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DWAF Water Resource Study in Support of the ASGISA EC Mzimvubu Development Project

Agricultural Assessment and Irrigation Water Use

VOLUME 2 OF 5

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DWA WATER RESOURCE STUDY IN SUPPORT OF THE ASGISA-EC MZIMVUBU DEVELOPMENT PROJECT

LIST OF STUDY REPORTS

REPORT	DWA report number
Summary Report	P WMA 12/000/00/3609
Existing water supply infrastructure assessment	P WMA 12/000/00/3609 Volume 1 of 5
Agricultural assessment and irrigation water use	**P WMA 12/000/00/3609 Volume 2 of 5**
Groundwater assessment	P WMA 12/000/00/3609 Volume 3 of 5
Water resources assessment	P WMA 12/000/00/3609 Volume 4 of 5
Assessment of potential for pumped storage and hydropower schemes	P WMA 12/000/00/3609 Volume 5 of 5
Rainwater Harvesting	P WMA 12/000/00/3609
An assessment of rain-fed crop production potential in South Africa's neighboring countries	P RSA 000/00/12510

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Author:	*Dr RJ Rutherfoord*
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DWAF WATER RESOURCE STUDY IN SUPPORT OF THE ASGISA-EC MZIMVUBU DEVELOPMENT PROJECT

AGRICULTURAL ASSESSMENT AND IRRIGATION WATER USE

EXECUTIVE SUMMARY

Introduction

This report summarises the current agricultural activities in the Mzimvubu Development Zone and provides a desktop assessment of the potential for further agricultural development in the area. Although based on reliable information and sound development principles, it is intended as an overview report to provide general guidance on the main opportunities for development as well as to highlight potential limiting factors that would need to be addressed for successful and sustainable development to be implemented. Further and more detailed investigations will therefore be required before firm decisions on any specific development options can be taken.

The area covered includes the whole of the Mzimvubu River catchment together with the north-eastern section of the Wild Coast region from the Mzamba area (Bizana) in north Pondoland to the Mgazana and Mgazi River basins west of Port St Johns. Within the Mzimvubu River catchment the focus with respect to future potential was mainly on the less developed former Transkei region.

This report was done at the request of AsgiSA-EC and forms part of the preparatory phase work of a general nature by the DWAF, to assist the AsgiSA-EC initiatives. The conclusions reached and recommendations made are those of the PSP and do not represent any decisions by DWAF.

Natural resources

The topography of the study area is very varied, ranging from the Drakensberg Mountains in the west and through rolling hills, to the Indian Ocean which forms the eastern boundary. Steep slopes and deeply incised river valleys are characteristic of the area.

Most of the area has a mild temperate climate. The area experiences summer rainfall that ranges from 600 mm to 1 500 mm per year on average.

Based on the physiographic characteristics and rainfall patterns in the region, seven agro-ecological zones were identified for classification of the agricultural potential. These are: the Montane; Upper Plateau (dry); Upper Plateau (wet); Minor Escarpment; Central Plateau; Coastal Region; and Great River Valleys.

About 340 000 ha of arable soils is estimated to occur in the Mzimvubu River catchment, of which of the order of 100 000 to 130 000 ha consist of high and moderate potential irrigable soils. Nearly 100 000 ha soils of high agricultural potential occur in the coastal areas.

Socio-economic overview

The main socio-economic factor that differentiates the study area is land tenure and the associated forms of land use, population dynamics, infrastructure and economic activity. Whilst large-scale commercial farming and associated economic activity developed in the former KwaZulu-Natal and Eastern Cape areas, much less development occurred in the former Transkei. The focus of this report is therefore to broadly identify agricultural development opportunities in the latter area.

Agricultural enterprise capability

A broad screening of enterprises was made to assess their adaptability to the respective agro-ecological zones. The focus was on the most likely enterprises to be grown or established in the catchment, without resorting to exotic and untested options. The enterprises were categorized under: food crops; bio-fuel crops; fodder crops; orchard crops; and livestock, with several potentially viable enterprises identified in each category.

Present agricultural land use

The present land use is characterized by large commercial farming enterprises and substantial irrigation in the former KwaZulu-Natal and Eastern Cape areas. Maize, vegetables, and subtropical fruit and nuts are grown. Extensive livestock production also occurs, with large areas under pasture.

Mainly subsistence agriculture is practiced in the former Transkei area. Maize and sorghum are grown under rain-fed conditions, where low production rates are generally achieved. Fruit trees and small vegetable gardens are associated with homesteads. Livestock rearing is widely practiced, although not commercially based. Because of the communal land use environment, severe overgrazing and related soil erosion occurs. The resultant conservation status of this sector is therefore generally low.

Agriculture in the coastal areas includes sugar cane, tea, vegetables, subtropical fruit and nuts, maize and livestock.

Irrigation Development Potential

With the exception of the Coastal Zone and Great River Valleys, the climate in the other areas is not suitable for large, capital intensive irrigation schemes. However, the topography of the coastal zone and large river valleys is characterised by steep incised valleys with irrigable soils restricted mainly to "pockets" of alluvial soils along the rivers, where they are threatened by flooding. Large river regulation works and expensive infrastructure will be required to enable substantial irrigation development in these areas.

The land tenure system is recognised as one of the most significant constraints to agricultural development in the region. Without freehold title (or at least a long-term form of land tenure) it is very difficult for any commercial enterprise, especially with expensive irrigation equipment, to be established and developed in a sustainable way.

The lack of skilled, experienced and commercially orientated farmers is also a major constraint to irrigation development. Any sophisticated and/or large-scale irrigation scheme will therefore require on-going management support on several aspects, and it is imperative that more effective agricultural support services be established.

Opportunities also exist for the development of less capital intensive, small-scale, community-based irrigation projects.

Key success factors required for sustainable irrigation development are covered in more detail in the report.

Conclusions

Substantial potential exists in the study area for the development of new agricultural enterprises under rain-fed conditions and for the improvement of existing agricultural practices and productivity. Whilst opportunity exists for small irrigation scheme developments, there are several limiting factors with respect to large irrigation schemes.

The paucity of infrastructure in the area, in particular roads and power, is a major obstacle to any kind of development.

An initial focus on the upgrading of rain-fed cultivation and livestock farming can bring great gains at moderate investment. Land tenure and some institutional and social systems will, however, have to be addressed.

DWAF WATER RESOURCE STUDY IN SUPPORT OF THE ASGISA-EC MZIMVUBU DEVELOPMENT PROJECT

AGRICULTURAL ASSESSMENT AND IRRIGATION WATER USE

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APPENDICES

LIST OF ABBREVIATIONS

KZN KwaZulu-Natal Province.

MDZ Mzimvubu Development Zone.

SAPWAT Simulation model for crop water use and irrigation requirements.

WR90 Surface Water Resources of South Africa, Water Research Commission, 1990.

PTO "Permission To Occupy" land tenure certificate applicable in areas of South Africa where communal land tenure applies.

SWOT An analysis of the Strengths, Weaknesses, Opportunities and Threats of any subject under study.

FAO Food and Agriculture Organisation of the United Nations

SECTION A: MZIMVUBU RIVER CATCHMENT

1 INTRODUCTION

The Mzimvubu River Basin discharges into the Indian Ocean and is bounded in the south by the Mthatha and Mbashe River catchments, in the west by the Orange River basin, in the north-east by the Mzimkhulu and Mtamvuna River catchments and in the east by the Pondoland Coastal catchments. Although the basin shares an international border with Lesotho, there are no shared rivers between them. This well-watered and relatively undeveloped catchment is 20 000 km^2 in extent.

The assessment of agriculture in the catchment and the estimation of present and future irrigation water use have the following specific objectives:

- Review present agricultural activities in the catchment,
- Estimate present irrigation water use,
- Assess the agricultural potential of defined agro-ecological zones within the catchment,
- Describe agricultural development opportunities within each zone,
- Recommend selected development opportunities that should receive further investigation and planning and recommend specific strategies to further the development of agriculture in the catchment.

When addressing agricultural development opportunities and recommendations in this report, only Sector 2 (“the old Transkei”) has been considered. However, this does not preclude significant development opportunities in Sector 1 (the area within the boundaries of KwaZulu-Natal (KZN) prior to 1994 and the Ugie/Maclear region which fell into the pre-1994 Eastern Cape boundary).

It was agreed that in addition to the Mzimvubu River catchment itself, the study area would be extended to include the Pondoland coastal region and the southern portion of the Mngazana and Mgazi river basins west of Port St Johns. This bigger study area is referred to as the Mzimvubu Development Zone (MDZ) and is reflected in **Figure 1.1**. This aspect of the study is been presented in **Section B** of this report.

This report was done at the request of AsgiSA-EC and forms part of the preparatory phase work of a general nature by the DWAF, to assist the AsgiSA-EC initiatives. The conclusions reached and recommendations made are those of the PSP and do not represent any decisions by DWAF.

2 THE NATURAL ENVIRONMENT

2.1 PHYSIOGRAPHY

The topography of the Mzimvubu River catchment is very varied, ranging from the Drakensberg mountains, which reach an altitude of 2 950 m and form the northern and north-western boundaries, to the Indian Ocean which forms the eastern boundary. The

Mzimvubu River and its four main tributaries, the Tsitsa, Tina, Kinira and Mzintlava rivers all have their headwaters in these mountains. After descending through the escarpment these tributaries and the Mzimvubu River itself flow through deep river valleys incised into the coastal belt, before discharging into the Indian Ocean at Port St Johns.

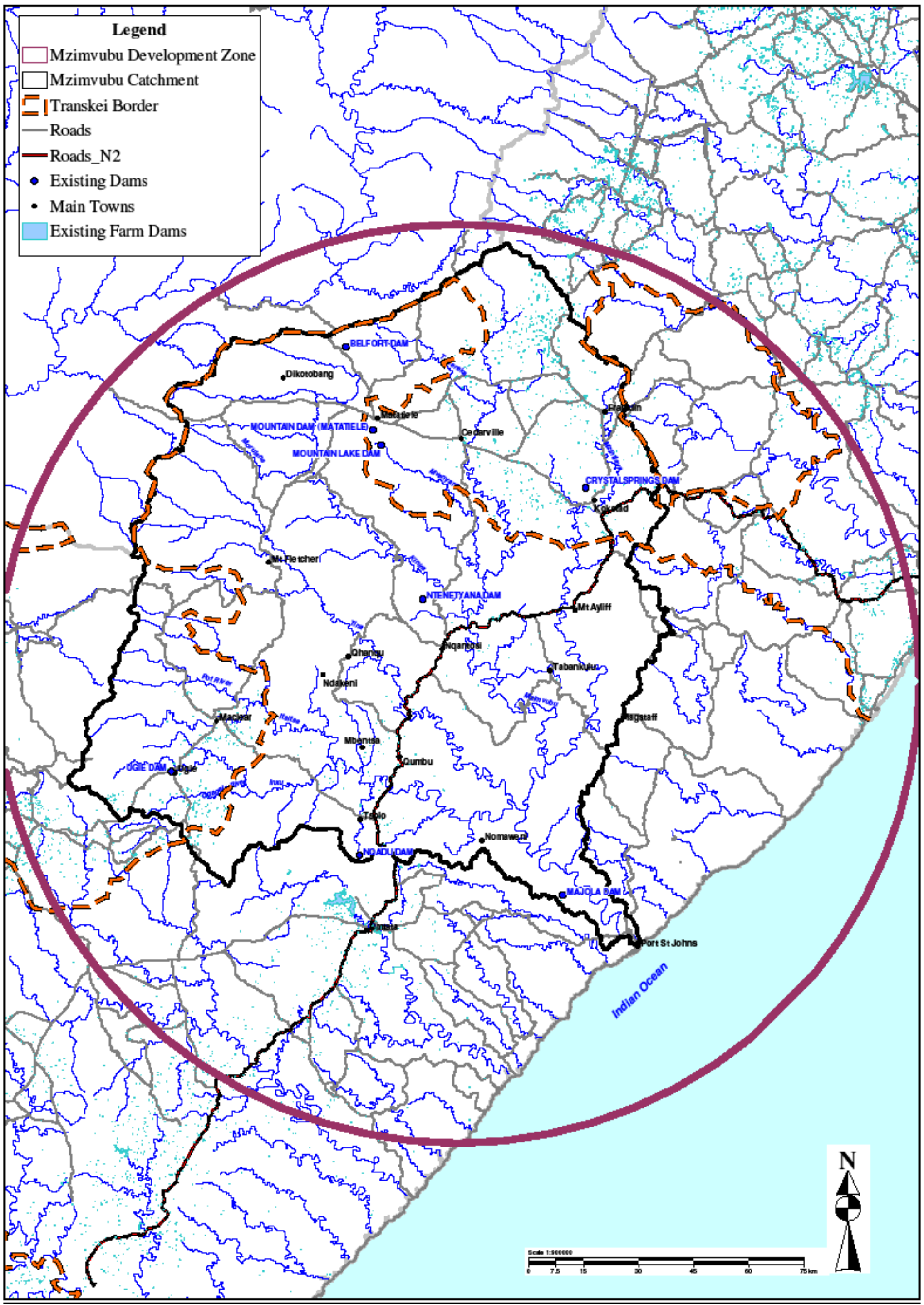


Figure 1.1 Mzimvubu Development Project study area

The catchment can be divided into six main physiographic zones (Hawkins, 1980) as follows:

- The Drakensberg mountain range which forms the northern and north-western boundaries of the Basin.
- The adjoining high plateau of rolling country at altitudes of between 1 300 m and 1 800 m.
- The minor escarpment which separates the high plateau from the central plateau and which consists of steep and broken country at altitudes of between 1 200 m and 1 700m.
- The central plateau of rolling country at altitudes of between 700 m and 1 200 m.
- The coastal belt, consisting generally of steep and broken country that extends approximately 30 km inland from the sea and rises to an altitude of approximately 700 m.

The great river valleys, which are deep and steep sided, flow across the central plateau.

2.2 CLIMATE

The climate and temperature variations of the Mzimvubu River Basin are closely related to elevation and proximity to the coast. The basin has a mild temperate climate along the coast to more extreme conditions inland with most rainfall occurring during the summer months.

2.2.1 Rainfall

Mean annual rainfall in the Basin varies considerably over short distances, because of the broken topography, from a minimum of 600 mm to a maximum of 1 500 mm. It is generally above 800 mm with the areas of lower rainfall being confined to the deep river valleys and a few isolated rain shadow areas. **Figure 2.1** illustrates the variability of mean annual rainfall within the catchment.

The catchment, as a whole, experiences summer rainfall. However, the peak rainfall period varies significantly within the catchment. The montane and upper plateau regions fall into the “mid-summer” period with rainfall peaking in January. The minor escarpment areas and central plateau fall into the “late summer” period with rainfall peaking in February. The coastal region and the lower reaches of the main river valleys fall into the “mid-to-late” period with rainfall peaking in January-February.

Table 2.1 gives the rainfall characteristics in terms of mean annual rainfall, rainfall seasonality, and rainfall concentration, for the seven agro-ecological zones, as defined for the purposes of this study in Chapter 2.3.

Rainfall seasonality (Schultze, 1997) is an important agro-hydrological consideration which determines the months of the year in which rainfall occurs predominantly. Rainfall concentration, on the other hand, describes the extent to which rainfall is concentrated over a short period of the year or spread over a longer period of time. The rainfall concentration index is expressed as a percentage in terms of which a concentration index of 100% would imply that all a location's rainfall falls in one month, whereas a concentration index of 0% would mean that the rainfall of each month of the year would be the same. The higher the concentration index the more concentrated the rainfall season will be irrespective of the quantity of rainfall.

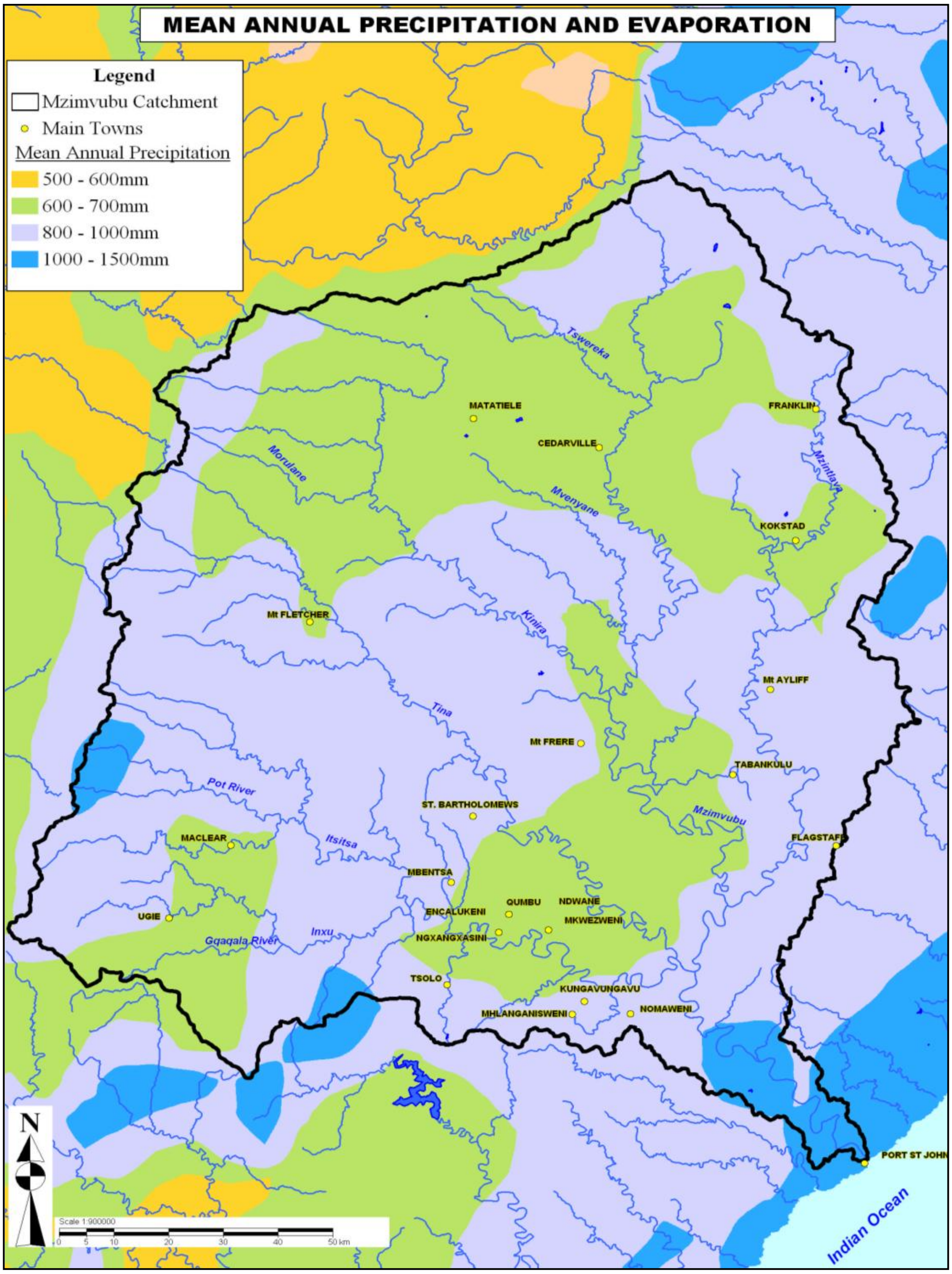


Figure 2.1 Mean annual precipitation in the Mzimvubu River catchment

Table 2.1 Rainfall characteristics of the defined agro-ecological zones

Agro-ecological zones Zone		Altitude (m.a.s.l)	Mean rainfall (mm)	Rainfall seasonality	Rainfall concentration (%)
1	Montane	>1 800	1 000 - 1 500	Mid-summer (Jan)	50 - 60
2a (dry)	Upper Plateau (dry)	1 300 - 1 800	700 - 800	Mid-summer (Jan)	50 - 60
2b (wet)	Upper Plateau (wet)	1 300 - 1 800	800 - 1 000	Mid-summer (Jan)	50 - 60
3 and 4	Minor escarpment	1 200 - 1 800	700 - 900	Late summer (Feb)	45 - 50
	Central Plateau	700 - 1 200		Late summer (Feb)	
5	Coastal	0 - 700	1 000 - 1 200	Mid to late summer (Jan to Feb)	30 - 45
6	Great River Valleys	0 - 700	700 - 800	Mid to late summer (Jan to Feb)	40 - 50

2.2.2 Temperature

The temperature patterns in the catchment are also largely influenced by altitude (**Table 2.2**). The high-lying montane and upper plateau regions experience frost in winter with mean daily minimum temperatures ranging from -2 ºC to 4 ºC in July.

Mean daily maximum temperatures in January range from 20 ºC to 24 ºC. The minor escarpment and central plateau regions also experience frost in winter but are generally warmer than the higher lying areas with mean daily minimum temperatures of between 2 ºC to 6 ºC in July and mean daily maximum temperatures between 24 ºC and 26 ºC in January.

The lower reaches of the main river valleys and the costal region experience warm, frost-free conditions with mean daily minimum July temperatures between 8 ºC and 10 ºC (>10 ºC in the coastal region) and mean daily maximum January temperatures of between 26 ºC and 28 ºC.

Table 2.2 Temperature characteristics of the defined physiographic zones

Zone	Altitude (m.a.s.l)	January		July	
		Mean daily Max (ºC)	Mean daily Min (ºC)	Mean daily Max (ºC)	Mean daily Min (ºC)
1	>1 800	20 to 22	10 to 12	14 to 16	-2 to 2
2 (a&b)	1 300 to 1 800	22 to 24	12 to 14	16 to 18	0 to 4
3	1 200 to 1 800	24 to 26	14 to 16	18 to 20	2 to 6
4	700 to 1 200	24 to 26	14 to 18	18 to 20	4 to 8
5	0 to 700	26 to 28	18 to 20	20 to 22	>10
6	100 to 700	26 to 28	18 to 20	20 to 22	8 to 10

2.2.3 Evaporation

Evaporation increases from the east to the west and from the coast to the interior. Gross mean annual Simon's Pan evaporation increases from about 1 100 mm along the coast to 1 400 mm in the west.

2.3 AGRO-ECOLOGICAL CLASSIFICATION

Hawkins Associates (1980) determined agro-ecological units for the catchment by selecting rainfall as the over-riding control and delineating sub-units according to temperature regime and relief.

For the purposes of this study the above system was modified to produce seven agro-ecological zones. These zones have been based mainly on the physiographic characteristics and rainfall patterns of the catchment. The zones (**Figure 2.2**) are:

(1) Montane – at an altitude above 1 800 m and a mean annual rainfall between 1 000 and 1 500 mm;

(2a) Upper Plateau (dry) – at an altitude between 1 300 and 1 800 m and a mean annual rainfall between 700 and 800 mm;

(2b) Upper Plateau (wet) - at an altitude between 1 300 and 1 800 m and a mean annual rainfall between 800 and 1 000 mm;

(3) Minor Escarpment – at an altitude between 1 200 and 1 800 m and a mean annual rainfall between 700 and 900 mm

(4) Central Plateau - at an altitude between 700 and 1 200 m and a mean annual rainfall between 800 and 1 000 mm;

(5) Coastal Region - at an altitude between 0 and 700 m and a mean annual rainfall between 1 000 and 1 200 mm; and

(6) Great River Valleys - at an altitude between 0 and 700 m and a mean annual rainfall between 700 and 800 mm.

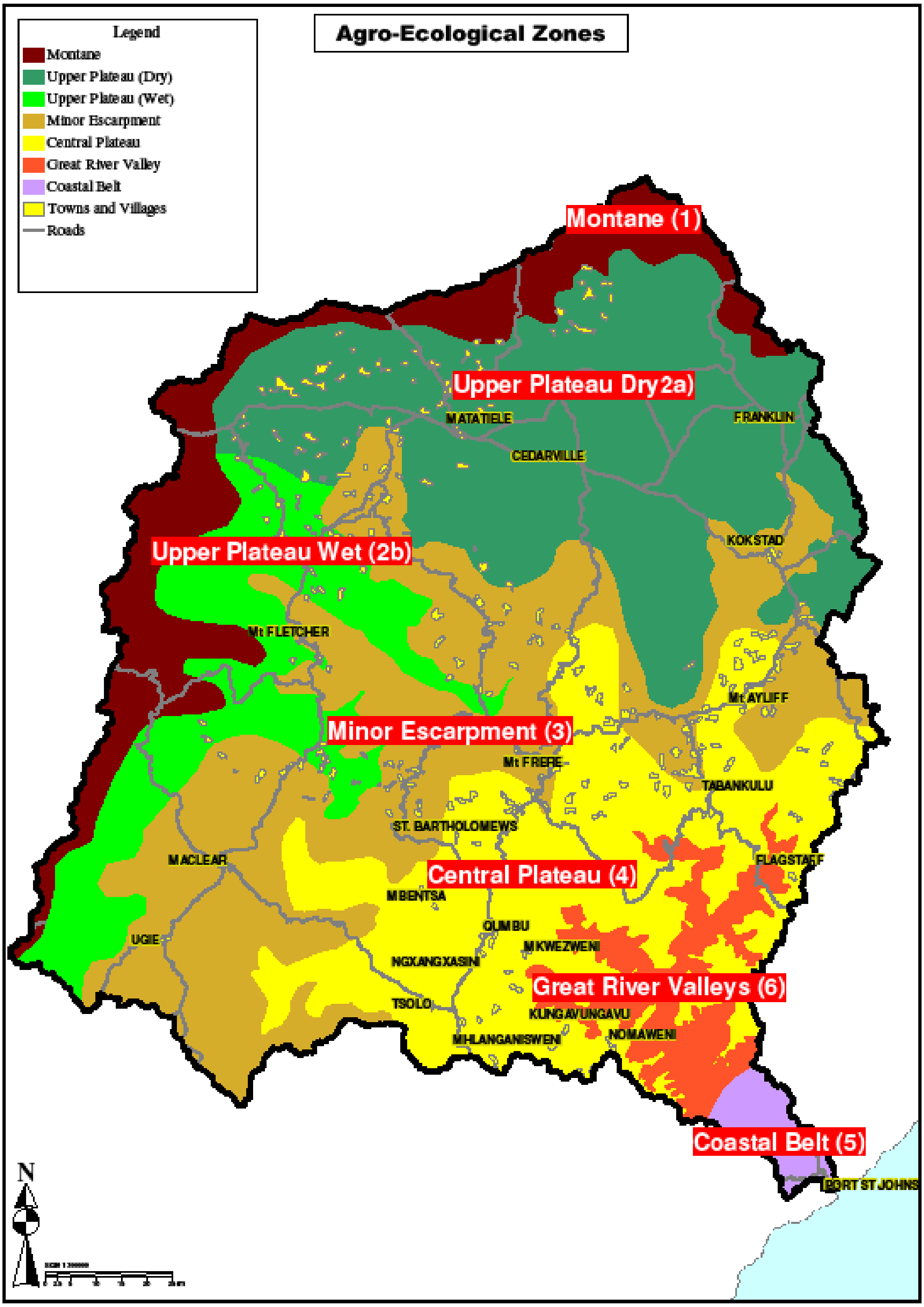


Figure 2.2 Defined agro-ecological zones

2.4 GEOLOGY, SOILS AND LAND USE POTENTIAL

The predominant rock formations in the Mzimvubu River Basin consist of mudstone, sandstone and shale of the Karoo Sequence with some localized intrusions of dolerite dykes and sills. Basaltic lavas of the Drakensberg Formation occur in the upper parts of the basin and small patches of Dwyka tillite occur in the lower part of the basin.

Two broad soil patterns dominate the landscape of the basin namely, red-yellow apedal freely drained soils and shallow and litholic soils. Most of the soils of this second group are prone to erosion due to their dispersive nature.

Land-type mapping at a scale of 1:250 000, that is available from the Institute of Soil, Climate and Water, formed the basis of the arable and irrigation potential of the soils in the study area and has been assessed as described in the following paragraphs.

2.4.1 "Land capability" approach

Scotney, et al (1987) assessed the land-use potential by means of a land capability classification system which uses the soil and slope parameters obtained from the land-type mapping. It has been estimated that a gross area of about 340 900 ha (17%) of the area of the catchment consists of arable soils. The remaining area is either non-arable or unsuitable for agriculture, making up 68% and 15% of the area of the basin respectively. These areas include land such as natural forest and riparian zones.

The main physical features of these arable soils are a dominant slope of less than 12%, an effective depth of greater than 450 mm, ploughing is possible, the clay content is between 5 and 50%, and where seasonal wetness does occur it is only for short periods.

The gross area of irrigable soils, with a high to moderate potential, that was estimated using the "Land capability" approach, is about 170 300 ha (8%).

At this level of investigation, the likely net area of irrigable soils would be in the order of 60% of the above gross area, before consideration of other factors such as water availability, socio-economic factors and likely overlap with other potential land uses. The net area of high and moderate potential irrigable soils, is thus about 102 000 ha.

The distribution of soils with arable and irrigation potential, using this approach, is not shown graphically in this report as the areas are extremely broad.

2.4.2 "Soil association" approach

Another useful basis for the assessment of arable (and irrigation) potential is the "Soil Association" approach. The soils of the Mzimvubu Catchment have been mapped in terms of Soil Associations at a reconnaissance level (Republic of Transkei, 1990) which, in turn, were derived from the agro-ecological regions compiled by Hawkins Associates (1980) and the South African Binomial Soil Classification System (MacVicar *et al*, 1977). The detailed map of soil associations from this report (which includes an estimate of arable and irrigable soil areas (ha) for each association polygon) provides the opportunity to illustrate their spatial distribution over the catchment.

The assessment of irrigation potential is based on the depth, texture and uniformity of the profile morphology. The ideal irrigation soil is deep, of medium texture, with good internal drainage and sloping sufficiently to allow the free drainage of surface and sub-surface water. A minimum soil depth of 800 mm, slopes not steeper than 8% and soil texture ratings higher than "marginal" for irrigation were the criteria used in this analysis.

The estimated gross area of arable soils in the catchment, using this approach, is 346 000 ha (17.3%). The net area (ha) of irrigable soils per agro-ecological zone within the study area is shown in **Table 2.3**.

Table 2.3 Irrigable soils per agro-ecological zone based on soil associations

Zone	Irrigable soils (ha)	
	Gross area (ha)	Net area (60%) (ha)
2a	49 914	30 000
2b	23 092	14 000
3	66 052	40 000
4	59 177	35 000
5	2 968	1 500
6	13 205	8 000
Total	**214 408**	**128 500**

The net area of irrigable soils, with a high to moderate potential, that was estimated using the "Soil Association" approach, is about 128 500 ha (also assuming 60% of gross area).

Figure 2.3 shows the spatial distribution of these irrigable soils (% total area) per quaternary catchment within the study area.

2.5 VEGETATION

The natural veld in the Mzimvubu River Basin varies between lush coastal tropical forest type near the coast and along the watersheds up to about 60 km from the coast, false grassland and karoo types in the deeper river valleys, temperate and transitional forest and scrub type further than 50 km away from the coast and areas of pure grassland type in the west and northwest further than about 120 km from the coast.

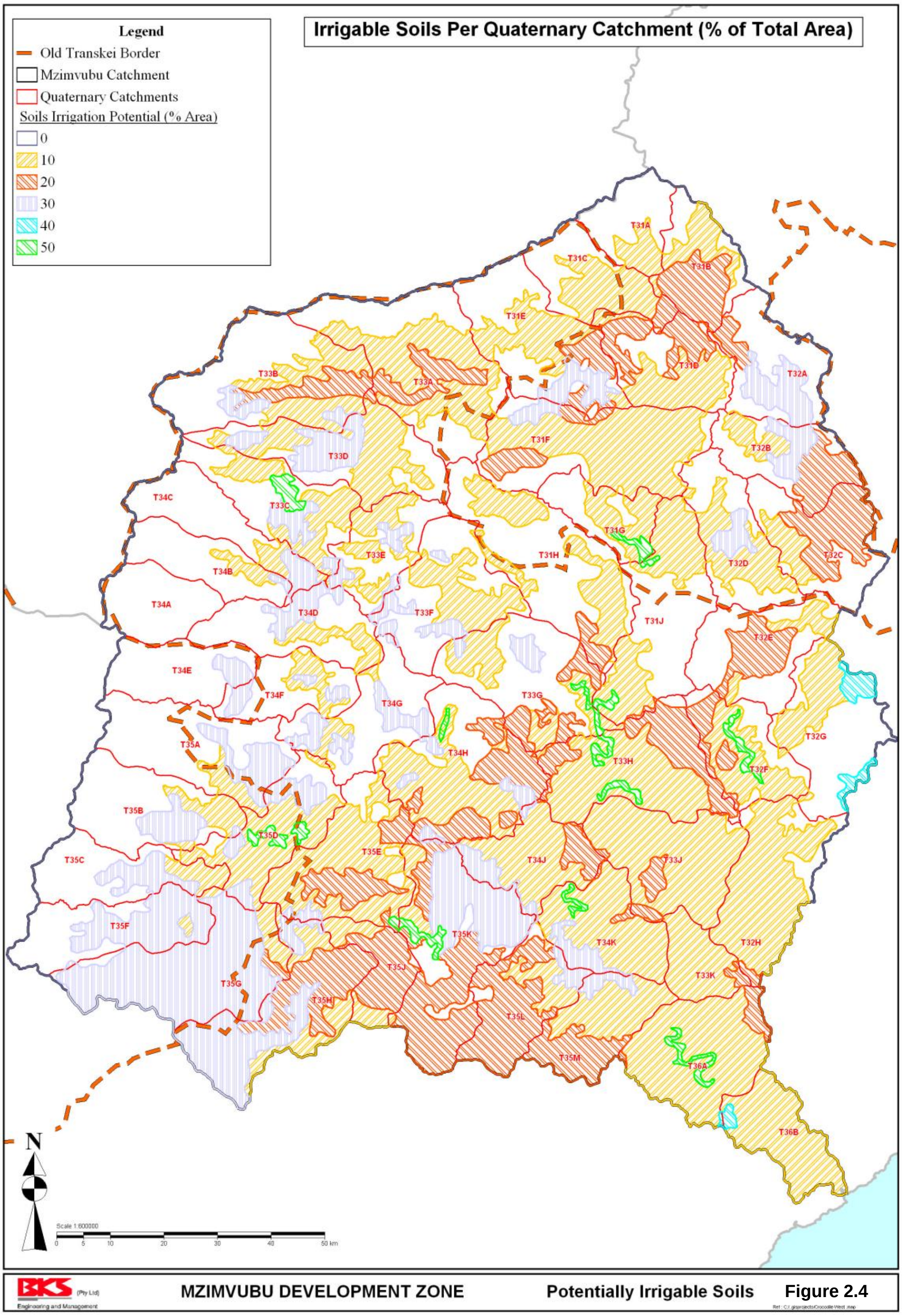


Figure 2.3 Potentially irrigable soils per quaternary catchment

3 SOCIO-ECONOMIC OVERVIEW

The main socio-economic factor that differentiates the catchment is land tenure. Land tenure differences and the associated forms of land-use, population dynamics, infrastructure and economic activity divide the catchment into two broad categories or sectors.

3.1 SECTOR 1

Sector 1 consists of the area within the boundaries of KwaZulu-Natal (KZN) prior to 1994 and the Ugie/Maclear region which fell into the pre-1994 Eastern Cape boundary where mainly freehold land tenure and associated commercial farming occurs. This area is characterized by:

- large-scale commercial farming that is mostly livestock based,
- commercial forestry
- a few country towns that support the farming communities.
- well-developed infrastructure in terms of roads, power supply, services and communications,
- a relatively low human population except in the town of Kokstad which is a busy regional centre.
- a satisfactory conservation status with good farming practices ensuring very few signs of overgrazing and soil erosion.

3.2 SECTOR 2

Sector 2 consists of the remainder of EC component of the catchment which fell into the pre-1994 Transkei and is characterized by:

- state-owned land that is mostly administered through the Tribal land tenure system.
- widespread rural villages in which most homesteads have a piece of land allocated to subsistence agriculture (750 – 1 200 m^2) and mostly planted to maize),
- consolidated rain-fed farming areas made up of many plots (1-3 ha in extent) “owned” by individuals or families under the “permission to occupy”, quitrent or leasehold tenure systems administered by the local Tribal Authority. These lands are usually situated adjacent to the villages whose residents cultivate the plots, although in many cases the distances to walk are considerable and arduous, large areas of communal grazing land which has manifested itself into severe overgrazing and related soil erosion. The conservation status of this sector is generally very low.

The two Sectors are shown in **Figure 3.1** in terms of the main differences in land tenure (communal land tenure and free-hold tenure).

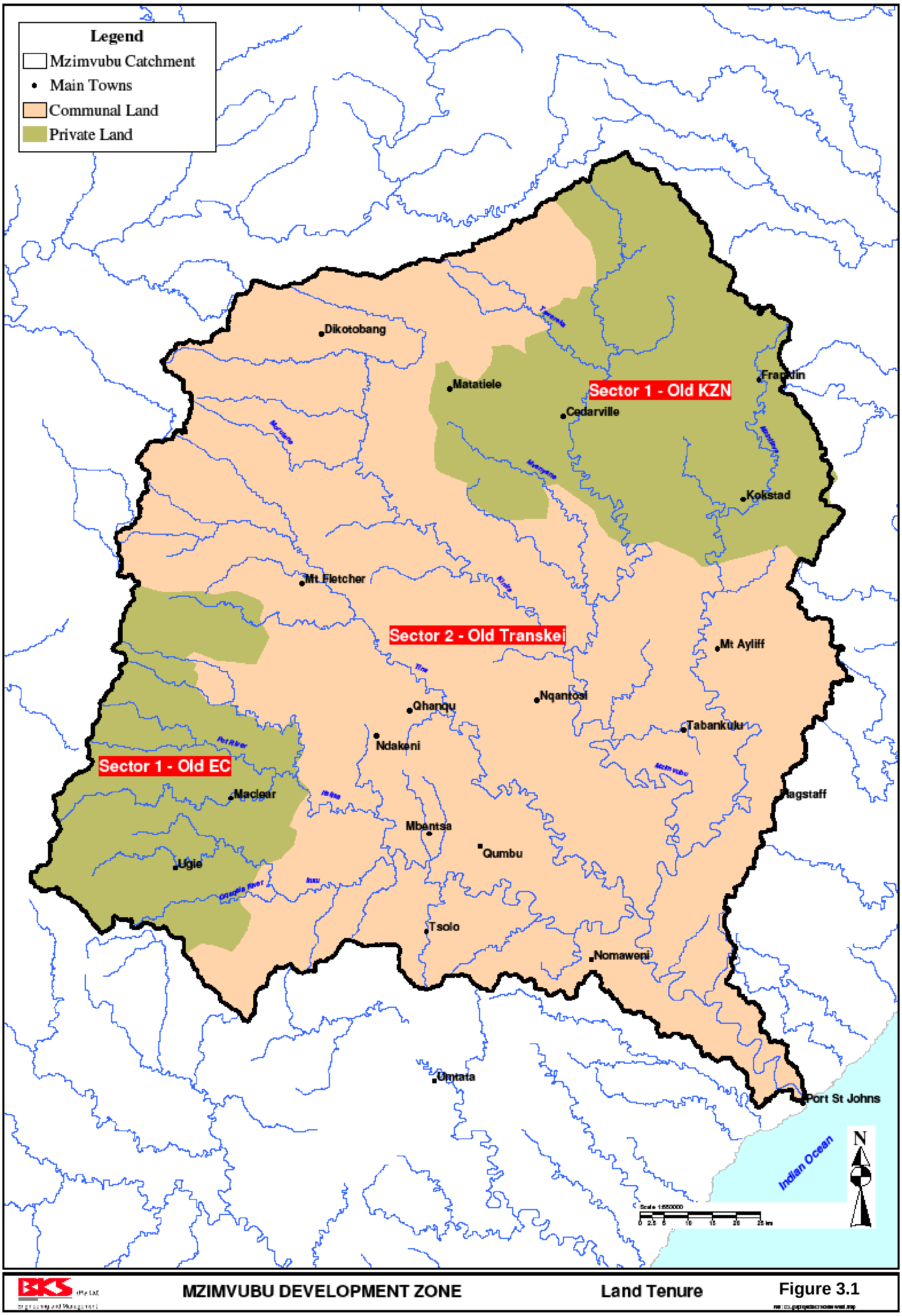


Figure 3.1 Land tenure (communal free-hold)

4 AGRICULTURAL ENTERPRISE ADAPTABILITY

Assessment of the adaptability of enterprises has been based on a number of criteria including:

- Ehler's classification system which categorises plants into climatic zones (Ehlers, JH, 1974);
- biological indicator species in the selected zones;
- present agricultural practices and; and
- interpolation from other areas with similar climatic and edaphic conditions.

Table 4.1 and **Table 4.2** list the main enterprises adapted to the six agro-ecological zones into categories of food crops, bio-fuel, fodder crops, and livestock enterprises. There are many more agricultural enterprises which are adapted to these areas (the Montane zone not being suitable for intensive agriculture). However the focus in this report is on the most likely enterprises to be grown or established in the catchment without resorting to more obscure and untested enterprises.

Table 4.1 Agricultural enterprise adaptability: Zones 2a, 2b, 3 and 4 (Upper plateau, Minor escarpment and Central plateau)

Food crops	Bio-fuel crops	Fodder crops	Livestock
Maize	Soybean	Ryegrass (annual)	Beef
Potato (summer)	Canola	Ryegrass (perennial)	Dairy
Dry bean	Sunflower	Kikuyu	Sheep
Soybean		Clovers	
Sunflower		Jap Radish	
Cabbage		Eragrostis curvula	
Cape Gooseberry			
Vegetables (summer)			

Table 4.2 Agricultural enterprise adaptability: Zone 5 (Coastal Region)

Food crops	Orchard crops	Livestock
Maize	Citrus (Valencia + easy peelers)	Beef
Potato (winter)	Banana	Sheep
Dry beans	Litchi	Goats
Vegetables (winter)	Mango	
	Macadamia	
	Granadilla	

Table 4.3 Agricultural enterprise adaptability: Zone 6 (Greater River Valleys)

Food crops	Orchard crops	Livestock
Maize	Citrus (Valencia + easy peelers)	Beef
Potato (winter)		Sheep
Dry beans		Goats
Vegetables (winter)		

5 PRESENT AGRICULTURAL LAND USE

5.1 PRESENT LAND USE OVERVIEW

A summary of overall land use in the catchment (including forestry, rangelands, rain-fed cropping, irrigation and residential - including homestead agriculture) is presented in **Table 5.1**. Information was derived from various sources including an analysis of satellite imagery, previous studies on the catchment, communication with government officials, institutions and land owners and extensive coverage of the study area on field visits.

Table 5.1 Present land use summary

Enterprise	Present land-use	
	%	(ha)
Forestry	1.5	30 000
Livestock grazing	90.7	1 813 000
Rainfed cropping	5.5	110 000
Irrigation	0.5	11 000
Residential (urban & rural)	1.5	30 000
Other	0.3	6 000
TOTAL	**100.0**	**2 000 000**
		(20 000 km^2)

Note: Residential areas include village commonage and homestead gardens

5.2 PRESENT IRRIGATION

Irrigated agriculture occurs mainly in Sector 1 and is associated with commercial farming enterprises and is largely linked to fodder and feed production for the livestock (mainly dairy) industry. The estimated present irrigation areas and cropping patterns in the Mzimvubu River catchment per zone is summarised in **Table 5.2**. This area of irrigation is significantly higher than previous estimates (Department of Water Affairs and Forestry, 2005; Republic of Transkei, 1990). This is due mainly to gradual expansion of irrigation in Sector 1 over the last 15-20 years.

5.2.1 KwaZulu-Natal (old) component of Sector 1

There are about 6 500 ha of irrigation in the area north and north-east of Kokstad around Cedarville, Swartberg, Franklin and Matatiele (**Figure 5.1**). Irrigation in this area falls within the agro-ecological Zone 2a and is almost exclusively linked to livestock production (both dairy and beef). The main pastures grown under irrigation (Table 4.1) include winter ryegrass, perennial ryegrass, Japanese radish and maize which is grown for both silage and grain. Maize is sold as grain if prices are attractive. A small amount of vegetable production takes place between Kokstad and Swartberg.

Table 5.2 Estimated present irrigation areas and cropping patterns per zone

Zone	Production centre	Irrigated area (ha)	Crops
2a	Kokstad / Franklin / Cedarville / Swartburg	6 553	Winter pasture (60%) Maize (20%) Permanent pasture (15%) Vegetables (5%)
3	Ugie / Maclear	3 418	Potato (25%) Winter pasture (40%) Maize (20%) Permanent pasture (15%)
4	Matatiele / Mt Frere	788	Maize (50%) Vegetables (50%)
5	Port St Johns	100	Sub-tropical fruit and nuts (60%) Vegetables (40%)
	Total	**10 859**	

The most widely used form of irrigation is the centre pivot which makes up about 80% of irrigation systems in the area. Other systems include pressure-driven "linear" systems, dragline sprinklers and portable pipe sprinklers. Supplementary irrigation is practiced during the summer months while winter pastures are usually dependent on irrigation after March. The standard of irrigation and general farming practices is high.

Irrigation water is sourced mainly from farm dams, which are extremely widespread in the area, groundwater sources and in some instances from direct river extraction. No irrigation schemes with managed water releases occur in the area.

Figure 5.1 Commercial irrigation between Cedarville and Matatiele in the old KwaZulu-Natal component of Sector 1

5.2.2 Old Eastern Cape (Ugie/Maclear) component of Sector 1

There is about 3 400 ha of irrigation in the Ugie/Maclear area. Irrigation in this area falls within agro-ecological Zone 3 and is linked to livestock production (both dairy and beef), potato and maize grain production (**Figure 5.2**). The main pastures and fodder crops grown under irrigation (Table 4.1) include winter ryegrass, perennial ryegrass and Japanese radish. Maize is grown for both silage and grain. Maize is sold as grain if prices are attractive. The high altitude and isolated nature of this area makes it highly suitable for potato production.

Figure 5.2 Commercial irrigation in the Ugie/Maclear region of Sector 1

The standard of irrigation and general farming practices is high.

Irrigation water is sourced mainly from farm dams and in some instances from direct river extraction. No irrigation schemes with managed water releases occur in the area.

With the relatively high, though variable rainfall, most irrigation is of a supplementary nature with actual quantities applied per season varying substantially from year to year.

5.2.3 Sector 2

Small areas of irrigation occur in Sector 2. They occur mainly in agro-ecological zones 2a, 3, and 4 (**Figure 5.3**). These are mainly community schemes with groups of participants who extract water directly from streams and rivers. The main crops grown are maize and vegetables for home consumption and local sales. Irrigation systems are conventional pipe and dragline sprinkler systems.

Figure 5.3 Typical small-scale irrigation in agro-ecological zones 2a, 3 and 4.

A significant number of homesteads (possibly 15%) have some form of off-roof rainwater storage system. However, very few are exploiting the opportunities of vegetable production using “harvested” rainwater. The rainwater harvesting programme that is being initiated in parallel with this study is seen as an affordable, manageable and sustainable form of food production in an area that is exposed to high levels of poverty and malnutrition.

In the Port St Johns area of zone 5, there are about 175 ha of active irrigation on the alluvial plain along the lower reaches of the Mzimvubu River (**Figure 5.4**). This frost-free area, which falls within agro-ecological zone 5, displays distinct sub-tropical growing conditions. Some 73 state-owned farms of about 5 ha each are presently leased out to farmers. However, only about 20 of these are currently being utilized effectively. The lack of full freehold title (or even long lease-hold title) on these farms is a disincentive to capital investment and as a result the current levels of production are low and returns are marginal. The most effective production is on a few farms where about 50 ha of cabbage and other vegetables are being grown. The farms with fruit and nut crops make up about 60 ha and have crops such as pecan nut, citrus (oranges), mango and avocado. The potential for significant expansion of this production area is high, provided the attempts presently underway to dispose of these farms with freehold title are successful.

Figure 5.4 Commercial irrigation in the Port St Johns area of Sector 2

5.3 PRESENT RAIN-FED AGRICULTURE

5.3.1 Sector 1

The commercial rain-fed agriculture of Sector 1 is largely focused on extensive livestock production on veld, supported by fodder crops and pastures grown under irrigation. Beef rearing is widespread in this sector. Maize grain is the main crop under rain-fed conditions, a small proportion of which is supplementary irrigated in dry years.

5.3.2 Sector 2

Rain-fed agriculture in Sector 2 has three dominant components.

(a) Firstly, most homesteads, in the widespread rural villages, include a piece of land allocated to subsistence agriculture (400 – 900 m^2) which is mostly planted to maize and some sorghum. At present these homestead plots are the most productive forms of rain-fed agriculture in the catchment and play a critical role in contributing to food security in the region. Fruit trees and small vegetable gardens are often associated with homesteads.

(b) Secondly, consolidated rain-fed farming areas made up of many plots (1-3 ha in extent) are situated as close as possible to villages. Individual plots within these consolidated areas are “owned”, by individuals or families from the adjacent villages, under the “permission to occupy” land tenure system and administered by the local Tribal Authority. Although these lands are situated as close as possible to the villages, in many cases the distances to walk are considerable and arduous. Maize is the dominant crop with sorghum and millet grown in small quantities. Intercropping with pumpkin, marrow and melons is common practice.

(c) A fundamental aspect of land use in this Sector is livestock rearing on communal grazing land. Cattle, sheep and goats are commonly found in all areas of this Sector. Conventional veld and soil conservation practices are extremely difficult to apply in a communal land-use environment and consequently this form of land use has manifested itself into severe overgrazing and related soil erosion. The conservation status of this sector is therefore generally very low. Because the livestock rearing is not commercially based, there is limited direct financial benefit to the livestock owners. The benefits are more related to the social and cultural structure of the communities including ceremonial activities and subsistence.

6 PRESENT IRRIGATION WATER USE ESTIMATES

6.1 CROP WATER REQUIREMENTS

In general, the crop water requirement calculations were made using the SAPWAT computer planning model. SAPWAT is a computer model for the estimation of crop water requirements and irrigation requirements for a wide range of commercial crops grown in a wide range of climatic conditions. The model is based on the universally recognized "Penman-Monteith" method of estimating reference evapotranspiration (ETo) and the FAO method of linking reference evapotranspiration to any given crop by way of a crop factor (kc) and a series of efficiency factors including irrigation method and effective rainfall. Where necessary, however, and as recommended by the model designers, supplementary information was imported, especially where the coverage contained within SAPWAT was limited. Rainfall data was utilised from WR90, SAPWAT and the Daily Rainfall Extraction Utility.

Three principal climatic data-bases were used (from SAPWAT), namely Mthatha, Kokstad and Ugie. These places all provided complete data in respect of the Reference Evapotranspiration calculation requirements.

All other stations had only rainfall and altitude data available together with latitudinal position. The use of supplementary rainfall data for a particular zone is shown individually on the bottom of the crop water requirement tables (see Appendix A).

Table 6.1 shows the location, altitude and MAP of several stations in and adjacent to the catchment, and indicates that Physiographic Zone 2a is well represented by Kokstad, Zone 3 by Ugie and Zone 6 by Mthatha. The latter lies outside the Mzimvubu catchment, but has similar characteristics in respect of altitude and MAP to much of Zone 6. Mthatha was also chosen to represent Zone 4, but with rainfall from Qumbu, which is located well within the zone.

For the coastal zone, (Zone 5) data for Sezela and Kei Mouth was used, with appropriate interpolation. These two sites gave evapotranspiration data with reasonably similar configuration and were equally spaced, at 180 km each from Port St Johns. It was considered that taking an average of these two coastal sites would give a good approximation for Port St Johns in respect of reference evapotranspiration (which employs monthly maximum and minimum temperatures, average monthly humidity, sunshine hours, wind speed and latitudinal position).

Zone 2b has not been included as no data for any site within that area was available.

Table 6.1 Location, altitude, longitude, latitude, MAP and the designated agro-ecological zone of several stations in and adjacent to the catchment

SITE	LATITUDE	LONGITUDE	ALTITUDE	M.A.P	ZONE
Qacha's Nek	30 07 32	28 42 07	2100	859	1
ElandsHeight	30 48 01	28 14 23	1930	819	1
Franklin	30 19 21	29 27 32	1542	549	2a
Matatiele	30 20 50	28 49 06	1530	670	2a
Cederville	30 23 24	29 03 10	1520	708	2a
Mt Fletcher	30 41 30	28 30 53	1460	687	3
Kokstad	30 33 12	29 25 35	1300	728	3
Ugie	31 11 44	28 13 58	1300	927	3
Maclear	31 04 32	28 21 26	1289	724	3
Tabankulu	30 57 49	29 18 18	1128	654	4
Mt Frere	30 52 07	29 00 35	1095	751	4
Mt Ayliff	30 48 35	29 22 25	1070	649	4
Tsolo	31 18 38	28 45 35	900	554	4
Bizana	30 51 40	29 51 26	880	755	4
Flagstaff	31 04 45	29 30 12	860	858	4
Umtata	31 35 09	28 47 28	700	654	4
Lusikisiki	31 22 06	29 34 57	550	1024	5
Port st Johns	31 37 28	29 32 39	10	1153	5
Holy Cross Mission	31 09 00	29 40 00	660	965	6

The crop growing periods are typical of the areas, but can be adjusted to accommodate practical crop rotations.

The irrigation requirement per crop for each zone is recorded in Appendix A as m^3/ha/annum. These figures multiplied by the estimated areas (ha) will give the total irrigation requirements. Further to this, conveyance efficiencies should be added - when subsequent design phases are undertaken.

The suite of spreadsheets compiled for the calculation of crop irrigation requirements is given in **Appendix A**.

A summary of the estimated irrigation requirements of the main existing or recommended crops for each of the agro-ecological zones is given in **Table 6.2**.

Table 6.2 Crop irrigation requirements summary (figures in m^3/ha/a)

Crop	Zone					Inter-zonal average
	2a	3	4	5	6	
Maize	2 904	3 012	3 764	2 682	3 791	3 230
Potato (summer)	3 312	3 356	3 974			3 548
Potato (winter)				2 632	2 684	2 658
Soybean	2 884	2 957	3 715			3 185
Cabbage	1 483	1 950	1 721	1 681		1 709
Vegetables (summer)	3 095	3 117	3 928			3 380
Vegetables (winter)				3 257	3 445	3 351
Annual ryegrass	6 390	7 250	7 389			7 010
Perennial ryegrass	6 000	6 579	7 247			6 609
Citrus				5 595	7 326	6 461
Banana				6 826		6 826
Mango				5 464		5 464
Macadamia				5 296		5 296
Litchi				5 464		5 464

6.2 IRRIGATION WATER USE FOR EXISTING CROPS IN EACH AGRO-ECOLOGICAL ZONE

The above crop irrigation requirements were used to estimate the total present irrigation water use in each of the defined agro-ecological zones (**Table 6.3** and **Table 6.4**). The table also shows the crop "mix", the ratio of different irrigation systems in use in each zone and the irrigation efficiencies applied to each system.

The total present irrigation use is shown to be in the order of 55 million m^3/a, which is significantly higher than previous estimates (Department of Water Affairs and Forestry, 2005; Republic of Transkei, 1990) due mainly to the expanded areas of irrigation of Sector 1 (Table 6.2).

Table 6.3 Present irrigation area and water use in the Mzimvubu River catchment

Zone	Centre	Area (ha)	Crops	Irrigation water use (million m^3/a)
Sector 1				
2a	Kokstad / Cedarville / Franklin / Swartburg	6 553	Pasture (75%) Maize (20%) Vegetables (5%)	35.0
3	Ugie / Maclear	3 418	Pasture (55%) Potato (25%) Maize (20%)	17.8
Sector 2				
2a, 3, 4	Mount Frere / Matatiele / Qumbu / Tabankulu	788	Maize (50%) Vegetables (50%)	2.2
5	Port St Johns	100	Fruit trees (60%) Vegetables (40%)	0.4
Total		**10 859**		**55.4**

Table 6.4 Present irrigation water use

Sector/zone/crop	% planted	Irrigation requirement		Irrigation system ratio			Efficiency factor			Irrigation requirement	Area	Irrigation requirement
		Gross	Net	Centre pivot	Sprinkler	Micro	Centre pivot	Sprinkler	Micro			
		(m³/ha/a)		(m³/ha/a)			(m³/ha/a)			(m³/ha/a)	(ha)	(million m³/a)
Sector 1												
Zone 2a				**0.80**	**0.20**	**0.00**	**0.85**	**0.75**	**0.90**			
Ryegrass	60	5 240	3 144	2 515	629	0	2 959	838	0	3 797		
Permanent pasture	15	4 920	738	590	148	0	695	197	0	891		
Maize	20	2 381	476	381	95	0	448	127	0	575		
Vegetable (cabbage)	5	1 216	61	49	12	0	57	16	0	73		
Sub-total	**100**		**4 419**							**5 337**	**6 553**	**35.0**
Zone 3				**0.70**	**0.30**	**0.00**	**0.85**	**0.75**	**0.90**			
Ryegrass	40	5 800	2 320	1 624	696	0	1 911	928	0	2 839		
Permanent pasture	15	5 263	789	553	237	0	650	316	0	966		
Maize	20	2 409	482	337	145	0	397	193	0	590		
Potato	25	2 685	671	470	201	0	553	268	0	821		
Sub-total	**100**		**4 262**							**5 215**	**3 418**	**17.8**
Sector 2												
Zones 2a, 3, 4				**0.00**	**1.00**	**0.00**	**0.85**	**0.75**	**0.90**			
Cabbage	50	645	323	0	645	0	0	861	0	861		
Maize	50	1 411	1 411	0	1 411	0	0	1 882	0	1 882		
Sub-total	**100**		**2 057**							**2 742**	**788**	**2.2**
Sector 5				**0.00**	**1.00**	**1.00**	**0.85**	**0.75**	**0.90**			
Cabbage	40	1 261	504	0	504	0	0	672	0	672		
Citrus	30	5 036	1 511	0	0	1511	0	0	1 679	1 679		
Mango	30	4 917	1 475	0	0	1475	0	0	1 639	1 639		
Sub-total	**100**		**3 490**							**3 990**	**100**	**0.2**
Total for catchment											**10 859**	**55.2**

7 IRRIGATION DEVELOPMENT CONSTRAINTS AND OPPORTUNITIES

7.1 INTRODUCTION

For the purposes of this study, only Sector 2 is being considered in terms of irrigation development.

There are many socio-political, cultural, technical, managerial and financial constraints that can mitigate against sustainable irrigation development in the study area. This does not imply that opportunities do not exist. If approached in the correct way with the full involvement of beneficiaries and supporting communities and with careful participatory planning and implementation, significant irrigation development could take place in the area. In this chapter:

- physical and socio-economic constraints to irrigation development in Sector 2 of the catchment are outlined,
- development opportunities are identified and specific categories of development recommended and
- key success factors for sustainable irrigation development are presented.

7.2 CONSTRAINTS AND CHALLENGES TO IRRIGATION DEVELOPMENT

7.2.1 Climate

The climate of all the agro-ecological zones in the catchment (with the exception of Zone 5 and 6 – the Coastal and Large River Valley Zones) is not suitable for large, capital intensive irrigation schemes. Generally temperatures are too low (frost is common) and rainfall is too high to justify such developments. Large irrigation schemes are usually found in frost-free regions with a temperature regime that is suitable for high value perennial crops or out-of-season winter production of high value annual crops such as vegetables grown on a commercial scale. Excessive rainfall on an irrigation scheme can be disruptive to production practices and can adversely affect crop quality, particularly during harvesting time.

The likely returns from relatively low-value irrigated crops will in most cases be inadequate to cover the cost of expensive irrigation water and not be able to provide the growers with a reasonable “take-home” income.

7.2.2 Topography

The topography of Zones 5 and 6 is characterized by steep incised river valleys where irrigable soils are restricted mainly to “pockets” of alluvial soils along the main rivers where flooding is an ever-present threat. These “pockets” of alluvial soils have a high irrigation potential from a climatic and soils perspective but significant irrigation development will be limited without the river-flow regulating effect of expensive large dams upstream of these areas. Furthermore the irrigable areas within Zone 6 are inaccessible and general infrastructure is limited.

7.2.3 Present land use

Most irrigable soils in the catchment are already in use for rain-fed subsistence agriculture with individually “owned” plots seldom exceeding 1 ha. Any irrigation scheme would therefore have to accommodate all existing land users in some way. However, small irrigated plots on capital intensive irrigation schemes have proved to be mostly unviable, particularly with the limited enterprise selection as determined by the climatic conditions.

With the reality of high population density spread throughout Sector 2 of the study area, allocation of farms large enough to be commercially viable and sustainable units is a real challenge.

The only way this can be achieved is if the present land “owners” on the consolidated agricultural areas (who, in practice struggle to obtain meaningful production from their lands) are assisted to produce their household food needs by alternative means (see “Homestead plot irrigation” in 7.3.1 below) thus creating the opportunity for the leasing of these lands for consolidation into viable commercial units under irrigation (or rain-fed) production.

7.2.4 Land tenure

Most land in the study area falls under the communal land tenure system in terms of which the Tribal Authority allocates the right to use or occupy land. A “permission to occupy (PTO)” certificate is the official “deed of occupation”. Despite this system being widely accepted by local communities, it is recognised as one of the most significant constraints to agricultural development in the region. Without freehold title (or at least a long-lease form of land tenure) it is very difficult for any commercial enterprise, especially with expensive irrigation equipment, to be established and developed in a sustainable way.

The communal land tenure system poses special challenges to irrigation development. The issue of who owns the irrigation infrastructure of a scheme and who is responsible for it’s maintenance and repair and the inability to offer land as a security for “on-farm” irrigation infrastructure and operating loans will always be a constraint to irrigation development.

This land-tenure limitation has been shown to be a major contributor to the failure of many small-holder irrigation schemes and other agricultural development initiatives in South Africa in the past. Every effort should be made to address this important issue on new development projects.

7.2.5 Commercial farming experience

The lack of skilled and experienced (commercially orientated) farmers in this sector of the catchment is also a major constraint to irrigation development.

Crop production in the area is based on the principle of low cost, low risk, low return, “subsistence-type” agriculture. The subsistence culture remains a significant constraint to the commercialization of agriculture.

Crop production under irrigation is a practice which farmers usually only contemplate after gaining experience with, and having confidence in, rain-fed agriculture on a commercial scale.

7.2.6 Scheme ownership

There is high risk in developing an irrigation scheme without considering the long-term ownership arrangements for the project. Government-owned agricultural projects (anywhere in the world) are doomed to failure. This is mainly due to the reality that governments are not structured appropriately for commercial management and without some equity stake in an irrigation project, the farmers will not have adequate incentive or responsibility for sustained commercial production. It is therefore essential that appropriate farmer-led institutional structures are developed that will allow for farmer "ownership" and appropriate management structures to operate. Such structures will need strong government intervention to ensure capacity building, training and mentorship for the structures and their personnel.

7.2.7 Scheme management

Any large-scale irrigation scheme will require on-going management support for:

- Maintenance and repair of bulk infrastructure such as dams, pumps, canals, pipelines, power supply, roads and buildings,
- Equitable distribution of irrigation water to participating farmers and
- Facilitation of co-ordinated support services to farmers.

Whether management is provided by an external agent, by a joint-venture partner or by local community members appointed by the farmers, there will be a considerable responsibility and cost to the farmers for that management to be effective.

7.2.8 Support services

For commercialisation of agriculture to take root in the area, and particularly on irrigation schemes, it is imperative that more effective support services be put in place to facilitate the change from subsistence agriculture. The main components of support required for agriculture are:

- Extension services and related skills and technology transfer
- Input supplies. Access to commercial supplies of agricultural requisites such as seed, fertilizer, chemicals and equipment
- Mechanisation services. Cultivation of crop lands is difficult without tractors and agricultural machinery. Some form of reliable contractor service needs to be in place to fill this gap.

- Credit facilities for input purchases. All commercial agricultural activities make use of production loans in some form or another. This has been largely unavailable to communities in tribal areas.
- Management skills and technical “know-how”. A major training and capacity building initiative is required to bridge the skills gap that exists between commercial farmers and subsistence farmers.
- Joint-venture initiatives in terms of which commercial farmers and agribusiness entities form joint-venture partnerships with local farmers / land users, for the development of commercial agricultural projects.
- Effective application of existing legislation relating to natural resource degradation, particularly with regard to soil erosion and removal of vegetation from wetland areas and riverine regions.

7.3 IRRIGATION DEVELOPMENT OPPORTUNITIES

The development opportunities outlined below have been divided into two categories. Firstly the opportunities in the communal areas of Sector 2 and secondly the Port St Johns farms where an exercise is presently underway to secure freehold title for the farms.

7.3.1 Communal areas

Small irrigation schemes

As outlined above the catchment is unsuitable for large irrigation schemes, particularly if designed to accommodate smallholder farmers.

One form of irrigation scheme which may be viable, are small (< 500ha), low-cost, community-based projects which are initiated and driven by existing land users.

To minimise capital investment and operating costs of such schemes, they should be established on irrigable areas close to the villages where the participants live, and preferably downstream of the water source. This implies that, in most cases, existing consolidated, rain-fed agricultural lands would have to be converted to irrigation.

The irrigation water should be sourced from multi-purpose small/farm dams which, if established up-stream of the irrigation area, will allow for low-cost, gravity-fed reticulation and on-scheme storage.

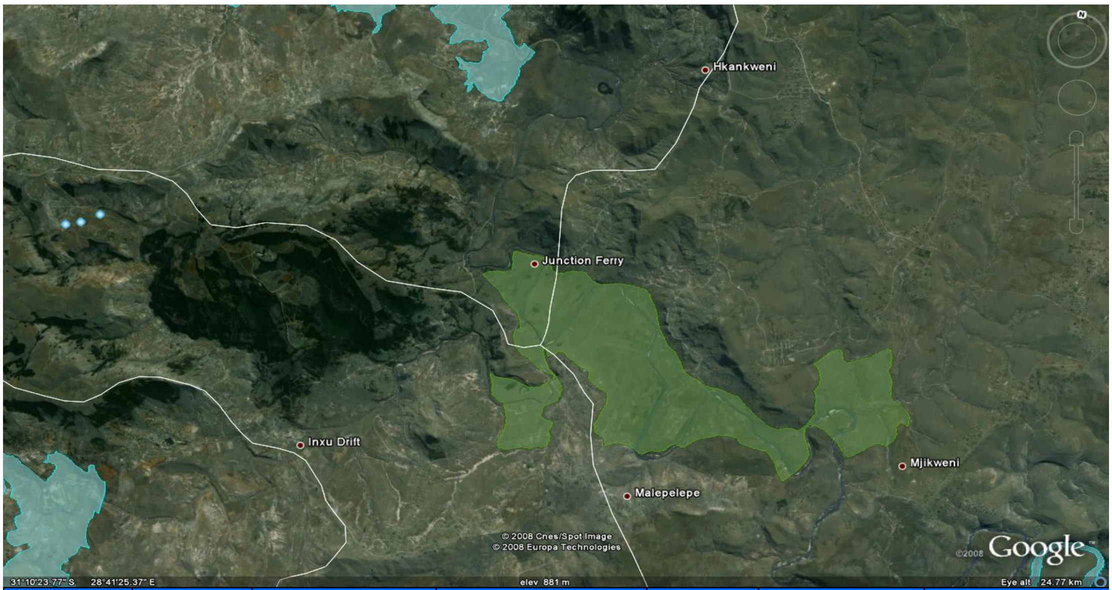
For such schemes to be viable and sustainable they should operate on a commercial basis. This implies that farm sizes should be large enough for commercial production (25 to 50 ha). This, in turn, implies that there will need to be consolidation of existing rain-fed “permission to occupy” land holdings which, on average, are about 1 ha in size. Leasing of “permission to occupy” land holdings is feasible provided an alternative source of food security for the present land users is found. The irrigated homestead plot concept may provide a solution in this regard.

A number of example sites for such irrigation schemes are shown in **Table 7.3** and **Figure 7.1**, **Figure 7.2** and **Figure 7.3**. They are indicative only and do not imply preferred or selected areas for small irrigation scheme development.

Table 7.3 Small irrigation schemes

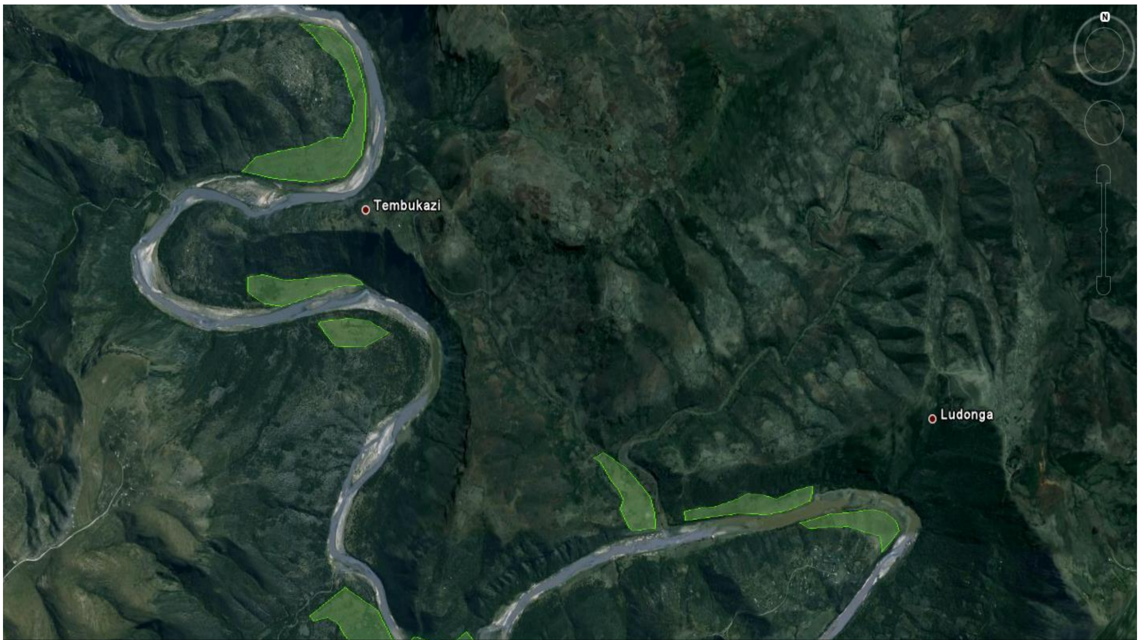
Zone	Site	Municipality	Nearest town	Quaternary catchment	Irrigation area (ha)	Water source
2a	13	Matatiele	Sikhetlane	T33F	480	Small dam
3	8	Ntabankulu	Emexegweni/ Kwa Zengele	T33D	432	Small dam
3	11	Elundini	Zintlawini	T35H	420	Small dam
4	3	Mhlontlo	Malepalele	T35K	500	Ntabaleng & Nomhala
4	6	Mzimvubu	Cabane/ Bomvini	T34H	480	Small dam
6	14	Nyandeni/ Qaukeni	Tembukazi	T36A	150	Mzimvubu River

Figure 7.1 Example of possible smallholder irrigation scheme on existing arable lands in Zone 2a



Zone	Site	Municipality	Nearest town	Quat.	Irrig. Area (ha)	Water source
4	3	Mhlontlo	Malepalele	T35K	500	Ntabaleng

Figure 7.2 Example of possible smallholder irrigation scheme on existing arable lands in Zone 4



Zone	Site	Municipality	Nearest town	Quat.	Irrig. Area (ha)	Water source
6	14	Nyandeni/ Qaukeni	Tembukazi	T36A	150	Mzimvubu River

Figure 7.3 Example of possible smallholder irrigation scheme on existing arable lands in the alluvial terraces of zone 6

Homestead plot irrigation

It is evident that the standard and intensity of rain-fed crop production on a fenced arable plot adjacent to most homesteads is much higher than production on the consolidated cropping areas situated some way from each village. The main crop grown on the homestead plots is maize with sorghum occasionally planted. The reason for the more successful production on these plots is their proximity to the homestead. Ease of access makes the crop production practices, in terms of planting, weeding, fertilizing with kraal manure, harvesting and providing security for the crop, much more manageable and less time-consuming than in the communal cropping areas.

The main limitation to production however is variable and often inadequate rainfall.

The concept of providing untreated irrigation water to homestead gardens is not a new one, but it is felt that the concept needs to be thoroughly researched and tested as a significant contributor to increased food security in the rural areas of the catchment.

The concept is to provide raw water to a tap/hydrant at the edge of a homestead plot for supplementary irrigation of grain crops and other food crops such as sweet potato, potato and vegetables.

The size of irrigated area within the homestead plot could be in the order of 0.1 ha which is sufficient to make a significant contribution to the household food needs and could also generate a modest cash income especially in the warmer parts of the catchment where, with irrigation, it is possible to produce two crops per year.

It is recognised that the issue of reticulating water to villages in Sector 2, which are often situated on relatively high ground, is a considerable challenge. Nevertheless there are a number of options for the sourcing of irrigation water, including:

(a) the construction of weirs on rivers high enough upstream to allow gravity reticulation in pipes or modest canals to reservoirs situated at a high point in the village;

(b) the combination of a micro hydro-power scheme with a small dam which could generate surplus power to cover the cost of pumping water to village reservoirs;

(c) the use of low-cost “ram” pumps for elevation of water from a weir or small dam to lower lying villages; and

(d) groundwater.

Homestead rainwater harvesting schemes

This topic is the subject of a parallel initiative in the catchment. However it is important in this report to endorse the value and sustainability of this form of water use. It is recommended that the concept of assisting interested and committed households to establish appropriate rainwater harvesting and storage facilities at their homesteads, with associated vegetable production, be adopted and implemented in terms of a well-researched, tested and phased programme throughout Sector 2 of the catchment.

7.3.2 Port St Johns farms

The unique sub-tropical climatic conditions prevailing in Zone 5 of the catchment coupled with the availability of the existing 73 Port St Johns farms which are presently being converted from state-ownership to free-hold tenure, provide an excellent opportunity for the commercial production of sub-tropical fruit and nut crops, particularly banana and macadamia. The 73 farms cover a total area of 3 650 ha of which about 5% (185 ha) is irrigable on alluvial flood plains of the Mzimvubu River.

On their own these farms would not constitute a viable entity to justify a banana ripening plant and a macadamia shelling and packaging plant. However, if linked to the adjacent Mngazana/Mngazi potential production area, a viable industry could be established with processing facilities in Mthatha.

7.4 ESTIMATED FUTURE IRRIGATION AREA AND WATER USE

Clearly, from the above discussion on irrigation development opportunities and recommended approaches, it would be pure speculation to predict the actual irrigation development in the Mzimvubu catchment over the next 10 to 20 years.

Nevertheless, **Table 7.4** summarises an attempt to project a possible irrigation development scenario which may assist in the medium- to long-term planning of the water resources of the catchment.

In this scenario it is assumed that:

- there will be no large irrigation schemes developed in the catchment;
- a limited number (say 20) of small community-based schemes with an average size of 250 ha will be developed;
- the irrigated homestead plot concept will be applied in say 150 villages with 250 plots per village and 0,1 ha per plot; and
- the development of 80% of the 73 Port St Johns farms which are presently being converted to freehold title.

Table 7.4 Estimated future irrigation development and water use in the Mzimvubu catchment

Sector	Present irrigation		Future new irrigation		Total irrigation	
	Area (ha)	Water use (million m^3/a)	Area (ha)	Water use (million m^3/a)	Area (ha)	Water use (million m^3/a)
1	9 971	52.8	-	-	9 971	52.8
2	888	2.6	-	-	962	2.6
	20 x 250 ha schemes		5 000	25.6	5 000	25.5
	150 villages x 250 plots x 0.1 ha		3 750	19.1	3 750	19.1
	Port St Johns farms (80%)		150	0.8	150	0.8
Total	**10 859**	**55.4**	**8 900**	**45.5**	**19 833**	**100.8**

For a catchment with substantial water resources, this projected irrigation water use may seem inappropriate. However, in view of the many constraints to irrigation development as outlined in this report, it is considered a reasonable and sustainable projection for medium- to long-term water resource planning.

7.5 KEY SUCCESS FACTORS REQUIRED FOR SUSTAINABLE IRRIGATION DEVELOPMENT

7.5.1 Focus on small community-based schemes

The focus of any irrigation development in the study area should be on small, community based projects which could take the form of

(a) small (<500 ha) schemes where existing, consolidated, rain-fed production areas are upgraded to irrigation and where irrigation water can be affordably and sustainably sourced and applied at low operating cost; and

(b) irrigation water supplied under gravity to traditional household plots in those villages where water can be affordably and sustainably sourced.

7.5.2 Voluntary participation only

Irrigation development should only be considered where communities and individual land holders have shown interest in and have requested assistance for such development.

7.5.3 Involvement of participants in all aspects of planning and development

The decision to go ahead with irrigation development should be followed with participatory planning and development. From the outset the scheme should “belong” to the beneficiaries and not to government or some other institution.

7.5.4 Securing of land tenure

To ensure successful irrigation development, adequate security of tenure is essential to allow investment by individuals in appropriate irrigation infrastructure and equipment.

7.5.5 Commercialisation of production

Commercialisation of production under irrigation is essential in order to ensure adequate income generation to cover the operating costs of irrigated farming and provide a worth while contribution to household income.

7.5.6 Establishment of community-owned institutional structures (ownership and management of schemes)

The complexity and sensitivity of sharing infrastructure and water on an irrigation scheme, no matter how small, requires control and management. It is essential that appropriate, community-owned, institutional structures are in place to take responsibility for the control and management of the scheme.

7.5.7 Support services in place

Fundamental to the sustainability of an irrigation scheme is the regular and reliable supply of the range of agricultural support services essential on an irrigation scheme, including financing, mechanisation, input supplies, technical support, and marketing structures.

7.5.8 Low cost of water

The viability of any irrigation scheme is a function of the cost of water and/or the cost of operating and maintaining the water supply. Any scheme should therefore be designed to minimise tariffs, and operating and maintenance costs.

A major contributing factor to the cost of pumped water is the pumping head (the height above the water source to which the water has to be elevated). A head of above 50 m is unlikely to be viable unless the irrigation water is used for intensive production of high-value crops.

7.5.9 Integrated water use from storage facility

The cost of building even a small dam or weir on a river in the catchment could not be justified for irrigation alone. It is recommended that any water storage infrastructure should be developed with a multi-purpose objective such as domestic, irrigation, livestock and possibly hydro-power generation.

7.5.10 Undertake viability assessment

Before embarking on any irrigation scheme development a detailed technical, social, and financial viability assessment should be undertaken which involves all stakeholders (particularly the participating farmers), in all aspects of the study.

SECTION B: EXTENDED AREA

1 INTRODUCTION

The extended area includes the north-eastern section of the Wild Coast region from the Mzamba area (Bizana) in North Pondoland to the Mgazana and Mgazi River basins west of Port St Johns.

This "Extension Area" report is presented in a less detailed format compared to the report for the catchment area. The focus is on providing an overview of the natural resources, socio-economic circumstances and present land use of this area adjacent to the Mzimvubu catchment and to outline agricultural development opportunities and constraints for the area. The report concludes with a brief "SWOT" (strengths, weaknesses, opportunities and threats) analysis which will assist in determining the sustainable development opportunities in the area.

2 NATURAL RESOURCES

2.1 TOPOGRAPHY AND SOILS

The complex geology of the area and the highly variable topography associated with the deeply incised coastal monocline has resulted in a highly variable soil pattern within the study area with shallow, unstable soils dominating the landscape. Nevertheless, there are areas with soils of high agricultural potential, particularly on doleritic soils and Ecca sediments on the top slopes and on the many alluvial terraces associated with the incised river valleys. However, very few detailed soil surveys are available for the area and this will hamper future planning of the region.

The study area contains substantial areas (blocks) of high agricultural potential soils. It has previously been estimated that this could be as much as 98 000 ha.

A generalized soil map is given in **Figure 2.1**.

2.2 CLIMATE

The natural resources of soil and rainfall together with moderate temperatures and lack of frost, combine to provide conditions suitable for the production of a wide range of high value crops, subsistence crops and forestry. Opportunities also exist for improved livestock production.

A rainfall map is given in **Figure 2.2**.

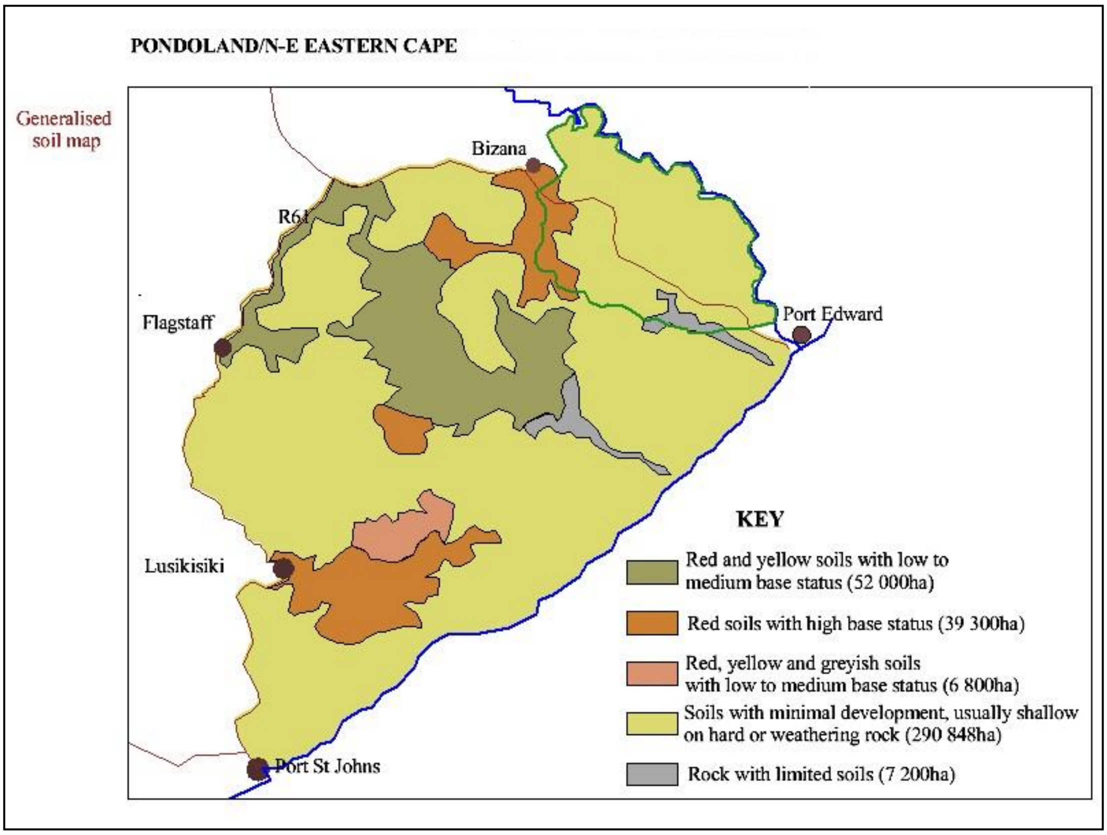


Figure 2.1 Generalised soil map

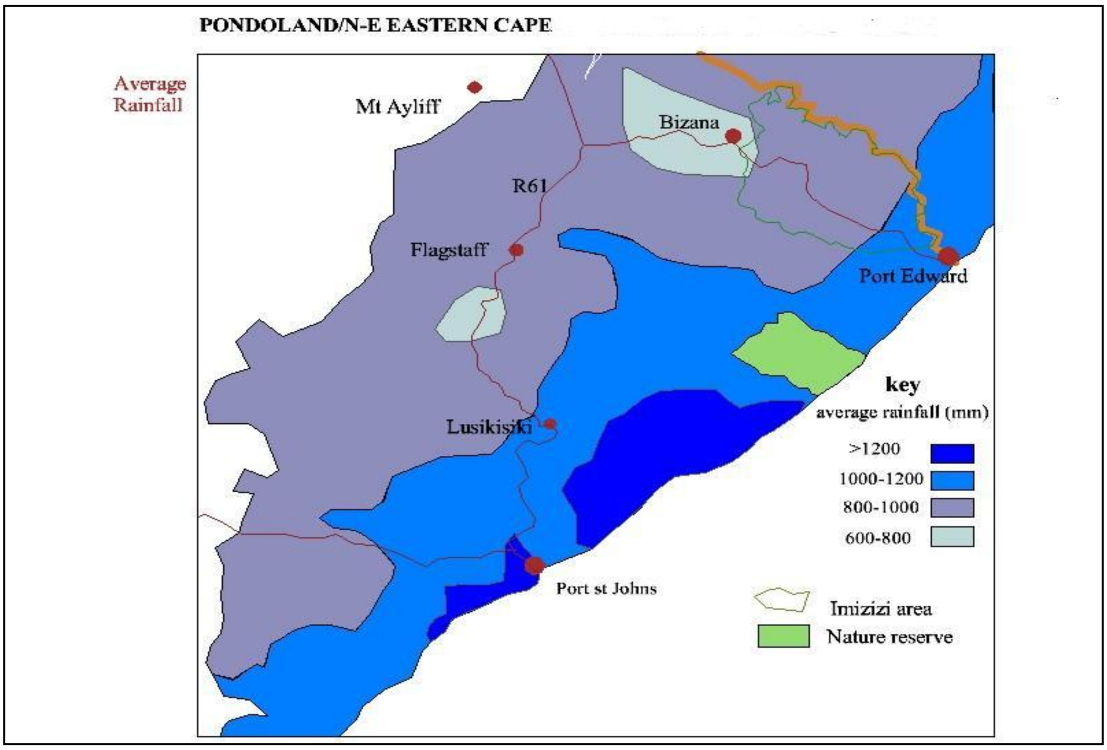


Figure 2.2 Rainfall map

3 SOCIO-ECONOMIC OVERVIEW

The area is characterised by largely rural communities living in scattered villages with a few regional towns that provide basic consumer services to the communities.

The population density increases from the relatively low population along the coast westwards to relatively high along the edge of the Mzimvubu River catchment.

The traditional communal land tenure system dominates the area. However the area does have large areas of State land which has been set aside for commercially-orientated agriculture.

The area reflects a very low level of economic activity and related high levels of unemployment and poverty.

The people within the area are mainly dependent on State pensions, remittances from family members working outside the area, income from tourism-related jobs and various forms of subsistence agriculture.

Besides the main road that runs north-south through the study area and the bulk infrastructure of the main towns like Lusikisiki and Port St Johns, the sparse infrastructure throughout the region is a constraint to development.

4 PRESENT AGRICULTURAL LAND USE

4.1 OVERVIEW

Food production from homestead plots is presently the most sustainable and effective agricultural activity and contributes significantly to livelihoods. Limited areas of semi-commercial vegetable production, under irrigation, occur on the alluvial soils adjacent to the larger perennial rivers that run through the study area to the coast. Rain-fed maize and sorghum production occurs on some top slopes in allocated cropping areas. These scattered production areas are managed at a subsistence level with very few inputs of fertilizer and plant protection chemicals. Yields are therefore very low and there is seldom a cash surplus generated from this form of land use.

Present livestock production in the study area is mainly restricted to the use of communal grazing land to maintain family-owned herds. Livestock provides traditional benefits in terms of many cultural requirements such as labola and ceremonial and festive occasions. Commercial off-take from this livestock is minimal and overgrazing on poor quality veld prevails throughout the study area. This in turn is causing significant degradation of landscapes in many areas. In the few areas where a more secure form of land tenure applies, the standard of livestock production and the degree of commercialisation is dramatically improved.

The only commercial agricultural enterprises that generate jobs and income for their community within the study area are the Magwa Tea Estate (2 000 ha) near Lusikisiki and the North Pondoland sugar project (2 750 ha), which is presently very run-down. Neither of these projects is irrigated, relying entirely on rainfall which is adequate to sustain commercial production.

Small-scale irrigators situated on alluvial terraces and pumping directly from the river is the only significant form of irrigation in the area. These schemes vary in size from 1.5 ha to 20 ha. Fifteen such schemes have been identified. Mainly vegetable crops and maize are grown with small areas of fruit trees found mainly in the Port St Johns area.

The commercial agricultural production areas are discussed in more detail below.

4.2 NORTH PONDOLAND: IMIZIZI

The Pondoland sugar project was established near Imizizi in the early 90's as a pilot project of some 2 750 ha under sugarcane with 250 individual lease holders on 11 ha units (see **Figure 4.2**). The area, which lies adjacent to the KwaZulu-Natal border, experiences warm, frost free conditions with a mean annual rainfall of between 1 000 mm and 1 200 mm, the highest in the study area. It is therefore well suited to sugarcane and bananas.

Figure 4.2 North Pondoland Sugar project

Originally the sugar estate was to comprise 10 000 ha, but for a number of reasons the development was never completed. The sugar cane from North Pondoland is crushed at the Umzimkhulu Mill, owned by Illovo Sugar. At present, the Estate is relatively run-down, and is operating well below its potential. This is partly due to land claims in the area. Other crops traditionally grown in the area include maize and various vegetables.

The soils under sugar cane are generally of good quality, and the terrain is rolling and well drained. The sugar estate is not irrigated as rainfall is sufficient, on average. Long-term averages of evapotranspiration and rainfall show that crop water deficiency is not a significant problem in the area. Droughts, when they do occur, will have a negative affect on yield.

The production area is considered to have a production potential less optimal than the primary sugarcane growing areas of the country. However, under good management, sugarcane production in the area is viable and sustainable.

4.3 CENTRAL PONDOLAND: LUSIKISIKI

The Lusikisiki area is well known for its tea production. Magwa Tea Estate (see **Figure 4.3**), established in the sixties, presently consists of 2 000 ha of tea plantations on four estates. The estates have experienced a volatile history, but have survived and are presently experiencing a reasonably stable period. The estates are significant employers of local labour.

Figure 4.3 Magwa tea estates in the Lusikisiki area

An area of state-owned land east of Lusikisiki (near Mkumbati Nature Reserve) known as Lukumbasi farms, covers some 3 000 ha in extent of which about 800 ha is suitable for cultivation. This area is well suited to a wide range of rain-fed field crops such as maize and dry beans and pastures for dairying. Poultry enterprises would also be well suited to the area.

4.4 SOUTHERN PONDOLAND: PORT ST JOHNS / MNGAZI / MNGAZANA

The river valleys of the Mzimvubu, Mngazi and Mgazana rivers near the coast provide a unique agro-ecological climate. These enclaves which experience a truly sub-tropical climate, coupled with good soils and good irrigation water resources, provide an excellent opportunity for a number of sub-tropical fruit and nut enterprises.

Present land use is restricted mainly to state-owned farms (**Figure 4.4**) leased to individual farmers (73 farms totaling 3 650 ha with about 5% irrigable soils). Production on these farms is restricted to low intensity vegetable production and a number of small orchards of mango, avocado, citrus, macadamia and bananas.

Figure 4.4 Port St Johns State owned farms

5 AGRICULTURAL AND FORESTRY DEVELOPMENT OPPORTUNITIES

Based on an evaluation of the agricultural potential of the area in terms of climate, soils, irrigation potential and economic viability, a number of development nodes have been identified.

5.1 NORTH PONDOLAND

Bio-fuels (sugarcane and canola)

The potential for sugarcane development is about 10 000 ha (including the existing 2 750 ha on the north Pondoland project) which would justify the establishment of a local sugar mill. This would greatly improve the viability of sugarcane farming in the area and would greatly enhance job opportunities and stimulate local economic development in the area. The alternative to a sugar mill is ethanol production.

In 2007 the Central Energy Fund commissioned a reconnaissance study on bio-fuel production in the North Pondoland area. The range of possible bio-fuel crops investigated included those suited to both ethanol and bio-diesel production. Sugar cane was identified as the most likely crop to spear-head bio-fuels development as a sugar estate is already established, and farmers are familiar with this crop. The hardiness of sugar cane and the possibility of extending the growing season to bridge low rainfall periods is seen as a major benefit of the crop.

However, there is good potential for including other bio-fuel crops in the area. A range of crops that are oil rich and are suited as feedstock for a bio-diesel plant were investigated. These included canola, sunflower, groundnuts and soybeans. The most promising of these is canola, based on recent field trials being undertaken by the Eastern Cape Department of Agriculture. Canola is of particular interest as it could be grown in rotation with maize under rain-fed conditions in the area or with supplementary irrigation on any smallholder irrigation schemes which may be developed in the future.

Bananas

The area is also well suited to rainfed banana production. This opportunity has not yet been tried commercially. However, there is excellent opportunity for at least 500 ha of banana production. The banana crop is particularly attractive because it is a high value perennial crop which comes into production within 18 months of planting, is less perishable than many other fruit crops and enjoys excellent local market demand.

As in the case of the Port St Johns area ripening facilities are essential to compete on the South African market. A ripening facility at Mthatha would be ideally placed to serve both production areas.

5.2 MNGAZANA/ MNGAZI

Macadamias

The area could accommodate about 200 ha of macadamia, producing about 450 t/a. The industry could involve both a commercial unit and out-growers and could be linked to the relatively new industry in southern KwaZulu-Natal. On-site processing could involve a de-shelling (cracking) plant.

Bananas

The potential exists for about 100 ha of bananas in the area. Access to a ripening fruit facility is necessary to serve the local market. Together with production in the Mbizana area, a viable project-linked banana ripening facility could be established in Mthatha.

A 100 ha banana enterprise could support about 80 permanent jobs equivalents. If bananas were selected instead of macadamias, a 300 ha banana industry would be possible.

Litchi, mango and citrus

Other crops with less financial return that are suited to the area include litchi, mango and citrus.

Vegetable production in river valleys with irrigation potential

The potential for vegetable production in this node is high, particularly in the lower lying areas that enjoy subtropical conditions with relatively warm and frost-free winters. Presently most of the demand for vegetables is met by imports into the area. It is envisaged that vegetable production could be established in alluvial soils under irrigation and would be produced on independent commercial units ranging from 1 to 50 ha in size. A total of at least 200 ha could be established in the areas. A range of crops can be produced including cabbage, sweet potato, onion, green maize and spinach. It would be necessary to establish a central market within the region (Mthatha) for vegetable production to be successful. This market itself is a private investment or joint venture opportunity.

Intensive vegetable production on 200 ha could support about 400 jobs.

5.3 LIVESTOCK DEVELOPMENT OPPORTUNITIES

There are opportunities to improve the productivity of livestock and to reduce stocking rates and rampant overgrazing through partial commercialisation of livestock rearing in the communal areas. This could be achieved through joint ventures with agribusiness entities which are seeking livestock-related joint-venture opportunities.

These initiatives would involve cattle-fattening enterprises, either with the establishment of intensive feedlot systems, or less intensive fattening operations on irrigated pastures with locally grown maize grain supplements. The livestock for these operations would be purchased from the communal grazing areas, thus facilitating an element of commercialisation of the existing livestock rearing systems. Households, whose land might be used for irrigated pastures, maize production and for the siting of feedlot structures, could participate in the benefits of such enterprises through equity-type schemes.

5.4 FORESTRY DEVELOPMENT OPPORTUNITIES

Forestry potential in the area is based on a study undertaken by the Department of Water Affairs and Forestry (DWAF). Two areas in the north-eastern sector of the study area have been identified. Firstly, an area south of Lusikisiki, which has high forestry potential based on soil type and rainfall (F1) and an area north-east of F1, with moderate potential for forestry development (Figure 1). Both areas extend substantially into areas of concentrated settlements and related high population density and onto high potential arable land - most of which is under cultivation. The remaining area encroaches onto highly valued communal grazing land. Any proposed forestry projects would therefore have to be preceded by a thorough public participation process and would have to involve all stakeholders/beneficiaries in its planning and implementation.

As in the case of the above agricultural development opportunities, any forestry development should preferably take the form of a joint-venture initiative involving a commercial forestry organisation such as Mondi or SAPPI. Both organisations have successful models of forestry joint ventures with rural communities.

However, because of the conflicting land-use issues, forestry development is not recommended as a high priority option for the area.

5.5 SUMMARY OF AGRICULTURAL AND FORESTRY DEVELOPMENT OPPORTUNITIES

The identified agricultural development opportunities for the “Extension Area”, which includes the Pondoland coast and Mgazi/Mngazana enclave, are summarised in **Table 5.1**.

Table 5.1 Summary of agriculture and forestry development opportunities in the area

Site		Main agricultural and forestry enterprise opportunities	Area (ha)	Jobs
1	Mzamba	Sugarcane (and mill)	5 000	750
		Banana (and ripening facility)	500	400
2	Lusikisiki	Maize (dryland), dairy, poultry	800	160
3	Port St Johns / Mngazi / Mgazana	Macadamia (and cracking plant)	200	300
		Banana (and ripening facility)	100	80
5	River Valleys with small-scale irrigation potential	Vegetables	200	400
6	Livestock enterprises	Cattle fattening	Not quantified	
7	Forestry enterprise	Timber	Not recommended	
	Total (excluding livestock and forestry)		**11 200**	**2 090**

6 CONSTRAINTS TO AGRICULTURAL AND FORESTRY DEVELOPMENT

6.1 INTRODUCTION

Very few agricultural and forestry project initiatives introduced into the study area over the years have been successful. There are many socio-political, technical, management and financial constraints that have mitigated against sustainable agriculture development. This does not imply that opportunities do not exist. If approached in the correct way with the full involvement of beneficiaries and supporting communities and with careful participatory planning and implementation significant development could take place in the area. To highlight the opportunities and constraints associated with such development, the following brief “SWOT” analysis has been undertaken.

6.2 BRIEF SWOT ANALYSIS

6.2.1 Strengths

- The area has one of the best agricultural climates in South Africa in terms of temperatures and plentiful, well distributed rainfall.
- The Mzimvubu area has been given Presidential Icon status, and also appears on the Eastern Cape PGDP.
- A significant portion of the area has suitable soils for rain-fed agriculture and good potential for irrigation of high-value orchard and vegetable crops on selected sites on alluvial soils in the south-east of the study area.
- Surface water is plentiful.
- Labour resources are plentiful.
- Large local market for edible crops exists and markets for high value products are available through established agricultural and forestry industries in neighboring regions/provinces.
- As is common in the Mzimvubu catchment the many homesteads in rural villages have arable plots which have the potential for increased productivity through the possible supply of extension services, fertilizers and untreated water for supplementary irrigation

6.2.2 Weaknesses

- Most land in the study area falls under the traditional land tenure system in terms of which the Tribal Authority allocates the right to use or occupy land. A “permission to occupy” certificate is the official “deed of occupation”. Despite this system being widely accepted by local communities, it is recognised as one of the most significant constraints to agricultural development in the region. Without freehold title it is very difficult for any commercial enterprise to be established and developed in a sustainable way.
- Lack of technical and management skills/experience for commercial agricultural development.
- Internal infrastructure is poor and access to ports is limited.
- Poor extension services.
- Processing plants are situated outside the area.
- Lack of well-structured farmer support services including production input supplies.
- Topography is broken by large river gorges and flash floods are quite common.
- Overgrazing has caused severe erosion in some of the steeper areas.

6.2.3 Opportunities

- Commercial production of orchard crops such as banana, macadamia and citrus and other high-value perennial crops such as sugar, tea and timber has proven to be successful and there is room for expansion.
- Ethanol from sugarcane and bio-diesel from annual crops such as canola, provide excellent development opportunities in the area.
- There is potential for irrigation expansion both for commercial production and for supplementary irrigation of homestead plots for food security and modest cash income.
- The opportunity cost of agricultural products such as maize, cabbage and other products in rural areas is high because of the high transport and middleman costs. These products therefore have a comparative advantage in most of this area.
- There are many suitable dam/weir sites.
- Export markets and strong local markets exist for a number of crops that have been identified.
- Production levels of most crops produced on tribal land is low. Productivity can be substantially increased.
- Large local market.

6.2.4 Threats

- Land claims and ensuing problems related to claims (particularly on the Pondoland sugar project).
- Inadequate involvement of communities in the planning of potential projects in their areas.
- High capital redemption costs for project infrastructure (who pays?).
- Overgrazing.
- Flood damage.
- Dumping of perishable products.
- Prevalence of HIV/AIDS which impacts on any activity, but especially on farming activities that demand physical activity.

7 CONCLUSIONS

7.1 CROP PRODUCTION OPPORTUNITIES

The study area provides a wealth of opportunities for substantial agricultural development, particularly for a number of high value crop and orchard enterprises, bio-fuels and food-security initiatives that could have significant positive impact on the regional economy through job creation, equity sharing opportunities, value chain benefits, entrepreneur development and food security. However, for such developments to take place in a sustainable way, a number of practical interventions will be essential. They include:

- The promotion of (and support for) the involvement of commercial joint-venture partners in equitable (win-win) relationships with local land users/owners.
- The commitment of organised agriculture (particularly in the identified enterprises) to support such initiatives.
- The support and involvement of government in a tangible and sustained way with regard to the specific support services outlined above.
- A commitment to the concept of providing supplementary irrigation water, via affordable and sustainable village-based systems, to homestead agricultural plots in the villages.

7.2 FORESTRY DEVELOPMENT OPPORTUNITY

The potential for forestry development, in terms of soils and rainfall, is good in selected areas. However the conflict of interests with other forms of land use such as crop cultivation on prime agricultural land and the high demand for veld for livestock grazing indicates that forestry could be a sensitive development option. Any forestry project under consideration would require the full involvement of potential beneficiaries and stakeholders in the planning and implementation of such a project.

7.3 LIVESTOCK DEVELOPMENT OPPORTUNITIES

Opportunities for the partial commercialisation of livestock rearing in the study area, which could include livestock fattening and finishing operations with joint-venture partners, should be investigated and promoted.

7.4 LACK OF INFRASTRUCTURE

The lack of infrastructure is obvious and has to be investigated and discussed. This includes, *inter alia*, roads, railway lines, markets, etc.

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Appendix A

Crop irrigation requirements per agro-ecological zone in the Mzimvubu River catchment

Appendix A-1 Crop irrigation requirements: Zone 2a (Upper Plateau - dry)

	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Summary of crop irrigation requirements
	Days	31	28	31	30	31	30	31	31	30	31	30	31	**365**	
Rainfall	mm/month	95	130	87	44	17	13	8	12	24	61	87	93	**671**	
Rainfall efficiency		0.65	0.60	0.70	0.75	0.80	0.80	0.80	0.80	0.80	0.70	0.70	0.65		
Effective rainfall	mm/month	62	78	61	33	14	10	6	10	19	43	61	60	**457**	
Reference Et	mm/day	4.4	4.0	3.2	2.8	2.1	1.8	2.1	2.6	3.5	3.8	4.3	4.5		
	mm/month	136	112	99	84	65	54	65	81	105	118	129	140	**1 188**	
Crop water deficit	mm/month	75	34	38	51	52	44	59	71	86	75	68	79	**731**	
														mm	**$m^3/ha/a$**
Maize	cf	1.14	1.14	0.67								0.43	0.75		
	IR (mm/month)	**104**	**47**	**31**								**36**	**72**	**290**	**2 904**
Potato (summer)	cf									0.52	0.95	1.09	1.03		
	IR (mm/month)									**54**	**87**	**91**	**99**	**331**	**3 312**
Soybean	cf	1.14	1.05									0.48	1.05		
	IR (mm/month)	**104**	**44**									**40**	**101**	**288**	**2 884**
Cabbage	cf				0.67	0.91	0.93								
	IR (mm/month)				**42**	**57**	**49**							**148**	**1 483**
Vegetables (summer)	cf	0.97	0.64								0.44	0.71	0.99		
	IR (mm/month)	**88**	**27**								**40**	**59**	**95**	**310**	**3 095**
Ryegrass (annual)	cf		0.30	0.64	0.97	1.00	1.00	1.00	1.00	1.00	0.77	0.70	0.30		
	IR (mm/month)		**12**	**30**	**60**	**63**	**53**	**72**	**87**	**105**	**71**	**58**	**29**	**639**	**6 390**
Perennial ryegrass	cf	0.81	0.81	0.77	0.68	0.59	0.54	0.54	0.54	0.58	0.67	0.76	0.81		
	IR (mm/month)	**74**	**34**	**36**	**42**	**37**	**29**	**39**	**47**	**61**	**61**	**63**	**78**	**600**	**6 000**

Irrigation efficiency (Centre Pivot):	**0.85**	% cover (centre pivot)	**0.8**	Weighted factor (efficiency/coverage)	**0.82**
Irrigation efficiency (Dragline Sprinkler):	**0.75**	% cover (dragline sprinkler)	**0.2**		

Notes:

Notes 1 Owing to the lack of detailed knowledge of the soils, actual rotations etc, factors used to derive effective rainfall have been based on the consideration of amount of monthly rainfall and season.

2 The irrigation requirement (IR) figures comprise the crop water requirement and an irrigation efficiency factor.

3 Calculations based on Kokstad climatic data and Matatiele rainfall.

4 For the purposes of water requirement calculations at this reconnaissance level, a single 'weighted' irrigation efficiency factor has been used - which takes account both of the efficiencies of the two systems employed within the zone and the different areas covered by each type.

Appendix A-2 Crop irrigation requirements: Zone 3 (Minor escarpment)

	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
	Days	31	28	31	30	31	30	31	31	30	31	30	31	**365**	
Rainfall	mm/month	126	114	97	32	5	11	9	14	30	78	106	102	**724**	Summary of crop irrigation requirements
Rainfall efficiency		0.60	0.65	0.65	0.75	0.80	0.80	0.80	0.80	0.75	0.70	0.65	0.65		
Effective rainfall	mm/month	76	74	63	24	4	9	7	12	22	55	69	66	**480**	
Reference Et	mm/day	4.6	4.0	3.5	3.0	2.4	2.0	2.2	3.0	3.7	4.1	4.2	5.0		
	mm/month	143	112	109	90	74	60	68	93	111	127	126	155	**1 268**	
Crop water deficit	mm/month	67	38	45	66	70	51	61	81	89	72	57	89	**788**	
														mm	**m³/ha/a**
Maize	cf	1.14	1.14	0.67								0.43	0.75		
	IR (mm/month)	**95**	**54**	**38**								**31**	**83**	**301**	**3 012**
Potato (summer)	cf									0.52	0.95	1.09	1.03		
	IR (mm/month)									**58**	**86**	**78**	**114**	**336**	**3 356**
Soybean	cf	1.14	1.05									0.48	1.05		
	IR (mm/month)	**95**	**50**									**34**	**116**	**296**	**2 957**
Cabbage	cf				0.67	0.91	0.93								
	IR (mm/month)				**56**	**80**	**59**							**195**	**1 950**
Vegetables (summer)	cf	0.97	0.64								0.44	0.71	0.99		
	IR (mm/month)	**81**	**30**								**40**	**51**	**110**	**312**	**3 117**
Ryegrass (annual)	cf		0.30	0.64	0.97	1.00	1.00	1.00	1.00	1.00	0.77	0.70	0.30		
	IR (mm/month)	**0**	**14**	**36**	**80**	**88**	**64**	**77**	**102**	**111**	**70**	**50**	**33**	**725**	**7 250**
Perennial ryegrass	cf	0.81	0.81	0.77	0.68	0.59	0.54	0.54	0.54	0.58	0.67	0.76	0.81		
	IR (mm/month)	**68**	**38**	**44**	**56**	**52**	**35**	**41**	**55**	**64**	**61**	**54**	**90**	**658**	**6 579**

Irrigation efficiency (centre pivot):	**0.85**	% cover (centre pivot)	**0.6**	Weighted factor (efficiency/coverage)	**0.80**
Irrigation efficiency (dragline sprinkler):	**0.75**	%cover (dragline sprinkler)	**0.4**		

Notes:

Notes 1 Owing to the lack of detailed knowledge of the soils, actual rotations etc, factors used to derive effective rainfall have been based on the consideration of amount of monthly rainfall and season.

2 The irrigation requirement (IR) figures comprise the crop water requirement and an irrigation efficiency factor.

3 Calculations based on Ugie climatic data with Maclear rainfall data.

4 For the purposes of water requirement calculations at this reconnaissance level, a single 'weighted' irrigation efficiency factor has been used - which takes account both of the efficiencies of the two systems employed within the zone and the different areas covered by each type.

Appendix A-3 Crop irrigation requirements: Zone 4 (Central Plateau)

	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
	Days	31	28	31	30	31	30	31	31	30	31	30	31	**365**	
Rainfall	mm/month	94	97	91	44	19	15	10	13	37	63	71	79	**633**	Summary of crop irrigation requirements
Rainfall efficiency		0.65	0.65	0.65	0.75	0.80	0.80	0.80	0.80	0.80	0.70	0.70	0.70		
Effective rainfall	mm/month	61	63	59	33	15	12	8	10	30	44	50	55	**441**	
Reference Et	mm/day	4.7	4.0	3.3	2.9	2.3	1.9	2.3	2.8	3.5	4.0	4.6	4.5		
	mm/month	146	112	102	87	71	57	71	87	105	124	138	140	**1 240**	
Crop water deficit	mm/month	85	49	43	54	56	45	63	76	75	80	88	84	**799**	
														mm	**m^3/ha/a**
Maize	cf	1.14	1.14	0.67								0.43	0.75		
	IR (mm/month)	**129**	**74**	**39**								**51**	**84**	**376**	**3 764**
Potato (summer)	cf									0.52	0.95	1.09	1.03		
	IR (mm/month)									**52**	**101**	**128**	**116**	**397**	**3 974**
Soybean	cf	1.14	1.05									0.48	1.05		
	IR (mm/month)	**129**	**69**									**57**	**118**	**372**	**3 715**
Cabbage	cf				0.67	0.91	0.93								
	IR (mm/month)				**48**	**68**	**56**							**172**	**1 721**
Vegetables (summer)	cf	0.97	0.64								0.44	0.71	0.99		
	IR (mm/month)	**109**	**42**								**47**	**84**	**111**	**393**	**3 928**
Ryegrass (annual)	cf		0.26	0.64	0.97	1.00	1.00	1.00	1.00	1.00	0.77	0.70	0.26		
	IR (mm/month)		**17**	**37**	**70**	**75**	**60**	**84**	**102**	**101**	**82**	**82**	**29**	**739**	**7 389**
Perennial ryegrass	cf	0.81	0.81	0.77	0.68	0.59	0.54	0.54	0.54	0.58	0.67	0.76	0.81		
	IR (mm/month)	**91**	**53**	**44**	**49**	**44**	**32**	**46**	**55**	**58**	**71**	**89**	**91**	**725**	**7 247**

Irrigation efficiency (centre pivot):	**0.85**	% cover (centre pivot)	**0.0**	Weighted factor (efficiency/coverage)	**0.75**
Irrigation efficiency (dragline sprinkler):	**0.75**	% cover (dragline sprinkler)	**1.0**		

Notes:

Notes 1 Owing to the lack of detailed knowledge of the soils, actual rotations etc, factors used to derive effective rainfall have been based on the consideration of amount of monthly rainfall and season.

2 The irrigation requirement (IR) figures comprise the crop water requirement and an irrigation efficiency factor.

3 Calculations based on Umtata climatic data and Qumbu rainfall.

4 For the purposes of water requirement calculations at this reconnaissance level, a single 'weighted' irrigation efficiency factor has been used - which takes account both of the efficiencies of the two systems employed within the zone and the different areas covered by each type.

Appendix A-4 Crop irrigation requirements: Zone 5 (Coastal Region)

	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Summary of crop irrigation requirements
	Days	31	28	31	30	31	30	31	31	30	31	30	31	**365**	
Rainfall	mm/month	134	140	143	77	55	34	41	45	85	122	149	130	**1 155**	
Rainfall efficiency		0.60	0.60	0.60	0.70	0.75	0.75	0.75	0.75	0.70	0.60	0.60	0.60		
Effective rainfall	mm/month	80	84	86	54	41	26	31	34	60	73	89	78	**735**	
Reference Et	mm/day	4.5	4.5	3.8	3.3	2.9	2.7	2.9	3.3	3.7	3.9	4.4	4.5		
	mm/month	140	126	118	99	90	81	90	102	111	121	132	140	**1 349**	
Crop water deficit	mm/month	59	42	32	45	49	56	59	69	52	48	43	62	**613**	
														mm	**m^3/ha/a**
Maize	cf	1.14	1.14	0.67								0.43	0.75		
	IR (mm/month)	**90**	**64**	**29**								**24**	**62**	**268**	**2 682**
Potato (winter)	cf				0.60	0.97	1.10	1.05							
	IR (mm/month)				**36**	**63**	**81**	**83**						**263**	**2 632**
Cabbage	cf				0.67	0.91	0.93								
	IR (mm/month)				**40**	**59**	**69**							**168**	**1 681**
Vegetables (winter)	cf			0.45	0.72	1.00	0.98	0.83	0.66						
	IR (mm/month)			**19**	**43**	**65**	**73**	**65**	**60**					**326**	**3 257**
Citrus	cf	0.83	0.83	0.85	0.57	0.86	0.86	0.86	0.84	0.83	0.83	0.83	0.83		
	IR (mm/month)	**55**	**39**	**30**	**29**	**46**	**53**	**57**	**64**	**47**	**44**	**39**	**57**	**560**	**5 595**
Banana	cf	1.00	1.00	1.00	1.00	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
	IR (mm/month)	**66**	**47**	**36**	**50**	**55**	**62**	**66**	**76**	**57**	**53**	**47**	**68**	**683**	**6 826**
Mango	cf	0.81	0.80	0.80	0.80	0.79	0.79	0.80	0.80	0.80	0.81	0.81	0.81		
	IR (mm/month)	**53**	**37**	**28**	**40**	**43**	**49**	**53**	**61**	**46**	**43**	**38**	**55**	**546**	**5 464**
Macadamia	cf	1.11	1.00	0.79	0.58	0.47	0.47	0.47	0.47	0.78	1.11	1.11	1.11		
	IR (mm/month)	**73**	**47**	**28**	**29**	**25**	**29**	**31**	**36**	**45**	**59**	**53**	**76**	**530**	**5 296**
Litchi	cf	0.81	0.80	0.80	0.80	0.79	0.79	0.80	0.80	0.80	0.81	0.81	0.81		
	IR (mm/month)	**53**	**37**	**28**	**40**	**43**	**49**	**53**	**61**	**46**	**43**	**38**	**55**	**546**	**5 464**

Irrigation efficiency (dragline sprinkler): 0.75
Irrigation efficiency (microjet sprinkler): 0.90

Weighted factor **0.84**

Notes:

Notes 1 Owing to the lack of detailed knowledge of the soils, actual rotations etc, factors used to derive effective rainfall have been based on the consideration of amount of monthly rainfall and season.

2 The irrigation requirement (IR) figures comprise the crop water requirement and an irrigation efficiency factor.

3 Calculations based on coastal climatic data (Sezela/Kei Mouth integrations) and Port st Johns rainfall data.

Appendix A-5 Crop irrigation requirements: Zone 6 (Great River valleys)

	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
	Days	31	28	31	30	31	30	31	31	30	31	30	31	**365**	
Rainfall	mm/month	87	80	86	53	17	11	13	14	25	62	78	92	**618**	Summary of crop irrigation requirements
Rainfall efficiency		0.70	0.70	0.70	0.75	0.80	0.80	0.80	0.80	0.80	0.70	0.70	0.65		
Effective rainfall	mm/month	61	56	60	40	14	9	10	11	20	43	55	60	**439**	
Reference Et	mm/day	4.7	4.0	3.3	2.9	2.3	1.9	2.3	2.8	3.5	4.0	4.6	4.5		
	mm/month	146	112	102	87	71	57	71	87	105	124	138	140	**1 240**	
Crop water deficit	mm/month	85	56	42	47	58	48	61	76	85	81	83	80	**801**	
														mm	**m^3/ha/a**
Maize	cf	1.14	1.14	0.67								0.43	0.75		
	IR (mm/month)	**129**	**85**	**38**								**48**	**80**	**379**	**3 791**
Potato (winter)	cf				0.60	0.97	1.10	1.05							
	IR (mm/month)				**38**	**75**	**71**	**85**						**268**	**2 684**
Vegetables (winter)	cf			0.45	0.72	1.00	0.98	0.83	0.66						
	IR (mm/month)			**25**	**45**	**77**	**63**	**67**	**67**					**344**	**3 445**
Citrus	cf	0.83	0.83	0.85	0.57	0.86	0.86	0.86	0.84	0.83	0.83	0.83	0.83		
	IR (mm/month)	**78**	**52**	**40**	**30**	**55**	**46**	**58**	**71**	**78**	**74**	**77**	**74**	**733**	**7 326**

Irrigation efficiency (dragline sprinkler): 0.75
Irrigation efficiency (microjet sprinkler): 0.90

Notes 1 Owing to the lack of detailed knowledge of the soils, actual rotations etc, factors used to derive effective rainfall have been based on the consideration of amount of monthly rainfall and season.
2 The irrigation requirement (IR) figures comprise the crop water requirement and an irrigation efficiency factor.
3 Calculations based on Umtata climatic data.

Appendix B

Canola as a bio-fuel crop in the Mzimvubu River catchment

CANOLA AS A BIO-FUEL CROP IN THE MZIMVUBU CATCHMENT

Description

Canola, *Brassica napus* (Argentine type) and *Brassica campestris* (Polish type) is the name for edible oilseed rape. It is edible because it contains less than 2% erucic acid in the oil and less than 3 mg/g of glucosinolates in the meal.

Like soybean, canola has both a high protein (28%) and high oil content (40%). When the oil is crushed out, a high quality and highly palatable feed concentrate of 37% protein remains. These characteristics make the crop suitable for bio-fuel production.

Adaptability

Canola is a winter annual crop that is adapted to handle the cool extremes of the temperate zones. Canola is sensitive to high temperatures, especially during flowering.

The crop can usually be grown wherever wheat is successfully grown. In the South African context that includes the Western Cape and the Eastern Free State. In the areas where summer rainfall prevails the exploitation of conserved soil moisture is essential to achieve viable yields. Trials in South Africa in recent years have revealed that “autumn” planting in late February takes advantage of late summer rains without exposing the crop to excessively high temperatures at the sensitive flowering stage. The crop has a deep taproot which allows it to make better use of stored soil moisture than say wheat.

Growth habit

Canola growth is characterized by six main growth stages. Much of the management of this crop is related to the length of time and plant characteristics within each of these stages.

- Stage 0 is pre-emergence. The germinating seedling may take from 4 to 10 days to emerge.
- Stage I is the seedling stage where the very young plant has just emerged from the soil. Since the early canola crop is a poor competitor, it is extremely important to get a good stand.
- Stage 2 is the rosette stage characterized by an increasing leaf area index. The plant will remain in this vegetative stage for several weeks. Tap root extension takes place during this phase.
- Stage 3. The bud stage. Increasing day length and temperatures initiate bolting and the beginning of Stage 3.
- Stage 4. Flowering begins Stage 4 and continues for 14 to 21 days.
- Stage 5, the ripening phase, begins when the petals fall from the last formed flower on the main stem. Pod fill is complete 35 to 45 days after flower initiation, and the seeds contain about 40% moisture at this point. The crop is considered ripe and ready for combining when 30 to 40% of the seed from pods on the main stem have turned color. Maturity is reached between 70 and 120 days depending on variety. Canola dries from bottom to top, requiring close monitoring and excellent management due to its susceptibility to shattering when mature.

Soil moisture requirements

Canola, which has a 3 to 4 month growing period, requires between 500 to 700 mm of winter rainfall (with a significant amount of stored summer rainfall in the soil) for economic growth and production. Where the crop is planted in autumn, in a summer rainfall environment, well managed soil-moisture conservation measures are essential.

Production constraints

- The crop shows a characteristic lack of early competitiveness.
- Many insects and pests affect canola crops through the various growth phases.
- Since rape seedlings are unable to compete with weeds, particularly during the long "dormant" rosette stage, a good plan for weed control is crucial. Cruciferous weeds are nearly impossible to control in the crop.
- Timely harvest of canola is critical to prevent shattering.
- Yields decline rapidly with increasing temperatures, largely due to heat stress.

Production benefits

- Canola is a good rotation crop for maize and other monoculture crops, but double cropping every year is not achievable.
- The crop allows a higher land use which improves the return to capital expenditure on equipment and other overhead costs and hence improves farm viability.

Suitability to the Mzimvubu River catchment

- The Basin shows distinct summer rainfall characteristics and therefore is not considered ideally suited to a winter crop like canola. The storage of late summer rainfall in fallow soils would however provide a means of growing the crop in the region.
- For the reasons outlined above canola requires a high level of management and a considerable degree of mechanization which may not be conducive to emerging farmers with limited resources. Commercially-based production is therefore a minimum requirement for this crop. Joint ventures between local farmers and "commercial" farmers could be an appropriate approach. Contract harvesting would also be recommended.