, as well as a sink for waste. Humanity should learn and adjust to live within the confines of the limitations of this biophysical environment (Goodland, 2005).

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Though this is an evaluation of Chirumanzu District, it is a representative sample of the whole land reform programme in Zimbabwe. Land reform in Zimbabwe is done following a national policy and, therefore, similar in all districts. Chirumanzu district is a major economic contributor to Zimbabwe through agricultural production and employment. The major economic activity in the district changed to agriculture after the closure in 1998 of Athens Mine in Mvuma. From 2000, many of the commercial beef producing farms were resettled. Therefore, Chirumanzu is a predominantly agriculture-based district dominated by farmers resettled in the former cattle ranches. Many of the resettlement beneficiaries depend on rain-fed agriculture for livelihood despite the district being a semi intensive farming area.

1.8.2 Study area

1.8.2.1 Location

Chirumanzu district is in the Midlands Province of Zimbabwe. The province is in the central parts of the country and its capital is Gweru, which is 80 km west of Chirumanzu District Offices along the highway to Bulawayo. Chirumanzu district comprises of 24 wards (Figure 1) and is bordered by Gweru district, along Ngezi River to the west, Gutu, along Shashe River, and Mashava to the east and south, while Chivhu makes the northern border, respectively. Gweru district is in the Midlands Province, Gutu and Mashava are in Masvingo Province while Chivhu is in Mashonaland East Province.

The district covers an area of 4 737 km^2, with a population of 70 441 (Central Statistical Office, 2002). It is composed of both communal areas, in the south, and resettlement areas, in the north. Of the 24 wards 10 are model A and A1 resettlement areas. The rest are made up of urban, A2 and indigenous owned farms and communal areas.

The study focuses on the northern parts of the district because that is where resettlement took place. The northern parts of the district are the former large-scale cattle ranch commercial farming areas. The southern parts of the district are communal areas. The northern parts of the

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district have sandy soils and vleis which are expensive to cultivate (Kori, 2004). These conditions do not favour high-density settlement, as they are vulnerable to erosion.

1.8.2.2 Climate and agro ecological regions

Between eighty and ninety per cent of the district is Agricultural Region III, while the remainder is Region IV (Gambiza and Nyama, n.d.; Moyo, 2000; AGRITEX, 2010). Chirumanzu receives between 450 and 800 mm of precipitation per annum. The mean temperature in region III is 21°C and 28°C for region IV. This results in better season quality in region III than region IV as shown by Table 1.1.

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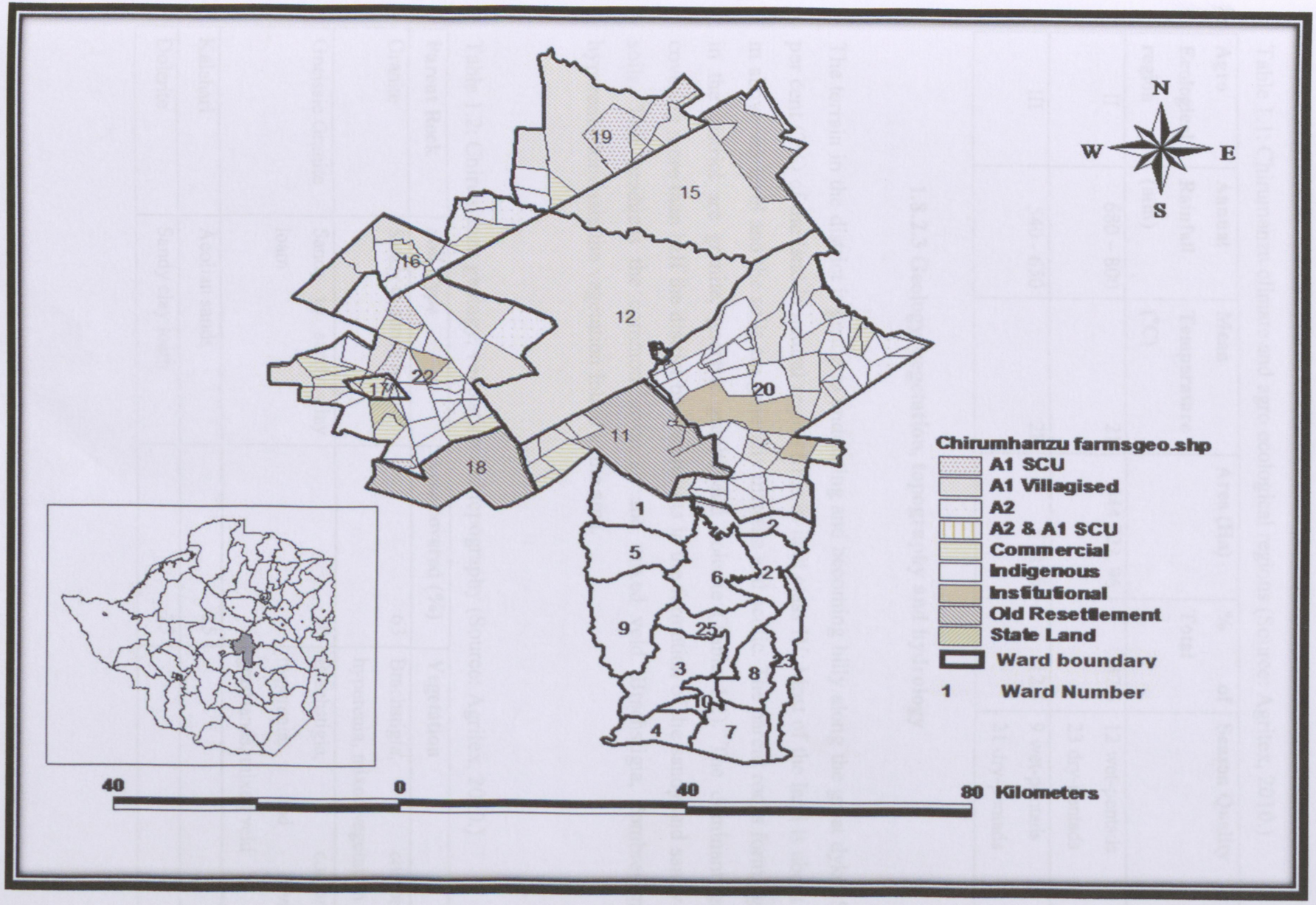


Figure 1.1: Chirumanzu District Farms and Wards (Source: Author, 2011)

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Table 1.1: Chirumanzu climate and agro ecological regions (Source: Agritex, 2010.)

Agro Ecological region	Annual Rainfall (mm)	Mean Temperature (°C)	Area (Ha)	% of Total	Season Quality
II	680 – 800	21	344 822, 96	87.6	12 wet-pentads 23 dry-pentads
III	540 - 650	28	57 146	12.4	9 wet-pentads 21 dry-pentads

1.8.2.3 Geology, vegetation, topography and hydrology

The terrain in the district is gentle to undulating and becoming hilly along the great dyke. Seven per cent (7%) of the land in natural region III is in land class IV. Most of the land is about 1080 m above sea level and the soils are generally infertile and acidic. The parent rocks forming soils in the district are granite, gneissic granite and dolerite (Table 1.2). The dominant granite covering more than half the district by area results in the formation of the sandy and sandy loam soils. This produces the common savannah and mixed veld. Brachstigia, combretum and hyperenia dominate the vegetation found in the area.

Table 1.2: Chirumanzu geology, vegetation and topography (Source: Agritex, 2010.)

Parent Rock	Soil Type	Area covered (%)	Vegetation
Granite	Sandy to sandy loam	63	Brachstigia, combretum, hyperenia, mixed vegetation
Gneissic Granite	Sandy to sandy clay loam	20	Brachstigia, combretum, hyperenia, and savannah grasslands, mixed veld
Kalahari	Aeolian sands	15	
Dolerite	Sandy clay loam	25	

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The major rivers found in the district are Munyati, Sebakwe, Shashe, Ngezi, Nyautonge, Nyamatikiti, Mumvumi, Nyamafufu and Bembezaan. Munyati and Sebakwe rivers have their catchment areas in Chivhu, Mashonaland East province, while Shashe drains from Gutu, Masvingo province. The rest of the rivers' catchments are within the district. All these rivers are found in the agro ecological region III and have numerous large perennial pools of water. A lake is found along Sebakwe River at the boundary with Kwekwe district. Nyamafufu and Bembezaan rivers have large dams.

1.9 Definition of key terms

- Biological capacity (biocapacity) (BC) – the ability of the ecosystem to produce valuable living materials and absorb waste materials generated by inhabitants.
- Consumption – use of goods and/ or services.
- Ecological Footprint (EF) – calculates the demand that populations and their activities place on the biosphere in a given year with the prevailing technology and resource management of that year.
- Ecological Footprint of Consumption – the area used to support a specific population's consumption, including absorption of wastes.
- Ecological Deficit/ reserve – the difference between biocapacity and Ecological Footprint. Deficit is when EF is greater than BC. Reserve is when BC is greater than EF.
- Equivalence Factor – Productivity based on a constant used to convert a specific land type into global hectares of biologically productive land.
- Footprint intensity – the amount of land in global hectares needed for the production of a specific quantity of resource or absorb a given quantity of waste. For example global hectares of grazing land required to produce a tonne of beef.
- Global hectare (gha) – a productivity-weighted area used to report biocapacity and Ecological Footprint.
- Land reform – the redistribution of agricultural land, especially by government measures, so that those owning none or little receive some of it.

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- Land type – a category of biologically productive land. There are five land types used in this study: cropland, grazing land, forest and built-up land.
- Footprint Account – a dataset that calculates the EF and BC of a named region.
- Yield – the amount of primary product in tonnes per year that humans are able to extract per unit area of biologically productive land.
- Yield Factor – a constant that accounts for productivity discrepancies of a particular land type between areas.
- Environment – the combined features and natural capital, that provide the basis for development, environmental management and conservation

1.10 Conceptual framework

The conceptual framework depicts the land reform programme as a balancing process which weighs the ecological footprint (EF) and the biophysical environment (BC). This weighing process has two possible outcomes: an ecological deficit or an ecological reserve. The weighing process in this instance is the planning considerations taken by the relevant authorities. These considerations weigh the ability of the ecological environment (BC) to support the human demands (EF) exerted by a certain population (Figure 1.2 below).

It is important to note that possible land uses are examined when considering land for resettlement. These include crop, grazing, forest and built-up land uses. These are then considered against the ecological services that the natural environment can deliver.

If the outcome of the land reform process is an EF larger than the BC then the lever will tilt towards the EF. This situation is environmentally unsustainable. When BC is greater than EF then the beam tilts towards the BC. This signals an environmentally sustainable situation where the ecological environment can *carry* human load.

In both outcomes, there is feedback to the land reform programme process. If the outcome is an ecological reserve, then there will be continuous improvement mechanism. These mechanisms

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maintain or improve the environmental status quo. When there is an ecological overshoot there should be interventions to prevent an environmental catastrophe.

The conceptual framework, as shown below, shows that this research considers land uses in relation to ecological services as determinants of environmental sustainability in the study area. The land uses under consideration are cropland, grazing land, forestland and built up land. The land uses embody the environmental situation obtaining in the land reform programme.

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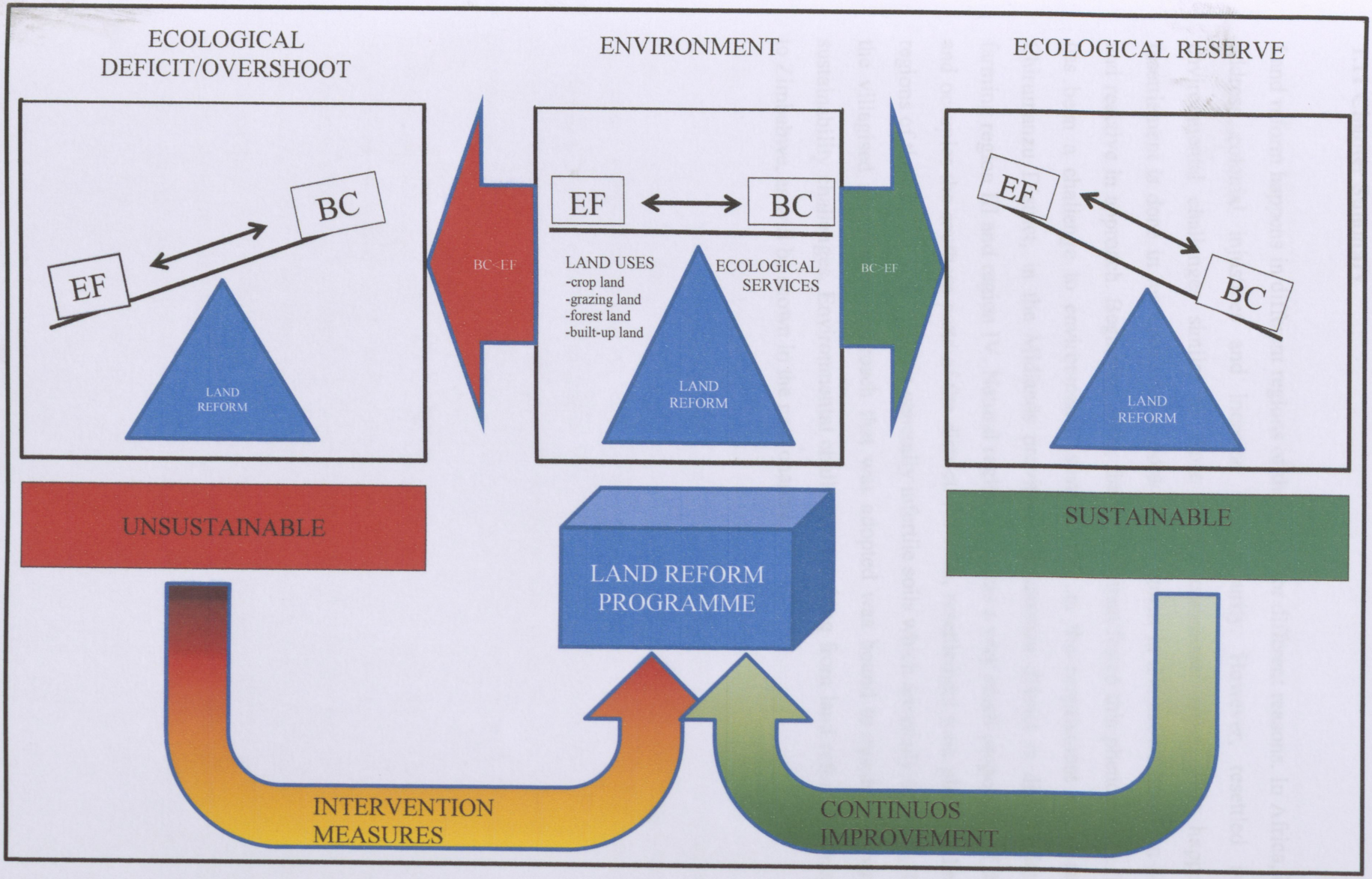


Figure 1.2: The Conceptual Framework (Source: Author, 2010- Informed by the works of The Global Footprint Network)

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1.11 Chapter Summary

Land reform happens in different regions of the world for different reasons. In Africa, it seeks to address colonial injustices and increase food security. However, resettled areas face environmental challenges similar to those in the communal areas. This happens when resettlement is done in resource poor regions. Resettlement in Zimbabwe has been piece meal and reactive in approach. Beginning 2000, the FTLRP manifested this phenomenon. The result has been a challenge to environmental sustainability in the resettlement araes, such as in Chirumanzu District, in the Midlands province. Chirumanzu district is divided into natural farming region III and region IV. Natural region IV forms a very small proportion of the district and occupies the southern parts of the district. As such, resettlement took place in the northern regions of the district. This area has generally infertile soils which are easily erodible. Therefore, the villagised resettlement approach that was adopted was bound to result in environmental sustainability challenges. Environmental challenges resulting from land reform are not peculiar to Zimbabwe, as will be shown in the next chapter.

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CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

For many developing countries in Africa, Asia and Latin America, land is a paramount source of livelihood, security and status (Deininger and Binswanger, 1999; Moyo, 2000; Toulmin and Quran, 2000). An estimated 70 per cent of these continents' population is rural. Land reform, which includes land tenure reform, is a central theme in attempts to eradicate rural poverty and food insecurity in many parts of Africa.

A host of research has informed the field of land reform. The topics range from discussions on how land reform was done in different places in the world to the evaluation of the outcomes of the reforms, from the causes to effects of land reform and from models to categories of beneficiaries (see Moyo, 1995, 2004, 2005; Musyoki, 1999; Gonese, *et al*., 2002; Manjengwa, 2006, 2009; Sikor and Muller, 2008). Various studies on Zimbabwe's land reform focused on the unique and widely publicised Fast Track Land reform. The studies cover different aspects of the programme, including the execution of the project and the impacts on agricultural production, economy, politics, livelihoods and the natural environment (see Chiremba and Masters, 2003; Manjengwa, 2006 and 2009; Chaumba et al, 2008; Zikhali, 2008; Muyengwa and Sango, 2008). However, little research has focused on environmental sustainability of the land reform programme.

Environmental sustainability is a cross cutting subject. The realisation that natural stocks are finite drives the subject of environmental sustainability (Goodland, 2005). Economists give a monetary value to natural resources as a measurement of sustainability (Moldan, *et al*., 2004; Singh, *et al*., 2009). They emphasise an accounting approach that focuses on maintenance of capital stocks. Social scientists use the standard of living as a measure of sustainability. The ecological approach takes natural resources as natural capital which produces interests (Ewing, *et al*., 2008). If humanity is consuming interests accruing from the natural capital, but not

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consuming the natural capital itself, then they are living sustainably. However, if they are digging into the natural capital stock, then there is a risk of environmental unsustainability.

This review aims at revealing the link between land reform, environmental sustainability and environmental sustainability measurement. It is divided into three sections. The first section reviews literature on land reform, the second section focuses on sustainability, while final section delves into an evaluation of environmental sustainability.

2.1 Land reform: a general perspective

2.1.1 Why land reform?

Specific objectives for land reform vary from one country to another, but all condense down to social, political and economic concerns (Gonese, *et al.*, 2002). Land reform seeks to alleviate poverty and promote rural development (Musyoki, 1999; Deininger and Binswanger, 1999; Moyo, 2000; Toulmin and Quran, 2000). Therefore, pressure for land reform usually comes from the poor and disadvantaged. Under such circumstances, land reform would have been driven by the need to address social and economic factors. These factors are reviewed individually below.

2.1.1.1 The political-economic motives

The drive behind the economic motive is the need to put underutilised or unutilised agricultural potential to maximum commercial production (Gonese, *et al.*, 2002). Many developing countries try to use land reform as a means to increase agricultural production, make agriculture more viable and promote individual responsibility over land (Mbaya, 2000).

In many countries, large corporate organizations and powerful political individuals used their strong influence to acquire large tracts of land, most of which they did not pay tax for. This made the class very rich at the expense of the government which needed land tax revenue and by raising the price of land beyond the reach of many (Gonese, *et al.*, 2002). Therefore, politicians use land reform or its promise to gain or remain in government.

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The needs to ensure equity, correct historical imbalances created by colonisation and fulfil liberation struggle promises drive land reform (Mbaya, 2000). Peasants used land reform, as a means to power in Mexico, Bolivia, Venezuela, and China, among other nations. Gonese, *et al.*, (2002) observe that in most of these situations, motives for social equality were strongly tinged by motives of political self-preservation. Political economic drivers also act as push factors for land policy reform in South Africa, Namibia, Mozambique, Swaziland, Lesotho and Zimbabwe (Mbaya, 2000).

2.1.1.2 The socio-political motives

Land ownership imbalance normally results in public pressure for land reform. Social movements with important peasant support led to revolutionary regimes implementing radical land reforms in Mexico, Bolivia, Cuba and Nicaragua. Similar processes produced massive land reforms in China and Vietnam. Popularly based insurgencies in Peru and El Salvador convinced nationalist military officers with state power to undertake land reforms. Important land reforms by authoritarian regimes in South Korea and Taiwan had partially similar origins (Barraclough, 1998). South Africa's land reform aims to "redress the injustices of apartheid, foster national reconciliation and stability, underpin economic growth, and improve household welfare and alleviate poverty" (Gonese, *et al.*, 2002:5).

At Zimbabwe's independence from colonial rule in 1980, about 6 000 (3% of the national population) commercial farmers owned close to 39% of the country's arable land while more than a million households, (97% of the national population), occupied about 41 per cent of the predominantly dry areas (Chitsike, 2003; Mushimbo, 2005; Moyo, 2005). It is observed that between 20 and 60 per cent of this land was idle or underutilized. Thus, social and economic forces drive land reform in Zimbabwe.

In Zimbabwe the fight for land by the local people started with the 1896 uprisings, popularly known as the 1st Chimurenga. The 2nd Chimurenga, which began in the 1960s, had land as one of

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its causes. After independence, the policy objective centred on eradication of rural poverty, land tenure reform and improving food security (Chitsike, 2003). An overview of how land reform was implemented from international level, African and to Zimbabwe can give a clearer perspective.

2.1.2 The international perspective

Land reform is a recurring and contentious theme in world history. It has been happening from time immemorial. The French Revolution (1789-1815) brought land reform to France and established the small family farm as the cornerstone of French democracy. Moyo (1995) states that land reforms have been undertaken in Africa, in America, in Asia, and in Europe over the last seven decades. Redistribution as a form of land reform has been favoured worldwide, particularly in former colonised countries, which would redistribute land as a form of social justice (Chigumira, 2006).

Serfdom was abolished throughout most of Europe in the 19th century. The Russian serfs were emancipated in 1861, and the Russian Revolution of 1917 introduced collectivization of agriculture. However land reform remained a potent political, social, economic and environmental issue in many parts of the world.

Land reforms have swept through many parts of the world during the modern age. Radical land reform programmes have followed historical moments including the Mexican Revolution of 1917, the Chinese Communist Revolution of the 1950s, and that of Bolivia in 2006. Sikor and Muller (2008) observe that land reforms were a key component of the socialist revolutions which took place in Russia, China, Eastern Europe, and parts of Asia, Latin America, and Africa in the 20th century.

The fundamental aspect of all land reforms has been the replacement of existing institutional arrangements governing possession and use of land. For example, after World War II, the incoming Communist governments promulgated land reform laws that made it illegal for any individual to hold more than 50 ha in former Czechoslovakia, Poland, Hungary and Romania; 35

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ha in Yugoslavia; and 20 ha in Bulgaria, resulting in 12 million hectares distributed to 3 million peasants (Gonese, *et al.*, 2002; Sikor and Muller, 2008). The outcome has been a higher population density, which had inherent challenges of environmental management and environmental sustainability. However, the policies were different in Africa.

2.1.3 The African perspective

Land reform is popularly associated with decolonization in Africa. It is perceived as part of the program for African empowerment and socialism. Land reform is widely understood as necessary for building sustainable development and security in the southern African region (Clover and Ericksen, 2009). If implemented properly by a national government and administration with international assistance, it should alleviate rural poverty, increase agricultural productivity, and strengthen the new nation state (Sikor and Muller, 2008).

The World Bank published a key policy document on land in 1975. As a result, land reform was part of the policy package offered to newly independent nations such as Egypt in the 1950s, Tanzania in the 1960s and Zimbabwe in the 1980s (Sikor and Muller, 2008). Redistributive land reforms, with differing objectives and approaches, therefore, became important state projects throughout the developing world during the 20th Century.

The passing of Law Number 178 in 1952 began the process of land reform in Egypt. Among the raft of provisions was the reduction of maximum land size to 300 feddans (a feddan equals about 0.42 hectare or 1.038 acres). If a landowner held land above that limit the regulations provided for redistribution with compensation in the form of government bonds which would mature in thirty years. The regulations were revised in 1958 and 1961 where the maximum land holding was reduced to 100 feddans.

In the 1960s, the Kenyan leader, Jomo Kenyatta launched a "willing buyer-willing seller" based that was funded by Britain, the former colonial power. The Kenyan land reform programme allowed for heavy investment of private capital by the elites: politicians, civil servants, and traders (Mushimbo, 2005). These elites purchased a quarter of the large-scale farms, and this

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speeded up land reform without depressing production (Bratton, 1987). The aim of land reform in Kenya was to promote employment creation and foster investment for rural development (Musyoki, 1999). In 2006, the new Kenyan government proclaimed that it would reposes all land owned by absentee landowners in the coastal strip and redistribute it to squatters (Joseph, 2006).

Clover and Ericksen (2009) show how historical inequity has caused both poverty and environmental change in southern Africa. Post-political independence land reforms intended to address the divisions and injustices of the past. These have in turn affected environmental, social and economic sustainability, not necessarily in a positive way. In Namibia legislation was passed in September 1994 promulgating a compulsory, compensated approach. Weidlich (2006) reports that the Namibian government announced intentions to acquire a targeted 10,3 million hectares of commercial farm land over a period of 15 years to resettle 6 727 families by 2020.

The 1912 and 1936 Native Lands Acts of South Africa "prohibited the establishment of new farming operations, sharecropping or cash rentals by blacks outside of the reserves" where they were confined and forced to live (Klaus, 1999:645). The law effectively dispossessed blacks of the majority of arable land and prohibited them from any farming activity outside of demarcated *Bantustans* (native reserves) that comprised a mere 7.7% of the country (Deininger and May, 2000). By 1994 up to 2.3 million African rural households were concentrated on 13% of the national land (Gonese, *et al*., 2002). The tenure was customary or Permission to Occupy (PTO) certificates. To this day, land ownership remains grievously skewed, with approximately 5% of the white population owning 87% of the land (Moyo, 2004). White South Africans are the predominant owners of the 15% of land classified as arable (FAO, 2005).

The objectives of the Land Reform Programme in South Africa are to redress the injustices of apartheid, foster national reconciliation and stability, underpin economic growth, and improve household welfare and alleviate poverty (Gonese, *et al*., 2002). The South African government states that it regards the redistribution and securitization of land rights for the rural poor as a crucial step in alleviating poverty and achieving long-term social stability (Cousins, 2000). The three pillars: redistribution, restitution and land tenure, are therefore, at the core of land reform in South Africa.

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There is currently a great deal of serious conflict over land throughout southern Africa but nowhere has it attracted much attention than in Zimbabwe (Manjengwa, 2006; Clover and Eriksen, 2009; Zikhali, 2008). Land is at the centre of Zimbabwe's policy and development process. The Zimbabwean Land Reform involves restructuring of access to land, and an overall transformation of the existing farming system, institutions and structures (Ministry of Lands, Land Reform and Resettlement, 2004; Moyo, 2005, Manjengwa, 2006). The land question in Zimbabwe embraces food security, settlement, economic and social development. However, issues of "environmental deterioration and management are implicated since agricultural production in the fragile savannah ecosystem has tended to bring with it deforestation and soil erosion" (Harts-Broekhuis and Huisman, 2001; Goebel, 2006). This brings the question of the environmental sustainability of land reform in Zimbabwe.

2.1.4 Land reform in Zimbabwe

2.1.4.1 Background

The European settlers, in colonial Zimbabwe, turned to agriculture after realizing that there colonization of both Matabeleland and Mashonaland had not yielded the expected huge mineral wealth (the second rand) across the Limpopo. They promulgated segregatory laws. Land was divided into prime land which was exclusively for whites and "Native Reserves" for Africans (Chitsike, 2003). Native reserves were created in 1898 and the Land Husbandry Act of 1930 gave a legal force to this segregation. This law practically gave 3 per cent of the national population about 39 per cent of the total arable land in the country (Chaumba, *et al.*, 2003; Chitsike, 2003; Moyo, 2005; Mushimbo, 2005). The areas allocated for Africans were small and were affected by poor precipitation and soil fertility. The correction of this anomaly forms the main objective and basis for land reform and resettlement in Zimbabwe.

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2.1.4.2 Objectives for land reform in Zimbabwe

After independence from Britain in 1980 the new Zimbabwe government established an intensive resettlement programme. This approach meant that adequate basic support services such as access roads, water and sanitation facilities, dip tanks, clinics, schools and rural service centres were provided before or as soon as settlers occupied distributed land (Moyo, 1995; Z.F.U., 1995). The specific objectives of the programme were:

- the reduction of population pressure in communal areas.
- the improvement of individual and cooperative agricultural productivity, hence food security and standard of living.
- the rehabilitation of victims of the liberation war.
- addressing inequitable land distribution, insecurity of land tenure and unsustainable and sub-optimal use of land in communal and large-scale commercial farms, respectively.
- to expand and improve the infrastructure and services that are needed to promote the well-being of the population and economic production (Moyo, 1995; Z.F.U., 1995; Ministry of Lands and Agriculture, 1999; Chitsike, 2003; Masiiwa, 2004).

Implementation had to follow these objectives. The government implemented the objectives with the help of donor agencies. The following section describes how it was implemented.

2.1.4.3 Land reform efforts in Zimbabwe

The new Zimbabwean government promised to acquire 8, 5 million hectares and resettle 163 000 households in 1980 (Moyo 1995; Ministry of Lands and Agriculture, 1999; Masiiwa, 2004). By 1997, only 71 000 families, (43.6%), had been resettled on 3, 5 million hectares (41.2%) of land (Ministry of Lands and Agriculture, 1999, Masiiwa, 2004). Only 19 per cent of this was classified as prime land, the rest was either marginal, or unsuitable for grazing or cultivation (Fox, *et al.*, 2006). This resulted in general disgruntlement and sporadic farm invasions.

Although farm invasions became a popular global news item, after 2000, they were not a completely new feature on the Zimbabwe. Land invasions had been taking place in different

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areas, but these were labelled as squatting. Invasions occurred, between 1980 and 1982, in Nyamandlovu near Bulawayo, Lupane, Gwai-Bembesi and the Mukosi River Ranch areas (Mushimbo, 2005). In 1997, Chief Svosve led his people's occupation of farms in Goromonzi; as there were other spontaneous responses to this in Insiza and Mrewa. However, the government evicted the occupiers as illegal settlers. Nevertheless, the government policy changed at the dawn of the new millennium, in 2000, when it tacitly and expressly supported the invasions.

The 2000 land occupations, extensive land reforms and processes of agrarian change in Zimbabwe resulted in growing research, debates and interest in Africa's land question, and an evaluation of the land issue's relevance to the global context and developmental agendas (Harts-Broekhuis and Huisman, 2001; Lebert, 2003; Waterloos and Rutherford, 2004; Moyo, 2005; 2008). The capitalist development that occurred during the colonial era and the attempts at a socialist approach in the decade after independence largely framed the land and agrarian question in Zimbabwe (Chigumira, 2006). Land reform efforts in Zimbabwe fall into two phases: the 1980 to 1999 and the post 1999 phases.

a) Land reform and resettlement (1980 – 1999)

At independence in 1980, land reform was identified as a bulwark against chronic poverty, household food security and inequalities which were the abhorrent legacy of the white colonial regime (Zimbabwe Institute of Land Policy Study, 2005). Land Reform and Resettlement Programme (LRRP) Phase I and II were launched in 1980 and 1998, respectively.

Zimbabwe carried out land reform under Models A to D (Table 2:1). The basis for Model A is the communal lands settlement system. It has a modified village setting with a fixed number of beneficiaries, village boundaries and demarcated arable holding and communal grazing areas. Areas with developed infrastructure resources could run on a cooperative basis called Model B. Model C, with a core estate, has elements of cooperative committees and is run by the Agricultural and Rural Development Authority (ARDA), which provides back-up services. Model D is operational in drier agro-ecological regions IV and V and land is used as ranches for communal grazing schemes. Legal ownership in all these categories is vested in the state.

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Table 2:1: Land Reform and Resettlement Phase I and II Models (Source: Adapted from Ministry of Lands and Agriculture, 1999)

Model	Characteristics
A	- A village as a nucleus - Individual arable holdings - Communal grazing - Communal water point
B	- Cooperative management of farm - Used on properties with well-developed agricultural infrastructure
C	- Core commercial estate with settler out growers - Core estate is well developed - Meant for development of small scale producers in more technically demanding activities - Individual arable holding - Communal grazing
D	- Meant for low rainfall areas - Ranches used for communal grazing - Aim to reduce pressure on communal grazing areas - Later modified and renamed Three Tier

The government followed an intensive package resettlement approach to implement this model. This intensive package entailed the provision of adequate basic support services, such as access roads, water, sanitation facilities, dip tanks, clinics, schools, and rural service centres, before or as soon as settlers occupied distributed land (Moyo, 1995; Z.F.U., 1995). The resettlement projects aimed to address three key issues:

- inequitable land distribution,
- insecurity of land tenure and
- unsustainable and sub-optimal use of land in communal and large-scale commercial farms, respectively (Ministry of Lands and Agriculture, 1999).

However, this approach failed to reach set targets. Under LRRP I the plan was to resettle 168,000 families, however, by 1997 only 71,000 families had been resettled (Ministry of Lands and Agriculture, 1999; Zanu (PF), 2000; Moyo, 2005; Manjengwa, 2006, 2009). Under LRRP II

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the plan was to resettle 91 000 families over 5 years (Muyengwa and Sango, 2008). However, this faltered again in 1999 after disagreements between the government and the donor community after the resettlement of less than 5000 families. Political, social and economic circumstances then triggered the widely publicised Fast Track Land Reform.

b) The Fast Track Land Reform (post 1999)

Following the popular rejection of the draft Constitution by the electorate in February 2000, the government amended the Constitution in April 2000 to allow for compulsory land acquisition without the obligation to pay compensation (Masiiwa, 2004; Fox, *et al.*, 2006). Thereafter, the FTLRP was officially launched on the 15th of July 2000 (Ministry of Lands, Land Reform and Resettlement, 2004).

There are both social and political factors that led to the FTLRP. However, three stand out as the major push factors towards this phase:

- The farm invasions which had begun in 1998.
- Failure to secure donor support for Phase II and guarantee by the former colonial power, Britain, to finance the programme, and
- The defeat of the government in the constitutional referendum and the emergence of the Movement for Democratic Change as a powerful political party (see Sachikonye, 2002; Human Rights Watch, 2002; Chaumba, *et al.*, 2003; Fox, *et al.*, 2006).

It should, therefore, be underscored here that the FTLRP was fundamentally different from the government directed, technocratically controlled intensive package approach. It was a more radical exercise that sometimes included forcible and sometimes violent, removal of the whites from the farms (Chiremba and Masters, 2003; Goebel, 2006, Fox, *et al.*, 2006). It is interesting to review the implementation of this phase of land reform, as it was a "knee-jerk" programme.

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2.1.4.4 FTLRP implementation

Resettlement under the FTLRP took place on two settlement variants, the A1 and A2 models put forward in the 1997 Land Policy. These were derived from the variants proposed in the previous LRRP Phase II in 1997 (Chigumira, 2006). This study focuses on the A1 model. The structure of model A1 is summarised in Figure 2.1.

The A1 model mainly targeted landless people and sought to decongest the communal areas (Fox, *et al.*, 2006). However, 20% of the land was reserved for the war veterans. Beneficiaries were resettled in either villages or self-contained small farm units (Ministry of Lands, Land Reform and Resettlement, 2004).

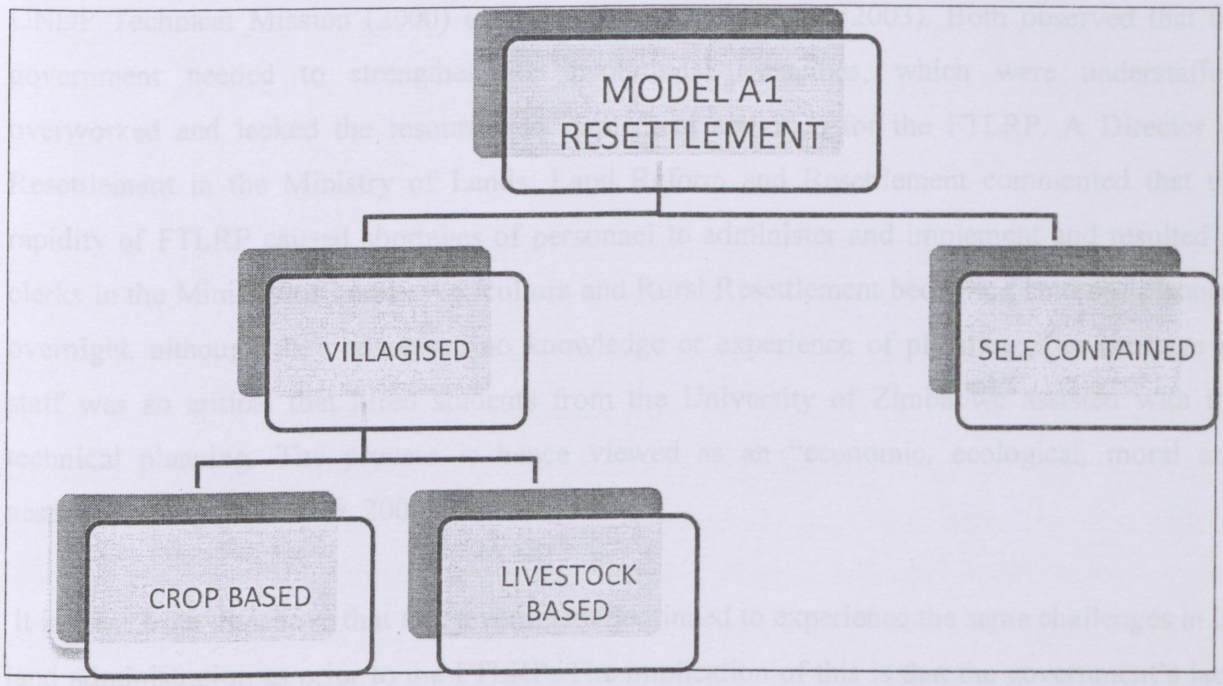


Figure 2:1: Structure of A1 Resettlement Model (Source: Adapted from Ministry of Lands, Land Reform and Resettlement, 2004)

The state owns all land in Zimbabwe (see Land Reform and Resettlement (Amendment) Act, 2005). However, Maunganidze (2004) indicated that beneficiaries under the A2 and A1 self-contained models were to get 99 and 25-year leases, respectively. Beneficiaries would have the option to purchase within the lease period.

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The process of land acquisition in the FTLRP was centralised and mainly administered by the Department of Lands in the Ministry of Lands, Agriculture and Resettlement and later Ministry of Lands, Land Reform and Resettlement now Ministry of Lands and Rural Resettlement. The Fast Track approach was a more "revolutionary" approach where land acquisition, beneficiary selection and resettlement support were command driven (Chiremba and Masters, 2003; Fox, *et al.*, 2006). The Department of Extension and Services (AREX) in the Ministry Agriculture, planned, surveyed and pegged the acquired farms with the active help of the veterans of Zimbabwe's war of liberation from colonialism (UNDP, 2000; Fox, *et al.*, 2006; Muyengwa and Sango, 2008).

AREX and Ministry of Lands, Land Reform and Resettlement got adverse reports from the UNDP Technical Mission (2000) and The Utete Commission (2003). Both observed that the government needed to strengthen its institutional capacities, which were understaffed, overworked and lacked the resources to implement activities for the FTLRP. A Director of Resettlement in the Ministry of Lands, Land Reform and Resettlement commented that the rapidity of FTLRP caused shortages of personnel to administer and implement and resulted in clerks in the Ministry of Lands, Agriculture and Rural Resettlement becoming land use planners overnight, although they possessed no knowledge or experience of planning. The shortage of staff was so critical that hired students from the University of Zimbabwe assisted with the technical planning. The process is hence viewed as an "economic, ecological, moral and aesthetic outrage" (Goebel, 2006: 37).

It is clear from the above that the government continued to experience the same challenges in its land administration as prior to the FTLRP. The implication of this is that the government's lack of physical and personnel resources and adequate coordination was likely to compromise its ability to implement the FTLRP effectively. In the end, environmental considerations could be compromised.

The FTLRP was criticised and condemned internationally, regionally and locally for the land occupations, the lack of rule of law, disrespect for property rights, inadequate planning and

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financial support (see UNDP Technical Mission to Zimbabwe Report, 2000 and 2001; Chigumira, 2006; Goebel, 2006). That the FTLRP was a reactionary rather than a planned activity is well documented and widely accepted (ZERO, 2005; Murombedzi, 2005; Goebel, 2006; Muyengwa and Sango, 2008; Manjengwa, 2009). It took a radical approach in that it was a drastic planned public intervention to redistribute land other than an evolutionary process seeking to improve access and security of tenure (Adams, 1995). Zimbabwe's liberation war veterans assumed the role of planning and allocating land. They allocated plots systematically using rudimentary markers such as pegs, trees and stones (Muyengwa and Sango, 2008).

Chaumba, *et al.* (2003) examine the land occupations and fast-track resettlement process in the Chiredzi District in Zimbabwe's southeast low veld. They argue, "their broad-brush representation as chaotic, violent, un-modern and unplanned obfuscates two overlapping phases underpinned by same logic. Rather than constituting a descent into anarchy, the state bureaucracy has been able to enact a rapid return to 'technocratic type' – if, indeed, this ever went away (pp. 541)."

The rationale behind carrying out land reform in the above way in Zimbabwe is the general theme in most of the literature on FTLRP. It is generally found that the main driving force behind the FTLRP is equitable land ownership between whites and blacks (Gonese, *et al.*, 2002; Zikhali, 2008). Some of the discussions focus on the impact of the land reform programme on total agriculture output and the incidences of rural poverty (Harts-Broekhuis and Huisman, 2001; Moyo, 2004; Chigumira, 2006; Zikhali, 2008.). Issues of environmental impact are also widely covered (Chaumba, *et al.*, 2003; Chigumira, 2006; Manjengwa, 2006 and 2009). A majority of the findings outline the way the land reform has resulted in the deterioration of vegetation cover, water resources and the use of wetland areas.

Against the given background, the purpose of this study then is to evaluate the ability of resettlement areas to sustain humanity without either the environment or standard of living deteriorating. The FTLRP is a permanent feature on the environment and land allocation was according to agro ecological zones. The ecological carrying capacity is of paramount importance

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in the land allocations. Therefore, the amount of land allocated to households depended on the agro-ecological region of the particular area.

2.1.4.5 Agro-ecological regions and A1 land allocations

The A1 villagised settlement type is a translocation type of resettlement. The village design is such that each household has an allocated residential and arable plot but grazing, woodlots and water resources are shared (Ministry of Lands, Land Reform and Resettlement, 2004). A gross amount of land was allocated to each household according to the agro ecological region, with at least 3 hectares for arable land (Table 2:3).

Table 2:2: Average land allocation per agro ecological region (Source: Ministry of Lands, Land Reform and Resettlement, 2004).

Agro Ecological Region	Average Hectares/ household
I	12
IIa	15
IIb	20
III	30
IV	50
V	70

Such household land allocations have implications on land use practices and environmental sustainability. However, the overriding objectives for land allocation, especially after 2000, segregated environmental considerations to the bottom of the objectives for resettlement. The objectives for the A1 resettlement model were to:

- relieve population pressure on land,
- improve household food security,
- provide basic social and infrastructural services which facilitate growth in the resettlement areas,
- provide an administrative system for the social management of the new areas, and

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- eliminate squatting and other disorderly settlements (Ministry of Lands, Land Reform and Resettlement, 2004).

It is important to note that without sound environmental policies linked to land reform, the above objectives will remain a pipe dream. Therefore, an overview of the relationship between land reform and the environment will put this argument into better perspective.

2.1.4.6 The environment and land reform

Environmental sustainability and access to resources, such as land, are critical for the livelihoods of poor populations. Many of the different ways in which the rural population in southern Africa, particularly Zimbabwe, pursue livelihood security, are based on access to ecologically diverse land. Land has multiple environmental, social and economic functions (Clover and Ericksen, 2009). Efforts to better the lives of people through access to land will fail unless they enhance, or at the very least, conserve, environmental resources (Khagram *et al.*, 2003). The key to the success of any land reform is not only its social and economic viability, but also the land use methods practiced and their environmental sustainability (Musyoki, 1999; Mohamed-Katerere, 2000). Despite the stated intention to address some of the challenges of overcrowding, land reform in Zimbabwe has paradoxically failed to address overcrowding and resource scarcity on marginal lands, and has instead brought in new ecological challenges (Harts-Broekhuis and Huisman, 2001; Chigumira, 2006; Goebel, 2006; Manjengwa, 2006 and 2009). Ironically, the pace of environmental degradation has nowhere been quicker than in resettlement areas (ZERO, 2005).

Literature on land reform places the natural environmental conditions at the centre of the success of land reform projects. Elliot and Campbell (2003), Mapedza *et al.* (2003), Elliot and Kinsey (2003), McCusker, (2004), UNDP (2004) and Elliot *et al.* (2006) explored and analysed socio-environmental and landscape changes linked to land reform processes. Chigumira (2006:160) appraised the impacts of FTLRP in Kadoma District, Zimbabwe and reported "households used natural resources intensively for consumption of water and food, construction, fuel, and mining."

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The research also found out that there is significant wildlife poaching. This is uncontrolled hunting that may lead to the extinction of some species.

In other studies focusing on land reform in Zimbabwe, illegal mining was also reported (Manjengwa, 2006). This puts arable land as well as grazing land at risk of takeover by panning if the ore happens to occur on such land. The gullies left by miners can also be a good beginning for gullying and siltation culmination in the death of watercourses.

The main source of energy in most developing countries is firewood. This puts a lot of pressure on forest resources and hence a challenge on the sustainability of forest resources. Given such challenges, one can argue that any land reform and resettlement process should be environmentally sustainable. Therefore, questions about sustainability need answers.

2.2 Sustainability: a general perspective

2.2.1 Background

Sustainability is not a new phenomenon. Writers, such as Mill and Malthus (18th century) included notions about economic sustainability in their works (Goodland, 1995; Goodland and Daly, 1996) and this culminated in the modern day neo-Malthusian understanding of the effect of exponential population growth on resources. However, the major breakthrough for sustainability was made in 1992 at the UN WCED in Rio de Janeiro. This culminated in the formation of the Bruntland Commission. Since then, the subject has taken centre stage in the world. However, there is no one universally accepted definition of sustainability.

2.2.2 Sustainability – a definition predicament

Sustainability is a cross cutting subject. It includes environmental, economic sustainability and social sustainability (Goodland, 1995, Goodland and Daly, 1996). Social sustainability is concerned with poverty reduction. Economic sustainability focuses on the provision of physical

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inputs, both renewable and non-renewable, into the production system (Goodland, 1995). Thus, there is no universally accepted definition.

Sustainability refers to the capacity of a phenomenon to be maintained or continue into the long-term future (Martin, 2003). It was defined as the level of human consumption which does not compromise the ability of the systems providing humanity with services from continuing to do so in the future (WCED, 1987; US National Research Council, 1999; Mayer, 2008). Sutton (2004) gave examples of what people seek to maintain and these include human life, the natural environment's capabilities to maintain life, renewable resources, society and quality of life. Therefore, sustainability issues arise when there is a real risk of a loss of the qualities that people treasure. The issue of sustainability rises whenever there is a threat to valuable resources (Sutton, 2004).

Sustainability as a concept has its roots in the realm of Sustainable development (SD). SD is defined in different ways by many authors, with more than 70 definitions (Lozano, 2008a). It should be noted here that sustainability and SD do not have the same meaning. The difference is that SD is the route to sustainability (Reid, 1995; Lozano-Ros, 2003; Martin, 2003). However, from the definitions, it is possible to distinguish five perspectives:

- the conventional economist's perspective
- the non-environmental degradation perspective
- the integrational perspective which encompasses the economic, environmental and social aspects
- the intergenerational perspective, and
- the holistic perspective (Lozano, 2008a).

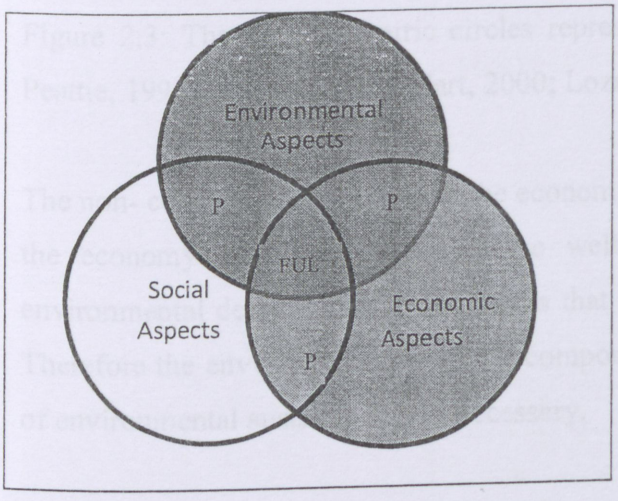
These categories of perspectives, however, converge when components of sustainability are categorised as economic, social and environmental (e.g. Goodland, 1995; Peattie, 1995; Goodland and Daly, 1996; Mebratu, 1998; Mitchell, 2000; Dalal-Clayton, 2002; Lozano-Ros, 2003; Lozano, 2008a). Therefore, a close and critical review of the components of sustainability is imperative.

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2.2.3 Components of sustainability

Though definitions differ depending on the field of the person concerned, there is some sort of consensus on the components of sustainability. The maintenance of natural resources (environment) is a subject that features prominently when sustainability is considered. The other components cover economic and social sustainability. A presentation of the components in the form of a Venn diagram (Figure 2.2) shows that full sustainability is attainable when all the three components integrate.



P = Partial Integration; Full = Full integration

Figure 2.2: The Venn diagram representation of Sustainability (Source: adapted from Peattie, 1995; Mitchell, 2000; Dalal-Clayton, 2002; Lozano-Ros, 2003; Lozano, 2008a).

The three sustainability components are interlinked. For full sustainability to be achieved all the three components should be integrate. However, the environment component features prominently more than the other two. Social and economic sustainability are difficult to achieve without environmental sustainability. That is why when represented using non-concentric circles, the environment component houses the other components (Figure 2:3).

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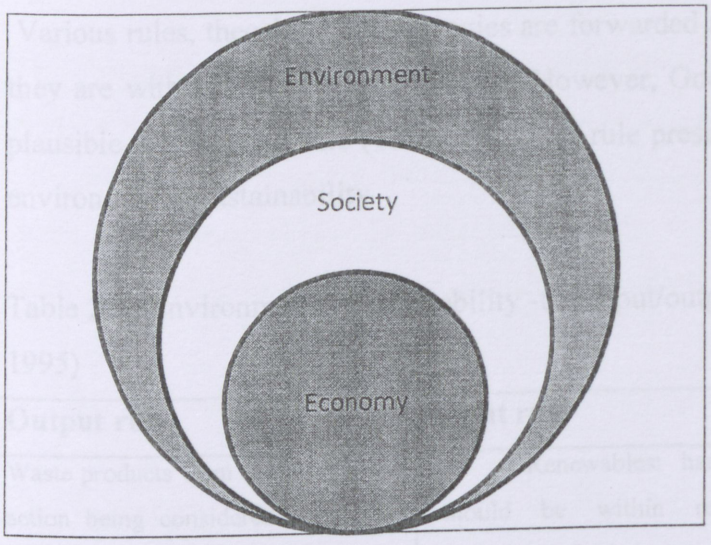


Figure 2.3: The non-concentric circles representation of Sustainability (Source: adapted from Peattie, 1995; Mebratu, 1998; Hart, 2000; Lozano, 2008a)

The non- concentric circles depict the economy as the centre of human activity and survival. For the economy to thrive, it has to be well embedded within the society. Moreover, the environmental determinism theory states that the environment influences society and economy. Therefore the environment is a bigger component of sustainability. Therefore, an understanding of environmental sustainability is necessary.

2.2.4 Environmental sustainability (ES)

Environmental sustainability is the ability to maintain the qualities that are valued in the natural and biological environment (Sutton, 2004). Defined as the maintenance of natural capital, environmental sustainability constitutes the input/ output rules (Table 2.3). ES is the unimpaired and indefinite maintenance of human support systems in the form of sinks and capacities (Goodland, 1995). A full environmental sustainability program should include actions that prevent threats and impacts from arising; actions that protect the environment from threats and damage; and restoration seeking to reverse damage already done. The need for sustainability arises from the realization that the nature of modern development patterns leads to biophysical challenges (Goodland, 1995).

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Various rules, theories, and ideologies are forwarded about environmental sustainability, just as they are with sustainable development. However, Goodland (1995) used a comprehensive and plausible input output rule (Table 2.3). This rule presents reasonable and practical principles of environmental sustainability.

Table 2.3: Environmental sustainability -the input/output rule (Source: adapted from Goodland, 1995)

Output rule	Input rule	Operational principles
Waste products from a project or an action being considered should be kept within the assimilative capacity of the local environment without degrading its future waste absorptive capacity or any other services.	a) Renewables: harvest rates should be within regenerative capacity of the system which generates them.	a) The scale (population x consumption per capita x technology) of the human economic subsystem should be limited to a level that is at least the carrying capacity.
	b) Non-renewables: depletion rates should be below the rate of development of renewable substitutes. Some portion from proceeds of using non-renewable resources should be channelled to research on sustainable substitutes.	b) Technological progress for sustainable development should be efficiency increasing rather than throughput increasing.
		c)Renewable resources should be exploited on a profit optimising, sustained yield and fully sustainable basis.

Nevertheless, despite some elaborate work to champion environmental sustainability, challenges exist.

2.2.5 Challenges to environmental sustainability

Some of the issues that pose major environmental sustainability challenges include:

- the destruction of the living environments (habitats) of native species,
- the discharge of polluting chemicals and other materials into the environment,
- the emission of greenhouses gases into the atmosphere that can cause climate change, and
- the depletion of low cost oil and other fossil fuels (Sutton, 2004).

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The challenge here is incapacitation of life support systems and capacities. Source capacities provide raw material inputs and sink capacities assimilate outputs or wastes. These source and sink capacities are huge but finite; sustainability requires that they be maintained rather than run down (Goodland, 1995). In order to be able to discuss environmental sustainability, an environmental understanding of sustainability evaluation is important.

2.3 An evaluation of environmental sustainability

The interaction between the human society and the environment is complex (Cabezas, Pawlowski, *et al.*, 2003; Mayer, *et al.*, 2004; Mayer 2008). There is need for individuals, society and organisations to find models, metrics, tools and methods to represent the extent to which current activities are sustainable (Singh, *et al.*, 2009). There is need to improve environmental management (WCED, 1987; Hezri and Dovers, 2006). This has given environmental practitioners a difficult task when it comes to evaluating development programmes.

The objective of sustainability assessment or evaluation is to furnish decision makers with nature-society systems perspectives for decision-making (Mayer, 2008; Singh *et al.*, 2009). Evaluation is an important component of the problem solving and continuous development and/or improvement cycle. Intergovernmental, international and national institutions, such as UNEP, UNDP, World Bank, World Resource Institute and European Environment, publish a number of environmental (sustainability) indicators. These all use different indicators to show environmental sustainability conditions. However, there is consensus that the environment is one of the three pillars of sustainable development (Goodland, 1995, Goodland and Daly, 1996; Moldan, *et al.*, 2004; Sutton, 2004). Thus, there are a host of methods derived to evaluate or assess the environmental impact of development programmes.

Different indicators measure environmental sustainability depending on the field of specialisation of the evaluator. Economists often emphasize an accounting approach that focuses on monetary aggregation, the maintenance of capital stocks and use of Gross Domestic Product (GDP) (Moldan, *et al.*, 2004; Singh, *et al.*, 2009). There are other indices too, such as Measure of

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Economic Welfare, Economic Aspects of Welfare (EAW), and Sustainable Progress Index (SPI). However, economists have neither the theoretical nor the empirical tools to predict the impact of economic activities on the environment (Lozano, 2008b). Economists confuse sustainability with economic viability in terms of sustained growth and self-sufficiency (Lozano, 2008a). The value of the environment cannot be expressed in monetary terms (Bartelmus, 1999). Therefore, social scientists have their own methods.

In the social sciences there is Human Development Index (HDI), especially used by UNDP; the Pressure State Response (PSR) model; Index of Social Progress (ISP), Sustainable Progress Index (SPI). These largely relate with the well-being of humanity rather than the environment. As a result, environmentalists developed their own methods, too. Here, the environmentalists focus is on natural resource depletion and whether the current rates of resource use are sustainable into the future or not (compare Goodland, 2005; Rees *et al.*, 2008). The Environmental Performance index (EPI), Environmental Sustainability Indicator (ESI), Environmental Pressure Indicators (EPI) and the Ecological Footprint (EF), inter alia, are used.

Spangenberg (2005) concludes that there cannot be one comprehensive measure or index of sustainability. Although the sustainability indicators are different, a valid indicator should, however, be able to:

- forewarn in order to prevent any damage,
- give enough information for strategy formulation,
- give complete communication, and
- support decision making (Berke and Manta, 1999; Lundin, 2003; Mayer, 2008; Singh, *et al.*, 2009)

Useful sustainability indicators should, therefore, be user-driven and policy-relevant, and simplify information in order to help communicate complex phenomena effectively. In addition, indicators also need to be factual and responsive to changes in time and/or space, and represent a good compromise between scientific rigor and conceptual simplicity (CBD, 1997). In light of the above, it is logical to briefly discuss some of the sustainability evaluation/assessment tools in order to reveal their relevance, strengths and weaknesses.

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2.3.1 Environmental sustainability evaluation/assessment tools

Determining the appropriate methodology for arriving at meaningful environmental indices is a debated research question (Ebert and Welsch, 2004; Zhou *et al.*, 2006). However, environmental sustainability evaluations or assessments examine environmental issues such as pollution, biodiversity, climate, energy, erosion, ecosystem services, environmental education, and many others (Ruez, 2011). Without environmental sustainability evaluation, the success or failure of even the most well intentioned actions can remain hidden.

Environmental sustainability evaluation should indicate whether the state of the environment has changed positively or negatively, and it should provide a measure of that change. An environmental sustainability evaluation is also more meaningful if it can quantify the results to facilitate comparison between different types of activities. The selected evaluation tool must use indicators that link with the targets, are reliable and repeatable, and can be generated in a cost and time efficient manner (Ruez, 2011).

Most evaluations focus on one or a few categories of environmental problems and do not attempt to be all-inclusive methods of evaluating sustainability. Below is a discussion on the more common tools.

2.3.1.1 Environmental performance index (EPI)

The EPI is designed to measure and compare environmental performance across countries. The EPI derives from a collection of data sets aggregated into four core indicators covering:

1. Air quality
2. Water quality
3. Greenhouse gas emissions and
4. Land protection (Bandura, 2008).

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Environmental Performance Index (EPI) brings a data driven, fact-based empirical approach to environmental protection and global sustainability. While policymakers are calling for increased intellectual rigor in environmental planning, large data gaps and a lack of time-series data still hamper efforts to track many environmental issues, spot emerging problems, assess policy options, and gauge effectiveness. The EPI seeks to fill these gaps and, more broadly, to draw attention to the value of accurate data and sound analysis as the basis for environmental policymaking. The EPI focuses on two overarching environmental objectives:

- reducing environmental stresses to human health;
- promotion of ecosystem vitality and sound natural resource management.

The two overarching objectives are evaluated using 25 performance indicators tracked in six well-established policy categories, which then combine to create a final score. The final score is a normalisation of all variables and takes the range between 0-100. The bigger the value the closer to the target is the performance and zero is the worst score (Singh, *et al.*, 2009).

2.3.1.2 Natural capital index (NCI)

A natural capital index (NCI) is an aggregated biodiversity indicator proposed for widespread international application (CBD, 1997; ten Brink, 2000; ten Brink *et al.*, 2002). The concept of NCI is based on the assumption that biodiversity loss can be modelled as a process driven by two main components: habitat loss due to conversion of natural areas into agricultural fields or urban areas, and degradation of the remaining habitat patches, caused by overexploitation, pollution, fragmentation, invasive species, inter alia (Czúcz, *et al.*, in press). Therefore, NCI was designed to answer the following three questions:

- How much biodiversity remains?
- What are the causes of loss? And
- What can we do about it?

To answer these questions the NCI considers biodiversity as natural capital with a common resource base. Thus, NCI summarizes the extent to which a landscape has preserved its original

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(baseline) natural capital (ten Brink, 2007).The framework of NCI relies on a simple and straightforward conceptual model:

$$NCI = q * a$$

Where

q = ecosystem quality and

a = ecosystem quantity.

Both quality and quantity are expressed relative to an 'optimal' or 'intact' baseline. Ecosystem quantity is calculated as a percentage of the total area (% area of the country or region). Ecosystem quality is calculated by counting the average abundance of a core set of characteristic animal and plant species. Quality is the ratio between the current situation and baseline state (percentage of the baseline). Accordingly, both are scaled between 0 and 1 (dimensionless). For quality 1 means the intact state and the quantity of 1 means that the natural ecosystems still occupy the entire study area.

Current NCI implementations focus is at the high-level policy contexts. It has thus far only been applied in global and national assessments only. It was applied by UNEP in 1997 and 2002 for global biodiversity assessments and in the Netherlands, the Philippines and Ukraine in 2002 and 2005 (Czúcz, *et al.*, in press). The biggest challenge facing high-level NCI implementations is the estimation of habitat quality for the identified habitat types, based on data available for the entire study area (Czúcz, *et al.*, in press). In practice, ecosystem quality data are not available, partially due to a lack of consensus on how to quantitatively measure ecosystem quality. The developers of NCI admit that, given the lack of data on ecosystem quality and the straight addition of the stressor presence, the index is not particularly rigorous (Mayer, 2008).

2.3.1.3 Environmental sustainability index (ESI)

An ESI benchmarks the ability of nations to protect the environment over the next several decades. The ESI tracks relative success for each country in five core components:

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1. Environmental Systems
2. Reducing Stresses
3. Reducing Human Vulnerability
4. Social and Institutional Capacity and
5. Global Stewardship (Bandura, 2008; Mayer, 2008).

In turn, these 5 components form 21 indicators, with each indicator combining two to eight variables, for 76 underlying data sets (Moldan, *et al.*, 2004; Mayer, 2008; Singh, *et al.*, 2009). The 76 indicators are first standardized using a variety of denominators depending on the units of the data (e.g., US$, hectares, etc.; Esty, *et al.*, 2005), outliers are replaced with observations closer to the mean (i.e., winsorized), and missing data are estimated. Countries with too few reported data are dropped from the analysis. The z-scores of the 76 standardized indicators are averaged into either 21 sub-indices, five ESI components or one index, the ESI. This measures all progress towards environmental sustainability. The score ranges from 0 (unsustainable) to 100 (sustainable).

The ESI combines data which have complex relationships to sustainability that the simple average methodology does not take into account (Vogelsang, 2002). However, no studies thus far support the index's implicit assumption that the relationships between sustainability indicators are linear and universal (Mayer, 2008). Furthermore, other sustainability indices are included in the 76 indicators, including the Ecological Footprint which uses some of the same data sources (Esty, *et al.*, 2005). This increases the risk of double counting and weighting problems. In addition the ESI gives all indicators the same weighting in the aggregation process, which can result in bias (Vogelsang, 2002; Morse and Fraser, 2005).

2.3.1.4 Living planet index (LPI)

This index is concerned with biodiversity. It measures trends in over 5000 populations of more than 1600 species of vertebrates in terrestrial, freshwater and marine ecosystems (WWF, 2008;

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Singh, *et al.*, 2009). It calculates the average annual rate of change for species populations. The LPI is an aggregate of the tropical and temperate indices with equal weighting.

The tropical index covers terrestrial and fresh water species of Afrotropical, Indo-Pacific and Neotropical realms. Species populations between tropics of Capricorn and Cancer are also included. The temperate index includes terrestrial and freshwater species populations from the Palearctic and Nearctic realms as well as marine species populations north of tropic of Cancer and south of tropic of Capricorn.

The year 1970 serves as the year with the base index against which the other indices are compared to show sustainability. However, the focus of LPI is fluctuation of population of non-human species (Mayer, 2008), which does not give a complete environmental sustainability index.

2.3.1.5 Environmental quality index (EQI)

Environmental Quality Index establishes a baseline for measuring change over time and/or monitoring differences in index scores across geographic units of interest. The multivariate utility theory is the basis for selection and definition of environmental factors and a numerical evaluation carried out applying the Analytic Hierarchy Process (AHP) method (Singh, *et al.*, 2009). A weighted aggregate of all environmental factors forms the EQI. It gives an approximate impact of each alternative. Each environmental factor is interpreted as a linear utility function, with values ranging between 0 – 10.

The following components make the EQI:

- Soil condition index,
- Water health index,
- Land habitat index, and
- Air quality index.

Soil erosion factors, residue cover or tillage practice, as well as crop rotation determine the soil index. Lake clarity and riparian buffers are the basis for the water health index. Habitat

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improvement and fragmentation determine the land habitat index. Emissions and particulates in the air give the air quality index.

2.3.1.6 The Ecological Footprint (EF) accounting system

First proposed in the 1990s by Wackernagel and Rees, the EF essentially accounts for exploitation of the environment's renewable resources and the assimilative capacity by a given population over specified time (Lewan and Simmons, 2001; Weidman and Lenzen, 2006). EF is a measure of sustainability, and use of "interest" rather than "capital". The system compares the demand on ecological services to the available supply (Ewing *et al.*, 2008; Ewing *et al.*, 2010). The Footprint is the area of ecologically productive land needed to maintain a population's consumption patterns and absorb its wastes with the prevailing technology (Wackernagel and Rees, 1996, 1997; Wackernagel *et al.*, 2002; Moldan, *et al.*, 2004; Mayer, 2008). The Footprint only deals with demands put on the environment and leaves out the social and economic dimensions of sustainability.

The Ecological Footprint system captures natural resource flow and not stock. Thus, the system clearly reveals where there are ecological deficits and reserves (Wackernagel, *et al.*, 2002). This is done through the calculation of the ecological demand and supply of each land use category. These disaggregated calculations are then condensed into a final consumption (EF) and supply (BC).

The environment has its capacity, ability and limit to provide for its inhabitants (Mayer, 2008). This ability to provide is the biological capacity. Resources used and wastes disposed into the environment are considered when calculating the EF. Land uses are put into six classes: arable, forest, grazing (pasture), built up (degraded), water and carbon uptake land (Lewan and Simmons, 2001; Ewing, *et. al.*, 2008).

EF and BC calculations are accounting methodologies used to quantify annual demand for and supply of ecosystem products and services (Ewing, *et al.*, 2008). The Global Footprint Network initiated the National Footprint Accounts in 2003 basing on the works of Wackernagel and Rees.

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The National Footprint Accounts calculate the EF and BC of countries. National Footprint Accounts aim to provide scientifically robust and transparent calculations that show countries' demands on global environmental regenerative and absorptive capacity (Ewing, *et al.*, 2008).

EF calculations use the yield per unit area of primary product flows to calculate the necessary area to support a given activity. Key to EF and BC calculations is the method used to aggregate areas of different types to enable international comparisons. A basic EF adds up several mutually exclusive uses of bio productive areas (Lewan and Simmons, 2001). Comparison between different land uses and different areas is afforded by "normalising" with an equivalence and yield factor for each land use's bio productivity (Lewan and Simmons, 2001; Wiedmann and Lenzen, 2007; Ewing, *et al.*, 2008). This will produce a standardised unit called a global hectare (gha).

An ecological deficit occurs when humanity's resource consumption demands exceed what the ecological environment can provide (Ewing *et al.*, 2010). Such a situation is a threat to the well-being of a society and, therefore an environmentally unsustainable situation. However, the EF system recognises that BC land does not necessarily lie within the physical location of the population (Wackernagel, 2004; Bagliani, *et al.*, 2008). In order to enable systematic natural resource flow calculations, assumptions anchor the Ecological Footprint system.

a) Ecological Footprint assumptions

Wackernagel, *et al.*, (2002) outline the assumptions on which EF accounting is based which are that:

- it is possible to track the majority of the resources people consume and the wastes they produce. These resources consumed and the wastes generated can be measured in physical terms (Monfreda, *et al.*, 2004). The EF analysis tracks the regenerative capacity of an ecosystem in terms of natural resource flows.
- most of these resources and waste flows are measurable in terms of biologically productive areas necessary to maintain the flows. Resources and waste flows that are not measurable are excluded from the accounts. This results in a systematic underestimation of humanity's true EF.

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- Each usable area is weighted according to its BC enabling conversion of different types of areas into global hectares (gha), hectares with world average bio productivity. "Usable" means the part of the ecosystem that can be renewably harvested and is valuable to people.
- Each global hectare (gha) represents a single use. Therefore, all global hectares in any single year represent the same amount of BC and an aggregate indicator of EF or BC is obtainable through addition. A piece of land provides only a single ecological service, avoiding double counting of land surfaces. This does not mean, however, that land surfaces are not capable of supporting more than one ecosystem service. Ecological Footprint accounts only for the extent to which one human use of the ecosystem excludes other uses.
- Human demand, expressed as EF, is directly comparable to the supply from nature, BC, as both are expressed in global hectares. It is the demand on natural capital versus the ability of the ecosystem to service the demand.
- Area demanded can exceed area supplied, if demand on an ecosystem exceeds that ecosystem's regenerative capacity. This is termed ecological deficit or ecological overshoot. This means humanity would be eating into capital stock of resources and accumulating waste in the environment. Either imports or overexploitation of the domestic resource capital addresses such situations. If the second scenario happens, then natural capital depletion happens.

For calculation of EF and BC, yield factors are introduced (Lewan and Simmons, 2001). These factors show how much higher or lower the yield per local hectare compare with the yield per unit area. Some biocapacity should be set aside for non-human use (Lewan and Simmons, 2001).

b) Strengths and limitations

The objective of the Ecological Footprint Accounting system, therefore, is to provide a scientifically robust and transparent calculation of the demands humanity places on the natural environment. This results in the building of a reliable and consistent method of calculation that allows for international comparison of different areas. Eventually, data are produced in a format

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useful for the development of policies and strategies for living within the environment's bio productivity.

Though there is criticism directed at the EF, it has fewer conceptual or practical problems than other single digit environmental indicators (Simmons, 2002). The condensing of data to form an indicator, like the EF, simplifies complex and detailed information, making communication easier (Adriaanse, 1995). An EF's strength is also in its conceptual simplicity as an indicator of sustainability. It is clear that if a population's footprint is larger than its biocapacity, it cannot sustain itself in the long run. In addition, footprints are possible to calculate for any population size.

While EF accounts provide a clear, intuitive measure of one important aspect of sustainability, it has philosophical and methodological shortcomings (Mayer, 2008). However, further modifications addressed the methodological shortcomings.

2.4 Chapter summary

Land reforms have occurred and are still occurring the world over for different reasons. In Zimbabwe, it aimed it aimed at correcting colonial injustices and reducing population pressure in the communal areas. It was thought that this would result in improved land usage and food security. However, studies have shown that environmental sustainability is important to the success of any land reform exercise. Environmental sustainability can be evaluated using different methodologies. These are summarised by the table below. This research will use the Ecological Footprint as explained in the next chapter on research methodology.

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Table 2:4: Summary of some environmental sustainability indicators (source: adapted from Singh, et al., 2009)

Name of index	Number of specific indicators	Scaling/ Normalisation	Weighting	Aggregation
Environmental Sustainability Indicator (ESI)	68	Mean subtraction and division by the standard deviation	Equal weights	Arithmetic average of the normalised indicators
Living Planet Index (LPI)	5000 populations of 1686 species	Ratio of current to 1970	Equal weights	Geometric mean
Ecological Footprint (EF)	6	Area	Equal weights	Summation
Environmental Performance Index (EPI)	Six policy categories	0-100	PCA/ experts	Weighted average
Environment Vulnerability Index (EVI)	50	1-7 (1=best; 7=worst)	Equal weighting	Average
Environmental Quality Index (EQI)	Based on multi-attribute utility theory	0-10 (linear utility function)	AHP	Geometric mean

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CHAPTER 3: RESEARCH METHODOLOGY

3.0 Introduction

This research takes a case study approach by studying Chirumanzu District in the Midlands Province of Zimbabwe. Table 3.1 shows a summary of the objectives, research questions, key variables, research instruments and the targeted sources of information for the research. This chapter examines the research design, research methods and analysis used to meet the objectives of this research. The chapter concludes by exploring the challenges faced in the research.

3.1 Research design

This research follows a hybrid approach which uses data from different sources to generate both quantitative and qualitative data analysis. Data at district and village/farm levels were collected through structured interviews with key informants and semi-structured interviews with households. This elicited both primary and secondary data.

This research needed vital environmental and land use statistics from relevant government departments in order to evaluate the environmental sustainability of land reform in Zimbabwe. Therefore, authority was sought from the head offices of the Ministry of Lands and Rural Resettlement, Ministry of Agriculture and Mechanisation, in Harare, to access this information through various government employees at district level. The clearance to use Chirumanzu district as a case study was sought and obtained from the Midlands Provincial Administrator and the Chirumanzu District Administrator. This permission enabled the researcher to gather relevant data from the District Agricultural Extension Officer (DAEO), the District Lands Officer (DLO), the District Veterinary Inspector (DVI) and from households where 150 semi-structured household interviews were carried out. Table 3.1 shows a matrix of objectives, research questions and the sources of the data.

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Table 3.1: The Research Matrix (Source: Researcher, 2011)

Objective	Research Questions	Key Variables/ Indicators	Research Instruments	Target Group	Research Assumptions
1. To calculate the Biological Capacity of the land reform programme.	a) What type of land uses are practiced in the area?	~land uses	1. Key informant interviews	District Lands Officer	The officers and households have time and willingly give data.
	b) What area (in hectares) is allocated for each land use type?	~area put under each land use	2. Literature study	Households	
	c) What are the yield and equivalence factors for the land uses?	~Constants	3. Household surveys	District Agricultural Extension Officer	
	d) What are the individual biocapacities for each land use?			District Administrator	
	e) What is the biocapacity of the study area?			Global Footprint Network documents	
2. To calculate the Ecological Footprint of land reform.	a) What are the land use types practiced in the area?	~ Ecological Footprint of Production for each land use	1. Key informant interviews	District Livestock Inspector	The officers and households have time and willingly give data.
	b) What are the yield and equivalence factors for each land use?	~ Ecological Footprint of Imports for each land use	2. Household surveys	Households; Grain marketing Board	
	c) What is the Ecological Footprint of each land use type?	~ Ecological Footprint of Exports for each land use	3. Literature study	District Agricultural Extension Officer	
	d) What is the Ecological Footprint of the study area?	~Constants		Global Footprint Network documents	
3. Calculate household biocapacity and Ecological Footprint.	a) How many households were resettled according to different resettlement models?	~ number of households settled	1. Key informant interviews	District Lands Officer	The officers have time and willingly give data.
	b) What is the Ecological Footprint and biocapacity for each	~Biocapacity	2. Household surveys	District Administrator	
	c) What is the Ecological footprint and biocapacity for each household in Zimbabwe?	~Ecological Footprint	3. Literature study	Global Footprint Network documents	
4. Evaluate environmental sustainability of land reform.	a) What is Ecological Footprint of the area?	~Ecological Footprint	1. EF formula	Global Footprint Network documents	
	b) What is the Biocapacity for the	~Biocapacity	2. BC formula	Literature study	
	c) Does the area have an ecological reserve or deficit?	~ Ecological reserve/deficit			

The research followed Wynberg and Sowman's (2007) steps proposed in An Environmental Assessment Tool for Land Reform Projects by to collect data for this research. This tool is straightforward, coherent, clear and discreetly structured for data collection. It enables collection of empirical, descriptive and spatial data for evaluation.

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The following steps, adopted from Wynberg and Sowman (2007), were followed in the execution of the study:

3.1.1 Desk based information gathering

This was a continuous process from the beginning to the conclusion of the research process. This served to evaluate the researcheability of the topic, literature survey, and understanding of the Ecological Footprint and environmental as well as land use practices in resettled areas.

3.1.2 Visiting stakeholders and experts in different fields

The experts in the fields of agriculture (AGRITEX), land reform and resettlement (Ministry of Lands and Rural Resettlement), and livestock (Veterinary Department) were consulted regarding their respective areas of expertise in resettlement areas. This gave vital statistics (Table 3.2) and a picture of the actual situation on the ground from an expert point of view. All land use types data are for 2010.

Table 3.2: Land use statistics and sources

Land use type	Data required	Source
Cropland	Area cultivated, crops cultivated, production	AGRITEX
Grazing land	Area for livestock grazing, livestock population, livestock feed and sources, livestock trade	AGRITEX, Vet Department, Ministry of Lands and Rural Resettlement, households
Built-up land	Households in resettlements, area allocated for homesteads, infrastructure developments (roads), and institutional developments.	Ministry of lands and Rural Resettlement, Chirumanzu Rural district Council, households
Forest land	Area for forests, Forest resource use	AGRITEX, Ministry of lands and Rural Resettlement, households

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3.1.3 Field assessment of environmental sustainability

150 household questionnaires were administered after getting expert information. Households were selected from five resettlement strata. The district had 5 167 households resettled by 2011 (Ministry of Lands and Rural Resettlement, 2011). Therefore, a sample of 150 households at 95% level gives a confidence interval of 7.89.

The household questionnaire had two sections. Section A, dealt with demographic characteristics of the household head. Section B, solicited for Ecological Footprint related information. This enabled the collection of statistics about land uses, livestock ownership, and forest resource use. The data was then manipulated to evaluate the environmental sustainability of Chirumanzu resettlement areas.

3.1.4 Evaluation of environmental sustainability

A compilation of data obtained from both the experts and field assessment was entered into Microsoft Excel worksheets for the calculation of the biological capacity and Ecological Footprint of the four land use types. This resulted in the disaggregated and aggregated biological capacity and Ecological Footprint. The household Ecological Footprint and biocapacity for the study area and for Zimbabwe was also calculated. Such calculations showed the environmental sustainability situation of the study areas at both household and resettlement area scale.

3.1.5 Preparation of an integrated environmental sustainability evaluation report

Following the calculation of the Ecological Footprint and biological capacity, tables and graphs are used to present the environmental sustainability status of the study area. Graphs and tables have the capability to vividly reveal the differences between Ecological Footprint and biological capacity and hence, the ecological deficit or reserve, whatever the case may be.

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Stakeholders and experts gave information by virtue of the offices they hold. However, the offices could not furnish statistics of livestock such as chicken, donkeys and pigs. Data on activities such as use of forest resources was obtainable only from the households. Therefore household interviews were carried out in order to get such data. The following section describes and explains how data for this study was collected.

3.2 Data collection and sources

Both primary and secondary sources provided data for this research. Primary data was collected through the administration of questionnaires to 150 sampled households. Government offices provided secondary data across all the four land use classes. The Ecological Footprint system uses a year as a temporal unit of measurement. Therefore, all the data collected for this study was for the year 2010.

The AGRITEX department and the Grain Marketing Board (GMB) supplied 2010 crop production and cropland use data. Livestock data for the same period were obtained from the Veterinary Department, AGRITEX and Ministry of Lands, Land Reform and Rural resettlement. All other data, except crop trade statistics obtained from GMB provincial offices in Kwekwe, was collected from the district offices in Mvuma.

Primary data were collected through a household survey. The households were selected by multi-stage cluster sampling. The following section covers how sampling was done to gather data from households.

3.2.1 Sampling

This research followed the multi stage cluster sampling method as shown by Figure 3.1. The division of resettlement schemes into old and new resettlement necessitated the multi-stage cluster sampling method. The new resettlement was divided into four sectors, according to the land use capability, and land settlement density. The sectors are intensive, semi- intensive, semi-

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extensive and extensive A1 villages. However, the old resettlement has one sector only. Therefore, there are five sampling sectors.

Before the implementation of the Fast Track Land Reform Programme (FTLRP), Zimbabwe followed four models of resettlement. Model A is the most intensive, while Model D is the most extensive in terms of area allocation per household. The study area has Model A only in the old resettlement. For the purposes of this research, new resettlement areas are classified into four sectors according to the amount of land allocated to each household as grazing land. The new resettlement areas were officially allocated either three or six hectares of arable land per household.

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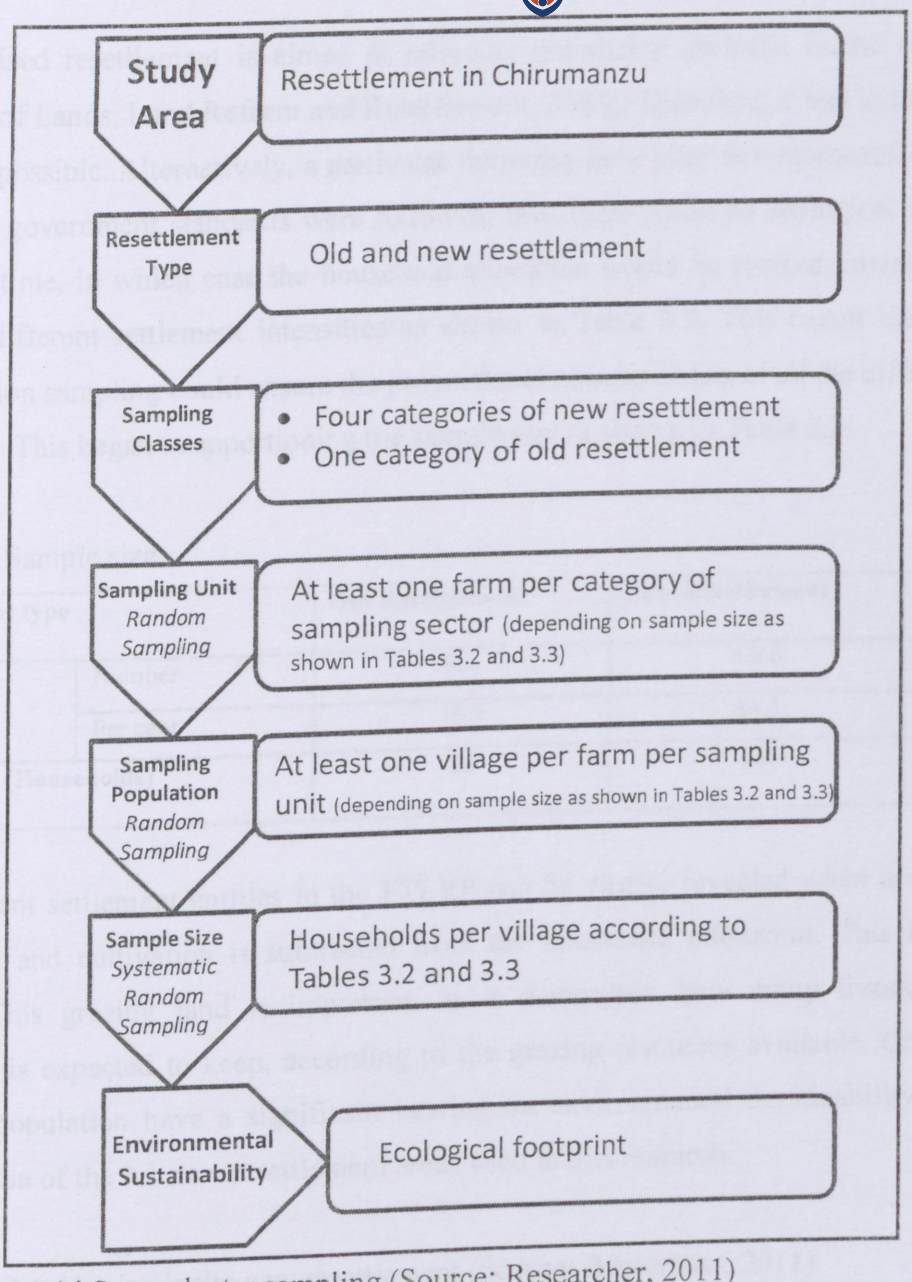


Figure 3.1: Multi Stage cluster sampling (Source: Researcher, 2011)

The government-recommended land area allocation per household for the study area is thirty hectares, inclusive of grazing, arable and homestead (Ministry of Lands, Land Reform and Resettlement, 2004). However, this was a government standard which is not cast in stone. The household allocations differed depending on different circumstances. Therefore, the reduction of the allocation per household could have aimed at resettling more households.

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A1 villagised resettlement is aimed at relieving population pressure in the communal areas (Ministry of Lands, Land Reform and Resettlement, 2004). Therefore, it had to cater for as many people as possible. Alternatively, a particular farm may have poor environmental conditions such that if the government standards were followed, then there could be ecological stress in a short period of time, in which case the household allocation would be revised upwards. This would result in different settlement intensities as shown in Table 3.3. This meant that proportionate classification sampling could ensure the proportional representation of all the different settlement intensities. This began at apportioning the sample size as shown in Table 3.2.

Table 3.3: Sample size

Resettlement type		**Old Resettlement**	**New Resettlement**	**Totals**
Households	Number	861	4306	5167
	Per cent	15.7	84.3	100
Sample size (Households)		**24**	**126**	**150**

The different settlement entities in the FTLRP can be clearly revealed when area allocated for homestead and cultivation is subtracted from the household allocation. This leaves land for grazing. This grazing land is important, as it determines how many livestock units each household is expected to keep, according to the grazing resources available. Grazing land and livestock population have a significant bearing on environmental sustainability. Below is the classification of the A1 new resettlement areas used in this research.

Table 3.4: Sample size in the new resettlement (Source: Researcher, 2011)

Settlement Type		**Intensive**	**Semi- intensive**	**Semi-extensive**	**Extensive**	**Total**
Grazing Area (Ha)		<25	25 - 34.9	35 - 44.9	>45	
Farms	Number	15	11	3	4	33
	Households	2887	1006	154	259	4306
	%	45.45	33.33	9.09	12.12	100
Sample Size (Households)		57	42	12	15	126

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Though the settlement types have a different number of farms falling in the groups, the criterion used to demarcate the farms is similar. The criterion involved a division of farm size by the land area to be allocated to each household to get the number of households to resettle. The land to be allocated per household depended partly on the land capability of the concerned farm and partly on the number of households on the waiting list. Thus, the environmental sustainability conditions in farms falling in the same category should be similar.

Pursuant to the sampling considerations described above, farms were randomly picked for the administration of the household questionnaire. Hlabati was picked from the old resettlement category. Central Estates Village 24 and 25 (intensive), England farm and Granitevale (semi-intensive), Crossmaloof (semi-extensive) and Hillview (Extensive) farms represented the FTLRP quota for the sample. Households indicated in the sample size column, in Table 3.3 above, were interviewed.

The interview solicited for biophysical information from the respondents. Statistics, such as area (ha) put under different land uses, production from different land uses, grazing resources, livestock resources and crop production, were gathered. This data was then captured into the Statistical Package for Scientific Solutions (SPSS) for manipulation and use.

The SPSS was used to calculate statistics which could not be obtained from government offices. Data from the government offices and that collected from the household survey was then entered into Excel worksheets to calculate the Ecological footprint and biological capacity.

3.3 Data Analysis

The difference between the Ecological Footprint (EF) and Biological Capacity or Bio-capacity (BC) (as proposed by the Global Footprint Network) determines environmental sustainability or lack of it in the study. The difference is termed ecological deficit (if negative) or ecological reserve (if positive). Both EF and BC are disaggregated into cropland, grazing, forest, and built up area. These land classes are discussed in detail below.

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Descriptive and graphical analysis of these aspects from the disaggregated and the condensed stages is done. The analyses are done through a comparison of the calculated BC and EF of each land use class. The comparison of the aggregate BC and EF gives the final environmental sustainability status of the study area.

3.3.1 Land use types of Ecological Footprint accounting system

The Ecological Footprint accounting system for this research considered four land use types: cropland, grazing land, forests for timber and firewood, and built up land (Wackernagel, *et al.*, 2002; Ewing *et al.*, 2008 and 2010). Each land use type has an ecological resource supply (biocapacity) and demand (Ecological Footprint) in the area. Therefore, the ecological Footprint accounting system has two wings: the Ecological Footprint and the Biocapacity.

The EF accounting system leaves out land use activities that it cannot measure. The study area is not characterised by large rivers. Therefore, fishing is a negligible practice. As such, fishing land use would not be possible to measure. The study area is a rural setting and use of fossil fuels is low. There are no carbon dioxide point sources. Thus, forests for carbon dioxide uptake land use are not considered. The different land use types this research covers are explained below.

3.3.1.1 Cropland use

This is the most bio-productive of all the land use types. It consists of areas used to produce food and fibre for human consumption and feed for livestock (Ewing *et al.*, 2010). At national level, footprint accounts calculate the cropland footprint according to the production quantities of 164 different crop categories. However, this is not the case at regional level, where few crops are grown.

Chirumanzu district is dominated by subsistence farming. Therefore, only 15 crops are grown in the district. With the exception of tobacco and cotton, all the other crops are food crops. No fodder crops are cultivated.

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Data for crop production was obtained from Agriculture, the AGRITEX services department in Mvuma, Food and Agricultural Organisation (FAO), and Famine Early Warning System Network (FEWSNET) in Harare. Trade statistics were obtained from the Grain Marketing Board provincial office in Kwekwe and from field data.

The calculations for the cropland footprint do not take into account the extent to which farming techniques or unsustainable agricultural practices cause long-term degradation of the soil. It only considers the amount of land available for crop production, its productivity and the population crop demand. This determines whether the district is growing crops within the capabilities (bio-capacity) of its environment.

3.3.1.2 Grazing land use

This is land used to raise livestock for meat, dairy, hide and wool products. Grazing footprint is calculated by comparing the amount of livestock feed available in an area with the amount of feed required for the livestock produced in that year. The remainder of feed demand is then assumed to come from grazing land. Since the yield of grazing land represents the amount of above the ground primary production available in a year, overshoot is not physically possible over periods of extended time for this land use type.

Livestock data was obtained from the Veterinary Department in Mvuma. This data was also tested with sample data to verify validity. The department could provide predominantly cattle data. However, production data had to be computed from the data available since it could not be obtained from official sources.

3.3.1.3 Forest for timber and fuel wood

The forest footprint, at national level, is calculated according to the amount of lumber, pulp, timber products and fuel wood consumed by an area on a yearly basis. Estimates of timber productivity are derived from the UNEC and FAO Temperate and Boreal Forest Resource Assessment, the FAO Global Fibre Supply Model and the IPCC (FAO, 1998; UNEC, 2000;

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FAO, 2000; IPCC, 2006). An average of 1.81 m^3 of harvestable under bark per hectare per year is given.

In the context of Chirumanzu District, household firewood use and timber for domestic construction represent the forest Footprint. Statistics for these uses were obtained through the household surveys.

3.3.1.4 Built-up land use

The built-up land footprint, at national level, would be calculated basing on the area of land covered by human infrastructure such as roads, housing, industrial structures and reservoirs for hydropower. It is assumed that built-up land occupies what was previously productive cropland (Wackernagel, *et al.*, 2002; Ewing *et al.*, 2008 and 2010). This assumption based on the understanding that human settlements are generally situated in highly fertile areas (Wackernagel *et al.*, 2002).

The built-up land Footprint calculations for Chirumanzu District were based on land covered by infrastructure such as roads, homesteads, business centres and schools. Industries are not considerable here as the study area is rural and there are no hydropower reservoirs. The infrastructure data was obtained from the District Development Fund (DDF), Chirumanzu Rural District Council (CRDC) and Ministry of Lands.

3.3.2 The Ecological Footprint calculation

An Ecological Footprint is a measure of the demand humanity places on renewable natural resources. It computes the aggregated demand for ecological resources in a particular year wherever they are located (Wackernagel, *et al.*, 2002). In terms of the EF systems, EF measures the amount of biologically productive land required to produce all the resources a population requires and absorption of the wastes generated given the prevailing technology and resource management practices (Kitzes and Wackernagel, 2009). It focuses on evaluation of the biologically productive territory actually used by a population.

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The ecological demand is presented as the average global area needed to support a specific human activity. An Ecological Footprint is expressed in units of global hectares (gha), defined as hectares of bio-productive land with world average bio-productivity. It is translated into gha by dividing the total amount of a resource consumed by the annual yield (in global hectares) of the resource per hectare. Global hectares are estimated using yield factors and equivalence factors. Yield factors compare the national average yield per hectare to world average yield in the same land category. Equivalence factors capture the relative productivity among the various land types.

An Ecological Footprint is, nevertheless, calculated using the following formula proposed by Ewing, *et al.*, (2008) and Kitzes, *et al.*, (2008):

Formula 3.1

$$EF = \frac{P}{Y_R} * YF * EQF$$

Where

P = the amount of a product harvested or waste emitted,

Y_R= the resettlement average yield for P, and

YF = the yield factor for the land use type in question

EQF = equivalence factor for the land use type in question.

It is important to note that this research focuses on harvested product only. Also important to notice is that the Yield factor of any product is defined as resettlement yield divided by district yield. This cancels out the yield factor, leaving the Ecological Footprint formula as:

Formula 3.2(Ewing *et al.* 2008; Kitzes, *et. al.*, 2008)

$$EF = \frac{P}{Y_D} * EQF$$

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Where Y_D = district average yield (t $wha^{-1}yr^{-1}$)

This research applied Formula 3.3. The sources described above provided production and area statistics. The production statistics are for resettled areas only. The division of area that produced a particular product and the quantity harvested gives the district average yield.

Be that as it may, it is important to understand the application of the EF formula in the calculation process. EF calculation follows five stages. Calculations began at stage five of each land use. Since different land uses record different aspects at different levels, it is logical to follow the application of the EF formula on each land use type.

3.3.2.1 Crop land Footprint

For cropland use, level five data record area and production at resettlement level (*prodstat_crop_r*) and district level (*prodstat_crop_d*) were recorded. Level five worksheets also record trade statistics (*tradestat_r*).This records imports into and exports out, of both crop and livestock products, by the resettled. There are no calculations done at this level.

The data recorded at level five is then escalated to stage four where calculations begin. This is where yields for both the resettlement are (*crop_yield_r*) and district (*crop_yield_d*) are calculated. Even the yield for trade (crop_trade_yield_d) is calculated. The yield is calculated by dividing production by area. This data is then fed into level three of the calculations.

Level three calculations determine the Ecological Footprint of production (EF_P), Ecological Footprint of imports (EF_I) and the Ecological Footprint of Exports (EF_E). This is the stage where the formula is applied. Production, import and export figures are obtained from *prodstat_r* and *tradestat_r*, respectively. Y_D figures come from *crop_yield_d* while the Global Footprint Network (2011) supplied the equivalence factor. The application of formula 3.3 results in EF_P, EF_I or EF_E. These three Footprints now show the amount of biologically productive land that the population of Chirumanzu resettlement areas used to produce, import and export different crops

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and crop products. An Ecological Footprint of Consumption is then calculated, to determine the actual Ecological Footprint.

The following formula calculates the Ecological Footprint of Consumption (EF_C). This calculation applies to all land uses.

Formula 3.3 (Ewing *et al.*, 2008; Kitzes, *et al.*, 2008)

$$EF_c = EF_P + EF_I - EF_E$$

Where

EF_C = Footprint of consumption associated with a product,

EF_P = Footprint of production associated with a product,

EF_I = Footprint of imports associated with a product,

EF_E = Footprint of exports associated with a product.

The Ecological Footprint of Consumption typifies the Ecological Footprint of the study area. These similar stages of calculation were followed for grazing land Footprint.

3.3.2.2 Grazing land Footprint

This is the longest calculation, as it has two units. One set of calculation computes livestock trade Footprint while the other computes livestock production Footprint. Livestock trade calculations act as a bridge between grazing land Footprint and cropland Footprint since livestock feeds on both grazing and cropland. Therefore, the livestock trade calculations produce livestock Ecological Footprint of imports (*livestock_efi*) and livestock Ecological Footprint of exports (*livestock_efe*). A separate section calculates the livestock Ecological Footprint of production (*livestock_efp*). However, calculations from both sections feed into a single level two calculation of the Ecological footprint of grazing (*ef_grazing*) personified by the grazing land Ecological footprint of consumption (EF_C).

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Level five data for the livestock trade calculation report the embodied Footprint of a tonne of feed for each feed category (*feed_intensity_d*) and the amount of feed needed to produce a tonne of each livestock or its products (*feed_mix_r*). Feed intensity calculates the Footprint of producing a tonne of livestock feed in the district for each category of feed. Feed mix computes the amount of feed needed to produce a tonne of each livestock product.

Feed intensity is obtained by dividing the equivalence factor by yield. The equivalence factor is obtained from the Global Footprint network (GFN) (2010), while crop residue for the resettlement (*crop_residue_r*) calculations provide the yield for feed derived from crop products. Feed mix is calculated differently.

Feed mix gives a proportion of feed type needed to produce a tonne of each livestock product. Therefore, each crop contributes a feed proportion required for the production of livestock products in tonnes of feed per tonne of live weight (tF t LW^{-1}). The contribution of the crop product or grass supply is expressed as a fraction of the total feed requirement. This eventually gives a percentage contribution of grass and crops to the feed mix. Figures used in feed mix calculation were obtained from Smil (2000). Feed mix data are used by another level five computation of feed intensity for the district.

Feed intensity is a calculation of the Footprint of a tonne of feed for each feed category. It is calculated by the division of Equivalence factor by yield. Yields are obtained from the resettlement crop yield calculations in the cropland Footprint calculation. Equivalence factors are obtained for the GFN (2011). The level five calculations for livestock trade also use *tradestat_r* and *crop_yield_r* calculations from the cropland Footprint section. The data is then used to calculate the livestock intensity of the district.

The Livestock intensity is a computation of the total Footprint in a tonne of each livestock product through summing the contribution of all feed types. The contribution of each feed type to each livestock product is calculated by multiplication of feed intensity values with feed mix values. This enables the calculation of the Ecological Footprint of Imports (EF_I) and Exports (EF_E) for grazing land use.

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The Footprints of imports and exports of livestock and livestock products are calculated at level three. Export and import statistics report the amount of each livestock or livestock products and come from the trade calculations. Where figures are reported as heads, weights are obtained from constants as explained in the grazing constants section below.

The Footprint is calculated for each feed source. This is executed through the multiplication of the total imported or exported quantity by the corresponding Footprint intensity value calculated in district livestock intensity computations. The Footprints of each feed source are then summed up to give a livestock Ecological Footprint of Export (*livestock_efe*) or import (*livestock_efi*).

It is important to note that only the Footprint of grass is the only figure applicable in the grazing land Footprint. The other Footprints are considered under cropland, where the feed originates. This then feeds into the final EF_C calculation. However, the livestock Ecological Footprint of the production calculation is separate.

The livestock Ecological Footprint of production (*livestock_efp*) begins with the calculation of livestock production at both district (*prodstat_livestock_d*) and resettlement (*prodstat_livestock_r*) level. Livestock population (*resourcestat_livestock*) and the grazing constants (*cnst_grazing*) are also recorded. Two calculation sheets, trade and production, from the cropland, also make the set of calculations at level five for livestock Ecological Footprint of production.

Production statistics for livestock report quantities of livestock products and the producing heads. Therefore, besides the constantans reported in the grazing constants sheet, other deductions regarding livestock and livestock products were made. The Vet Department provided statistics for heads slaughtered, imported or exported. A standard Tropical Livestock Unit (TLU) of 250 kg live weight (Köster, 2010) was used to convert heads to meat or hides produced. Cattle were treated as equal to one TLU, and 0.1 TLU for goats and sheep (FAO, 2005; Gwaze, *et al.*, 2009; Köster, 2010). For pigs the conversion factor was 0.2, while that of poultry was 0.01 (FAO, 2005).

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Using the above standards, a 7 per cent of live weight (South African Department of Agriculture and Environmental Affairs, 2005) for cattle and 11 per cent live weight (FAO, 1985) for goats and sheep at slaughter was used to calculate the green hide production from livestock. For meat production the following formula was used:

Formula 3.4 (Wulf, 1999; McKiernan, *et. al.*, 2007)

Total Meat = (Dressing per cent * Carcass Cutting Yield) * Live Weight

Where

Total meat = the end product of slaughter of a live animal,

Dressing per cent = the proportion of the live weight of the animal that will form the carcass, and

Carcass cutting yield (dressing per cent) = the percentage of the carcass that will become meat.

Different ranges for carcass cutting yield and dressing per cent are given for different livestock species. The figures given in Table 3.4 were used in this study.

Table 3.5: Livestock dressing and carcass cutting per cent

Name	Dressing Per cent	Carcass Cutting Yield	Source
Cattle	62	69	Wulf, 1999; McKiernan, 2007
Sheep	54	73	Wulf, 1999; McKiernan, 2007
Goats	54	73	Wulf, 1999; McKiernan, 2007
Pigs	74	78	Wulf, 1999; McKiernan, 2007

It is important to note that data are very difficult to access from government departments at local level. Therefore, reasonable deductions had to be adopted using constants. These deductions provided the required production figures. They divide production by the number of producing heads giving yield per each livestock head. The data from production sheets is used to calculate feed demand and residue supply.

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Feed demand is a computation of the amount of feed needed to produce the stock of livestock as reported in *resourcestat_livestock*. The multiplication of heads by feed intake gives feed demand. *Resourcestat_livestock* supplied heads statistics while feed intake was obtained from Köster (2010). A further multiplication by 364.8 gave the feed demand an annual dimension and a division by 1000 converted it to tonnes per year. Feed demand is calculated for each livestock or livestock product and all are summed up to give the feed demand for the whole district.

In addition, a residue supply is calculated to obtain the amount of crop residues used as crop feed in the resettled areas. The residue feed available for livestock feed is the division of area cultivated for the concerned crop by dry fodder yield. Area was derived from crop production statistics while Reddy, *et al.*, (2003), supplied dry fodder yield. These data sets then feed into the calculation of the grazing land Ecological Footprint of production.

Grazing Ecological Footprint of production (*grazing_efp*) computes the total pasture demand needed to feed the livestock population in the resettlement areas. The calculation assumes that livestock feed on available crop residues, and grazing land meets the rest of the feed demand. The estimated Footprint of production is calculated by converting the demand for pasture grass into the global hectares needed to produce it by applying formula 3.2. If this estimation is less than the available grazing biocapacity, then it is the grazing land Footprint of production. The estimated grazing Footprint of production, for Chirumanzu, was less than the calculated biocapacity. Therefore, the estimated grazing Footprint of production was the actual grazing Footprint of production. An application of formula 3.3 to this computation, together with the grazing Footprints of imports and exports calculated the grazing Ecological Footprint of consumption.

3.3.2.3 Forest land Footprint

Forestland Footprint evaluates human demand on the forest ecosystem. The forestland production data was for fuel wood and timber products used by households. To obtain forest yield, the production figures were divided by forest area in the resettlement. The forest area data was obtained from the Ministry of Lands and Rural Resettlement. The calculation of the

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forestland Ecological Footprint of production applied formula 3.1. There were neither traced imports nor exports of forest resources, thus this translated into the forestland Ecological Footprint.

3.3.2.4 Built-up land Footprint

Built-up land Footprint calculates the bio productive land that has been occupied by human infrastructural development. Calculation begins with the identification of land uses, their types and the area (ha) they occupy. This land use type does not have level four computations. Therefore, it jumps form land areas to the calculation of the Ecological Footprint of consumption through the application of formula 3.2. The formula is applied to the land uses related with infrastructural development only. All the other land uses are dealt with individually. It is not possible to import or export built-up land. Therefore the calculated built–up land Footprint of production is the built-up land Footprint.

All Ecological Footprint computations from the four land use types were then brought together in a summary calculation sheet.

3.3.2.5 The Chirumanzu District Ecological Footprint

This sheet combines all the Footprints of production, imports and exports from the four different land uses. All the Footprints are summed up. The totals give the Ecological Footprint of production, imports and exports for Chirumanzu resettled areas. The total for the Ecological Footprint of consumption gives the Ecological Footprint for the study area. This is the basis for the calculation of household Ecological Footprint.

3.3.2.6 Household Ecological Footprint

The household is the unit of planning used to resettle farmers. A comparison of the number of households resettled with the set target assists in the evaluation of the success or failure of the

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land reform programme in Zimbabwe. Therefore, it is also logical to evaluate environmental sustainability at household level.

The number of households are divided by the calculated Ecological Footprint for each land use type to get the Ecological Footprint per household. The same method was also applied for Zimbabwe using statistics from the 2010 National Footprint Accounts calculated by the GFN. This then allowed a comparison between Zimbabwe and Chirumanzu. However, sustainability of the environment can only be evaluated with the Ecological Footprint compared against the available biocapacity.

3.3.3 Biocapacity calculation

Bio-productivity refers to land and water that supports significant photosynthetic activity and accumulation of biomass, excluding barren areas of low, dispersed productivity (Ewing *et al.*, 2010). It also includes the ability of land to absorb wastes generated by humanity. This does not mean that the barren areas do not support life but that their production is too widespread to be directly harvestable by humans (Wackernagel, *et al.*, 2002; Ewing, *et al.*, 2008 and 2010). Bio-capacity is a sum measure of the amount of land available, weighted by the productivity of that land. It is a representation of the ability of the environment to produce crops, livestock (pasture), timber products (forest), fish and the forests' capacity to take up carbon dioxide. Bio-productive land occupied by infrastructure (built up land) is not omitted. Simply put, Bio-capacity is a measure of the terrestrial and aquatic environments' ability to produce ecological resources.

Bio capacity is calculated by the following formula (Ewing, *et al.*, 2008; Kitzes, *et al.*, 2008):

Formula 3.5

$$BC = A * YF * EQF$$

Where

A = the area available for a given land use type,

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YF and EQF are yield factor and equivalence factor, respectively, for the land use type in question.

The biocapacity calculation involves two stages. The first stage involves the identification of land uses. Since this had been done in the calculation of built-up land Footprint, the same worksheet was utilised. Application of formula 3.5 computed the biocapacity for each land use type. The method applied in the Ecological footprint calculation was also applied for household biocapacity.

The calculations explained above exploited the equivalence and yield factors. While the Equivalence factors are internally calculated by the GFN, yield factors for this research were calculated for use in the Ecological Footprint and biocapacity computations. The equivalence factors were requested from and supplied by the GFN.

3.3.4 Yield factors

A yield factor is the ratio of resettlement to district average yields calculated as the annual availability of usable ecological services in the resettlement. Yield factors account for the differences in productivity of a given land use type between the district and a resettlement average in the same land area type (Ewing, *et al.*, 2008). These differences are because of the different natural and human settings of different settings. The natural factors include, inter alia, precipitation and soil quality, and as management systems (Wackernagel, *et al.*, 2004; Ewing, *et al.*, 2008). Therefore, the yield factor compares the production of a specific land use type in an area with the average world hectare of the same land use type. It was calculated using the following formula.

Formula 3.6 (adapted from Kitzes, *et al.*, 2008)

$$YF = \frac{\sum A_D}{\sum A_R} \qquad \textit{where} \qquad A_R = \frac{P_R}{Y_R} \qquad \textit{and} \qquad A_D = \frac{P_R}{Y_D}$$

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Where

YF = yield factor for a given land use type,

A_R = area harvested for a given quantity of product in the resettlement areas,

A_D = area that would be required to produce a given product quantity using district average land,

P_R = amount of given product extraction in the resettlement areas,

Y_R = yield for product extraction in the resettlement areas,

Y_D = district average yield for product extraction.

All the production and area data were provided by government offices in Mvuma.

3.3.5 Equivalence factors

Equivalence factors convert world average land of a specific type to the common unit of global hectares (Wackernagel, *et al.*, 2004; Ewing, *et al*, 2008, 2010). Equivalence factors are based on estimates of achievable yields from the Global Agro Ecological Zone (GAEZ). Thus, an equivalence factor is a suitability index which compares the maximum possible yield on that land type with the current theoretical yields for that crop (Wackernagel, *et al*, 2004, Ewing, *et al.*, 2008, 2010). Equivalence factors are based on assessment of the relative productivity of the different types of land in any given year. The Global Footprint Network calculates equivalence factors internally. Therefore, this research used the factors shown in Table 3.5.

Table 3.6: 2010 Equivalence factors (Source: Global Footprint Network, 2010)

Land Cover	EQF
Cropland	2.51
Grazing land	0.46
Forestland	1.26
Built-up land	2.51

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Schematically put the components of the bio-capacity and ecological footprint calculations for this study are as shown by Figure 3.1.

3.4 Advantages of the Ecological Footprint accounting system

The Ecological Footprint Accounting system provides a novel perspective that can help stimulate practical solutions to the growing ecological challenges of the world. It answers the question about how much ecological productivity is demanded by a specific activity (Global Footprint Network, 2010). The aggregation of data to form an indicator simplifies complex and detailed information, thus making communication easier (Adriaanse, 1995). The Ecological Footprint system selects key topics, leaving out variables which cannot be accounted for, packages data, and aggregates it using conversions to simplify information.

The Ecological Footprint's attempt to quantify the ecological consumption and supply, combined with the simplicity of a single calculated figure, give it the status of an objective tool for measurement of phenomena that are difficult to quantify. An EF's potential for pedagogical purposes and dissemination is however, without any competitor (Schaefer, *et al.*, 2006).

A comparison of the area assists in the establishment of the land that is available. In addition, EF accounts are easy to visualise and communicate. This gives a comprehensive rejoinder to the question of how much of the earth's bio-productivity that we can demand as compared to what is available. The answer to that question points to the environmental sustainability of our ways of living.

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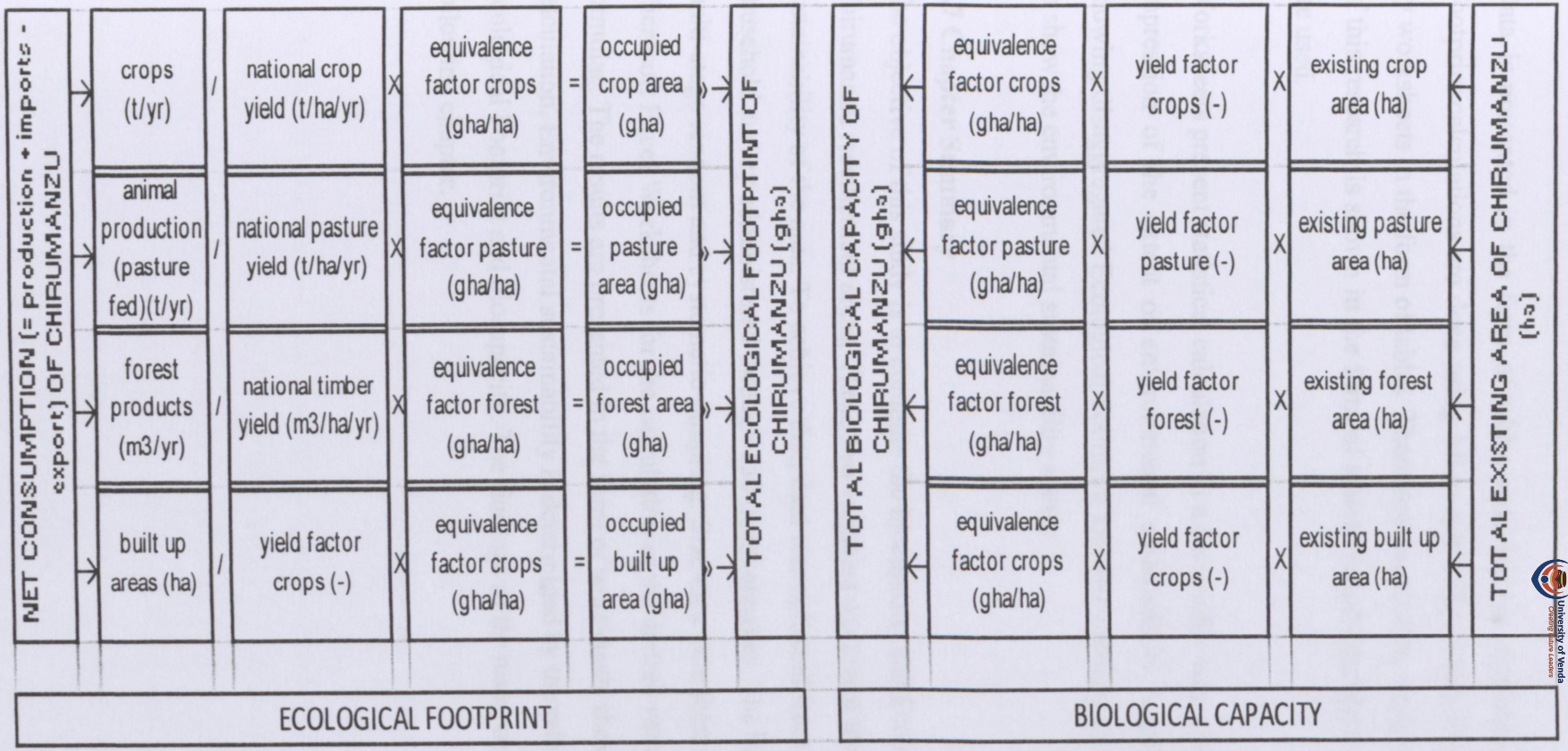


Figure 3.2 Structure of the Ecological Footprint and Biocapacity calculations (Source: adapted from Monfreda, *et al.*, 2004:235; Wackernagel, *et al.*, 2005:10)

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3.6 Data Presentation

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Data is presented in the form of tables showing the computations and in graphical form. Footprint calculations are done using Microsoft Office Excel 2010 and the process is shown by worksheets in the form of tables. Therefore, most of the work presented in the next chapter of this research is shown in the form of tables. Where appropriate, pie charts and bar graphs are used.

Worksheets present statistical calculation in a discernible way. Graphs and charts give a vivid impression of the extent of environmental sustainability. Comparative graphs and tables showing disaggregated Ecological Footprint and Bio-capacity of the land use types are used to show the environmental sustainability status.

3.7 Chapter Summary

The objective of this study is to compute the biocapacity and Ecological Footprint of Chirumanzu resettlement areas. These two variables can reveal the environmental sustainability of the area. To achieve that, data was collected from government offices and a household survey administered through 150 questionnaires. The households were selected by multi-stage random and systematic sampling. Statistics were then input into SPSS and Microsoft Excel Worksheets for the calculation of the desired variables using the different formulae. The results are presented in the form of worksheets showing all the stages of calculation. Environmental sustainability is determined by the relationship between the Ecological Footprint and biocapacity. The findings of the research are presented in the following chapter.

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4.1 Introduction

This chapter presents and analyses the results emanating from the computation of the Ecological Footprint and Biological capacity of Chirumanzu resettlement areas. The calculations resulted in thirty-three individual worksheets. In all worksheets blank cells indicate zero values while a hyphen indicates inapplicable.

The computations are divided into a hierarchical structure of five levels. Generally, computations at Level 1 derive their data from computations at Level 2; those at Level 2 depend on calculations at Level 3, in that order. At Level 5 there is normally no calculation and worksheets contain raw data collected from the field. They serve as data sources for calculations to be done in higher-level worksheets.

Each computation is named descriptively according to its function within the Footprint and Biocapacity calculation sequence. A full description of each worksheet, its input and output, dependencies, equations and data sources is given.

In addition to being divided into levels, worksheets are divided into groups according to the four land use types they represent. The four major land use types, whose Ecological Footprint and Biocapacity are calculated, are cropland, grazing land, forestland, and built-up land. Each of the four land use types has a single Level 2 worksheet, and a variable number of three Level 3, 4 and 5 worksheets. A fifth and sixth computation set calculates the biological capacity of all the land types, while another calculates the yield factors, respectively.

Computation levels and land use types are the organising framework for the Ecological Footprint accounting system. This chapter details and analyses the results of the computations of each of the four land types starting with Level 5. All the worksheets of the different land types are then coalesced into one worksheet which summarises all the Ecological Footprint and Biocapacity calculations. The final summary gives the environmental sustainability status of the resettlement areas of Chirumanzu district.

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Following below, is a presentation and analysis of the results of the Ecological Footprint and Biocapacity of the four land use types considered in this study. It begins with the cropland Footprint, followed by grazing land, forestland and then built-up land Footprints. This is followed by biocapacity and yield factors calculation results. All the calculations are put together in a footprint summary to show the environmental sustainability of Chirumanzu resettled areas. A summary of the chapter wraps up the presentation and analysis of results.

4.2 Yield factors

The computation of the Ecological footprint and biocapacity employ yield factors. Therefore, it is logical to present the results of yield factor computations before the results of Ecological Footprint and biocapacity computations.

There are two yield factor computation datasheets. A general datasheet (*yf*) reports yield factors for all land uses and another one (yf_crop) reporting yield factors for all crops.

4.2.1 Yield factor (*yf*)

This reports the yield factor for all land use types, excluding cropland which is treated separately. YF is calculated using formula 3.6. Although all the land uses in Chirumanzu, are reported in Table 4.1, the cropland yield factor is obtained from the separate computations for crops.

Table 4.1: Yield Factors

Land type	Resettlement Yield	District Yield	Yield Factor
Crop land	23859.8	31771.17	1.34
Grazing land	160619.35	413203.30	2.57
Forest land	1223.28	1529.1	1.25
Built up land			1.34

Yield factors give the ratio of resettlement areas to district average yields for each land use type. The yield factor of the grazing land is a measure of average tonnes of dry matter produced on grazing land. The yield factor for built up land is set equal to cropland using the

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assumption that most infrastructure is developed on productive or previously productive cropland. These statistics are important in the computation of both the Ecological Footprint and biocapacity. The crop yield factors (*yf_crop*) are reported below.

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4.2.2 Crop Yield factors (*yf_crop*)

This datasheet reports the yield factor for cropland. It considers the yield for all crops grown in the resettlement areas in relation to the whole district. The application of formula 3.6 computes the yield factor for each crop. The final yield factor is computed through applying formula 3.6 on the resettlement and district totals.

The results reveal yield factor differences in crops. The lowest yield factor of 0.99 wha ha^{-1} (world hectares per hectare) is reported for tobacco and sunflower. The highest yield factors are 2.34 and 1, 58 wha ha-1 for finger millet and sorghum, respectively. The total of 1.34 wha ha-1 represents the cropland yield factor. Appendix 24 shows the statistics.

All the results evaluating the Ecological Footprint and biocapacity for the four land use types employ these yield factors. The following sections reporting on the Footprints and biocapacity reveal the use of the yield factors.

4.3 Cropland Footprint

The cropland Footprint reflects the amount of land necessary to grow all crops consumed by humans and livestock in the area. This should typically include agricultural products, market animal feed and grasses cropped and used as livestock feed (Kitzes, et. al., 2008). However, in Chirumanzu District resettlement areas, the farmers negligibly neither buy market animal feed nor grow grass crops for animals. The farmers only grow food crops for their own consumption. Livestock, except pigs and chicken, feed on natural veld and crop residues.

This work tracks the production of 15 categories of agricultural products. All the cropland data was obtained from AGRITEX, Mvuma. The data was given at ward level. Therefore, it was easy to separate cropland data for resettlement areas from the rest of the district. The data was then put through the Ecological Footprint system as shown below.

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4.3.1 Crop Production and Trade

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This is the beginning of computations for the Ecological Footprint. Data sets at this level do not usually make any calculations. They just report raw data form the source. There are three cropland worksheets at this level, namely *prodstat_crop_r*, *prodstat_crop_d* and *tradestat_r*.

4.3.1.1 Crop production in the resettlement (*prodstat_crop_r*)

This data sheet reports the amount of crops produced in the resettlement areas of Chirumanzu District and the area harvested to produce these crops. There are 15 crops cultivated in the study area. The data sheet shows that maize gets the largest share in terms of land allocation (78%) and production (85%). Groundnuts (8, 5% and 5, 1%) and Bambara nuts (4, 9 % and 2.9 %) distantly follow it. These three crops form the basic food for the households in the area. However, productivity is mostly on maize, the main staple cereal in the country. Tobacco and cotton, the only commercial crops cultivated on small tracts of land, yielded a negligible production (0, 4 and 0, 08 %, respectively). These statistics are shown in Appendix 1.

Prodstat_crop_r data set feeds into the computations for district yield for all agricultural products. Production statistics reported in *prodstat_crop_r* also form basis for the computation of crop residue available as livestock feed in the study area.

4.3.1.2 Crop Production in the District (*prodstat_crop_d*)

Prodstat_crop_d reports the amount of crops produced in the whole district of Chirumanzu as well as the area harvested to produce those crops. This includes all the different settlement and production types found within the district. As with the resettlement areas, 15 crops the data set reports production for 15 crops.

All the crop production and land allocation characteristics are similar to those reported in *prodstat_crop_r*. The figures depict that the most produced crop is maize (78%) and cotton (0, 04%) is the least produced. Maize production takes 69.6 %, while cotton takes 0.05 % of the land allocation put under crops. Therefore, the production trend in the resettlement is similar to that of the district. This data is essential for the calculation of district crop yield

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(*crop_yield_d*) and district crop trade yield (*crop_trade_yield_d*) for various crops. Appendix 2 shows the data set.

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4.3.1.3 Crop trade in the resettlement (*tradestat_r*) area

The *tradestat_r* data sheet shows the imports and exports of all agricultural products traded by the resettlement areas. These imports and exports include food aid coming into or leaving the area. It states both crop and livestock trade statistics. It falls under the cropland component though it also contributes in both grazing land and livestock trade computations. Statistics for this data sheet were obtained from the Grain Marketing Board, AGRITEX, and the Department of Social Services. The department of Social Services supplied food aid statistics.

The data sheet shows that crop imports into the resettlement areas were in the form of donated maize seed. This is classified under food aid. In terms of livestock; only live cattle were bought into the resettled areas.

On the export side, virtually all crops, livestock and livestock products were exported. None of them, however, was food aid. Live cattle at (36.5%) marginally lead maize at (33.7%), while goat meat is the least exported at 0,003%. Thus, trade was more on live cattle and maize despite maize getting more land allocation. These figures are recorded in Appendix 3.

Crop trade data works in the computations in both the cropland and grazing land. In the cropland section *tradestat_r* feeds into the computation of crop Ecological Footprint of imports (*crop_efi*) and exports (*crop_efe*). In grazing land section *tradestat_r* is the data source for the computation of livestock intensity (livestock_*intensity_d)*, livestock Ecological Footprint of imports (*livestock_efi*) and exports (*livestock_efe*). These calculate the Footprint embodied in the trade of livestock products.

4.3.2 Crop yields

This is the beginning of calculations for the cropland Ecological Footprint. Data sheets at this level contain the first calculations between raw data and the calculation of the footprint. The computations are typically yield calculations. These are resettlement crop yield

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(*crop_yield_r*), district crop yield (*crop_yield_d*) and district crop trade yield (*crop_trade_yield_d*).

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4.3.2.1 Crop yield in the resettlement (*crop_yield_r*)

Crop_yield_r computes the average yield of the 15 crops grown in the resettlement areas. This worksheet is also a data source in the calculation of yield factor for crops.

A division of the production quantities by the area harvested calculates the yields. The *prodstat_crop_r* data sheet supplies the production and area figures. The yield is a computation of the average yield per hectare for the 15 crops grown in the resettlement areas. The unit of measurement for crop yield in the resettlement is tonnes per world hectares per hectare per hectare (wha ha^{-1}).

The calculation sheet shows that wheat (3 wha ha^{-1}), sweet potatoes (2.05 wha ha^{-1}) and tobacco (1.44 wha ha^{-1}) are the high yielding crops in the area. Pearl millet (0.2 wha ha^{-1}), sorghum (0.24 wha ha^{-1}) and rice (0.28 wha ha^{-1}) produce the least yield per hectare of land in the resettlement areas. Appendix 4 presents these data. These figures are also important in the computation of yield factors for crops.

4.3.2.2 Crop yield in the district (*crop_yield_d*)

This data sheet calculates the district average yield for the 15 crops considered for calculation of the Ecological Footprint of production for Chirumanzu District. The calculation method is similar to that done for *crop_yield_r*. Values in this worksheet come from *prodstat_crop_d* data set. The difference between *crop_yield_r* and *crop_yield_d* is that the former calculates the average yield for crops in the resettled areas, while the later calculates average yield for crops in the whole district. Appendix 5 reports these computations.

Statistics show that both wheat (3 t wha ha^{-1}) and pearl millet (0.13 t wha ha^{-1}) are also the highest and lowest yielding crops, respectively, at the district level. Productivity at district level is lower than at resettlement level, as shown by the lower yields per hectare in the *crop_yield_d* worksheet. Maize yield is 24% lower at district level.

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4.3.2.3 District crop trade yield (*crop_trade_yield_d*)

This computation sheet calculates yields for all crop products traded by the district. The worksheet uses total production and area harvested to calculate the yield of all traded crop products. The calculation method is similar to *crop_yield_d* and *crop_yield_r*. The results of this computation are similar to *crop_trade_yield_d* since the figures are the same. The *Crop_trade_yield_d* worksheet is important for the calculation of crop Ecological Footprint of exports (*crop_efe*) and imports (*crop_efi*). All the level four computations are useful for the calculation of the Footprints of production, imports and exports.

4.3.3 Ecological Footprint of production, imports and exports

Level three computations convert quantities (in tonnes) of a product into the number of global hectares necessary to produce it. This is where Footprint values are actually calculated. The data used in these worksheets usually comes from either Level 4 or Level 5. For cropland Footprint three Level 3 data sheets compute cropland Ecological Footprint of production (*crop_efp*), imports (*crop_efi*) and exports (*crop_efe*). Presented below are the three computations.

4.3.3.1 Cropland Ecological Footprint of production (*crop_efp*)

Crop_efp calculates the Footprint of production for each of the 15 crops produced in Chirumanzu District resettlement area. This data sheet computes the quantity (EF_P), in global hectares, of land used in the production of crops in the study area. Application of formula 3.2 (Chapter 3) computes the EF_P. Multiplication with the Equivalence Factor converted units of measurement from tonnes per year and world hectare per hectare to global hectares. Production data for the computations come from *prodstat_crop_r* (Level 5) while yield were calculated in *crop_yield_d* (Level 4) and Equivalence Factor is supplied by the GFN (2010).

Computation results show that maize (57918.47 gha) groundnuts (5120.2 gha) and Bambara nuts (3450.1 gha) have the highest Footprints. Wheat (55.47 gha), cotton (65.43 gha) and pearl millet (74.36 gha) have the least Ecological Footprints, in that order. This shows that farmers in the resettlement areas use available Biocapacity predominantly for the production of subsistence crops. Appendix 6 presents the results of the computations and are an input

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into the calculation of the Ecological Footprint of Consumption in the final crop Ecological Footprint computation data set (*ef_crop*).

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4.3.3.2 Cropland Ecological Footprint of exports (*crop_efe*)

This computation sheet reports the Footprint of export for the crop products traded by Chirumanzu district resettlement areas. The computations are similar to the *crop_efp* described above. However, statistics for *crop_efe* come from *tradestat_r* and *crop_trade_yield_d* for the export and yield figures, respectively.

Computation results show that maize (922.55 gha) had the highest Ecological Footprint in exports, while sunflower (0.82 gha) was the least. Several food crops show no trade figures. Worth noting here is the fact that tobacco (222.27 gha) and cotton (65.43 gha) are the only cash crops cultivated in the resettlement areas of Chirumanzu. Such statistics show that farmers in the resettlement areas are predominantly subsistence farmers. Statistics from this worksheet feed into the calculation of the cropland Footprint (*ef_crop*) and appendix 7 presents them.

4.3.3.3 Cropland Ecological Footprint of imports (*crop_efi*)

Crop_efi calculates the Footprint of imported agricultural products. Data and calculations are similar to *crop_efp* and *crop_efe*. Statistics show that the district only imported maize. This was in the form of maize seed aid.

It is important to observe that crop imports are mainly done by non-governmental organisations (NGOs) in the form of food aid. However, there is very little activity by NGOs in resettlement areas. NGOs are only visible in the old resettlement and almost absent in the new resettlement areas. This justifies the low EF_I as expressed in appendix 8.

Despite the low presence of NGOs in the resettlement areas, it is important to note that resettlement areas are the more productive regions of the district. Therefore, the region generally has surplus crops rather than deficits. Therefore, there is bound to be more exports than exports.

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The three Ecological Footprint calculation sets were combined into one computation set to find the cropland Footprint.

4.3.4 Cropland Ecological Footprint

A single data set at this level presents the Ecological Footprint for cropland, *ef_crop*. This data sheet summarises the cropland Footprints for production, imports and exports and then calculates the ecological Footprint of consumption. The crop Ecological Footprint of Consumption (EF_C) is actually the Ecological Footprint for the cropland use as reported in Table 4.2.

Table 4.2: Cropland Ecological Footprint (*ef_crop*)

Level 2

Name	EF_P	EF_I	EF_E	EF_C
[-]	[gha]	[gha]	[gha]	[gha]
Crop Products	72889.53	329.08	1238.81	71979.80
Cropland in Livestock		1329.59	1653.12	-323.54
Total	**72889.53**	**1658.67**	**2891.93**	**71656.27**

The crop products row represents values drawn from Level 3 data sheets in the cropland Footprint computation. Therefore the totals from the worksheets bearing those names were used. An application of formula 3.3 (Chapter 3) computes the cropland Ecological Footprint of consumption (EF_C), which, consequently, is the cropland Ecological Footprint. Cropland in livestock row reports Footprint embodied in livestock trade computed in the livestock trade section. It represents crop products used as livestock feed.

Results reveal that the district has a negative net imports balance in livestock resources which embody cropland use. This is shown by a negative EF_C of the cropland in livestock column. Computations in *ef_crop* combine with Footprints with Footprints of other land uses to compute the Ecological Footprint of Chirumanzu resettlement. Therefore, the following section presents results of calculations of grazing land Footprint.

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4.4 Grazing land Footprint

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The grazing land Footprint evaluates demand for grazing biocapacity to feed livestock. This demand includes the embodied grazing land in traded livestock products. This is the longest and complex of the Footprint calculations. It relies on a host of constants in order to calculate the grazing land demand.

The calculation of the grazing land Footprint is divided into the section computing livestock trade and the section calculating grazing land. The grazing land section calculates everything to do with the grazing land Footprint of production. The livestock trade section deals with trade in livestock and livestock products, results of which are the livestock Ecological Footprint of imports(*livestock_efi*) and exports (*livestock_efe*). The grazing land section produces the grazing land Footprint of production (*grazing_efp*). The three Footprints all feed into grazing land Footprint, *ef_grazing*. The grazing land Footprint results presented below begin with the grazing land before presenting the livestock trade Footprint computation results.

a) The grazing land Ecological Footprint of production

4.4.1 Livestock production and resources

This section has six livestock-related computation sheets. However, of the six, two come from cropland use calculations. These are *tradestat_r* and *prodstat_crop_r* data sheets. These are not repeated here as they have been presented above. They are referenced to where necessary.

4.4.1.1 Livestock production in the resettlement (*prodstat_livestock_r*)

This data sheet reports statistics on livestock products tracked in the resettlement areas. The data, reporting heads only, was collected from the Vet Department in Mvuma. Therefore, grazing constants became useful in conversions. The data set also computes yield. The yield reveals the number of animals producing a particular product.

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The results reveal that cattle products were the highest in production while goat products were the lowest livestock products from the area. Cattle yields gave the highest returns per animal of 0.11 t $wha^{-1}yr^{-1}$(tonnes per world hectare per year) in meat product. Goats yield a low 0.003 $wha^{-1}yr^{-1}$ in goatskin production. This can be attributable to the relatively wet conditions in the resettlement areas which do not favour goats. Appendix 9 shows these statistics. Data from this worksheet is used in the *feed_demand_r* worksheet.

4.4.1.2 Livestock population (*resourcestat_livestock*)

Resourcestat_livestock reports the population of live animals in the resettlement areas of Chirumanzu district. Data shown in Table 4.3 was obtained from the Veterinary Department; Agritex; Ministry of Lands and from the field.

Table 4.3: Livestock Population in the Resettlement (*resourcestat_livestock*)

Level 5

Name	Stocks
[-]	[head]
Cattle	16921
Goats	4603
Sheep	808
Donkeys	526
Chickens	11234
Pigs	1044

The worksheet shows that cattle were the dominant livestock in the area, while donkeys were the least common. This worksheet does not perform any calculations but is a data source for the computation of livestock feeds needed to support the livestock population of the resettlement areas (*feed_demand_r)*. Computation of livestock feed demand employs various grazing constants.

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4.4.1.3 Grazing land constants (*constant_grazing*)

This data sheet reports several constants used for the computation of the grazing land Footprint. These constants were obtained from Köster (2010), Gwaze, *et al.* (2009), South African Department of Agriculture and Environmental Affairs (2005), McKiernan, *et al.* (2007), Smil (2000), Wulf (1999) and FAO (1985; 2005).

Grazing land constants are important for the calculation of feed intensity (*feed_intensity_d)* and the grazing land Footprint of production (*grazing_efp)* as well as livestock imports (*livestock_efi)* and exports (*livestock_efe*. The constants are shown in appendix 10.

4.4.2 Livestock feed demand and supply

This section is composed of two computation data sets from the grazing land Footprint. No farmers in the area under study were using market feed or growing supplementary grasses for their livestock. Therefore, there was no need to include data sets covering those feeds. Livestock in the resettlement areas of Chirumanzu mostly rely on natural veld. The data sets show computations for feed required to support livestock (*feed_demand_r*), while the other report calculations show results for the crop residues available and used as livestock feed (*residue_supply_r*).

4.4.2.1 Livestock feed requirements in the resettlement (*feed_demand_r*)

This datasheet computes the total amount of feed needed in the resettlement areas to sustain its livestock population. Feed demand is computed by multiplying heads by feed intake and number of days in the year. Feed demand is then converted to tonnes before being used in the computation of the Ecological Footprint of production (*grazing_efp*).

The feed demand data set calculates the annual feed needed by each animal or for the production of each animal product. This data set employs numerous constants drawn from grazing constants.

Results show that cattle, as a large species and the common livestock in the study area, needed more feed than any other livestock species. Cattle needed 38 579.88 tonnes of dry

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matter per annum while chicken required 11 509.69 tonnes of dry matter per annum. The lowest feed demand came from sheep which required 238.75 tonnes of dry matter per year. The calculation results are shown in appendix 11. These statistics are more influenced by livestock populations in the species than their feed requirements. Cattle and chicken are the most populous livestock species, hence the highest feed demand.

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4.4.2.2 Livestock feed from crop residue (*residue_supply_r*)

This data set reports the supply of crop residue used as livestock feed in the resettlement areas of Chirumanzu. Crop residues constitute a significant proportion of livestock feed early in the dry season.

Results show that maize provides the bulk of crop residue although Bambara nuts, sugar beans, cowpeas and soya beans have the highest crop residue yields. Maize supplies more than half of the crop residues (53%) used as livestock feed. Groundnuts (19%) and bambara nuts (15%) also provide reasonable crop residue feed. The residue supply statistics are shown in appendix 12.

4.4.3 The grazing land Ecological Footprint of production (*grazing_efp*)

This section reports the total pasture grass required to feed livestock in the resettlement areas of Chirumanzu. This calculation estimates the grazing land Ecological Footprint of production (Est. EF_P). Est. EF_P reports the grazing land Footprint of production. The Ecological Footprint accounting system requires that if the Est. EF_P is larger than the calculated Biocapacity, then the calculated biocapacity caps the Ecological Footprint of production (EF_P).

Computation results revealed that the grazing land biocapacity was larger than the Est. EF_P. Therefore, the estimate is the figure used in these calculations. EF_P adjusts the estimated EF_P recorded in Est. EF_P column so that it reveals grazing land available domestically.

The assumption taken by this computation is that livestock feed on crop residues and grazing land. The estimated Footprint of production is obtained using formula 3.2 on pasture grass demand and the results are shown in appendix 13.

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4.4.4 Grazing land Ecological Footprint (*ef_grazing*)

This data set summarises the grazing land Footprints of production, imports, exports and computes the consumption. This is where the Ecological Footprint of the grazing land is calculated and it is shown in the EF_C column in Table 4.4.

The domestic grazing land row contains a Footprint of production, while grazing land in livestock reports the Footprint embodied in the imports and exports of livestock and livestock products. The values in this datasheet come directly from *grazing_efp*, *grazing_efp* and *grazing_efe*. The EF_C is calculated using Formula 3.3. The results reveal that the study area exported more than it imported livestock Footprint. The grazing land Footprint is completed with the calculation of livestock_*efi* and *livestock_efe* in the livestock trade worksheets.

Table 4.4: Grazing Land Ecological Footprint(*ef_grazing*)

Level 2

Name	EF_P	EF_I	EF_E	EF_C
[-]	[gha]	[gha]	[gha]	[gha]
Domestic grazing land	16121.69			16121.69
Grazing land in Livestock		2493.73	2667.93	-174.20
Total	**16121.69**	**2493.73**	**2667.93**	**15947.49**

b) Livestock trade Ecological Footprint

This section is a bridge between the grazing land and the cropland Footprint sections. This is because livestock are fed from both grazing land and cropland land use types. Therefore, this section does not compute a footprint of production. It accounts for both cropland and grazing land Footprints that are embodied in livestock and livestock products trade only.

4.4.5 Livestock feed mix and intensity

There are two livestock trade data sheets at this level. One shows the Footprint represented by a tonne of feed for each category of feed (*feed_intensity_d*). The other shows the estimated amount of feed needed to produce a tonne of livestock products (*feed_mix_r*).

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4.4.5.1 Livestock feed intensity (*feed_intensity_d*)

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This worksheet reports the embodied Footprint of a tonne of feed for each category of feed. The Footprint intensity is obtained by dividing EQF by yield. In all cases, crop residue for the respective crop is referred to. The intensity gives the global hectares used for the production of each tonne of feed.

The feed intensity results revealed that it needed more land (in gha) to produce a tonne of livestock feed from crop residues than natural grass. It needed about 22 gha to produce a tonne of crop residue while a tonne of grass was produced on 0.62 gha. Appendix 14 reports these results.

4.4.5.2 Livestock feed mix (*feed_mix_r*)

This data sheet reports an estimation of the amount of feed needed to produce a tonne of each livestock or its products. This data is adapted from Smil (2000). Results show that cattle and donkeys feed almost entirely on grass. Furthermore, pigs and chicken feed on crops while sheep and goats survive on crop residues. Appendix 15 reports the results in detail.

The crop total column sums up all figure recorded under different crops which are used as feed. The Total Feed Requirement (TFR) is the aggregate amount of feed required for the production of each animal product. It is measured in tonnes of feed per tonne of final product.

Crop products, except crop residues, are removed since livestock in Chirumanzu predominantly feed on grass and crop residues. Therefore, grass forms almost the whole diet for cattle, and donkeys. These statistics are useful for the computation of livestock intensity.

4.4.6 Livestock intensity (*livestock_intensity_d*)

This datasheet reports the district average embodied Footprint for each feed type for the livestock products tracked in the livestock trade section of the Ecological Footprint accounting system. The intensity column reports the total Footprint embodied in a tonne of each livestock unit or livestock product, by aggregating the contributions of all feed types.

The amount of crop feed intensity allocated to each type of livestock or livestock product is calculated by multiplying feed intensity values from the *feed_intensity_d* worksheet with the feed mix value in the *feed_mix_r* worksheet. Results show that pigs and chicken have a higher feed Footprint than larger livestock. Pigs require 37.5 and chicken need 36.4 global hectares global hectare tonnes per day [gha $(t\ d)^{-1}$]. This is because pigs and chicken feed on crop feeds only, while larger livestock like cattle feed on grass. Values from *livestock_intensity_d* are reported in appendix 16 and feed into the livestock Ecological footprint of exports (*livestock_efe)* and imports (*livestock_efi).*

4.4.7 Livestock Ecological Footprint of imports and exports

These datasheets join grazing land Ecological Footprint of production datasheet calculated in the grazing land calculations to compute the final grazing land Ecological Footprint. The worksheets are *livestock_efi* and *livestock_efe* which report import and export of livestock and livestock products.

4.4.7.1 Livestock Ecological Footprint of imports (*livestock_efi*)

Livestock_efi reports the import Footprint of all livestock and livestock products. Results show that only live cattle were imported into the resettlement areas of Chirumanzu. Therefore, animal weights drawn from *cnst_grazing* were employed to convert from live heads to tonnes.

The footprint reported for grass imported in live cattle. The Footprints are calculated by multiplication of the total imported quantity (in tonnes) by the corresponding Footprint intensity value in the *livestock_intensity_d* worksheet. Only the embodied Footprint of grass production goes into the total grazing land Footprint. Crop feed total and other concentrate feed embodied Footprint values are considered in the cropland use type. Therefore, considering them here would amount to double counting, hence compromise the Footprint. The computation results are shown in appendix 17.

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4.4.7.2 Livestock Ecological Footprint of exports (*livestock_efe*)

This datasheet reports the Footprint of export of livestock and livestock products. It is identical to *livestock_efi* and the calculation procedure is the same. Results reveal that live cattle and cattle meat are the highly exported livestock products of the area. As shown in appendix, 18 2171.83 and 485.46 gha were exported as live cattle and cattle meat, respectively. These figures also reveal the population figures of the other livestock. As cattle are the most commonly owned livestock, it is also the most traded. The *Livestock_efe* datasheet feeds into *ef_crop* and *ef_grazing* computation. The total grazing land Ecological Footprint was reported above. Hence, the following section reports the Forest Land Footprint.

4.5 Forest land Footprint

This Footprint calculation section evaluates the human demand on the regenerative capacity of the forests in Chirumanzu resettlement areas. It delves into two types of production. The first is wood used for fuel and timber used for other domestic and commercial purposes.

The forestland Footprint represents the area of the world average land needed to supply wood for fuel and construction and other domestic uses in Chirumanzu resettled areas. These are the two significant uses of forest resources tracked in the study area. All the resources were used as primary products.

4.5.1 Forest resources production (*prodstat_forest_r*)

There is a single Level 5 datasheet for the forestland Footprint. It is *prodstat_forest_r* and reports the total production, import and export quantities for wood and timber.

All forest products used in the resettlement areas occur locally and are used for domestic purposes. Therefore, there are no values for imports and exports. The reported production values show that more forest resource production is for firewood. The resettlement areas are rural and firewood is the primary source of energy. The values reported in *prodstat_forest_r* are recorded in appendix 19. These statistics then feed into the computation of forest yield.

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4.5.2 Forest yield (*forest_yield_r*)

This datasheets in the forest land Footprint computation reports forest yield. There is a single datasheet for this level, *forest_yield_r*. The yield shows the average production per unit area for each product through dividing production by area. Forest yield is the average net annual increment for all forests. As reported in appendix 20, the forestland has equal yield for both fuel wood and timber resources.

The yield in this datasheet is used for the computation of forestland yield factors (*yf*) and forestland Ecological Footprint of production (*forest_efp*).This data feeds into the computation of Biocapacity for forestland.

4.5.3 Forest land Ecological Footprint of production (*forest_efp*)

There is a single datasheet for the forestland Footprint calculation of the Chirumanzu resettlement areas. This is because there were neither imports nor exports which were traceable. Therefore, the *forest_efp* worksheet is the only one reported here.

The Forest Ecological Footprint of production shows the Footprint of production for the forest products traced in the study area. The EF_P is calculated by applying Formula 3.1. The results (appendix 21) reveal that firewood has a larger Ecological Footprint of production than the timber products. This shows the importance of firewood as a source of fuel in the rural communities.

4.5.4 Forest land Ecological Footprint (*ef_forest*)

Ef_forest datasheet reports the aggregation of the Footprint of production, imports, and exports in order to compute the Footprint of consumption. The Footprint of consumption is the Ecological Footprint of the concerned land use type as shown in Table 4.5.

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Table 4.5: Forest land Ecological Footprint (*ef_forest*)

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Level 2

Name	EF_P	EF_I	EF_E	EF_C
[-]	[gha]	[gha]	[gha]	[gha]
Timber Products	481.67			481.67
Wood Fuel	1926.67			1926.67
Total	**2408.33**			**2408.33**

For the forestland Footprint; there were neither exports nor imports which could be traced. Therefore, there are no figures recorded under Ecological Footprint of imports or exports. After applying Formula 3.3, the Ecological Footprint of production remains the Ecological Footprint of consumption. The total feeds into the summary for all land use types to give the Ecological Footprint for the study area. This will be presented later after the presentation of Footprints for all land use types. As such, the following column deals with the built-up land Footprint.

4.6 Built-up land Footprint

The built-up land Footprint reports the bio-productive land embodied in the human activities which include construction. The computations cover infrastructure areas used for housing, transportation and institutional development. The Footprint Accounting system assumes that built-up land occupies the most productive land which could have been used for crop production (Ewing *et al.* 2008; Kitzes, *et. al.*, 2008). Therefore, the calculations apply Yield and Equivalence Factors for cropland.

The calculations begin with a dataset of land uses (*land_use*) which feeds into the infrastructure Ecological Footprint of production(*infrastructure_efp*) dataset. Built-up land computations do not have Level 4 datasheets which usually calculate yields.

4.6.1 Land uses (*land_use*)

This datasheet serves as a reference source for areas covered by infrastructural developments. It shows the land use types and the area they occupy. This is the same *land_use* data sheet used in Biocapacity calculation.

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The land uses are grouped into the four land use types under consideration (appendix 22). It is shown that pastures for livestock take more land (160916 ha), arable land for crops (20820 ha), built up land (4624 ha) and forestland occupy less area (1529 ha).This land use data feeds into the computation of the infrastructure Ecological Footprint of production (*infrastructure_efp*).

4.6.2 Built-up land Ecological Footprint of production (*infrastructure_efp*)

This section reports the Footprint of areas occupied by human settlements and developments. The EF_P is calculated through the application of formula 3.2. Appendix 23 shows that for most of the area in Chirumanzu is occupied by homesteads (58.5%), followed by roads (17.4%), while health institutions at (0.09%) occupy the least area. This then feeds into the *ef_built* datasheet.

4.6.3 Built-up land Ecological Footprint (*ef_built*)

The *ef_built* datasheet summarises the built-up land Footprint of production and consumption. It is not practically possible to import or export infrastructure Footprints. Therefore, the Footprint of consumption and production for the built-up land are equal.

Table 4.6: Built up land Ecological Footprint (*ef_built*)

Level 2

Name	EF_P	EF_I	EF_E	EF_C
[-]	[gha]	[gha]	[gha]	[gha]
Infrastructure	16937.01	-	-	16937.01

This datasheet feeds into the summary worksheet which aggregates all worksheets to show a single Footprint for the area.

4.7 The Ecological Footprint of Chirumanzu resettlement

This section puts together all the Footprints reported under the four land use types to compute the Ecological Footprint of Chirumanzu resettlement areas. Totals from the ecological

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footprint of production, imports, exports and consumption are considered. All are summed up to give totals which represent the Ecological Footprint of the study area. The totals row under the Ecological Footprint of Consumption in Table 4.7 is shows the Ecological Footprint for the resettled areas of Chirumanzu.

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Table 4.7: Chirumanzu Resettlement Ecological Footprint

Demand Type	$EF_{Production}$	$EF_{Imports}$	$EF_{Exports}$	$EF_{Consumption}$
[-]	[gha]	[gha]	[gha]	[gha]
Cropland	72889.53	1658.67	2891.93	71656.27
Grazing Land	16121.69	2493.73	2667.93	15947.49
Forest Land	2408.33			2408.33
Built up Land	16937.01	-	-	16937.01
Total	**108356.56**	**4152.40**	**5559.86**	**106949.10**

It is important to note that the Ecological Footprint determines the environmental sustainability of the area in relation to the biological capacity. Therefore, the following section reports the Biocapacity of the study area.

4.8 The Chirumanzu resettlement biocapacity

Biocapacity refers to the amount of biologically productive land area available within an area. Biocapacity is reported for all the four land use types. It is paramount to note that although built-up land does not generate resources, infrastructure occupies the Biocapacity of the land they cover. Biocapacity is calculated by the application of formula 3.4 and the results are shown in Table 4.8.

Table 4.8: Chirumanzu Resettlement Area Biocapacity

Level 2

Land_use Type	Area	Yield Factor	EQF	Biocapacity
[-]	[ha]	[wha ha-1]	[wha ha-1]	[gha]
Crop land	20820.50	1.34	2.51	70112.35
Grazing land	160619.35	2.57	0.46	190073.52
Forest	1529.10	1.25	1.26	2408.33
Infrastructure	4624.50	1.34	2.51	15554.04
Total	**187593.45**			**278148.25**

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The Biocapacity datasheet shows that grazing land use has the highest Biocapacity (68.3%) followed by cropland (25.2%) while forestland (0.9%) is the least. Such a land use situation will show environmental sustainability when compared with the Ecological Footprint of the related land uses.

4.9 Environmental sustainability of land reform

This section brings together the Ecological Footprint and biocapacity in order to reveal the environmental sustainability status of land reform in Chirumanzu. The Ecological Surplus reveals the environmental sustainability status. The ecological surplus is a result of biocapacity minus the Ecological Footprint of consumption. Table 4.9 reports the results.

Table 4.9: Chirumanzu District Environmental Sustainability, 2010

Demand Type	EF Production	EF Imports	EF Exports	EF Consumption	Biocapacity	Ecological Surplus (BC-EF_C)
[-]	[gha]	[gha]	[gha]	[gha]	[gha]	[gha]
Cropland	72889.53	1658.67	2891.93	71656.27	70112.35	-1543.91
Grazing Land	16121.69	2493.73	2667.93	15947.49	190073.52	174126.02
Forest Land	2408.33			2408.33	2408.33	
Built up Land	16937.01	-	-	16937.01	15554.04	-1382.96
Total	**108356.56**	**4152.40**	**5559.86**	**106949.10**	**278148.25**	**171199.15**

The ecological surplus (reserve) calculates the excess land (or deficit) for each land use. This column determines the sustainability of the individual land uses and eventually gives the total ecological surplus (or deficit) for the area. Results show that all land uses, except cropland use, are positive. The district has an ecological reserve. The ecological reserve depicts that the population in resettlement areas in Chirumanzu district were generally living within the capabilities of their environment's biological capacity. This means that the resettlement areas, and therefore land reform, were largely environmentally sustainable. This, however, needs more analysis to give a clearer meaning to these statistics.

The planning unit for land allocation in Zimbabwe is a household. Land is allocated to a household head. A view of the Ecological Footprint status at household level can shed more light on the environmental sustainability of land reform in Chirumanzu district.

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4.9.1 Household Ecological Footprint and biocapacity

Land allocation and land planning for resettlement is done for households or families. Therefore, it is important to determine the Biocapacity and Ecological Footprint at household level. As of April 2011, there were 5167 households resettled in the Chirumanzu district. Household Ecological Footprint and Biocapacity for each land use type are shown in Table 4.10.

Table 4.10: Chirumanzu District Environmental Sustainability per household

Demand Type	$EF_{Production}$	$EF_{Imports}$	$EF_{Exports}$	EF Consumption	Biocapacity	Ecological Surplus ($BC-EF_C$)
[-]	[gha household^{-1}]	[gha household^{-1}]	[gha household^{-1}]	[gha household^{-1}]	[gha household^{-1}]	[gha household^{-1}]
Cropland	14.11	0.32	0.56	13.87	13.57	-0.3
Grazing Land	3.12	0.48	0.52	3.09	36.79	33.7
Forest Land	0.47	0.00	0.00	0.47	0.47	
Built up Land	3.28			3.28	3.01	-0.27
Total	**20.97**	**0.80**	**1.08**	**20.70**	**53.83**	**33.13**

Each household has a total Ecological Footprint of 20.7 gha. The highest contributor to the Footprint is the cropland Footprint which contributes 72.62%. This is followed by grazing land (3.39%), built-up land (8.8%) and finally forestland Footprint with a low 2.47%. This reveals that crop production is the dominant activity in the resettlement areas.

However, that is not the case in terms of biological capacity. Each household is entitled to a total 53.83 gha of biocapacity. This figure is largely made of grazing land use which is at 68.92%. This evidently reveals that each household is entitled to more grazing Biocapacity than cropping. Cropping biocapacity is 21.21 % of the total. One can thus observe that households should be more active in livestock production. Such a situation speaks to environmental sustainability.

4.9.2 Household environmental sustainability

It is important to understand how each land use type relates to its biological capacity at household level. The ecological remainder and ecological reserve show the relationship. An

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Ecological remainder is the difference between biological capacity and Ecological Footprint of production. Ecological surplus (reserve) the difference between Biocapacity and Ecological Footprint.

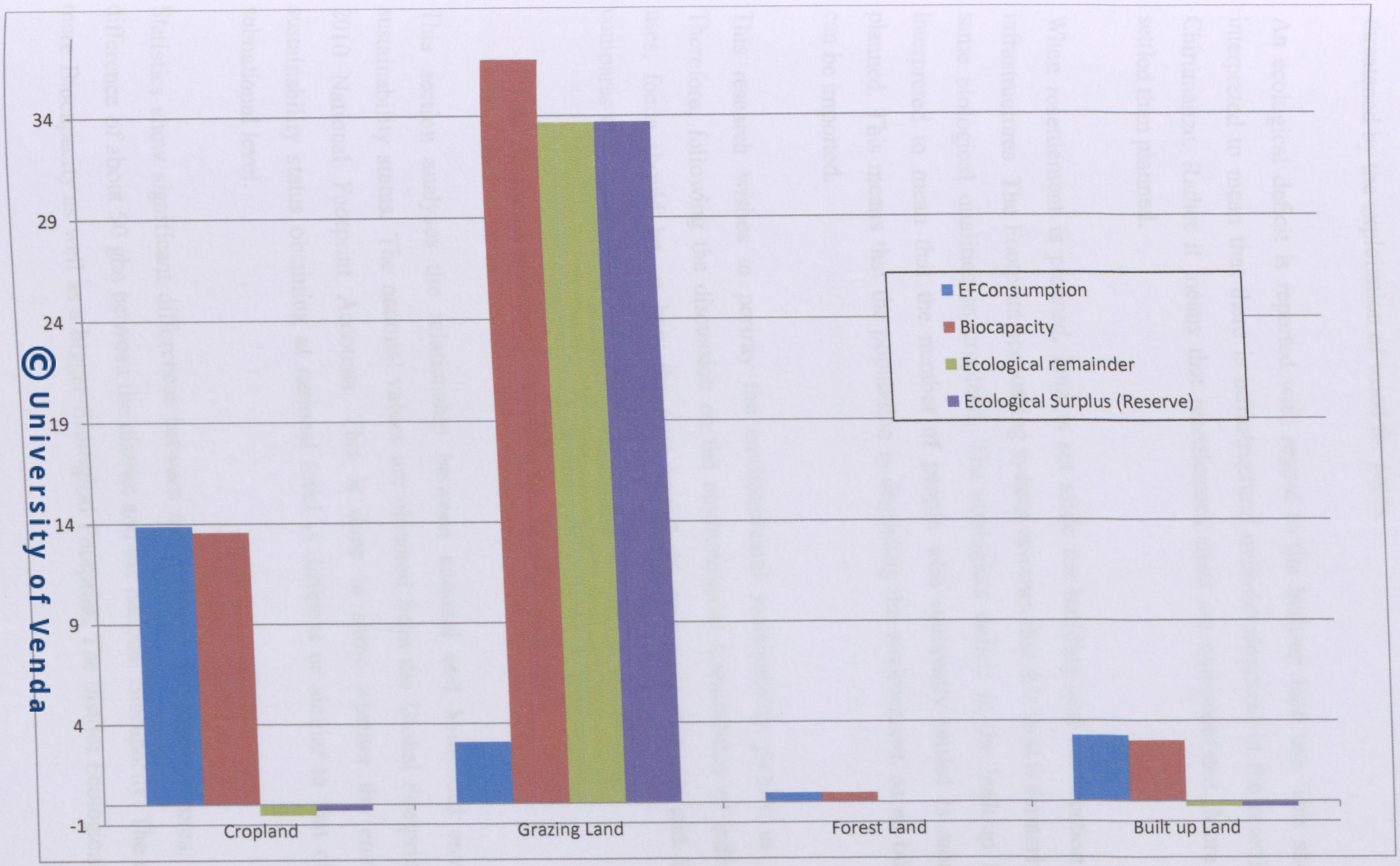
The most important aspect here is the ecological reserve. The ecological reserve is indicative of environmental sustainability. Statistics for Chirumanzu show that grazing land use has the highest Biocapacity but very low ecological Footprint. This results in a very high ecological reserve of 33.7 gha per household. Therefore, it can be observed that in terms of grazing resources, Chirumanzu district is significantly environmentally sustainable. Figure 4.1 shows the environmental sustainability status per household.

An interesting environmental sustainability status is portrayed in the cropland use. Most resettled families cultivate land for subsistence and sell the surplus. This largely contributes to the lager cropland Footprint as compared to other land uses. It therefore results in an ecological deficit for the cropland as both ecological reserve (-0.3 gha) and ecological remainder (-0.54 gha) are negative. Three interpretations with significant implications on the environment in the resettled areas are deductible here. This means that Chirumanzu is doing any one of the following:

- importing biocapacity,
- liquidating its ecological resources, or
- emitting wastes into the environment.

All the arrows point to an environmentally unsustainable condition. In terms of cropping, therefore, the population is living unsustainably and this can have a negative impact on food security in future.

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Figure 4.1: Environmental sustainability per household

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The forestland use Footprint is equal to the Biocapacity. Such a situation is termed an ecological equilibrium. Households use dry firewood from dead trees. Green trees are only used for poles, but the use of poles is not a daily routine. Therefore forest productivity is not threatened by the exploitation of wood for poles.

An ecological deficit is reported with regard to the built-up land use. This should not be interpreted to mean that there is infrastructural over-development in the resettled areas of Chirumanzu. Rather it means that resettlement areas are overpopulated. More people are settled than planned.

When resettlement is planned, land is set aside for building and construction of various infrastructures. The Footprint accounting system assumes that this land is formerly or has the same biological qualities as cropland. The ecological deficit in the built-up land use is interpreted to mean that the number of people who eventually settled is more than the planned. This means that the population is degrading the environment, as no build-up land can be imported.

This research wishes to portray the environmental sustainability picture in Zimbabwe. Therefore, following the discussion on the environmental sustainability of individual land uses, focus should be on how the total household ecological footprint and Biocapacity compares with the national parameters.

4.9.3 National and district environmental sustainability

This section analyses the relationship between national and household environmental sustainability status. The national values are obtained from the Global Footprint Network 2010 National Footprint Accounts. This is done to show whether the environmental sustainability status obtaining at national level is different or similar to that obtaining at subnational level.

Statistics show significant differences between national and subnational figures. There is a difference of about 50 gha between the district and the national Biocapacity. The district has more Biocapacity as well as a bigger Ecological Footprint. The district Ecological Footprint

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is 15.82 gha per household larger than the national [illegible] Zimbabwe has a national overshoot of 1.4 gha per household, while Chirumanzu resettlement areas have a large ecological reserve of 34.73 gha. The values are depicted in Figure 4.2. Therefore, Chirumanzu resettlement areas are more ecologically sustainable than Zimbabwe.

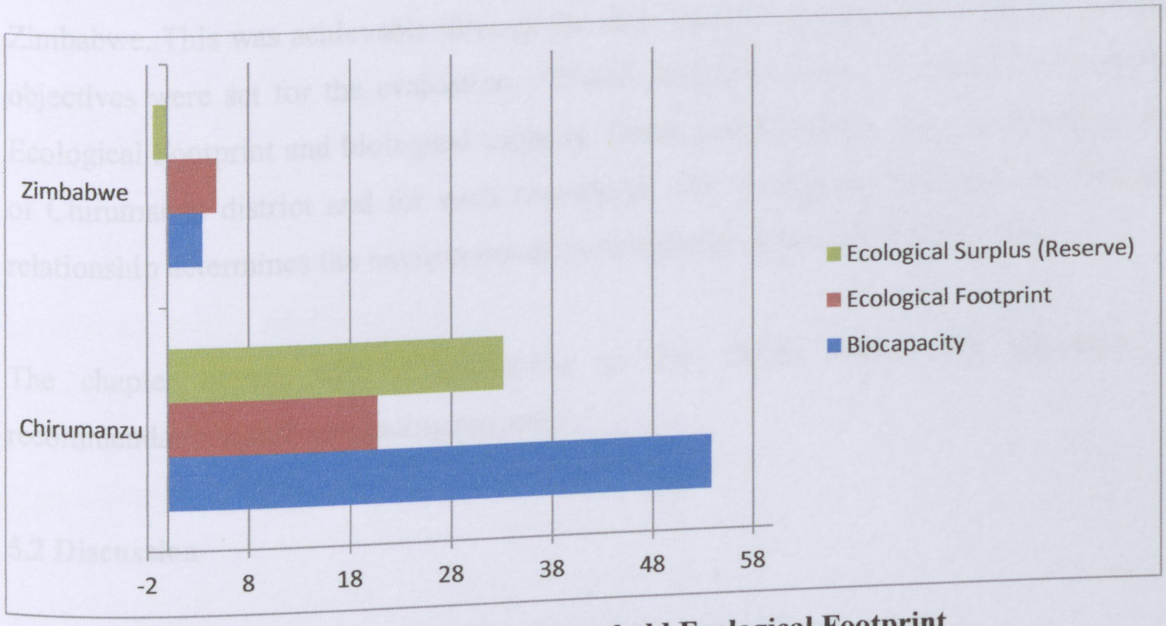


Figure 4.2: Chirumanzu and Zimbabwe household Ecological Footprint

4.10 Chapter summary

Thirty tree datasheets computed the Ecological Footprint and biocapacity of Chirumanzu resettlement. The district has an Ecological Footprint of 106 949.10 gha and a biocapacity of 278 148.25 gha. The household biocapacity is 53.83 gha against an Ecological footprint of 20.7 gha. This gives an ecological reserve of 34.37 gha. This technically means that the population in Chirumanzu is living within the ecological capacity of the environment. Such a situation is indicative of an environmentally sustainable land reform. Following these results is a discussion, conclusion and recommendations.

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5.1 Introduction

The aim of this research was to evaluate the environmental sustainability of land reform in Zimbabwe. This was achievable through the case study of Chirumanzu district. Four specific objectives were set for the evaluation. . These objectives were to compute and analyse the Ecological Footprint and biological capacity. These computations were for resettlement areas of Chirumanzu district and for each household. The Ecological Footprint and biocapacity relationship determines the environmental sustainability status of the study area.

The chapter begins with a discussion on the results under each objective, some recommendations and concluding remarks.

5.2 Discussion

5.2.1 Biocapacity of the resettlement areas

The first objective of this research was to calculate the biocapacity of resettled areas of Chirumanzu. Biocapacity is the ability of the ecosystem to produce valuable living materials and absorb wastes generated by inhabitants. This is an important aspect in terms of sustainable use of natural resources. It refers to what is available for human use. In terms of the Ecological Footprint accounting system, biocapacity is the natural capital on whose accumulated interests humanity should survive. If humanity eats into the natural capital it will accrue less or no interests and eventually run out. Such a scenario spells an environmental disaster, as it is environmentally unsustainable.

The Chirumanzu resettlement areas have a large Biocapacity. Biocapacity, however, treated in isolation, does not communicate to environmental sustainability. Rather, it speaks to land uses. Each identified land use's biocapacity is calculated. The land uses for the calculation of biocapacity in this research were cropland, grazing land, forestland and built-up land. The biocapacity results portray an interesting picture of land uses in the resettlement areas.

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Grazing land contributes almost three quarters to the total biological capacity. This speaks to land use planning and the land uses actually practiced. The basis of land resettlement planning was on land capability (Ministry of Lands, Land Reform and resettlement, 2004) according to the agro-ecological regions. Grazing land biocapacity is a direct derivation from grazing area allocated at planning stage. This means that during the planning phase of resettlement (Chaumba et al, 2003), the best possible land uses were considered and land allocated according to the best land use practice suitable for the area. The expectation is that farmers resettled in Chirumanzu practice livestock rearing as indicated by the large share of land allocated for grazing.

The land capability anchored resettlement-planning attempts to address the land reform's twin objectives of food security and environmental sustainability. Recommending the best suitable land use to resettlement areas according to their natural resource endowment can address food security issues. That is why there are differences in recommended arable land allocations according to the natural farming regions (Ministry of Lands, Land Reform and Resettlement, 2004). This was meant at ensuring that food security is achievable, not only through crop production, but also through the best viable land use for the land concerned. That is why the government adopted the wildlife based land reform programme in 2007 to address land reform in regions where crop cultivation is unprofitable. The dry southeaster Lowveld of Zimbabwe had the pilot project of this programme.

Land reforms are also projected as seeking to ensure the sustainable use of natural resources. Considering that Chirumanzu resettlement areas have sandy soils and vleis which are expensive to cultivate (Kori, 2004), the dominance of the grazing land biocapacity makes sense. It reveals that resettlement, even after 2000, was not as haphazard as reported in the mass media. This research thus agrees with Chaumba et al, (2003) who state that *there was order in the disorder*. Under such a scenario one can actually argue that land reform in Zimbabwe reasonably attempts to address the issue of environmental sustainability.

That cropland use biocapacity is the second in the contribution to biocapacity should not come as a surprise. The A1 villagised resettlement's objective was to decongest the communal areas. Therefore, people resettled as such have little understanding of agriculture. To them agriculture, and food security, is not complete without crop cultivation. As a result, despite the poor crop cultivation qualities of the soils in the region, land had to be allocated

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for arable crop production. Many of the resettled farmers are extending their arable land beyond the recommended limits in an attempt to increase crop production.

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However, it should be noted that a large number of the resettled farms were used as cattle ranches before resettlement. The land capability characteristics of the region determined this. Where crops were cultivated it was under irrigation and with extensive artificial fertilizers use. This applies to both old and new resettlement areas. For example, in the Lynwood old resettlement scheme with 17 villages, only two used to be under crop production under irrigation before resettlement. Many parts of area are low lying, with low nutrient sandy soils while other areas are vleis which are more prone to waterlogging. Such conditions are not favourable for crop cultivation. In the new resettlement, most of the areas are too dry for rain fed crop cultivation. In the Baru, Orton's Drift and Sebakwe sections in Central Estates the soils are acidic and shallow. The dominant vegetation is Mopani trees. Such an area is, therefore, not suitable for crop cultivation. This supports a situation where cropland biocapacity is lower than grazing land.

Grazing and cropland uses are the cornerstones of the achievement of food security in land reform. Therefore, the two land uses' sustainability is critical. The grazing land and cropland biocapacity attempt to address observations by Musyoki (1999), Mohamed-Katerere (2000) and Khagram et al (2003) that the key to the success of any land reform is not only its social and economic viability, but also the land use methods to be practiced and their environmental sustainability. This comes from the observation that there was planning in accordance with the land capabilities to avoid environmental degradation. However, the Ecological Footprint will determine the achievement of environmental sustainability.

The built up land use biocapacity is the third in the hierarchy of contribution to the total biocapacity. That built-up land use was allocated more land than forestland use is a worrying situation. Built-up land use is more of *sunken* biocapacity as compared to the forestland use. No biocapacity is returnable to the environment from built-up land use. Rather it consumes biocapacity. Therefore it was as had been expected that the built-up land contributes the least biocapacity.

The least contribution to total biocapacity is from the forestland use. Though each village was planned with a 5-hectare woodlot, this was practiced in the old resettlement schemes only. Be

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that as it may, most of them are poorly managed and resource use not monitored. Therefore, the forest resources harvested in the resettlements are from natural forests.

Biocapacity statistics show that the resettled areas of Chirumanzu district are mainly suitable for livestock rearing. Crop production is mainly for subsistence purposes. This confirms the classification of the region into natural farming region III (Vincent and Thomas, 1960; Gambiza and Nyama, n.d.) and justifies why most of the farms were formerly cattle ranches before resettlement. The land capability classification and climate conditions favour livestock rearing, hence more land allocation for grazing than cropping. This is the picture biocapacity paints of land use and land capability in Chirumanzu. However, the Ecological Footprint portrays a different picture.

5.2.2 Ecological Footprint of the resettlement areas

The second objective of this research was to compute the biocapacity of Chirumanzu resettlement areas. Ecological Footprint is the demand that populations and their activities place on the biosphere in a given year, with the prevailing technology and resource management of that year. The Ecological Footprint accounting system considers the Footprint as the *withdrawal* of resources from the *balance* in the account, biocapacity. For environmental sustainability to prevail, the *withdrawal* rate should not exceed the *interest* rate on the *capital*. In this case biocapacity is the *capital* and the regenerative capacity of biocapacity is the *interest* rate.

As with biocapacity, Ecological Footprint alone does not indicate the environmental sustainability status of land uses. However it reveals the land use practices in the area of interest. Therefore a discussion of the contributions of each land use to the total Footprint can reveal the pattern of land uses actually obtaining in Chirumanzu resettlement areas.

The cropland use dominates the Ecological Footprint. It contributes more than 70% to the total Footprint. Such a situation contradicts what the biocapacity portrayed. Following the principle of environmental determinism, the ecological capabilities of Chirumanzu, as represented by biocapacity, dictate that the highest contribution to the total Ecological Footprint should be from grazing land use. However, this was not the case. Such a situation indicates two possible scenarios. The one hand is that farmers did not follow advised land use

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practices. The other hand could be that there was lack of effective communication from the relevant offices about the best land use practices suitable for the areas concerned. The second scenario can hold true to new resettlement areas where planning was haste (Chigumira, 2006; Manjengwa, 2006 and 2009; Muyengwa and Sango, 2008) and manpower shortages resulted in unqualified people allocating land (Muyengwa and Sango, 2008). This resulted in people settling in ways that disregarded the planning by the Ministry of Agriculture and later Ministry of Lands and Resettlement (Chigumira, 2006; Goebel, 2006, Manjengwa, 2006 and 2009; Chagutah, 2007). This portrays a populist angle of land reform without due consideration for environmental sustainability.

Though the Ecological Footprint has a larger contribution from cropland use than grazing land use, this may not necessarily imply that farmers deliberately defy the environmental and planning requirements. It could be a manifestation of the economic and social environmental determinism. Zimbabwe had the fastest declining economy between 2000 and 2009. The economic situation could not afford farmers the expensive livestock related inputs. In fact the price of cattle soared to unprecedented levels. On the other hand crop cultivation is cheaper and affordable. Some farmers can till their land by hand. In addition, the government also provides tillage assistance through the District Development Fund and the Operation Maguta. All these encouraged higher cropland use than grazing land use.

In addition to the economic and government policy influences, the social environment also encourages crop cultivation. Black African farmers in general and Zimbabweans in particular believe that the more land is put under crops the more respect one gets in society as a hard worker. Large expanses of cropland are regarded as a basis of better harvests and, consequently, food security. They are also regarded as an expression of interest in the land and security from underutilisation accusations which result in losing the land. As a result, farmers tend to concentrate on crop cultivation despite the adverse environmental conditions. This holds true for Chirumanzu resettled farmers.

In terms of the built up land and forestland use, forestland use generates more interest. The forestland use contributes very lowly to the total Ecological Footprint. Though each village was planned with a 5 hectare woodlot, this was implemented in the old resettlement only. The major issue, however, is the inability of households or authorities to account for forestland resource use. The resettlement areas use firewood as a source of fuel and extra income from

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wood sales. They also harvest poles for construction. However, all these uses are not managed or measurable. There is need for a stand-alone study to accurately measure how much firewood each household uses per time. The same applies to the selling of firewood and poles for construction. Therefore, the forestland Footprint is highly influenced by difficulties faced in accounting for resource use.

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5.2.3 Household biocapacity and Ecological Footprint

The third objective of this research was to compute the Ecological Footprint and biocapacity of each household. Dividing the district biocapacity and Ecological Footprint with the number of households resettled by April 2010 achieved the objective. The GFN 2010 National Footprint Accounts report provided national figures.

A direct comparison of the household Footprints and biocapacity was done for each land use type as well as the totals. For cropland, grazing land and built-up land uses Chirumanzu district had larger Ecological Footprint and biocapacity than Zimbabwe. However, for forestland use, national figures are larger than subnational figures for both Ecological Footprint and biocapacity.

That the national figures are generally lower than the district figures does not necessarily reflect on the environmental sustainability status of the nation. The figures reflect the influence of the urban households on the national Footprint accounts. It is, however, unfortunate that information for national accounts excluding the urban households is not available. This would have given a much more comparable picture. Nonetheless, the situation revealed shows that at local level, the biocapacity available is higher than at national level. The national statistics show an ecological deficit, while districts statistics report a reserve. This shows that though a national Footprint account can report an unsustainable situation, it does not mean that the whole nation is environmentally unsustainable. There are a lot of generalisations at a larger scale than at a smaller scale. Therefore, a smaller scale can be more reliable than a larger scale evaluation due to lesser generalisations.

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5.2.4 Environmental sustainability

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The final objective of this research sought to evaluate the environmental sustainability of land reform. Environmental sustainability evaluation brings together the Ecological Footprint and biocapacity. For each land use type it is important to understand how it relates to its biological capacity. The ecological surplus (reserve) shows the relationship. It is termed ecological reserve when it is positive and ecological deficit when negative.

General results reveal that Chirumanzu district has an ecological reserve. Humanity is exploiting less biocapacity than the environment can generate. Such a scenario means people are not eating into their *capital*, which is an indication of a sustainable utilisation of environmental resources.

It is important, however, to note that the household is the unit of resettlement planning. In addition, the Chirumanzu District resettlement areas are in natural farming region III suitable for extensive cattle ranching and cropping under irrigation (Vincent and Thomas, 1960; Gambiza and Nyama, n.d.). However, the Ecological Footprint tells us that the dominant land use is crop farming. Therefore, the total Ecological Footprint masks the differences obtaining between biocapacity and Ecological Footprint of individual land uses. Keeping these factors in mind, the relationship between the Ecological Footprint and biocapacity for each land use sheds light into the environmental sustainability status of land reform in Zimbabwe in general and in Chirumanzu in particular.

5.2.4.1 Grazing land use environmental sustainability

It is reasonable to expect that a land use with a larger biocapacity has a correspondingly higher Ecological Footprint. However this is not the case in the findings of this research. Cropland use has the highest Ecological Footprint while grazing land use has the largest biocapacity. While the available biocapacity points to livestock inclined agricultural practice, the Ecological Footprint points more to crop cultivation related agriculture. This points to the practice of agricultural activities that are not suitable for the agro-ecological class or region. The cropland Footprint supports the observation by Murombedzi (2005) that settlers are exploiting natural resources to open up new lands for agriculture without considering environmental consequences. However, the ecological reserve (deficit) gives the environmental sustainability condition.

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The relationship between the grazing land Footprint and biocapacity is intriguing. The results show that grazing land use has the highest Biocapacity but a very low Ecological Footprint. This results in a very high ecological reserve at both district and household level. Resettled farmers exploit only 8.4% of the grazing land Biocapacity available per household. Two deductions can be made from these statistics. First, there is a high Ecological Footprint of export in livestock resources which influences the situation. This reduces the Ecological Footprint of consumption. Second, there is a low livestock ownership in the resettlement areas.

Grazing land use has a net negative Footprint of import for the resettled areas. This means that there is significant Biocapacity exploited outside the area through exports. Considering the foregoing, it is observed that in terms of grazing resources, Chirumanzu district is significantly environmentally sustainable. However, further analysis considering the livestock ownership deduction is intriguing.

Considering the grazing land use Footprint as a proxy for livestock ownership, one can deduce that though there is environmental sustainability portrayed by the large ecological reserve, it is not by design. Land reform in Zimbabwe seeks to enhance household food security (Chitsike, 2003; Masiiwa, 2004), among other aims, through increased land use. Cropping and livestock rearing are the land uses that can guarantee food security. Thus, if livestock resources (population) were as high as arable land use, a completely different picture could be portrayed. Livestock population has a direct bearing on livestock feed demand. Livestock feed demand influences the livestock Ecological Footprint.

It is arguable, therefore that the ecological reserve is because of low livestock ownership portrayed by the very low grazing land usage. Taking the low grazing land usage into consideration can compel on to argue that grazing land use in the resettlement areas is *livestock-limited* environmentally sustainable. The *livestock-limited* sustainability culminates from the fact that grazing land usage is very low as a direct result of low or economically limited livestock ownership.

Considering that crop land use and built up land use have ecological deficits, it is conceivable that the economic inability of resettled farmers limit their ability to own

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livestock. Had the economic situation been conducive, a theoretical ecological deficit would only be averted by the Ecological Accounting system rules governing the relationship between grazing land Footprint and biocapacity. It is not practical to have a grazing land use deficit. Therefore, the rule states that if the estimated Ecological Footprint of production in the *grazing_efp* is larger than the calculated Biocapacity, calculated biocapacity caps the Ecological Footprint of production. This results in a theoretical ecological equilibrium. This research observes, therefore, that in terms of grazing land use, resettlement areas are under-utilised rather than environmentally sustainable. In light of that this research will describe the grazing land environmental condition as *livestock- limited* environmental sustainability.

5.2.4.2 Crop land use environmental sustainability

Cropland use contributes the largest proportion to the total Ecological Footprint. The cropland Ecological Footprint is larger than the biocapacity. This gives an ecological deficit. The ecological deficit reported in the cropland Footprint agrees with the observation Harts-Broekhuis and Huisman (2001) that resettlement schemes were implemented in vulnerable and agro-ecologically resource poor regions. The cropland Footprint is eating into the *capital*.

Three interpretations with significant implications on the ecological environment in the resettled areas are deductible from the ecological deficit in the cropland use. This means that Chirumanzu is either importing biocapacity as recorded in *crop_efi*, liquidating its ecological resources or emitting wastes into the environment. Results show that imports are insignificant. Therefore the situation is that settlers are clearing more land for crops (Murombedzi, 2004) than planned and crop cultivation results in the discharge of wastes into the environment. The arrows point to an environmentally unsustainable condition. Farmers are liquidating ecological resources and at the same time polluting the natural environment.

The cropland environmental sustainability status means that the regenerative capacity of the land in terms of crop production is under threat. It is under threat from two fronts created by the cropland use. One front is through over-exploitation of land. More land than planned was put under crops. Farmers think that the arable land allocated to them does not meet their demands or there are more households settled than planned and are under pressure to be productive from arable land.

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A reasonable deduction would be that more households were settled than planned and are under pressure to be productive from arable land. Farmers in the resettlement araes do not have title to the land they occupy. This is especially applicable to the new resettlement areas. Literature is pregnant with the disregard of expert planning in this regard (Chigumira, 2006; Goebel, 2006, Manjengwa, 2006 and 2009; Chagutah, 2007; Muyengwa and Sango, 2008). Untrained people became planners overnight, demarcated and allocated land to farmers during the Fast Track land Reform Programme. The emphasis was on the numbers rather than the environmental capability of the land (Manjengwa, 2006 and 2009). No wonder Fox et al., (2006) described it as a fast track to environmental degradation. Farmers settled in this way are under pressure to produce from arable land to show their interest in the land or risk forfeiture.

Cropland use environmental sustainability is of paramount importance to land reform. It has a direct bearing of food security, one of the key land reform deliverables. If there is a cropland use ecological deficit, it implied a bleak future for crop production, and hence food security. In the long run, therefore land reform would not have achieved one of its objectives. This is because the ecological environment is like a huge shock absorber. It can tolerate stress for a long time to only give in when the whole system is dilapidated. If that happens to resettlement areas, it is indicated by a huge decline in crop production because of a fall in the land productivity. Land productivity can decline because of the accumulation of artificial fertilizers in the soil or depletion of important crop nutrients from the soil caused by monoculture, common in the resettled areas. Considering that more land is already under crops, soil management practices such as fallow will be difficult to implement. Such a scenario calls for a research that can predict when the environmental ceiling will be reached.

While it is noted that land reform has increased household crop production and improved livelihoods (Deininger and May, 2000; Scoones, 2010), and income (Chaumba, et al, 2003; Zikhali, 2008) the cropland Ecological Footprint should not be misconstrued to be referring to that. The cropland Footprint is concerned with the degradation of once productive land. The Footprint refers to the environment's regenerative capacity exploited in the production of the said crops. Environmental sustainability is concerned with maintenance of the ability of the ecological environment to continue providing that capacity indefinitely. The maintenance of ecological sustainability will ensure that resettled farmers will not find themselves living in a land base with ever decreasing biocapacity. Thus, in terms of cropland use, therefore, the

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population is living unsustainably and this has a negative impact on food security in the future.

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5.2.4.3 Built-up land use environmental sustainability

This is an important but often overlooked aspect of the environment. In planning biocapacity occupied by built up land is not given the priority it deserves. Yet infrastructural development is important to the success of any land reform programme, and, hence, environmental sustainability. Infrastructural facilities promote human well-being. The quality of human life dictates human livelihood's reliance on natural resources. The poor a population is, the more it relies on natural resource extraction. A poor people prioritise its survival than environmental protection thus, compromising environmental sustainability. Such a situation is evident in Zimbabwe's resettled areas where gold panning has flourished along rivers (Manjengwa, 2006), and roadsides are littered with bundles of firewood for sale. This has resulted in the decimation of forests at an alarming rate (Ministry of Lands, Land Reform and Resettlement, 2004) and degradation and pollution of watercourses due to gold panning and gold extraction chemicals such as mercury, respectively.

The built-up land considers land used for infrastructural development. Another ecological deficit is reported in the built-up land use. That there is an ecological deficit should not be misconstrued to mean *overdevelopment* in infrastructure. Rather it points to less development. Less infrastructural development leads to environmental degradation (ZERO, n.d.).

While acknowledging that resettlement planning was not completely lost (Chaumba et al, 2003), the built-up land use Ecological Footprint seems to agree with the observation that land reform in Zimbabwe has failed to address overcrowding, but has, instead brought new ecological challenges (Chigumira, 2006; Goebel, 2006, Manjengwa, 2006 and 2009; Chagutah, 2007; Mukwada, 2007).The contributions from the different infrastructure development components into the built-up land Footprint show that homesteads consume the highest biocapacity. The Footprint can arguably be interpreted to mean that more people have been resettled than planned; recreating the communal congestion and the related environmental challenges (Mukwada, 2007).

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Cropland use and built-up land use are closely related as they link with the number of households settled. The cropland ecological deficit is largely attributable to more households resettled than planned. Therefore, an ecological deficit in the built-up land can also be attributable to more households having been resettled than planned.

Built-up area can neither be imported nor exported. Thus, an ecological deficit points to liquidation of ecological resources and environmental pollution. Therefore, in terms of the built-up land Footprint resettlement in Chirumanzu and, hence, Zimbabwe can be referred to as *recommunal* areas.

5.2.4.4 Forest land use environmental sustainability

Regarding the forestland use, the Ecological Footprint is equal to the Biocapacity. Such a situation is termed an ecological equilibrium. Households use dry firewood from dead trees. Green trees are only used for poles. The use of poles is not a daily routine and the exploitation of timber for poles is not a threat to the forests.

It should, however, be pointed out that the planning of resettlement was done with every village allocated 5 hectares for a woodlot. This was, however, applied in the old resettlement areas only. The woodlots are nonetheless poorly managed. The communal ownership system prevailing in the resettlement areas prevent effective management of resources. As such, resource use from the forests is difficult to track.

The situation with communal forests in the resettlement areas reveals the lacking priority given to the forest resources despite the government acknowledging that forests are disappearing at an alarming rate. Having reported that forests are shrinking at a rate of 100 000 to 320 000 per year (Ministry of Lands, Land Reform and Resettlement, 2004), forest resources clearly need more attention than just planning on paper.

The initiatives expressed in the resettlement planning need institutional support for effective implementation. Despite the establishment of the Environmental Management Agency (EMA) and the Forestry Commission as well as their inclusion in the District Lands Committee, these institutions are not visible in the resettled areas. These institutions should champion sustainable forest resources use practices to avert the extinction of forests.

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Following the discussion of the environmental sustainability at individual land uses level, it is logical to fit the findings into the land reform conceptual framework. Though the whole district would bring a biocapacity larger the Ecological Footprint, individual land uses need attention. Cropland use and built-up land need intervention measures. Therefore, in concluding this research, it is important to consider that the overall district environmental sustainability situation masks important detail revealed at land use level.

5.3 Conclusions

This study's objective was to evaluate the environmental sustainability of land reform in Chirumanzu district. The research assumption was that land use practices significantly influence environmental sustainability of land reform in Zimbabwe. This meant that it focused on resettled areas of the district. To determine the environmental sustainability of the land reform, the study employed the Ecological Footprint system. The Ecological Footprint required the calculation of Biocapacity and Ecological Footprint of the four land use types under consideration in the study area. The identified land uses were cropland use, grazing land use, forestland use and built-up land uses.

The study concludes that, from the Ecological Footprint accounting system, land reform in Zimbabwe is generally environmentally sustainable. There is a symbiotic relationship between land reform and environmental sustainability. That relationship needs recognition at all levels of the land reform process. However, a generalisation of results masks the different situations that were obtaining on the ground. Different land uses present different ecological conditions.

The different ecological conditions portrayed by different land uses reveal that land reform in Zimbabwe was driven by socio-politico-economic imperatives. The social imperative aimed at addressing the historical injustices of the colonial period. The removal of African people from their land during the colonial period also resulted in their economic deprivation since they were settled in ecologically resource poor regions. They were deprived of their economic means of production. In the same breath, politicians carried out land reform in Zimbabwe to fulfil their political promises of the liberation struggle and maintain grassroots

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support. In so doing the ecological environment became a victim. The ecological pictures painted by different land uses portray this.

The grazing land use showed a huge ecological reserve. That resettled households exploit less than 10% of the calculated biocapacity indicates lack of livestock than careful environmental planning and management. This shows that beneficiaries were resettled to address the social and economic injustices of the past as well as for politicians to gain political mileage with the rural poor. In that light, it is concluded that the grazing land use was *livestock-limited* environmentally sustainable.

Cropland use revealed an ecological deficit. Considering that resettlement was planned and each household allocated grazing and arable land, an ecological deficit should not be the result. However, the planning process in the Fast Track phase, which settled more than 80% of households in Chirumanzu, was command driven (Chigumira, 2006; Muyengwa and Sango, 2008). This resulted in more households being resettled than planned. The resettled households had to show their interests in the land through exploiting the allocated arable land. This resulted in a twin dilemma of more households clearing more land than allocated, hence an ecological deficit. This is an environmentally unsustainable condition.

Built-up land considers biocapacity occupied by infrastructural development. The ecological deficit reported in this land use points to the poor planning exhibited in the fast Track Land Reform programme. More households were resettled than planned. It is, therefore concluded that land reform in Zimbabwe was done to settle as many household as possible without environmental considerations.

Forestland use reveals an ecological equilibrium. However the government concedes that forests are disappearing at an alarming rate. Every village was planned with an allocation of a 5 hectare woodlot. This was implemented in the old resettlement only. The woodlots in the new resettlement are poorly managed and resource exploitation is difficult to trace. It is therefore, concluded that forest resources are neglected in the resettlement areas of Zimbabwe. The communal ownership of the woodlots makes management difficult and resource use difficult to track.

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These observations need attention in order for environmental sustainability in land reform to be achieved. The attainment of environmental sustainability in land reform will allow other land reform objectives to be achievable. Without environmental sustainability all the land reform accomplishments will be short term. Therefore, the following recommendations are proposed.

5.4 Recommendations

Land reform in Chirumanzu district is generally environmentally sustainable. Nonetheless, an analysis of the environmental sustainability status of individual land uses shows that though land reform is environmentally sustainable, there are some areas which need attention. It is important to understand that there is a strong symbiotic relationship between the environment and land reform. Considering the ecological situations portrayed by the cropland and built-up land uses, one would say land reform is needed to improve the environmental sustainability of rural land use practices. Therefore, there is a strong need to entrench the environmental sustainability inscription to the land reform process. The environmental sustainability dimension of land reform is as important as the social and economic dimensions. The three should not be separable if a land reform process has to succeed.

Cropland and built-up land uses have an ecological deficit. It has been observed that the ecological deficits could be a result of the poor implementation of the resettlement plan by the *overnight* land allocators in the Fast Track land Reform. This has resulted in more households being resettled than planned. These households are also under pressure to prove that they need the land, thus resulting in an ecological deficit.

In light of the above, it is recommended that an audit be carried out to ascertain the number of households settled against the planned. The audit should also check the acreage each household would have put under crops against the planned acreage. It is also recommended that the relevant government departments encourage households to stick to the allocated land use limits. To avoid pressure on households to produce from arable land even if the environmental conditions do not permit, it is recommended that land use diversity be encouraged. Crop cultivation is not the only land use that can sustain livelihoods. Government should follow up and implement the proposed wildlife based land reform it adopted in 2007, for example.

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When crop production is practiced in unsuitable environmental conditions, yields are often low. Subsistence farmers naturally turn to increase more acreage in an attempt to increase yields. Education and agricultural resources should be availed to farmers to encourage intensive rather than extensive land uses.

There, is insecurity of tenure, as a result, the land reform beneficiaries may not be willing to venture into land use practices which take longer to show results lest they are accused of underutilisation of land and will lose it. In addition, the lack of secure ownership discourages and prohibits long-term and sometimes risky investment. Farmers cannot use the land as collateral to get loans from banks to invest in the land forcing them to resort to the cheapest land use practice, crop cultivation. Therefore, it is recommended that the government give secure tenure to land owners in resettlement areas.

It is also observed that the environmental sustainability shown in the grazing land use is *livestock-limited*. Therefore, this study recommends that conditions be improved for resettled farmers to acquire livestock. This could be improved through securitisation of their land tenure to enable them to use the land as collateral to secure loans for livestock purchasing. The government can also implement the revolving heifer project in partnership with the private sector and Non-profit Organisations. This project loans heifers to and the farmer will pass on the first calf to a next beneficiary, keeping the original cow as his own. Such projects can give responsibility to the farmer because of the prospect of owning cattle.

Concerning forestland use, it was observed that this is the most neglected wing of the land reform process. Despite its inclusion in the land use plans, it was not implemented. The government institutions tasked with overseeing the protection of forests are invisible. The institutions should be more active and encourage sound natural resource management practices in the resettled areas. It is recommended that EMA and Forestry commission carry out environmental impact accounts of resettled areas periodically for continuous improvement. They should keep natural resource inventories for each resettlement scheme.

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5.5 Recommendation for further research

The ecological conditions portrayed by each of the four land uses present areas for further research. It is intriguing to explore the possibilities available to the resettled areas for addressing the issues of the ecological deficit in cropland use, which have a direct bearing on food security. Though the overall Footprint portrays an environmentally sustainable situation, it does not shoe the extent of the sustainability. Therefore, a study which can reveal the extent of sustainability can contribute significantly to the debate of environmental sustainability of land reform.

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Appendix 1: Crop Production in the Resettlement (*prodstat_crop_r*)

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Level 5

Name	Area	Production
[-]	[ha]	[t yr^{-1}]
Maize	17032	15488
Finger millet	370.55	130
Sorghum	184.5	43.65
Pearl Millet	19.41	3.89
Ground nuts	1847.2	936.12
Bambara Nuts	1065.5	523.15
Sugar beans	276.3	136.1
Cow peas	260.51	96.513
Sunflower	73.7	33.73
Soya beans	105.76	58.33
Sweet potatoes	260.2	533.32
Rice	31.2	8.68
Tobacco	89.7	128.8
Cotton	18.1	11.9
Wheat	22.1	66.3

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Appendix 2: Crop Production in the District (*Fodstat_crop_d*)

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Level 5

Name	Area	Production
[-]	[ha]	[t yr^{-1}]
Maize	32763	21990
Finger millet	2292	342.5
Sorghum	1624	244.2
Pearl Millet	320	42
Ground nuts	6176	2834
Bambara Nuts	2039	776
Sugar beans	316	141
Cow peas	440	132
Sunflower	163	75.23
Soya beans	179	67
Sweet potatoes	364	586
Rice	71	17
Tobacco	132	192
Cotton	23	10.5
Wheat	196	588

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Appendix 3: Crop Trade in the Resettlement (*tradestat_r*)

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Level 5

Name	Import + Food Aid	Export + Food Aid
[-]	[t yr-1]	[t yr-1]
Maize	88	246.7
Cattle (live)	306	266.5
Cattle meat		59.57
Sorghum		0.11
Goat (live)		0.4
Goat meat		0.02
Sugar beans		0.16
Cow peas		2.14
Sunflower		0.15
Pigs (live)		0.03
Pig meat		6
Sheep (live)		0.05
Tobacco		128.8
Cotton		11.9
Wheat		8.49

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Appendix 4: Crop Yield in the Resettlement (*crop_yield_r*)

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Level 4

Name	Production	Area	Yield
[-]	[t yr^{-1}]	[ha]	[t wha ha^{-1}]
Maize	15488	17032	0.91
Finger millet	130	370.55	0.35
Sorghum	43.65	184.5	0.24
Pearl Millet	3.89	19.41	0.2
Ground nuts	936.12	1847.2	0.51
Bambara Nuts	523.15	1065.5	0.49
Sugar beans	136.1	276.3	0.49
Cow peas	96.513	260.51	0.37
Sunflower	33.73	73.7	0.46
Soya beans	58.33	105.76	0.55
Sweet potatoes	533.32	260.2	2.05
Rice	8.68	31.2	0.28
Tobacco	128.8	89.7	1.44
Cotton	11.9	18.1	0.66
Wheat	66.3	22.1	3

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Appendix 5: Crop Yield in the District (*crop_yield_d*)

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Level 4

Name	Production	Area	Yield
[-]	[t yr^{-1}]	[ha]	[t wha ha^{-1}]
Maize	21990	32763	0.67
Finger millet	342.5	2292	0.15
Sorghum	244.2	1624	0.15
Pearl Millet	42	320	0.13
Ground nuts	2834	6176	0.46
Bambara Nuts	776	2039	0.38
Sugar beans	141	316	0.45
Cow peas	132	440	0.3
Sunflower	75.23	163	0.46
Soya beans	67	179	0.37
Sweet potatoes	586	364	1.61
Rice	17	71	0.24
Tobacco	192	132	1.46
Cotton	10.5	23	0.46
Wheat	588	196	3

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Appendix 6: Cropland Ecological Footprint Production(*crop_efp*)

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Level 3

Name	Production	Yield	EQF	EF_P
[-]	[t yr^{-1}]	[t wha ha^{-1}]	[t wha ha^{-1}]	[gha]
Maize	15488	0.67	2.51	57918.47
Finger millet	130	0.15	2.51	2184.07
Sorghum	43.65	0.15	2.51	728.95
Pearl Millet	3.89	0.13	2.51	74.36
Ground nuts	936.12	0.46	2.51	5120.2
Bambara Nuts	523.15	0.38	2.51	3450. 1
Sugar beans	136.1	0.45	2.51	765.6
Cow peas	96.513	0.3	2.51	807.49
Sunflower	33.73	0.46	2.51	183.45
Soya beans	58.33	0.37	2.51	391.15
Sweet potatoes	533.32	1.61	2.51	831.5
Rice	8.68	0.24	2.51	91.01
Tobacco	128.8	1.46	2.51	222.27
Cotton	11.9	0.46	2.51	65.43
Wheat	66.3	3	2.51	55.471
Total Crop products				**72889.53**

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Appendix 7: Cropland Ecological Footprint of Export(*crop_efe*)

Level 3

Name	Export	Yield	EQF	EF_E
[-]	[t yr^{-1}]	[t wha ha^{-1}]	[t wha ha^{-1}]	[gha]
Maize	246.7	0.67	2.51	922.55
Finger millet				
Sorghum	0.11	0.15	2.51	1.84
Pearl Millet				
Ground nuts				
Bambara Nuts				
Sugar beans	0.16	0.45	2.51	0.9
Cow peas	2.14	0.3	2.51	17.9
Sunflower	0.15	0.46	2.51	0.82
Soya beans				
Sweet potatoes				
Rice				
Tobacco	128.8	1.46	2.51	222.27
Cotton	11.9	0.46	2.51	65.43
Wheat	8.49	3	2.51	7.1
Total Exports				**1238.81**

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Appendix 8: Cropland Ecological Footprint of Import (*crop_efi*)

Level 3

Name	Import	Yield	EQF	EF_I
[-]	[t yr^{-1}]	[t wha ha-1]	[t wha ha-1]	[gha]
Maize	88	0.67	2.51	329.08
Finger millet				
Sorghum				
Pearl Millet				
Ground nuts				
Bambara Nuts				
Sugar beans				
Cow peas				
Sunflower				
Soya beans				
Sweet potatoes				
Rice				
Tobacco				
Cotton				
Wheat				
Total Imports				**329.08**

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Appendix 9: Livestock Production in the Resettlement (*prodstat_livestock_r*)

Level 5

Name	Production	Heads	Yield
[-]	[t yr^{-1}]	[head]	[t wha^{-1} yr^{-1}]
Cattle Hides	22.75	1300	0.02
Cattle meat	139.04	1300	0.11
Goat meat	0.02	2	0.01
Goatskins	0.01	2	0.003
Pig meat	7.19	249	0.03

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Appendix 10: Grazing Constants (*cnst_grazing*)

Level 5

Name	Unit	Value	Notes
[-]			All livestock are expressed as a fraction of TLU. Each Tropical Livestock Unit is 250 Kg.
Cattle	[t head $^{-1}$]	1	
Goats	[t head $^{-1}$]	0.1	
Sheep	[t head $^{-1}$]	0.1	
Pig	[t head $^{-1}$]	0.2	
Poultry	[t head $^{-1}$]	0.01	
Cattle hide	[%LW]	7	
Goat skin	[%LW]	11	
Sheep Skin	[%LW]	11	
Cattle Dressing	[%LW]	62	
Cattle Cutting Yield	[%Carcass]	69	
Goat Dressing	[%LW]	54	
Goat cutting Yield	[%Carcass]	73	
Sheep Dressing	[%LW]	54	
Sheep Cutting Yield	[%Carcass]	73	
Pig Dressing	[%LW]	74	
Pig Cutting Yield	[%Carcass]	78	

Appendix 11: Livestock feed demand in the district (*feed_demand_d*)

Level 4

Name	Heads	Feed Intake	Feed Demand
[-]	[head]	[kg dm head^{-1} day^{-1}]	[t dm yr^{-1}]
Cattle	16921	6.25	38579.88
Goat	4603	0.81	1360.13
Sheep	808	0.81	238.75
Donkey	526	6.25	1199.28
Chicken	11234	2.8085	11509.69
Pig	1044	5.22	1988.04

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Appendix 12: Crop residue Supply in the Resettlement (*residue_supply_r*)

Level 4

Crop Name	Production	Area	Dry fodder yield	Residue Feed	Yield
[-]	[t yr^{-1}]	[ha]	[t ha^{-1}]*	[t]	[t wha ha^{-1}]
Maize	15488	17032	13.5	1261.63	0.07
Finger millet	130	370.55	6.55	56.57	0.15
Sorghum	43.65	184.5	13.95	13.23	0.07
Pearl Millet	3.89	19.41	6.55	2.96	0.15
Ground nuts	936.12	1847.2	4.15	445.11	0.24
Bambara Nuts	523.15	1065.5	2.9	367.41	0.34
Sugar beans	136.1	276.3	2.9	95.28	0.34
Cow peas	96.51	260.51	2.9	89.83	0.34
Sunflower	33.73	73.7			
Soya beans	58.33	105.76	2.9	36.47	0.34
Sweet potatoes	533.32	260.2			
Rice	8.68	31.2	9	3.47	0.11
Tobacco	128.8	89.7			
Cotton	11.9	18.1	0		0.00
Wheat	66.3	22.1	4.4	5.02	0.23
Total	18198.48	21656.73		2376.98	0.11

* Class mark constant figures (Source: Reddy et al., 2003)

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Appendix 13: Grazing land Ecological Footprint of Production (*grazing_efp*)

Level 3

Name	Feed supply	Feed Demand	Yield	EQF	Est EF_P	EF_P
[-]		[t dm yr^{-1}]	[t wha ha^{-1}]	[t wha ha^{-1}]	[gha]	[gha]
Residue Feed	2376.98		no figures needed			
Market Feed						
Cropped Grass Feed						
Total Feed demand		54875.78				
Pasture Grass demand		52498.80	2.57	0.79	16121.69	16121.69

Appendix 14: District Livestock Feed intensity (*feed_intensity_d*)

Level 5

Product Name	Yield	EQF	Intensity
[-]	[t wha^{-1} yr^{-1}]	[gha wha^{-1}]	[gha t^{-1}]
Maize	0.07	2.51	33.89
Rice Bran	0.11	2.51	22.59
Sorghum	0.07	2.51	35.01
Soy Meal	0.34	2.51	7.28
Soybeans	0.34	2.51	7.28
Sunflower Meal	0.46	2.51	5.44
Sunflower seed			
Wheat	0.23	2.51	11.04
Fish Meal			
Other Concentrate Feed			
Grass	0.74	0.46	0.62
Crop Residue	0.11	2.51	22.87

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Appendix 15: Feed Mix in the resettlement areas (*feed_mix_r*)

Level 5

Name	Grass %	Crop %	Crop Total	TFR	Maize	Sorghum	Fish Meal	soya cake	Wheat	Other Concentrate Feed	Grass	Grass crops	Crop residue
[-]	[-]	[-]	tF t LW^{-1}	tF t LW^{-1}	tF t LW^{-1}	tF t LW^{-1}	tF t LW^{-1}	tF t LW^{-1}	tF t LW^{-1}	tF t LW^{-1}	[-]	tF t LW^{-1}	tF t LW^{-1}
Cattle	99.99	0.00279412	0.19	68							13.11		0.19
Chickens		100	1.70	3	0.63	0.28	0.03	0.34		0.42			0.12
Donkey	99.99	0.00191176	0.13	68							8.97		0.13
Goats	100	0	0.00	38							38		
Pigs		100	1.72	3	0.77	0.18	0.03	0.22	0.07	0.45			0.12
Sheep	100			23							23		

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Appendix 16: District Livestock intensity (*livestock_intensity_d*)

Level 4

Name	Intensity	Intensity Crop	Intensity Grazing	Maize	Sorghum	Soya cake	Wheat	Grass	Crop residue
[-]	[gha (t d)$^{-1}$]	[gha (t d)$^{-1}$]	[gha (t d)$^{-1}$]	[gha (t d)$^{-1}$]	[gha (t d)$^{-1}$]	[gha (t d)$^{-1}$]	[gha (t d)$^{-1}$]	[gha (t d)$^{-1}$]	[gha (t d)$^{-1}$]
Cattle	12.49	4.35	8.15					8.15	4.35
Chickens	36.37	36.37		21.35	9.80	2.47			2.74
Donkey	8.55	2.97	5.58					5.58	2.97
Goats	23.62		23.62					23.62	
Pigs	37.51	37.51		26.09	6.30	1.60	0.77		2.74
Sheep	14.30		14.30					14.30	

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Appendix 17: Livestock Ecological Footprint of Imports (*livestock_efi*)

Level 3

Product Name	Import	Total	Crop feed Total	Other Concentrate Feed	Grass
[-]	[t yr^{-1}]	[gha]	[gha]	[gha]	[gha]
Cattle (live)	306	3823.32	1329.59		2493.74
Chickens					
Donkeys					
Goats					
Pigs					
Sheep					

Appendix 18: Livestock Ecological Footprint of Export (*livestock_efe*)

Level 3

Product Name	Export	Total	Crop EF_E	Grazing EF_E
[-]	[t yr^{-1}]	[gha]	[gha]	[gha]
Cattle (live)	266.50	3329.79	1157.96	2171.83
Cattle meat	59.57	744.30	258.83	485.46
Donkeys				
Goats (live)	0.40	9.45		9.45
Goat meat	0.02	0.47		0.47
Pigs (live)	0.30	11.25	11.25	
Pig meat	6.00	225.08	225.08	
Sheep (live)	0.05	0.71		0.71

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Appendix 19: Forest Production in Resettlement (*prodstat_forest_r*)

Level 5

Name	Production	Imports	Exports
[-]	[t]	[t]	[t]
Timber Products	4848.71		
Wood Fuel	19394.85		

Appendix 20: Forest yield in the Resettlement(*forest_yield_r*)

Level 4

Name	Production	Area	Yield
[-]	[t]	[ha]	[t wha^{-1} yr^{-1}]
Timber Products	4848.71	305.82	15.86
Wood Fuel	19394.85	1223.28	15.86

Appendix 21: Forestland Ecological Footprint of Production (*forest_efp*)

Level 3

Name	Production	Yield	EQF	EF_P
[-]	[t]	[t wha^{-1} yr^{-1}]	[wha ha-1]	[gha]
Timber Products	4848.71	15.86	1.26	481.67
Wood Fuel	19394.85	15.86	1.26	1926.67

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Appendix 22: Land uses in the Resettlement (*land_use*)

Level 5

Source	Land Type	Description	Area
[-]	[-]	[-]	[ha]
AGRITEX; Min. of Lands; researcher.	Crop Land	Arable land for crops	20820.5
AGRITEX; Min. of Lands; Vet. Dept.; researcher	Grazing Land	Pastures for livestock	160619.35
AGRITEX; Min. of Lands; researcher	Forest Land	Forest area	1529.1
Min. of Lands; CRDC; DDF; Roads Dep't; DA.; researcher.	Infrastructure	Built land	4624.5

Appendix 23: Infrastructure Ecological Footprint of Production (*infrastructure_efp*)

Level 3

Name	Area	Yield Factor	EQF	EF_P
[-]	[ha]	[wha ha-1]	[wha ha-1]	[gha]
Roads	803.5	1.34	2.51	1505.06
Service Centre	535	1.34	2.51	1002.13
Health Institutions	4	1.34	2.51	7.49
Homesteads	2706	1.34	2.51	5068.70
Schools	576	1.34	2.51	1078.93
Total	**4624.5**	**1.34**	**2.51**	**8662.31**

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Appendix 24: Yield Factors for Crops (y_{Crop})

Name	$Area_R$	$Area_D$	Yield Factor
[-]	[ha]	[wha]	[wha ha^{-1}]
Maize	17032	23116.42	1.36
Finger millet	370.55	866.67	2.34
Sorghum	184.5	291.00	1.58
Pearl Millet	19.41	29.92	1.54
Ground nuts	1847.2	2035.04	1.10
Bambara Nuts	1065.5	1376.71	1.29
Sugar beans	276.3	302.44	1.09
Cow peas	260.51	321.71	1.23
Sunflower	73.7	73.33	0.99
Soya beans	105.76	157.65	1.49
Sweet potatoes	260.2	311.25	1.20
Rice	31.2	36.17	1.16
Tobacco	89.7	88.83	0.99
Cotton	18.1	25.87	1.43
Wheat	22.1	22.10	1.00
Total	**21656.73**	**29055.11**	**1.34**

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Appendix 25: Permission – Ministry of Agriculture

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All correspondence should be addressed to the Director
Department of Agricultural Technical and Extension Services

MINISTRY OF AGRICULTURE, MECHANISATION AND IRRIGATION DEVELOPMENT

AGRITEX
Head office
No. 1 Borrowdale road
Ngungunyana building
Harare

P.O. Box CY 2505, Harare, Zimbabwe Tel: (+263) 04-791355

Ref:

1 February 2011

The District Agricultural Extension Officer

Chirumanzu District

Re: REQUEST FOR PERMISSION TO ADMINISTER A MASTERS RESEARCH QUESTIONNAIRE

The attached letter refers.

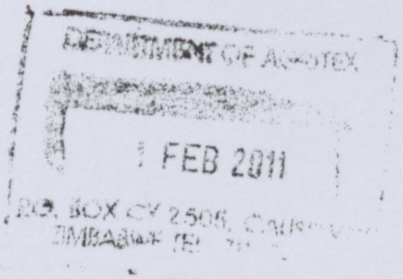
Please can you kindly assist the student.

B. Mache

Acting Director Technical Services

FOR PRINCIPAL DIRECTOR

AGRITEX



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Appendix 26: Permission – District Administrator

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COM/GEN

District Administrator's Office,
P.O. Box 63,
MVUMA.

13 April, 2011.

The Chief Executive Officer - CRDC
.....
I. O. C Mvuma ZRP
.....
Council Chairman
.....
All Headmens and Village Heads
.....
Chief Chirumanzu
.....
Chief Hama
.....

RE: APPROVAL FOR MASTERS RESEARCH PROPOSAL FOR EDMORE KORI (11606872)

The District Administrator's has no objection whatsoever for Edmore Kori, a Masters Student at Venda University. His proposed topic is;

An Assessment of the environmental sustainability of the land reform programme in Zimbabwe: A case study of Chirumanzu District.

This letter, serves as permission for the research to be carried out in Chirumanzu District. The research will be for academic purposes only.

Your assistance to this study is greatly appreciated.

Thank you.

DISTRICT ADMINISTRATOR
LOCAL GOVT P.W & N.H
13 APR 2011
P.O. BOX 63, MVUMA
ZIMBABWE

CHINGWE R.
ACTING DISTRICT ADMINISTRATOR.

Cc Lands
Cc Agritex
Cc Chief Hama
Cc Chief Chirumanzu n

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Appendix 27: Permission – Ministry of Lands and Rural Resettlement

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All correspondence should be addressed to

"THE SECRETARY"

TELEPHONE:

797325-30/ 794242-9/ 701163/ 701166

FAX: 797335

ZIMBABWE

MINISTRY OF LANDS AND RURAL RESETTLEMENT
Block 2, Makombe Building

Private Bag 7779

Causeway

Harare

REF: P/KORI E.

19 April 2011

Mr Edmore Kori
C/O University of Venda
P. Bag X 5050
Thohoyandou 0920
South Africa

PERMISSION TO ADMINISTER A MASTER'S RESEARCH QUESTIONNAIRE: MR E. KORI: LAND OFFICER: MASHONANALND CENTRAL PROVINCE

Reference is made to your application letter dated 26 January 2011 on the above subject.

Please be advised that the Secretary for Lands has granted you permission to administer a research questionnaire on the evaluation of the environmental sustainability of the land reform in Zimbabwe, a case study of Chirumanzu District.

The research and findings should be used for academic purposes only. Furthermore, you are to provide the Ministry with a copy of your Research Report upon completion of the investigation research.

B. Zvigadza
FOR SECRETARY FOR LANDS AND RURAL RESETTLEMENT

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Appendix 29

Household Questionnaire

Research topic: An evaluation of environmental sustainability of land reform in Zimbabwe: A case study of Chirumanzu District.

ADMINISTRATION

Administered by..... Date...../...../2011

Administered at..... **Questionnaire No.....**

SECTION A: DEMOGRAPHIC CHARACTERICTICS OF HEAD OF HOUSEHOLD (tick appropriate box)

Sex	Male	Female	**Age**	<20	21 to 30	31 to 40	41 to 50	51 to 60	>60

Marital status	Single	Married	Widowed	Separated

Highest educational level	Grade 7	Junior Certificate	Ordinary Level	Advanced Level	Tertiary

SECTION B: ECOLOGICAL FOOTPRINT INFORMATION

1. Farm name ..... Stand Number.....

2. Area where homestead is built.....ha. 3. Area cleared for cultivation.....ha

4. Livestock ownership

Livestock type	Number	Bought 2010	Sold 2010	Grazing (tick appropriate box)*				Watering (tick appropriate box)*			
				a	b	c	d	a	b	c	d
Cattle											
Donkey											
Goat											
Sheep											
Horse											
Other: Specify.....											

*a=within household plot; b=within farm; c=next farm; other: specify

5. Crops grown, fertilisers and pesticides used in 2010

Name of Crop	Fertilizers used	Qnity (Kg)	Pesticides used	Qnty
1				
2				
3				
4				
5				

6. Area cultivated, crop production and consumption in 2010

Crop	Harvest and Consumption				
	Area (Ha)	Production (t)	Food aid received (t)	Bought (t)	Sold (t)
1					
2					
3					
4					
5					

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7. Land allocated and requirements

Land use	Requirement (ha)	Allocated (ha)
Crops		
Livestock		
Homestead		
Conservation		
Other: Specify.....		

8. Which natural resource(s) is (are) highly used in your area? Why is that so?

Natural resource	Uses of the natural resource	Sources (tick appropriate box)*			
		a	b	c	d
1					
2					
3					
4					
5					

*a=within individual plot; b=within farm; c=neighbouring farm; d=other: specify.

9. How is (are) the use of the resource(s) managed?

Natural resource	Management strategy/ system	Responsible authority
1		
2		
3		
4		
5		

10. Dou you think the management strategy mentioned in 11 above will save the resource(s) from overexploitation. Y/N. Give reasons for your answer.

Y	N

.....

.....

11. Firewood use in the household.

Number of bundles of firewood (per week/ month)	Average bundle weight (kg)		Source of firewood (tick appropriate box)	
.....bundles per week/month*	Wet wood		Within household plot	Within farm
	Dry wood		Neighbouring farm	Other: Specify

*delete the inapplicable

12. How do you think natural resources in your area should be managed? Who should be responsible?

Natural resource	Management strategy	Responsible authority
1		
2		
3		
4		
5		

13. How do you think environmental management can be improved in your area?

.....

.....

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Appendix 29

Questionnaire for District Lands Officer

Research topic: An evaluation of environmental sustainability of land reform in Zimbabwe: A case study of Chirumanzu District

ADMINISTRATION

Administered by.....Date...../...../2011

Administered at..... **Questionnaire No.....**

SECTION A: GENERAL LAND REFORM INFORMATION

1. Total area and households per land reform scheme

Scheme	Area			Population (households)		Totals
	Arable	Grazing	Conservation	Planned	Settled	
Old resettlement (old reset)						
New resettlement (A1 villagised) (new reset)						
District						

2. Land uses area for schemes (actual)

Scheme	Land use area			
	Arable	Built up	Grazing	Conservation
Old Res.				
New Res.				
District				

3. Government recommended (planned) area allocation for land uses.

Scheme	Land use area allocation			
	Arable	Built up	Grazing	Conservation
Old Res.				
New Res.				

SECTION B: ECOLOGICAL FOOTPRINT INFORMATION

4. Land under infrastructure in the resettlement areas 2010

Type of infrastructure	Area		
	Old resettlement	New resettlement	District
Schools			
Roads			
Service centre			
Other specify			

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5. Livestock grazing per livestock unit

Livestock	Area requirements			
	Intensive	Semi-intensive	Semi-extensive	Extensive
Cattle				
Goat				
Sheep				
Donkey				
Other Specify.....				

6. Available area for livestock

Livestock	Area available and population		
	Area Avail.	Pop	Deficit (surplus)
Goats			
Sheep			
Donkeys			
Other Specify.....			

7. Area reserved for conservation per village (ha)

Scheme	Intensive	Semi-intensive	Semi-extensive	Extensive
Old Rest.				
New Rest.				

8. How does land reform policy accommodate environmental sustainability?.....
9. What is the policy on conservation of natural resources in the resettlement areas?.....
10. How does the policy ensure environmental sustainability?.....
11. How is the policy on conservation of natural resources in resettlement areas administered?.....
12. What do you think are the improvements needed in the implementation of the policy on conservation in resettlement areas to ensure environmental sustainability?.....
13. Which natural resource(s) is (are) in high demand in resettlement areas?.....
14. What are the measures taken to avoid overuse of these resources?.....
15. How does land reform conform to the Intensive Conservation Plan? .....

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Appendix 10

Questionnaire for DAEO

Research topic: An evaluation of environmental sustainability of land reform in Zimbabwe: A case study of Chirumanzu District.

ADMINISTRATION

Administered by.....

Date...../...../2011 **Questionnaire No.....**

Administered at.....

SECTION A: GENERAL LAND REFORM INFORMATION

1. Area and households per land reform scheme.

Scheme	Area				Population (households)	
	Arable	Grazing	Home stead	Conservation	Planned	Settled
Old resettlement (old reset)						
New resettlement (A1 villagised)						

2. Ideal or recommended area allocation for land reform in the district.

Land use type	Area allocation			
	Intensive	Semi-intensive	Semi-extensive	Extensive
Arable				
Built up				
Grazing				
Conservation				

SECTION B: ECOLOGICAL FOOTPRINT INFORMATION

3. Crops grown in the district in 2010.

Crop	Fertilizers used		Chemicals used	
	Name	Qnty per ha (t)	Name	Qnty per ha (t)
	a.		i.	
	b.		ii.	
	c.		iii.	
	a.		i.	
	b.		ii.	
	c.		iii.	
	a.		i.	
	b.		ii.	
	c.		iii.	

4. Crop production

Crop	Old Resettlement			New Resettlement			District		
	Area (Ha)	Production (t)	Yield (t/ha)	Area (Ha)	Production (t)	Yield (t/ha)	Area (Ha)	Production (t)	Yield (t/ha)

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5. Area reserved for conservation (forests) per village (ha)

Scheme	Intensive	Semi-intensive	Semi-extensive	Extensive	Totals
Old Rest.					
New Rest.					
District					

6. What is the policy on conservation of natural resources in the resettlement areas?.....
7. How does the policy ensure environmental sustainability?.....
8. How is the policy on conservation of natural resources in resettlement areas administered?.....
9. What do you think are the improvements needed in the implementation of the policy on conservation in resettlement areas to ensure environmental sustainability?.....
10. Which natural resource(s) is (are) in high demand in resettlement areas?.....
11. What are the measures taken to avoid overuse of these resources?.....
12. How does land reform conform to the Integrated Conservation plan?.....

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