

**THE IMPACT OF NANDONI DAM CONSTRUCTION ON SELECTED  
INDIGENOUS PLANT SPECIES DIVERSITY: A CASE STUDY IN THULAMELA  
MUNICIPALITY WITHIN VHEMBE DISTRICT OF LIMPOPO PROVINCE, SOUTH  
AFRICA**

**By**

**Ntevheleni, Justice Thovhogi**

**Student number: 8300708**

A dissertation submitted in fulfilment of the requirements for the degree of Master's  
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Venda

**SUPERVISOR: PROF. B.D.O. ODHIAMBO**

**CO- SUPERVISOR: MR. M.H. LIGAVHA-MBELENGWA**

**CO- SUPERVISOR: DR. M.J. MOKGOEBO**

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## **Dedication**

I dedicate this dissertation to the Thovhogi family and my grandchildren.

## Declaration

I, **Thovhogi, Ntevheleni Justice** hereby declare that the dissertation for the Master's 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 in execution, and that all materials contained therein have been duly acknowledged by complete references.

Signature:  Date: 04/08/2023

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## **Abstract**

The study assessed the impact of Nandoni Dam construction on selected indigenous plant species (IPS) diversity: A case study in Thulamela Municipality within Vhembe District. The construction of Nandoni Dam started in 1998 and was completed in 2005. The research focused on the following three specific objectives: to examine the selected IPS diversity before dam construction, to determine whether some selected IPS diversity were protected after dam construction, and to assess the community's perceptions on the need to develop long-term management plans for the conservation of selected IPS diversity.

The literature reviewed concentrated on the background of the study, problem statement, justification of the study, Environmental Impact Assessment (EIA), and other studies. Under the methodology of data collection and research design, both qualitative and quantitative methodologies were used. Primary data collection includes field surveys, interviews, and observations. Secondary data were collected from documentary reviews, library books, published articles, theses, *etc.* Permission was requested and granted by the traditional leaders of Tshiulungoma, Budeli, Dididi, and Mulezhe villages, which were affected by the construction of Nandoni Dam.

For systematic data analysis, the researcher used Statistical Package for the Social Sciences (SPSS) Version 25, narrative, and ethnography. Government officials were visited and communicated face-to-face and telephonically. Ethical consideration was granted by UHDEC. Results: Documentation of selected IPS diversity before 1998; photos of submerged and protected selected IPS diversity after dam construction in 2005. Recommendation: Community environment alliance, public community education on EIA reports, and conservation of selected IPS diversity.

Keywords: Assessment, Conservation, Construction, Impact, Nandoni Dam, Selected Indigenous Plant Species diversity

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## CHAPTER ONE: BACKGROUND TO THE STUDY

### 1. 1. Introduction

This research aimed at assessing the impact of Nandoni Dam construction on selected indigenous plant species (IPS) diversity: A case study in Thulamela Municipality within Vhembe District of Limpopo Province, South Africa. The construction of dams in South Africa and worldwide is generally associated with the provision of drinking water to communities and animals while preserving downstream and upstream plant communities and irrigation to grow food. Barriers built across rivers hold back water to form a lake behind the walls. This water could be used for industrial supply and the management of demand downstream during periods of low flow. Approximately 800 000 dams are currently in operation worldwide, with 50 000 dams considered large with a height of more than 15 meters (Collier, 2009). South Africa receives less than 500 mm of rainfall per year, being one of the 30 driest countries in the world, and has more than 500 governmentally registered dams, supplying about 37 000 billion m<sup>3</sup> of water to all South Africans (DWAF, 2004; Ndwambi, 2015). According to Robert and Gwinn *et al.* (1993), intensive development of an area entails a complete change of the area affected and the removal of much of its wild or natural quality. Obviously, clear cutting then favoured IPS diversity that preferred open areas at the expense of those that required dense forest cover.

A combined Environmental Impact Assessment (EIA) report, Archaeological Impact Assessment (AIA), Socio-Impact Assessment (SIA), and Botanical Impact Assessment (BIA) were conducted at the Luvuvhu dam project (later known as Nandoni Dam) for the relocation of Mulezhe, Budeli, and Tshiulungoma (Bester, 1998). The latest Environmental Impact Assessment (EIA) study was conducted from the beginning of March 2003 up to the end of June 2003, by Professor D.M.K. Mathekga from the University of Venda for Sciences and Technology, then the School of Mathematics and Natural Sciences, Department of Botany and Biology, two students, Interested Affected People's (IAP), recruited communities with special knowledge of selected IPS diversity, students from Madzivhandila Agricultural

College, traditional healers, and the officer, Mr. Netshiungani, the official from Thohoyandou Botanical Herbarium Garden.

Participants identified selected IPS diversity that needed to be relocated, protected, and conserved before the construction of Nandoni Dam. Names of selected IPS diversity were recorded; specimens of their small branches with leaves were cut, labelled and collected to be stored in the herbarium of the Department of Botany and Zoology at the University of Venda for use by future generations of researchers.

Construction of dams is generally associated with the provision of water to communities and agriculture for developmental purposes. However, their very existence always brings about unforeseen negative impacts on selected IPS diversity. Water availability in dams causes changes in vegetation along riverbanks, upstream and downstream. The actual problem with Nandoni Dam was that most of the vegetation growing on the upper stream of the dam including some selected IPS diversity, was totally submerged in water. The construction of Nandoni Dam contributed immensely to the destruction of selected IPS diversity. For example, some communities staying along the Luvuvhu River, in the villages of Tshiulungoma, Budeli, Dididi, and Mulezhe dug the soil, cut, and chopped selected IPS diversity for medicinal use, cultural values, domestic use, firewood, construction, brick formation, and carving, which they sell for socio-economic benefits (Bester et al. 1998).

In 1980, the World Conservation Strategy (WCS), the most widely accepted definition presented by the International Union for Conservation of Nature and Natural Resources (IUCN), was that of “the management of human use of the biosphere so that it may yield the greatest sustainable benefit while maintaining its potential to meet the needs and aspirations of future generations”. The document defined the objectives of the conservation of selected IPS diversity as: “maintenance of essential ecological processes, life-support systems, preservation of genetic diversity, and guarantee of the sustainable use of selected IPS diversity and ecosystems” (Gwinn, Norton, *et al.*, 1993: Vol. 16).

## **1. 2. Problem statement**

The construction of dams is generally associated with the provision of water to communities and agriculture for developmental purposes. Intensive development of an area for waterpower and the construction of settlements and town malls is prevalent (Soanes & Hawkers, 2005). However, their very existence always brings about unforeseen negative impacts on IPS diversity (Norton, 1993). The greatest single cause of the depletion of natural plant communities and wild species, especially selected IPS diversity at Nandoni Dam, was the desire to use the river and land for more productive purposes. Many of the lands that were cleared eventually proved to be poorly suited for the purposes for which they were intended and were ultimately abandoned. Nevertheless, it was then no longer possible to protect the natural plant communities (IPS diversity) that previously existed in this particular area.

The suspected impact on ecosystem functioning of the area along the Luvuvhu Mutoti Dam was negatively affected during the recently completed construction of Nandoni Dam. The dominant IPS diversity, such as *Piliostigma thonningii*, *Peltophorum africanum*, *Pterocarpus angolensis*, *Diospyros mespiliformis*, *Ficus sycomorus*, and *Combretum imberbe*, was submerged under water as it was not protected before the completion of the Nandoni Dam in 2005 (Bester, 1998). The construction of the dam could have altered indigenous plant diversity, and which led to the current composition of vegetation in the area. Therefore, the need arises to find out if certain IPS were relocated, protected, and conserved before and after the construction of the dam so that better mitigation strategies could be suggested for the management of the area in the vicinity of the Nandoni dam.

## **1. 3. Research Aim and Specific Objectives**

### **1.3. 1. Research Aim**

The aim of the study was to assess the impact of Nandoni Dam construction on selected indigenous plant species (IPS) diversity.

### **1. 3. 2. Specific objectives**

- To examine plant species (IPS) density before the construction of Nandoni Dam in 1998.
- To determine whether some of the selected indigenous plant species (IPS) were relocated, protected, or conserved after the construction of Nandoni Dam in 2005.
- To assess the community's perceptions on the need to protect and conserve the remaining indigenous plant species (IPS) diversity at Nandoni Dam.
- To come up with strategies that could minimize the problem.

### **1. 3.3. Research questions**

- How was the selected indigenous plant species (IPS) diversity examined before the construction of Nandoni Dam in 1998?
- What happened to some selected indigenous plant species (IPS) diversity - were they relocated, protected, and conserved after the construction of Nandoni Dam in 2005?
- What were the community's perceptions of the need to protect and conserve some of the remaining indigenous plant species diversity or richness?
- Which strategies can be implemented to curb the impacts of the Nandoni dam?

## **1. 4. Delimitation of the study and the description of the study area**

### **1. 4. 1. Delimitation of the study**

The study was conducted at Nandoni Dam in Thulamela Municipality within Vhembe District, Limpopo Province, South Africa. Nandoni Dam is geographically located at longitudes 22° 59' 20" S and latitudes 30°36' 27" E.

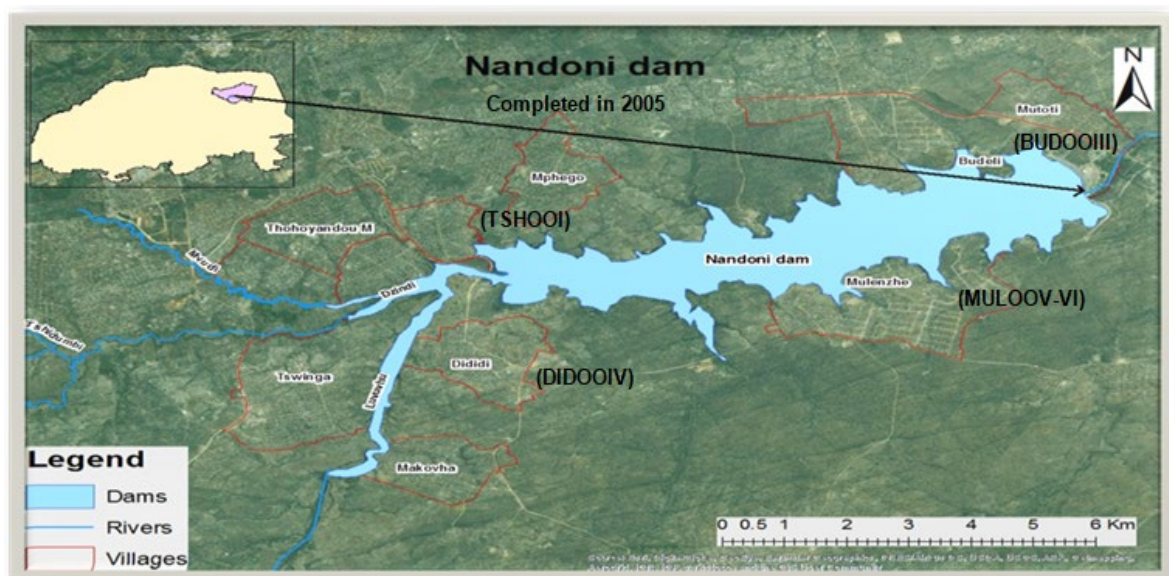
### **1. 4. 2. Description of the study area**

#### **1. 4. 2. 1. Location**

The study was conducted at Nandoni Dam, situated on the Luvuvhu River and previously known as Mutoti Dam. Nandoni means iron smelting ovens. Iron remnants were discovered underneath the water during dam construction. The dam is bounded

geographically by longitudes 20°59'20" S, and latitudes 30°36'27"E (Figure 1.1). It is an earth-filled concrete type of dam, built in Thulamela Municipality within Vhembe District of Limpopo Province in South Africa. The dam is situated approximately 12 kilometres south-east of Thohoyandou town in Thulamela Municipality along the provincial road R524 that leads to the Kruger National Park.

The total capacity of the dam is 164 000 000 cubic meters ( $5,8 \times 10^9$  cubic ft.), catchment area is 13 90 km<sup>2</sup>, the surface area is 1,570 ha (3,900 acres), the height is 43 meters (141 ft.), and the length is 2,215 meters (1,267 ft.) (Nandonidam.com.za, 2005).



**Figure 1. 1 Aerial photograph map showing the location of Nandoni Dam on the Luvuvhu River (Source: Field survey data, 2020)**

The main tributaries of the Luvuvhu River are the Lutanandwa River, the Dzondo River, and the Dzindi River which is the first main tributary that flows into the Luvuvhu River (North). The second main tributary is the Mvudi River, which receives its water from two rivulets, namely, the Gologodo River and the Tshidumbi River (North). Therefore, the Luvuvhu River flows a course along the Southern edge of the Zoutpansberg and eventually joins the Limpopo River in the far Northern corner of the Kruger National Park on the border between South Africa, Zimbabwe, and Mozambique (Maputo).

Nandoni Dam supplies drinking water in the Vhembe and Mopani Districts of Limpopo Province, South Africa. During serious droughts during the early 1990s, numerous boreholes in the former Gazankulu and Venda failed, and consequently drinking water had to be delivered by tankers. Such incidents led to the Department of Water Affairs and Forestry (DWAFF) conducting an EIA in 1998 and a feasibility study for providing a steady water supply to the Vhembe Region. The construction of Nandoni Dam, just like any other development, destroyed the selected IPS diversity or richness, and communities residing in the basin of the dam were directly affected by the project.

#### **1. 4. 2. 3. Vegetation (selected Indigenous Plant Species (IPS) diversity)**

The dominant vegetation types of selected IPS diversity along the Luvuvhu River - and Nandoni Dam (study area) were *Combretums*, e.g., *Combretum* subsp. *apiculatum* (532), *Combretum. molle* (537), *Combretum. imberbe* (539), *Combretum microphyllum* (540.1), *Combretum collinum* subsp. *gazense* (541); *Senegalia ataxacantha* (160), *Acacia caffra* (162), *Acacia gerrardii* var. *gerrardii* (167), *Acacia erioloba* (168), *Acacia nigrescens* (178), *Acacia polyacantha* subsp. *campylacantha* (180), *Acacia tortilis* subsp. *heteracantha* (188); and *Ficus sansibarica* (47), *Ficus burkei* (48), *Ficus capensis* (50), *Ficus sonderi* (64), *Ficus sycomorus* (66). The area of Nandoni Dam is also characterized by invasive selected IPS diversity of shrubs and herbs such as *Dichrostachys cinerea* subsp. *africana* (190), *Cynodon dactylon* (kikuyu-grass), *Caesalpinia decapetala*, *Bauhinia galpinii* (208.2), *Ziziphus Mucronata* (447), *Ricinus communis*, etc. They really disturb the soil and do not allow selected IPS diversity to grow in the same area (Morotoba, 2010; Bester, 1998; Van Schaik, 1981).

## 1. 5 Justification of the study

This study is very important because there is a need to come up with strategies that can be used to minimize the impact of dam construction on selected IPS diversity. The impact of dam construction on selected IPS diversity can be so high, that even human life besides vegetation, or selected IPS diversity, and animal lives could be immensely destroyed (Netswera, 2011).

There was relatively, little formal enquiry regarding the impact of Nandoni Dam construction on selected IPS biodiversity in the study area. Exceptional literature reviews were conducted by Ngoma (2003), who studied the socio-economic impact of Nandoni Dam construction; Dzaga (2005), who researched the role of catchment activities on the water quality of Nandoni Dam; Neduvhuledza, who studied mitigation on resettlement; and Mokgoebo (2012), who focused on the vegetation at Nandoni Dam and Ndwambi (2015), who conducted a study on the socio-economic and environmental impact of Tshakhuma Dam.

According to Lessard and Hayes (2003), in the past decades, communities did not really consider dam construction imperative but only regarded dams as dangerous for kids' safety. Farmers understood and appreciated the construction of dams for the purposes of irrigation and human consumption. This research is of paramount importance because there is a need to come up with strategies that could be used to minimize the impact of Nandoni Dam construction on selected IPS diversity (Hornby, 2010). Accordingly, the impact of Nandoni Dam construction on selected IPS diversity, if not researched further, could cause irreparable damage to the environment. Selected IPS diversity is not an enemy that needs to be attacked, bulldozed, cut down, or destroyed. It needs to be conserved and protected during EIA for use by future researchers and cleared only for a particular project, like the construction of dams, roads, agriculture, settlements, malls, and towns (Holy Bible, 1997).

The National Environmental Management Act (NEMA) (1998) states that sustainable development requires the integration of social, economic, and environmental factors in planning, implementation, and evaluation of decisions to ensure that development serves present and future generations. Everyone has the right to have the environment

protected for the benefit of present and future generations, promoting conservation, securing ecologically sustainable development, using natural resources while a promoting justifiable economy, and social development.

Despite the negative and positive impacts of Nandoni Dam construction, the literature reviewed generally focused on the socio-economic values as a result of the relocation and settlement of the communities residing along Nandoni Dam. According to Ndwambi (2015), the vegetation of Tshakhuma Dam was described as rich in flora species. The dominant vegetation cover observed included agricultural forest and bushes. The mountains surrounding the Tshakhuma Dam were always green during rainy seasons and serve as proof of the selected IPS richness and catchment area for the dam. This study remained silent on the protection and conservation of selected IPS diversity growing upstream and downstream of Tshakhuma Dam.

## CHAPTER TWO: LITERATURE REVIEW

### 2. 1. Introduction

The purpose of this chapter was to assess the impact of Nandoni Dam construction on selected IPS diversity or richness before and after the construction of the dam. This chapter aims at finding out what other scholars have investigated or researched based on the research problem that the study was interested in and how other scholars have theorized and conceptualized issues and ideas.

### 2. 2. Dominant selected Indigenous Plant Species (IPS) diversity found at the study area

In short, the researcher's interest is in the most recent, credible, and relevant scholarship or literature reviews of the study area. An effective literature review needs to take advantage of the various main sources of information or database.

The reason for conserving and protecting some of the remaining selected IPS diversity was for future generations of researchers (Soanes & Hawkers, 2006). For example: *Annona senegalensis* (105), *Ficus burkei* (48), *Ficus sycomorus* (66), *Salix sub serrata* (362), *Ximenia americana* (102), *Vangueria infausta* (702), *Combretum imberbe* (538), *Acacia rehmanniana* (182), *Dichrostachys cinerea subsp. Africana* (190), *Bauhinia galpinii* (208.2), *Rhus tomentosa* (394), *Adansonia digitata* (467), *Ziziphus mucronata subsp. mucronata* (447), *Pterocarpus angolensis* (236) (Von Breitenbach, 1981). These are the selected IPS diversity restricted to a certain area that needed to be conserved for use by a future generation of researchers (Stott, 1981; Soanes & Hawkers, 2006).

### 2. 3. Conservation of selected indigenous plant species (IPS) diversity

It is a reality that bush clearing will have to be done to make the area accessible to developers, and this must be negotiated directly with local Headmen residing in the particular area where the project is to take place. According to [Bester \(1998\)](#), Act No. 20 of the former Venda Homeland, the Venda Nature Conservation and National Parks Act of 1986, which is still applicable today, the following *Aloe* species, *Aloe greatheadii*

(28), *Aloe arborescens* (28.1), *Aloe angelica* (28.4), etc., are protected, and permits are needed for their removal. *Aloes* contain dried juice and leaves, which are used as medicine (Schmidt et al., 2002).

Thus, the most widely accepted definition presented in 1980 in the World Conservation Strategy by the International Union for Conservation of Nature and Natural Resources (IUCNNR) is that of the management of human use of the biosphere so that it may yield the greatest sustainable benefit while maintaining its potential to meet the needs and aspirations of future generations (Gwinn & Norton, 1993: Vol. 16).

The Mine Health and Safety Environmental Act (MHSEA), Act No. 29 of 1996, Regulation 5.13. 2, stipulates that if the vegetation, (selected IPS diversity) is disturbed due to access roads, dam construction, or site clearing, such vegetation or selected IPS diversity shall be re-established to the satisfaction of the Director of Mineral Development (DMD) through the Environmental Management Programmer Process (EMPP) (Morotoba, 2010).

## **2. 4. The Constitution of the Republic of South Africa**

According to the Constitution of the Republic of South Africa 1996, Act 24 of 1996, Chapter 2, Bill of Rights, Sections (a) and (b), everyone has the right (a) to an environment that is not harmful to their health or wellbeing and (b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that (ii) promote conservation and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic, environmental, and social development.

Accordingly, the construction of Nandoni Dam had an impact on selected IPS diversity, which grew along the Luvuvhu River, upstream and downstream of the dam. Thus, the research focused on the assessment of the impact of Nandoni Dam construction on selected IPS diversity or richness.

## **2. 5. Environmental Impact Assessment (EIA)**

Environmental Impact Assessment (EIA) as a tool used to identify the environmental, social, and economic impacts of a project prior to decision-making aims at predicting environmental impacts at an early stage of project planning, designing and finding ways and means to reduce adverse impacts, shaping projects to suit the local environment, and presenting the prediction and options to decision-makers (Mitchell, 1995). Accordingly, the feasibility studies that took place at Nandoni Dam between 1998 and 2005 (Bester, 1998) impacted the selected IPS diversity that normally grew in a particular ecosystem, within the surrounding habitat (Soanes & Hawkers, 2005). It was not clear how some of the selected IPS diversity was relocated or conserved after the construction of the dam.

## **2. 6. Dam safety and other studies**

According to Fema (1998), dam safety is the art and science of ensuring the integrity and viability of dams so that they do not present unacceptable risks to the environment, the public, property, or the communities at large. Dam construction requires the collective application of engineering principles, experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe function is not explicitly determined by its original design and construction. Studies to date have mainly examined the impacts of the construction of Nandoni Dam on socio-economic and environmental activities. The study conducted by Neduvhuledza (2011) was based on the assessment of the implementation of mitigation measures on the impact of Nandoni Dam construction on the surrounding communities, which was of paramount importance. His studies never focused on the impact of dam construction on selected indigenous plant species; instead, he carried on with mitigation, socio-economic impacts, and how communities were affected morally and psychologically as they lost their relationship with nature, deceased relatives, and their graves.

## **2. 7. Deforestation**

One of the most dramatic changes in the volume of the earth's biomass has been caused by deforestation. Deforestation, as the process of cutting, chopping, uprooting, and bulldozing down selected IPS diversity, always occurred during the construction

of dams, industrialization, big projects that are accompanied by community development, clearing land for farming and the construction of roads, bridges for transportation purposes, which needed proper management (Soanes & Hawker, 1997). The study focused on a program to safeguard the future of endangered IPS diversity that remained during the construction of Nandoni Dam. While there is truth in this assertion that would seem intuitive that other factors, such as the diversity or richness of selected IPS before and after the construction of Nandoni Dam, influenced deforestation and the extent of biodiversity loss due to anthropogenic activities such as brick formation and medicinal and cultural values. Since dam construction leads to deforestation, it also leads to fragmentation of ecosystems, and fragmentation will isolate one area from another by creating patches of habitat (Fahrig et al., 2019). Dams generally lead to a decline in biodiversity, but the impacts depend on the scale (Jansson, 2006). This often happens when forests are lost due to being submerged at the margins of rivers (McAllister et al., 2001). Some of the sins of building a dam, as listed by WWF (2013) include disregarding downstream flow, biodiversity, and the mishandling of possible impacts and risks.

## **2. 8. Geographic fieldwork**

According to Lounsbury and Aldrich (1979), a major part of their geographic fieldwork was concerned with the special recording of landscape features such as physical, cultural, and economic activities that could be observed and classified or categorized. A well-organized field mapping problem consisted of six distinct phases, which should be completed in order. These phases were: determination of precisely which data were essential to the solution of the specific field mapping problem; selection of the scale or level resolution of the data obtained; choice of the classification system(s) employed in categorizing the data; and selection of the most effective base map for the specific problem; and actual field mapping.

However, we focused on those highly critical phases for the selection of the base map upon which data were collected and recorded. For example, in this research, the following research aids were employed: Aerial maps, showing the study area, the case study of Nandoni Dam construction in Thulamela Municipality within Vhembe District of Limpopo Province, South Africa, the vegetation or selected IPS diversity of Luvuvhu

River prior to Nandoni Dam construction in 1998, the relocation of human settlements, showing the GBU of four villages affected by the construction of Nandoni Dam after 2005, and the GPS of the study area where mostly primary data were recorded and collected through techniques such as field surveys, interviews, and observation. The study methodologies used were both qualitative and quantitative in approach. All features and characteristics, such as legend, direction, colours, GPS, scale, etc., were clearly provided in order to avoid miscalculation of data collection.

## **2. 9. Base maps for field studies**

Mapping implied recording facts, drawing boundaries, and making notes on something. That “something” if it contained an adequate number of orientations or reference represented the spatial or aerial extent of field observations, recorded accurately, could represent a base map (Lounsbury & Aldrich, 1979). The base map determined, to some extent, how the field data was analyzed and presented in their final forms, both statistically and cartographically. For this study, the following types of maps served as adequate base maps: the conventional vertical aerial photographs, and topographic maps (Kitchin & Tate, 2000). Conventional aerial photographs were extremely useful because they provided a large number of varieties of control or reference points. Using those photos, a field worker could determine without difficulty where the researcher was at any given time and could accurately plot whatever data were being mapped. For example, to examine selected IPS richness or diversity before the construction of Nandoni Dam in 1998 and determine whether the selected IPS richness or diversity were protected and conserved after the construction of the dam in 2005.

Topographic maps, or quadrangles differ from aerial photographs in that not all visible artificial features of the landscape are illustrated. Topographic drainage patterns and major artificial features appeared, but not land use minor to topographic features (relief so small that it fell between contour lines), detailed vegetative cover, or soil types (Hornsby, 2010). The United States Geological Survey (USGS) has been producing topographic maps for almost a century, and much of the continental United States, Alaska, Hawaii, and Puerto Rico were mapped. Individual maps were published as part of a map series (Lounsbury & Aldrich, 1979). Both conventional vertical aerial photography and topographic maps were used in this study to determine selected IPS

richness after the construction of the dam in 2005. The researcher considered upstream and downstream selected IPS diversity to trace changes in selected IPS richness.

## **2. 10. Natural resources**

Resources such as water, energy, IPS diversity, atmosphere, soil, stones, minerals, etc. are natural resources. According to William & Thomas (1997), natural resources are defined as objects, materials, creatures, or energy found in nature that can be used by a population over five billion, reaching towards six billion before the turn of the century, and machines allowed one person to do work that armies or workers could not do. Yet many continued to treat nature as a gift that is endless, boundless, and inexhaustible. That cannot continue. It was for that reason that the researcher envisaged the process of relocating selected IPS diversity before the construction of Nandoni Dam in 1998. The researcher assessed the Department of Water Affairs and Forestry (DWAF) completed Environmental Impact Assessment (EIA) activity at the first phase of feasibility studies at Nandoni Dam, to avoid destroying selected IPS diversity or richness in that habitat (Mitchell, 1995).

## **2. 11. Act No. 107, 1998: NATIONAL ENVIRONMENTAL MANAGEMENT ACT OF 1998**

Many inhabitants of South Africa live in an environment that is harmful to their health and well-being, everyone has the right to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that promote conservation, secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

The researcher, after considering Act No. 107 of 1998, including the Environmental Impact Statement (EIS), National Environmental Policy Act (NEPA), National Environmental Advisory Forum (NEAF), and Environmental Management Programmer Process (EMPP), decided to embark on the research entitled, “The impact of Nandoni Dam construction on selected IPS diversity, a case study in Thulamela Municipality within Vhembe District of Limpopo Province, South Africa.”

The main aim of the study was to assess the impact of Nandoni Dam construction on selected IPS diversity. The objectives of the study were adhered to by the researcher to such an extent that it yielded a comprehensible dissertation.

According to Netswera (2011), afforestation is the planting of trees; therefore, the planting of relocated selected indigenous plant species (IPS) diversity along the river assisted in controlling flooding downstream and in the upper stream of Tshakhuma Dam, thus allowing the river to flood naturally in places in order to prevent flooding in settlement areas. Organizing the community's participation in the conservation of selected IPS diversity was important. The study conducted by Ndwambi (2015) focused on the socio-economic and environmental impact of the construction of Thakhuma Dam, henceforth, such studies included both negative and positive impacts and never discussed the impact of dam construction on selected IPS diversity. Therefore, the researcher was challenged and motivated to conduct research on the impact of Nandoni Dam construction on selected IPS diversity, a case study in Thulamela Municipality within Vhembe District of Limpopo Province, South Africa.

## **2. 13. Managing our Natural Resources**

-Natural Resources can be defined as all those things with which people come into contact and can be used to perform any useful function (William & Thomas, 1997). For example, objects, materials, creatures or energy found in nature that can be used by humans. Yet many continue to treat nature's gifts as endless, boundless, and exhaustible. That cannot continue, though the world population is over five billion, racing towards six billion before the turn of the century. Our natural resources must be well managed and controlled so that we can use them without destroying their balance, or at least without permanently upsetting that balance. People change things as we plough fields, clear forests, drain swamps, build dams, cities, and highways. Such massive changes in the ecosystems affect every living thing, including humans, and select IPS diversity or richness. The Holy Bible, Deuteronomy Chapter 20, verses 19 – 20, stresses that "the trees of the fields are man's life and should not be destroyed. Eat the fruit, but do not cut down the trees". They are not enemies that need to be attacked, but you may cut down trees that you know are not valuable for food, medicinal, cultural value, etc. Use them to make equipment you need to build bulwarks

against the city that makes war with you, roads, bridges, human settlements, towns, cities, dams for irrigation and drinking water.

## **2.14 Conceptual framework**

According to de Vos (2011), conceptual frameworks are defined as typologies, models, and theories in which phenomena are classified in terms of characteristics that they have in common with other phenomena. They include building blocks, assessment processes, and procedures followed during research.

### **2. 14. 1. Building blocks**

Building blocks of science are identified as concepts, statements, conceptual frameworks, and paradigms used during research (Soanes & Hawkers, 2006).

### **2. 14. 2. Assessment**

Hepworth et al. (2002) define assessment as a process taking place between therapist and client where information is gathered, analyzed, and synthesized to give a total picture of the client's needs and strengths. The verb, assess, means to calculate, or estimate the value, importance, or quality of a survey (Soanes & Hawkers, 2006).

In this research, we assessed the impact of Nandoni Dam construction on selected IPS diversity using the verb assess on several occasions as the pillar and aim of embarking on this thought-provoking research on the impact of Nandoni Dam construction on selected IPS diversity, a case study in Thulamela Municipality within Vhembe District of Limpopo Province, South Africa.

## CHAPTER THREE: RESEARCH METHODOLOGY

### 3. 1 Introduction

In this chapter, we present a description of research methodology and data collection in the study area. Nandoni Dam is a case study in Thulamela Municipality within Vhembe District of Limpopo Province, South Africa, that was used as a research design. All the methods for collecting and interpreting data have been highlighted in this chapter.

### 3.2 Data collection methods

#### 3. 1. 1 Observation

The observation was conducted for the purpose of identifying areas for field surveys and studying the neighbouring community sites in order to determine the appropriate sampling method. The other purpose of the observation of the research area was to study the general environmental conditions in order to avoid bias when overlaying transects. Observation was also conducted to assess the vegetation's composition and diversity. The findings were recorded as trees, shrubs, and herbs in the worksheets. Specimens in the form of small branches with leaves were collected and kept at the University of Venda Herbarium in the Botany Department of the School of Mathematical and Natural Sciences. The observation took a period of four (4) months, from March to June 2018.

For secondary data collection, we used documentary reviews, journals, newspaper articles, and books. The methodologies that were used were both qualitative and quantitative in approach. Qualitative data was collected through interviews. For primary data collection, techniques such as, field surveys, interviews, and observation were used.

Relevant institutions (the Department of Environmental Affairs and Forestry, the Department of Water and Sanitation, and the Department of Botany and Natural Sciences at the University of Venda) were contacted telephonically and face-to-face. Document reviews such as library books, published conference papers, articles,

theses, dissertations, and South African Geographical Journals, provided the researcher with the socio-economic values of selected IPS diversity found in the study area.

An ecological survey (primary data collection) was conducted, and the evenly distributed transverse transects were made across the randomly selected sampling sites while each transverse transect was attended and the physiognomic analysis was done to determine different plant life forms, frequency or occurrence, status, and growth condition.

Relevant literature was used for selected IPS identification that was conducted in the study area. The growing conditions of the selected IPS diversity found in the sampling site were recorded on the worksheet, applying tally methods, focusing on the research processes and kinds of tools and procedures used during data collection and analysis. We visited Thohoyandou Botanical Herbarium Gardens, Websites, Media, EIA, BIA, AIA, and IAPs with the knowledge of selected IPS diversity, the Constitution of South Africa, and The Holy Bible for further secondary data collection.

Government and Department officials were interviewed telephonically and face-to-face after the pilot study. The objectives of the study formed the integral backbone of the research in this chapter on methodology and data collection (Bester, 1998; Tate, 2000; Ghauri & Gronhaug, 2005). The whole area of the four villages that were affected by the construction of Nandoni Dam, the Geo-botanical units GBU: (TSHOOI) of Tshiulungoma one, BUDOOIII (Budeli three), DIDOOIV (Dididi four), and MULOOV-VI, (Mulenzhe five and six) were covered on foot. During the field survey, interviews, and observations, some of the selected IPS diversity was identified, while their names, socio-economic benefits, and cultural values were recorded in the worksheets and kept at the herbarium of the Department of Botany, School of Mathematics and Natural Sciences at the University of Venda during the EIA, which was conducted for a period of four months from March to June.

In order to identify which indigenous plant species were present before the construction of the dam, an orthophoto map (1:10 000) and a topographical map (1:50 000 CD) were used. The orthophoto was used to identify the location of plant species

along the Luvuvhu River prior to the construction of the dam. The topographical map was used to identify the types of vegetation that existed prior to the construction of the Nandoni dam. Vegetation on the topographical map was identified as either natural (trees, woodland, marshes, vlei) or man-made (orchards, vineyards, recreation ground, cultivated land). Density measurements were done by calculating the surface area covered by terrestrial vegetation (trees and grasses) on aerial photographs and orthophotos. The aerial photographs and orthophotos were purchased from the Surveys and Mapping Department in Pretoria. The following aerial photos and orthophotos were used (Table 3.1):

**Table 3.1 Aerial photographs and orthophotos for Nandoni dam (Source: Field data, 2020)**

<b>Aerial photographs for job number 908 of 1987</b>			
<b>Strip number</b>	<b>Photo number</b>	<b>Area</b>	<b>Scale</b>
12	274 & 275	Nandoni	1: 16 666
<b>1: 10 000 orthophotos</b>			
<b>Title</b>			<b>Area</b>
2230 DC 21 MPHEGO			Nandoni
2230 DC 22 MPONDI			Nandoni
2230 DC 23 MAKUMEKE			Nandoni
2330 BA 1 DIDIDI			Nandoni

To calculate the total surface area (cover) covered by vegetation downstream and upstream of the Nandoni dam, the map was covered with a grid of squares, with each square having a size of 0.2 cm. This meant that one square on a 1:10 000 orthophoto equalled 0.0004 km<sup>2</sup> or 400 m<sup>2</sup> on the ground. The total number of squares on an

orthophoto map containing vegetation were added together to determine the total surface area covered by vegetation prior to the construction of the Nandoni dam.

On the 1:16 666 aerial photographs, the grid contained squares of 0.25 cm, which was equivalent to 1736 m<sup>2</sup> or 0,001736 km<sup>2</sup> on the ground. The following formula was used to calculate the total vegetation cover prior to the construction of the dam:

$$\text{Area} = S \times S$$

Where S = one side of a square

Cover was expressed in km<sup>2</sup> and percentage. The area that was covered with squares on the 1:10 000 and 1:16 666 photos downstream and upstream of the dam from where cover was calculated equalled 1,5 km<sup>2</sup>. The total number of squares that covered a total surface area of 1.5 km<sup>2</sup> on a 1: 10 000 orthophoto was 3750, and for a 1:16 666 was 880. Vegetation was identified based on key elements of aerial photograph interpretation as outlined by Lillesand et al. (2004):

- (i) **Shape:** This looks at the general form, outline of objects and their configuration for example, a soccer field will appear rectangular while a cricket field will look round.
- (ii) **Size:** The sizes of objects are considered based on the scale of the image. For example, a small barn might be misinterpreted as a storage shed if the size of an object is ignored.
- (iii) **Pattern:** This refers to the spatial arrangement of objects. The spatial arrangement of natural forests is different from that of orchards.
- (iv) **Tone:** This is the relative brightness or colour of objects in an image.
- (v) **Texture:** This refers to the frequency of change in tone in an image.
- (vi) **Shadows:** They are important in two respects: (1) the shape or outline of a shadow affords an impression of the profile view of objects; and (2) objects within shadows reflect little light and are difficult to discern on an image.

**Vegetation density** was measured in the field to determine the current density downstream and upstream of the Nandoni dam. The study area was divided into 10

sampling units. Each sampling unit covered an area of 20 m x 20 m, giving a total surface area of 400 m<sup>2</sup>. These sampling units were located along the river and extended to a total distance of 200 m downstream and upstream of the dam, respectively. This was done to measure the density of trees and shrubby vegetation. Density measurements were done for the following plant species: *Annona senegalensis* (African custard-Apple) (105), *Ficus burkei* (Common wild fig) (48), *Ficus sycomorus* (Sycamore) (66), *Salix sub serrata* (Flute willow) (362), *Ximenia americana* (Hog plum) (102), *Vangueria infausta* (Wild medlar) (702), *Combretum imberbe* (Leadwood) (538), *Vachellia rehmanniana* (Silky thorn) (182), *Dichrostachys cinerea subsp. africana* (Sickle bush) (190), *Bauhinia galpinii* (Pride of de Kaap) (208.2), *Rhus tomentosa* (Real white currant) (394), *Adansonia digitata* (African baobab) (467), *Ziziphus mucronata subsp. mucronata* (Buffalo thorn) (447), *Pterocarpus angolensis* (Kiaat or paddle-wood) (236). The numbers in brackets indicate the botanical numbers obtained from the South African National Biodiversity Institute (SANBI) list. These plants were restricted to a certain area that needed to be conserved to be used by future generations (Stott, 1981; Soanes & Hawkers, 2006). Abundance measurements were taken for each plant species, and the totals were used to measure relative density.

Plant diversity for the same tree species was also measured upstream and downstream of the Nandoni dam. To measure plant diversity after the construction of the dam, the Simpson Diversity Index was used. The diversity index was calculated based on the following formula:

$$\text{Simpson Diversity Index (D)} = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Where  $\sum$  = sum of (total)

$n$  = the number of individuals of each different species

$N$  = the total number of individuals of all the species

The Simpson Diversity Index was considered in this study because it could compare diversity data from different sampling sites across the study area. Diversity was measured by comparing upstream and downstream vegetation data.

### **3. 2. Research design and types of research design adopted.**

#### **3. 2. 1. Research design**

For this study, the term research design is applied to qualitative design or strategies available to the prospective researcher. In this instance, the researcher used a field survey (quantitative approach), interviews, and observation as qualitative approaches. Data collection from the study area was surveyed and observed by group participation, while selected IPS diversity and abundances were quantified. Therefore, the researcher accepted that this research design adopted mixed methods in which both quantitative and qualitative approaches were used. All those decisions a researcher made in planning, preparation, processing, and researching the literature reviewed and surveyed would reflect the end product and a dissertation that will assist future generations of researchers.

#### **3. 2. 2. Types of research design adopted**

The study was both quantitative and qualitative in approach. We used the following techniques during primary data collection: field surveys, interviews, and observation. Thus, the collected data on selected IPS diversity and abundance in the study area were quantified. That was a quantitative approach. Therefore, the research design adopted was both quantitative and qualitative in approach.

For this study, we identified only five traditions of qualitative research designs. Those included narrative, phenomenology, ground theory, ethnography, and case study research designs. According to Vos (2011), in qualitative research designs, the researcher's choice and action determine the design or strategy. During the entire study process, the researcher created research strategy designs best suited to that study and also designed the whole project around the strategy chosen. Our choice of designs which were best suited to the study and also designed for the whole project, were narrative, ethnographic, and case study approaches (Soanes & Hawkers, 2006).

A narrative approach was used because there were interactions with the participants during data collection and the identification of selected IPS diversity in the study area.

The ethnographic research approach was employed because of the time spent with the community members during field surveying, interviewing, and observing relating to the conservation of selected IPS diversity took a period of four (4) months, from March to June. A case study of Nandoni Dam in Thulamela Municipality within Vhembe District of Limpopo Province, South Africa, was used as a research design because the entire location of the study, data collection, objectives of the study, research problem statement, justification of the study, and identification of selected IPS diversity (vegetation map prior to dam construction in 1998, Figures 1. 3a and 1.3b), described only convergence occurrences in Thulamela Municipality.

### **3. 3. Sampling method and unit of analysis**

#### **3. 3. 1. Sampling method**

Random sampling was used to select respondents in order to acquire information on the selected IPS diversity. Participants from the communities affected by the construction of the dam were involved in field surveys, interviews and observation for primary data collection. The sampling method was used as a representative group that was selected from the population and was thus smaller than the population (Denzin & Lincoln, 2009). Therefore, the researcher used a mixed-methods approach. Both qualitative and quantitative methodologies were used, as they are qualitative in nature. A stratified random sampling design was used as a qualitative and quantitative approach. Given the high cost of personal interviews, the data collection method for the study, the time available, and the financial implications, a sample size of sixty (60) participants covered only four villages, namely, Tshiulungoma, Budeli, Dididi, and Mulenzhe, which were mostly impacted by the Nandoni Dam construction in 2005.

#### **3. 3. 3. Unit of analysis**

Both qualitative and quantitative approaches were used and sampling involved the selection of study units for analysis (Creswell, 2007). We used two instruments for data analysis the Statistical Package for the Social Sciences (SPSS) Version 25, and Thematic Analysis using its sub-type for data analysis information. Then, the documentary reviews for secondary data analysis and data collection were used.

### **3. 4. 1. Interviews**

Permission and appointments for interviews were made before the interviews. All sixty respondents were explained the purpose of why they were to visit the study area, which was Nandoni Dam before construction in 2003 and after construction in 2005. The interview was conducted face-to-face at the study area for a period of four (4) months, from March to June. Relevant departments, viz., the Department of Environmental Affairs and Forestry, Water, and Sanitation, were contacted telephonically in order to obtain relevant information.

### **3. 5. Data analysis**

The collected data were analyzed using both qualitative and quantitative methods. Descriptive statistics were used to summarise the data in the form of a pie-chart, tables and figures as representations of the selected IPS diversity that were examined before Nandoni Dam construction to further determine if some of the protected IPS diversity were conserved or relocated by Thohoyandou Botanical Herbarium Garden, Kruger National Park Board, Department of Environment and Forestry, and Department of Water and Sanitation. We realized that data analysis required qualitative and quantitative analytic strategies. For example, scientific method analysis strategies, mixed method analysis strategies, and post modern analysis strategies should be considered before deciding on a strategy to be used. For the purpose of this study, we used two instruments for data analysis: Social Package of Social Sciences (SPSS) Version 25 for systematic analysis and narrative for thematic analysis to analyze data on vegetation that were collected by means of participants during primary data collection using field surveys, interviews, and observations.

For Secondary data collection and analysis, we used human document reviews (Creswell, 2003). Visit Table 4. 1: Showing Statistical representation results on vegetation growth (selected IPS diversity) before and after the construction of Nandoni Dam.

### 3. 8. Unit of sampling

A sampling size of 60 respondents from the four villages - Budeli (773 households), Dididi (872 households), Mulenzhe (781 households), and Tshiulungoma (827 households) - participated. Four villages were divided into four units, and each unit had 15 respondents (or participants). Slovin's formula was used to determine the sample size from each village:

$$\text{Sample size } (n) = N \div 1 + N (e)^2$$

Where  $n$  = sample size

$N$  = population of the study

$E$  = the margin error in the calculation

According to the formula, a total of 48 respondents were sampled from the four villages. The location of each unit, from each of the four villages was worked out using the quadrant method, showing the number of units and Global Positioning System (GPS) co-ordinates (Martin & Paddy, 1992). A questionnaire was given to each participant who was randomly chosen. Naming those selected IPS diversities that were dominant, looking at their life forms, status, growth conditions, benefits/values, i.e., socio-economic, and environmental.

To assess community's perceptions of the need to conserve and protect selected IPS diversity and richness. Lists of identified and selected IPS diversity were compiled and presented as tables and figures for use by future generations of researchers. Referred to Appendices A, B, and C as indicated after References. Those lists included selected IPS diversity that was protected by the Act 20/1986 of the former Venda Homeland, selected IPS diversity that was submerged in water, whose dry stems are seen inside the dam as water subsided during dry seasons, and those that remained after the construction of Nandoni Dam in 2005.

## CHAPTER FOUR: RESULTS AND DISCUSSIONS

### 4.1 Introduction

This chapter provides the results / findings that were found during the study. The results of this research are discussed in this chapter based on the following three objectives of the study: to examine selected IPS diversity before the construction of Nandoni Dam in 1998 to determine whether some of the selected IPS diversity was relocated, protected, and conserved after the construction of Nandoni Dam in 2005, and to assess the community's perceptions on the need to protect and conserve the remaining selected IPS diversity in the study area.

### 4.2 Species cover prior to the Nandoni construction

The species cover was calculated from the available 1:16 666 aerial photographs and 1: 10 000 orthophotos. The area covered by the vegetated area was calculated using the square method, and the results that were obtained showed that both downstream and upstream areas had a greater surface area cover, which was over 75%. For the 1987 aerial photograph, the total surface area covered by vegetation was over 80%.

From the 1997 orthophotos, out of 3750 squares, 3177 squares contained vegetation upstream of the dam. Only 573 squares did not have vegetation. Therefore, the total coverage for 1997 was 85% of vegetation. The downstream area prior to the construction also recorded over 80% cover. From the 3750 squares only 501 did not contain vegetation. This results in a total cover of 87% of vegetation.

In the 1987 aerial photographs, out of 800 squares of 0.25 cm in size, 117 squares did not contain vegetation upstream of the dam. This was a total cover of 85% with no vegetation. Downstream of the dam also showed a higher cover of 87%, with only 103 squares that did not contain vegetation. This means that there was no significant change in vegetation cover from 1987 to 1997 prior to the construction of the dam.

The total surface area covered by the upstream area in 1997 was 1.27 km<sup>2</sup>. For the downstream section of the dam the total surface area was 1.29 km<sup>2</sup>.

However, in the 1987 aerial photographs, the total surface area covered by vegetation upstream of the dam was 1.19 km<sup>2</sup>. The total surface area for the downstream section

was 1.21 km<sup>2</sup>. The total surface area cover showed a minor change from 1987 to 1997, but it could show that there was a slight increase in vegetation cover. Table 4.1 shows changes in vegetation cover and cover percentage:

**Table 4.1 Vegetation cover percentage and total surface area in km (Source: Field data, 2019)**

Year	Squares with vegetation	Squares without vegetation	Percentage cover (%)	Surface area cover (km <sup>2</sup> )
<b>1987</b>	<b>Upstream</b>			
Out of 800 squares (0,25 cm square size)	683	117	85	1.19
<b>1997</b>	<b>Upstream</b>			
Out of 3750 squares (0,2 cm square size)	3177	573	85	1.27
<b>1987</b>	<b>Downstream</b>			
Out of 800 squares (0,25 cm square size)	697	103	87	1.21
<b>1997</b>	<b>Downstream</b>			
Out of 3750 squares (0,2 cm square size)	3249	501	87	1.29

Vegetation density results indicate that there has been a reduction in plant cover since 1997. To determine relative density for each species, abundance measures per sampling unit were taken, and the results of the abundance measures and density measurements have been depicted in Table 4.2. *Dichrostachys cinerea subsp. Africana* was found to be the most dominant species, with the highest abundance values both upstream and downstream of the dam. *Ekebergia capensis* and

*Adansonia digitata* were the least dominant species, with the lowest abundance values of 7 and 8, respectively. This explains why they were absent in many sampling units.

**Table 4.2 Abundance values and relative density results (Source: Field data, 2019)**

Scientific name	Abundance measures (Downstream)	Relative density (Downstream) (%)	Abundance measures (Upstream)	Relative density (Upstream) (%)
<i>Senegalia caffra</i>	04	0.6	07	1
<i>Acacia nigrescens</i>	145	21.2	164	23
<i>Dichrostachys cinerea</i> subsp. <i>africana</i>	189	27.7	203	28.5
<i>Ficus burkei</i>	07	1	04	0.6
<i>Combretum imberbe</i>	167	24.5	181	25.4
<i>Ficus sycomorus</i>	82	12	93	13.1
<i>Gardenia spatulifolia</i>	06	0.9	05	0.70
<i>Berchemia discolor</i>	63	9.2	49	6.9
<i>Ekebergia capensis</i>	07	1	00	00
<i>Adansonia digitata</i>	08	1.2	00	00
<i>Ziziphus mucronata</i>	05	0.7	06	0.8
<b>TOTAL</b>	<b>683</b>	<b>100</b>	<b>712</b>	<b>100</b>

Diversity results indicate that areas downstream of the Nandoni dam were found to be more diverse despite a cut in water supply through the erection of the Nandoni dam wall. This shows that there was an insignificant impact on tree diversity despite the upstream presence of the dam wall. However, the effect could have manifested itself if this study had also considered riparian vegetation. The information depicted below shows diversity results both upstream and downstream of the dam. Table 4.3 shows diversity results for the upstream and downstream sections of the Nandoni dam.

**Table 4.3 Diversity results for upstream and downstream of the dam (Source: Field data, 2019)**

<b>Vegetation</b>	<b>Downstream</b>	<b><i>n</i>-1</b>	<b><i>n</i>(<i>n</i>-1)</b>	<b>Upstream</b>	<b><i>n</i>-1</b>	<b><i>n</i>(<i>n</i>-1)</b>
<i>Senegalia caffra</i>	4	3	12	7	6	42
<i>Acacia nigrescens</i>	145	144	20880	164	163	26732
<i>Dichrostachys cinerea subsp. africana</i>	189	188	35532	203	202	41006
<i>Ficus burkei</i>	7	6	42	4	3	12
<i>Combretum imberbe</i>	167	166	27722	181	180	32580
<i>Ficus sycomorus</i>	82	81	6642	93	92	8556
<i>Gardenia spatulifolia</i>	6	5	30	5	4	20
<i>Berchemia discolor</i>	63	62	3906	49	48	2352
<i>Ekebergia capensis</i>	7	6	42	0	-1	0
<i>Adansonia digitata</i>	8	7	56	0	-1	0
<i>Ziziphus mucronata</i>	5	4	20	6	5	30
<b>Total</b>	<b>683</b>		<b>94884</b>	<b>712</b>		<b>111330</b>

**(Downstream)** Simpson Diversity Index (D) =  $1 - \frac{\sum n(n-1)}{N(N-1)}$ , D=  $1 - \frac{94884}{465806}$ , D= 1- 0,20, D= **0.80**

**(Upstream)** Simpson Diversity Index (D') =  $1 - \frac{\sum n(n-1)}{N(N-1)}$ , D=  $1 - \frac{111330}{506232}$ , D= 1- 0,22, D= **0.78**

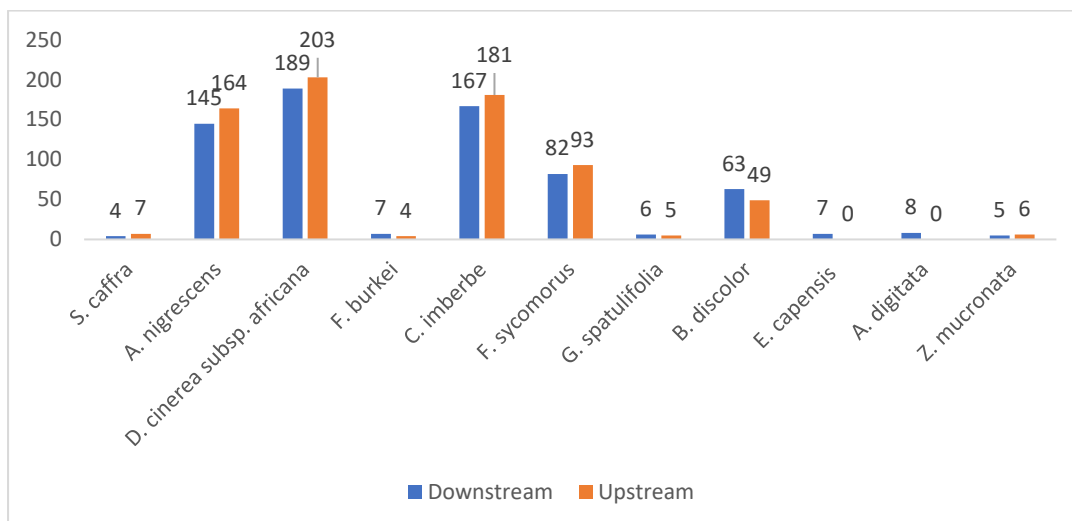
### 4.3. Relocated plant species.

Table 4.4 shows a list of species that were present before and after the construction of the dam. The data in the table describes the species in terms of life form, ecological status, and percentage cover for all study units. Results indicate that there were eleven (11) species that were identified. Quantification of species after the completion of the dam showed that *Dichrostachys cinerea subsp. africana* species (28.1%) was more dominant and *Ekebergia capensis* species (0.5%) was the least dominant in the study area. *Dichrostachys cinerea subsp. africana* species was dominant because, naturally, its ecological status was found to be abundant, while *Ekebergia capensis* was found to be a rare species. Figure 4.1 shows the abundance values of each species for upstream and downstream section of the Nandoni dam.

**Table 4.4 Species that were present prior to and after the construction of the dam (Source: Field data, 2019)**

Botanical number	Scientific name	Life forms	Status	Abundance value	Percent age cover
162	<i>Senegalia caffra</i>	Tree	Rare	11	0,78853
178	<i>Acacia nigrescens</i>	Tree	Common	309	22,15054

190	<i>Dichrostachys cinerea subsp. africana</i>	Shrub	Abundant	392	28,10036
48	<i>Ficus burkei</i>	Tree	Rare	11	0,78853
539	<i>Combretum imberbe</i>	Tree	Abundant	348	24,94624
66	<i>Ficus sycomorus</i>	Tree	Common	175	12,5448
691	<i>Gardenia spatulifolia</i>	Shrub	Rare	11	0,78853
449	<i>Berchemia discolor</i>	Tree	Frequent	112	8,028674
298	<i>Ekebergia capensis</i>	Tree	Rare	7	0,501792
467	<i>Adansonia digitata</i>	Tree	Rare	8	0,573477
447	<i>Ziziphus mucronata</i>	Tree	Rare	11	0,78853
				<b>1395</b>	<b>100</b>



**Figure 4.1 Abundance values for species that existed before and after the dam (Field data, 2019)**

#### **4.4 Community's perception on the need to conserve indigenous plant species**

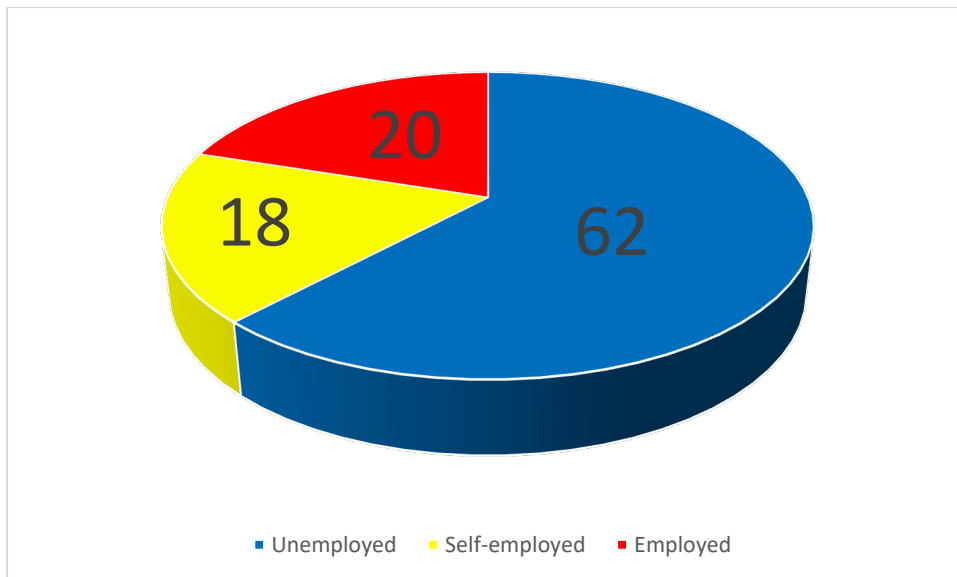
Sixty respondents from four villages were selected using random sampling. These villages were Dididi, Budeli, Mulenzhe, and Tshiulungoma. The responses have been combined and analysed to determine the people's perceptions regarding the need for conservation of indigenous plant species.

##### **4.4.1 Educational status**

Of the 60 respondents, 45 (75%) had secondary education. Twelve percent (7) of respondents possessed post-secondary education, and the remaining 13% (8) had no formal schooling. This suggested that most of the respondents could read and write and therefore understood the impacts of any changes in the diversity of indigenous plant species in their area.

##### **4.4.2 Employment status**

Sixty-two percent (37) of the respondents were unemployed, 20% (12) were employed, and the remaining 18 percent (11) were self-employed. This means that a total of 80% of respondents were not employed. This suggested that these were the people who relied on the environment for their rural livelihoods. This will put more pressure on the natural resources in the vicinity of their areas or villages. The unemployment problem can also lead to illegal extraction of indigenous species for monetary gains and excessive degradation of rural agriculture. Figure 4.2 shows the employment status of respondents from the four villages. For example, Moreto and Lemieux (2015) noted in their study that the main driving force behind elephant ivory poaching was unemployment. It is therefore highly possible that if many people continue to be unemployed, more pressure will be put on the environment and the valuing of natural resources by local people will soon decline. This will also make it difficult for people to conform to environmental legislation.



**Figure 4.2 Employment status percentage of respondents (Source: Field data, 2019)**

#### **4.4.3 Length of stay in the area**

Out of 60 respondents, 87% (52) indicated that they had been living in the area for more than 20 years, and the remaining 13% had been living in the area for more than 10 years but less than twenty (20) years. This suggests that the majority of respondents have experienced any environmental changes that might have taken place in their area since the construction of the Nandoni dam. This means that all the responses from the respondents would be based on real-life experiences rather than folklore narratives.

#### **4.4.4 Necessity to conserve indigenous plant species**

Fifty-three percent (32) of respondents indicated that there was a need to conserve indigenous plant species, and the remaining forty-seven percent (28) stated that there was no need for that. The respondents who indicated that there was a need to conserve indigenous plant species argued that indigenous plant species play a critical role in the lives of rural communities, and some community members have sentimental values attached to some of the indigenous plant species. Others indicated that some of the indigenous plant species act as totems for their families or clans. Those who indicated that there was no need to conserve indigenous plant species argued that

nature can replenish itself, and others indicated that as long as people are unemployed, there will always be a need for them to depend on nature to make ends meet. This is a sign that unemployment is negatively correlated with unemployment. As long as there are still many people who are employed, there will always be pressure on the environment.

#### 4.4.5 Importance of indigenous plant species to community members

Table 4.5 shows the common responses of community members regarding the importance of indigenous plant species to them. The majority of respondents (48%) use indigenous plant species for fuelwood and others sell fuelwood to members of other communities other than their own. This is a form of informal trading that is not often regulated by local authorities. This will put pressure on indigenous plants and ultimately lead to serious environmental degradation. This could have been caused by the high unemployment rate in the area. Twenty-five percent also use indigenous plants as building materials. This practice leads to extraction, which will lead to environmental degradation. The collection of fuelwood and use of plants as building materials will reduce the diversity of trees, which could contribute to global warming. Trees are good at storing carbon, which is a major contributor to global warming (Turner-Skoff & Cavender, 2019). Fifteen percent use indigenous plants as sources of food, and the remaining twelve percent use them as totems. All these activities mentioned by respondents involve the extraction of plants, which might lead to degradation if done on a large scale.

**Table 4.5 Importance of indigenous plant species to community members (Field data, 2019)**

Responses	Frequency	Percentage
Fuelwood	29	48
Building material	15	25
Totems	7	12
Source of food	9	15
<b>Total</b>	<b>60</b>	<b>100</b>

#### 4.4.6 What should be done to conserve indigenous plant species?

When asked about what should be done to conserve indigenous plant species, respondents provided different responses, but the majority believed that the government and municipality should provide people with jobs and stop corruption. Table 4.6 shows the responses of respondents from the four villages. Forty-three percent of respondents believed that if the government and municipalities had provided people with jobs indigenous vegetation would have been conserved. Very few (10%) believed that environmental education could promote the conservation of indigenous tree species. Twenty-eight percent (28%) stated that indigenous plant species could be conserved if people resisted deforestation. This is a challenge for local authorities if the majority of their citizens still depend on natural resources for their livelihood and if the majority of these citizens are also unemployed. The other 18% believed that if more people were employed to enforce environmental legislation, then conservation of indigenous plants would improve.

**Table 4.6 What should be done to conserve indigenous plant species? (Field data, 2019)**

Responses	Frequency	Percentage
Hire more people to enforce environmental laws	11	18.3
Government and municipalities should provide people with jobs	26	43.3
Stop deforestation	17	28.3
Increase environmental education	06	10
<b>Total</b>	<b>60</b>	<b>100</b>

#### 4.4.7 People responsible for conservation of indigenous plant species

When asked who should be responsible for the conservation of indigenous plant species, the majority of respondents stated that the local municipality should be responsible. Eighty percent (80%) stated that the local municipality should be responsible for the conservation of indigenous plant species. The remaining 20%

stated that local people should be responsible for the conservation of indigenous plant species. It is interesting to note that respondents put the responsibility of conserving indigenous vegetation on the shoulders of the local municipalities. This simply implies that the responsibility for species conservation is left in the hands of municipalities. This means people do not value the resources from which they benefit. This also explains the dependence of local inhabitants on local authorities for conservation matters. This might be due to the loss of indigenous knowledge and more dependence on the government for social welfare issues. This makes it difficult for people to value natural resources and conserve them.

#### **4.4.8 Impact of Nandoni dam on indigenous plant species**

Respondents were asked if the Nandoni dam had an impact on indigenous plant species. The majority of respondents (78%) stated that the construction of the dam had an impact on indigenous plant species. They stated that since the construction of the dam, there had been a lot of invasive alien plant species and a decline in indigenous plant species in the vicinity of the dam. Others stated that the construction of the dam increased uncontrolled deforestation for the fuelwood business. The remaining 22% stated that the construction of the dam did not impact indigenous plant species but also noted a decline in the number of indigenous plant species, not due to the construction of the dam but due to uncontrolled fuelwood collection and plant harvesting. The increase in the number of indigenous plant species is a cause for concern, as these species have negative consequences for indigenous plant species. Some of the problems include deterioration in water quality, biodiversity loss, accelerated poverty and hunger, and damage to the growth of the economy (Day et al., 2018). Biodiversity loss in an area where people depend on natural resources will automatically increase poverty and hamper economic growth. Therefore, it is possible that this impact has started to manifest itself in the study area.

#### **4.4.9 What developers need to do to conserve indigenous plant species**

When respondents were asked what they think developers should do with indigenous species that are affected by developmental projects such as dam or road construction, the majority (42) (70%) stated that they need to be replaced. The remaining

respondents (18) (30%) respondents believed there was no action needed since the disturbed vegetation would re-establish itself. This means that reforestation is necessary after developmental projects in order to restore ecosystem functions in an area.

## CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

### 5.1 Introduction

Chapter five provides a summary of the results of the research and recommendations created to address the problem in the future for the next generation of researchers. The title of the research is centred on the impact of Nandoni Dam construction on selected indigenous plant species (IPS) diversity: a case study in Thulamela Municipality within Vhembe District of Limpopo Province, South Africa.

### 5. 2. Conclusions

The research was conducted at Nandoni Dam, which was previously known as Luvuvhu Mutoti Dam. The study focused on the impact of Nandoni Dam construction, a case study in Thulamela Municipality within Vhembe District of Limpopo Province, South Africa. The main aim of the study is to assess the impact of Nandoni Dam construction on selected IPS diversity. The results indicated that there was a total of eleven (11) indigenous species that were relocated and replaced through reforestation after the completion of the Nandoni dam. This implies that the degree of impact on the indigenous plant species was minimal, as the number of affected species was restricted to eleven species only. The diversity and relative density results indicated that the vegetation regeneration after the construction of the dam was a success.

The eleven (11) odd selected IPS diversity in the study area village were selected IPS diversity of the *Combretums* and *Acacias*. The vegetation cover results showed that there was an insignificant difference between the upstream and downstream sections of the dam prior to and after the construction of the Nandoni dam. This shows that the dam had little impact on many species, and there was a reforestation process immediately after the construction of the dam.

Questionnaire results showed that there is a need, if not a challenge, for the local authorities and government to provide employment to local communities. This will reduce pressure and overdependency on the natural environment. Many community

members also believed that the Nandoni dam did not impact much on indigenous vegetation species. The survey results also showed minimal impact on the diversity of the indigenous plant species that were affected. However, the lack of knowledge by community members regarding the possible impacts of developmental projects only shows that environmental education and public participation processes were necessary in rural communities that do not have access to libraries or other sources of information except local community members. The belief that nature can replenish itself is also not good for environmental sustainability and has the potential to accelerate deforestation in the vicinity of the dam in the near future.

## **5. 2. Recommendations**

### **5. 2. 1. Protection of remaining species**

It is recommended that the remaining selected IPS be protected, conserved, and allowed to grow upstream and downstream to form buffer zones, as well as relocated and collected by the Department of Nature Conservations, Kruger National Park (KNP), and Skukuza Nursery. This should be done to avoid extinction.

### **5. 2. 2. Environmental Impact Assessment (EIA)**

It is essential that any construction development projects, such as relocation of human settlements, mining, and dam construction, be preceded by an Environmental Impact Assessment (EIA) and public participation processes.

Environmental effects must be considered before any activity. Environmental Impact Assessment reports should be shared with local communities through local authorities. This enduring legacy not only symbolized a new commitment to selected IPS diversity protection but also an affirmation of trust in the use of science for planning and decision making. NEPA represents the national environmental goals and policies that are intended to mitigate mistakes of the past and avoid possible threats in the future through thoughtful and coordinated planning efforts, also considering the formation of alternative strategies (Smith, 1993).

### **5. 2. 3. The Constitution of South Africa (1996) on the Bill of Rights, Environment Section 24**

In the Constitution of the Republic of South Africa, on the Bill of Rights, Section 24 (a) and (b), it states that everyone has the right guaranteed to an environment that is not harmful to their health or wellbeing. To have an environment protected for the benefit of present and future generations through reasonable legislation and other measures, (i)–(ii) the government must act reasonably in order to protect the environment by preventing pollution and ecological degradation, promoting conservation of selected indigenous plant species (IPS), and securing ecologically sustainable development and use of natural resources while promoting justifiable economic and social development. The researcher therefore encourages communities to be conscious and respectful in protecting the environment, including selected IPS diversity or richness, in order to create a conducive environment for future generations of researchers to enjoy the benefits thereof.

### **5. 2. 4. Government Gazette 27th November 1998 (ACT NO.107 OF 1998). National Environmental Management Act (NEMA) 1998.**

The principles set out in Section 2 of the National Environmental Management Act No.107 of 1998 apply throughout South Africa to the actions of all organs of state that may significantly affect the environment. (c) serve as guidelines by reference to which any organ of state must exercise any function when taking any decision in terms of this Act or any statutory provision concerning the protection of the environment. Including selected indigenous plant species diversity. Environmental management must place people and their needs at the forefront of its concerns, and serve their physical, psychological, developmental, cultural, and social interests equally. (4) (a) Sustainable development requires the consideration of all relevant factors, including the following: (i) avoiding the disturbance and biological loss of ecosystems; or in instances where they cannot be avoided, they should be minimized and remedied. (viii) That negative impacts on the environment, including selected IPS diversity and on people's environmental rights be anticipated and prevented, and where they cannot be prevented together, minimized and remedied.

(b) Environmental management must be integrated, acknowledging that all elements of the environment are linked and interrelated, and it must consider the effect of decisions on all as part of the environment and all people in the environment by pursuing the selection of the best practicable environmental option. All people must have the opportunity to develop the understanding, skill, and capacity necessary for achieving equitable and effective participation, and participation by vulnerable and disadvantaged people must be ensured.

A decision must take into account the interests, needs, and values of all interested and affected parties, and this includes recognizing all forms of knowledge, including traditional and ordinary indigenous knowledge of selected IPS richness or diversity.

(i) The social, economic, and environmental impacts of activities, including disadvantages and benefits, must be appropriate in the light of such consideration and assessment.

(o). The environment is held in public trust for the people; the beneficial use of environmental resources must serve the public interest and the environment.

#### **5. 2. 5. Further research by future generations of scholars**

It was not possible for this study to cover all aspects of the phenomena under investigation in this research on the impact of Nandoni Dam construction on selected indigenous plant species (IPS) in Thulamela Municipality within Vhembe District of Limpopo Province, South Africa. Further research is therefore, required to be conducted on the importance of selected indigenous plant species (IPS) diversity that is growing upstream and downstream of Nandoni Dam along the Luvuvhu River.

There is a need to identify and compile a list of almost all the names of selected IPS diversity growing along the Luvuvhu River, including Nandoni Dam and Albasini Dam

within Vhembe District of Limpopo Province, South Africa, for the use of future environmental science researchers.

Tropical rivers have heavy rains, which are accompanied by flooding of small rivers that flow to the Luvuvhu River. Something must be done to prevent the selected IPS diversity from submerging due to dam construction. A buffer zone at the interface of the dam and indigenous species should be constructed.

It is recommended that the National Environmental Advisory Forum (NEAF) be established. (a) The minister of the Department of Environmental and Water Affairs be informed of the views of stakeholders regarding the application of the principles set out in Section 2 of the NEAF and advise the minister. This is a form of public participation on (b), (i) any matter concerning environment management and government, specifically the setting and achievement of objectives and priorities for environmental government and the appropriate method of monitoring compliance principles.

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## APPENDIX A

### Questionnaire for respondents from the four villages

#### A. Demographic characteristics

##### 1. Educational status

No formal schooling	
Primary	
Secondary	
Post-secondary	

##### 2. Employment status

Unemployed	
Self-employed	
Employed	

#### B. Conservation of the indigenous plant species

3. For how long have you been staying in your area?

<10 years	
10-19	
>20	

4. Do you think it is necessary to conserve indigenous plant species?

Yes	
No	

5. Please explain why you say so .....

6. In what way are indigenous plant species important to community members?  
.....

7. What do you think should be done to conserve indigenous plant species in your area? .....

8. Who do you think should be responsible for the conservation of indigenous plant species in your area?.....

9. Do you think the construction of the Nandoni dam has had an impact on indigenous plant species?

Yes	
No	

10. Please explain why you say so .....

11. Do you think it is necessary for developers to replace any indigenous plant species that were removed through developmental projects such as dam and road construction?

Yes	
No	

12. Please explain why you say so .....

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**Thank you for your cooperation**

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