CONCEPTUALISING LONG-TERM MONITORING TO CAPTURE ENVIRONMENTAL, AGRICULTURAL AND SOCIO-ECONOMIC IMPACTS OF THE MZIMVUBU WATER PROJECT IN THE TSITSA RIVER

Report to the

WATER RESEARCH COMMISSION

by

JJ van Tol, W Akpan, D Lange, C Bokuva, G Kanuka, S Ngesi, KM Rowntree, G Bradley & A Maroyi

University of Fort Hare

WRC Report No. KV 328/1/14

ISBN 978-1-4312-0527-1

April 2014

Obtainable from

Water Research Commission
Private Bag X03
Gezina, 0031

orders@wrc.org.za or download from www.wrc.org.za

The publication of this report emanates from a project entitled *Conceptualising long-term monitoring to capture environmental, agricultural and socio-economic impacts of the Mzimvubu Water Project in the Tsitsa River* (WRC Project No. K8/1027).

EXECUTIVE SUMMARY

The Ntabelanga valley is deemed the appropriate site for building a large, multipurpose storage dam in the Mzimvubu basin. This study was conducted to conceptualise a long- term monitoring project to capture the impact of the proposed dam on environmental, socio-economic and agricultural aspects. The study firstly described the current situation in the Ntabelanga valley whereupon suggested monitoring aspects/actions were identified.

Long-term climatic data shows the distinct seasonal distribution of rainfall. Long-term streamflow data illustrates that the Tsitsa River is prone to extremely high peakflows and also that baseflow in this river seldom cease. In general the soils bordering the proposed dam site are unsuitable for crop production and irrigation due to their high susceptibility to erosion. Areas with deep sandy soils in *A*- and *E*-land types were identified; these soils have the potential to be developed intensively. The extent of erosion in the study area, especially land type *Db344,* is extreme. Wetlands and a natural forest in the study area were identified; however a number of smaller wetlands, not delineated, exist in the area. Environmental aspects that will be impacted by the dam include streamflow regimes, streamflow volumes, water pollution, dissolved oxygen levels, sediment and nutrient loads, groundwater quality and quantity, changes in stream morphology, aquatic biodiversity and abundance and riparian vegetation. All of these aspects will be subjected to long-term monitoring.

Preliminary sociological data reveal a deep-lying narrative and vision of the “good life” in the study area. Though evidently submerged under the gloom of poverty, hidden by barren hills, and somewhat eclipsed by a deep distrust of government, such a narrative and vision, nonetheless, exists. The respondents’ sophisticated articulation of the choices the dam project opens up, and of their readiness to take advantage of the project to attain self-reliance and improve their lives, is a strong case for a long-term scientific project that monitors the socio-economic impact of the dam. This is despite the fears also expressed about the potential socio-ecological risks that the dam poses at the local level. Hopes and fears of the kinds expressed by respondents are powerful ingredients for constructing a robust ‘social sustainability matrix’ that will boost the overall understanding of the long-term local impact of the dam. The hopes and fears of communities affected by the dam should be captured and related to actual changes in the socio-economic situation. A number of socio-economic aspects that should be subjected to long-term monitoring were identified namely, increased occupational and entrepreneurial opportunities, enhanced household incomes and skills development, impacts on sociocultural and capital resources.

The agricultural data indicate that the main activities, livestock, crop and vegetable production, used to provide enough income to sustain members of the two communities in the past. However, presently this is not the case anymore and agriculture is a rather supplementary activity. All main activities contribute to food security and additional small income, but the lack of sophisticated production inputs, such as quality seeds, fertilizer, the absence of crop rotations and mulching, and the dependency on unsteady rains, prevent agriculture from playing a more important role in the livelihoods of the two communities. In regard to a long-term monitoring project, the building of the dam

and with it, the consistent availability of water for agricultural production, may indeed provide the opportunity for increasing agriculture's importance in terms of contribution to livelihoods, and through this, improve the lives of community members. Consequently, it would be interesting to monitor how the communities might take advantage of the dam. Rejuvenation of the agricultural sector in the study area is one of the main motivations behind the Mzimvubu water project. The impact of the dam on agricultural practices should be quantified. This will include measurement of yields; areas cultivated and used for grazing; crop diversity; ratios between irrigation and rain-fed agriculture; ratios between livestock and crop production and household income from agriculture.

In this interdisciplinary project the interactive relationships between different disciplines will be integral to the proposal for long-term monitoring. These intersections were identified and should be quantified in the long-term. The report ends with a section on priority monitoring actions, i.e. aspects that should be monitored continuously, followed by a proposed timeline of monitoring actions.

ACKNOWLEDGEMENTS

The authors would like to thank the Research Manager, Mr W Nomquphu of WRC Project K8/1027 for the assistance and the constructive discussions during the duration of the project.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CA	Conservation Agriculture
CBO	Community Based Organisation
DWA	Department of Water Affairs
FGD	Focus Group Discussion
NAS	National Academy of Science
NCOP	National Council of Provinces
NGO	Non-Governmental Organisation
PTO	Permission to Occupy
SAWS	South African Weather Service
SMME	Small, Medium and Micro-sized Enterprises
TMU	Terrain Morphological Unit
WRC	Water Research Commission

1 INTRODUCTION

The Mzimvubu River is the largest undeveloped river in South Africa. This is despite the facts that the river has high annual runoff, high environmental status (NFEPA Report, 2011), high tourism potential, and is suitable for afforestation and moderately suitable for dryland/rainfed and irrigation agriculture (NWRS2, 2012). For these reasons, the Department of Water Affairs (DWA) investigated the potential of building a multipurpose dam in the Mzimvubu basin to serve as a catalyst for economic and social development. After studying 19 potential sites, the Minister of Water and Environmental Affairs (Mrs Molewa) stated in her budget speech (21st May 2013) that the Ntabelanga site in the Tsitsa river was chosen as the most appropriate site for the multipurpose dam. A smaller dam will also be built for generation of hydroelectricity. Initial documents suggested that this smaller dam will be built upstream of the Ntabelanga dam, however recent information revealed that a dam (Laleni) approximately 20 km downstream of the Ntabelanga dam is the most feasible. Initially the building of the building of the dam/s was said to commence early in 2016, however, in the National Council of Provinces (NCOP) speech Mrs Molewa proclaimed that construction will start early or mid-2014. Most recent information suggests that the building will commence in October 2014.

Globally, large dams are vital development infrastructure. They help society to meet various needs. These needs can include water for domestic and industrial use, agricultural irrigation, and hydro-electric power. Dams can also help to "*reduce peak discharge of flood wate*r" and "*increase the depth of water in a river so as to improve navigation*" (Altinbilek, 2010:10). In the case of the proposed Ntabelanga dam, benefits such as job creation and agricultural rejuvenation have been highlighted by the Department of Water Affairs (DWA, 2012:2). Therefore, the development of the dam is being conceptualised in a way that will ensure that it is in tandem with the Eastern Cape Government's vision for the Mzimvubu River Basin. This vision includes afforestation, irrigation, hydropower, water transfer and tourism (DWA, 2012:1).

Despite the widely acknowledged benefits of large dams (see Altinbilek, 2002), dam development continues to come up against important questions of social and environmental sustainability. In other words, the success of a dam project is no longer just a matter of whether it is 'technologically feasible' or whether it will drive 'economic development': it is equally an important sociological matter. Success is increasingly being measured by the extent to which the project coheres with specific social and environmental dynamics in the local area – in the short-, medium- and long term. While protests against dams – or, for that matter, pro-dam advocacy – are sometimes ideologically and politically motivated and have little to do with observed impacts (Raina, 2000:147-148; Biswas, 2004), studies have shown that a failure to pay close attention to specific socio-cultural dynamics in the local area could expose the project to invidious local resistance, if not immediately, then certainly in the long run (see Uphoff, 1996; Bisht, 2009). Indeed, difficulties could arise even though local residents appeared to have initially welcomed the project (Akpan, 2006:224).

There is also the crucial question of environmental impact, and, as indicated earlier, long-term monitoring of this is important for determining the long-term sustainability of a dam project. A large body of literature exists on the environmental impacts (both positive and negative) of dam construction (see for instance, Beck, Claassen & Hundt, 2012; Dumas et al., 2012). Nevertheless, because every river is unique in terms of its morphology, the landscapes it flows through and the species its supports, the impacts of dam construction on ecosystems will also be unique. According to McCully (2001:31), a ''*dam [dam construction] can be regarded as a huge, long-term and largely irreversible environmental experiment without a control*".

Obviously, dam constructions have a direct impact on the environment through permanent inundation of previously dry areas, alteration of stream flow regimes (reduction in natural flooding), and fragmentation of river ecosystems, thereby reducing species diversity in almost all cases. Indirectly, land-use change associated with dam constructions – and this is both an environmental and a sociological issue – can significantly alter the equilibrium of ecosystems. These changes, generally, can lead to more intensive land utilisation. The irrigated land, previously used for rainfed cropping or grazing, for example, can result in more strain on the environment. Needless to say, these impacts add to the controversies around large dam projects (Biswas, 2004). Frequently, scientific studies associated with dam construction focus more on finding out the most technically feasible place to build it, than on the long-term socio-environmental issues that come in its train.

This report therefore propose procedure for long- term monitoring of environmental, agricultural and socio-economic changes associated with the building of the Ntabelanga dam. The current situation in the Ntabelanga is first described with the focus on the physical environment (climate, streamflow, soils and environmental sensitive areas), the dominant agricultural practices as well as the perspectives, hopes and fears of communities in the study area. Information regarding the Laleni dam and potential irrigation sites was only available at the end of this project and were consequently not included in the *status quo*. The *status quo* is followed by suggested monitoring actions and methodologies that should be followed to capture the impact of the dam (before, during and after construction) on the environment, agriculture and people.

2 STUDY AREA AND A DESCRIPTION ENVIRONMENTAL ASPECTS

The Mzimvubu River falls within the Mzimvubu to Keiskamma Water Management Area 12. The Tsitsa River is one of the main tributaries of the Mzimvubu River and falls within tertiary catchments T35A-E. The planned Mzimvubu water project will consist of two dams, Ntabelanga and Laleni, that will be used for irrigation and hydroelectricity generation respectively (Figure 2.1).

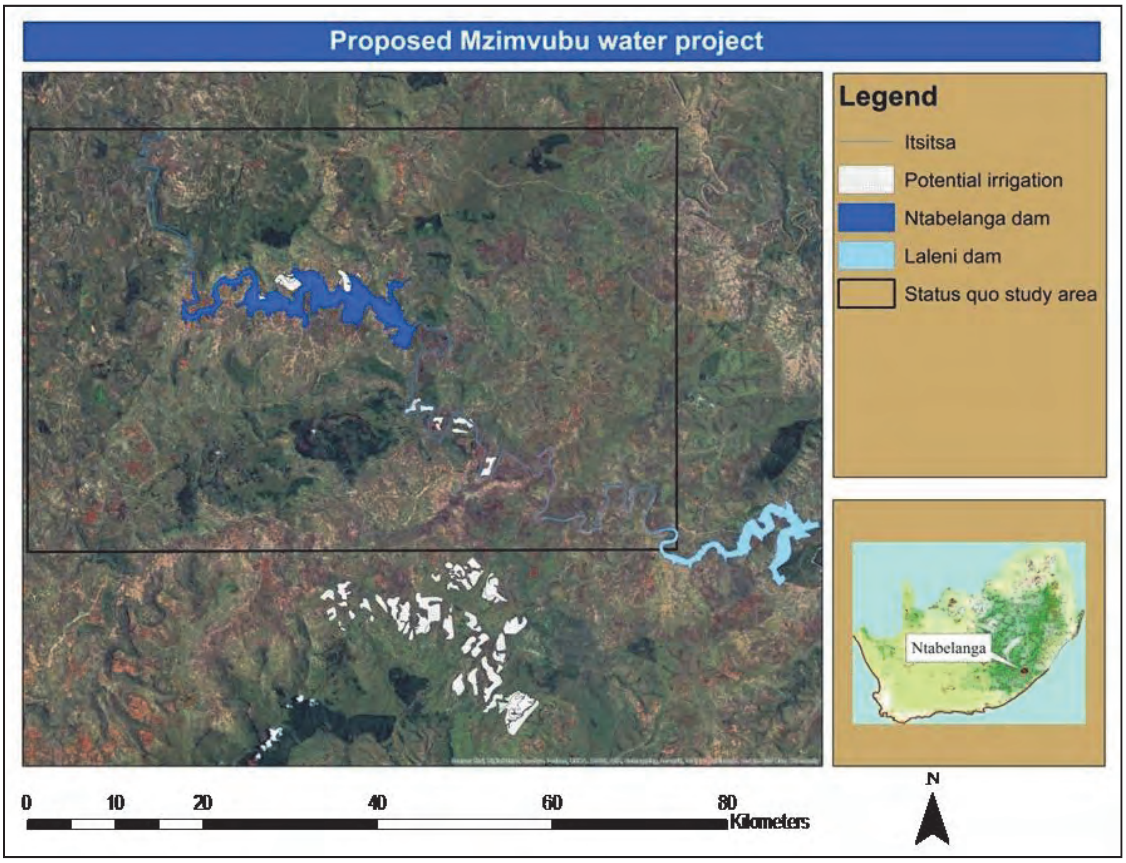

Figure 2.1: Predicted inundation footprint of Ntabelanga and Laleni dam with proposed irrigation areas (inundation footprints obtained from DWA and Jeffares & Green (Pty) Ltd).

2.1 The Ntabelanga Study Area

An area of approximately 1 500 km^2 surrounding the dam was selected for general descriptions of the soils, agricultural practices and environmentally sensitive areas (Figure 2.2). Although the greater part of this area will not be influenced directly by the planned development, it was used to illustrate the nature of the environment in the vicinity of the dam. It should be noted that when this short term study commenced information regarding the Laleni dam and potential irrigation areas was not available and was consequently not included in the description of the physical environment. These areas do however form an integral part of the design of the long-term monitoring project.

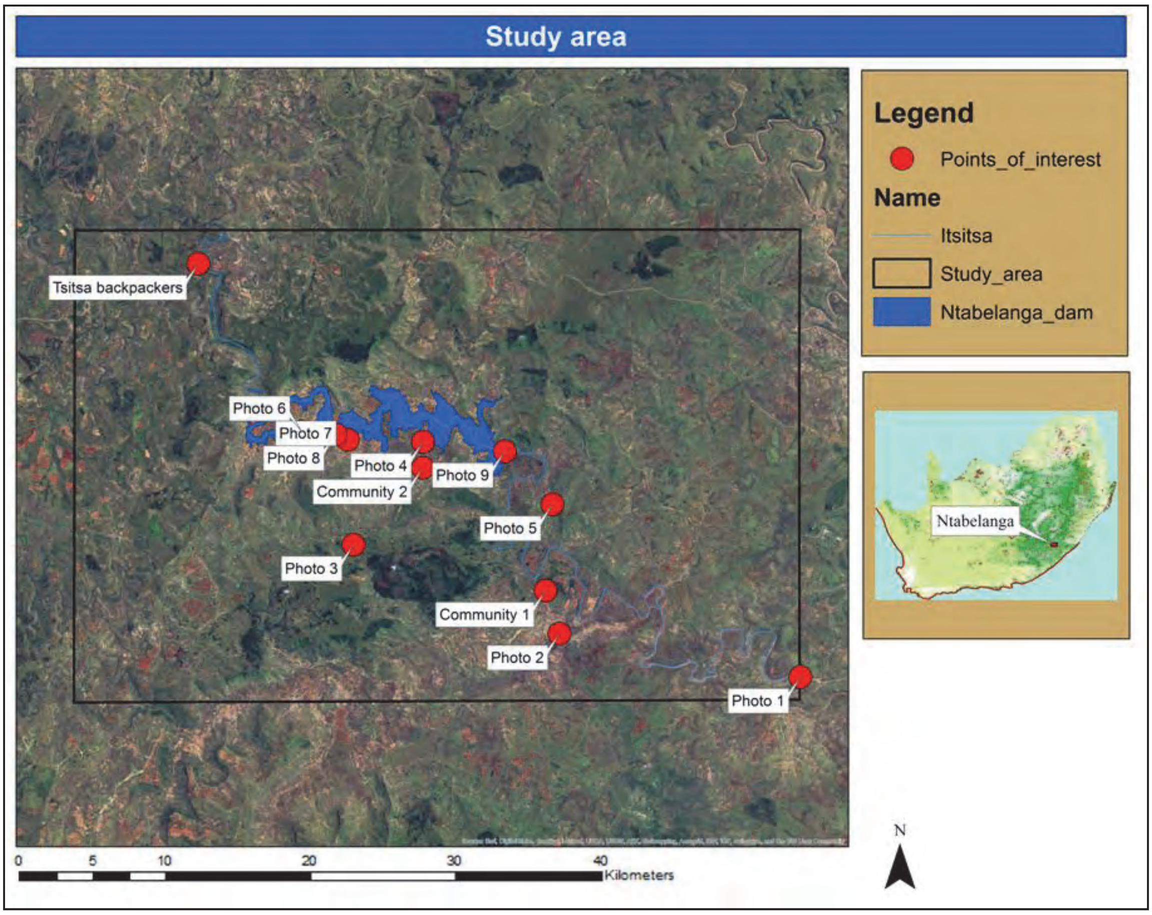

Figure 2.2: The study area for description of physical environment, socio-economic and agricultural *status quo* with predicted footprint of the Ntabelanga dam (obtained from DWA and Jeffares & Green (Pty) Ltd).

The proposed Ntabelanga dam is nestled between mountains, the foothills of the Drakensberg escarpment (Figure 2.3). The relief suggests that agricultural (irrigation) development will be limited to areas directly next to the proposed dam. The steep slopes hinder easy access to the dam and the communities around the dam. The proposed Ntabelanga dam wall is located in a scenic gorge, approximately 200 m wide (Figure 2.4). Below the proposed dam wall, the Tsitsa River meanders through relatively large, flat alluvial plains (Figure 2.5).

The proposed development will influence different communities on different levels for example: those below the dam will generally enjoy positive impacts of the dam such as constant water flow, less flooding, etc., whereas the population directly next to the dam will generally suffer from a loss of grazing land, limited access to free flowing water, etc. For these reasons two communities were identified to conduct sociological and agricultural research.

Community 1 (Ntzebe Village) lies on the banks of the Tsitsa River approximately 3 km downstream of the proposed dam wall (Figure 2.2 & Figure 2.6). Sociological insights obtained from this community are assumed to be indicative of perspectives of the population downstream of the dam.

Community 2 (Lower Sinxaku) is located on the edge of the anticipated footprint of the Ntabelanga dam (Figure 2.2 & Figure 2.7). Insights from this community are assumed to reflect those of communities around the actual Ntabelanga dam footprint.

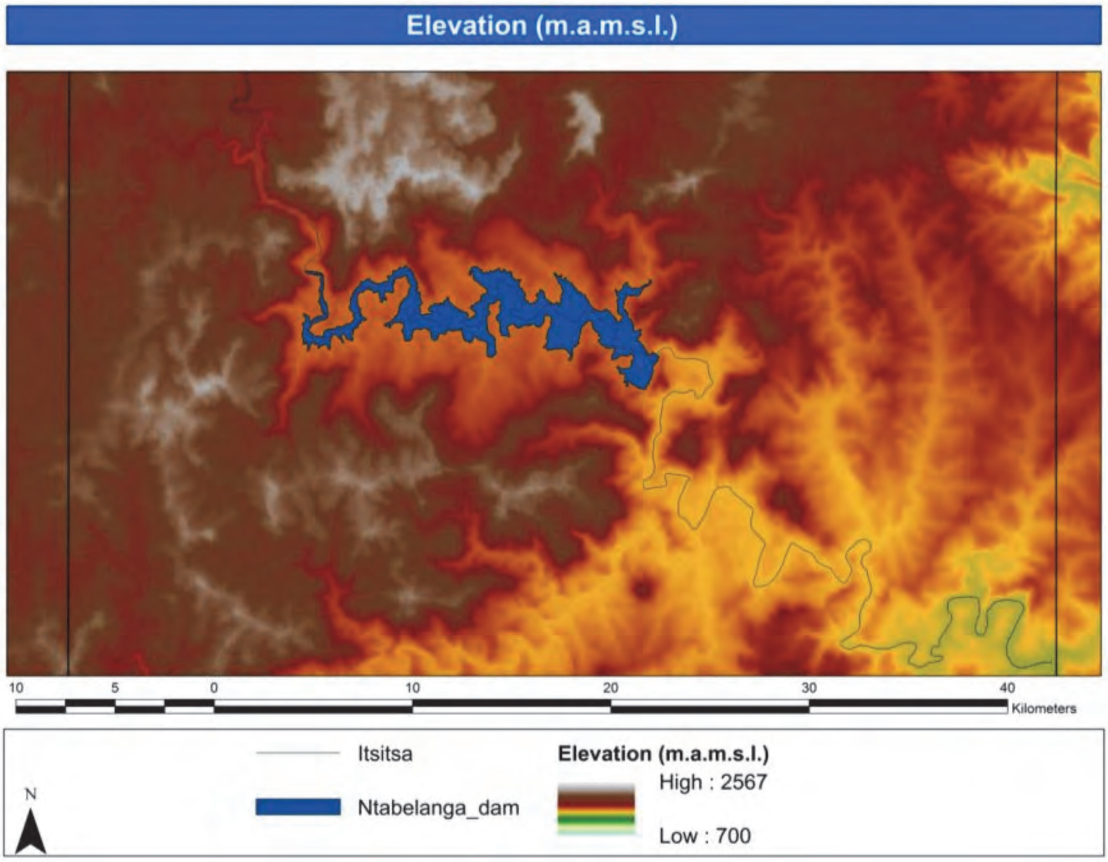

Figure 2.3: Elevation expressed as meters above mean sea level (m.a.m.s.l) of the study area.

Figure 2.4: Location of proposed Ntabelanga dam wall (red arrow) and downstream view of the Tsitsa River (Located at Photo 9 in Figure 2.2).

Figure 2.5: Alluvial plains along the Tsitsa River below the proposed dam wall (located at Photo 5 in Figure 2.2).

Figure 2.6: Community 1 (Ntzebe) in the background on the banks of the Tsitsa River downstream of the proposed dam wall (located at Photo 2 in Figure 2.2).

Figure 2.7: View of the Ntabelanga (located at Photo 3 in Figure 2.2). Part of community 2 (Lower Sinxaku) is encircled in red. Note the extent of gully erosion in the foreground.

2.2 Description of Environmental Situation

This section briefly outlines some of the dominant environmental aspects in the study area. All the information, with exception of the soil map of Land Type Db344 and the extent of erosion, was obtained or refined from existing databases or published sources and referenced accordingly.

2.2.1 Methodology

Climatic and Streamflow Information

Climatic data for the study area is scarce. The DWA weather stations in the vicinity of the study area have no meteorological data recorded. For this reason we have obtained rainfall from the South African Weather Service (SAWS) of two sites (Elliot and Mthata) closest two the study area. This data was only used to evaluate seasonal rainfall patterns and average monthly rainfall volumes. The assumption was that, although rainfall volumes will differ between the sites, seasonal rainfall patterns for the study area will be reflected by averaging the data from the sites. A fair assumption when the good correlation between the sites (Figure 2.8) is considered. As both sites fall within the summer rainfall area, a rainfall season is considered to start at the 1st of August of one year and ends at the 31st of July the following year. Seasons where more than 10 days of rainfall data were missing was omitted from the study.

Streamflow in the Tsitsa River was measured at DWA weir T3H006 at Xonkonxa approximately 20 km downstream of the proposed dam (Figure 2.2 and Figure 2.10). The Tsitsa River at this weir drains a catchment area of 4268 km^2. Daily average flow ($m^3.s^{-1}$) at T3H006 for the period November 1951 to November 2011 is presented in Figure 2.11. Total daily flow was calculated by multiplying the daily average flow ($m^3.s^{-1}$) with 86 400. A good continuous dataset of streamflow exists from August 1998 to January 2013. These data were used to calculate monthly variation in streamflow as presented in Table 2.3: Summary of monthly streamflow, presented as daily average (m3.s-1) measured at T3H006 in the Tsitsa River.

Soil and Erosion Information

Broad descriptions of the soils and soil distribution patterns were obtained from the land type data base (Land Type Survey Staff, 1972-2006). The average soil depth as well as the average clay content was obtained from the database.

The extent of erosion was determined by visually identifying and demarcating erosion gullies from 1:10 000 aerial images using Global Mapper v14.2.1 (Blue Marble Geographics, 2013). This method only accounted for gully erosion and not for sheet and/or interrill erosion. Land types (Land Type Survey Staff, 1972-2006) were used to explain the prominence of erosion in certain areas. A land type is an area with similar climate, topography and soil distribution patterns at a scale of 1:250 000. ArcMap v10.1 (Environmental Systems Research Institute, 2010) software was used for all GIS related work, with exception of identification of the erosion gullies.

Land type Db344 covers large areas (7 417 ha) adjacent to the dam (Figure 2.13). This land type was selected to identify erosion sensitive areas based predominantly on surface colours. Large areas of the surface in the Db344 have been exposed either by erosion or cultivation and prominent red and grey colours could be identified and were demarcated manually using ArcMap. The surface colours reflect *inter alia* the geological formation and soil moisture regime and can therefore be interpreted in relation to the sensitivity to erosion (Table 2.1). The vegetative cover of some areas in Db344 was too dense to accurately identify the surface colour. The sensitivity to erosion of these areas were determined with approach similar to that followed by Van Zijl et al. (2013); where the sensitivity to erosion was determined by the ability of the land to promote overland flow (Table 2.1). Soil associations are groups of soil that will behave similarly with respect to a certain characteristic. Db334 were divided into three soil association groups in terms of the sensitivity to erosion based on the surface colour and soil forms occurring in the area as reported in the land type inventory (Land Type Survey Staff, 1972-2006).

Table 2.1: Surface colour, interpretation and soil association group of land type Db344

Surface colour	Interpretation	Sensitivity to erosion*
Grey	Parent material: mudstone. Saturation of surface horizon, leading to bleached colours of A-horizon. Removal of dark coloured surface horizon; subsurface horizons exposed. Complete removal of solum; mudstone exposed. High Na content	High
Red	Parent material: Dolerite. Free drained soils. Stable and rich in Ca and Mg.	Low
Vegetative cover	Steep (>10%) convex slopes: Overland flow likely Concave positions with flow accumulation (>100 cells): promote gully erosion	High
	Moderate (3-10%) convex and concave slopes with limited flow accumulation: Overland flow possible but not dominant	Moderate
	Flat areas (slope < 3%) overland flow unlikely	Low

*Soil association group

Soil forms as classified by the South African Soil Classification System (Soil Classification Working Group, 1991) encompass a number of different properties which can be interpreted in terms of sensitivity to erosion. The accuracy of the soil association map was determined by classifying 43 randomly distributed soil profiles in accordance with the South African Soil Classification System and relating the classification to the sensitivity of the soils to erosion in terms of the three soil association groups.

<u>Wetlands and Natural Forests</u>

Major wetlands and the location of natural forests were obtained from the Land Cover Database, 2000 (Van den Berg *et al*., 2000). A few smaller wetlands were identified during the two field visits to the site.

2.2.2 Climatic Information

The limited climatic information in the study area makes it difficult to infer relationships between rainfall and runoff (streamflow). The attempt to generate seasonal rainfall trends based on the available data from two SAWS sites is presented Figure 2.8.

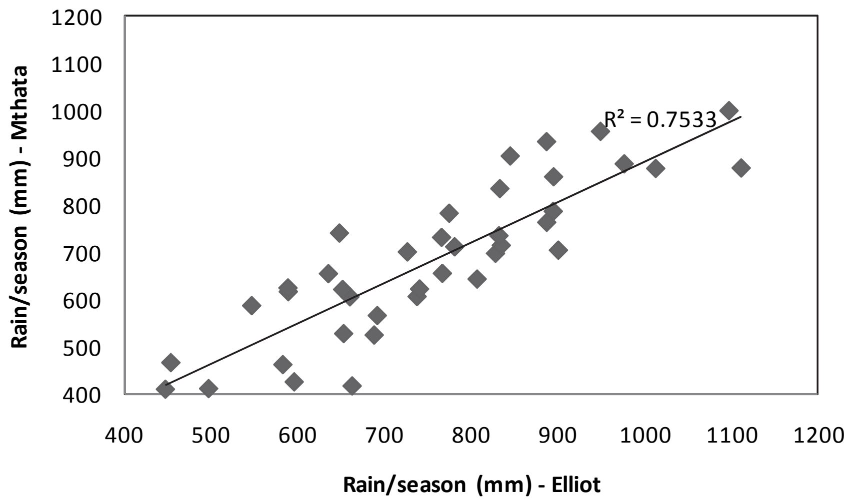

Figure 2.8: Correlation between seasonal rainfall (mm) of SAWS sites in Elliot and Mthata.

Figure 2.8 shows a good correlation between the seasonal rainfall of the two selected SAWS sites (R^2 = 0.75). The seasonal rainfall is generally higher in Elliot compared to that of Mthata, presumably due to higher elevations and the proximity of the escarpment, favouring the generation of orthographic rain. Elliot is 1451 m.a.m.s.l. compared to the 685 m.a.m.s.l. of Mthata. The selected study area is geomorphologically in the middle of these two sites and it was decided to average the rainfall of the sites in order to gain an idea of the long-term seasonal rainfall patterns as well as average monthly rainfall for the selected study area. A summary of this data is presented in Figure 2.9 and Table 2.2 respectively.

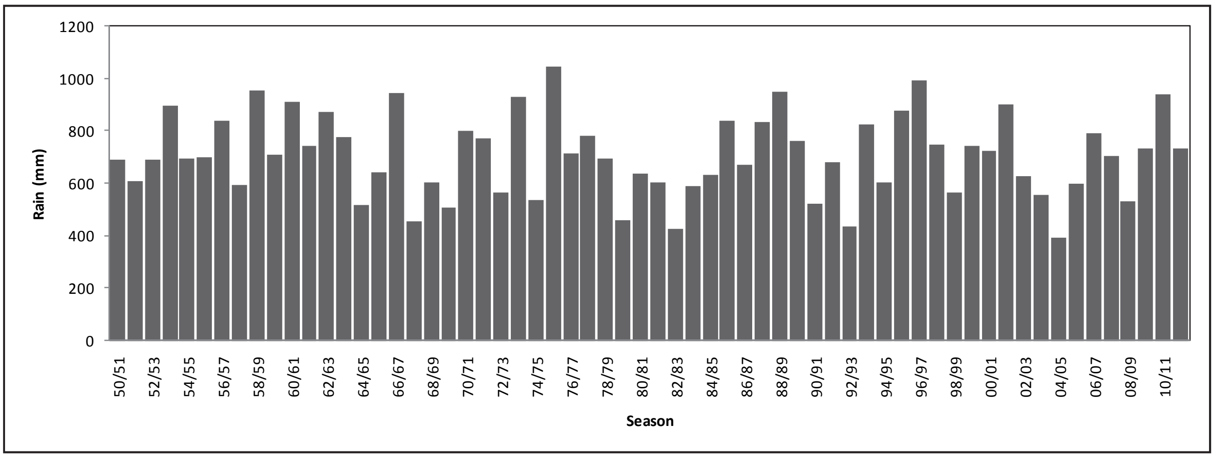

Figure 2.9: Average seasonal rainfall (mm) of SAWS sites Elliot and Mthata.

The average seasonal rainfall presented in Figure 2.9 suggests that there are definite dry and wet seasons typically associated with semi-arid areas (Note that there are seasons missing on the x-axis; it is therefore not a continuous chronological dataset). The minimum rainfall per season is approximately 400 mm whereas the highest rainfall recorded per season is well over 1 000 mm. This variation in rainfall highlights the challenges associated with dry-land crop production in semi-arid areas, i.e. in some years precipitation is insufficient to produce cash crops for example maize.

Table 2.2: Summary of average monthly rainfall (mm) data for the SAWS sites Elliot and Mthata

	Minimum	Maximum	Average	Std. Dev
January	33.7	205.5	100.5	41.5
February	9.0	203.6	101.1	44.1
March	17.4	243.4	97.9	50.4
April	0.0	173.9	48.8	35.2
May	0.0	112.3	24.2	25.2
June	0.0	129.6	14.9	21.8
July	0.0	65.5	14.3	17.3
August	0.0	101.7	22.5	23.1
September	0.2	161.2	34.6	28.8
October	14.7	214.0	66.9	37.9
November	2.1	212.2	87.9	44.4
December	19.5	259.7	99.3	54.0

The monthly rainfall volumes presented in Table 2.2 shows distinct summer rainfall characteristics with the majority of the rain recorded between November and March. These months, the growing season for most summer crops, are also marked by the largest deviation and variation in the rainfall. The minimum rainfall recorded indicates that during some months the risk for dry-land crop production can be immense.

The maximum monthly rainfall volumes presented in Table 2.2 is rather dubious. In April 1978, Ds. W. Botes recorded more than 700 mm at a mission station south-east of Mthatha (Botes, 2013). Regardless of errors in the existing database it is clear that the variation in rainfall will significantly influence the potential for crop production in the area.

In order to relate rainfall to streamflow, precipitation data in the headwaters of the Tsitsa River will be a prerequisite. A number of research projects (the majority funded by the WRC) have been conducted in the Mooi River catchment (and more specifically the Weatherley sub-catchment) one of the major tributaries to the Tsitsa River. This data might become very valuable in future monitoring of environmental aspects influenced by the building of the Ntabelanga dam.

2.2.3 Streamflow in the Tsitsa River

An image of weir T3H006 approximately 20 km downstream of the proposed dam wall is presented in Figure 2.10. This weir is in a good condition and well maintained. A number of DWA weirs are present in the Tsitsa and its tributaries above the proposed dam. None of these are, however, generating data at present. T3H003 at Halcyon drift approximately 20 km upstream of the proposed dam can be vital for future monitoring of in- and outflows to and from the Ntabelanga dam. Efforts should therefore be made to get T3H003 in operating condition.

Figure 2.10: DWA gauging weir T3H006 approximately 20 km downstream of the proposed dam wall (Photo 1 in Figure 2.2).

Daily average flow ($m^3.s^{-1}$) at T3H006 for the period November 1951 to November 2011 is presented in Figure 2.11. Periods with missing data (e.g. 1984) is also included in Figure 2.11. The cumulative flow from November 1951 to January 2013 was calculated and is presented in Figure 2.12.

Figure 2.11 shows that the Tsitsa River at T3H006 is subject to extremely high flows on a regular basis. The maximum daily average flow recorded in the time period was on the 21st of March 1976 when 927 $m^3.s^{-1}$ or 80 million $m^3.day^{-1}$ flowed over weir T3H006. The regular flooding of the Tsitsa River can be expected to have significant positive and/or negative effects on the river ecosystem.

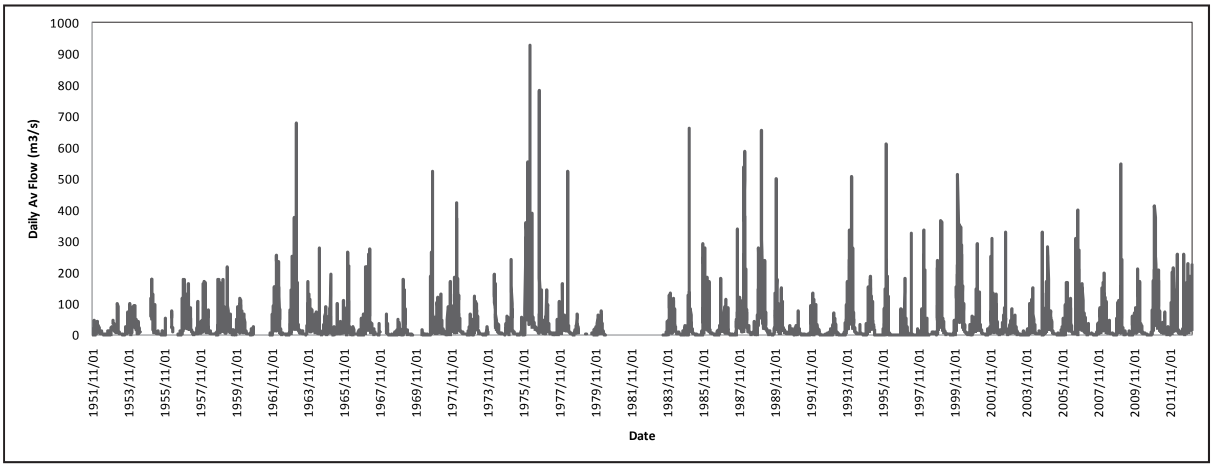

Figure 2.11: Daily average streamflow ($m^3.s^{-1}$) measured from 1951 to 2011 at T3H006 in the Tsitsa River.

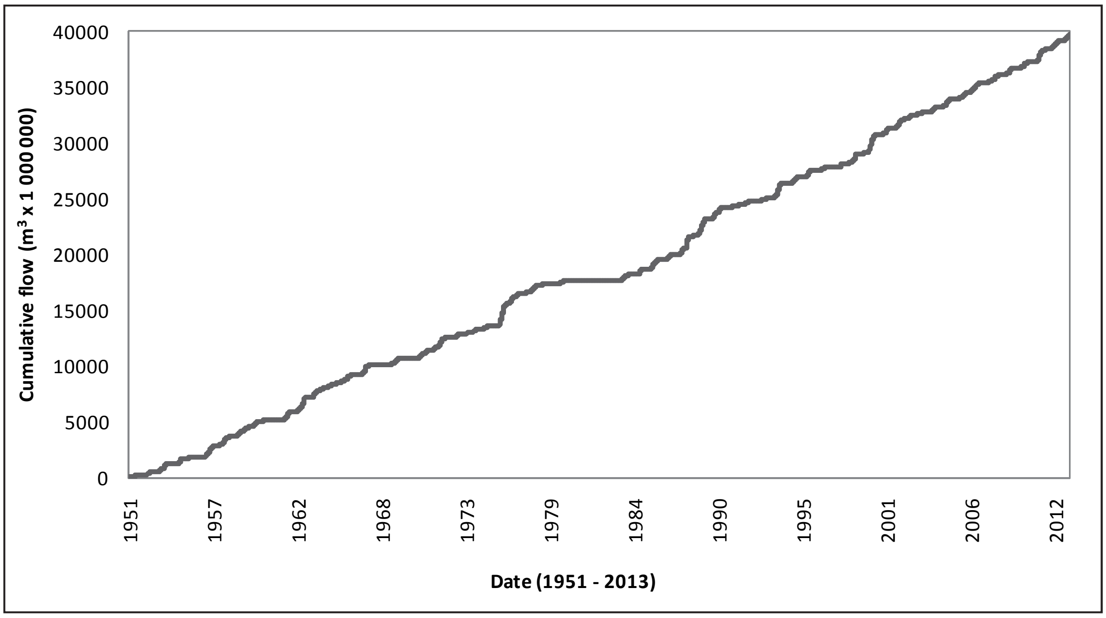

Figure 2.12: Cumulative flow (million m^3) from 1951 to 2013 measured at T3H006 in the Tsitsa River.

Figure 2.12 indicates that the total seasonal streamflow trends were fairly constant during the past 60 years. Except for certain periods (e.g. 1979 to 1984) with missing data, there was no considerable deviation in the cumulative flow line, despite major land-use change (afforestation) in the headwaters of the Tsitsa River.

The monthly streamflow variations calculated from the good continuous dataset (August 1998-January 2013) is presented in Table 2.3. During the selected 15 year period, streamflow in the Tsitsa River never ceased. The lowest daily average flow (0.2 $m^3.s^{-1}$) was recorded in October 2010 and the highest flow was measured in February 2009 with a daily average of 547.3 m^3; it translates to approximately 47 million m^3 per day.

The months with the lowest flow were August-December. These months mark the start of the growing season for summer crops, which typically require adequate water for establishment and reducing the risk of low yields or crop failure.

Table 2.3: Summary of monthly streamflow, presented as daily average ($m^3.s^{-1}$) measured at T3H006 in the Tsitsa River

	Minimum	Maximum	Average	Std. Dev
January	3.0	512.9	55.5	64.9
February	8.3	547.3	63.2	63.1
March	4.9	345.8	45.5	47.4
April	3.6	259.6	23.6	29.1
May	2.3	116.1	10.0	12.2
June	2.0	45.4	5.6	5.6
July	1.3	74.4	4.7	7.7
August	0.8	309.0	9.3	22.9
September	0.3	398.1	10.4	34.0
October	0.2	271.8	14.1	30.1
November	0.7	251.4	21.3	32.7
December	0.9	308.4	43.2	43.5

2.2.4 Soils

The broad land types in the study area are presented in Figure 2.13. They are briefly explained using the description of the Land Type Survey Staff (1972-2006) with some inference to their agricultural and ecological significance.

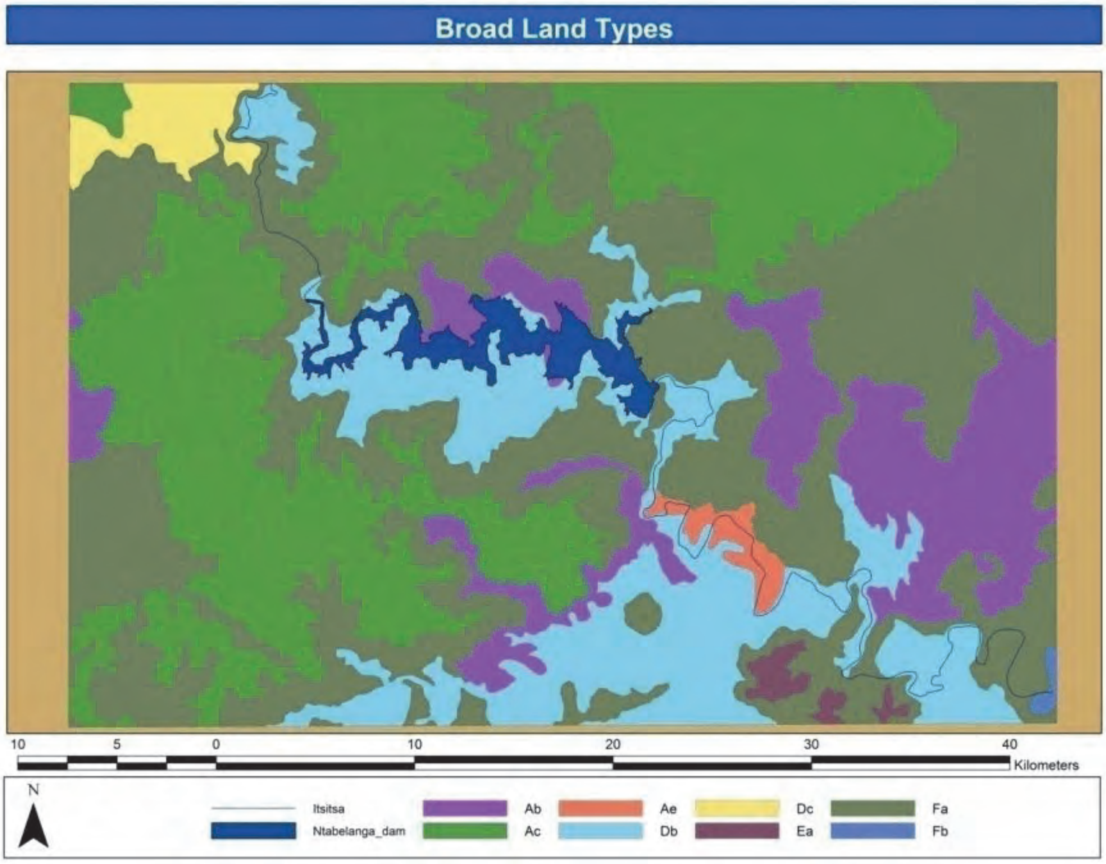

Figure 2.13: Broad land types of the study area.

A-land types in Figure 2.13 (i.e. Ab, Ac and Ae) refer to regions where freely drained yellow and red soils occupy more than 40% of the land area. The soils of *A*-land types are generally considered to be good for crop production and suitable for irrigation. Since these soils are freely drained saturation seldom occurs thereby reducing the chances of erosion. If brief description of the sub-classes follows:

- ***Ab***: red dystrophic and/or mesotrophic soils where yellow soils occupy less than 10% of the area whereas dystrophic and/or mesotrophic soils occupy a larger area than the high base status red-yellow apedal soils.
- ***Ac***: red and yellow soils occupy more than 10% of the area each. Distrophic and/or mesotrophic soils cover an area greater than high base status red and yellow apedal soils.
- ***Ae*:** refers to an area where more than 40% of the soils are red, high base status soils deeper than 300 mm.

D-land types in Figure 2.13 (i.e. Db and Dc) refer to regions where duplex soils are dominant. When exposed surfaces (bare rock, boulders, etc.) are omitted, 50% of the land area should be occupied by duplex in order for the land type to classify as a *D*-land type. The dominant soils in these land types are, therefore, marked by soils with textural differences between A and B horizons. Finer textured B horizons limit the suitability for agricultural production on these soils. The increase in texture is generally associated with a decrease in hydraulic conductivity and the formation of perched water tables on the A/B horizon can result. These soils are, therefore, generally susceptible erosion, especially in the *Db* land types. A short description of the subclasses follows:

- ***Db***: refers to an area where duplex soils with a non-red B horizon cover more than 50% of the land area.
- ***Dc***: in this land type duplex soils cover more than 50% of the land area and more than 10% of the remaining land area is occupied by soils with one or more of the following diagnostic horizons: vertic A, melanic A or red structured B.

E-land types (i.e. Ea in Figure 2.13) consist of soil with high base status dark or red soils (normally with a high clay content). These soils are weathered from basic parent materials (e.g. dolerite). Half of Ea land types are covered by soils with vertic A, melanic A and red structured B horizons. The soils of these land types are generally stable and resistant to erosion. Depending on the effective soil depth these soils can be suitable for crop production.

F-land types (i.e. Fa and Fb in Figure 2.13) are generally young landscapes where the dominant pedological processes have been weathering, clay illuviation and formation of orthic A horizons. Although the dominant soil forms are normally shallow Glenrosa and Mispah forms, any other soil forms can be accommodated in *F*-land types provided that they do not qualify the area for inclusion in other land types. The dominant soils in these land types are often shallow, thereby limiting the suitability for crop production. These land types are often found on relatively steep slopes, thereby increasing the risk of erosion of the soils. A brief description of the sub-classes follows:

- ***Fa***: refers to areas where lime does not occur frequently in the soils.
- ***Fb***: lime occurs frequently in one or more of the valley bottom soils.

The average soil depths and clay contents were derived from the broad land types, explaining the close associations between Figure 2.13, Figure 2.14 and Figure 2.15.

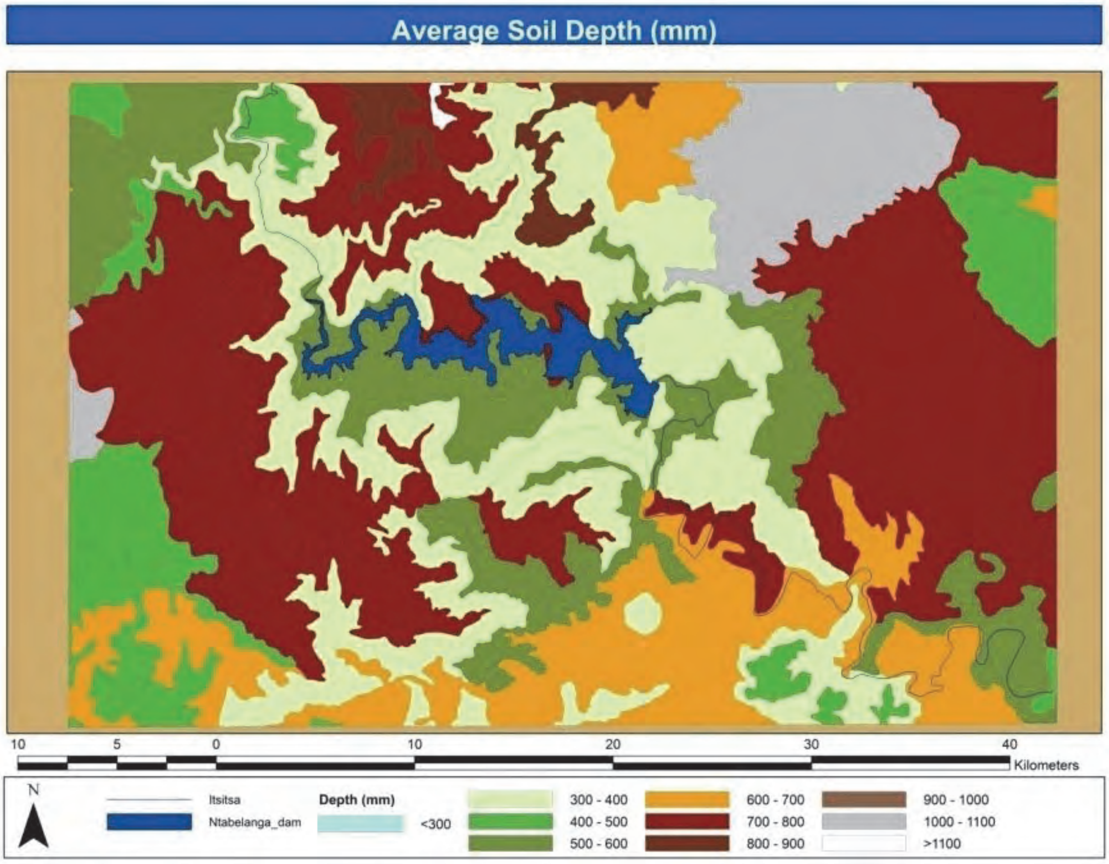

Figure 2.14: **Average soil depth derived from land types in the study area.**

Steep slopes (Figure 2.3) of relatively young landscapes (*F*-land types) are marked by shallow soils of the mountains surrounding the dam. Deeper soils occur on the *A*-land types (see discussion above). Directly north of the dam, deep freely drained soils of land type *Ab249* is found (Figure 2.13 and Figure 2.14). These soils are sandy (Figure 2.15), with an average clay content of between 15-20%. Land type *Ab249* covers an area of approximately 1 800ha, although some of it will be submerged by the dam. Initial evaluations suggests that irrigation directly from the dam will be limited to these soils as the rest of the land bordering the dam are marked by relatively shallow duplex soils with average clay contents of 25-30%. The duplex nature of these soils makes them susceptible to erosion (see evidence in the following section).

Below the dam wall in the vicinity of community 2, land type *Ae382* marks deep well drained sandy soils, suitable for agricultural production and irrigation. This land type covers an area of approximately 930ha with deep Hutton soil forms dominating 45% of the land area.

Although the aim of this report is not to evaluate the agricultural potential of the area, it is worth noting that even when the broad land types are deemed unsuitable for crop production and/or irrigation, there might still be suitable soils within the land type. For example in land type *Db333,* which covers 20 000ha, approximately 5% (1 000ha) is covered by deep Oakleaf soils occurring in valley bottom positions (TMU 5). Detailed investigations must, therefore, be conducted to determine the developmental suitability of the soils bordering the dam and the river downstream.

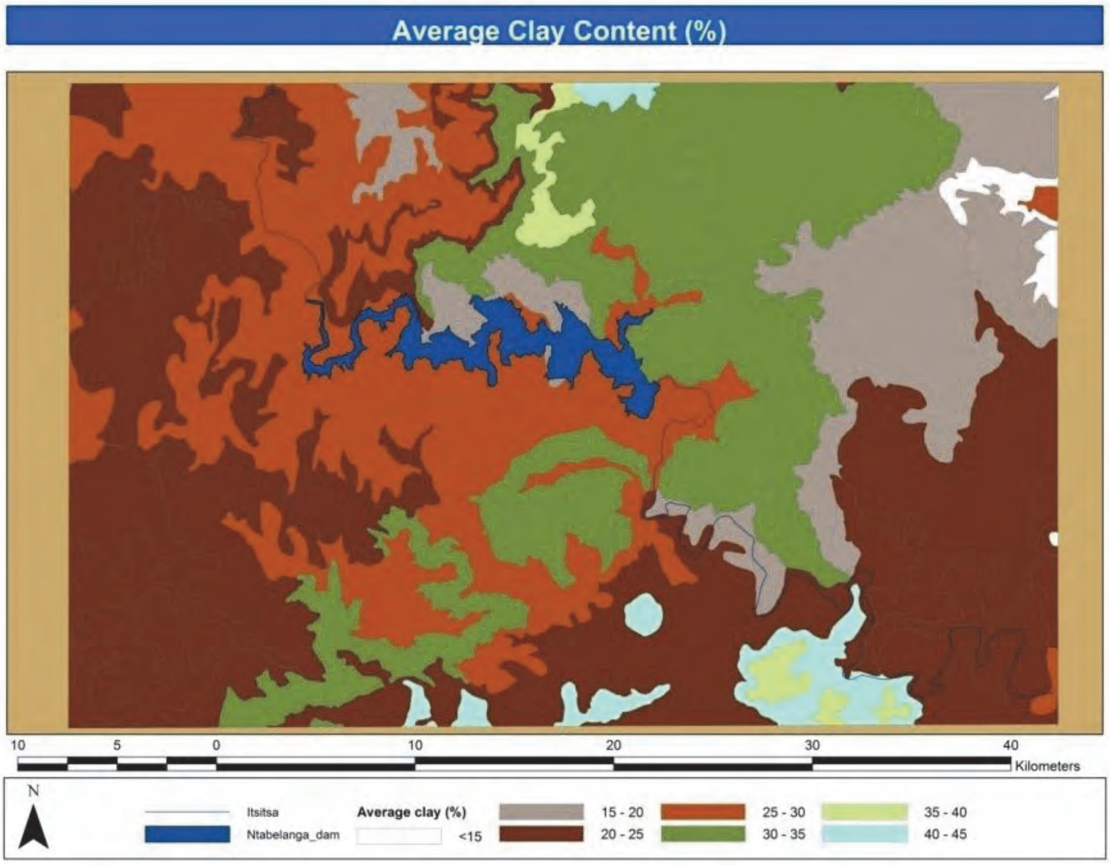

Figure 2.15: **Average clay content (%) of soils in the study area**

Soil Erosion

The extent of eroded land overlain on different broad land types in the study area is presented in Figure 2.16. Approximately 3 820 ha have been severely eroded. Erosion is prominent on Db, Fa and Ab land types with approximately 30, 18 and 15% of the land affected by gully erosion respectively.

Fa land types are young landscapes and with shallow soils on relatively steep slopes. The shallow depth and steep slopes limit the suitability of Fa land types for crop production and increase the likelihood of erosion occurring.

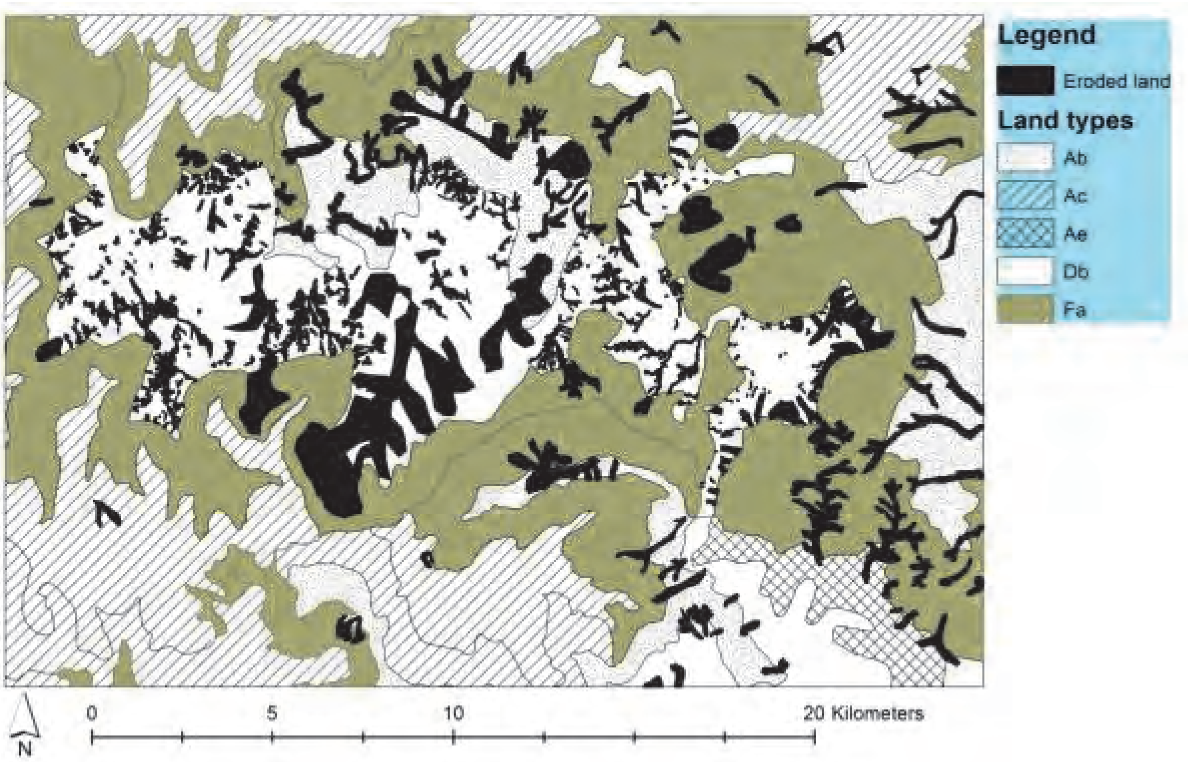

Figure 2.16: Severely eroded land and broad land types of the study area.

Ab land types refer to regions where freely drained yellow and red dystrophic and mesotrophic soils occupy more than 40% of the land area. The soils of Ab land types are generally considered to be good for crop production and suitable for irrigation with low sensitivity to erosion. It was therefore rather surprising to observe the degree of erosion on these land types. Aerial photographs suggest that gully erosion originate on old cultivated lands (Figure 2.17). Even with contouring the removal of natural vegetation and disruption of the soil structure by cultivation resulted in significant erosion on these land types.

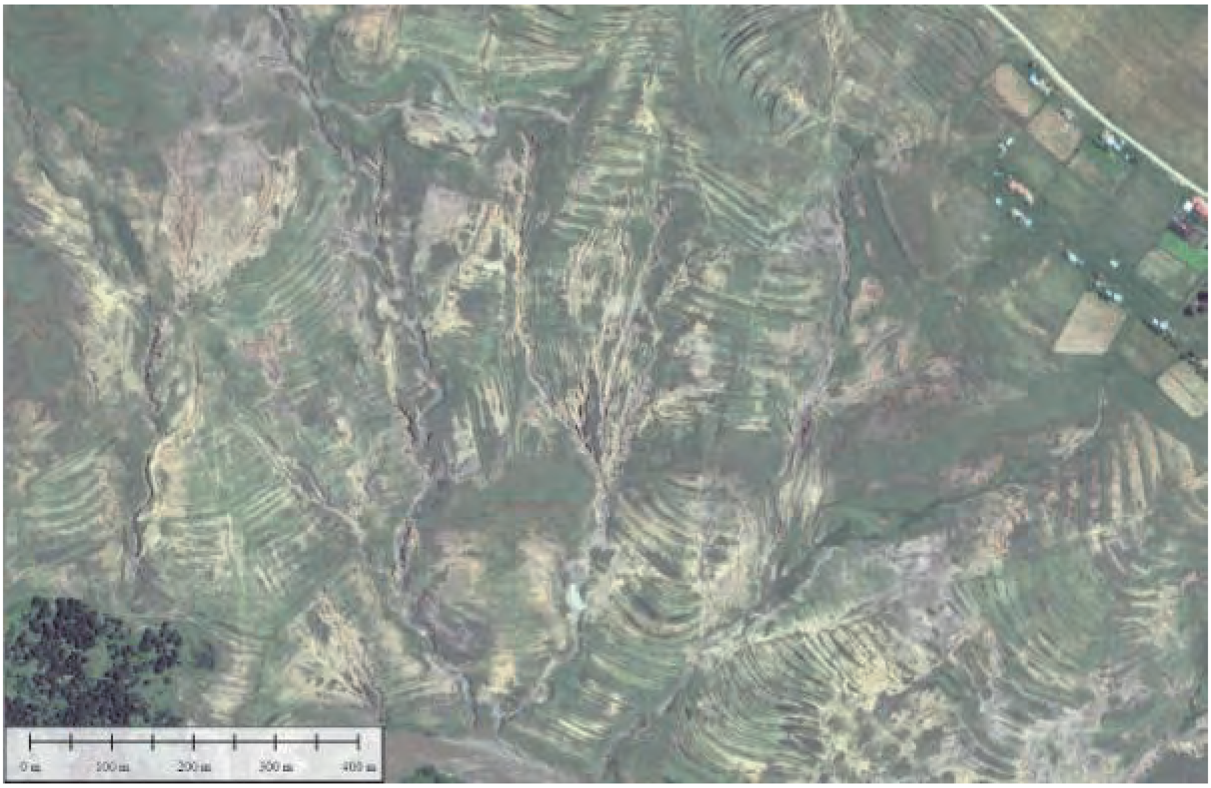

Figure 2.17: Example of gully erosion commencing on old cultivated lands in land type Ab.

In Db land types, duplex soils with non-red B horizons cover more than 50% of the land area (Land Type Survey Staff, 1972-2006). These soils are prone to erosion; the textural discontinuity often results in the generation of lateral flow and the B horizons are often marked by high Na contents making the soils highly dispersive, especially for duplex soils formed on Beaufort sediments.

The coverage of erosion sensitive soils in land type Db344 is presented in Figure 2.18. This soil association map was validated using 43 randomly distributed profiles classified according to the South African Soil Taxonomy (Soil Classification Working Group, 1991). These observations and their sensitivity to erosion is briefly summarised in Table 2.4.

Table 2.4: Summary of soil observations and their sensitivity to erosion in Db344 (then number following the soil form indicates the frequency of occurrence)

Soil forms	Erosion sensitivity
Cartref (1); Glenrosa (2); Katspruit (7); Mispah (6); Sterkspruit (9); Westleigh (1)	High
Bonheim (1); Valsrivier (4)	Moderate
Avalon (1); Dundee (1); Hutton (1); Montagu (2); Mayo (3); Oakleaf (2); Tukulu (2)	Low

The erosion sensitivity was predicted correctly for 31 of the observation, yielding an acceptable map accuracy of 72% according to Van Zijl et al. (2013). Noteworthy is that the majority erroneous predictions were between ‘moderate’ and ‘low’ sensitivity classes (75% of error).

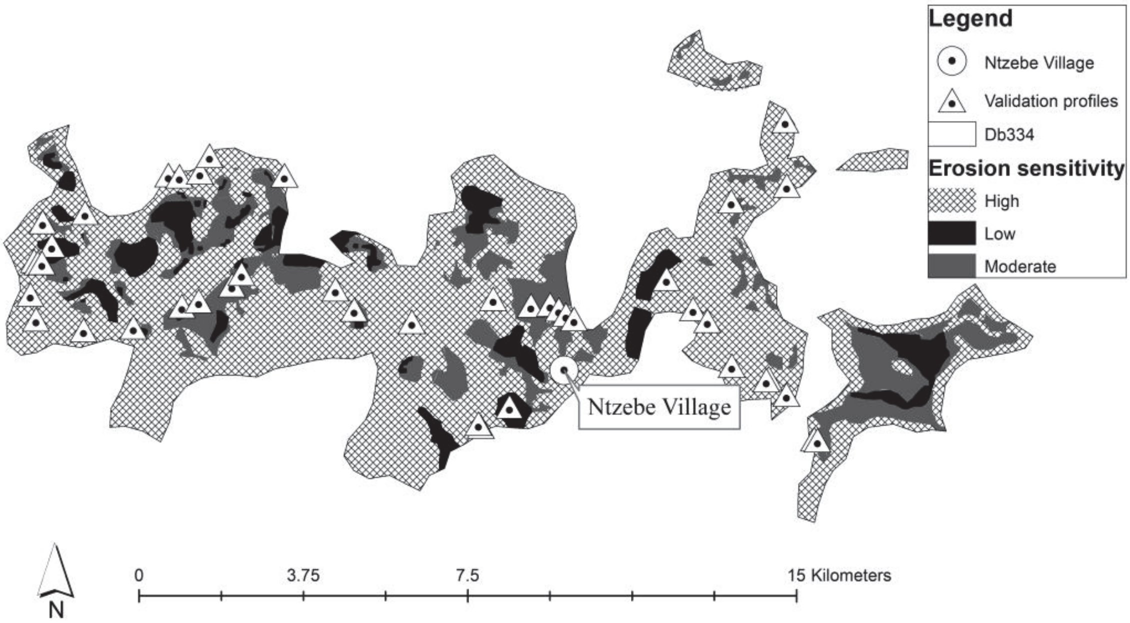

Figure 2.18: Sensitivity of soils to erosion in land type Db344.

Only 756 ha (10.2%) of the soils in Db344 have a low sensitivity to erosion. The majority (5 286 ha or 71.3%) of Db344 is covered by soils highly sensitive to erosion with the remaining 1375 ha (18.5%) having moderate sensitivity to erosion. Current crop production practices are closely associated with the soils having low sensitivity to erosion. Based on the extent of eroded land (Figure 2.16) and the dominance of soils with high sensitivity to erosion (Figure 2.19) any large scale expansion of crop production practices seems unlikely on Db344.

Figure 2.19 to Figure 2.21 accentuates the extent of erosion in the study area. Efforts to stop erosion are presented in Figure 2.22. From the interviews it became clear that people and government tried to reduce erosion along roads through a process called *'IZIKREKELA'*, whereby both men and women carry big stones and deposit them in gullies to stop the furthering of erosion. Apparently this process was stopped a few years ago.

The extent of land degradation is further highlighted by Figure 2.23 showing natural degraded grasslands in the study area (NLC, 2000). The majority of natural grasslands bordering the dam have been subject to degradation.

Figure 2.19: Severe gully erosion on an Estcourt soil form (located at Photo 4 in Figure 2.2).

Figure 2.20: Gully erosion located at Photo 6 in Figure 2.2. Full-grown *Acacia* trees highlight the extent of the erosion.

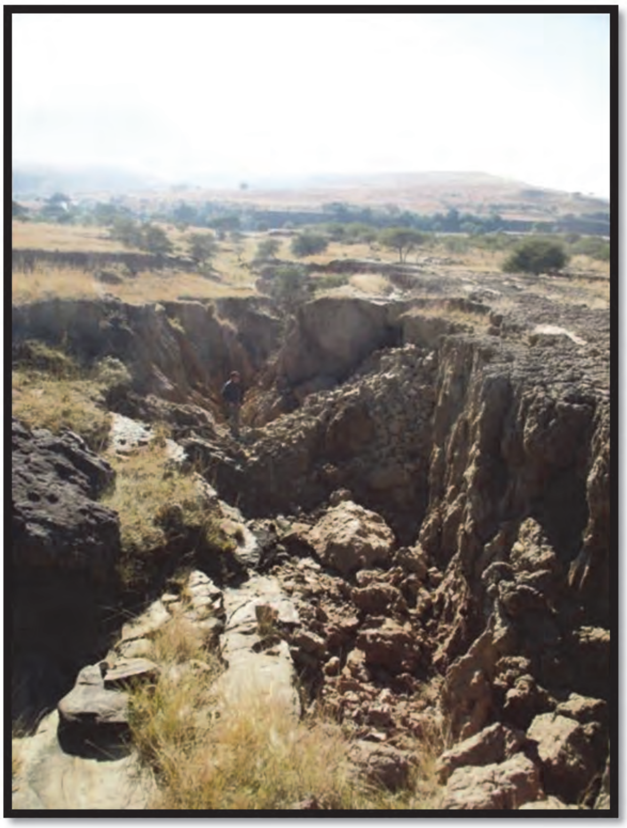

Figure 2.21: Inside one of the gullies in Figure 2.20.

Figure 2.22: Efforts to stop erosion along the road (Located at Photo 7 in Figure 2.2).

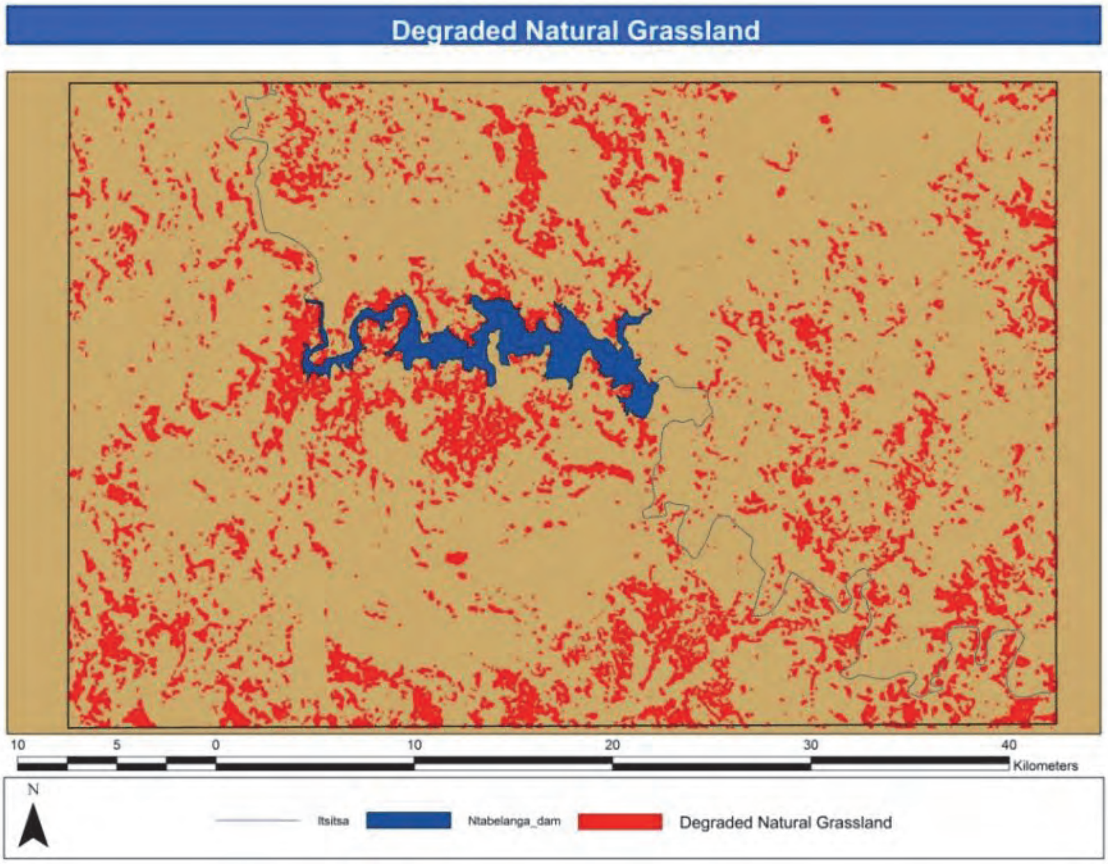

Figure 2.23: **Degraded natural grassland in the study area.**

2.2.5 Wetlands and Natural Forests

The occurrence of wetlands and natural forests are presented in Figure 2.24 (Van den Berg *et al.*, 2000). The natural forests are generally found on steep slopes and higher elevations (Figure 2.3) where orthographic rain creates a micro-climate suitable for their occurrence.

Figure 2.24 only shows the location of relatively large wetlands in the study area. A number of smaller wetlands were identified in the study area during the two field visits (e.g. Figure 2.25). The degradation of these wetlands can have significant influences on the water delivery to streams, both in terms of water quantity and quality.

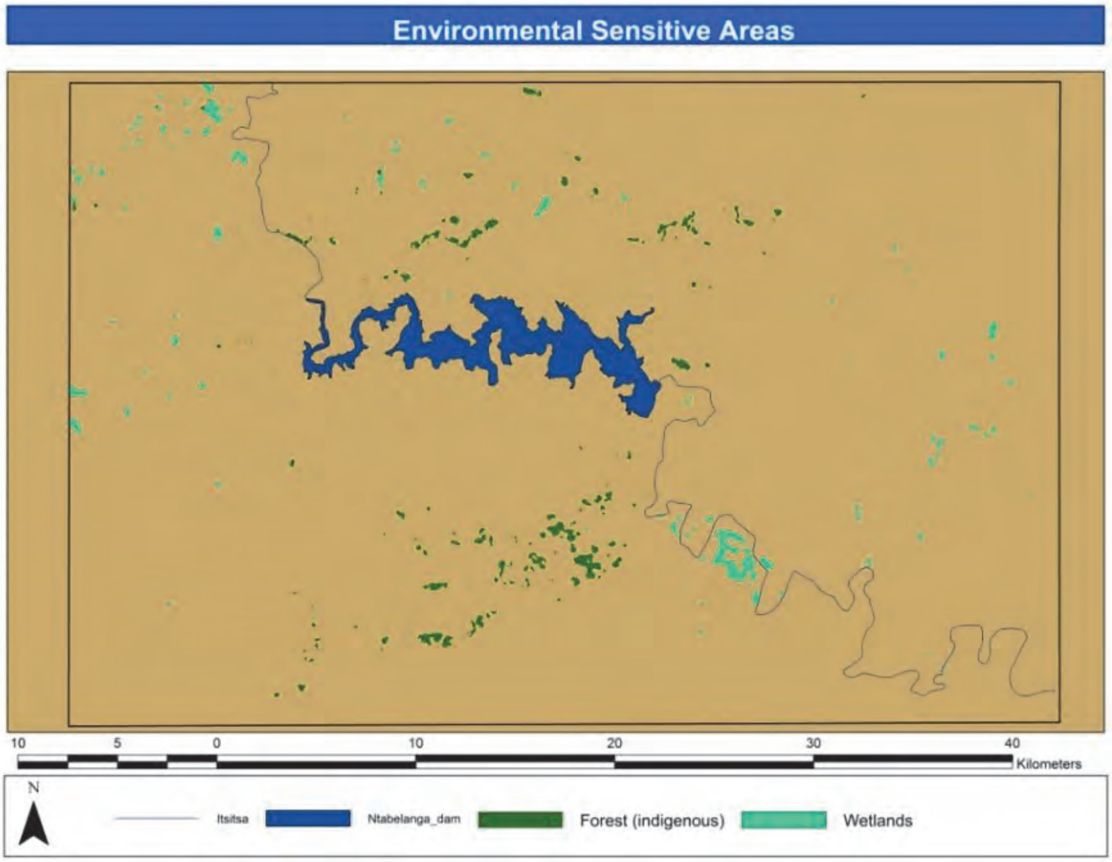

Figure 2.24: **Location of wetlands and indigenous forests in the study area.**

Figure 2.25: A typical wetland occurring widely in the study area (located at Photo 8 in Figure 2.2).

3 SOCIO-ECONOMIC AND AGRICULTURAL STATUS QUO

3.1 A Sociological Appraisal: The Status Quo

As earlier indicated, from an infrastructure standpoint, dams symbolise development, modernization, and empowerment. In specific social locales, such as the Ntabelanga area, a rural area needing serious economic intervention, the sum total of benefits could easily justify a characterization of large dams as harbingers of socio-economic renewal – or cornucopia (Biswas, 2004). These attributes obviously underpinned President Jacob Zuma's (2013) depiction of the proposed Ntabelanga Dam as "critical for rural livelihoods", and the equally ambitious statements made about the project by Water Affairs Minister Edna Molewa in her 2013 Budget Speech (Molewa, 2013). What, then, does one make of strong counter-sentiments, such as when a dam is described as "flood that would stay forever and drown the whole valley" (see Huges 2006:832) and a harbinger of social upheaval (see Goutlet, 2005), or depicted using any other negative imagery? There is a conjecture, and it is that a dam developer's dream remains unrealized unless careful attempts have been made to understand and address the sustainability dilemmas and socio-ecological anxieties that a project of this type can throw up.

From a sociological point of view, therefore, an important task for the researchers was to gauge local perceptions and sentiments towards the proposed Ntabelanga Dam, with a view to proposing a long-term study to monitor possible changes in such perceptions and sentiments over the medium to long term, as the dam project progresses and its anticipated benefits take root. The guiding question was: What do the local people perceive to be the potential (socio-economic) benefits – and risks – of the proposed dam project, and in what ways are they likely to position themselves to benefit from the project and navigate perceived risks?

The next three sections are devoted to brief conceptual and methodological notes, a presentation of field findings, and an attempt to make sense of the findings against the background of the earlier stated aim of pointing to community variables and dynamics that might need to be taken seriously as the dam project unfolds.

3.1.1 Methodology

From the outset, the study was designed as a small-scale, pilot initiative, focusing on two communities. The one, Lower Sinxaku (referred to as Community 2 in this report), is located near the dam wall; the other, Ndzebe Village (or Community 1), is located approximately three kilometres downstream (as the crow flies). The idea was to gain a sense of what the social sentiments would be in a typical 'dam wall' community, as well as in one that is a few kilometres downstream. Both communities – like the rest of the broad network of villages of which they form part – share striking similarities – physically, socio-economically and culturally. As described in detail in Section 5 below, the main economic activities of the majority of residents, but especially older men and women, is livestock farming and subsistence crop production. The youths do not describe themselves as being "centrally involved" in farming, even though they play a visible role (as herders) in the livestock sub economy. Strikingly absent in both communities are modern commercial activities, at whatever subsistence level. For instance, there were no spaza shops. The hub of buying and selling for the two villages were the towns of Maclear and Tsolo respectively.

To ensure that the study helped to shed light on both concrete community development issues relating to the dam project in question and on broader issues of sociological scholarship, the researchers dissected the research question ("What do the local people perceive to be the potential (socio-economic) benefits – and risks – of the proposed dam project, and in what ways are they likely to position themselves to benefit from the project and navigate perceived risks?") utilising a humanistic sociological approach (specifically, 'sociology of hope') and the 'asset-based community development' framework.

One interesting insight in humanistic sociology is that communities possess an inner resilience and a deeper rationality that transcend the outer decay, poverty and brokenness that appear to define their social existence. It is such resilience and rationality that enable community members to sometimes achieve success despite daunting socio-economic adversity. It is within the discourse of hope that conventional sociology – and conventional social science in general – has been criticised for being unduly fixated with "aspects of social phenomena that merely present a shock value" (Akpan, 2010: 121) and for being obsessed with pathology and the negative (Glass, 1970:191; see also Jeffries, 1999).

Guided by a need to understand the dam communities from a perspective of hope rather than simply of deficit, poverty, despair and brokenness, the researchers designed the sociological leg of the study in such a way that, within the community-dam project nexus, one could gain a sense of at least three "hope dimensions". These were:

- Community's "vision of the good life"
- "Hope-inspiring benefits" of the proposed dam
- Opportunity-preparation intersect

Utilised as a complementary conceptual resource, "asset-based community development" helped the researchers to begin to interrogate the extent to which the community, both as individuals and as a collective, was likely to convert the proposed dam into, among other things, an economic opportunity. The "asset perspective" emphasises a shift from a view of community as an eternal target of charity and welfare to that of a community as a repository of "assets" – a treasure-trove of strengths, talents and opportunities. The dam might be a government-sponsored project, but could the community claim it as a developmental asset; did it, for instance, have the potential to unlock hidden entrepreneurial energy within the dam communities?

Since the research question also spoke of "fears" and "risks", the researchers drew on the propositions of both the sociology of hope and asset-based community development to delineate a set of empirical criteria to guide the data collection on this prospect.

<u>Data Collection</u>

With the research question broken into the above two sets of empirical criteria ("hope" and "fears/risks"), focus group discussions (FGDs) and in-depth interviews were held in the two communities. Three (3) FGDs were held in Community 2, amongst a purposively constituted, mixed group of elderly residents (males and females), a women-only group, and a youth-only group (male and females). Two FGDs were held in Community 1 – amongst purposively constituted groups of “elders” and “youth”. In addition, a subset of FGD participants in the two villages were selected as in-depth interview respondents.

The sociological data were collected over two days (13 and 14 June, 2013), with the help of two research assistants – a Master’s student and a sociology honours student. Some of the data were intended to form part of the empirical aspects of the honour’s student’s research project.

The June 2013 data collection was preceded by an initial visit to the communities earlier in the year. It was during that visit that the two study communities were identified, with Community 1 (the downstream community) being the one accessed before Community 2 (the more pivotal, ‘dam wall’ community). This hopefully clears any confusion about why in some sections of this report Community 2 is mentioned before Community 1! Contacts made with the Headmen and other residents of the two villages during the initial visit enabled the researchers to properly plan the June 2013 data collection. The FGDs and interviews took place in neutral venues (primary school classrooms), were conducted in IsiXhosa (the main language spoken in the area), recorded on digital audio devices and later transcribed by the research assistants. Visual data (photographs) were collected during the two visits. In keeping with good social research practice, all respondents signed informed consent/voluntary participation forms.

3.1.2 Results

It probably needs re-stating that the crucial discourse around which this pilot study revolves is that even the most well-intentioned development project, such as the proposed multipurpose Ntabelanga Dam, could ignore, or even undermine, the very socio-ecological and cultural resources on which its sustainability ultimately depends. This is a long-standing thesis of sustainable development (see de la Court 1990:10-12). While the earlier section of this report elucidates the dam-environment nexus focusing on environmental aspects to be monitored over the long term, the present section draws attention to issues of social equity and local empowerment, and highlights the imperative of ensuring that social concerns are not relegated to the periphery of discussions pertaining to the dam’s overall socio-ecological sustainability. The lurking dilemma is that the dam’s developmental promises and potentials are one thing; matching these with local people’s hopes and aspirations (and circumventing their worst fears) is another.

One striking finding made during the initial visit to the communities in March 2013 and during the formal data collection visit in June was the near-total absence of awareness about the dam project in the two communities. This was surprising considering that by the time of the initial visit in March, the dam had featured prominently in the President’s State of the Union Address earlier in the year. By the second visit, a nationally televised Parliamentary Speech by the Minister of Water Affairs, in May 2013, had further brought news of the proposed Mzimvubu Dam to the South African public. The size of the proposed dam (sixth biggest in South Africa), its importance in the scheme of national infrastructure priorities (the so-called “infrastructure build” programme), and its potential social and environmental impact, all make the dam a pivotal project, especially considering the impoverished social backdrop of its location. The fact that even members of the 'dam wall' community lacked awareness about the project was difficult to explain.

To ensure that the awareness problem did not create any credibility gaps during the FGD and in-depth interview proceedings – but also careful not to create any "false hopes" or raise "false expectations" in the community – the researchers referred the research participants to both the President's 2013 State of the Nation Address and the Water Affairs Minister's 2013 Budget Speech in which the proposed dam was underlined as urgent, important and impending. Appropriate verbal and visual techniques were employed to give the participants an idea of the size of the proposed dam. All of this was aimed at creating the right levels of intersubjectivity, since the term "dam" is widely used in the study communities to describe what should more accurately be termed a "pond". None of the research participants had yet seen a dam of the magnitude and scale proposed for the Mzimvubu River Basin.

The results of the sociological appraisal are presented in two broad segments. The first set of results is directly related to what, in this report, is termed a "hope dimension". The second sub-segment is devoted to a summation of community members "fears" concerning the project.

An attempt is then made, based on the findings, to highlight a set of variables and/or community dynamics that could be incorporated into a holistic monitoring initiative aimed at ensuring the long-term socio-environmental sustainability of the multi-purpose dam.

Hope Dimension

Vision of the "Good Life"

Both in the FGDs and the individual interviews, the researchers probed how community members felt the proposed dam would impact on the quality of social existence locally – compared to the present when there was no such project. One crucial finding was that in both villages, and amongst the different categories of FGD participants (elders, women, the youth), almost every speaker prefaced his or her remarks with strong skepticism about such a project ever materializing, to start with. There were remarks such as:

> *It has been a long while since we were promised taps, but till today we are still waiting* (Elderly FGD participant, Ndzebe Village)
>
> *Ministers cannot be trusted, as they always make empty promises* (Elderly FGD participant, Lower Sinxaku)
>
> *We are too scared and sceptical to listen to anything that comes from the Ministers because it is never true* (Elderly FGD participant, Lower Sinxaku)
>
> *We no longer trust anything that the government says it will do, as it is just empty promises* (Elderly FGD participant, Lower Sinxaku)
>
> *One Minister came to us and promised to deliver clinics but we are still waiting to this day, what we just heard was that he was fired from the position and we are still waiting for the clinic to be built* (Elderly FGD participant, Lower Sinxaku).

> *I don't believe that it will happen. I doubt it. These things don't happen for a village like this in the Transkei* (Youth FGD participant, Lower Sinxaku)

Once the conversations had moved beyond scepticism, respondents appeared to project into the multi-purpose dam images of a future renewed, a future preferred, a future of fulfilled hopes:

> *We would like to have a proper irrigation scheme so that we could access water, so that we could start planting. Our community used to be sustained through planting crops. We want to plant crops again. The existing river (Tsitsa River) doesn't help much. Having this new big dam will change the people's lives for better; we would then be able to feed our families through agriculture* (Elderly FGD participant, Lower Sinxaku).

It seemed noteworthy that respondents appeared to want to return, using the new irrigation possibilities offered by the dam, to a 'past' in which crop production suffered lesser stress, or be transported to a future of water abundance:

> *We do not have anything that we depend on, we no longer have big harvest. We now only plant crops in good seasons. We do not have crops in winter as we do not have water supply, we only depend on the rain to water our crops* (Participant, Women FGD, Lower Sinxaku).

Hopes were expressed that the dam would usher in a new era of economic opportunities and self-reliance, especially given the prevailing unemployment and social-grant dependency in the community. The remarks of one youth FGD participant (Lower Sinxaku) suggested that the future was replete with hopeful possibilities:

> *There will be job creation, there is a possibility that a school will be built, training of people to become life savers. Tourism will take off as the dam will attract tourism. Recreational activities like dancing and so forth will start and youths will start to own businesses like hair salons and sell food in restaurants.*

Hope-inspiring Benefits of Proposed Dam

The long list of benefits cited by the respondents buttressed long-documented views of dams as cornucopia (see Biswas, 2004). Importantly, it suggested that despite widespread poverty and apparent gloom, ordinary community members could relate to the proposed dam project in a way that gives voice to sophisticated inner yearnings. The list included the following:

- Acquisition of better agricultural skills (moving beyond subsistence farming)
- Diversification of occupational interests (acquisition of engineering and tourism-related skills such as boat-building and life-saving, breaking the present reliance on "nursing" and "teaching")
- Improved harvests due to better irrigation
- Improved community nutritional status (ready availability of milk from healthy, cabbage-fed cows)
- Healthier livestock production due to better irrigated grazing fields.
- Improved public health due to envisaged closer proximity of water taps to homesteads

The proposed dam would breathe life into every sphere of the community, except, perhaps, the spiritual. According to one interviewee in Ndzebe Village, "Sangomas and Church people will not use the dam for spiritual purposes; they use running water from streams and rivers for their rituals". (This view was, however, contradicted by an elderly FGD participant in Lower Sinxaku, who felt the dam would necessitate the building of small "swimming pools" for baptismal purposes.)

Opportunity-preparation Intersect

Another facet of the inquiry, still guided by the "hope" and "asset" framework elucidated earlier, was to find out the extent to which the proposed dam represented not just a developmental opportunity for people in the study area, but also – and perhaps more importantly – an opportunity that would find in the community a measure of preparation amongst community members. The question posed to the research participants was: *"What do you think community members (men, women, the youth) should do so as to better benefit from the dam project (before, during and after construction)?"* How would they leverage the opportunities provided?

The respondents noted that the possibility of dam developers and managers recruiting high-ranking personnel in the area, in the immediate, was remote given the very low skills base. Some respondents, however, indicated that while there was paucity of relevant skills in the area, there was an abundance of social capital. This would enable the villagers to relate to the project as their own. Before the commencement of construction, for instance, the possibility existed of villagers setting up a "neighbourhood watch" to secure the building materials and the entire construction operations. They would also demand that any "outsiders" hired for security duties, if they were hired at all, were appropriately qualified and people of integrity. "This is our dam project, after all", one elderly FGD participant in Ndzebe Village enthused.

In Community 2, some members of the Elders FGD saw the dam as an opportunity for the old and the young to close ranks, so that both the elders and the youth benefit from the project. FGD participants spoke of setting up a "Committee" that would keep an eye on "wayward youths", as no one would want to see the project fail. In the words of one respondent, "we would do everything to avoid situations whereby our projects get to nowhere as that affects the development of our villages."

Fear Dimension

Did the proposed project pose any risks for local residents, socio-economically, politically, culturally, or otherwise – at least in their own perceptions? What were their worst fears? This question was important for gauging how local residents might relate to the project in the short, medium and long terms, despite the anticipated benefits.

Several fears were expressed in both communities. These included the prospect of social displacement (and of "people ending up being given smaller plots than their original homesteads"), loss of agricultural fields, inundation of burial sites, and safety issues (children tragically drowning in the dam). For one respondent, the prospect of loss of agricultural field was a strong enough reason to stop the dam project. Other fears included suicides (the dam becoming a spot where young people take their lives), "new kinds of murder" (criminals using the dam to "hide" the bodies of their victims), livestock loss (animals drowning in the process of drinking at the dam), and "mysterious phenomena" (such as the dam becoming the abode of "big snakes that cause tornadoes"). Expatiating on this last cause of trepidation, one elderly respondent in Community 1 remarked thus:

> *We cannot shy away from our beliefs as Xhosa people. Take for example what happens in one dam near Mthatha, we believe that there is* Nkanyamba *living in that dam. People that live near there say that some days they wake up to a clear blue sky. Then suddenly, there will be thick dark clouds from out of nowhere. Dark clouds will envelop the town and the weather will become so violent.*

Another fear – a well-documented threat in the community development literature (see Akpan 2006) – was socio-political conflict, the kind that revolves around greed and local opportunism. One respondent phrased it in the following words:

> *We are scared of politics because it is just lies. You would find that in politics they would say this today, tomorrow it's another story, and totally different to what was said yesterday. As a result, there would be formation of new parties within the communities and those new parties would cause division among the members of the same community. So we do not want the involvement of politics in our village. With too much politics, the things planned by that community, such as new projects, would end up fading before they even start.*

WHY FEAR?

While some of the expressed fears ("tornado snakes", for example) had no scientific basis, it was found that most respondents had a referential basis for them. In other words, the respondents "learnt" about them from somewhere. They reported their direct experiences of animals being washed down the river when it rained, and of children being exposed to danger while playing towards the river. The television was a constant source of news about suicides.

Some respondents indicated that their knowledge of the problem of "top-down" decision-making had an influence on how they perceived the dam project. One interviewee in Community 2, aged 45-50 years, who used his personal car as a taxi, felt strongly about the "alienating politics" of top-down decision-making and about what could "go wrong" if the government failed to "sit down and discuss the land issues with the chief and the 'dam committee'" before embarking on the dam construction. According to this respondent:

> *The land that you see belongs to the chief and there are portions of it dedicated to crops. If the construction of this dam will affect other people's agricultural land, then there must be talks with that land owner and there must be an agreement from both parties that the government can actually use that land. It must not be a situation whereby the government just comes in and decides on where the dam would be without consulting the chief and the community members. That would be a recipe for conflict. Take for example, there are areas that are solely used as cemeteries. Government cannot take decisions without consulting the chief and other relevant stakeholders.*

For most respondents, however, these fears were not strong enough to warrant community action aimed at stopping the project.

3.1.3 Discussion

Even from this limited appraisal, it is clear that the proposed dam represents a canvass of opportunities for people in the study area, despite the deep fears it also provokes. There is an unmistakable narrative and vision of the “good life” in the study community – a narrative which may seem submerged under the gloom of poverty, hidden by barren hills, and somewhat eclipsed by a deep distrust of government. It speaks to a collective aspiration and strong longing for community development and local empowerment. The findings echo the results of previous studies, especially one in which impoverished residents of rural communities that were otherwise rich in natural resources saw those natural resources as a vital developmental asset, and defined community development as ‘social infrastructure’, ‘local empowerment’, ‘reparation’, and ‘sustainability’ (Akpan, 2006:233). Yet, it is equally undeniable that the fears and negative sentiments reported above constitute a compelling counter-narrative that no project developer or development facilitator can afford to take lightly.

3.2 Current Agricultural Situation

3.2.1 Introduction

This section provides a brief, preliminary overview of the dominant agricultural practices in the communities as at the time of the field work in 2013. The submitted results derive, as mentioned in the previous sections, from published sources, FGDs and interviews with local residents, and observations.

<u>Farming System</u>

The study area falls within the *Maize Mixed Farming System* (No. 9) as classified by Dixon et al. (2001: 31) for Sub-Saharan Africa. According to Dixon et al., this farming system is the most important food production system in East and Southern Africa, spreading across plateau and highland areas at altitudes of 800 to 1 500 m.a.m.s.l. In general, the farming system is characterized by the production of maize. The main sources of income are migrant remittances, cattle, small ruminants, tobacco, coffee and cotton, plus the sale of food crops such as maize and pulses. Cattle are kept for ploughing, manure, breeding, milk, dowry, savings and emergency sale; livestock density is higher than in any other production system in the region (Dixon et al., 2001, p.48). The farming system also contains dispersed irrigation schemes, but these are mostly on a small-scale level. Most of these characteristics can be found in the study area.

<u>Land Tenure</u>

The land tenure system in the study areas is characterized by state-owned land that is administered through the Tribal Authority stems. The rural communities are widespread and most homesteads (of approx. 1ha) in these areas have a part of the homestead land allocated to subsistence agriculture (between 0.1 to 0.5ha). Each family has another approx. 1ha of arable land allocated to it by the tribal authorities. These two areas are ‘owned’ by individuals or families, many times with a Permission to Occupy (PTO) ‘title’.

Figure 3.1: A typical rural village in the study area with a homestead per house and consolidated arable lands.

The arable lands are sometimes consolidated rain-fed farming areas, which can be made up of several plots (1 to 3ha or more). Usually, these lands are in the vicinity of the villages whose residents cultivate the plots, though in some cases the distances to walk are substantial and tiring. Furthermore, large areas of communal land are typically used for grazing of livestock, especially cattle, which includes the higher lying mountain areas surrounding the communities. These areas are ‘owned’ by the entire community.

3.2.2 Present Dominant Agricultural Practices

The dominant agricultural practices are livestock, crop and vegetable production. It is noticeable that, in both communities, irrigation is not used in any of the agricultural activities, neither on the homestead fields, nor on the arable lands. Likewise, no forestry activities by communities can be found in the study area (Figure 3.2).

Livestock

Livestock (cattle, goats and sheep) plays an important role in the rural areas in the Eastern Cape; often more important than crop production. The management is, as mentioned in subchapter 5.2.2, practiced on communal land, but no grazing regimes exist in both communities. Consequently, severe overgrazing and related soil erosion accrues. A reaction to this has been found in community 1, where cattle is handed over to grazing areas, ‘owned’ by another clan, on the other side of the Tsita river for a cost of R20 per annum per head. The perception in the community is that the grazing areas on the other side of the river are more fertile. It could not be ascertained if community 2 has a similar management arrangement.

In addition, some of the animals, oxen, horses and/or donkeys, are used for crop production on the arable fields, either for ploughing or for transport of the harvest. It could be observed and interviews confirmed that pastures on communal grounds for the improved feeding of livestock are not planted and never were in the past.

Livestock rearing is widely practiced, although not commercially based. Due to this fact, there is limited direct financial benefit to the livestock owners, though some of the income is used, e.g. for paying school fees. Smaller animals such as chicken, geese, rabbits and ducks are generally for food production and for generating small amounts of extra income. The importance of livestock is related to the social and cultural structure of the communities, including ceremonial activities. Within this domain, each species (cattle, goats and sheep) has a specific function, e.g. cattle are used for funerals.

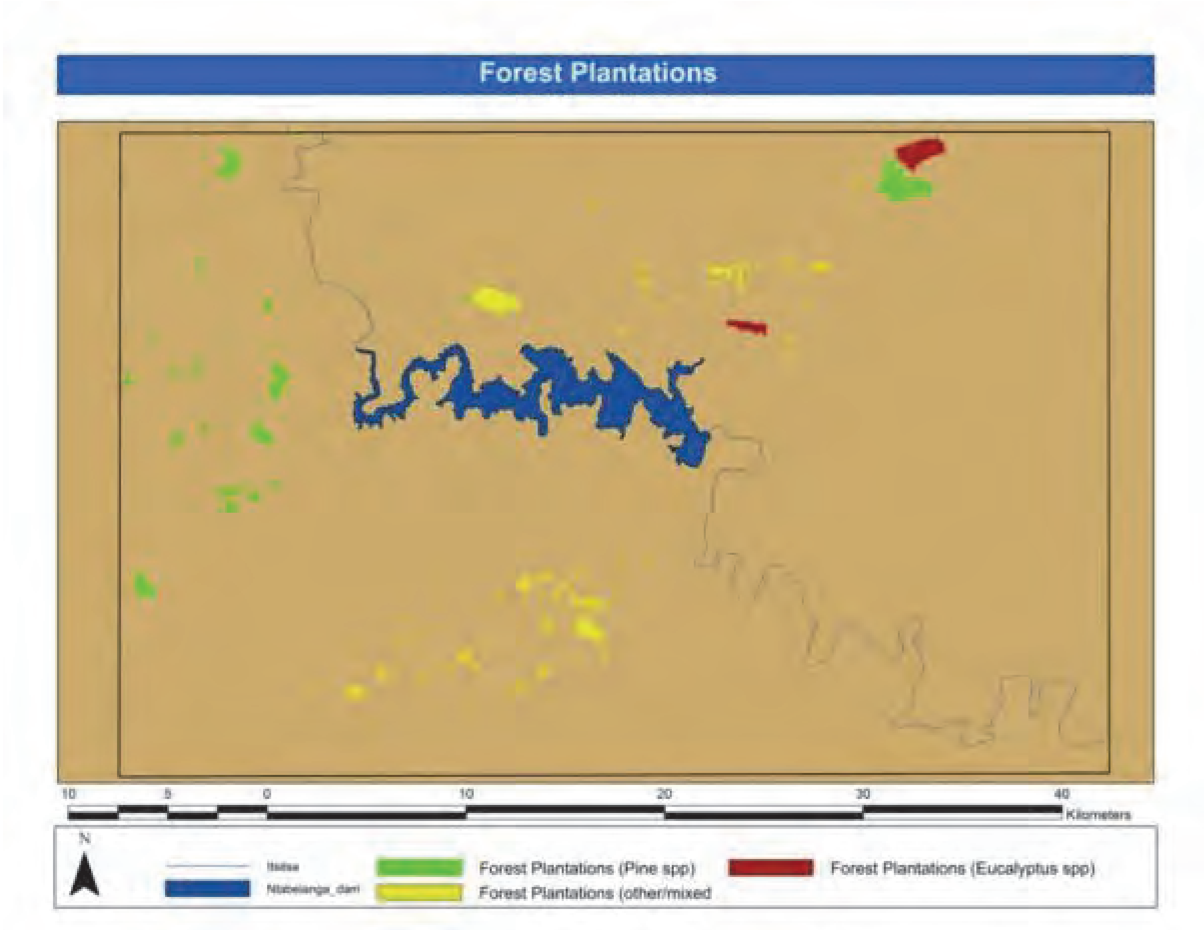

Figure 3.2: Forest plantations in the study area.

<u>Crop Production</u>

The communities stated that in the past, crop production used to provide a good living standard; in present, however, it does not anymore. The main crop grown in the communities is maize, mainly for home consumption, but also for small additional incomes, coming from local markets (bought by other community members or sold in the towns of Tsolo or Maclear). Overall, community 1 states that approx. 500ha are dedicated to maize production. Nevertheless, low maize yields are generally achieved. A variety of reasons can be observed or are given by the communities for the low production: i) absence of crop rotations resulting in mono-cropping, ii) late arrival of seeds from the Eastern Cape Department of Agriculture resulting in late planting, iii) lack of own quality seeds (e.g. proper seed selection of own seed stock), iv) other inputs are not used such as fertilizer for top-dressing or agro-chemicals, and v) insufficient water available throughout the season due to relaying on rains and the absence of mulching (i.e. increased evaporation rates).

The animal manure, which is available in the homesteads or nearby, is only partially applied due to the fact that heavy loads of manure are not transported to the arable fields; chemical fertilizer is only used when provided for by government. In the two communities, only some members can afford to pay for tractor services and, consequently, other community members' fields are cultivated by using animal traction for crop planting. Rainwater harvesting on homestead fields is generally not practices although many of the houses in both communities have 'JoJo tanks'; the harvested water needs to be used for household consumption.

Figure 3.3: A typical homestead with a maize field and a 'JoJo Tank' (see right side) in community 1 of the study area

<u>Vegetable Production</u>

The main vegetables grown are cabbage, spinach, potatoes, beetroot, green mealies (vegetable maize), pumpkins, and beans, and are used for supplementary home consumption and local markets, as in the case of maize. Overall, community 1 states that 200ha are dedicated to these vegetables. Like in the case of crop production, inputs are seldom used because community members cannot afford or access them. Nevertheless, a considerable amount of time is spent by women to produce vegetables in the homesteads. A significant number of homesteads have some form of off-roof rainwater storage system ('JoJo Tanks'), see Figure 26. However, very few are exploiting the opportunities of vegetable production using "harvested" rainwater for the same reason as in the previous sub-chapter.

3.3 Conclusion regarding the Status Quo

There is a discernible narrative of hope, and of fear, vis-à-vis the proposed multipurpose dam project. A future of self-reliance and improved socio-economic existence in the community is imagined, and this is tied to specific direct and indirect benefits of the dam, but particularly the local people's fairly sophisticated understanding of the role of irrigated agriculture. They include:

- Acquisition of better agricultural skills (moving beyond subsistence farming)
- Diversification of occupational interests (acquisition of engineering and tourism-related skills such as boat-building and life-saving)
- Improved harvests due to better irrigation
- Improved community nutritional status (ready availability of milk from healthy, cabbage-fed cows)
- Healthier livestock production due to better irrigated grazing fields
- Improved public health due to envisaged closer proximity of water taps to homesteads

On the other hand, the prospect of a large dam of the scale proposed for the Ntabelanga valley is a major cause for concern. There is a perception that the project could become a seedbed of local opportunism and political conflict, besides the possibility that large-scale, socially destabilizing, injustice-engendering displacements might occur. Local anxieties also revolve around cultural setbacks (inundation of burial sites), crime, and general safety issues affecting humans and livestock.

The small-scale, qualitative nature of the study means that a number of important community dynamics, was not covered – and yet should be. A holistic understanding of community dynamics is crucial for monitoring the long-term local impact of the dam. The following dynamics, which are better studied using community surveys (complemented with available Census and other statistical data), are deemed particularly important:

- Demographic profile of the communities
- Socio-economic profile
- Social capital profile

The researchers plan to expand the team and include other experts so as to adequately meet the demands of this truly multi-disciplinary research initiative.

4 PROPOSED MONITORING OF ENVIRONMENTAL ASPECTS

4.1 Water Quantity

4.1.1 Streamflow Regimes

All large storage dams influence the natural flow regimes of rivers; extremely high peak flows (floods) are reduced whereas the baseflow is generally increased. *"River and floodplain ecosystems are closely adapted to the annual cycle of flooding and drying.*" (McCully, 2001:47). Changes in the natural flow stream flow regime can therefore significantly influence ecosystems downstream of the dam. These indirect impacts are discussed in more detail in the relevant sections. Figure 4.1 presents an overview of the Tsitsa River meandering through the two proposed dams.

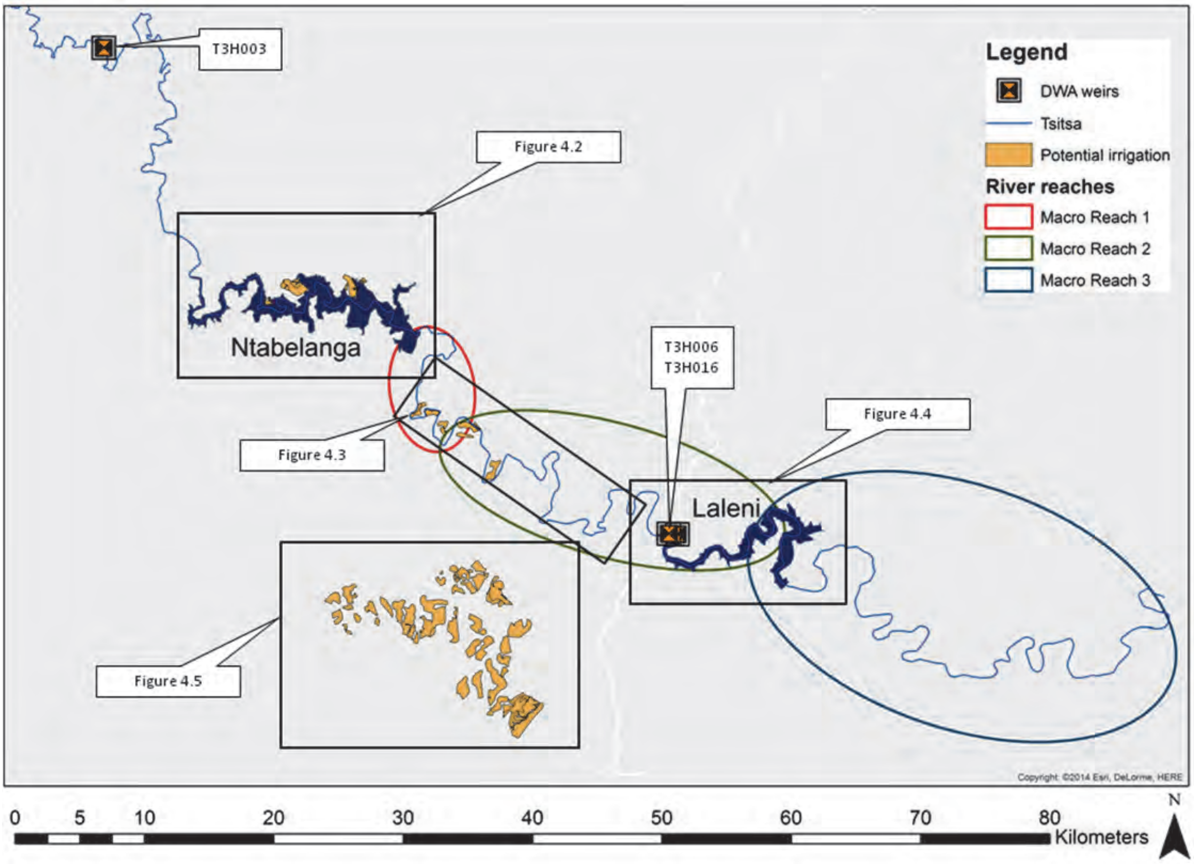

Figure 4.1: The Mzimvubu water project with Ntabelanga and Laleni dams with identified macro reaches and DWA weirs in Tsitsa River (inundation footprints obtained from DWA and Jeffares & Green (Pty) Ltd).

<u>**Monitoring actions – Streamflow Regimes**</u>

- Measurement of streamflow at a selected weir below the dam wall; most likely to be DWA weir T3H006 approximately 20 km downstream of the proposed dam wall (Figure 4.1).
- Obtain discharge records from the Ntabelanga and Laleni dams – after dams are closed.
- Compare long-term streamflow records (1952 to present) before the dam to the changes in streamflow regimes after the dam is build.

- **Note: T3H006 falls within the inundation footprint of the Laleni dam – this might create monitoring problems should discharge records from the Ntabelanga dam are not available**

4.1.2 Evaporation from the Dam

Due to the larger surface area, evaporation losses from large dam reservoirs can be enormous. The increase in evaporation will alter the streamflow regimes below the dam significantly and should be quantified to determine the impact of the dam on limited water resource.

Monitoring actions – Evaporation from the Dam

- Direct measurements of evaporation from surface water of both dams during different climatic conditions (seasons)
- Indirect long-term measurements through balancing the inflows and the outflows from the dams to and from determine the evaporation losses.
- Stream flow measurements:
  - Outflow – T3H006 or directly from the dam wall.
  - Inflow – T3H003, 20 km upstream (not currently functional). **It will be of utmost importance to ensure that a monitoring station upstream of the proposed dams is in working condition.**

4.1.3 Groundwater Levels

After the dam is closed, groundwater levels in areas next to the dam are expected to rise significantly until the dam is filled to capacity. This positive impact could make fresh water more readily available and reduce pumping costs or costs for the establishment of new wells. Below the dam wall, deepening of the stream bed can, however, result in a substantial lowering of the water table levels. Figure 4.2 to Figure 4.5 presents access points that can be used to evaluate groundwater levels and groundwater quality. The location of these Figures in relation to the greater project is shown in Figure 4.1.

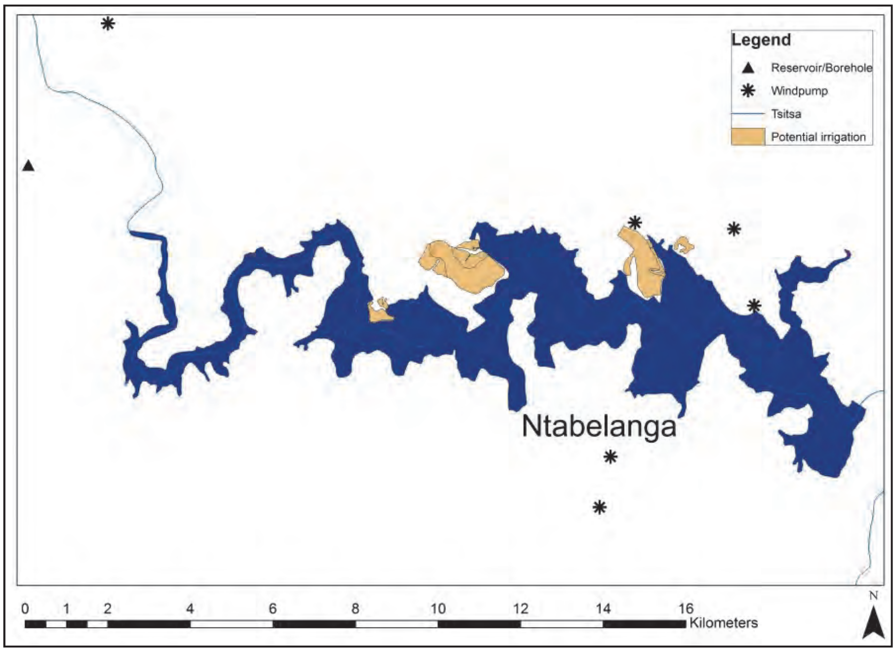

Figure 4.2: Water access points and potential irrigation sites around the planned Ntabelanga dam.

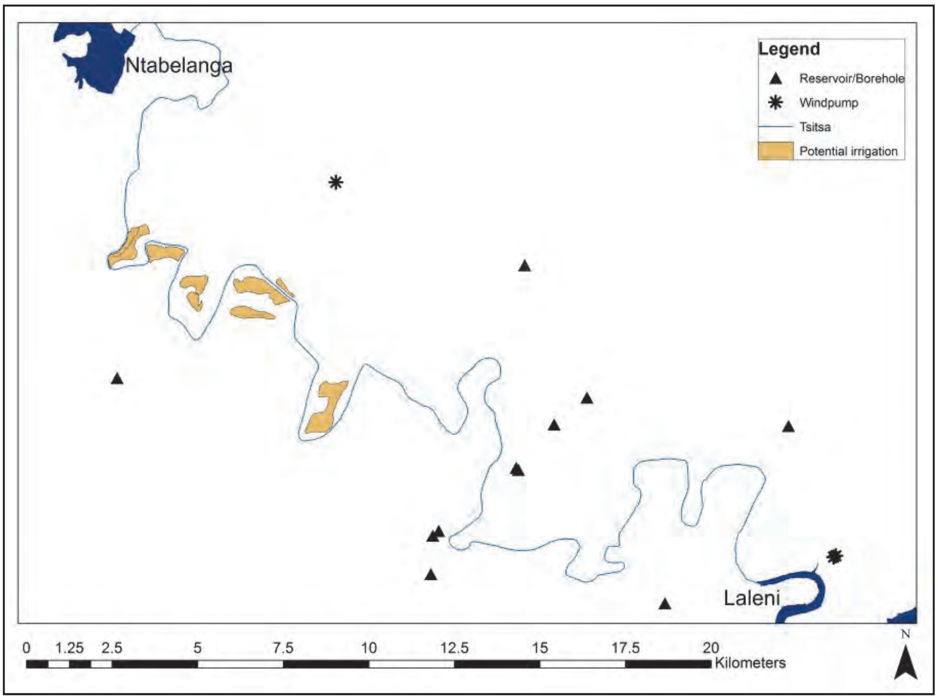

Figure 4.3: Water access points and potential irrigation sites between the planned Ntabelanga and Laleni dams.

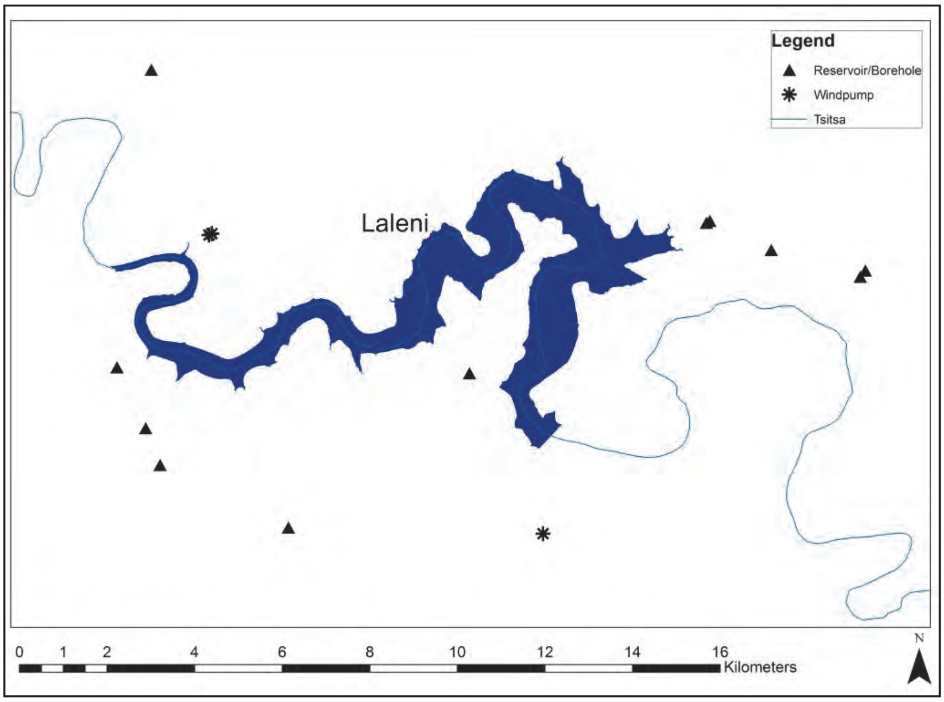

Figure 4.4: Water access points around the planned Laleni dam.

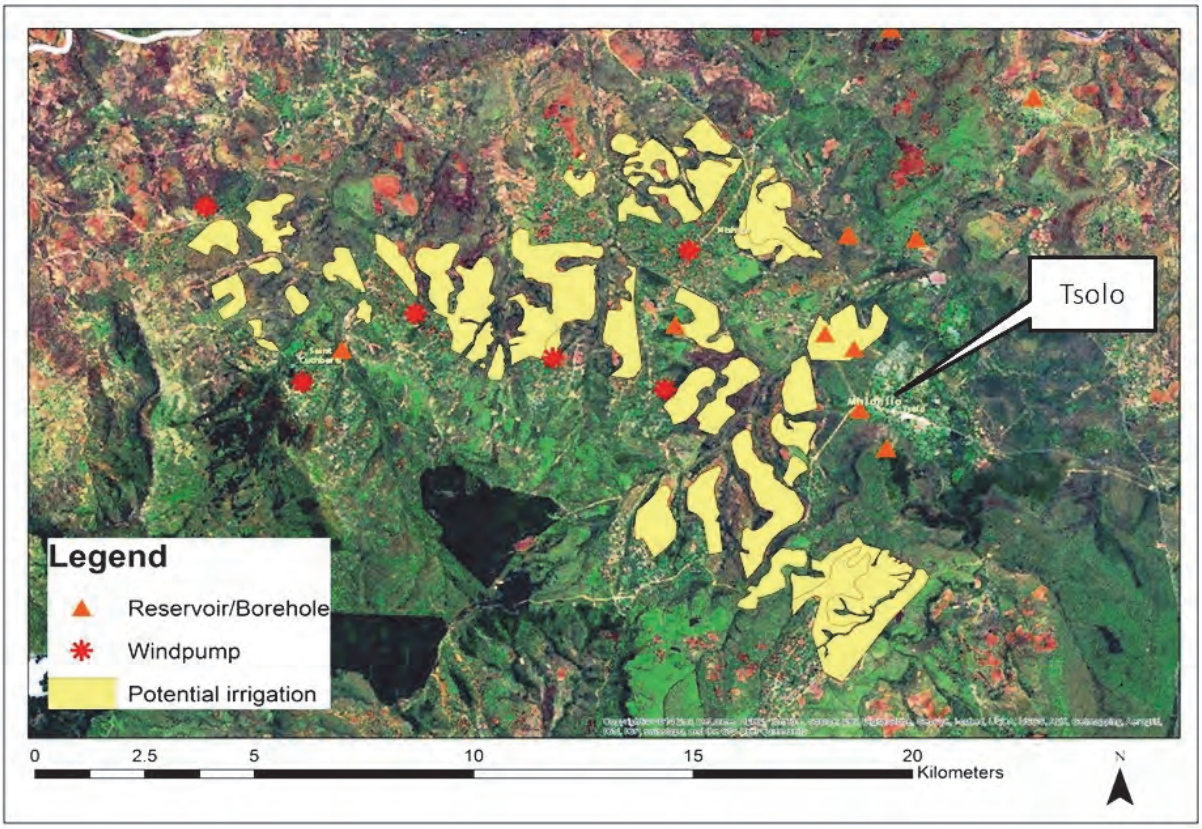

Figure 4.5: Water access points in and around main proposed irrigation sites.

There are a great number of water access sites that can be used for continuous monitoring of groundwater levels (Figure 4.2-Figure 4.5). Identification of representative sites should be done by expert geohydrologists'.

Monitoring action – Groundwater Levels

- Identification of representative monitoring boreholes next to and below the dam walls as well as in and around potential irrigation schemes.
- Measurements of water levels in identified monitoring holes on regular intervals to capture seasonal and climatic fluctuations before the dams are closed and before irrigation on proposed irrigation schemes commence.
- Measurements of water levels in identified monitoring holes on regular intervals to capture seasonal and climatic fluctuations after the dams are closed and after irrigation commenced.
- Statistical comparisons on before and after situations.

4.2 Water Quality

The alteration in the biological, chemical, physical and thermal equilibrium when flowing water is stopped, can significantly deteriorate the quality of the water. The degree of deterioration is directly proportional to the storage time of the dam. Large dams with long retention times can lower the water quality of the dam and the stream below the dam to such an extent that it might be toxic to all biota (McCully, 2001).

4.2.1 Water Temperature

Water stored behind a large reservoir is usually colder during summer and warmer during winter than that of the natural flowing water (McCully, 2001). The alteration in water temperatures may disrupt the life cycle of aquatic biota and can cause significant alterations in the chemical composition of river water.

Monitoring actions – Water Temperature

- Establish baseline database through measurements of water temperatures during different climatic and streamflow stages at identified locations below the proposed dam walls before dams are closed.
- The temperature of in-flowing water (above the dams) will be measured at different depths on regular time intervals. These temperatures will serve as additional baseline data or the *natural* temperature of the Tsitsa River.
- The temperature of out-flowing water (below the dam) will be measured at specific locations (various distance from the dam wall) and depths on regular time intervals and be compared to the *natural* temperature.
- Water temperature in the dam will be measured at selected positions and depths on regular intervals.

4.2.2 Dissolved Oxygen

The decomposition of submerged soils and vegetation decrease the levels of dissolved oxygen of the water, especially in the first few years after a dam is closed. This in turn will negatively influence the biodiversity of aquatic creatures downstream. The acidic deoxygenated water can also dissolve minerals (for example Fe and Mn) from the hypolimnion. Since large dams trap sediments, and with it nutrients (especially P), algae might flourish near the surface. Through the process of photosynthesis the algae enrich the dissolved oxygen levels of near surface water. When the algae die, sink and are decomposed on the lake bed, it may deplete the already low levels of dissolved oxygen near the hypolimnion (McCully, 2001).

Monitoring actions – Dissolved Oxygen

- Establish baseline database through measurements of dissolved oxygen during different climatic and streamflow stages at identified locations below the proposed dam walls before dams are closed.
- The dissolved oxygen levels of in-flowing water (above the dam) will be measured at different depths on regular time intervals. These levels will serve as additional baseline data or the *natural* dissolved oxygen concentration of the Tsitsa River.
- The dissolved oxygen levels of out-flowing water (below the dam) will be measured at specific locations (various distance from the dam wall) and depths on regular time intervals and be compared to the *natural* dissolved oxygen concentration.
- Dissolved oxygen levels in the dam will be measured at selected positions and depths on regular intervals.
- Measurement of the algae population in the dam over the long term.

4.2.3 Water Pollution

Besides the influence of thermal and dissolved oxygen fluctuations on water quality, direct pollution of the dam water can also impact the water quality negatively. The communities in the Ntabelanga area currently utilise the water from the Tsitsa River for domestic purposes and drinking water. Careful monitoring of the water quality is therefore of paramount importance.

In rural areas, pit-latrines can serve as sources of pollution. The expected rise in the water table levels next to the dam will decrease the contact time of nutrients and microbial pollutants with aerated soil, where it is normally decomposed or transformed to non-toxic forms. Examples of nutrients and microbial that can be detriment to the water quality are Nitrate, Phosphorous, *E. coli, enterococci, somatic coliphages* and *helminth* ova. Furthermore, dams tend to concentrate natural levels of nutrients and pollutants to such an extent that, in the worst case, it can become lethal for humans and livestock.

Agricultural practices using pesticides, fungalcides and herbicides are potential contamination points of fresh water/rivers and an accumulation of these over time due to build-up resulting from dams can lead to toxic levels being reached for both humans and animals (domestic and wild-life).

Selected water quality measurements were conducted for the Tsitsa River at a site approximately 20 km downstream of the proposed dam wall. Measurements of EC, TDS, pH, base forming cations, Cl, F, Si, SO_4, NH_4, NO_3, KN, PO_4, and TP were conducted at regular intervals from 1995. These results are summarised in Figure 4.6

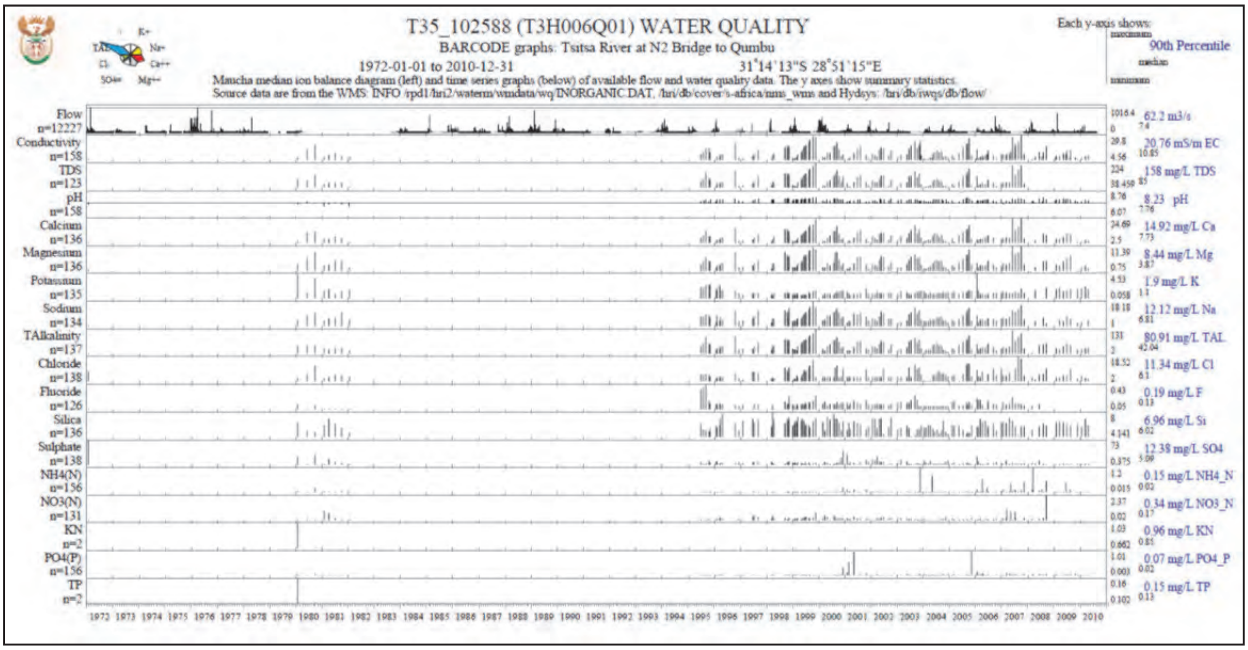

Figure 4.6: Water quality indicators measured in the Tsitsa River.

__Monitoring actions – Water Pollution__

- Establish baseline database through measurements of water quality indicators during different climatic and streamflow stages at identified locations below the proposed dam walls before dams are closed.
- Continuously measure indicators of water quality at selected sites above, in the dam and below the dam.
- Identification of potential sources of nutrient and microbial pollution (Kirschner *et al.,* 2009; Farnleitner *et al.*, 2010).
- Identification of potential pesticides, fungicides and herbicides present in the river up-stream and down-stream from the dam as well as monitoring the levels of these in the river and dam (Barr abd Needham, 2002; Masiaa *et al.,* 2013; Schriks *et al.,* 2010)
- Monitor the contribution of these sources to the water quality of the dam and the river downstream.

4.2.4 Groundwater Quality

The oxygen depleted water near the hypolimnion is generally acidic and can dissolve minerals from the lake bed. This may result in dangerously high levels of minerals leaking towards groundwater reservoirs. In addition, the increase in pollutants of the surface water might filter down to groundwater reservoirs and can negatively impact this important source of fresh water.

Monitoring actions – Groundwater Quality

- Identification of representative monitoring boreholes next to and below the dam walls as well as in and around potential irrigation schemes.
- Measurements of groundwater quality indicators in identified monitoring holes and from windpumps on regular intervals to capture seasonal and climatic fluctuations before the dams are closed and before irrigation on proposed irrigation schemes commence.
- Measurements of groundwater quality indicators in identified monitoring holes and from windpumps on regular intervals to capture seasonal and climatic fluctuations after the dams are closed and after irrigation commenced.
- Statistical comparisons on before and after situations.

4.3 Sediment Loads

All dams trap sediments and large dams without low-level outlets can trap between 90-100% of the inflowing sediments (McCully, 2001). Sedimentation of dams not only reduces the storage capacity of the dam but also deprive floodplains downstream of valuable nutrient rich sediments vital for the sustainability of the ecosystem as well as agricultural production.

Monitoring actions – Sediment Loads

- Establish baseline database through measurements of sediment loads during different climatic and streamflow stages at identified locations below the proposed dam walls before dams are closed.
- The sediment loads of in-flowing water (above the dam) will be measured at different depths on regular time intervals. These levels will serve as additional baseline data or the *natural* sediment load of the Tsitsa River.
- The sediment load levels of out-flowing water (below the dam) will be measured at specific locations (various distance from the dam wall) and depths on regular time intervals and be compared to the *natural* sediment loads.

4.4 Morphological Effects

Any disturbance in the hydraulic and sediment regime will directly influence stream channel morphology (Rowntree & Dollar, 2008). Large reservoirs without low-level outlets trap approximately 90% of the incoming sediments. Water exiting the dam is therefore sediment deprived and will seek to recapture sediments through erosion of the stream bed and stream banks directly below the dam wall.

The river bed can be eroded by several metres within a few years after the dam has been built (McCully, 2001). The deepening of the river can significantly lower groundwater levels and may result in the loss of productive agricultural land. As dams greatly reduce the magnitude of peak flows, the capacity of rivers to flush sediments is reduced, resulting in aggradation and channel sedimentation downstream (Petts and Gurnell, 2005; Rowntree & Dollar, 2008). Table 4.1 summarise of the impact and causes of altering flow and sediment regimes on downstream river morphology. These impacts should be subjected to long-term monitoring.

Table 4.1: Impacts and causes of a dam on downstream morphology (Beck & Basson, 2003)

Impact	Cause
Riverbed degradation	Clear water spillage due to sediment trapped in reservoir
Coarsening of bed material	Clear water releases
Reduced sediment transport capacity	Attenuated flood peaks, coarser bed materials, flatter slopes
Riverbed aggradation	Reduced sediment transport capacity, tributary sediment supply
Increased riparian vegetation	Long periods of low or no flows
Narrowing of river channel	Increased riparian vegetation and smaller floods

There is a lack of sediment yield data for the catchment the Ntabelanga Dam site but they are expected to be high due to a combination of highly erodible duplex soils and inappropriate land use. The land adjacent to the reservoir itself exhibits severe erosion in the form of deeply incised and extensive gully networks and village settlements. This erosion will contribute much fine sediment as well as coarser sediment that can contribute to bedload. The upper catchment, which has less intensive land use, shows less evidence of erosion, but yields are still likely to be moderately high. Above the reservoir site the river is confined within the Tsitsa Gorge and will receive a high volume of bedload. It is the loss of trapped bedload that will have the biggest effect on downstream channel processes; unless deposited on a floodplain, finer sediment carried in suspension is more likely to be washed downstream with minimal morphological impact.

From initial explorations the Tsitsa River below the dam site can be divided into three macro reaches identified from Google Earth (Figure 4.1). These reaches can be expected to respond differently to a changed flow and sediment regime. For the first 16.6 km there are small tributaries with eroded catchments that will contribute sediment to the main channel. This sediment input will to some extent offset any incision due to sediment poor water released from the dam. At 16.6 km a large tributary enters from the right hand bank (west). The catchment of this tributary exhibits widespread erosion and clearly makes a significant contribution to the sediment load carried by the Tsitsa. The character of the main river changes below the confluence, becoming wider and exhibiting more sediment bars. With a reduction in flooding due to the dam, in-channel sedimentation is likely to cause significant morphological changes downstream of the confluence. Other tributaries also contribute flow and sediment to the main channel downstream of the confluence, but the present-day impact on the channel is not noticeable from Google Earth, 80 km below the dam wall the Tsitsa River is confined within a gorge for a further 70 km to the confluence with the main river. It is likely that the channel gradient steepens and the channel morphology is dominated by bedrock. Due to its distance from the dam wall and the increased gradient this macroreach is not likely to experience significant morphological change. However, with reduced flows the impact on habitat could be more significant as the channel will not be able to adjust to the new regime. Smaller flows will be contained within the original larger channel.

Monitoring actions – Morphological effects

- Refine the subdivision the channel below the dam into macro-reaches based on channel gradient, degree of confinement, tributary inputs and channel morphology.

Prior to the dam construction:

- For each macroreach, characterise the stream channel at selected positions before the dam is build. Key features would include:
    - Channel cross-section dimensions and shape (from field surveys)
    - Depositional features, including type and sediment characteristics (direct observation and field measurement)
    - Relationship of channel features to vegetation patterns (as there are strong feedback effects between channel form and vegetation)
    - Hydraulic surveys to establish the relationship between channel form, flow hydraulics and sediment transport potential. These would require that stage-discharge rating curves be established at selected cross sections, ideally linked to a DWA flow gauging station.
    - Interpret stream habitat conditions from the above.

Post dam construction.

- Continued hydraulic monitoring at a range of flows
- Repeat surveys of channel cross sections at the end of the wet season.
- Repeat surveys of bed sediments at the end of the wet season.
- Interpret stream habitat conditions from the above

4.5 Soil Quality

A key motivation behind the Mzimvubu water project is rejuvenation of agricultural sector through irrigation. A total of 2 868 ha has been identified for commercial irrigation of which 2 450 lies in the Tsolo district (Figure 4.5) and the rest around the Ntabelanga dam (Figure 4.2) and along the Tsitsa River before the Laleni dam (Figure 4.3). Most dams in the world have been built to supply water for irrigation. Intensification in land use (for example irrigation of dry lands or crop production on grazing areas) often results in the degradation of the land and especially degradation in soil quality. Besides the influence of irrigation on soil quality a net loss in the carbon balance are also associated with inundation of natural soils; this should be quantified.

4.5.1 Salinisation

All irrigation water contains dissolved salts, plant roots extract the water but salts accumulate in the soil. This ultimately leads to salinisation. To counter this process flushing of salts from the root zone is mostly recommended. Depending on the depth of the water table and the drainage characteristics of the land, over irrigation can lead to salinisation of groundwater levels and a reduction in water quality of both groundwater and streamwater. The soils weathered from Beaufort sediments, the dominant geology in the study area are rich in sodium. When sodium is the dominant cation in irrigation water it leads to the accumulation of Sodium on the exchange complex, a process known as alkalinisation. The dispersive nature of alkaline soils disrupts the structure of the soil and leads to crust formation, reduced permeability for air and water.

4.5.2 Soil Erosion

The degree of soil erosion in the Ntabelanga area has been highlighted in the section 2.2.4. Although the majority of the area which was studied to familiarise ourselves with the *status quo* is not part of the planned irrigation developments, it is still a concern that the communities around the dam intensify land use on soils not suitable for development leading to erosion induced soil degradation. Even when suitable soils are identified for irrigation development, intensification in land use generally results in a reduction in soil quality by reducing organic matter contents, depletion of nutrients and compaction. Degradation in soil quality is however depended on the nature of cultivation practices, for example Conservation Agricultural (CA) might actually increase soil quality.

<u>Monitoring actions – Soil Quality</u>

- Irrigation schemes (before irrigation)
    - Identify representative soils on proposed irrigation schemes.
    - Classify soils according to South African Soil Classification (Soil Classification Working Group, 1991) as well as an international soil classification system.
    - Determine capability and suitability of representative soils.
    - Measure soil chemical, physical and biological quality indicators such as:
        - Organic carbon
        - Electrical Conductivity (EC)
        - Exchangeable and extractable bases
        - Hydraulic conductivity
        - Macroporosity, etc.
- Irrigation schemes (after irrigation)
    - Repeat measurements of soil quality indicators yearly after irrigation commence.
- Wetlands
    - Identify representative wetlands before dams are closed.
    - Describe and classify soils and soil hydromorphology.

- Continuously measure soil water regimes of representative wetland soils before and after dams are closed.
    - Determine the impact of the dams on representative wetlands.
- Carbon losses
    - Quantify Carbon in soils that will be inundated.
    - Estimate direct carbon loss associated with the dams
- Erosion
    - Identify representative sites/erosion gullies.
    - Determine the rate, extent and causes of erosion in identified areas.
    - Monitor the changes in the extent of erosion in identified areas over the long term.

4.6 Aquatic Biodiversity

According to the World Bank, people displaced by dams can restore their incomes through aquaculture and fish-related employment (McCully, 2001). In the previous sections, possible impacts of a dam on *inter alia* water quality and quantity has been highlighted. Changes in the natural river ecosystem, as imposed by the building of a large storage dam, always influence aquatic biodiversity negatively (McCully, 2001). Reducing the biodiversity and abundance of fish and other aquatic biota, may impact communities adjacent to the river and distort the natural ecosystem equilibrium.

Monitoring actions – Aquatic Biodiversity

- Determine the current aquatic biodiversity and specie abundance in selected areas (see discussion on macro reaches – section 4.4) in the Tsitsa River.
- Continuously monitor aquatic biodiversity and specie abundance after the dam is constructed in selected areas at fixed time intervals.

4.7 Riparian Vegetation

River damming provides a dominant human impact on river environments worldwide, and while local impacts of dam flooding are immediate (Braatne *et al.*, 2008), subsequent ecological impacts are multiple, varied and complex. Riparian vegetation is often very distinct and different from the surrounding vegetation. It contains highly diverse plant communities that are structured by different levels and frequency of flooding, which creates disturbance and acts as a dispersal mechanism for plants. It is the ability of plant species to tolerate different levels of inundation and nutrient enrichment among other factors, which determine the structural, compositional and functional characteristics of riparian vegetation. The largest upstream impact of dams on riparian vegetation is of course biomass submergence. While downstream, invasion by terrestrial plant species occurs when the flow regime of a river is reduced. Reed and exotic species invasion usually occurs after extensive deposition of large quantities of sediments in the river bed. Assessment of the current status of riparian vegetation and monitoring long-term impacts of the proposed on both riparian vegetation and adjacent vegetation is therefore important.

Monitoring actions – Riparian Vegetation

- This assessment will be initiated with a survey of the pertinent literature, past reports that exist for the study area.
- Riparian zones and adjacent vegetation will be assessed based on the following: Vegetation type: verification of type and its state or condition based, supported by species identification using Gerber et al. 2004; Germishuizen and Meyer 2003; Henderson 2001; Mucina and Rutherford 2006; van Wyk and van Wyk 1997. Plant samples will be collected, pressed and dried for later verification.
- For long-term monitoring, permanent plots will be established and assessed at regular intervals. Criteria to be used to assess the Present State of Riparian Zones and adjacent vegetation will include:
  - Changes in species diversity, richness, cover, height, functional types, etc.
  - The presence and degree of disturbances (*sensu* Kemper 2001) within the Riparian zones.
  - The abundance of invasive plant species within the Riparian zones. This approach will assist in evaluating whether there are any structural, compositional and functional changes of riparian vegetation including invasion or disappearance of species.

5 PROPOSED MONITORING OF SOCIO-ECONOMIC ASPECTS: IMPACTS ON LIVELIHOODS, SOCIO-CULTURAL RESOURCES AND SOCIAL CAPITAL

As shown in the sociological appraisal, the crucial discourse around which this pilot study revolves is that even the most well-intentioned development project, such as the proposed multipurpose Ntabelanga Dam, could ignore, or even undermine, the very socio-ecological and cultural resources on which its sustainability ultimately depends. This is a long-standing thesis of sustainable development (see de la Court 1990:10-12). As such, the sociological aspects of this study draw attention to issues of social equity and local empowerment, and highlight the imperative of ensuring that social concerns are not relegated to the periphery of discussions pertaining to the dam's overall socio-ecological sustainability. The lurking dilemma is that the dam's developmental promises and potentials are one thing; matching these with local people's hopes and aspirations (and circumventing their worst fears) is another.

From the qualitative sociological data obtained during the pilot study, local residents see the proposed dam as a community development project with a potential to unlock diverse futures: they expressed hopes of, among other things, obtaining new skills and upgrading existing ones, accessing new entrepreneurial opportunities, and attaining improved social existence as a result of the dam project. These benefits connote not just community development, but also, in some ways, community empowerment. The finding echoes the results of previous studies, especially one in which impoverished residents of rural communities that were otherwise rich in natural resources saw those natural resources as a vital developmental asset, and defined community development as 'social infrastructure', 'local empowerment', 'reparation', and 'sustainability' (Akpan, 2006:233).

The question then is: what variables and/or community dynamics must be monitored, how, and towards what end? Although this pilot study did not cover the socio-economic profiles of the communities, nor did it capture the social capital profile (vital for understanding the factors that could galvanise community members into taking advantage of the livelihood and other opportunities provided by the dam project), three distinct areas of impact can be delineated for the purposes of continuous, long-term monitoring. These are: impacts on: (i) skills, livelihoods and income; (ii) social capital, and (iii) existing socio-cultural resources. An elaboration is provided below.

5.1 Impacts on Skills, Livelihoods and Income

Two dimensions are delineable for long-term monitoring purposes, namely: occupational and entrepreneurial spinoffs, and impacts on local skills and income. The questions to be investigated in relation to the two dimensions are highlighted below.

5.1.1 Occupational and Entrepreneurial Spinoffs

- To what extent is the dam project engendering the creation of small and micro agricultural and other businesses in the local communities?

- To what extent is the dam engendering improvements in local agricultural practices and the creation of value chains?
- Against the background that agricultural activities in the study communities currently take place on homesteads, to what extent does the dam project induce changes in agricultural practices?

Monitoring actions – Occupational and Entrepreneurial spinoffs

- Designing a longitudinal study.
- As part of the longitudinal study, conducting a survey of entrepreneurial initiatives (SMMEs) in the local communities (before, during and after the dam construction), with a view to establishing their linkages to the dam project. Baseline data must be obtained before and/or during the construction phase.
- Conducting a survey and carrying out a qualitative study of agricultural practices in the local area with a view to understanding how these have changed vis-à-vis the dam construction.

5.1.2 Local Skills and Income

- How is the dam project impacting on the income status of local community members?
- To what extent is the dam project expanding (sustainable) employment opportunities in the local communities, and what is the rate of access – as well as quality of access – to such opportunities by community members?
- How is the dam project impacting on skills levels in the local communities (especially among the youth)?

Monitoring actions – Local skills and Income

- Designing a longitudinal study.
- As part of the longitudinal study, conducting socio-economic surveys at regular intervals to establish changes in income levels, changes in social grant dependency, employment opportunities and access, as well as skills levels – and how these are linked to the dam project. Baseline data must be obtained before or during the construction phase.

5.2 Impacts on Existing Sociocultural Resources

- In the event that the dam project results in development-induced displacement and resettlement, does such a process result lead to resource losses, deficits, and deprivations (for example, reduced landholding, shrunken agricultural fields, inundation of burial sites), and to what extent are community members satisfied/unsatisfied with available remedial measures?

- What is the extent of local residents' current levels of dependence on the Tsitsa River, and how will a change in access to the river impact on livelihoods and overall community well-being?

<u>Monitoring actions – Impacts on Existing Sociocultural Resources</u>

- Designing a longitudinal study.
- As part of the longitudinal study, conducting a survey and also utilising qualitative methods (at regular time intervals) to establish how the dam project (and especially a possible displacement and resettlement) has impacted on existing sociocultural resources, with close attention to possible losses, deficits, deprivations, as well as overall satisfaction/dissatisfaction profile *vis-à-vis* remedial measures.
- Conducting a survey and also utilising qualitative methods to establish local people's dependence on the Tsitsa River. Comment: socio-cultural dependency? For instance, I recall that people said the river is used for baptising.
- At regular time intervals, conducting a survey and also utilising qualitative methods to gauge how a possible displacement and resettlement (and a resultant change in access to the river) impacts on livelihoods and overall well-being.
- Obtaining baseline data before and/or during the construction phase.

5.3 Social Capital Impacts

- In the event that the dam project triggers a re-mobilisation of social capital (local political assets, grassroots associations, civic and faith-based initiatives), what effect does such re-mobilisation have on overall local sentiments towards the dam project and/or the associated spinoffs?
- How does the dam project impact on social cohesion?

<u>Monitoring actions – Social Capital Impacts</u>

- Designing a longitudinal study.
- Conducting a survey (before and/or during the dam construction) to establish the current social capital profile of the local communities as well as the robustness of that profile.
- Conducting surveys at regular time intervals to establish changes occurring in that profile – and how these are linked to the dam project and/or its spinoffs.
- Baseline data must be obtained before or during the construction phase.

A research initiative for monitoring the above dynamics will, however, require more than the qualitative data obtained during the pilot study, which did not, for instance, cover the demographic, socio-economic and social capital profiles of the communities. For a robust baseline to be constructed, complementary quantitative data will need to be collected, utilising community surveys and secondary sources.

Furthermore, while monitoring and evaluation must necessarily form part of the planning and implementation of any major development project, the emphasis must be made that the proposed long-term monitoring initiative should be carried out as an independent research initiative driven by experts based at universities, research institutes, and related institutions. High-level independent scientific involvement goes a long way towards enhancing the credibility of the overall monitoring initiative.

6 PROPOSED MONITORING OF AGRICULTURAL ASPECTS

As stated in the previous chapters, the Mzimvubu Dam is mainly built for two reasons, first the generation of hydroelectric power and second, the regulation of water flow below the dam wall. The latter would lead to constant availability of water for communities for the use of agricultural production, especially through irrigation.

The agricultural data obtained during the pilot study in the research area indicate that the agricultural core issues, livestock, crop and vegetable production, used to provide enough income to sustain members of the two communities in the past. However, this is not the case anymore, as agriculture is now mostly a supplementary activity. All main activities contribute to food security and additional small income, but the lack of sophisticated production inputs, such as quality seeds, fertilizer, the absence of crop rotations and mulching, and the dependency on unsteady rains, restricts agriculture from playing a more important role in the livelihoods of the two communities. During the interviews with the two communities it became clear that high expectations exist among community members that agriculture would return to have more importance in their livelihoods.

In terms of agriculture, similar dam projects show that communities might indeed take advantage of the constant water availability by increasing the irrigated areas (Ozcan *et al*., 2012:309). However, it is also known that, in terms of agriculture, mostly downstream communities are to benefit from large dams whereas upstream or dam vicinity communities are prone to lose, and in certain cases even worsen their living standards (Duflo and Pande, 2007:626). The displacement of communities is one of the severest negative impacts that such dam projects can have.

Nevertheless, with regard to a proposed long-term monitoring project, the building of the dam may indeed provide the opportunity for increasing agriculture's importance in terms of contribution to livelihoods, and through this, improve the lives of some community members. And yet, it can be expected that upstream, vicinity and downstream communities differ in positive and negative impacts. Consequently, it appears to be important to monitor how each community might benefit or lose from the Mzimvubu Dam project and how their expectations and fears, in regard to agricultural aspects, change over time as these communities develop an understanding of what the Mzimvubu Dam actually means for their respective community.

The monitoring should be divided into the three main agricultural core issues in the communities, namely livestock, crop and vegetable production. Additionally, an overall impression, also for agricultural value chains and spin-offs (as mentioned in the previous chapter) should be gathered in order to show how the importance of the three activities changes in the respective communities as well as if, when and how more or less emphasize is given to agriculture in general in each community, especially focusing on the difference between upstream, vicinity and downstream.

The monitoring of the agricultural aspects should be conducted through a set of instruments and methods with predefined indicators and at least three points of time: pre-dam building, during the dam building and post-dam building. There are at least four (4) research methodologies and technologies, both quantitative and qualitative, that should be applied simultaneously and are related to the environmental and sociological aspects of this study: (i) observation (e.g. backed-up by photos); (ii) interviews with farmers (e.g. focus groups, semi- or standardised interviews); (iii) data elevation on fields (e.g. measurement of areas and yields, soil samples); and (iv) satellite images at different intervals (e.g. Landsat time series half-yearly or yearly). Likewise, this would allow for triangulation and verification of data as well as an attempt to comprehend how realistic agriculture-related community expectations were.

The focus-group interviews with farmers in both communities will be part of the sociologic-aspect and have been described above. For the agricultural aspects, semi-standardised interviews will be conducted using questionnaires. The questionnaire can be found in annex 3. The first set of questionnaires pre-dam building will serve as a baseline against the results from the 'during dam building' and 'post-dam building' will be compared in order to identify the changes accrued in both communities as well as to see if 'hopes' and 'fears' have realised or not, and perhaps to find reasons why.

6.1 Overall Agricultural Aspects

At this stage and as a result of the previously mentioned considerations, the following overall agricultural core issues would require monitoring action in order to determine if indeed agriculture alters its importance for each of the two affected communities. At the same time, guiding questions are given below:

a) Size of agricultural land – is there more, equal or less area used for agricultural production?
b) Change of location – do agricultural areas change locations? For instance, it can be expected that due to the constant availability of water, agricultural areas change location, e.g. by choosing fields closer to the river or due to inundation of existing agricultural fields.
c) People/households involved in agricultural activities directly – do households that have previously not participated in agricultural activities or only practiced parts of the core issues start or increase their agricultural activities? Have households decreased or stopped their agricultural production?
d) Taking of soil conservation measurements – do communities take precaution or other actions to stop or reverse soil erosion?
e) Number of irrigation schemes – do these replace, for instance, rainfed production or grazing area?
f) Area rainfed vs. irrigated – is there a shift from rainfed to irrigation production overall?
g) Food vs. Market – are cattle, crops and vegetable consumed or mainly sold?
h) Development interventions in the agricultural sector or related to it – are there more government, Non-Governmental (NGOs) or Community Based Organisations (CBOs) active with development interventions due to the dam being built?
i) Integration of agricultural core issues – what alteration in importance does each core issue have, how are they being integrated and is there any new core issues emerging (e.g. forestry, value adding)?
j) Change in agricultural expectations and fears – how do expectations and fears change from before, to while and after, the dam has been built?

Monitoring Action – Overall agricultural aspects

In order to monitor the change of the overall agricultural core issues, the following monitoring action with the concerned measurement unit is proposed, which will be elevated by the researchers using the results from community members interviews and satellite images:

a) Size of agricultural land – agricultural area in ha per time unit.
b) Change of location – location of each agricultural area per time unit.
c) People/households involved in agricultural activities directly – number of households active in agriculture time unit.
d) Taking of soil conservation measurements – classify soil conservation initiatives per time unit.
e) Number of irrigation schemes – number and size of irrigation schemes per time unit.
f) Area rainfed vs. irrigated – areas size in ha per time unit.
g) Food vs. market – number of produce and animals consumed, stored or sold per time unit.
h) Development interventions in the agricultural sector or related to it – number and kind of intervention.
i) Integration of agricultural core issues – size and number of each core issue, overlapping of same areas per time unit, and area and kind of new core issues.
j) Change in agricultural expectations and fears – for example, fears of possible resource shrinkage (inundation of grazing and cropping areas) and resource loss (animal drownings) during and after the dam construction?

6.2 Livestock Aspects

In the communities, livestock presents one of the most important issues. For instance, cattle are used for production, transport and rituals, depending on the species. In the two pilot communities, it was ascertained that overgrazing is a problem. With the building of the dam and the establishment of a reservoir or lake, it can be expected that grazing areas will diminish in size or even change location, especially in the vicinity of the dam and upstream (Ozcan *et al*., 2012:308). The reaction and changes to this seem to be of interest for long-term monitoring. Three main core issues can be identified for long-term monitoring for each of the affected communities:

a) Grazing area change – are communal grazing areas changing location and/or size?
b) Amount of livestock changes – is the number of livestock changing and are the numbers of different species of livestock being changed?
c) Use of livestock – for what do communities use livestock, e.g. cultivation, transport, meat production, and is this changing from before the dam was built?

Monitoring Action – Livestock aspects

In order to monitor the change of the livestock core issues, the following monitoring action with the concerned measurement unit is proposed, which will be elevated by the researchers using the results from community members interviews (structure interviews) and satellite images

a) Grazing area change – area in ha per time unit.
b) Amount of livestock changes – number and kind of livestock per time unit.

c) Use of livestock – use of each species of livestock per time unit.

6.3 Crop Production Aspects

From the existing literature it is clear that dam building impacts crop production areas. In particular, these areas are cultivated with crops that are suitable for irrigation and replace crops more suitable to rainfed production. Consequently, cropping patterns are altered, but can, at the same time, increase salination and waterlogging of arable lands (World Commission on Dams, 2000:66) as well as increase the incidence of fungal contaminations. This means that large dams are provoking a shift in crops species in affected areas, but similarly in soil properties and may require an increase in the use of chemical pesticides, fungicides or herbicides. Likewise, it would be interesting to see if the profit of crop production is changing, e.g. through additional irrigation costs. Three core issues can be identified for long-term monitoring for each of the affected communities:

a) Areas of crop production change – are cropping areas changing location and/or size?
b) Diversification of crop production – are more or different crops cultivated in the communities?
c) Output of crop production – are yields increasing and is production more profitable?

Monitoring Action – Crop production aspects

In order to monitor the change of the crop production core issues, the following monitoring action with the concerned measurement unit is proposed, which will be elevated by the researchers using the results from community members interviews (approx. 10% of community households using structured questionnaires and the FG-discussion describe in section 8) and satellite images:

a) Areas of crop production change – area in ha per time unit.
b) Diversification of crop production –crops species and area per time unit.
c) Output of crop production – yields in t/ha, and income and production cost in R/ha.

6.4 Vegetable Production Aspects

As in the case of crop production, the existing literature indicates that dam building impacts vegetable production areas. Moreover, the interviewed communities had already mentioned that they desired to start or increase the vegetable production in their respective areas. Evidently, it seems justified to use the change in vegetable production for a long-term monitoring. Three main core issues can be identified for each of the affected communities:

a) Area of vegetable production change – are vegetable areas changing location and/or size?
b) Diversification of vegetable production – are more or different vegetable produced in the communities?
c) Output of vegetable production – are yields increasing and is production more profitable?

Monitoring Action – Vegetable production aspects

In order to monitor the change of the vegetable production core issues, the following monitoring action with the concerned measurement unit is proposed, which will be elevated by the researchers using the results from community members interviews (approx. 10% of community households using structured questionnaires and the FG-discussion describe in section 8) and satellite images::

a) Areas of vegetable production change – area in ha per time unit.
b) Diversification of vegetable production – number and vegetables per time unit.
c) Output of vegetable production – yields in t/ha, and income and production cost in R/ha.

7 CROSS-CUTTING ISSUES: PROPOSED INTERDISCIPLINARY MONITORING OF ENVIRONMENTAL, SOCIO-ECONOMIC AND AGRICULTURAL ASPECTS

The proposed monitoring activities suggested in the foregoing environmental, sociological and agricultural appraisals present an opportunity for robust interdisciplinary collaboration. Defined as a mode of inquiry and knowledge production that "integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or field of research practice" by the National Academy of Science (NAS) et al. (2004:26), interdisciplinarity opens up the possibility of understanding the dam-environment-community nexus in a holistic way. It will generate cross-cutting issues that will be relevant to the different disciplines taking part in this project. Figure 7.1 and Figure 7.2, for example, offer a preliminary idea of the possible areas of intersection to be explored in the long-term scientific monitoring of the dam project.

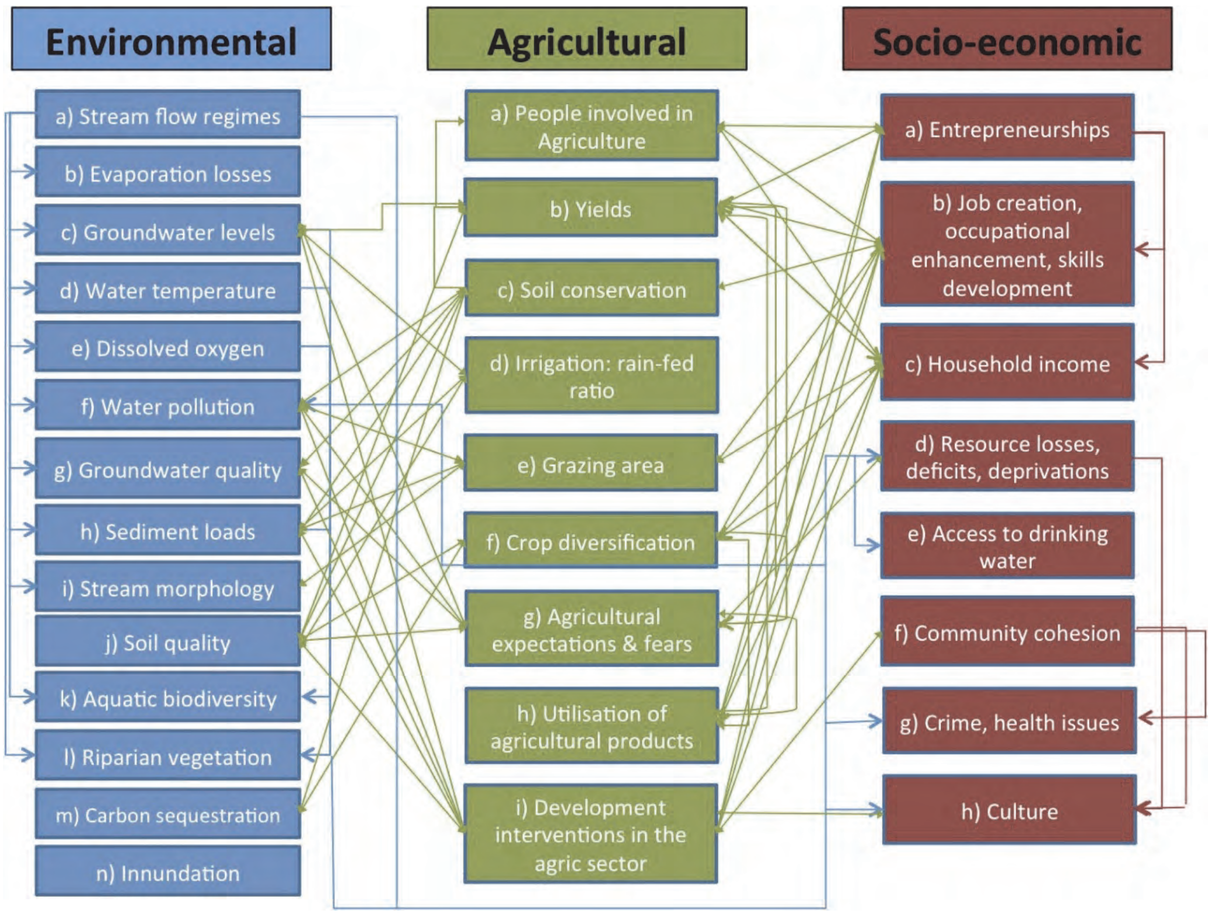

Figure 7.1: Intersections – Possible cross-cutting issues for transdisciplinary monitoring.

Figure 7.1 depicts the three broad disciplines (environmental, agricultural and socio-economic), for which the likely monitoring actions have been alluded to in the previous chapters. The arrows indicate the cross-cutting nature of the issues, and, no doubt, the imperative of interdisciplinary, collaborative monitoring research. For instance, soil quality (environment j) might influence crop yields (agriculture b) that communities currently obtain, and/or will obtain in the future. At the same time, household income (socio-economic c) might well depend on these yields – and an increase in household income could impact on socio-economic relations and social cohesion (socio-economic f). In the long-term monitoring proposal, the direct and the indirect intersection will be determined and how these should be monitored.

As an additional attempt to highlight the intersections, Figure 7.2 depicts the overlapping monitoring actions for the three aspects. Noticeably, it is only in the environmental aspects that a few monitoring actions (b, d, e, i, k) are expected to be done independently of the other disciplines.

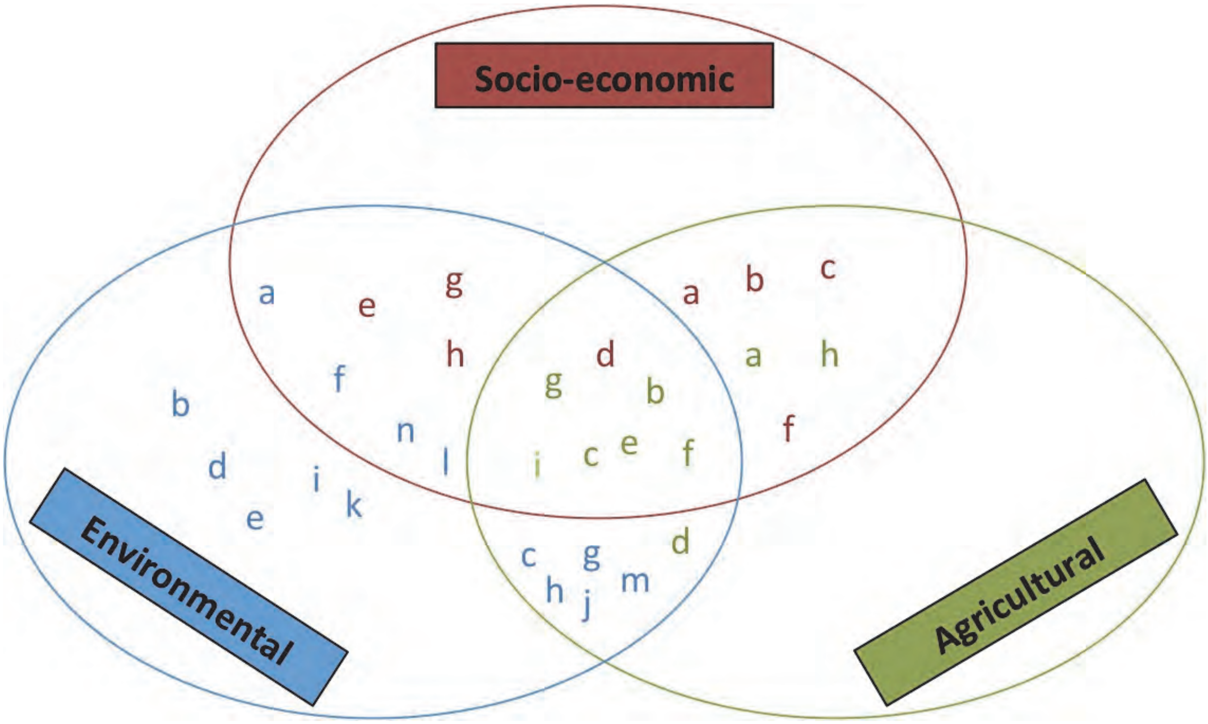

Figure 7.2: The three broad disciplines and their overlapping monitoring actions.

Of further importance is that all agricultural aspects appear to intersect with one or the other discipline, but mostly with both. Certainly, this has to do with the very nature of agriculture as it depends on both the environment and human activities. Likewise, the socio-economic monitoring actions intersect with the other aspects too, but are more equally distributed between one or the other aspect or both. This will have importance for the long-term monitoring. The interdisciplinary research methodologies employed would need to take the intersections into account in order to avoid unnecessary research activities. The researchers hope to further develop Figure 7.2 into an 'intersection web'.

8 PRIORITY MONITORING ACTIONS

It should be mentioned that this short-term study was based, proceeded on the assumption that the construction of the Ntabelanga Dam would commence early in 2016. However, in a recent declaration, Water Affairs Minister Edna Molewa stated that the dam building will start early to mid-2014. Were that to be the case, there would have been a relatively uninterrupted link between the long term and long-term phases of the socio-ecological study. However, even with such an optimistic commencement date, the researchers would still have needed to close some gaps in the data, so as to establish a robust baseline against which the long-term monitoring would be undertaken.

Closing this gap has now become quite crucial, but it will be critically so should the construction be delayed. For instance, the emphasis was earlier in the report about the need for the socio-economic, demographic, as well as social capital profiles of the study communities to be captured in 2014 (preferably before the dam construction commences). Equally important is the need, among other priority monitoring activities, to accumulate a physical database throughout 2014 focusing on stream and groundwater quality and sediments to ensure that the researchers are not caught unawares should the dam building start in 2014. The researchers feel a strong need in the present report to make a strong case for another small grant from Water Research Commission to conduct a short-term, bridging study in 2014 to generate these important baseline (mostly) quantitative data.

9 MONITORING TIME FRAME (PHASE 1)

Although it is difficult to determine exactly when the Mzimvubu project will commence, it is even more difficult to predict when the dams will be closed and/or when irrigation on will be implemented. We are however confident that the dams will be built in the near future and for this reason it is vital that a robust baseline database should be established. With this in mind, we propose a monitoring timeline in Table 9.1 for the first phase of project, namely establishing a robust database. This timeline is based on a few assumptions regarding the start and end date of the project as well as the availability of funding:

- Dam building will commence in October 2014.
- Funds for continuous monitoring will be made available in April 2015.
- At least one of the dams will be closed by June 2017.

Capacity building in the form of student training will form an integral part of this proposed project. The number of students involved in various monitoring actions is therefore highlighted in Table 9.1. We realise that population of a database seldom results in higher level post-graduate degrees, i.e. MSc and PhD (with special reference to the ‘environmental’ aspects). The interdisciplinary nature of the project will however facilitate a holistic approach to ecosystem understanding and can therefore enhance the quality of research outputs.

As mentioned in chapter 8, socio-economic research should continue uninterruptedly throughout 2014. Once funding is approved, specialist researchers in various fields will identify sites for instrumentation of continuous monitoring equipment and fieldwork (Table 9.1). Some monitoring actions do not require continuous measurements and others only need to be conducted once, e.g. identification of riparian vegetation.

Table 9.1: Proposed time frame for phase 1 of long-term monitoring of the Mzimvubu water project

		2014	2015												2016												2017							Post-dam
		Apr - Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	CONSTRUCTION COMPLETED - DAM WALL CLOSED	Measurement interval
Environmental																																		
Water quantity	Streamflow	Continuous measurements (DWA weir)																																Continuous
	Evaporation																																	Continuous
	Groundwater		Site identification			Instrumentation		Continuous measurements (Q, R, S)																										Continuous
Water quality	Temperature																																	Continuous
	Dissolved oxygen																																	Continuous
	Pollutants																																	Continuous
	Groundwater																																	Continuous
Sediment loads																																		Continuous
Morphological effects																																		Annually
Soils	Carbon Balance	A*																																
	Soil quality		Site identification					F					F																O					Annually
	Wetlands					Instrumentation		Continuous measurements (P)																										Continuous
	Erosion																																	Annually
Aquatic biodiversity	Fish							G					G					L					L					L						Biannually
	Other biota																																	Biannually
Riparian vegetation																									M									Annually
Socio-economic																																		
Occupational and Entrepreneurial spinoffs		B	Longitudinal study design			D					D						J						J						J					Biannually
Local skills and Income																																		Biannually
Impacts on Existing Sociocultural Resources		C				E					E						K						K						K					Biannually
Social Capital Impacts																																		Biannually
Agricultural																																		
Overall			Farms/Farmer identification					H,I					H,I							H,I					N							N		Annually
Livestock production																																		Annually
Crop production																																		Annually
Vegetable production																																		Annually

*Letters refers to different students working on various aspects while populating the baseline database.

10 CONCLUSIONS

The Ntabelanga valley is deemed the appropriate site for a large storage dam in the Mzimvubu basin. The first section of this report focused on the *status quo* in the study area in terms of the environmental, agricultural and socio-economic situation. In a subsequent instalment, aspects that might be affected by the building of the dam were identified through a dissection of existing literature and workshops with experts in relevant fields.

A large storage dam will alter streamflow regimes and through enhanced evaporation reduce the total streamflow volume. Water quality is often impacted negatively through chances in water temperatures, oxygen levels and sediment and nutrient loads. The reduction in water quality and altered flow regimes can influence the riparian vegetation and aquatic life through reduction in specie biodiversity and abundance. Changes in stream morphology are almost always a consequence of a large dam. These aspects should be quantified before the dam is build and on regular time intervals after the closing of the dam to capture the impact of the dam on the relevant aspects.

As the main objective of the dam is to rejuvenate agriculture in this rural area, significant changes can be expected in terms of the area under cultivation, crop diversity and cultivation methods as well as in the ratio between crop and livestock farming. Intensification of agricultural practices will no doubt impact soil quality in terms of erosion, nutrient and organic matter depletion. Current agricultural practices should be quantified in terms of area cultivated, livestock numbers, agricultural income, etc. and should be monitored continuously to grasp the impact of the dam on the agricultural sector.

Success of large infrastructural projects is increasingly being measured by the extent to which the project coheres with specific social and environmental dynamics in the local area. The expectations and fears of the communities to be affected by the dam should be understood and quantified where possible. Continuous monitoring of changes in local perspectives in relation to actual impacts should be conducted. Examples of socio-economic aspects that will be monitored are occupational and entrepreneurial benefits, improved skills and income and loss of resources (sociocultural and material).

The interdisciplinary nature of this project is reflected through the number of identified intersections between environmental, agricultural and socio-economic disciplines. Holistic monitoring of these interactive relationships will be integral in the proposal for long-term monitoring of the impacts of the Ntabelanga dam on the community and the ecosystem.

11 REFERENCES

AKPAN, W., 2006. Between responsibility and rhetoric: Some consequences of CSR practice in Nigeria's oil province. *Development Southern Africa*, 23: 2, June. 223-240.

AKPAN, W., 2010. Confronting the referentialisation challenge: Back to hope, being and other 'forgotten' sociologies. *South African Review of Sociology.* 41:3. 117-126.

ALTINBILEK, D., 2002. The Role of Dams in Development. *International journal of water resources development,* 18:1. 9-24.

BARR, D. B., & NEEDHAM, L. L. 2002. Analytical methods for biological monitoring of exposure to pesticides: a review. *Journal of Chromatography B,* 778, 5E29.

BECK, J.S. & BASSON, G.R., 2003. The hydraulics of the impacts of dam development on the river morphology. WRC report No. 1102/1/03. Water Research Commission, Pretoria.

BECK, M.W., CLAASEN, H. & HUNDT, P.J., 2012. Environmental and livelihood impacts of dams: common lessons across development gradients that challenge sustainability, *International journal of river basin management,* 10:1. 73-92.

BISHT, T.C., 2009. Development-Induced Displacement and Women: The Case of the Tehri Dam, India. *The Asia Pacific journal of anthropology,* 10:4. 301-317.

BISWAS, A. K., 2004. Dams: cornucopia or disaster? *International Journal of water resources development,* 20:1. 3-14.

BOTES, W.P.G., 2013. Personal Communication.

BRAATNE J.H., ROOD S.B., GOATER L.A. AND BLAIR C.L. 2008. Analyzing the impacts of dams on riparian ecosystems: a review of research strategies and their relevance to the Snake River through Hells Canyon. Environmental Management 41: 267-281.

DE LA COURT, T. 1990. *Beyond Brundtland: Green development in the 1990s.* New York: New Horizon

DEPARTMENT OF WATER AFFAIRS (DWA), 2012. Feasibility Study: Mzimvubu Water Project. *Newsletter 1.* August.

DIXON, J., GULLIVER, A., GIBBON, D. and M. HALL (ed.), 2001: Farming systems and poverty: Improving farmers' livelihoods in a changing world. FAO and World Bank, Rome and Washington, D.C., 412 pp.

DUFLO, E., PANDE, R., 2007. Dams, *The Quarterly Journal of Economics*, MIT Press, Vol. 122 (2), pages 601-646.

DUMAS, D., MIETTON, M., HAMERLYNCK, O., PESNEAUD, F., KANE, A., COLY, A., DUVAIL, S. & BABA, M. L. O. 2010. Large dams and Uncertainties: The Case of the Senegal River (West Africa). *Society and natural resources: An international journal,* 23:11. 1108-1122.

FARNLEITNER, A.H., RYZINSKA-PAIER, G., REISCHER, G.H., BURTSCHER, M.M., KNETSCH, S., KIRSCHNER, A.K., DIRNBOCK, T., KUSCHNIG, G., MACH, R.L. AND SOMMER, R. 2010. Escherichia coli and Enterococci Are Sensitive and Reliable Indicators for Human, Livestock and Wildlife Faecal Pollution in Alpine Mountainous Water Resources. *J. Appl. Microbiol.*, 109 (5), 1599-1608.

GERBER A., CILLIERS C.J., VAN GINKEL C. AND GLEN R. 2004. Easy identification of aquatic plants. Department of Water Affairs and Forestry, Pretoria.

GERMISHUIZEN G. AND MEYER N.L. 2003. Plants of southern Africa: an annotated checklist. Strelitzia 14, South African National Biodiversity Institute, Pretoria.

GLASS, J.F., Toward a sociology of being: The humanistic potential. *Sociological Analysis* 32:4. 191-198.

Global Mapper v14.2.1, 2013. *Blue Marble Geographics*. Hallowell, ME, USA.

GOULET, D., Global governance, Dam Conflicts, and Participation. *Human Rights Quarterly* 27:3. 881-907.

HENDERSON, L. 2001. Alien weeds and invasive plants: a complete guide to declared weeds and invaders in South Africa. Agricultural Research Council, Pretoria.

HUGHES, D.M., Whites and Water: How Euro-Africans Made Nature at Kariba Dam. Journal of Southern African Studies. 32:4. 823-838.

JEFFRIES, V., The integral paradigm: The truth of faith and the social sciences. *The American Sociologist.* 43 (Winter). 36-55.MCCULLY, P., 2001. *Silenced rivers: Ecology and politics of large dams.* Plymouth: Zed Books.

KEMPER N.P. 2001. Riparian vegetation index. Water Research Commission Report no. 850/3/01.

KIRSCHNER, A.K.T., KAVKA, G.G., VELIMIROV, B., MACH, R.L., SOMMER, R. AND FARNLEITNER, A.H. 2009 Microbiological Water Quality along the Danube River: Integrating Data from Two Whole-River Surveys and A Transnational Monitoring Network. *Water Res.,* 43 (15), 3673-3684.

LAND TYPE SURVEY STAFF, 1972-2006. Land types of South Africa: Digital map (1:250 000 scale) and soil inventory datases. ARC-Institute for Soil, Climate and Water, Pretoria.

MASIAA, M. IBA˜NEZB, C. BLASCOA, J.V. SANCHOB, Y. PICOA, F. HERNANDEZ., ET AL 2013. Combined use of liquid chromatography triple quadrupole mass spectrometry and liquid chromatography quadrupole time-of-flight mass spectrometry in systematic screening of pesticides and other contaminants in water samples. *Analytica Chimica Acta* 761, 117-127

MOLEWA, B.E., 2013. Minister of Water and Environmental Affairs 2013 Budget Speech and Responses by ANC and DA. May 21. http://www.pmg.org.za/print/briefing/20130521-minister-water-and-environmental-affairs-2013-budget-speech-and-responses-anc-and-da Accessed 14 July, 2013.

MCULLY, P., 2001. Silenced Rivers: the Ecology and Politics of Large Dams. Zed Books, London.

MUCINA L. AND RUTHERFORD M.C. 2006. The vegetation of South African, Lesotho and Swaziland. Strelitzia 14, South African National Biodiversity Institute, Pretoria.

NATIONAL ACADEMY OF SCIENCE, NATIONAL ACADEMY OF ENGINEERING, INSTITUTE OF MEDICINE, 2004. Facilitating Interdisciplinary Research. Washington, DC: The National Academies Press.

NFEPA Report, 2011. National freshwater ecosystems priority areas. Department of Water Affairs. Pretoria.

NWRS2, 2012. Natural water research strategy 2: Managing water for an equitable and sustainable future. Department of Water Affairs. Pretoria.

OZCAN, O., BOOKHAGEN, B., MUSAOGLU, N., 2012. Impact of the Atatürk Dam Lake on Agro-Meteorological Aspects of the Southeastern Anatolia Region Using Remote Sensing and GIS Analysis. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume XXXIX-B8, 2012, 305-310.

PETTS, G. E., & GURNELL, A.M., 2005. Dams and geomorphology: Research progress and future directions. *Geomorphology* 71, 27-47

RAINA, V., 2000. Why people oppose dams: environment and culture in subsistence economies, *Inter-Asia Cultural Studies,*1:1. 145-161.

ROWNTREE K.M. & DOLLAR, E.S.J., 2008. Contemporary Channel Processes. In Lewis C.A. (ed.), *Geomorphology of the Eastern Cape, South Africa.* NISC, Grahamstown, South Africa, 43-62.

SCHRIKS, M., HERINGA, M.B., VAN DER KOOI, M.M.E., DE VOOGT, P., VAN WEZEL, A.P., 2010. Toxicological relevance of emerging contaminants for drinking water quality. *Water Res.* 44 (2), 461-476.

SOIL CLASSIFICATION WORKING GROUP. 1991. Soil classification: a taxonomic system for South Africa. *Memoirs on the Agricultural Natural Resources of South Africa* No. 15. SIRI, D.A.T.S., Pretoria.

UPHOFF, N., 1996. Learning from Gal Oya. Possibilities for participatory development and post-Newtonian social science, IT Publications, London. (2nd edition)

VAN DEN BERG, E.C., PLARRE, C., VAN DEN BERG, H.M. & TOMPSON, M.W., 2008. The South African National Land-cover 2000. Agricultural Research Council – Institute for Soil, Climate and Water, Pretoria.

VAN WYK B. AND VAN WYK P. 1997. Field guide to trees of southern Africa. Struik Publishers, Cape Town.

VAN ZIJL, G.M., LE ROUX, P.A.L. & TURNER, D.P., 2013. Disaggregation of land types using terrain analysis, expert knowledge and GIS methods. *South African Journal of Plant and Soil*. DOI: 10.1080/02571862.2013.806679.

WORLD COMMISSION ON DAMS, 2000. Dams and Development. A New Framework for Decision-Making. London and Sterling, VA.

APPENDICES

ANNEX 1: Consent Form for Interviews

Ethics Human 2011

<< >>

OFFICE USE ONLY

Ref	Date

INFORMED CONSENT by Participant

I hereby agree to participate in research regarding **COMMUNITY SENTIMENTS AHEAD OF A DAM CONSTRUCTION.** I understand that I am participating freely and without being forced in any way to do so. I also understand that I can stop this interview at any point should I not want to continue and that this decision will not in any way affect me negatively.

I understand that this is a research project whose purpose is not necessarily to benefit me personally.

I have received the telephone number of a person to contact should I need to speak about any issues which may arise in this interview.

I understand that this consent form will not be linked to the questionnaire, and that my answers will remain confidential.

I understand that if at all possible, feedback will be given to my community on the results of the completed research.

....

Signature of participant **Date:**..

I hereby agree to the tape recording of my participation in the study

....

Signature of participant **Date:**..

Faculty Social Sciences & Humanities
mlhz/
February 2013

Page | 18 of 18

ANNEX 2: FGD Interview Guide

University of Fort Hare
Together in Excellence

TO BE COMPLETED BY INTERVIEWER:

Name of Interviewer: ____ Type of Interview group (Youth, Elders, etc.)____________________

No. of interviewees in group: _____________________________________

Name of community: ____

Date of interview: ____

Time of interview: ____

Interview recorded on tape? Yes: _________ No: ____________

Informed consent form signed? Yes: _______ No: ____________

SECTION A

1. Interviewee Particulars:

a. Sex: Male ------------------------- Female: ----------------------

b. Occupation ---

----

c. Highest level of formal education: ---

d. Age range (approximate):

18-25 --------- 25+ - 30 ------------ 30+ - 35 ------------ 35+ - 40 -------------
40+ - 45 ------- 45+ - 50 ------------ 50+ - 55 ------------- 55+ - 60 -------------
Above 60 -----

SECTION B

2. Compared to this time when there is no dam of this scale, how will life in this community be better as a result of the proposed dam (during and after construction)? *[Interviewer prompt: probe various dimensions – socio-economic, household, etc.)*

   Interviewer Notes: --

   ----

3. In your view, what specific benefits do you think the proposed dam will bring? *[Interviewer prompt: probe various dimensions – agricultural, household, socio-economic, cultural/spiritual]*

   Interviewer Notes: --

   ----

4. Is there a particular way in which the dam project can be managed (before, during and after construction) so as to positively impact on the community? *[Interviewer prompt: refer to the benefits just discussed]*

   Interviewer Notes: --

   ----

5. In your view, what do you think community members (men, women, the youth) should do so as to better benefit from the dam project (before, during and after construction)?

   Interviewer Notes: --

   ----

6. Are there any fears that you as a community have with regard to the proposed dam construction (socio-economically, politically, culturally, or otherwise)? What are these fears?

   Interviewer Notes: --

   ----

7. Why and how did such fears come about? *(Interviewer prompt: where do the fears stem from? Fear of government? Fear of flooding? Fear of the "unknown", Social fears – project will bring "strangers" who will "corrupt" the youths, etc.)*

   Interviewer Notes: --

   ----

8. How will the community address those fears?

   Interviewer Notes: --

   ----

9. In the light of the fears we have just discussed, if you had your way as a community, would you rather stop the project?

   Interviewer Notes: --

   ----

10. What steps would you take to voice your concerns and fears to the government? *(Interviewer prompt: What channels of communication are currently available to conveying dissatisfaction with government projects, specifically a project of this magnitude?)*

Interviewer Notes: --

SECTION C

11. What is the major crop produced in this area? *(Interviewer prompt: probe this in hectares, if possible – how many hectares are devoted to the production of this crop)*
    a. ---
    b. ---
    c. ---
    d. ---
    e. ---

12. Which other crops are produced *(Interviewer prompt: Interviewer prompt: probe this in hectares, if possible – how many hectares are devoted to the production of these other crops?)*
    a. ---
    b. ---
    c. ---
    d. ---
    e. ---

13. To the best of your knowledge, what kinds of crops did people produce in the past (approximately 10-20 years ago, or further back)?
    a. ---
    b. ---
    c. ---
    d. ---
    e. ---

14. Where do people currently obtain their seed?
    a. --
    b. --
    c. --
    d. --

15. Do people use fertilizer? Yes ----------------- No ----------------------

16. What is the typical yield for each crop?
    a. --
    b. --
    c. --
    d. --

17. How do people produce crops in the present (e.g. contractors for ploughing, only by hand, etc.)?
    a. Use of contractors ---
    b. Only by hand? --
    c. Other (Please specify) ---

18. Do people have vegetable gardens? Yes -------------------- No -------------------------

19. Do they produce vegetables? Yes --------------------- No -------------------------

20. If yes, which ones?
    a. --
    b. --
    c. --
    d. --

21. How important is livestock in this community?

    ----

22. Which animals (livestock) do people have?
    a. --
    b. --
    c. --
    d. --

23. Where is the grazing area?

----

24. How big is the grazing area?

----

25. To the best of your knowledge, is the grazing area bigger or smaller than before?
    a. Bigger than before ---
    b. Smaller than before ---
    c. Very much the same as before ------------------------------------
    d. Can't say ---
    e. Other responses ---

26. Are there more or fewer animals than before in this community?
    a. More than before ---
    b. Fewer than before ---
    c. Very much the same as before ------------------------------------
    d. Can't say ---
    e. Other responses ---

27. Is there any grazing regime *(Interviewer prompt: e.g. grazing patterns/management, specific areas for specific animals, specific areas for specific sections of the community, specific areas for specific seasons, etc.)?*

----

28. If the Dam is built, how do you expect your agricultural production (i.e. crops and animals) to change? *(Interviewer prompt: Let participants freely elaborate on this?)*

SECTION D

29. Do people notice the extent of erosion in this community?

Yes --------------------------------- No -------------------------------------

30. Has the erosion become worse now than in the past?

a. Worse than in the past --
b. Not as bad as in the past --
c. About the same as in the past ---
d. Don't know --
e. Other responses --

31. How does the erosion directly impact the community?

Interviewer Notes: ---

----

32. What do people think is the cause of erosion?

Interviewer Notes: ---

----

33. To the best of your knowledge, are there methods/ways to stop the erosion?

Interviewer Notes: --

----

34. If irrigation were introduced and new areas developed for crop production, how do you think this will impact on the erosion problem?

Interviewer Notes: --

----

35. Does the stream (Ititsa) sometimes overflow its banks?
Yes ------------------------------ No ------------------------------

36. If yes, how high does the water rise?

Interviewer Notes: --

----

37. How often does the overflow happen?

Interviewer Notes: --

----

38. Do people drink water directly from the stream?

Interviewer Notes: ---

----

39. If yes, is there a suspicion that people in the community sometimes get sick from drinking the stream water?

Interviewer Notes: ---

----

40. To the best of your knowledge, is there a change in the rainfall (pattern and amount) in recent years? (e.g. Is there more or less rain these days?)

Interviewer Notes: ---

ANNEX 3: Questionnaire for Agricultural Core Issues – Mzimvubu Dam

1. Overall Agricultural Core Issues

a) Size of agricultural land in the communities – agricultural area in ha per time unit.
(Guiding question: is there more, equal or less area used for agricultural production?)

Pre-Dam Building	During Dam Building	Post-Dam Building
Ha	Ha	Ha

b) Change of location – location of <u>each</u> agricultural area per time unit.
(Guiding question: do agricultural areas change locations? For instance, it can be expected that due to the constant availability of water, agricultural areas change location, e.g. by choosing fields closer to the river or due to inundation of existing agricultural fields.)

Name of agricultural area	Pre-Dam Building	During Dam Building	Post-Dam Building
	GPS Co-ordinates		

NB. If agricultural area is not used, fill in N/A

c) Households involved in agricultural activities directly – number of households active in agriculture per time unit.
(Guiding question: do households that have previously not participated in agricultural activities or only practiced parts of the core issues start or increase their agricultural activities? Have households decreased or stopped their agricultural production?)

Pre-Dam Building	During Dam Building	Post-Dam Building
Household Number	Household Number	Household Number

d) Taking of soil conservation measurements – classify soil conservation initiatives per time unit.
(Guiding question: do communities take precaution or other actions to stop or reverse soil erosion?)

Soil Conservation Measurements	Pre-Dam Building	During Dam Building	Post-Dam Building
Counters	Y/N		
Crop Rotations			
Mulching			
Planting along slopes			
Other (specify)			
Other (specify)			

NB. Extend table to the number of soil measurements

e) Number of irrigation schemes in the community – number and size of irrigation schemes per time unit.

(Guiding question: Do these replace, for instance, rainfed production or grazing area?)

Irrigation scheme name and location (GPS)	Pre-Dam Building	During Dam Building	Post-Dam Building
Name: GPS:	Ha		
Name: GPS:			

NB. Extend table to the number of irrigation schemes

f) Area rainfed vs. irrigated – areas size in ha per time unit.

(Guiding question: is there a shift from rainfed to irrigation production overall?)

Agricultural area	Pre-Dam Building	During Dam Building	Post-Dam Building
Rainfed	Ha		
Irrigated			
Total	**Ha**	**Ha**	**Ha**

NB. The total must match the Ha in 1 a)

g) Food vs. market – number of produce and animals consumed, stored or sold per time unit.

(Guiding question: are cattle, crops and vegetable consumed or mainly sold?)

Enterprise	Pre-Dam Building	During Dam Building	Post-Dam Building
Crops (specify)	Consumed/stored/sold		
Animals (specify)			
Vegetables (specify)			
Other (specify)			
Other (specify)			

NB. Specify for each crop, animal and vegetable or other enterprise the number, weight (e.g. kg or bags) and the price. In case of sold, where did they sell and, if possible, the price. See if there are price difference between selling in community and market.

h) Development interventions in the agricultural sector or related to it – number and kind of intervention.

(Guiding question: are there more government, Non-Governmental (NGOs) or Community Based Organisations (CBOs) active with development interventions due to the dam being built?)

Development Intervention	**Pre-Dam Building**	**During Dam Building**	**Post-Dam Building**
Name, Organisation, kind of interventions (e.g. food security, HIV/AIDS)			

NB. NB. Extend table to the number of development interventions

i) Integration of agricultural core issues – size and number of each core issue, overlapping of same areas per time unit, and area and kind of new core issues.

(Guiding question: What alteration in importance does each core issue have, how are they being integrated and is there any new core issues emerging (e.g. forestry, value adding)?)

Observation:

____

____

____

____

NB.

j) Change in agricultural expectations and fears – for example, fears of possible resource shrinkage (inundation of grazing and cropping areas) and resource loss (animal drowning) during and after the dam construction?

(Guiding question: how do expectations and fears change from before, to while and after, the dam has been built?)

Part of Focus Group Discussion see section 8.

2. Livestock Production

10% of households in each community should be sampled.

a) Grazing area change – communal grazing area in ha per time unit.
(Guiding question: Are communal grazing areas changing location and/or size?)

Name of grazing area	Pre-Dam Building		During Dam Building		Post-Dam Building	
	GPS Co-ordinates	ha				

NB. If grazing area is not used, fill in N/A. Extend table to number of grazing areas.

b) Amount of livestock changes – number and kind of livestock per time unit for each household.
(Guiding question: is the number of livestock changing and are the numbers of different species of livestock being changed?)

Species	Pre-Dam Building	During Dam Building	Post-Dam Building
Cattle	Number		
Oxen			
Sheep			
Goats			
Horse			
Other (specify)			

c) Use of livestock – use of each species of livestock per time unit.
(Guiding question: for what do communities use livestock, e.g. cultivation, transport, meat production, and is this changing from before the dam was built?)

Species	Pre-Dam Building	During Dam Building	Post-Dam Building
Cattle	Consumed/Cultural/Sold/Other		
Oxen			
Sheep			
Goats			
Horse			
Other (specify)			

3. Crop Production

10% of households in each community should be sampled.

a) Areas of crop production change – area in ha per time unit.
(Guiding question: are cropping areas changing location and/or size?)

Name of cropping area	Pre-Dam Building		During Dam Building		Post-Dam Building	
	GPS Co-ordinates	ha				

NB. Homestead fields to be included. If cropping area is not used, fill in N/A. Extend table to number of cropping areas.

b) Diversification of crop production – crops species and area per time unit.
(Guiding question: are more or different crops cultivated in the communities?)

Name of crop	Pre-Dam Building		During Dam Building		Post-Dam Building	
	Y/N	ha				

NB. Extend table to number of crops.

c) Output of crop production – yields in t/ha, and income and production cost in R/ha.
(Guiding question: are yields increasing and is production more profitable?)

For each crop use the cropping budget in Annex 4

4. Vegetable Production

10% of households in each community should be sampled.

a) Areas of vegetable production change – area in ha per time unit.
(Guiding question: are vegetable areas changing location and/or size?)

Name of vegetable area	Pre-Dam Building		During Dam Building		Post-Dam Building	
	GPS Co-ordinates	ha				

NB. Homestead fields to be included. If vegetable area is not used, fill in N/A. Extend table to number of vegetables areas.

b) Diversification of vegetable production – number and vegetables per time unit.
(Guiding question: are more or different vegetable produced in the communities?)

Name of vegetable	Pre-Dam Building		During Dam Building		Post-Dam Building	
	Y/N	ha				

NB. Extend table to number of vegetable.

c) Output of vegetable production – yields in t/ha, and income and production cost in R/ha.
(Guiding question: are yields increasing and is production more profitable?)

For each vegetable use the cropping budget in Annex 4

ANNEX 4: Example of a per hectare crop/vegetable budget

	PER HECTARE CROP/VEGETABLE BUDGET					
	UNIT	**QUANTITY**	**PRICE**	**PAID[1]**	**SUB-TOTAL**	**TOTAL**
			R/Unit	**Y/N**	**R/ha**	**R/ha**
		2014/15	**2014/15**	**2014/15**	**2014/15**	**2014/15**
INCOME	kg					
COSTS						
A. Technical Input						
Seeds	kg					
Fertilizer/Manure	l/kg					
Herbicide	l					
Bags	bags					
Transport	kg					
B.Physical Input/Labour[2]						
Crop						
Soil preparation	days					
Planting	days					
Top-dressing	days					
Application of herbicides	days					
Application of pesticides	days					
Irrigation	days					
Weeding - manual	labour days					
Harvesting	days					
C. Interest[2]						
D. Total Costs						
GROSS MARGIN						
TOTAL LABOUR DAYS	labour days					
RETURN TO LABOUR	per day					

[1] In case, for instance, when the household is part of a development intervention and receives input for free or it was bought on own account.

[2] Opportunity cost applicable for family labour or hired labour's salary

[3] Calculated at ?% total annual costs of technical input for ? month – in case inputs are bought on credit.