# Assessment of the Irrigation Potential in Burundi, Eastern DRC, Kenya, Rwanda, Southern Sudan, Tanzania and Uganda

# Final Report
# Appendix Tanzania

July 2012

**Client**
Nile Basin Initiative
NELSAP Regional Agricultural Trade and Productivity Project

**Report FutureWater: 114**


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# PREFACE

The Nile Basin Initiative (NBI), under the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) and the project Regional Agricultural Trade and Productivity Project (RATP) announced a Request for Proposals (RFP) entitled "Assessment of the Irrigation Potential in Burundi, Eastern DRC, Kenya, Rwanda, Southern Sudan, Tanzania and Uganda" in July 2010 (RATP/CONSULTANCY/04/2010). The study was categorized as "preparation for a development program" and has therefore a strategic perspective.

FutureWater, in association with WaterWatch, submitted a proposal in response to this RFP. Based on an independent Technical and Financial evaluation FutureWater, in association with WaterWatch, has been selected to undertake the study.

The consulting services contract was signed between the "Nile Basin Initiative / The Regional Agricultural Trade and Productivity Project" and "FutureWater in association with WaterWatch" entitled "Consulting Services for Assessment of the Irrigation Potential in Burundi, Eastern DRC, Kenya, Rwanda, Southern Sudan, Tanzania and Uganda". This contract was dated 5-Feb-2011 and total project duration is 16 months. The Contract Reference Number is: NELSAP CU/RATP2/2011/01. Tangible outputs of this study area:

- Inception report
- Phase 1 report
- Seven country reports phase 2
- Final report

The Consultants wish to acknowledge the support, fruitful discussions and useful comments from all NBI-RATP staff and stakeholders in the countries. In particular Dr. Innocent Ntabana and Dr. Gabriel Ndikumana are acknowledged for starting this initiative and their support and advice on the study.

Various people and institutions have contributed to this specific country/focal area report: Eng. Amandus Lwena, Gaspar Mashingia, Wilson Kalumuna, Mbogo Futakamba, amongst others. Their contribution is highly appreciated.

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# 1 Introduction

## 1.1 Background[1]

Tanzania (Figure 1) is located in East Africa and shares its borders with Kenya and Uganda in the north, Rwanda, Burundi and the Democratic Republic of Congo to the west, and Zambia, Malawi and Mozambique to the south. The Indian Ocean is located at the eastern border of Tanzania. Tanzania covers an area of 945,203 km$^2$, of which 6.2% is water. The 2009 population estimates is 43.7 million.


**Figure 1: Map of Tanzania (source: CIA Factbook).**

### *1.1.1 Socio-economy*

Agricultural Sector is still the leading sector of the economy of Tanzania, despite the rapid growth of the mining sector, and accounts for over a quarter (1/4) of the GDP and export earnings. The agricultural GDP has grown at 3.3% per year since 1985, the main food crops at 3.5%, and export crops at 5.4% per year. Over 80% of the poor people live in rural areas and their livelihood depends on agriculture. Moreover, about 80% of the population live and earn their living in rural areas with agriculture as the mainstay of their living. It has linkages with the non-farm sector through forward linkages to agro-processing, consumption and export. These linkages provide raw materials to industries and a market for manufactured goods. The agricultural sector has maintained a steady growth rate of over 3% per annum over the last decade. Although this is greater than the growth rate of the population, this rate is considered to be unsatisfactory, because it has failed to improve the livelihood of the rural population whose major occupation is agriculture. This has often resulted in localized food insecurity and hunger, which has been intensified by the lack of access to external resources for households.

[1] Information in this chapter is among other sources based on: FAOSTAT, CIA world fact book, UNDP, phase 1 report. Ntamavukiro, 2007 and Niyongabo, 2007.

### 1.1.2 *Millennium Development Goals, current status*

The Millennium Development Goals (MDG) report, published in 2010, is not only giving an update about the current state of the MDGs, but also looks back to 50 years independence. To achieve the objectives of the MDGs, the government implemented a strategy for growth and poverty reduction. This strategy contains clear guidelines and an action plan to bring it into practice.

Tanzania is clearly on track to achieving the MDGs related to primary education, child mortality, gender equality, and access to improved sanitation, but is lagging behind in other MDGs. Although progress has been made, the spread of HIV/AIDS is the single most impoverishing force facing people and households in Tanzania today. If not halted and reversed, it threatens not only the achievement of the targets in the Poverty Reduction Strategies MKUKUTA and MKUZA but the MDGs more broadly.

Despite the progress made, the country still faces huge challenges: economic growth has been neither broad based nor robust enough to lead to a significant reduction in poverty, and indicators for social progress are less than impressive. As a result, the overall human development remains low, with a human development index of 0.398 in 2010, compared to 0.329 in 1990.

With a sound policy framework for poverty reduction and its comprehensive poverty monitoring system, Tanzania can achieve most of the MDGs by 2015, if concerted efforts are directed towards addressing the HIV/AIDS pandemic, strengthening institutional, structural, policy and infrastructural capacity, improving efficiency in resource mobilization, and strengthening the PRS focus on MDGs as a strategic tool for meeting the 2015 target.

Although recent statistics and information (2000/01 and 2007 HBS) show that it is unlikely that Tanzania will reduce extreme poverty by 2015, Tanzania has a potential of reducing food poverty by 2015, if the current efforts to revive and accelerate agriculture production can be sustained (MDGR 2008).

Policy direction towards a pro-poor growth strategy targeting investments in key areas such as income and employment generating activities, provision of basic services such as health and quality education and infrastructure would be critical for meeting the MDG targets.

A condensed overview is provided here about the current status of the MDGs and its projection to achieve these MDGs is provided by UNDP[1].

**Goal 1: Eradicate Extreme Poverty and Hunger**

- 1.1 Proportion of population below
  - ► Not achievable
- 1.8 Under-5 Underweight
  - ► Not achievable
- 1.8 Under-5 Stunted
  - ► Not achievable

**Goal 2: Achieve universal primary education**

- 2.1 Net enrolment ratio in primary education
  - ► Achievable
- 2.2 Gross enrolment ratio in primary education
  - ► Achievable

[1] http://www.tz.undp.org/mdgs_progress.html

**Goal 3: Promote gender equality and empower women**

- 3.1 Ratio of girls to boys in primary school
  - ► Achievable
- 3.2 Ratio of girls to boys in secondary school
  - ► Achievable
- 3.3 Ratio of females to males in tertiary education
  - ► Achievable probable
- 3.4 Proportion of women among members of Parliament
  - ► Achievable probable

**Goal 4: Reduce child mortality**

- 4.1 Under-five mortality rate
  - ► Achievable
- 4.2 Infant mortality rate
  - ► Achievable probable
- 4.3 Proportion of children vaccinated against measles
  - ► Not achievable

**Goal 5: Improve maternal health**

- 5.1 Maternal Mortality Ratio
  - ► Not achievable
- 5.2 Proportion of births attended by skilled health personnel
  - ► Not achievable

**Goal 6: Combat HIV/AIDS, malaria and other diseases**

- 6.1 HIV prevalence, 15-24 years
  - ► Achievable
- 6.3 Number of malaria cases and incidence
  - ► Achievable probable
- 6.3 Number of tuberculosis cases and incidence
  - ► Not achievable

**Goal 7: Ensure environmental sustainability**

- 7.8 Proportion of rural population using an improved drinking water source
  - ► Not achievable
- 7.8 Proportion of urban population using an improved drinking water source
  - ► Achievable
- 7.9 Proportion of people with access to improved sanitation
  - ► Achievable

**Goal 8: Develop a global partnership for development**

- Not assessed yet

### 1.1.3 Poverty reduction strategy [1]

Tanzania is implementing its poverty reduction strategy through its so called MKUKUTA II. The overall focus is to continues to be that of accelerating economic growth, reducing poverty, improving the standard of living and social welfare of the people of Tanzania as well as good governance and accountability. MKUKUTA II is a vehicle for realizing Tanzania's Development Vision 2025, the Millennium Development Goals (MDGs).

Though MKUKUTA II builds on its predecessor's strategy, it is oriented more towards growth and enhancement of productivity, with greater alignment of the interventions towards wealth creation as a way out of poverty. This orientation thus opens space for realignment of subsequent medium term strategies and calls for more active private sector participation. MKUKUTA II has also been informed by changes in the global environment. The recent global financial and economic crises will continue to have ramifications on Tanzania's economy for some time. Besides the shocks, policy developments at the global and regional levels have continued to shape the way Tanzania interacts with other economies .There are opportunities and, sometimes, constraints associated with WTO, EPA policies related to global economic architecture, climate change, as well as regional developments such as the onset of the East African Common Market .MKUKUTA II takes cognizance of the opportunities associated with these developments, such as, trade expansion, joint infrastructure development, and also non-economic benefits such as regional peace initiatives .

MKUKUTA II emphasizes on (i) focused and sharper prioritization of interventions - projects and programmes - in key priority growth and poverty reduction sectors (ii) strengthening evidence-based planning and resource allocation in the priority interventions (iii) aligning strategic plans of MDAs and LGAs to this strategy (iv) strengthening government's and national implementation capacity (v) scaling up the role and participation of the private sector in priority areas of growth and poverty reduction, (vi) improving human resources capacity, in terms of skills, knowledge, and efficient deployment (vii) fostering changes in mind-set toward hard work, patriotism, and self-reliance; (viii) mainstreaming cross cutting issues in MDAs and LGAs processes, (ix) strengthening the monitoring and reporting systems; and (x) better implementation of core reforms, including paying strong attention to further improvement of public finance management systems .

### 1.1.4 Legal framework

The new National Water Policy (NAWAPO) of July 2002 is the outcome of a review of the national water policy of 1991. The review was carried out under the River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP) and the new policy incorporated the principles of IWRM that were initiated by the Dublin Water Conference. In July 2002 the Government of Tanzania issued the National Water Policy whose main objectives were to establish a comprehensive framework: for sustainable development and management of water resources and for participatory agreements on the allocation of water uses. The policy incorporated the decentralization drive that was launched by the Local Government Reform Program. The Ministry of Water became responsible for the Policy, Legal and Institutional Frameworks function and the operational function was delegated to Local Government Authorities. Basin Water Offices were established to coordinate water resource management between the Regional and Local Government authorities at river basin level. In February 2005 the Government issued the National Water Sector Development Strategy 2005 to 2015.

[1] This section is based on: Second National Strategy for Growth and Reduction of Poverty (NSGRP II)


**Figure 2: Map of Mwanza zonal irrigation area showing Lake Victoria regions (Source: EUWAP, 2010)**

| TANZANIA – INSTITUTIONAL | |
|---|---|
| Main guiding policies, act and ordinances | • *The National Irrigation Policy (2009), it covers all areas of irrigation interventions*<br>• *National Irrigation Management Plan 2002 (NIMP), proposes an irrigation development programme that includes only smallholder schemes and is to be implemented by 2017 (ICID).*<br>• *Tanzania Development Vision 2000-2025 (TDV-2025)(GoT, 2009)*<br>• *National Strategy for growth and Reduction of Poverty (NSGRP-MKUKUTA) June 2005*<br>• *Agricultural Sector Development Strategy (ASDS) 2001*<br>• *Agricultural Sector Development Programme (ASDP) 2006*<br>• *Rural Development Strategy (RDS) 2001*<br>• *Water Resources Management Act No. 11 (2009) (WRMA)*<br>• *5-year water resource management plans exist at catchment level (Kashaigilli, 2010, pp. 48)* |
| Institutional mandate irrigation development (Kashaigilli, J.J., 2010) | • *Ministry of Water and Irrigation, decentralized till scheme level through District Offices; Regional and local Government Authorities (LGA)Irrigation Scheme Management Support Teams (SMST)*<br>    o *Water Resource Division*<br>• *Other institutions are catchmennt and sub-catchment water committees of the basin (need to be established as section 29 of WRMA articulates) (Kashaigilli, 2010, pp. 40)*<br>• *Tanzania National Committee for Irrigation and Drainage (TANCID)* |
| Water Permit System – Drillers (Kashaigilli, 2010, p. 40) | *Application for "Permit for water well drilling and installation" at Basin Water Boards, Water Resources Division. DDCA (Drilling and Dam Construction Agency) is a licensed driller* |
| Water Permit System – Users (Kashaigilli, 2010, p. 48 and 49) | *These are issued by the Basin water Boards (section 43 of the WRMA) provision will be set out by WRMA for quantity, pollution, drainage, etc., same applies for groundwater use, section 54 of the WRMA, according to safe yield of aquifer, as described in section 61 of the WRMA. As WRMA is new current permits are issued without considering existing policy framework.* |
| Other institutions involved in irrigation development | *International donors are dozens World Bank, USAID and IFAD* |
| Local organizations | • *WUAs are established as part of section 80, WRMA*<br>• *Irrigators organization will be established and participate in O&M of scheme management (GoT, 2009)* |

| | |
|---|---|
| Private sector | • *The participation of Private Sector in construction, consultancy services, support services and management in irrigation development in Tanzania is very low.(GoT, 2009, pp. 32)* |
| Support to small scale irrigation development (vocational sector, land planning) | *There are ultiple academic and research institutions relevant of implementation of National irrigation policy, as mentioned: Sokoine University of Agriculture (SUA), University of Dar es Salaam (UDSM), Ardhi University, Dar es salaam Institute of Technology, Ministry of Agriculture Training Institutes (MATIs), Ministry of Agriculture Research Institutes (MARIs), Water Development and Management Institute (WDMI), Vocational Education Training Authority (VETA) (GoT, 2009)* |
| Land tenure | *Most of the arable land is categorised as village land and some as general land. However, land administration procedures are not streamlined to the extent that the granting of title deeds is painstakingly slow (GoT, pp. 36)* |

| TANZANIA - SOCIO-ECONOMIC | |
|---|---|
| Food exports, FAO (current US$M) (FAO Statistical Yearbook 2010) | 361.59 |
| Food imports, FAO (current US$M) (FAO Statistical Yearbook 2010) | 554.49 |
| Imports/exports | 1,53 |
| Health expenditure per capita (World Bank, current US$, 2009) | 25 |
| Improved water source (% of population with access) (World Bank, | 54 |
| Improved water source, rural (% with access) (Kashaigilli, J.J.,2010) | 53 |
| Improved water source, urban (% with access)(Kashaigilli, J.J., 2010) | 73 |
| Poverty (% below national poverty line) (Kashaigilli, J.J., 2010) | 33.4 |
| Illiteracy rate –Male (15+) (UNICEF, 2009) | 21 |
| Illiteracy rate --Female (15+) | 33.1 |
| Primary completion rate, total (% of relevant age group) (World bank, | 74 |
| Road density (road km/100 sq. km of land area) (IRF, 2008) | 9 |
| Road to arable land density (road km/1000 sq. Km arable land) (IRF, | 8.33 |
| Roads, paved (% of total roads) (FAOSTAT, 2008) | 7 |
| Electric power consumption (kWh per capita) (World Bank, 2009) | 61 |
| Country area (km2) (FAOSTAT, 2009) | 947,300 |
| Land area (km2) | 885,800 |
| Population, Projected/Estimated (FAOSTAT, 2010) | 44,841,000 |
| Urban population (% of total population) (FAOSTAT, 2010) | 26 |
| Rural population (% of total population) (FAOSTAT, 2010) | 74 |
| Population density (pp/km$^2$) (World Bank, 2010) | 51 |
| **AGRICULTURAL** | |
| Agricultural exports (US$M) (FAOSTAT, 2008) | 954.06 |
| Agricultural Import (Current US$M) | 643.26 |
| Import/export | 0,67 |
| Value added in agriculture, growth (%) (World Bank, 2010) | 5 |
| Value added, agriculture (% of GDP) (AQUASTAT, 2006) | 45.3 |
| Employment agriculture (% of population) (Kashaigilli, J.J., 2010) | 79 |
| Agricultual machinery (tractors /100 square km arable) (World bank, | 19.00 |
| Agriculture value added per worker (Constant 2000 US$) (WB, 2009) | 283 |
| Fertilizer consumption (kg per hectare of arable land) (WB, 2008) | 5.9 |
| Cereal cropland (% of land area) (of which irrigated, %) (WB, 2009) | 6 |
| Agricultural area (FAO Resource Stat, 2009) | 35,500,000 |
| Arable land (FAO Resource Stat, 2009) | 10,000,000 |

| IRRIGATED AGRICULTURE | |
|---|---|
| Irrigated land (% of crop land) (Aquastat, 2002) | 1.79 |
| Irrigated land entire country (ha) (Kashaigilli, J.J.,2010 and AQUASTAT, 2000) | 200,000 - 854,300 |
| Actually irrigated (ha) | n.a. |
| Irrigation potential (entire country) (Kashaigilli, J.J.,2010 and AQUASTAT, 2007) | 2,100,000-2,132,000 |
| Irrigated Land nile basin (potential) (Bastiaansen and Perry, 2009) | 475 |
| Irrigation schemes in Nile Basin | n.a. |
| Small schemes (national level) (ha) | n.a. |
| Medium schemes (national level) (ha) | n.a. |
| Large schemes (national level)(ha) | n.a. |
| Potential schemes (Nile Basin) | n.a. |
| Water Sources | All irrigation sites are irrigated with surface water |
| Water Sources - Names | Pangani river basin |
| Irrigated area per household (ha) (national level) | n.a. |
| **SUSTAINABLE WATER ABSTRACTION RATES (AQUASTAT, 2000)** | |
| Renewable resources (km3/year) | 96.27 |
| Overlap | 26 |
| Surface water | 92.27 |
| ground water | 30 |
| Dependency ratio | 12.75 |
| **ACTUAL WATER ABSTRACTION RATES** | |
| Groundwater (km3/year) (Kashaigilli, J.J., 2010) | 1.27 |
| Surface (km3/year) | 3.89 |
| Total water withdrawal (km3/year) (Kashaigilli, J.J., 2010 and AQUASTAT, 2002) | 5.14- 5.18 |
| % of renewable water resources | 5.36 |
| **Water abstraction points** | |
| Deep Motorized boreholes (Kashaigilli, J.J., 2010) (2005) | 1,497 |
| Motorized boreholes | n.a. |
| Manual boreholes (Kashaigilli, J.J., 2010) (2005) | 9,281 (growth 1,600 per year) |
| Protected shallow wells (Kashaigilli, J.J., 2010) (2005) | 4,871 |
| Windmill boreholes (Kashaigilli, J.J., 2010) (2005) | 475 |
| Springs | n.a. |
| Water networks | n.a. |

| **IRRIGATION PERFORMANCE (Bastiaansen and Perry, 2009)** | |
|---|---|
| Overall Irrigation performance Large Scale Irrigation (0-5) | 3.17 |
| Result Oriented Performance | 3.07 |
| Sustainability Oriented Performance | 2.7 |
| Process Oriented Performance | 3.65 |
| **Detailed Irrigation Performance Parameters** | |
| Water Productivity (Performance 0-5) (Rank within Nile Basin 1-8) | 3.1 (2) |
| Agricultural water Productivity | 3.1 (3) |
| Crop consumptive use | 3.2 (4) |
| Beneficial Water Use | 3.2 (4) |
| Adequacy | 3.3 (3) |
| Uniformity | 4.5 (2) |
| Reliability | 3.1 (7) |
| Sustainability | 3.9 (1) |
| **AGROPHYSICAL (Bastiaansen and Perry, 2009)** | |
| Irrigated crops (ha) | Maize (16,000), Rice (34,000), Vegetables (38,000), Citrus (7,000), Sugarcane (13,000) |
| Cereal yield rainfed (kg/ha) (Nett yield) | 1,335 |
| Biomass production (satellites) (kg/ha) (Nett yield) | 16,947 |
| Cereal yield irrigated (kg/ha) (Nett yield) | 7,346 |
| Yield Increment | 6,01 |
| Net Increment | 1,803 |

# 2 Countrywide irrigation potential

## 2.1 Terrain and soil

### *2.1.1 Relief, climate, and hydrography*

Tanzania is mountainous in the northeast, where Mt. Kilimanjaro, Africa's highest peak, is located. To the north and west are the Great Lakes of Lake Victoria and Lake Tanganyika. Central Tanzania comprises a large plateau, with plains and arable land. The eastern shore is hot and humid, with the island of Zanzibar lying just offshore.

Tanzania has a tropical climate with temperatures in the highlands ranging between 10 and 20°C during cold and hot seasons, respectively. The remaining part of the country has temperatures rarely falling below 20°C. The hottest period extends between November and February (25-31°C), while the coldest period occurs between May and August (15-20°C). The annual temperature is 32°C and the climate is cool in the high mountain regions. Tanzania has two rainfall regions, with one being modal (December-April), and the other being bimodal (October-December and March-May). The former is experienced in southern, south-west, central and western parts of the country, and the latter is found to the north and northern coast. One third of Tanzania receives less than 800 mm of rainfall, which is characterized as the arid or semi-arid area. Only one-third of the rest of the country has precipitation of above 1,000 mm. According to Rwehumbiza (2007), seven main agro-ecological zones are present in Tanzania.

### *2.1.2 Terrain suitability*

The terrain slope is a key characteristic for assessing the irrigation potential. Steeper slopes evidently are less suitable for irrigation. Different types of irrigation also have different associated slope suitability. Three different irrigation types are included in the suitability analysis: border/furrow, sprinkler irrigation, drip irrigation, and hill-side irrigation (see main report). The base of this analysis is the digital elevation model of the 90-meters SRTM. This DEM was used to derive slopes and to undertake the suitability analysis.

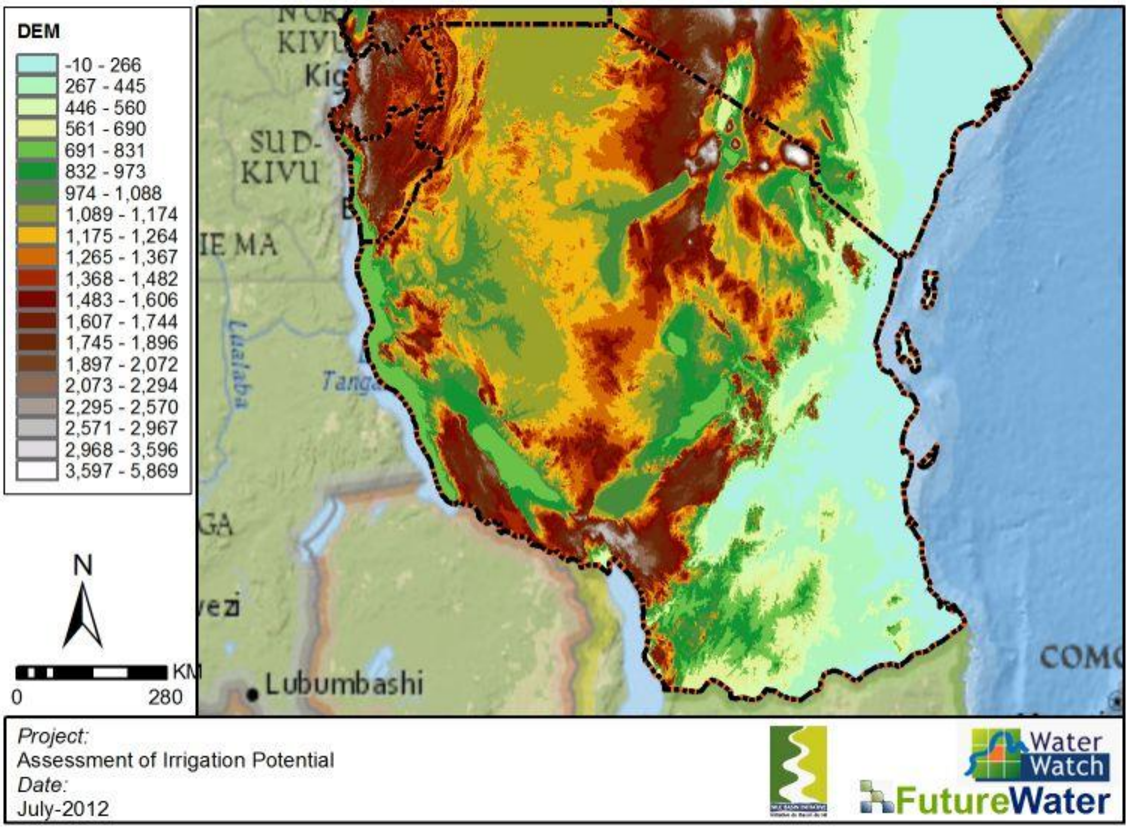
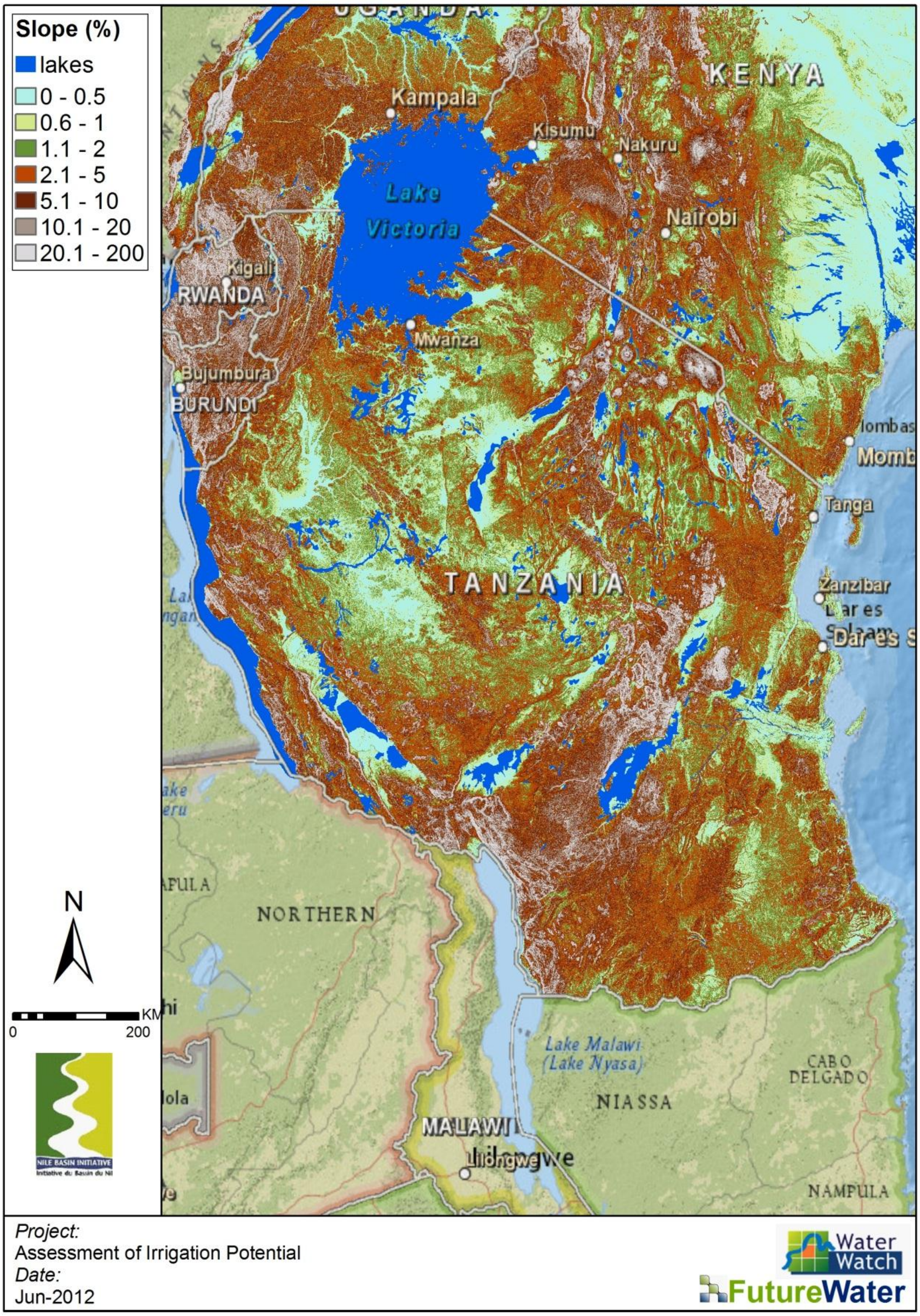
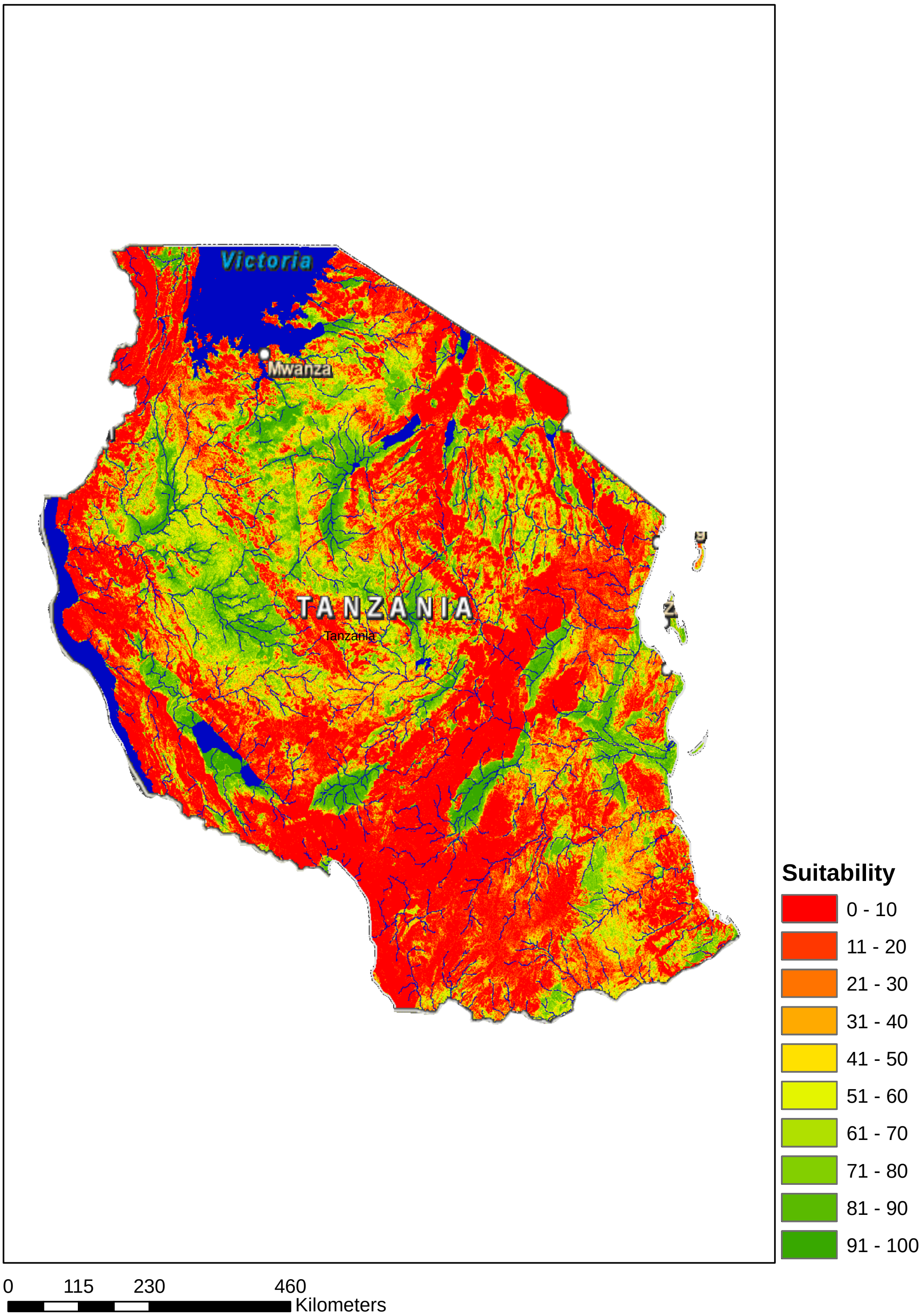



**Figure 3: Digital Elevation Model of Tanzania.**

In Figure 3 the DEM for the country is shown. Tanzania is characterized by large relatively flat areas and more mountainous regions. Associated slopes can be seen in Figure 4. Based on these slope classes for each of the three irrigation types suitability for irrigation has been determined. It is clear that suitability for surface irrigation, drip irrigation and hill-side irrigation is wide-spread over the country.


Slope (%)
lakes
0 - 0.5
0.6 - 1
1.1 - 2
2.1 - 5
5.1 - 10
10.1 - 20
20.1 - 200
N
KM
0
200
NILE BASIN INITIATIVE
Initiative du Bassin du Nil
KENYA
Kampala
Kisumu
Nakuru
Lake Victoria
Nairobi
Kigali
RWANDA
Mwanza
Bujumbura
BURUNDI
Tanga
TANZANIA
Zanzibar
NORTHERN
Lake Malawi (Lake Nyasa)
NIASSA
CABO DELGADO
MALAWI
NAMPULA
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
WaterWatch
FutureWater


Victoria
Mwanza
TANZANIA
Tanzania
Suitability
0 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
0
115
230
460
Kilometers

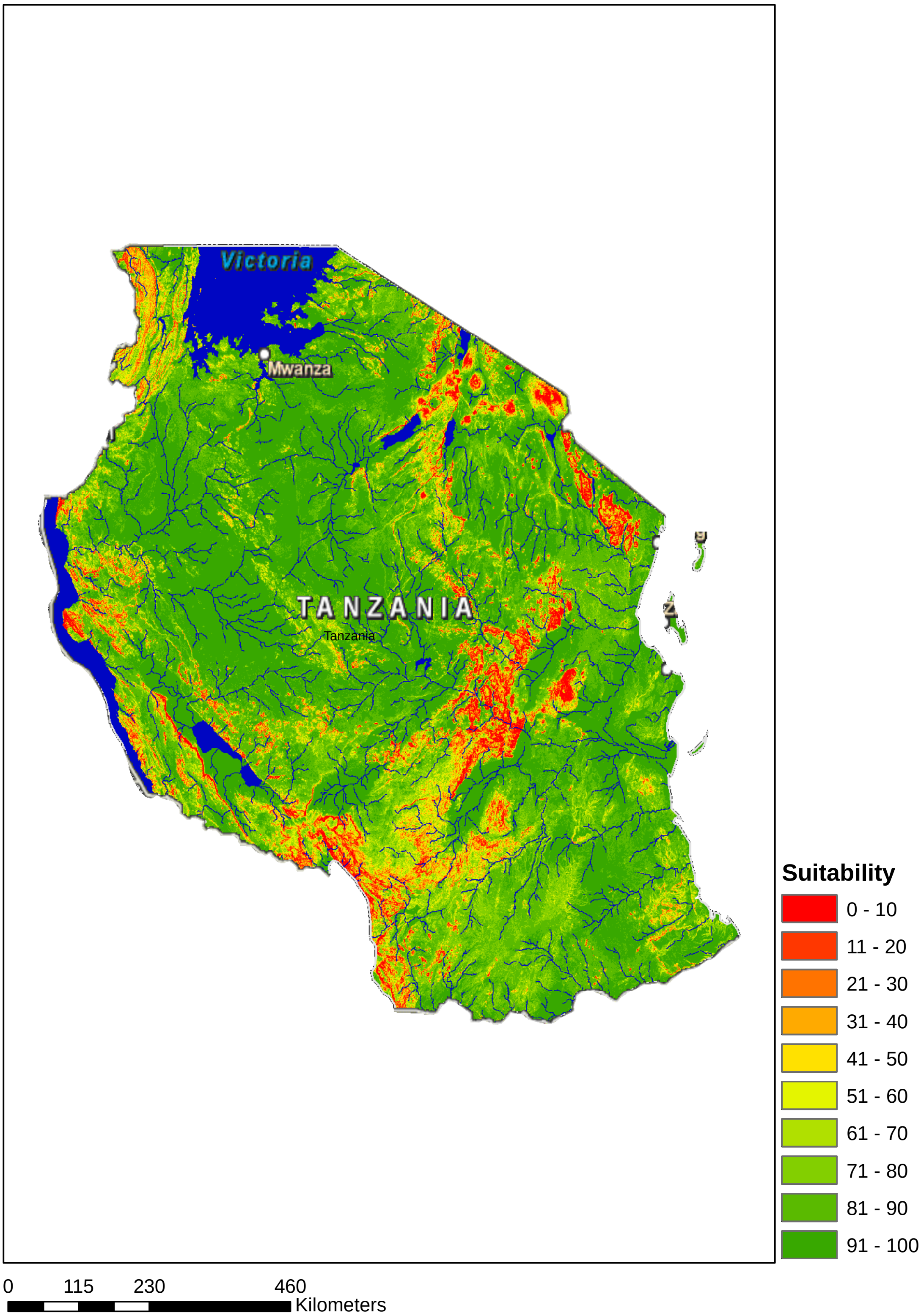
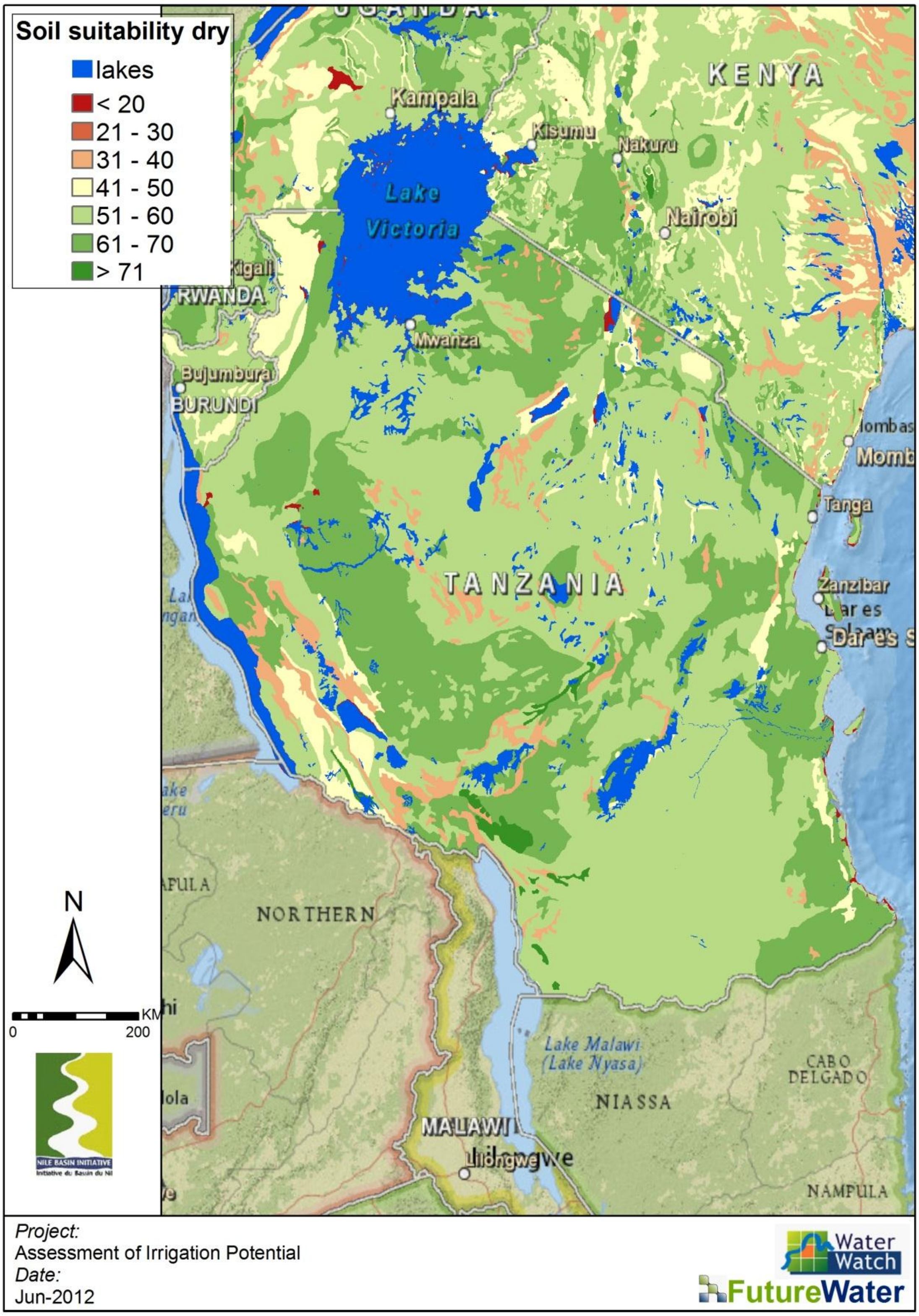



**Figure 4: Terrain slope as percentage (top), surface irrigation (middle), and drip irrigation (bottom).**

### 2.1.3 Soil Suitability

Based on local soil maps as combined in the Harmonized World Soil Database (HWSD) soil suitability for irrigation has been assessed based on the FAO methodology (for details see main report). The following characteristics are included in the soil suitability assessment: (i) organic carbon, (ii) soil water holding capacity, (iii) drainage capacity, (iv) soil texture, (v) pH, and (vi) soil salinity. Given the quite different characteristics for rice crops, two suitability maps were created.

Concerning the soil, Tanzania has a high suitability for both, dry crops and paddy.


Soil suitability dry
lakes
< 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
> 71
KENYA
Kampala
Kisumu
Nakuru
Nairobi
Lake Victoria
Kigali
RWANDA
Mwanza
Bujumbura
BURUNDI
Tanga
Zanzibar
TANZANIA
NORTHERN
Lake Malawi (Lake Nyasa)
NIASSA
CABO DELGADO
MALAWI
NAMPULA
N
KM
0
200
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater

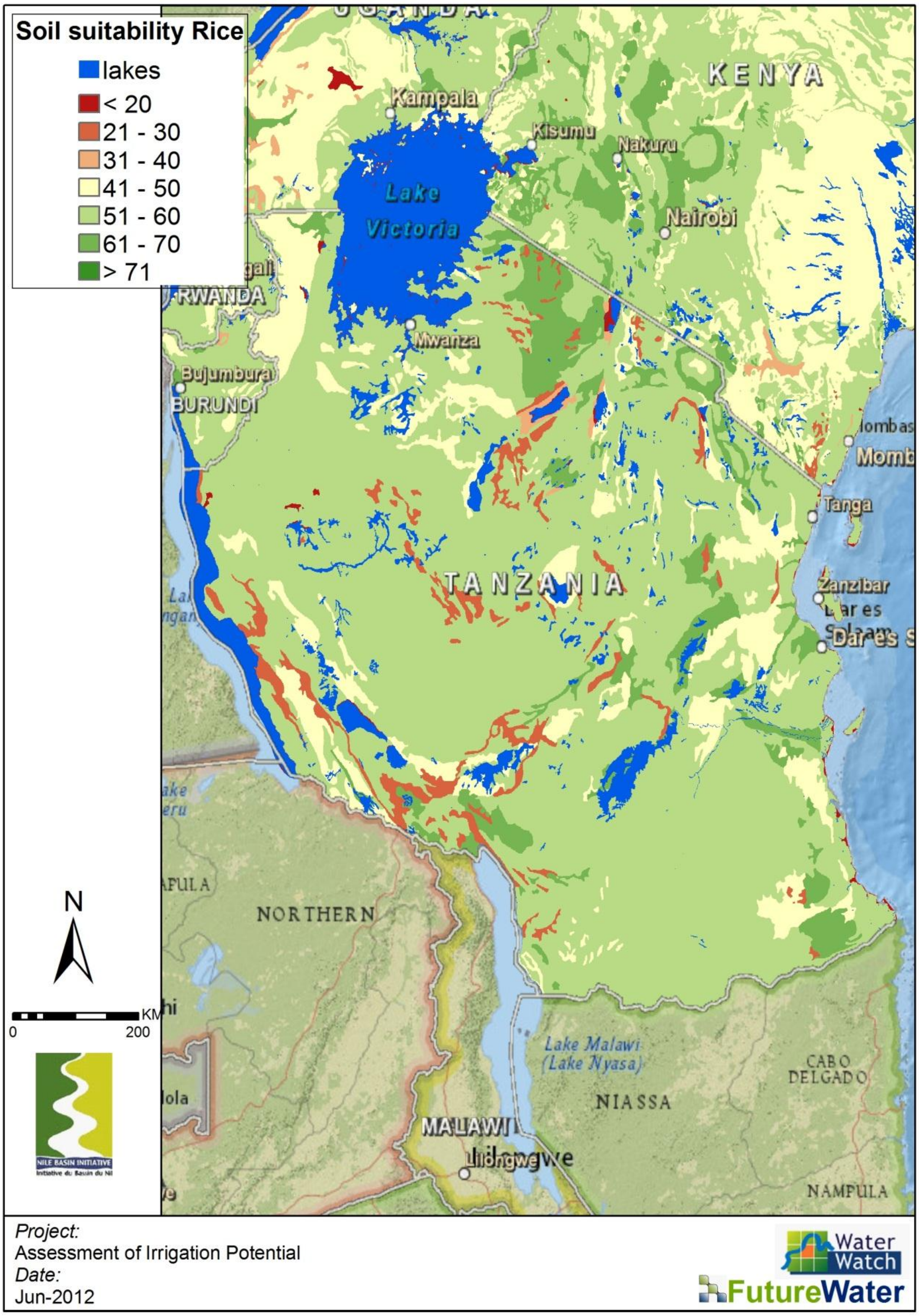



**Figure 5: Soil suitability for dry crops (top) and rice/paddy (bottom) (Source: study analysis)**

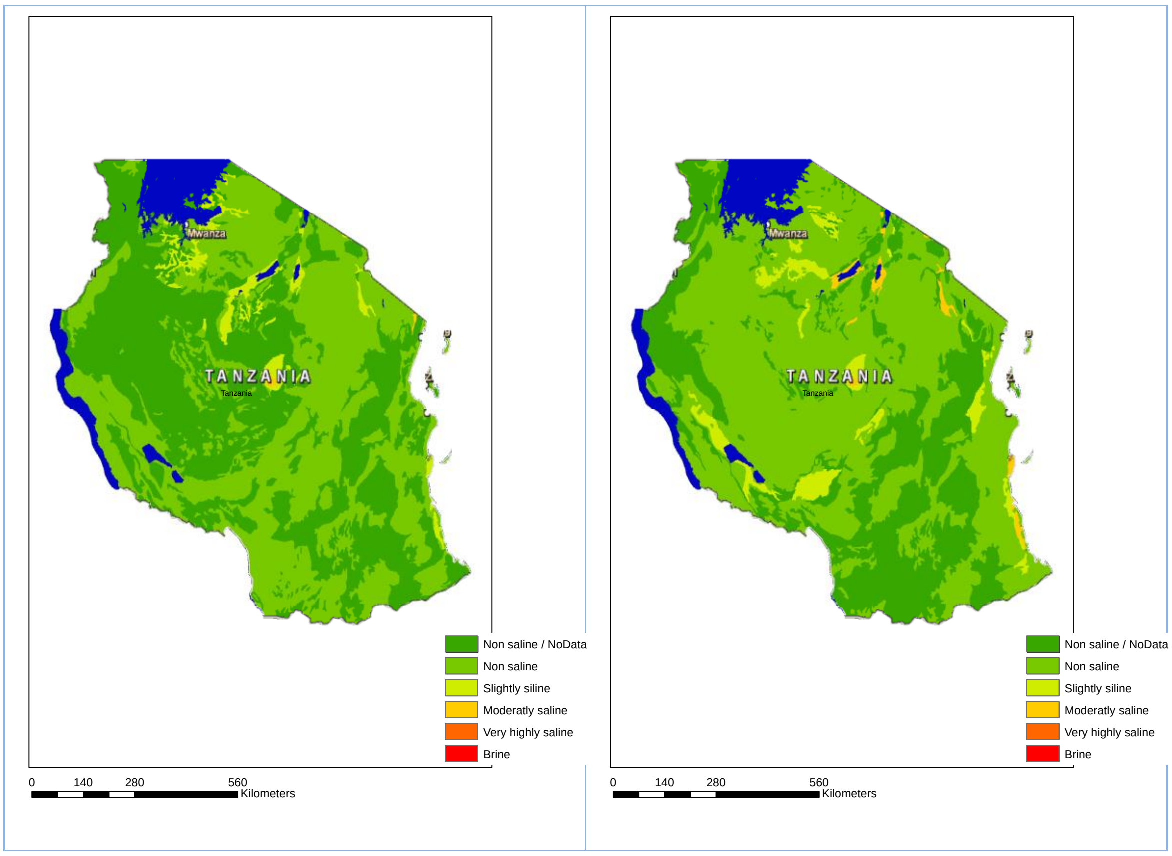


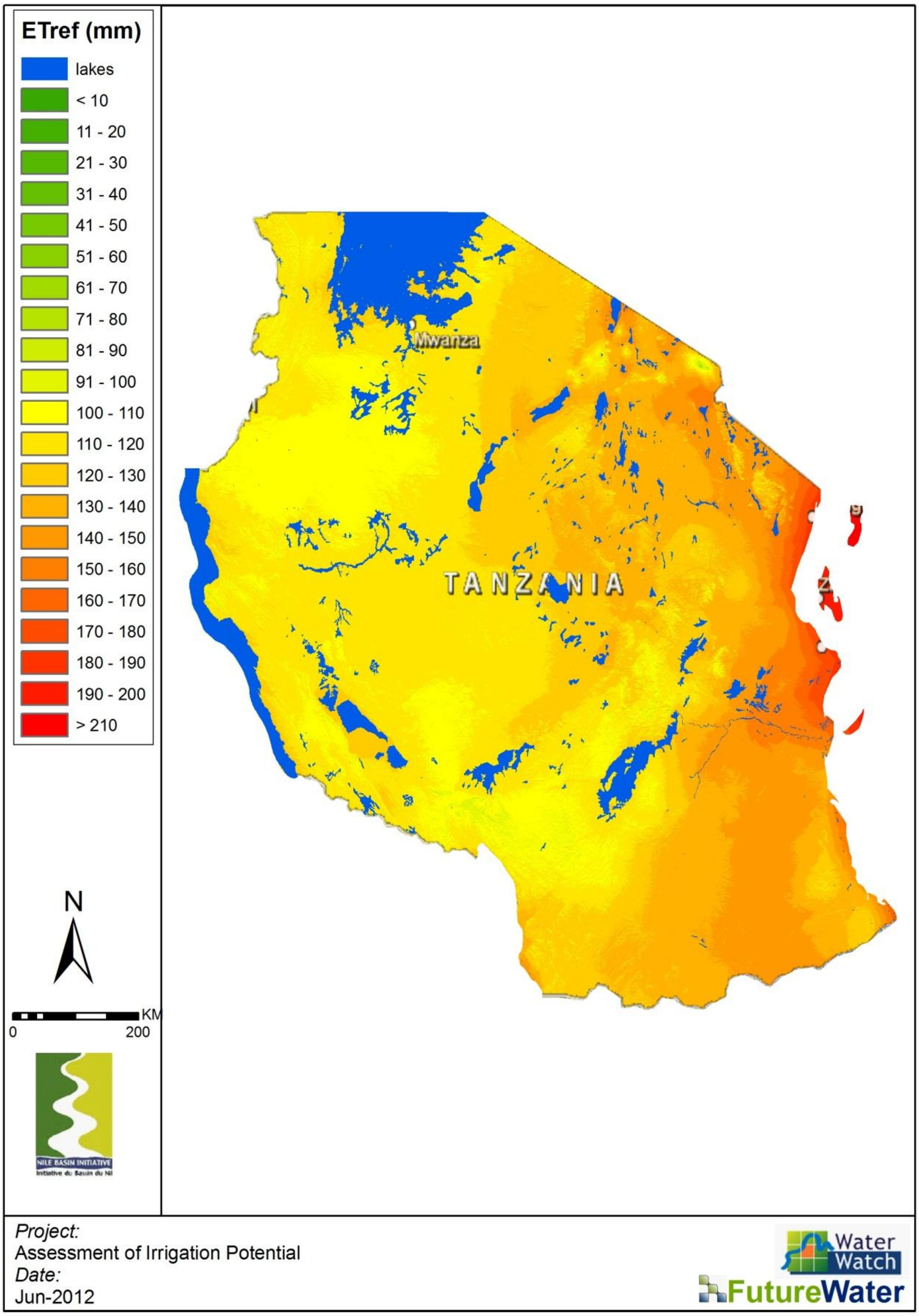

**Figure 6: Salinity, top-soil (left) and sub-soil (right). (Source: study analysis).**

## 2.2 Water

### *2.2.1 Irrigation water requirements*

The amount of water needed during a growing season depends on the crop, yield goal, soil, temperature, solar radiation, and other bio-physical factors. The amount of water required for irrigation is also a function of rainfall and irrigation efficiencies. During Phase 1 of this study the irrigation water requirements are based on an innovative method using satellite information (see main report for details). The following maps provide for each month the reference evapotranspiration (= evaporative demand of the atmosphere), the actual evapotranspiration under current conditions and the final irrigation water requirements.

*January*


ETref (mm)
lakes
< 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
100 - 110
110 - 120
120 - 130
130 - 140
140 - 150
150 - 160
160 - 170
170 - 180
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Water Watch
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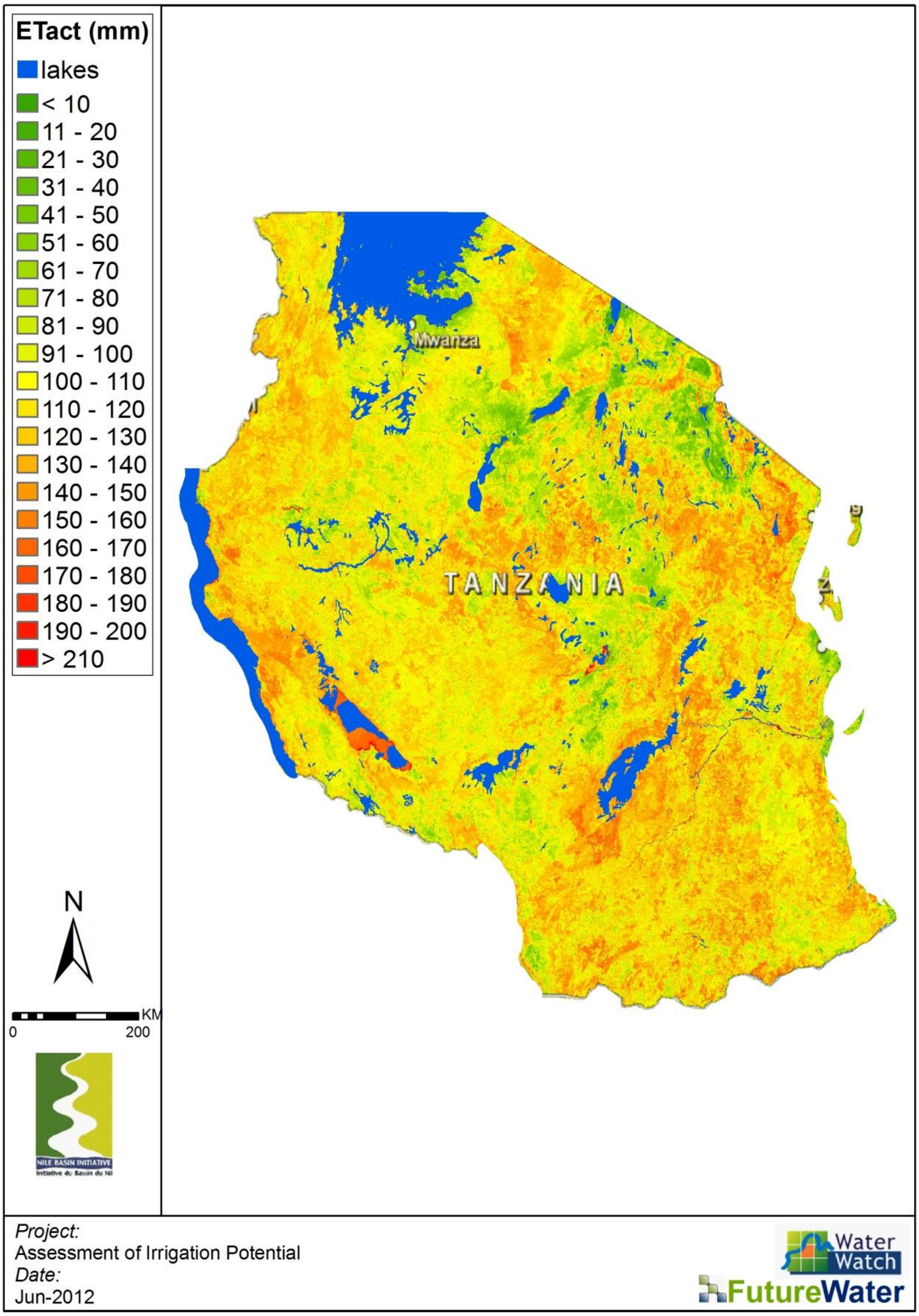
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WaterWatch
FutureWater

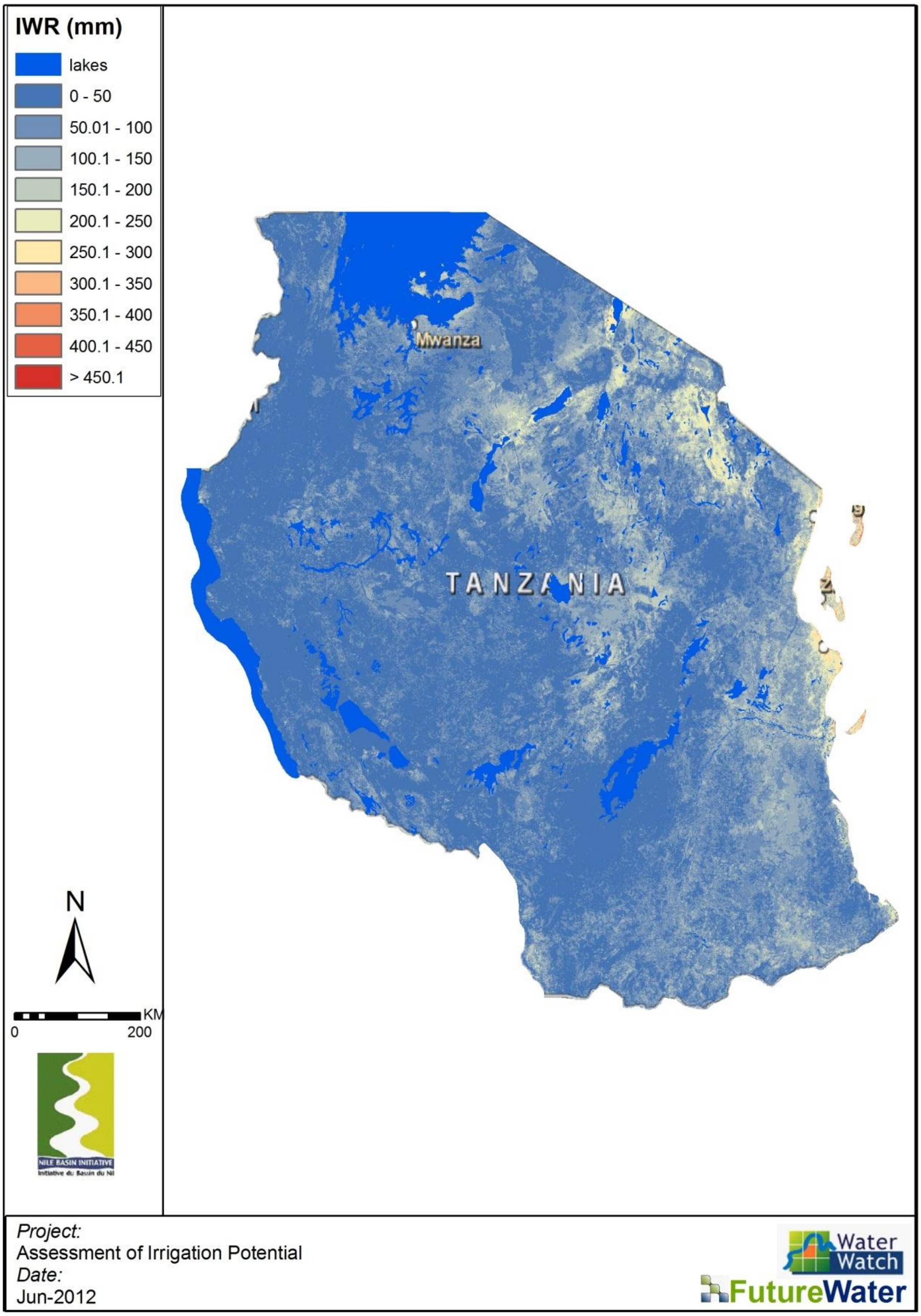
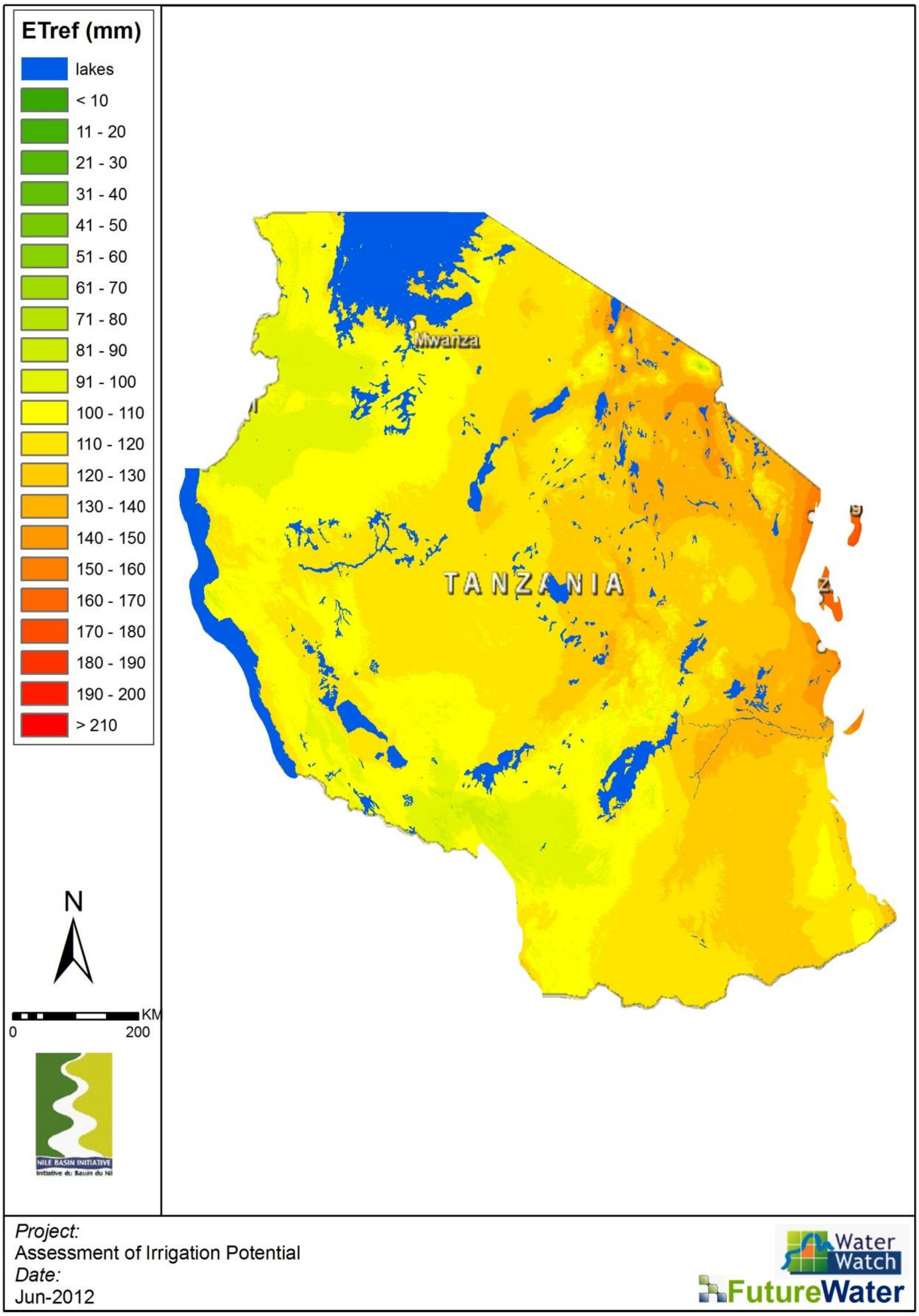



**Figure 7: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom). for January (Average 2001-2010). (Source: study analysis).**

### *February*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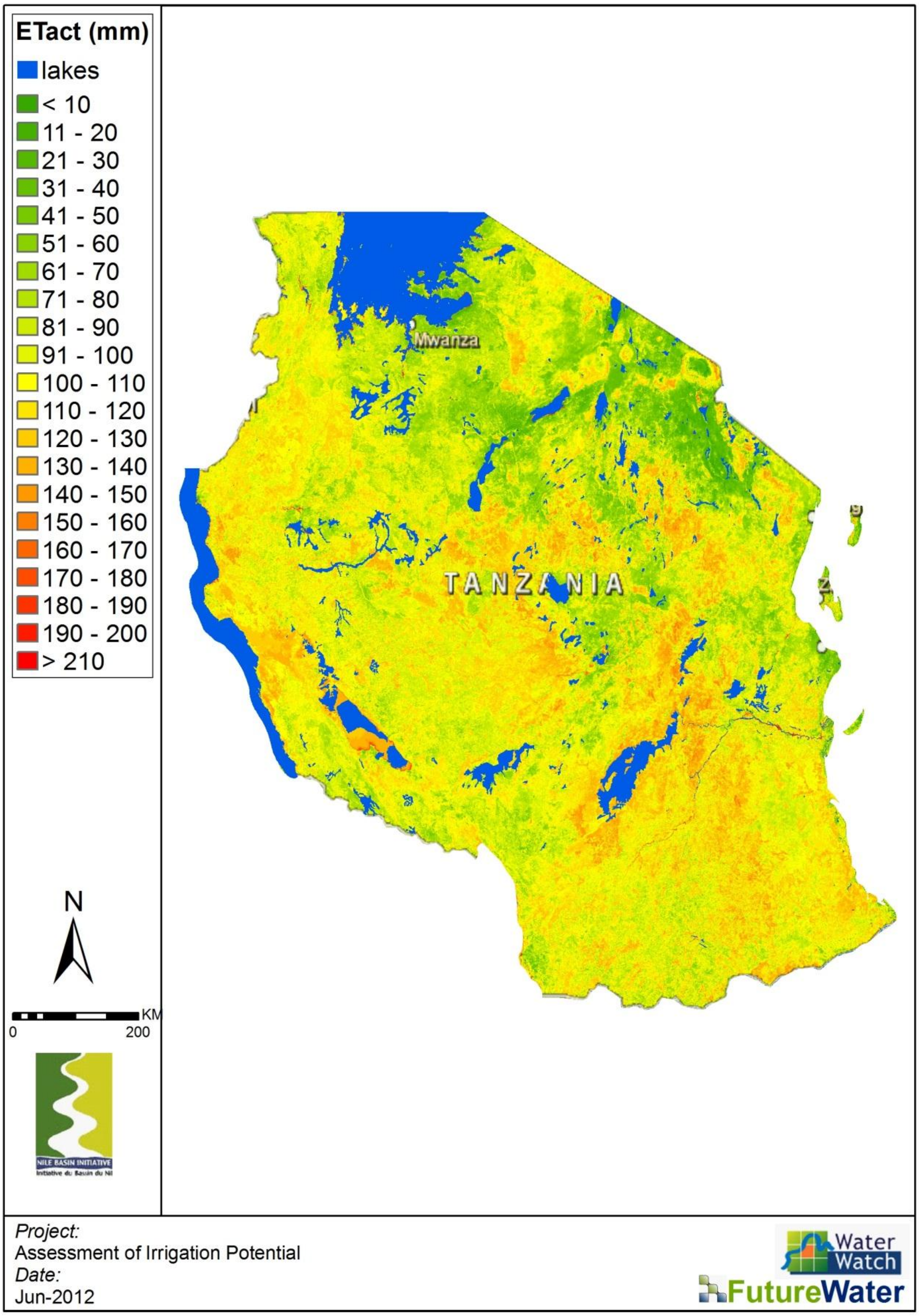
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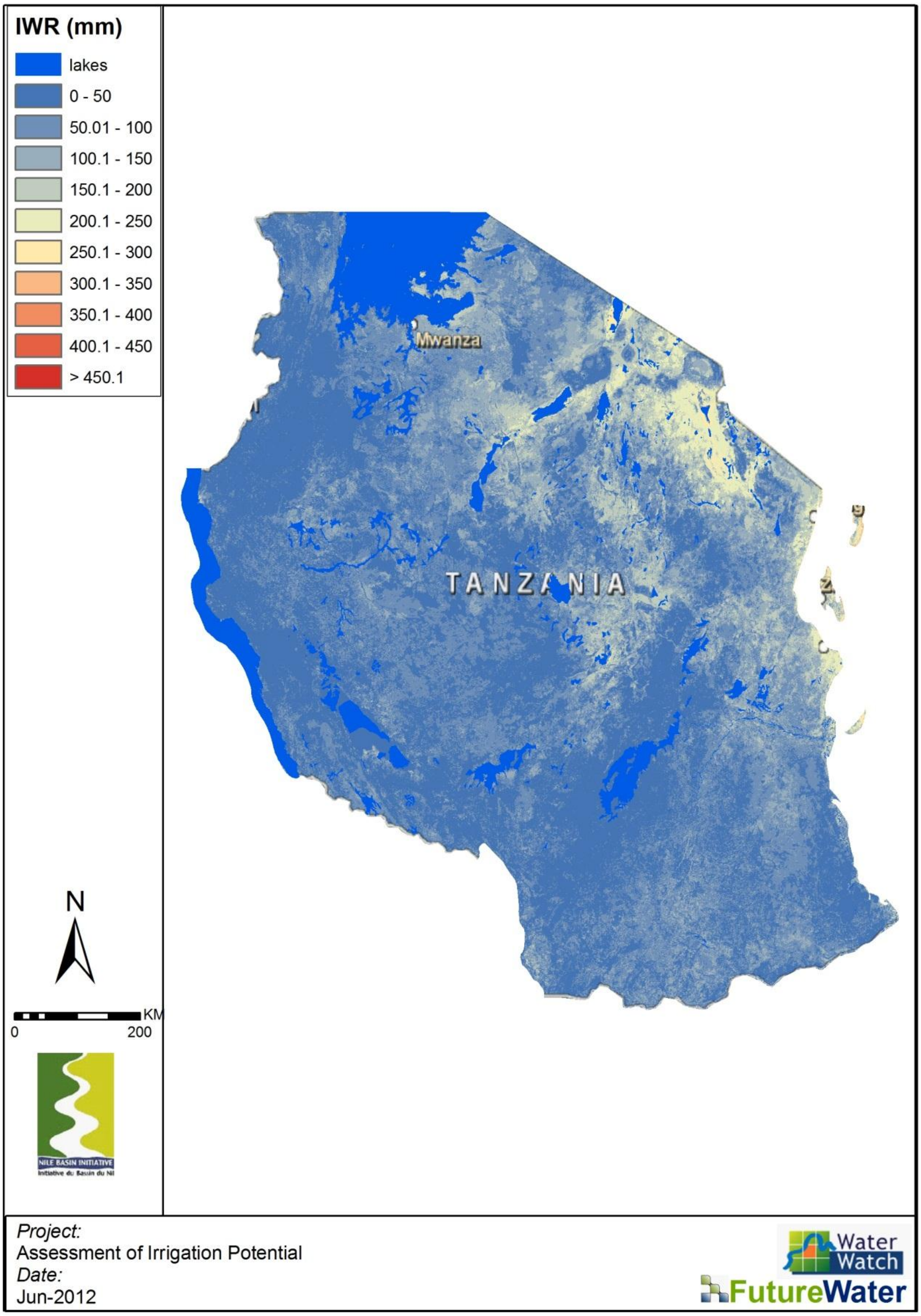
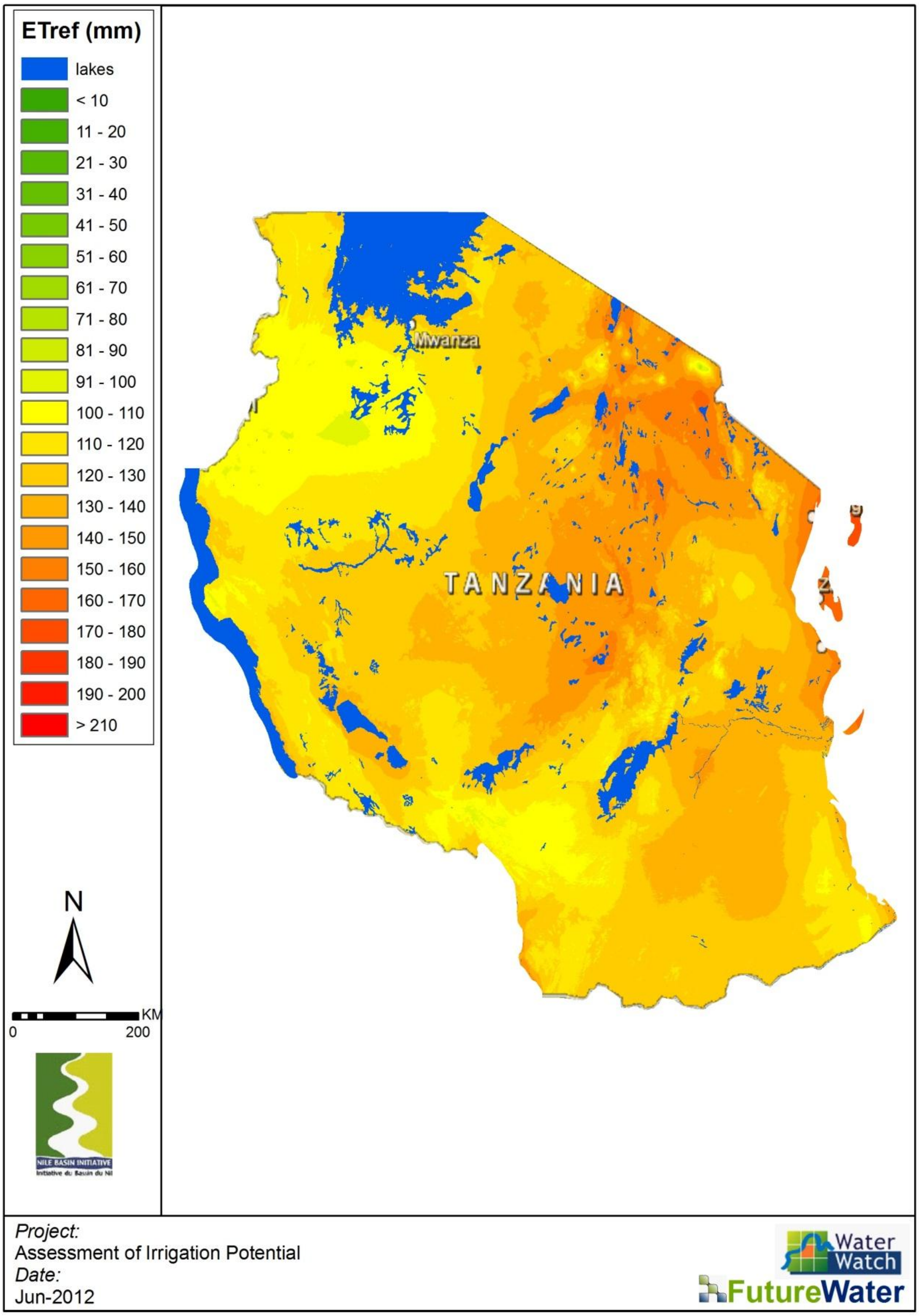



**Figure 8: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom). for February (Average 2001-2010). (Source: study analysis).**

## *March*



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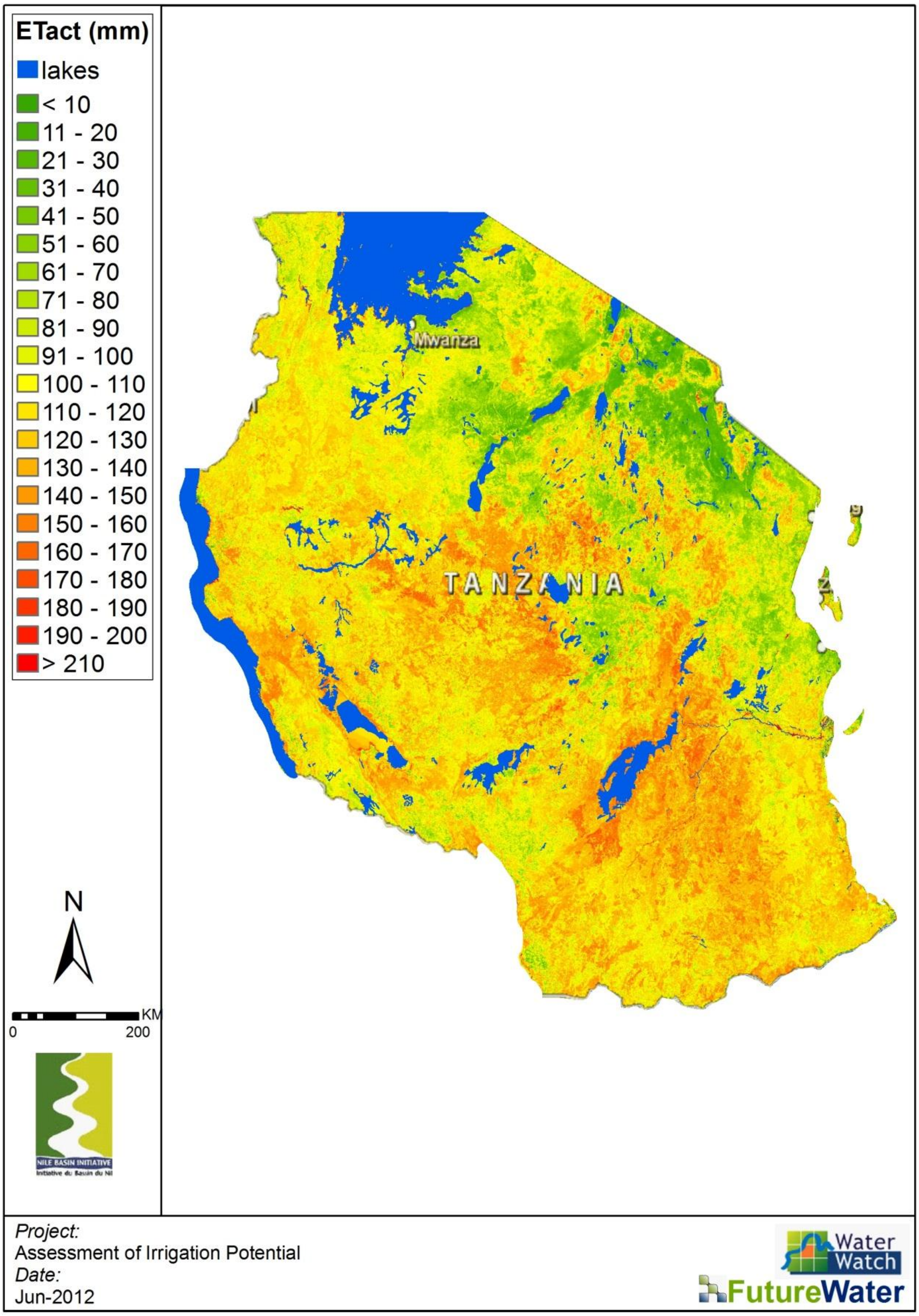
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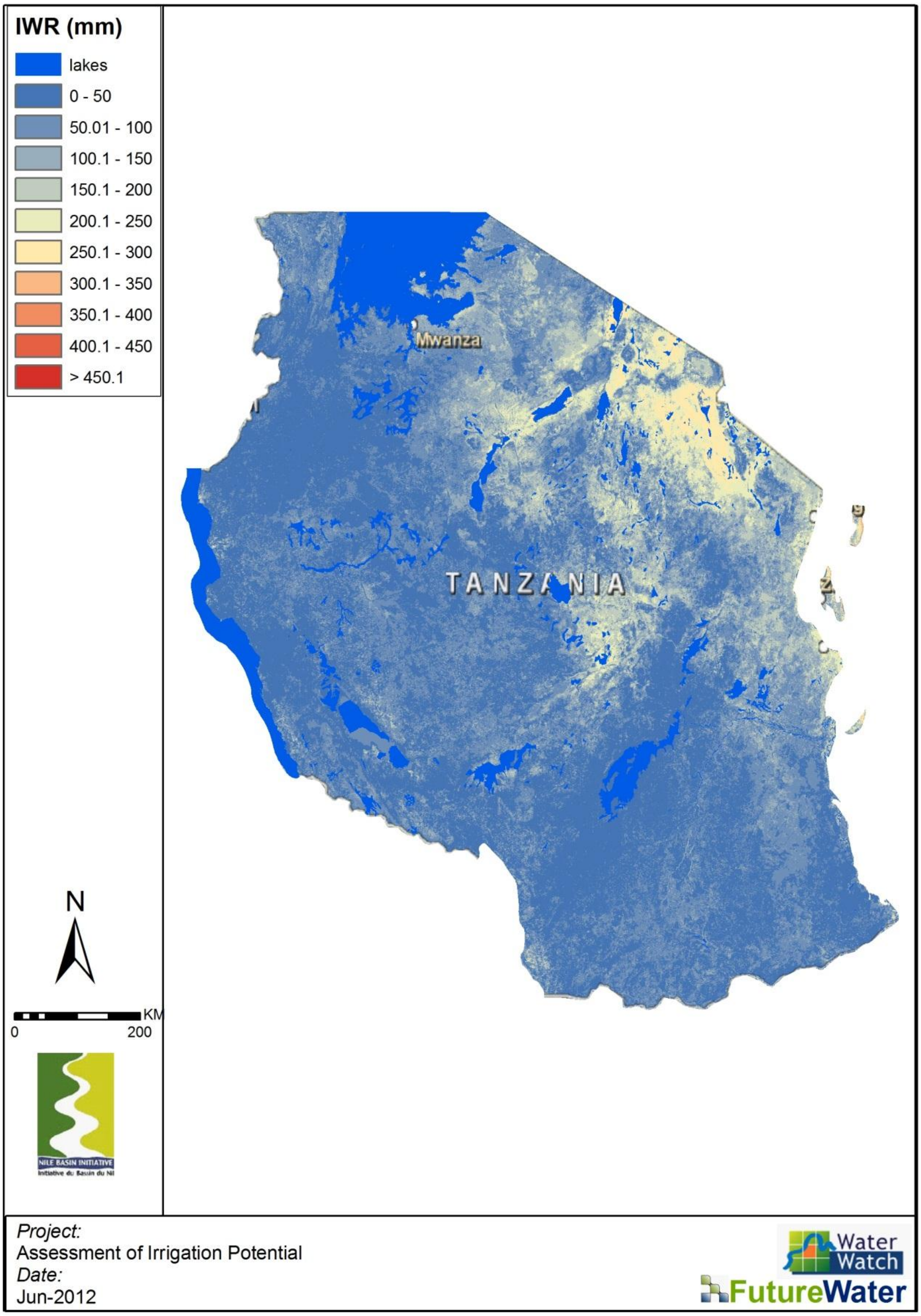
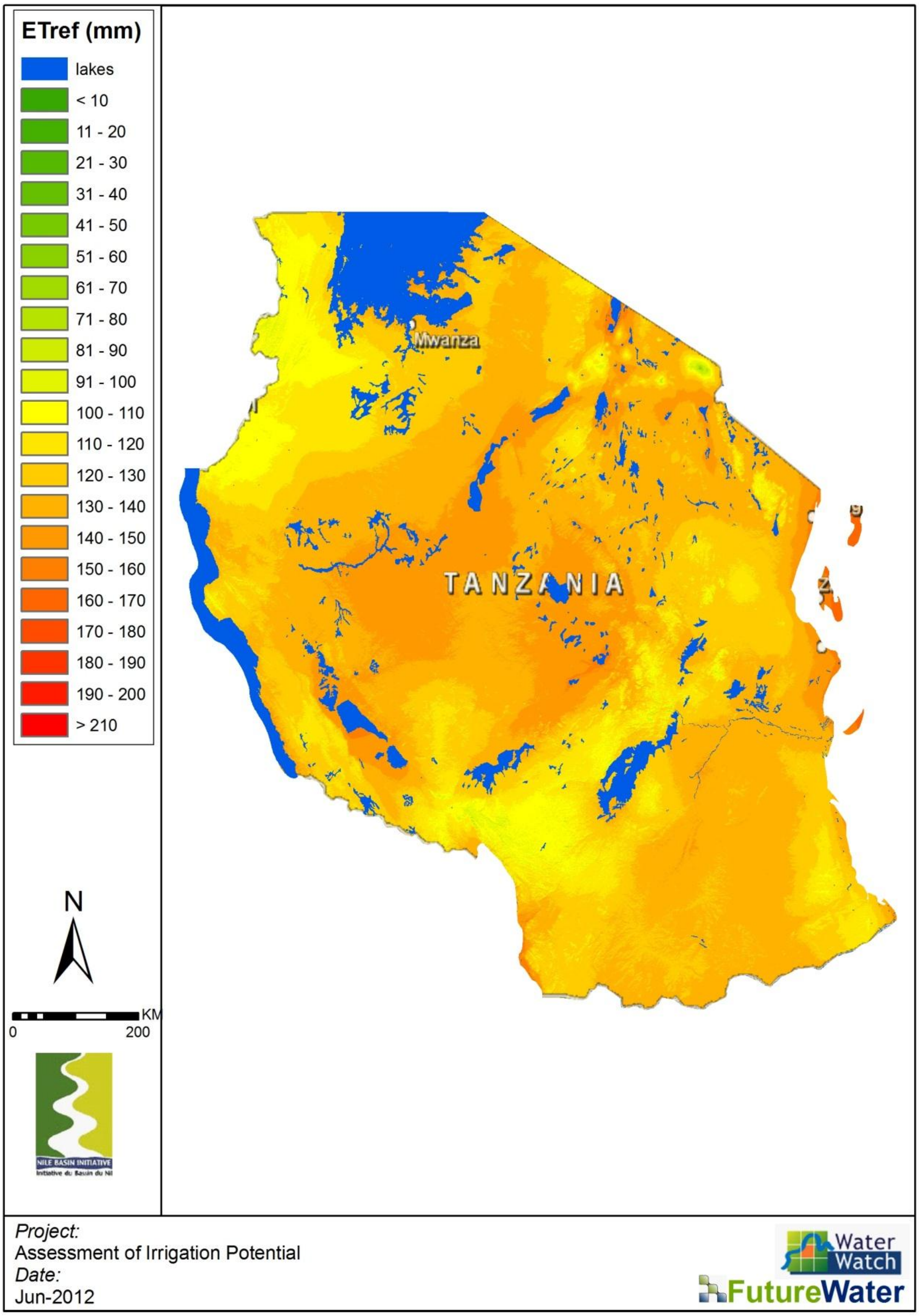



**Figure 9: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom). for March (Average 2001-2010). (Source: study analysis).**

### *April*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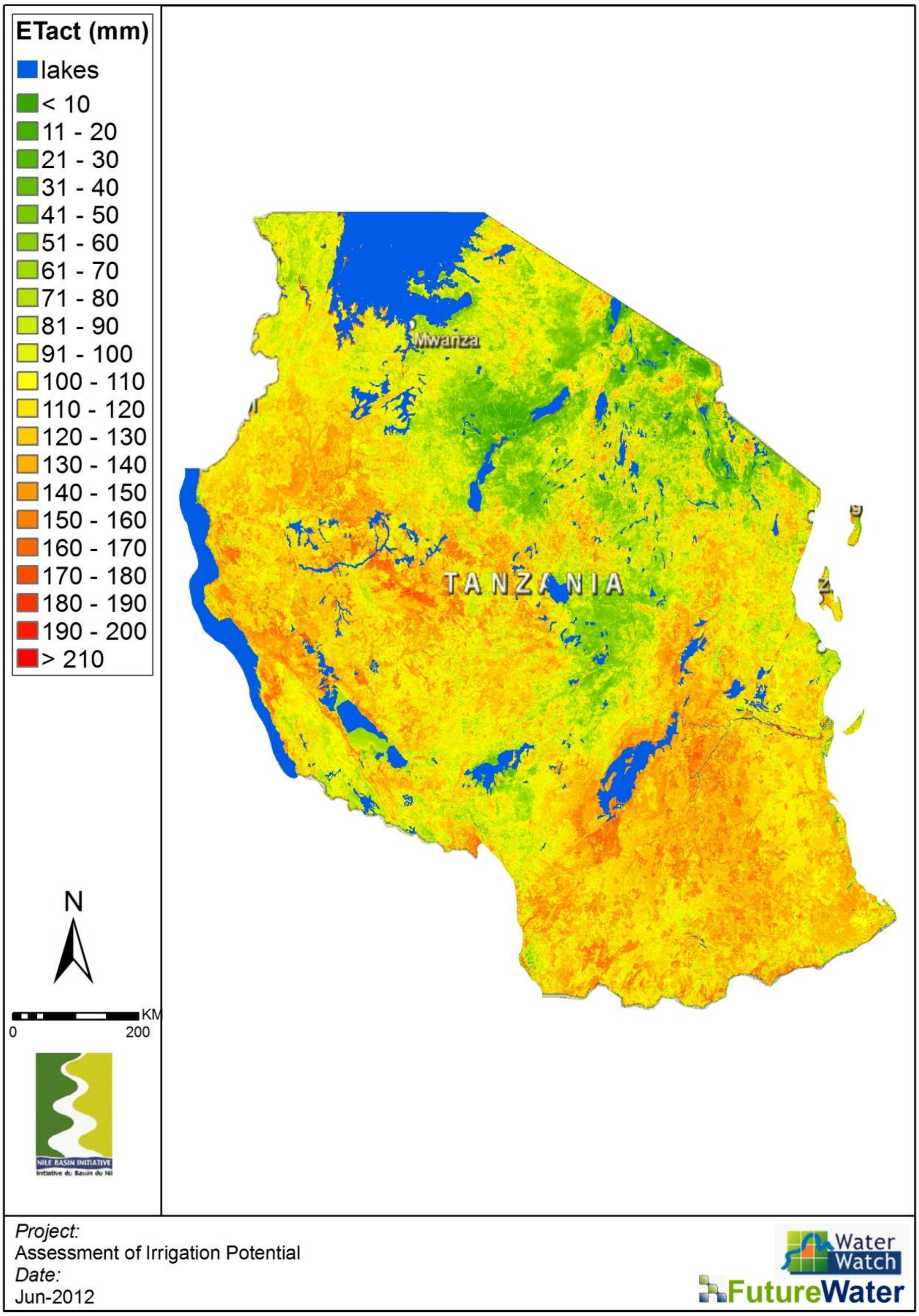
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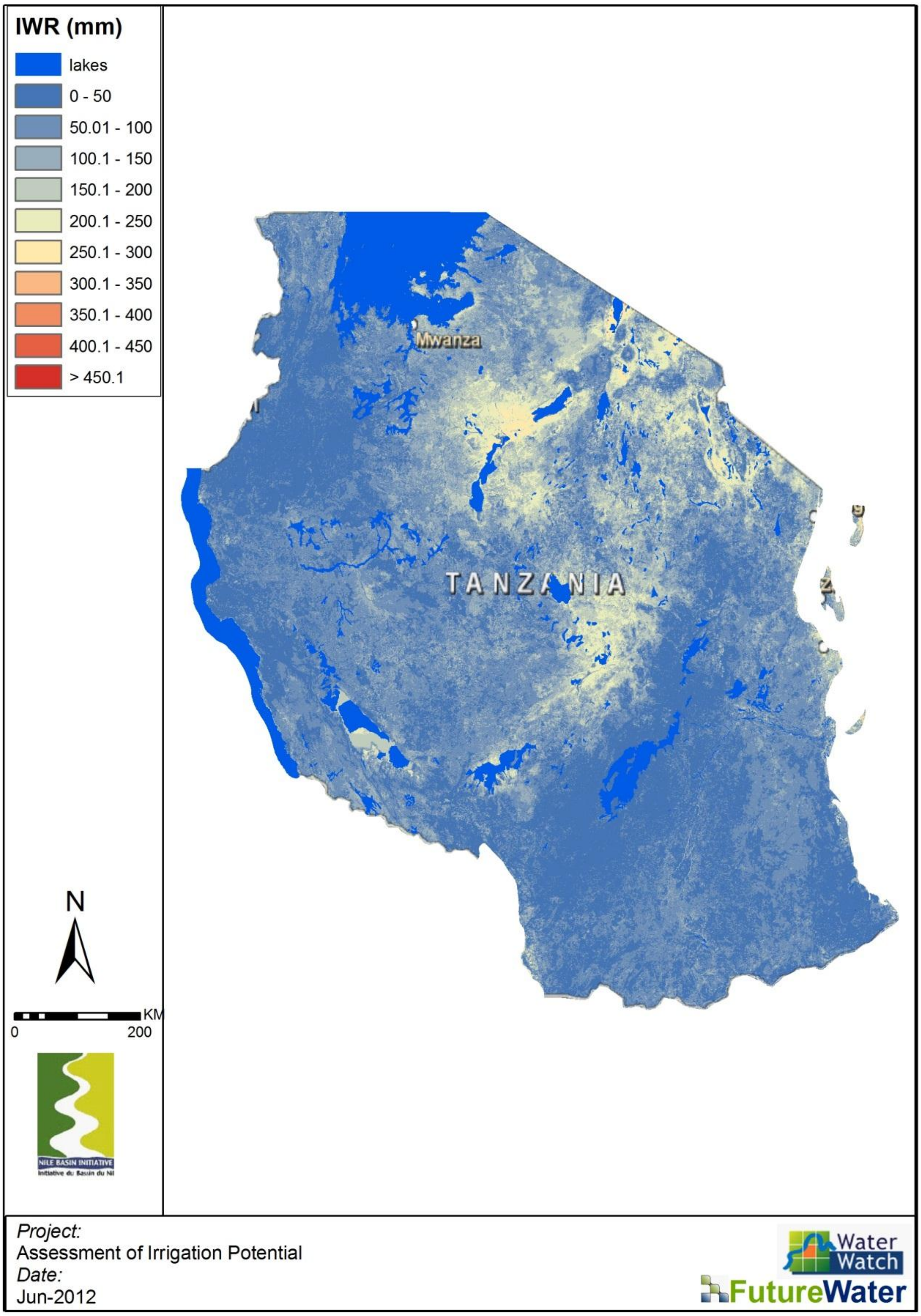
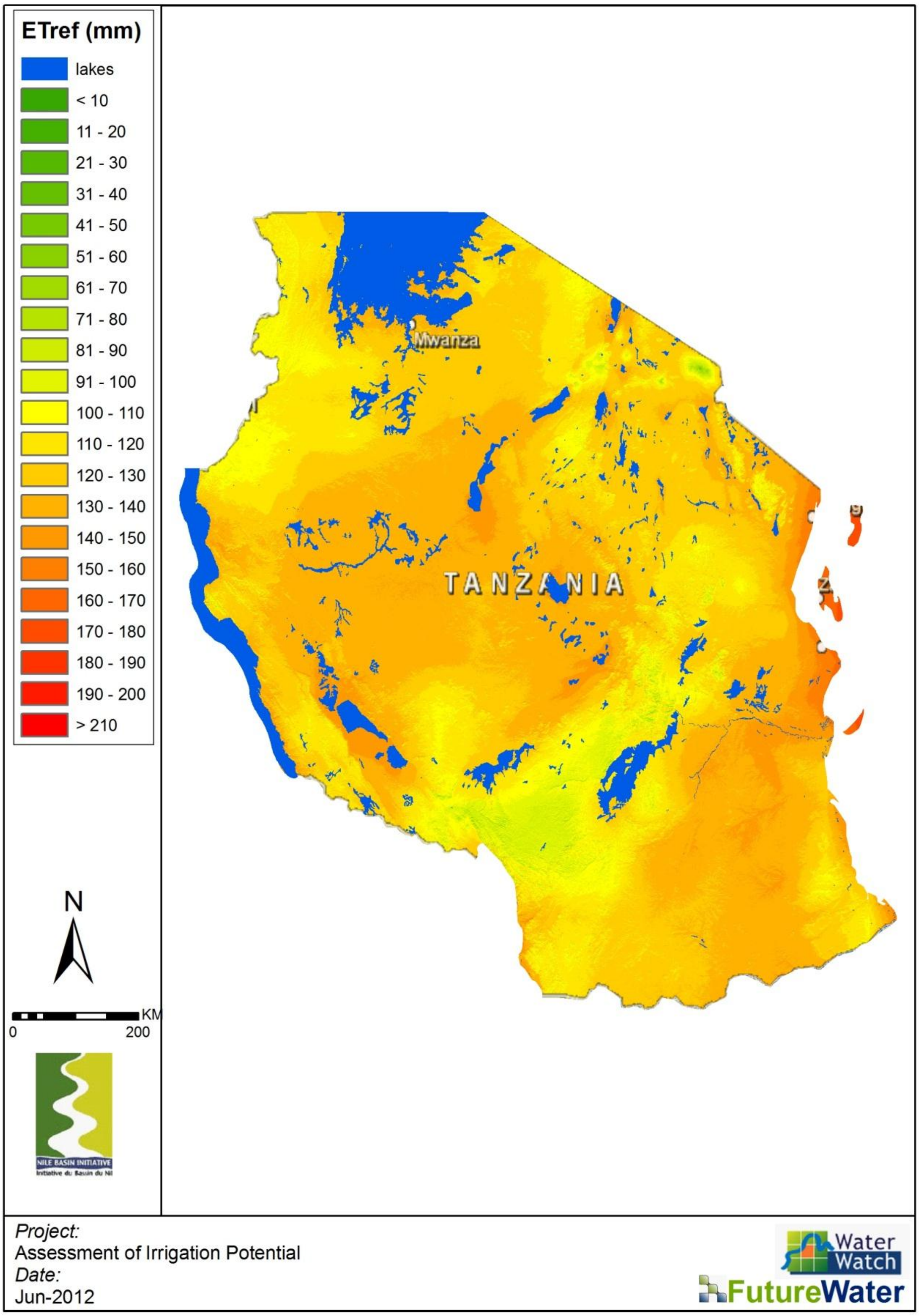



**Figure 10: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom). for April (Average 2001-2010). (Source: study analysis).**

*May*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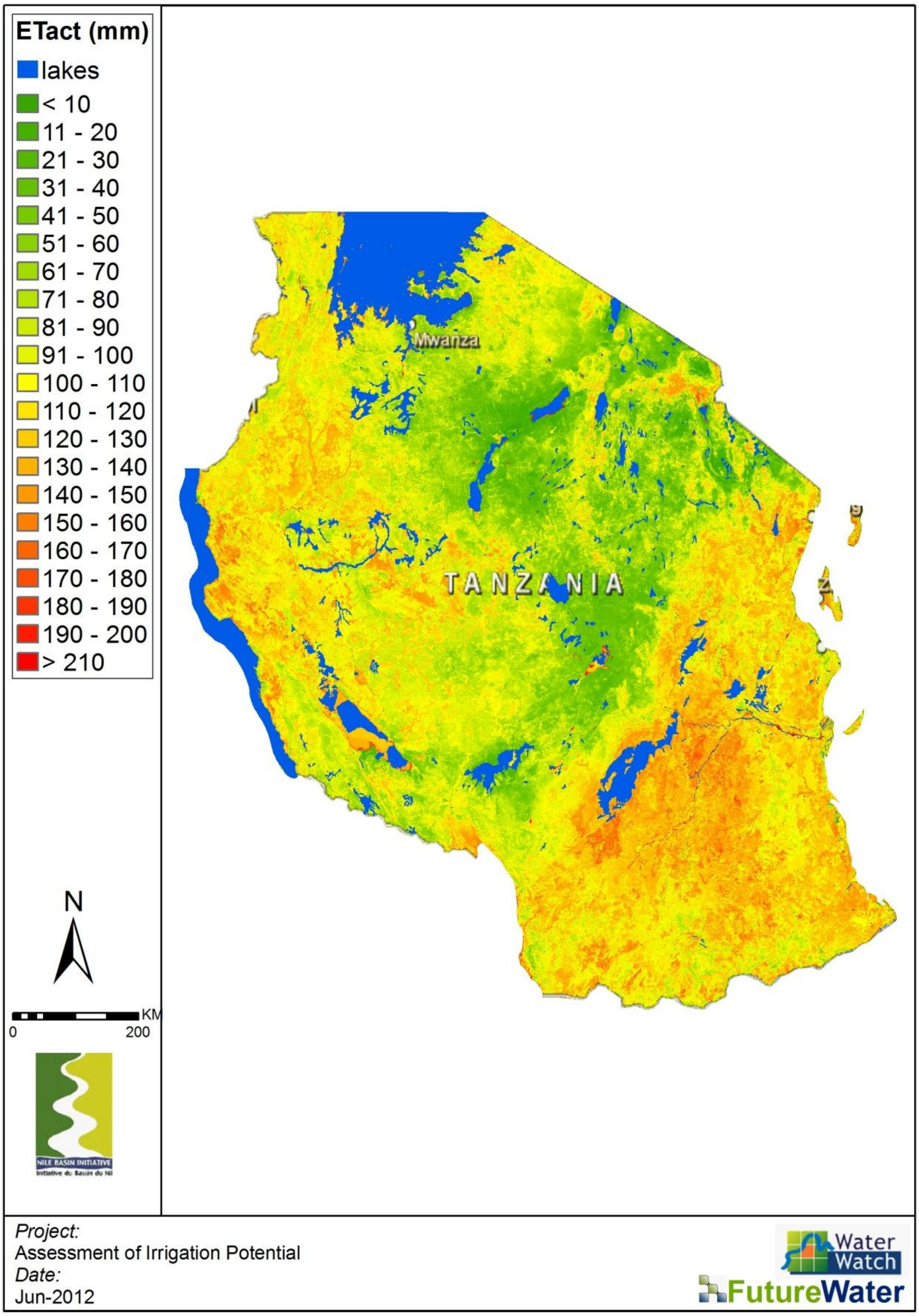
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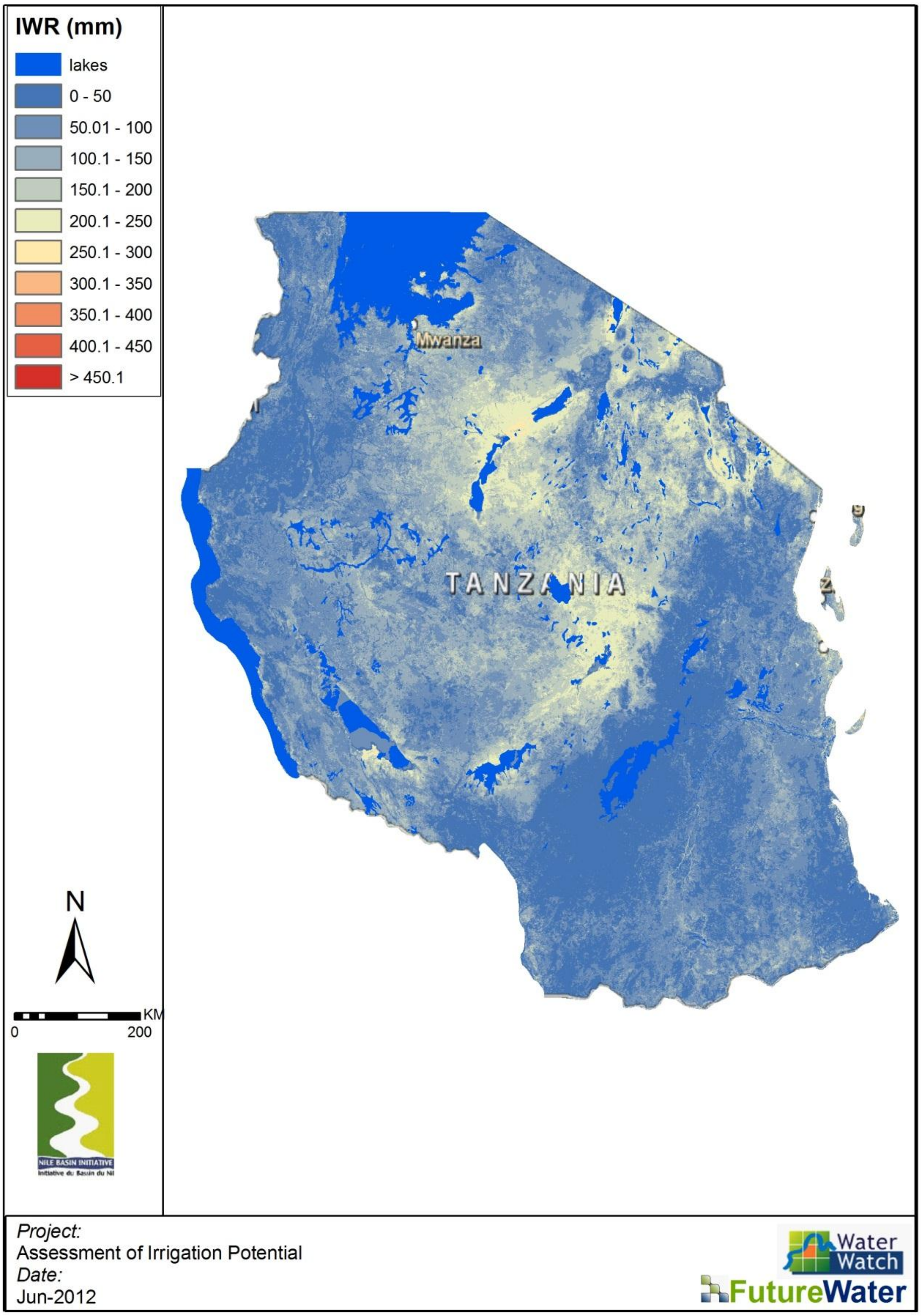
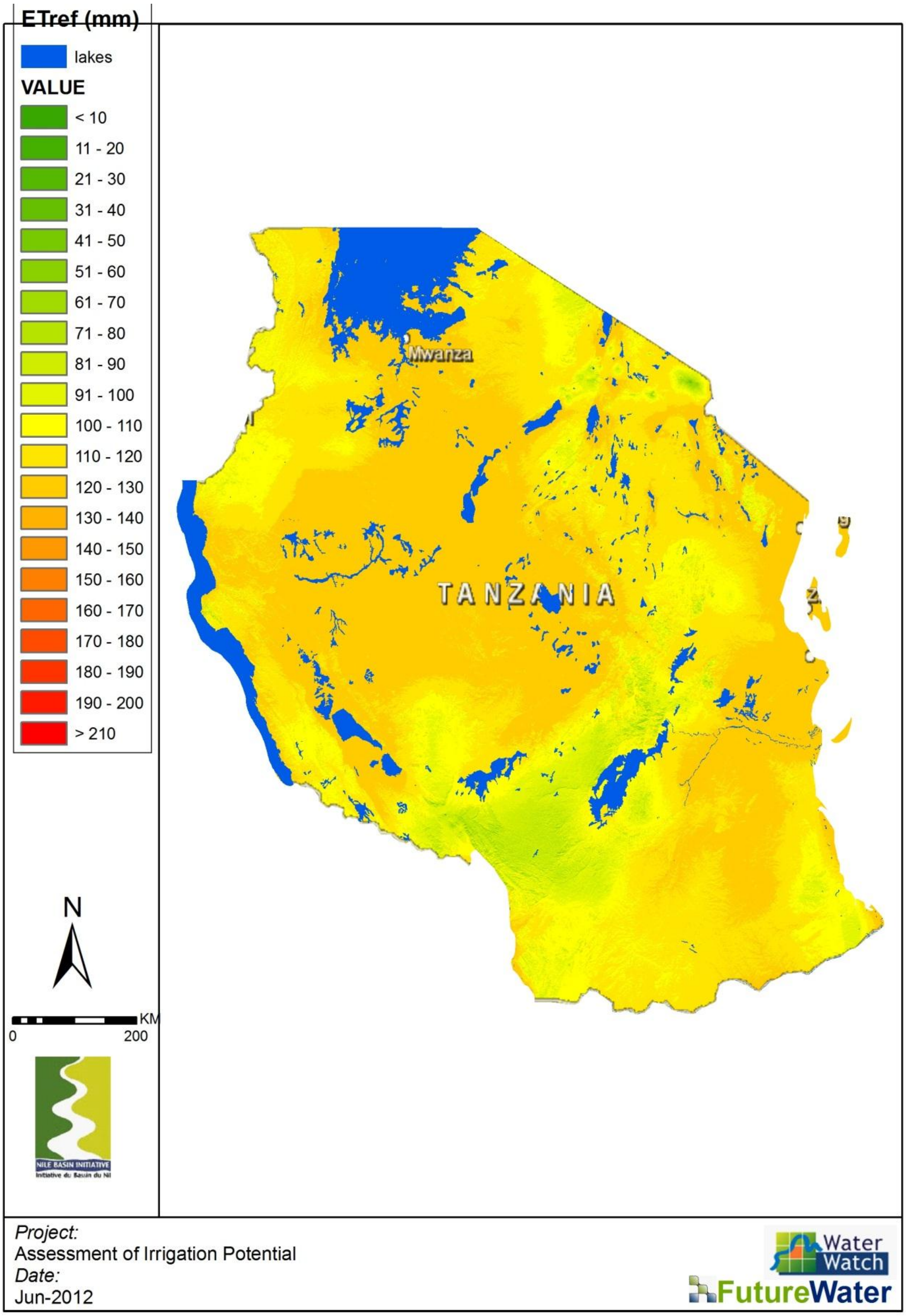



**Figure 11: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom) for May (Average 2001-2010). (Source: study analysis).**

### *June*


ETref (mm)
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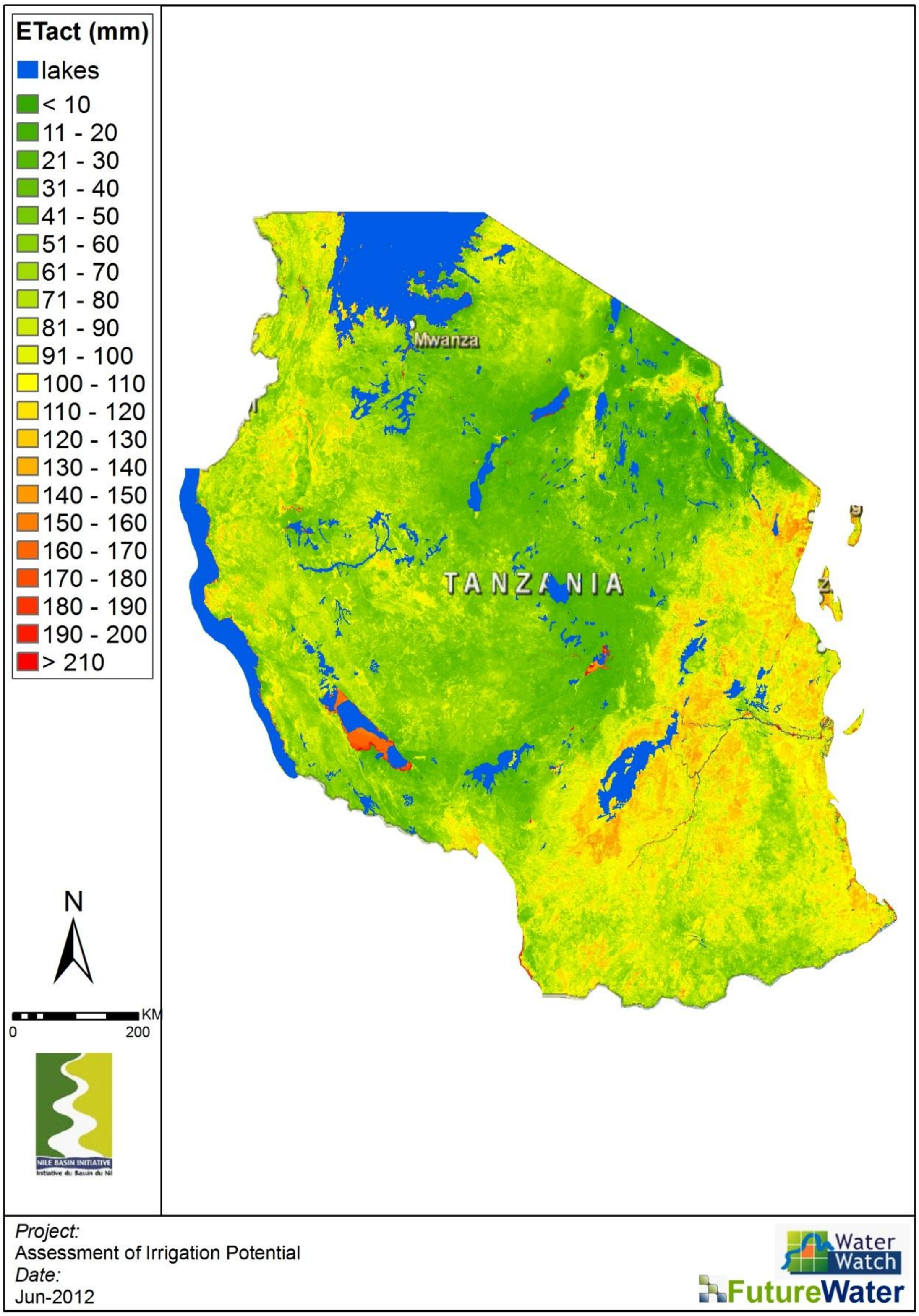
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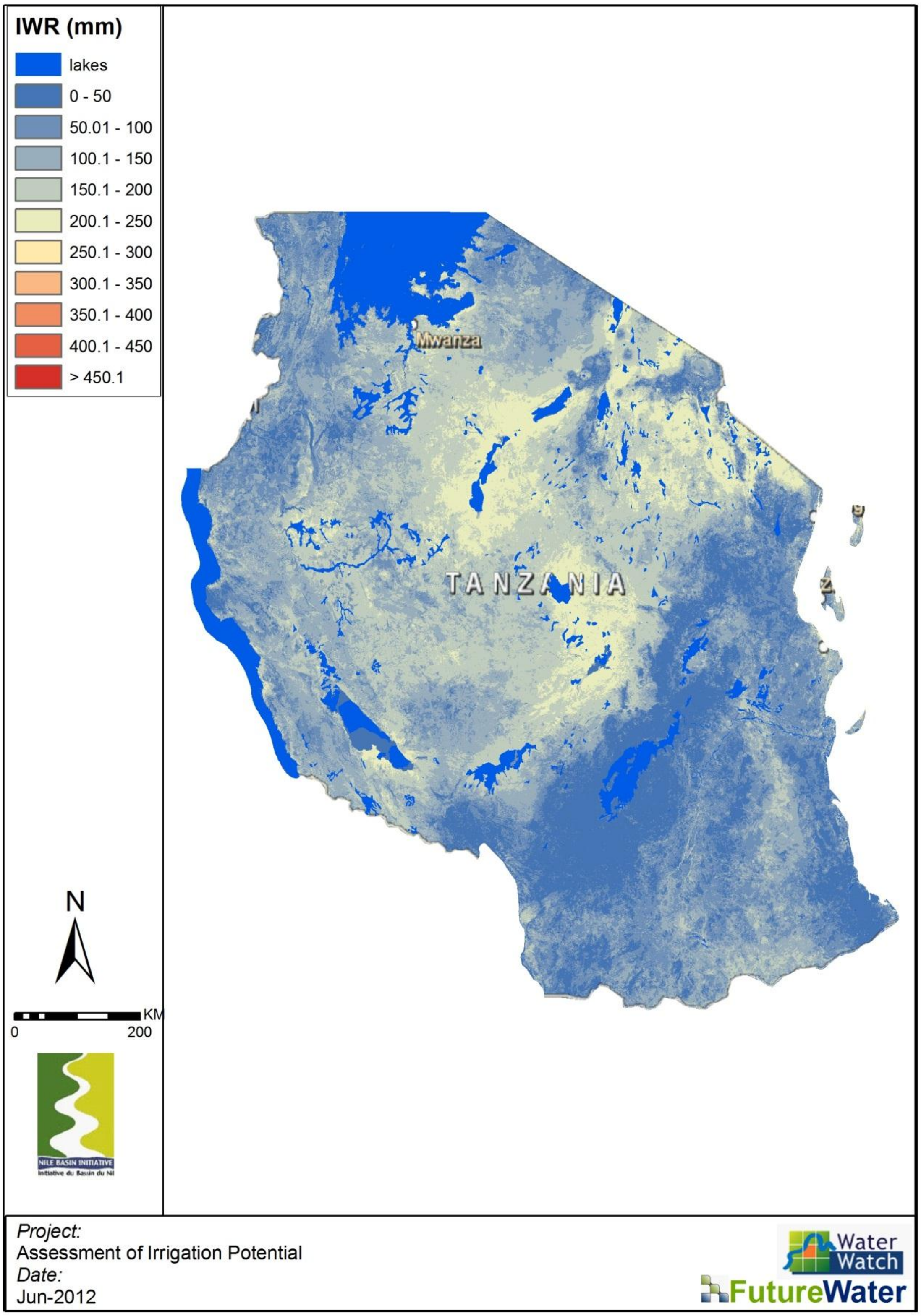
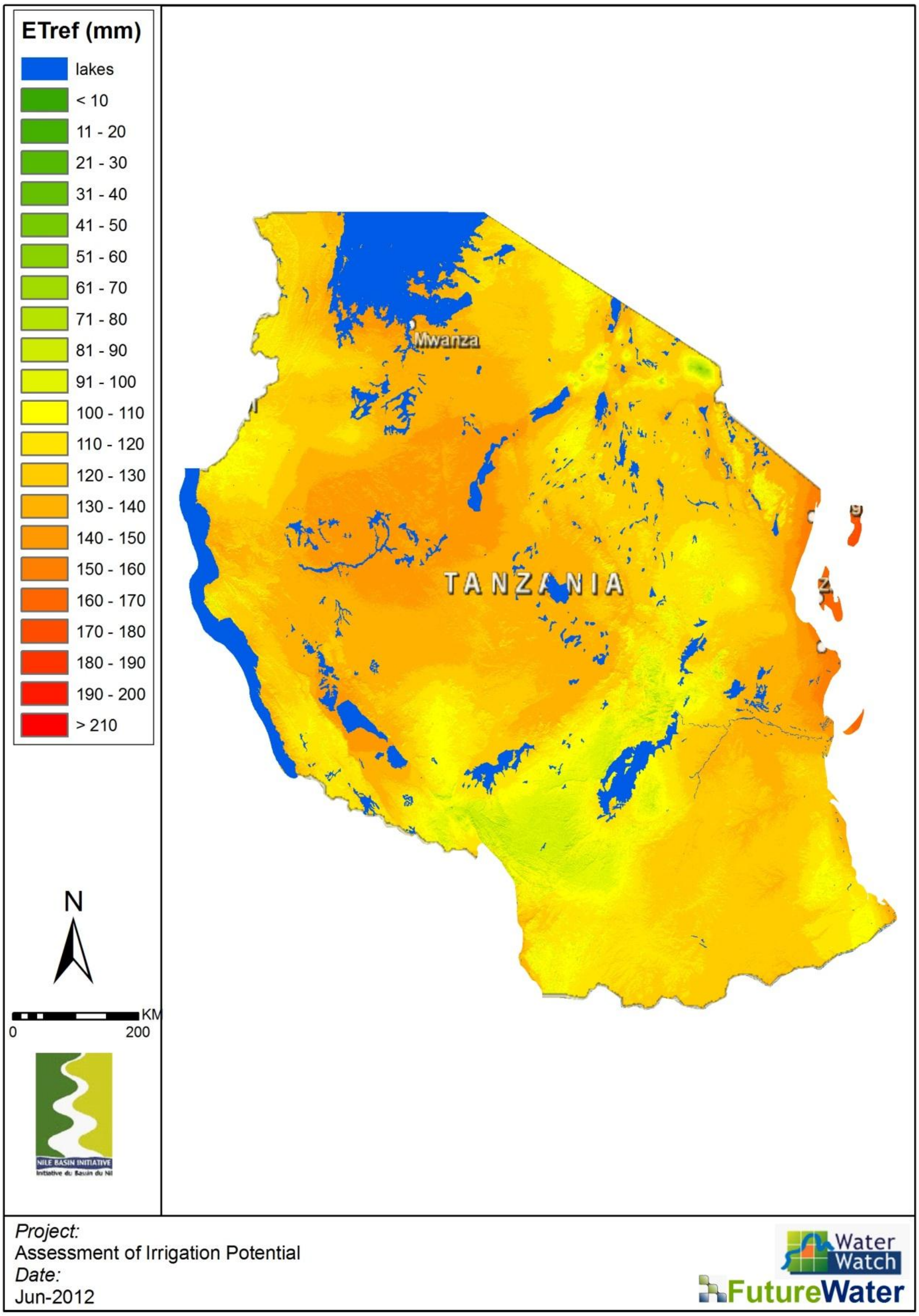



**Figure 12: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom). For June (Average 2001-2010). (Source: study analysis).**

*July*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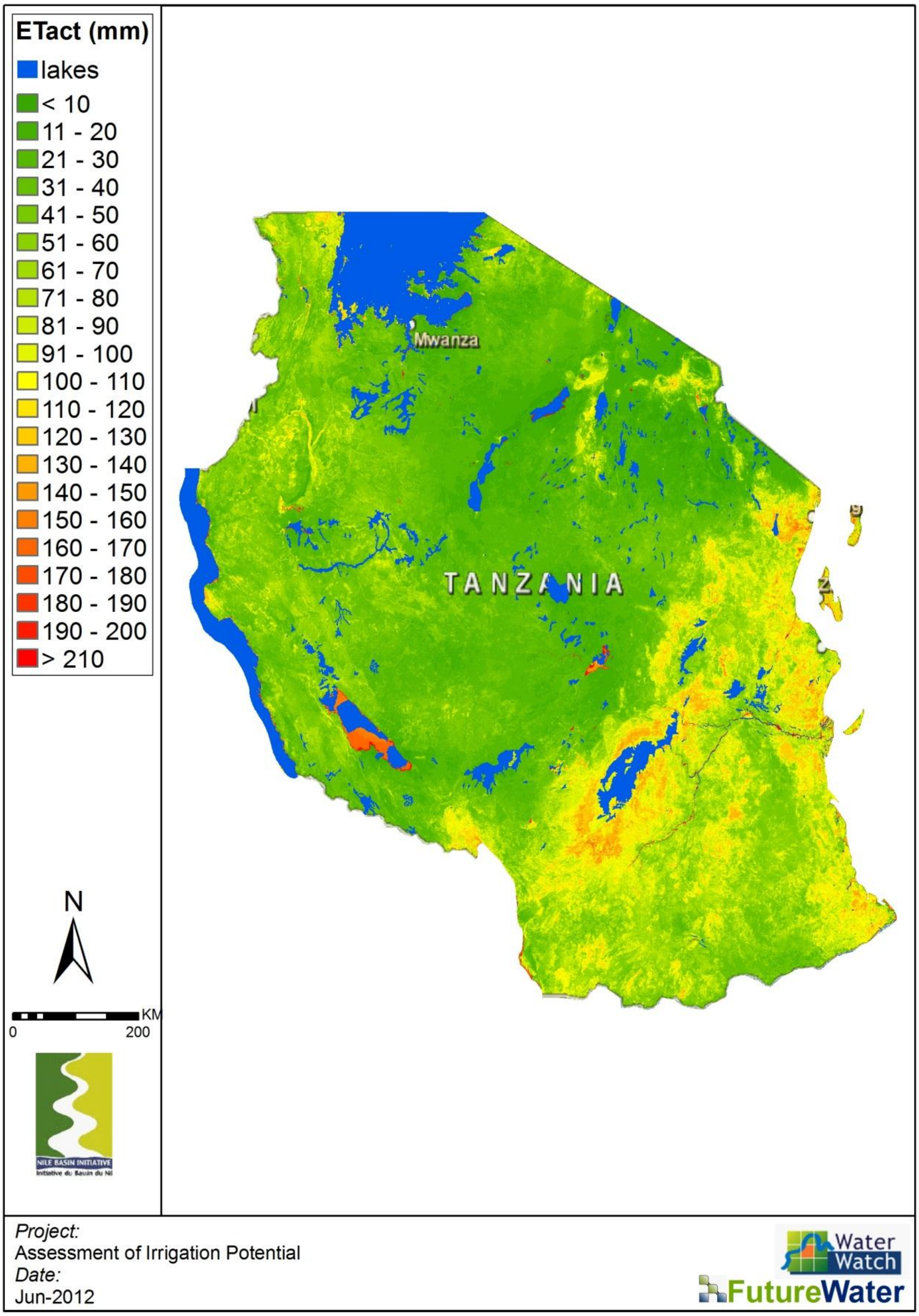
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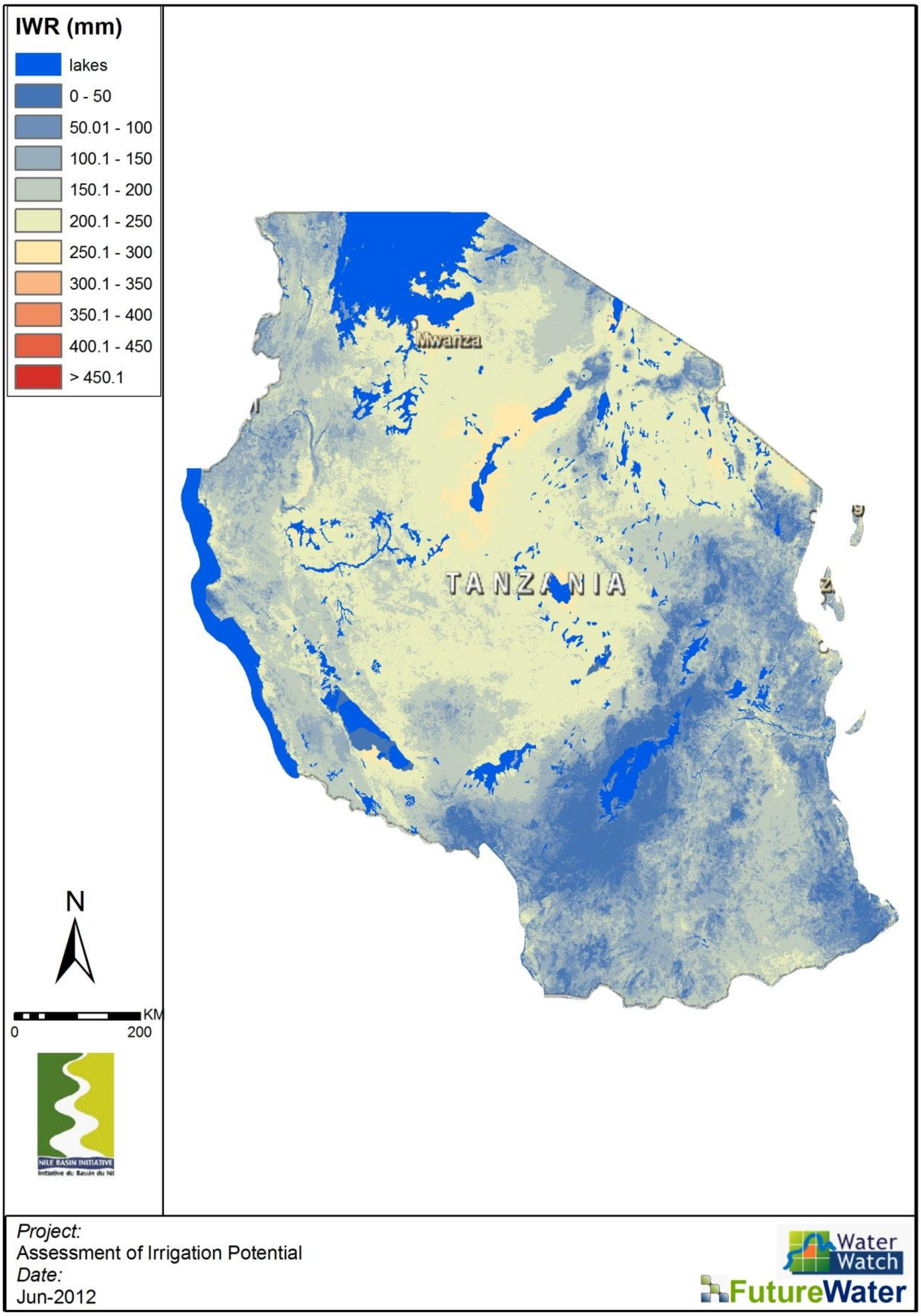
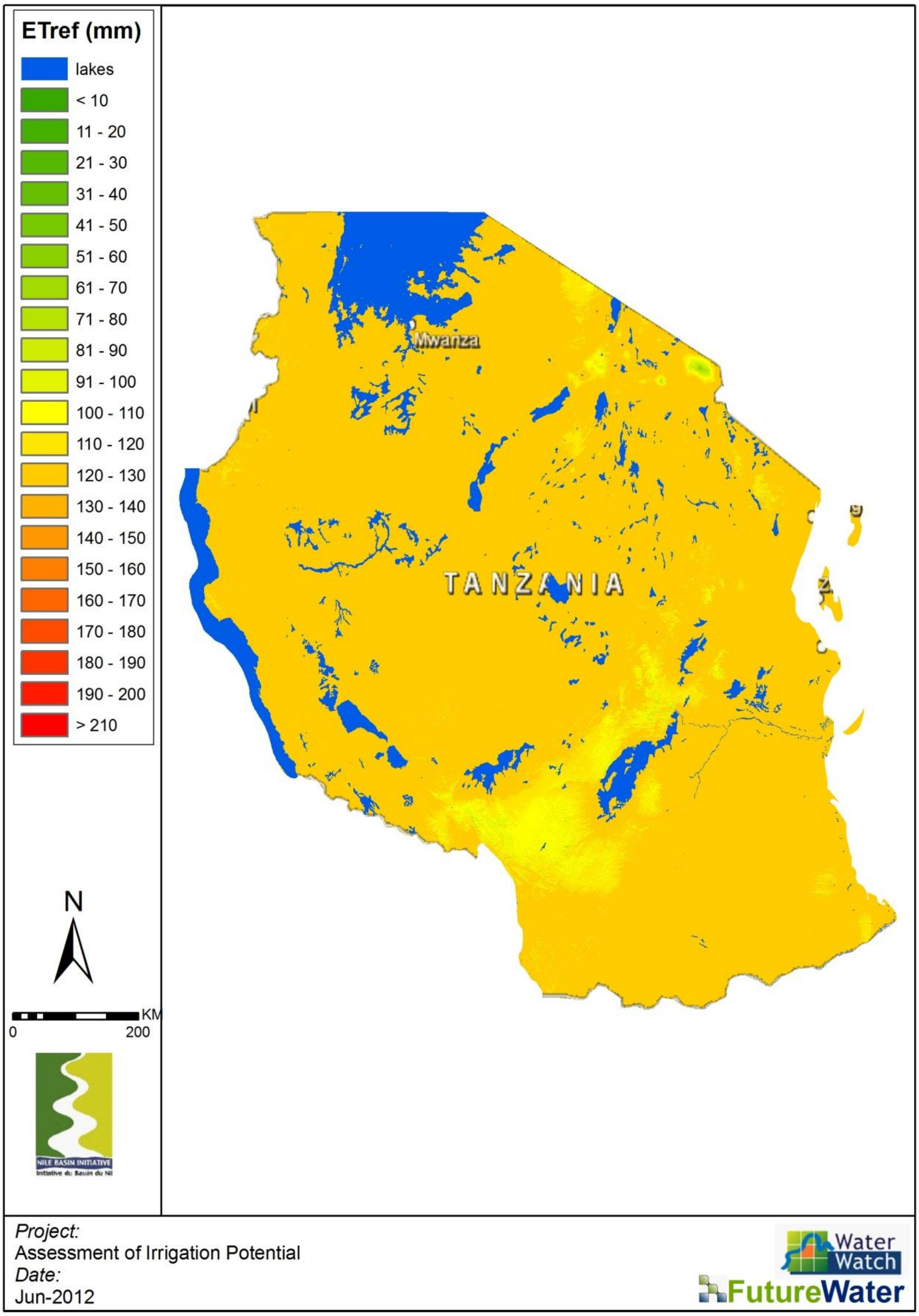



**Figure 13: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom) for July (Average 2001-2010). (Source: study analysis).**

### *August*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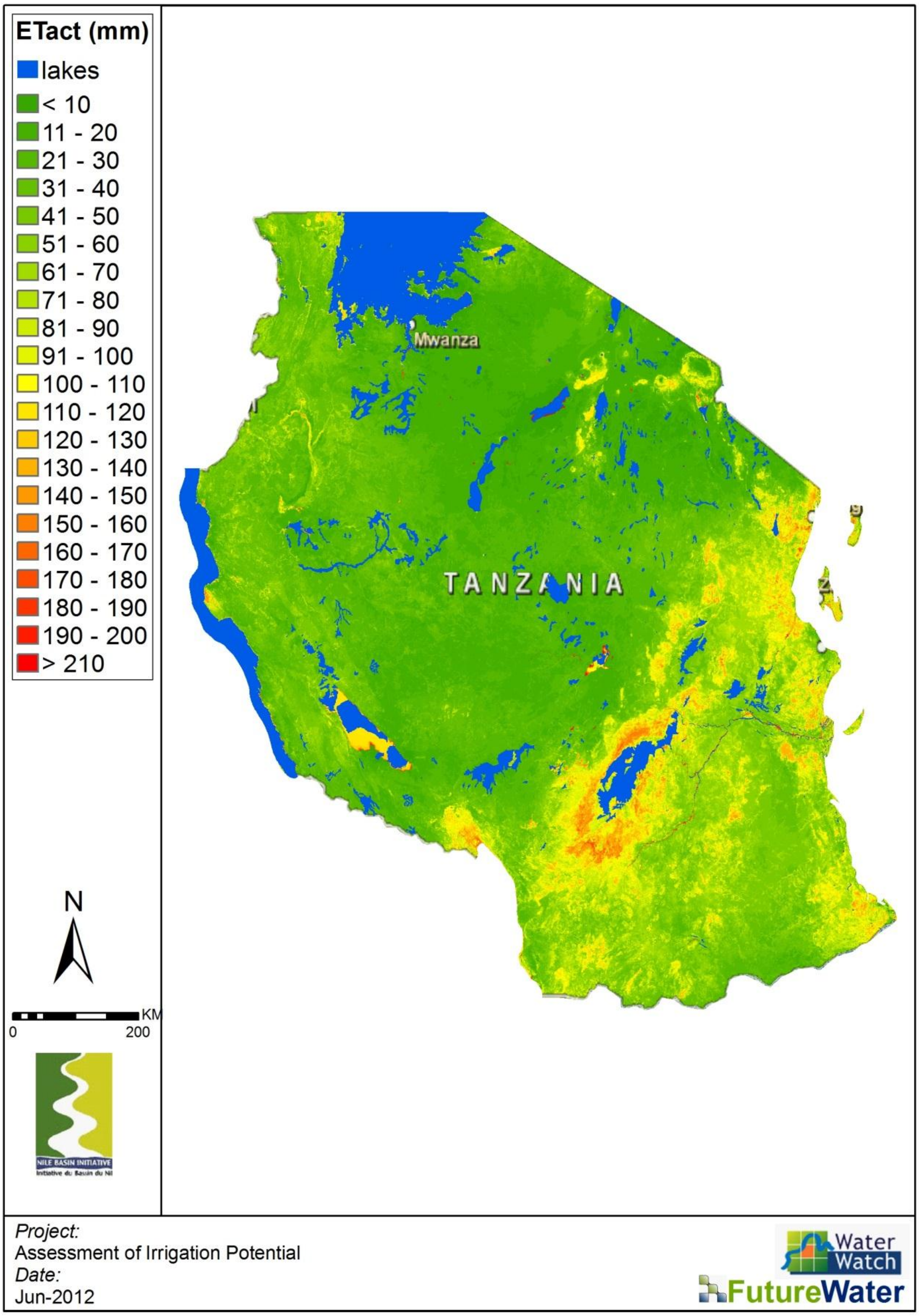
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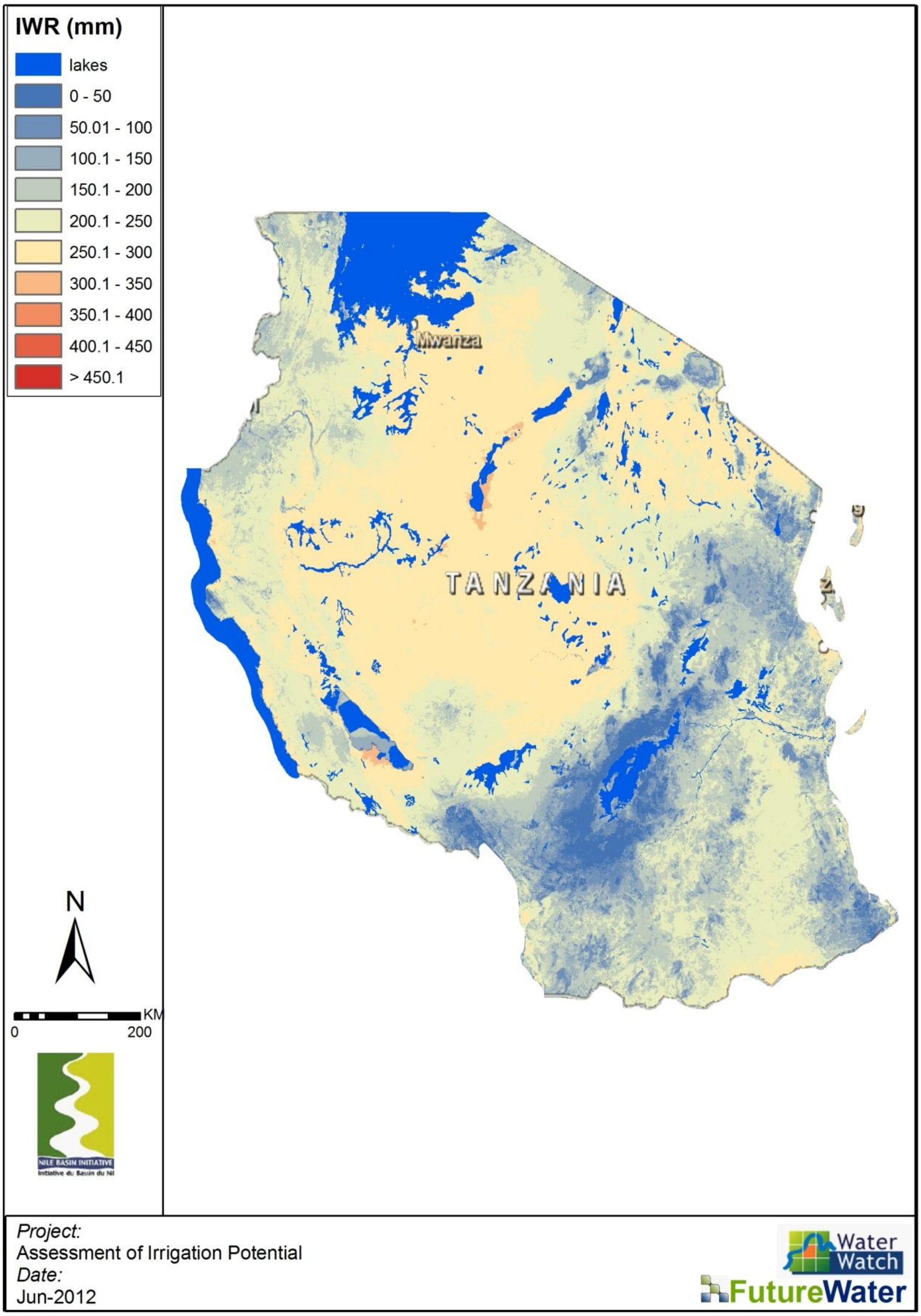
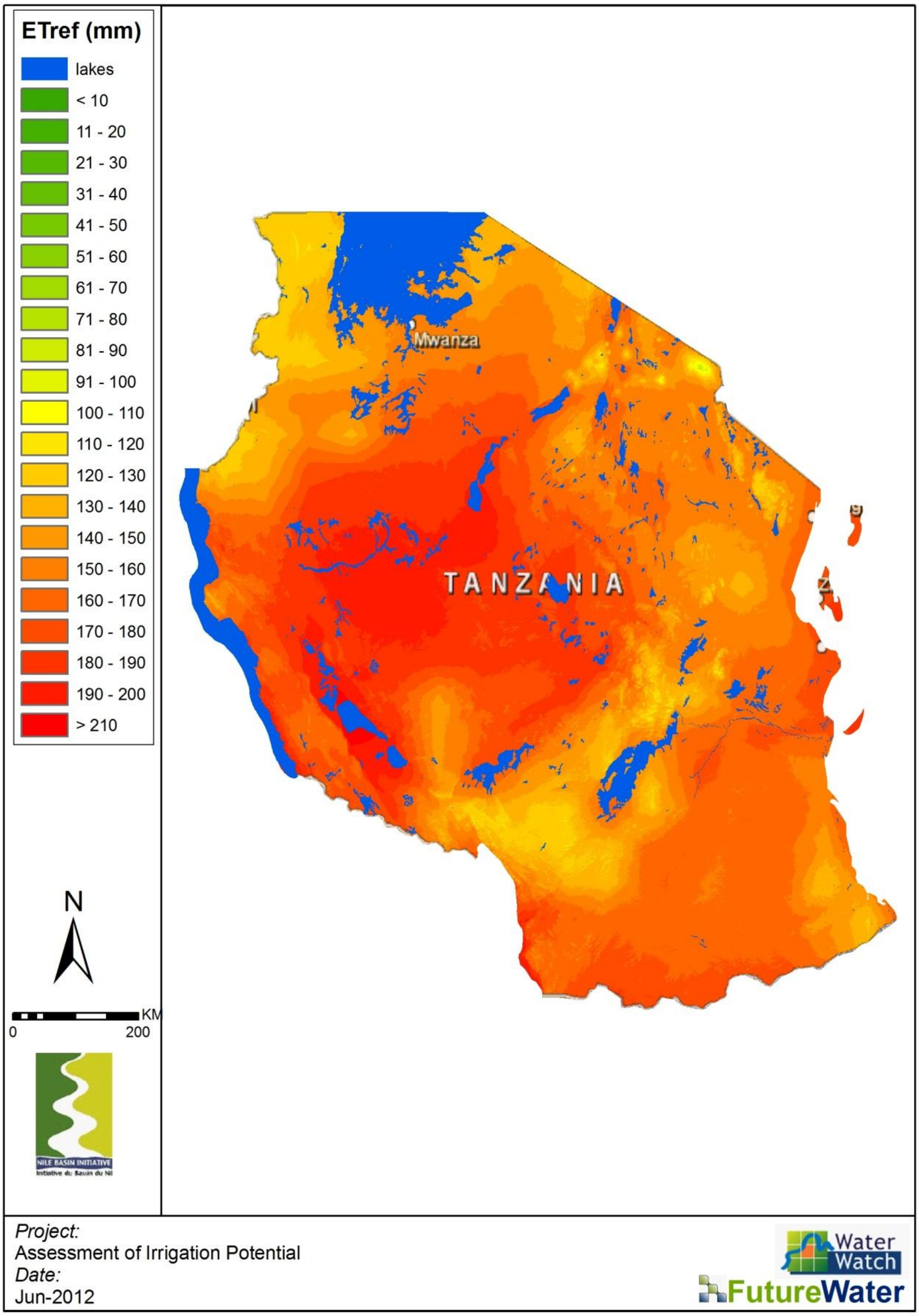



**Figure 14: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom) for August (Average 2001-2010). (Source: study analysis).**

### *September*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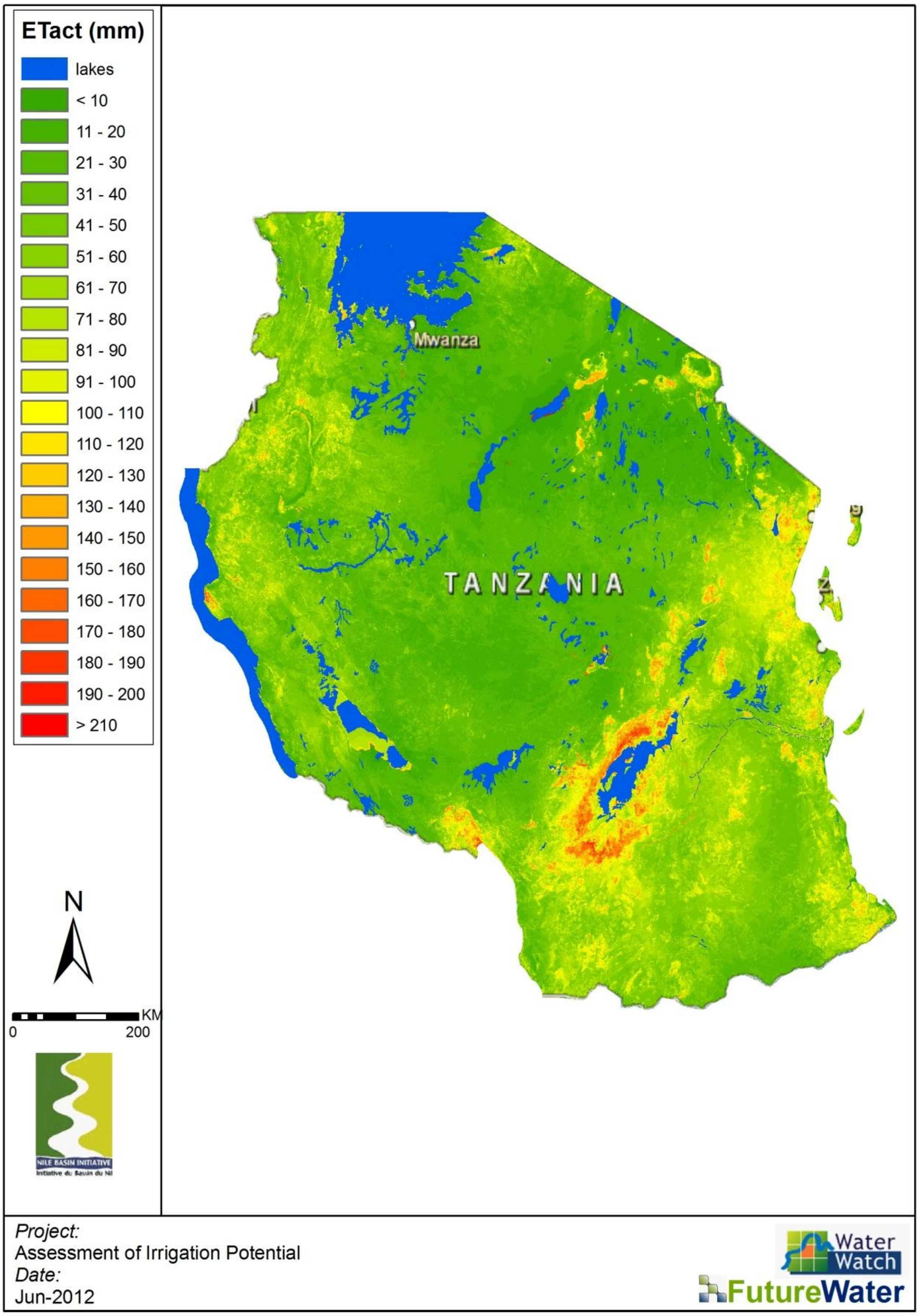
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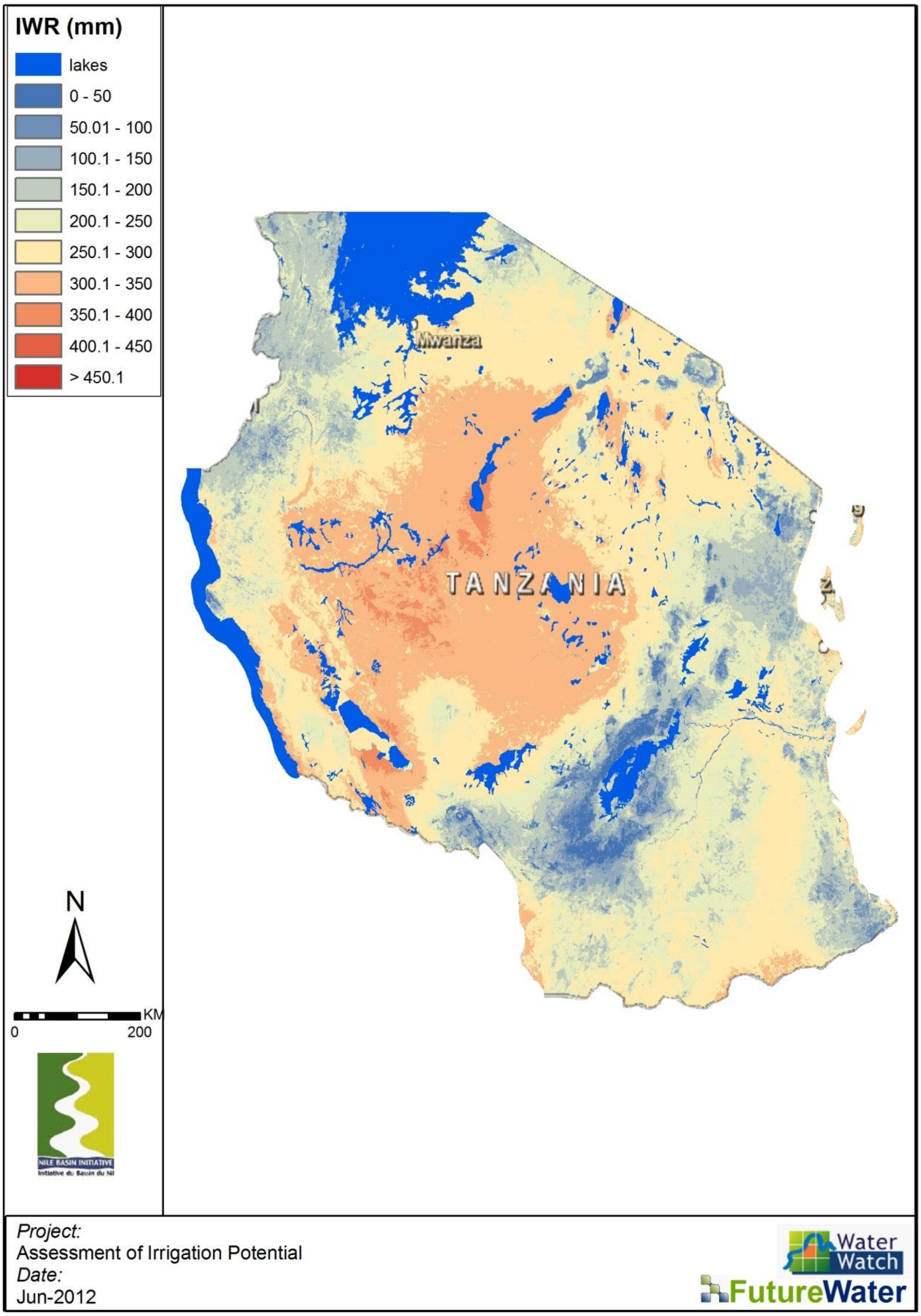
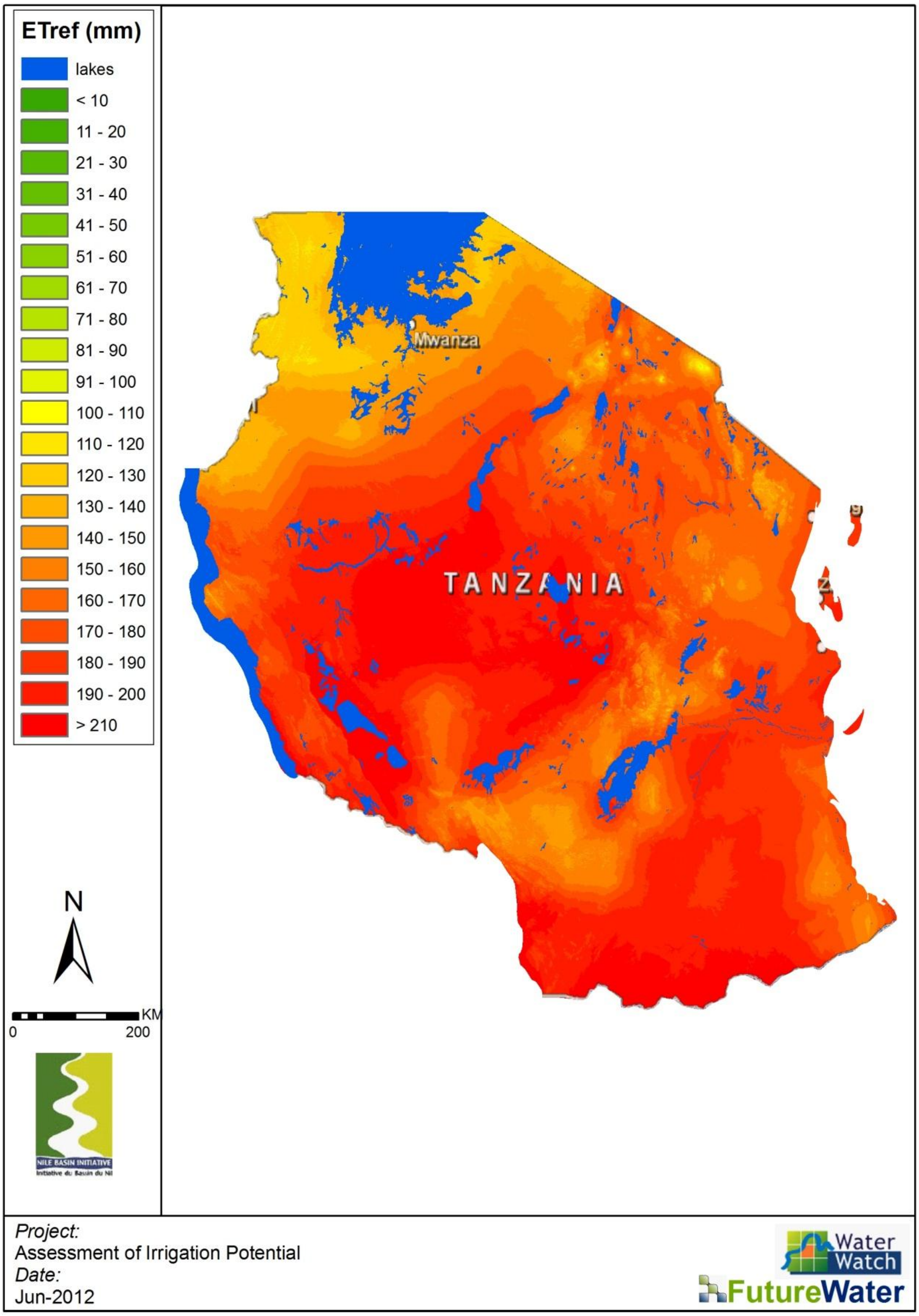



**Figure 15: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom) for September (Average 2001-2010). (Source: study analysis).**

### *October*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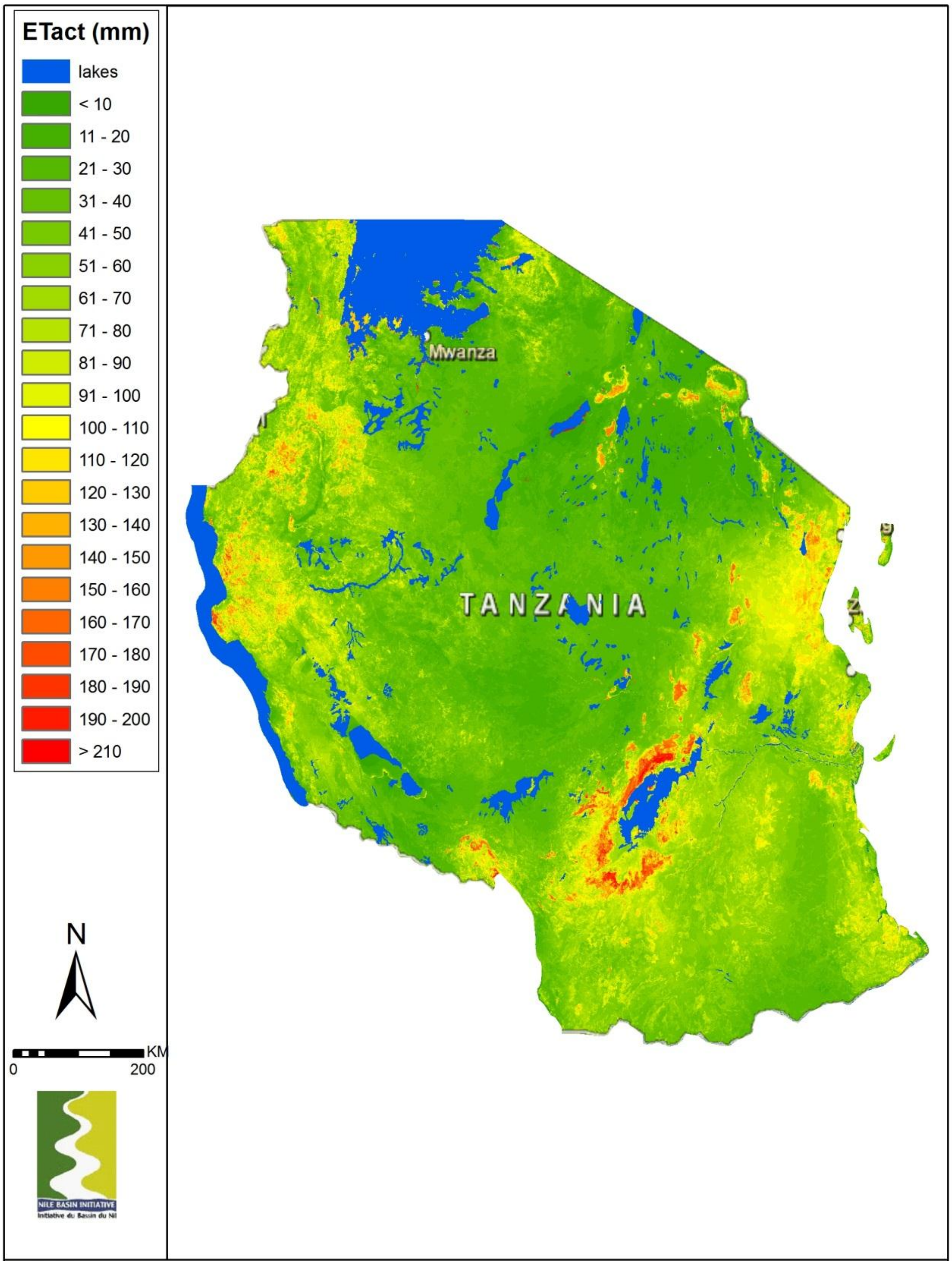


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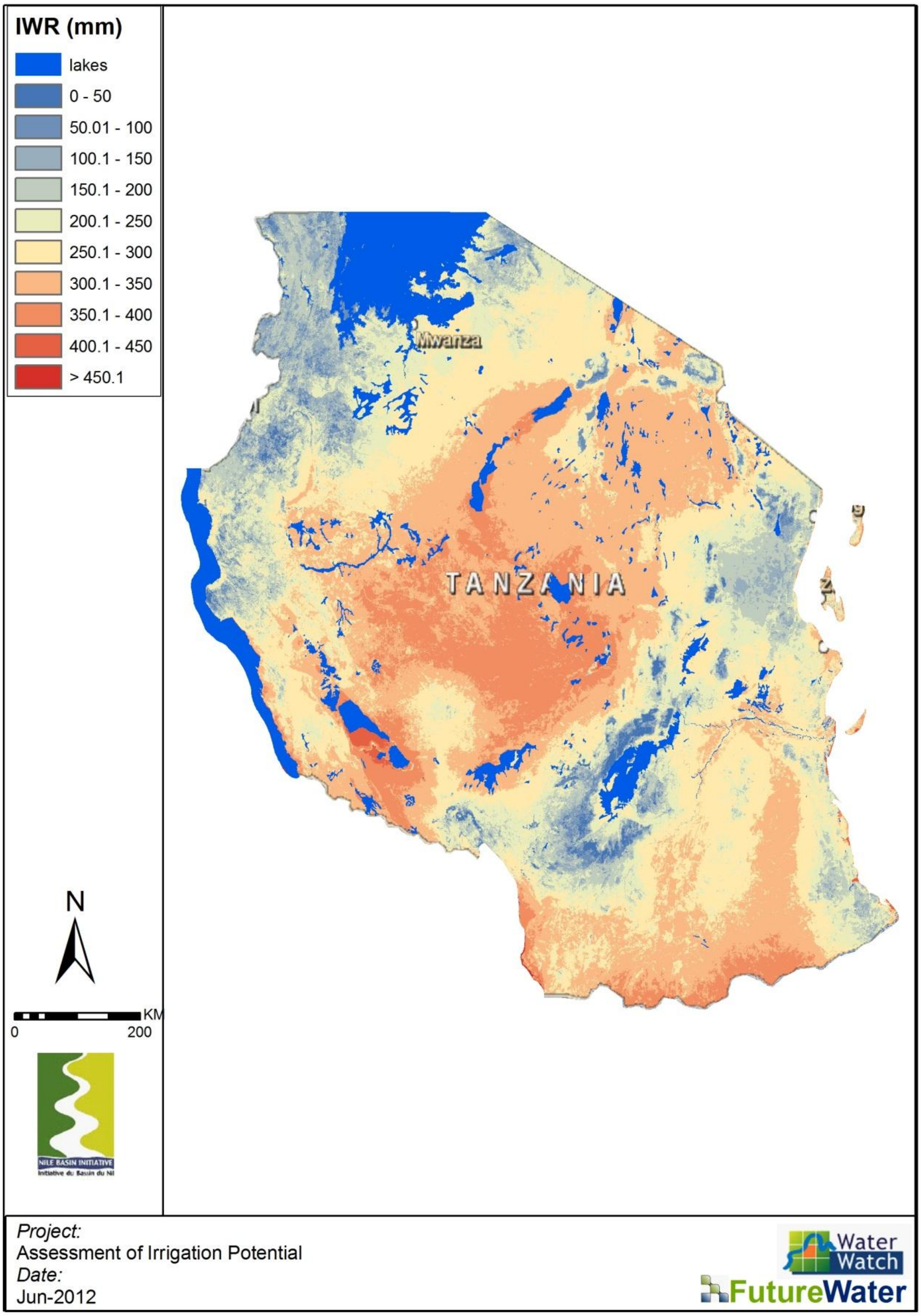
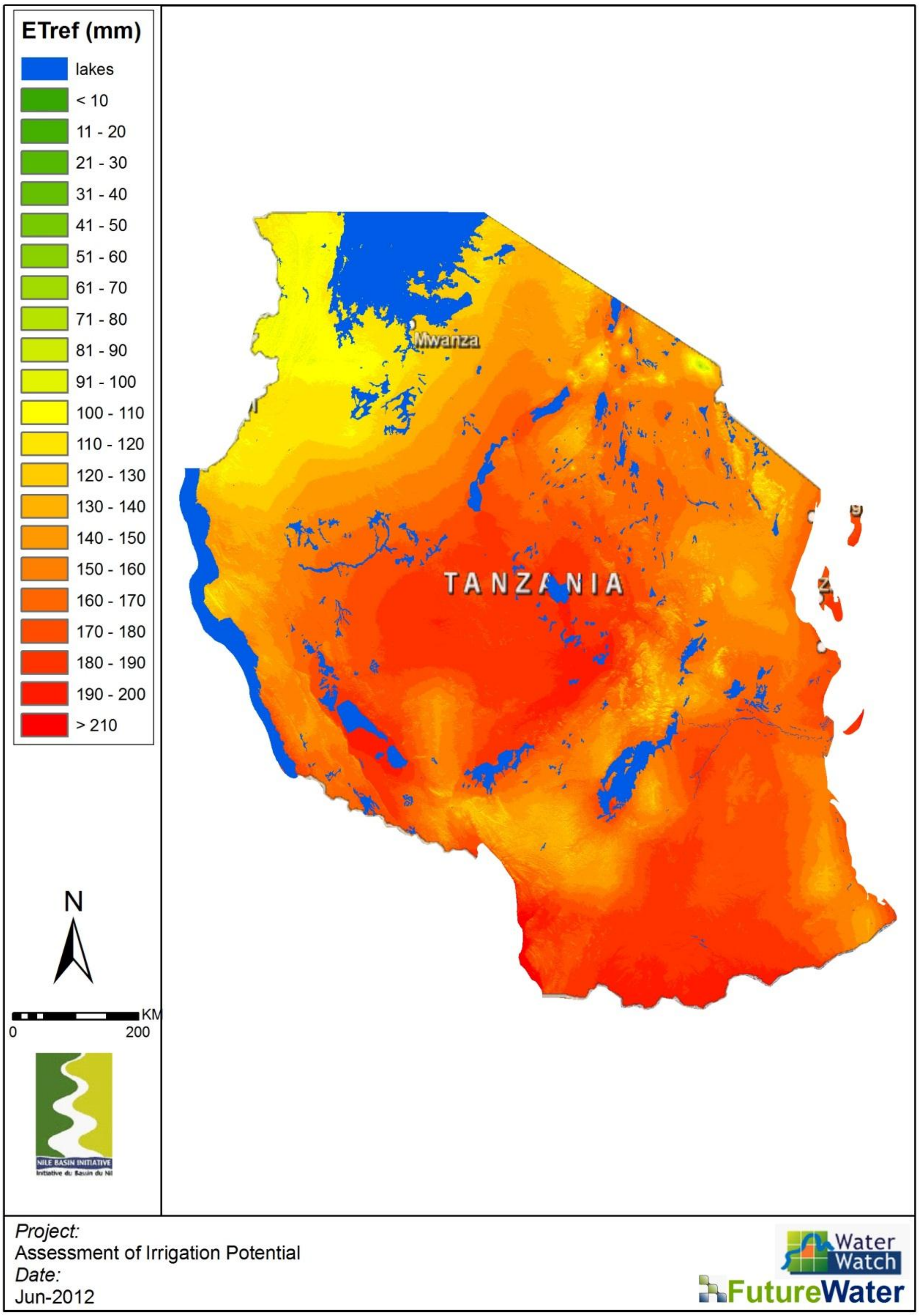



**Figure 16: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom) for October (Average 2001-2010). (Source: study analysis).**

### *November*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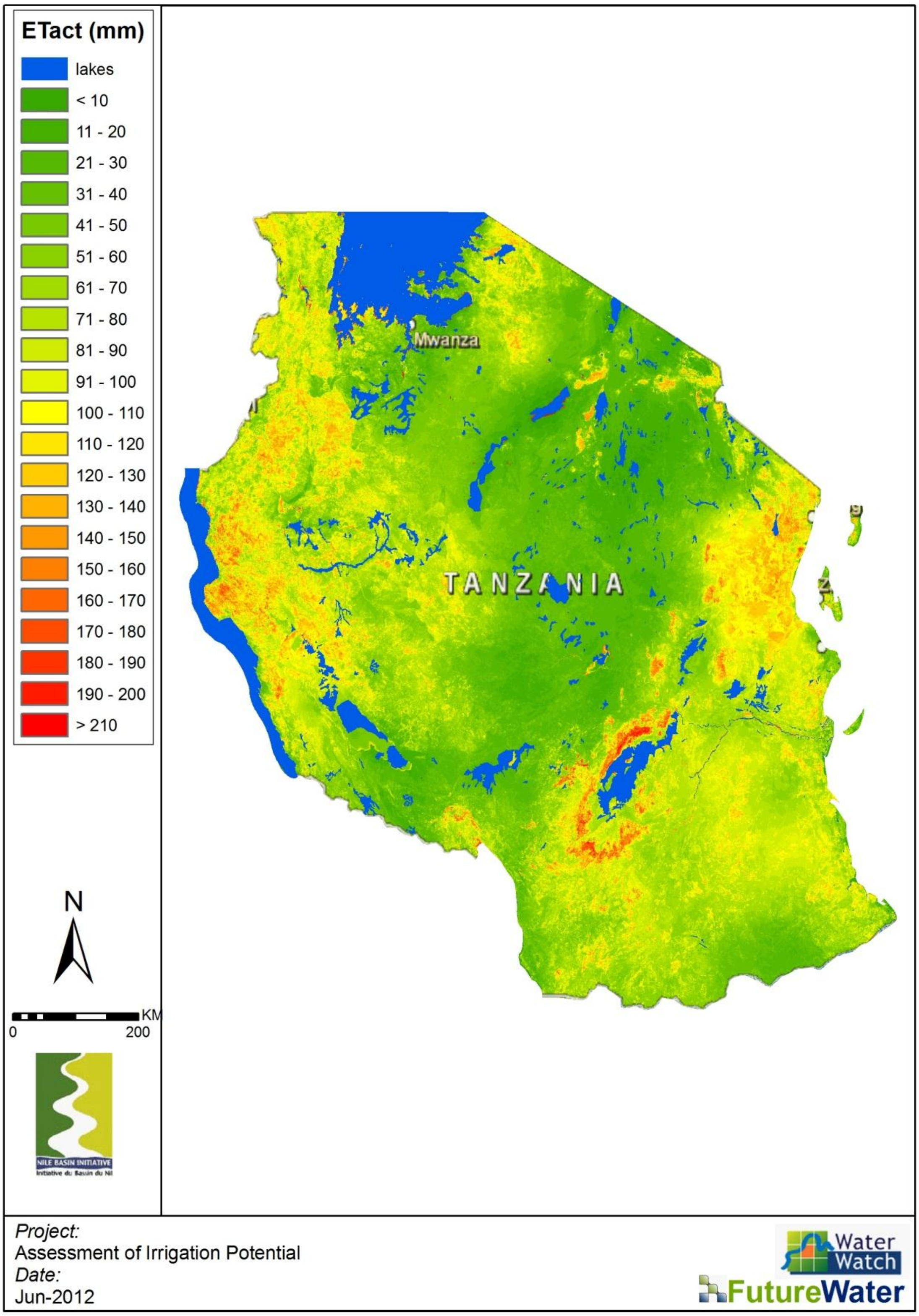
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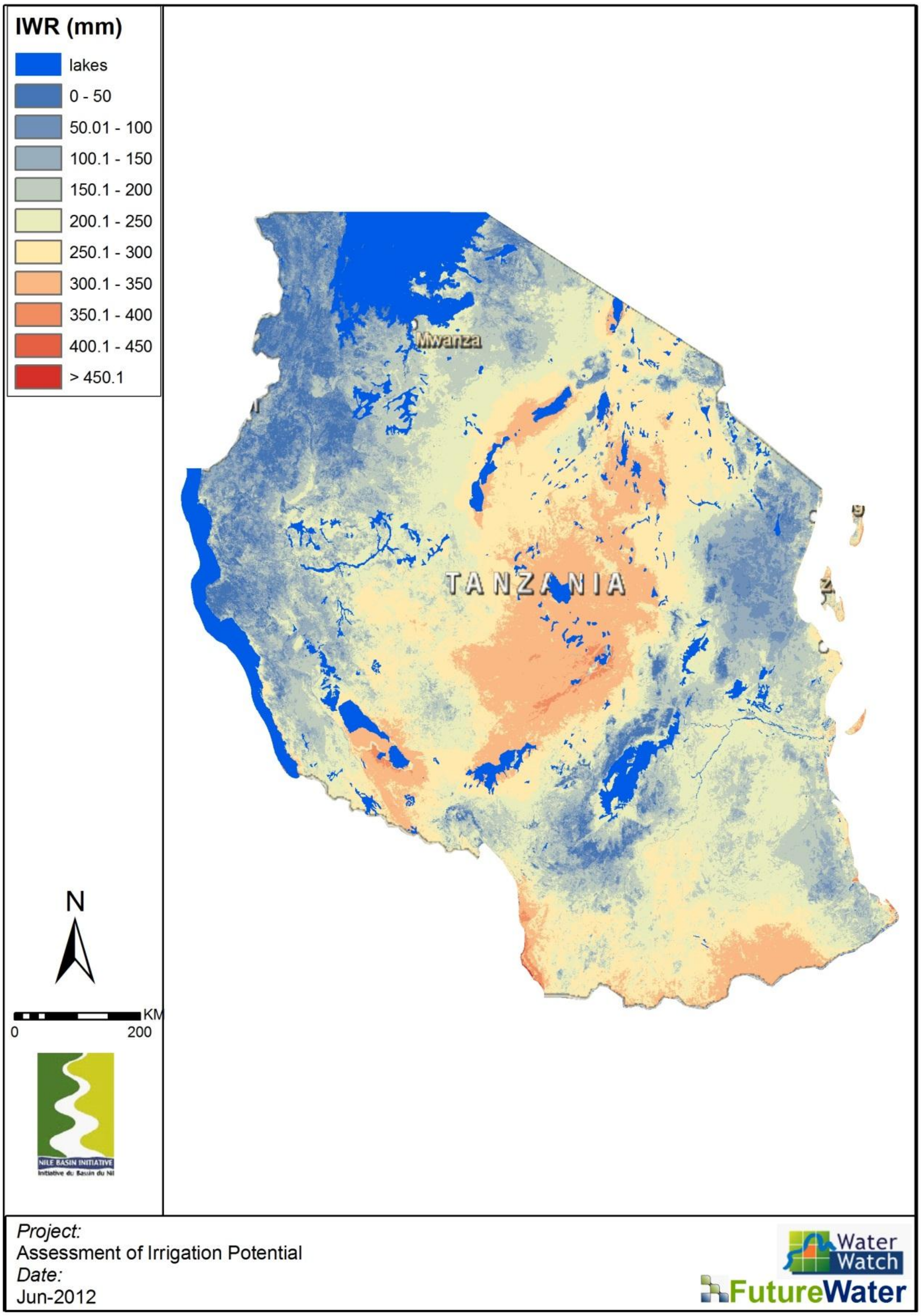
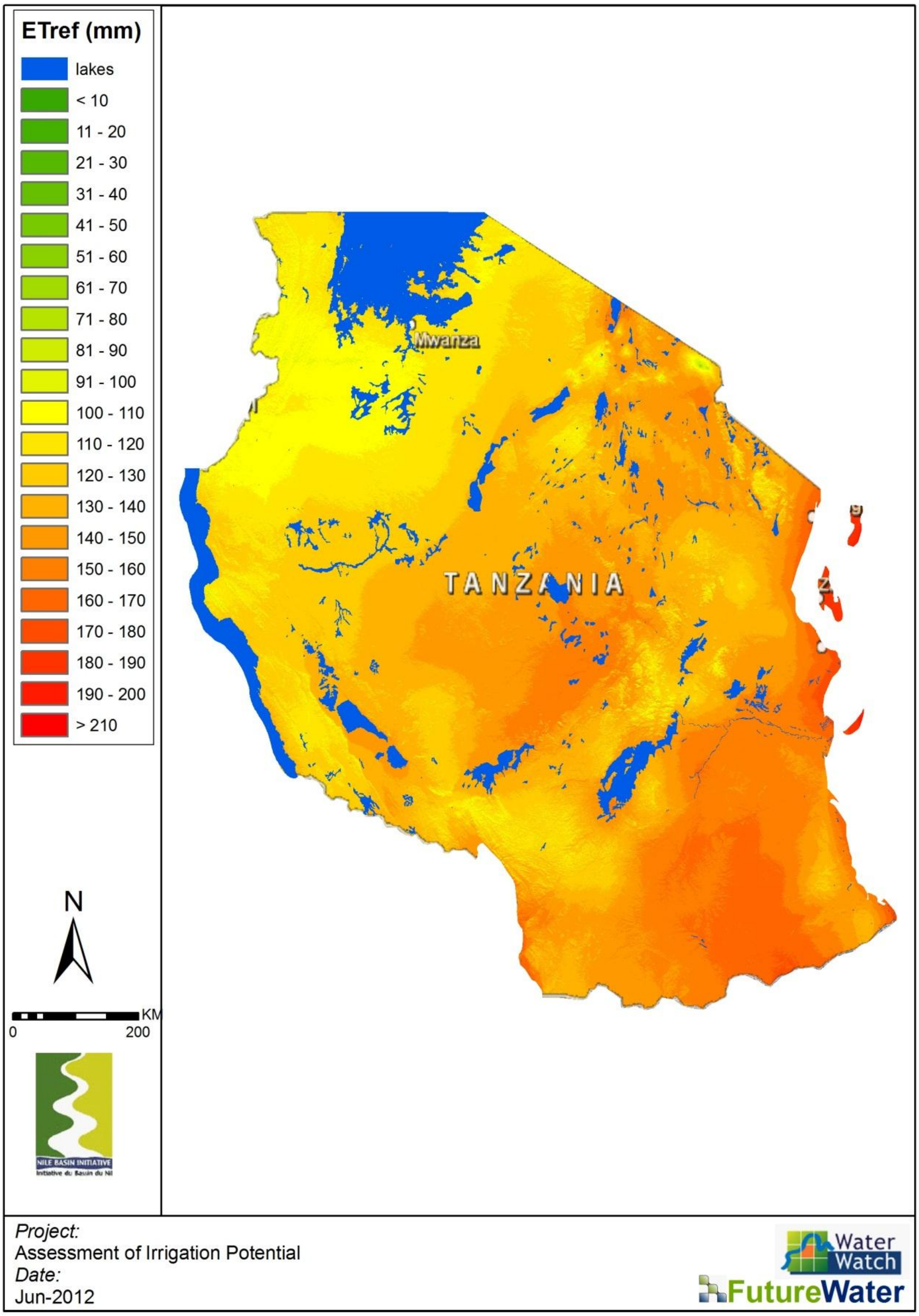



**Figure 17: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom) for November (Average 2001-2010). (Source: study analysis).**

***December***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Water Watch
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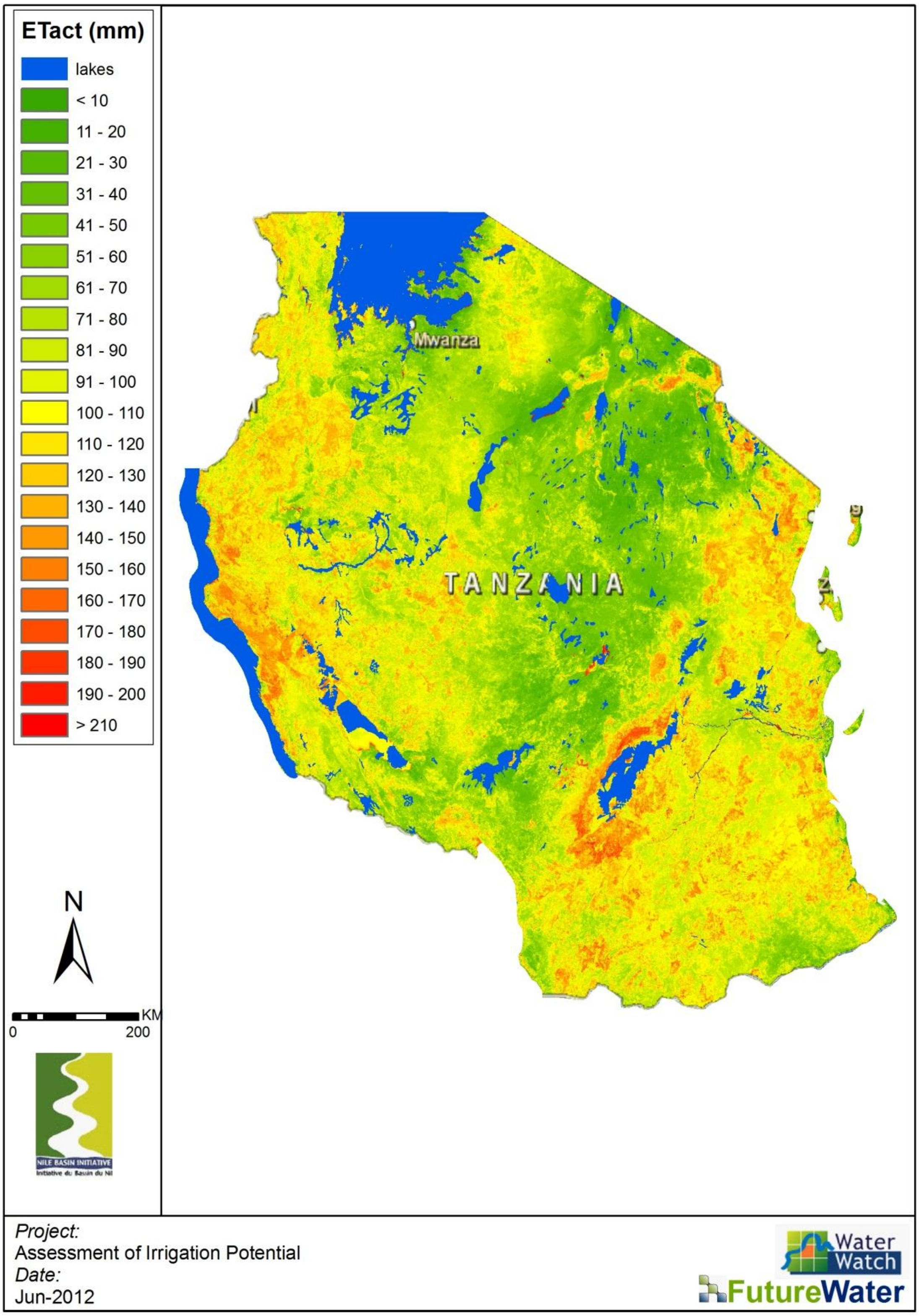
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51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
100 - 110
110 - 120
120 - 130
130 - 140
140 - 150
150 - 160
160 - 170
170 - 180
180 - 190
190 - 200
> 210
Mwanza
TANZANIA
N
KM
0
200
NILE BASIN INITIATIVE
Initiative du Bassin du Nil
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater

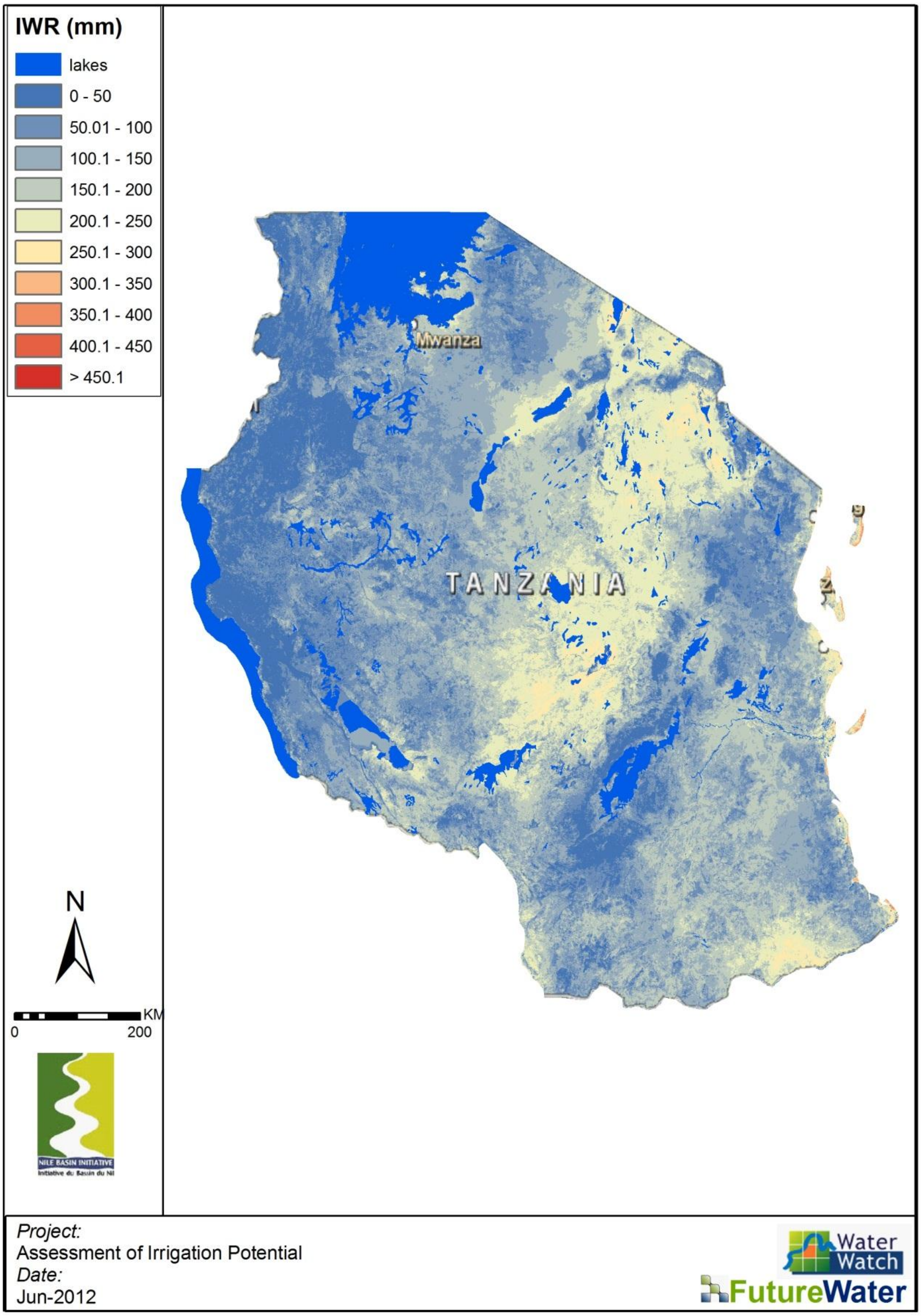


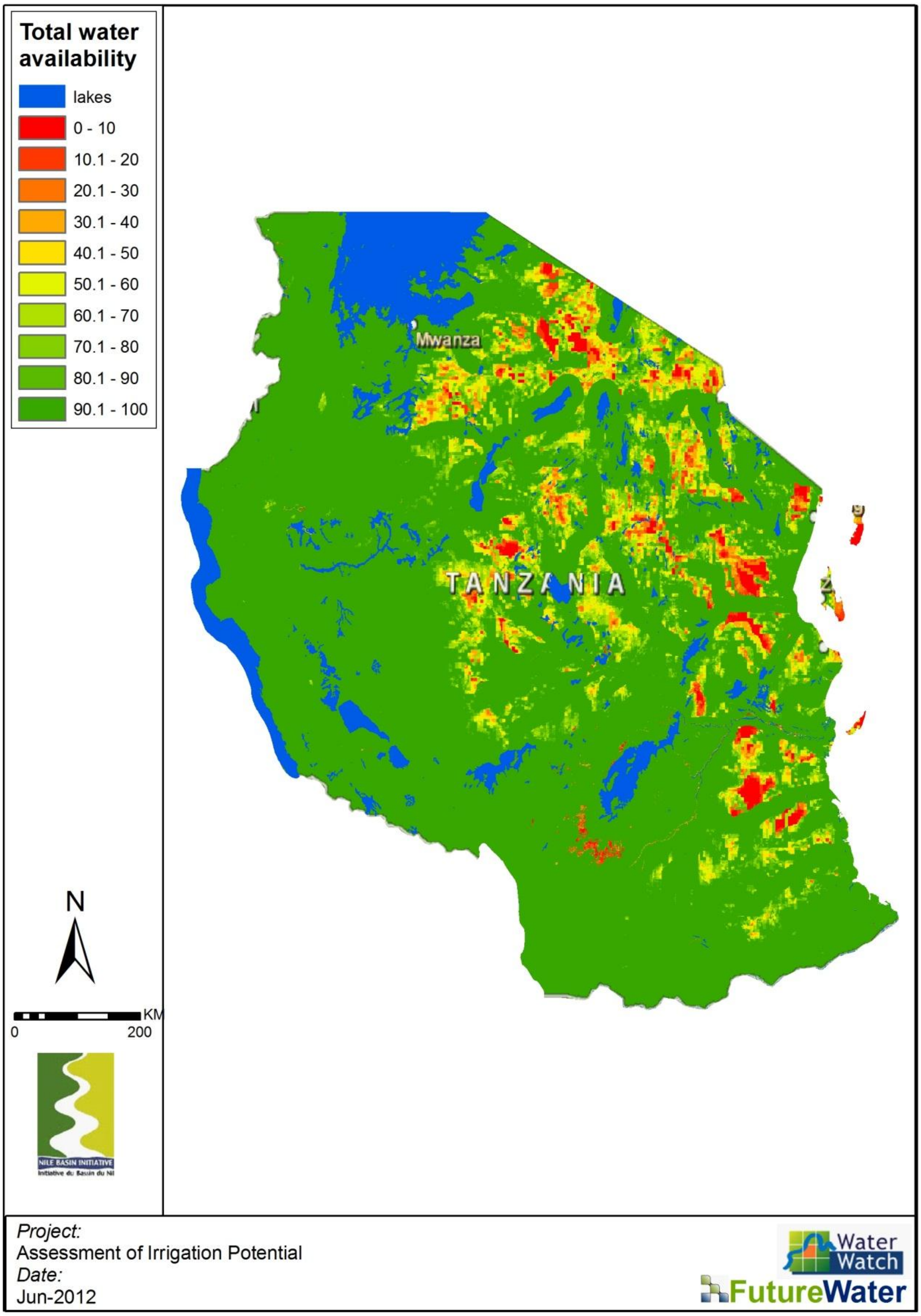

**Figure 18: Reference evapotranspiration (top), actual evapotranspiration (middle), and irrigation water requirement (bottom) for December (Average 2001-2010). (Source: study analysis).**

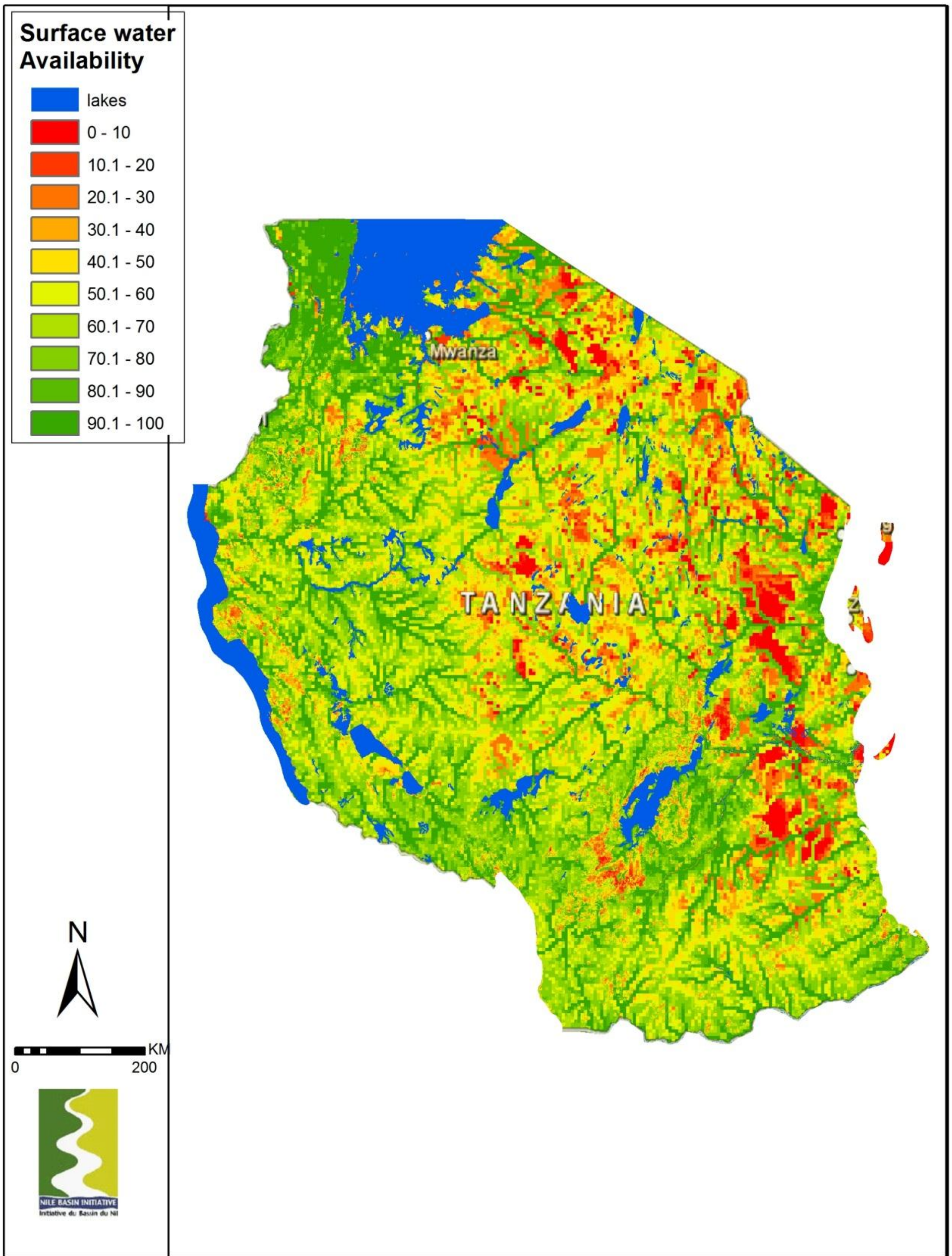
### *2.2.2 Water availability for irrigation*

#### 2.2.2.1 NELmod

Water for irrigation can originate from three main sources: surface water, groundwater, and reservoirs. Based on the water availability (NELmod results), and irrigation demands (ETLook/SEBAL results) coverage of irrigation water requirements has been made (for details see main report). As explained in detail in the main report this water availability reflects only the need for irrigation, e.g. if rainfall occurs the irrigation water requirement is lower. Also the assumption that reservoir water can be used is based on the long-term annual flow rather than on restrictions for construction of a reservoir.

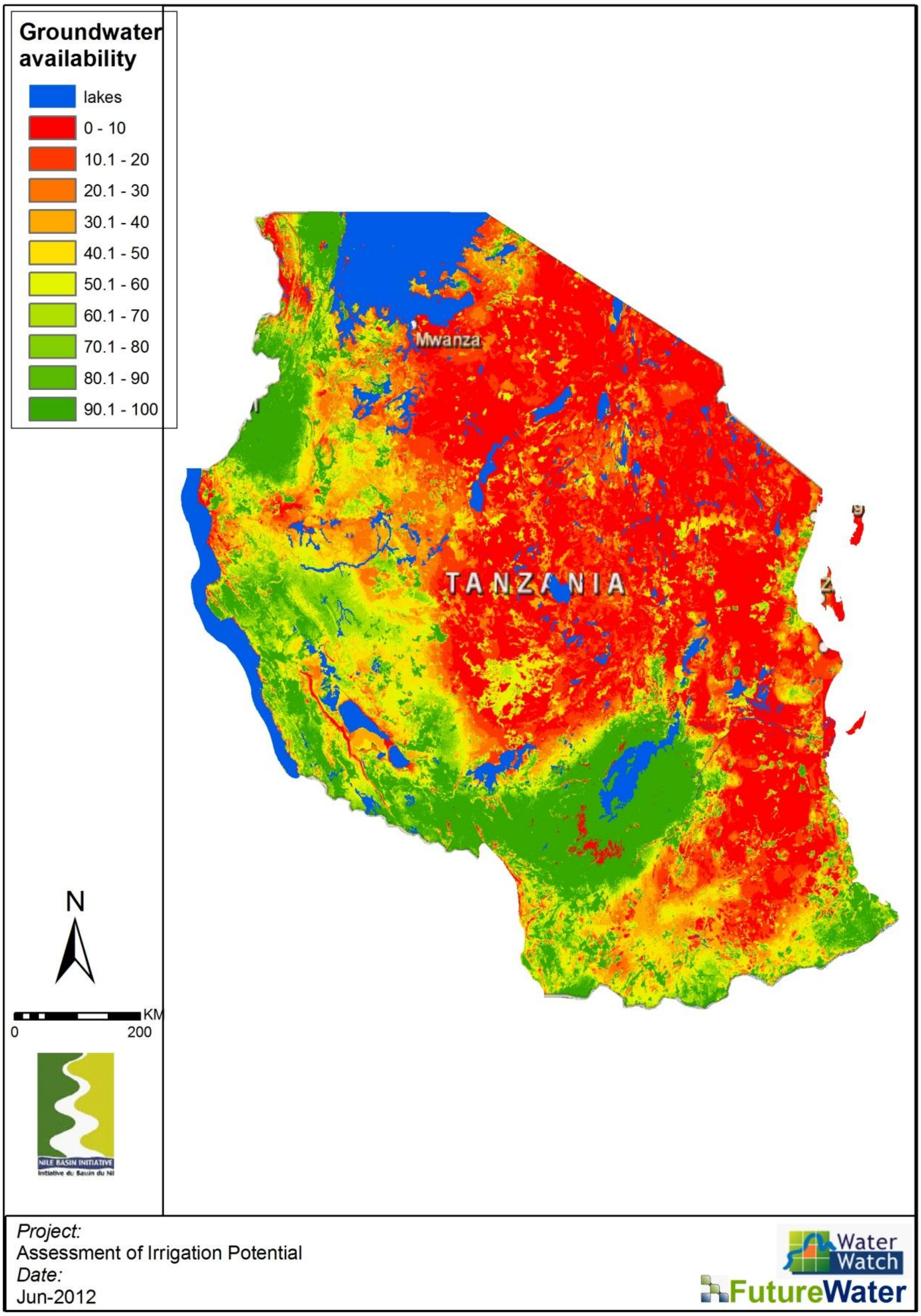
Results indicate that water availability for irrigation in the country is very high. Main sources are the surface water in the South West in combination of the potential reservoirs.


Total water availability
lakes
0 - 10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 50
50.1 - 60
60.1 - 70
70.1 - 80
80.1 - 90
90.1 - 100
Mwanza
TANZANIA
N
KM
0
200
NILE BASIN INITIATIVE
Initiative du Bassin du Nil
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater




*Project:*
Assessment of Irrigation Potential
*Date:*
Jun-2012

WaterWatch FutureWater


Groundwater availability
lakes
0 - 10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 50
50.1 - 60
60.1 - 70
70.1 - 80
80.1 - 90
90.1 - 100
Mwanza
TANZANIA
N
KM
0
200
NILE BASIN INITIATIVE
Initiative du Bassin du Nil
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater

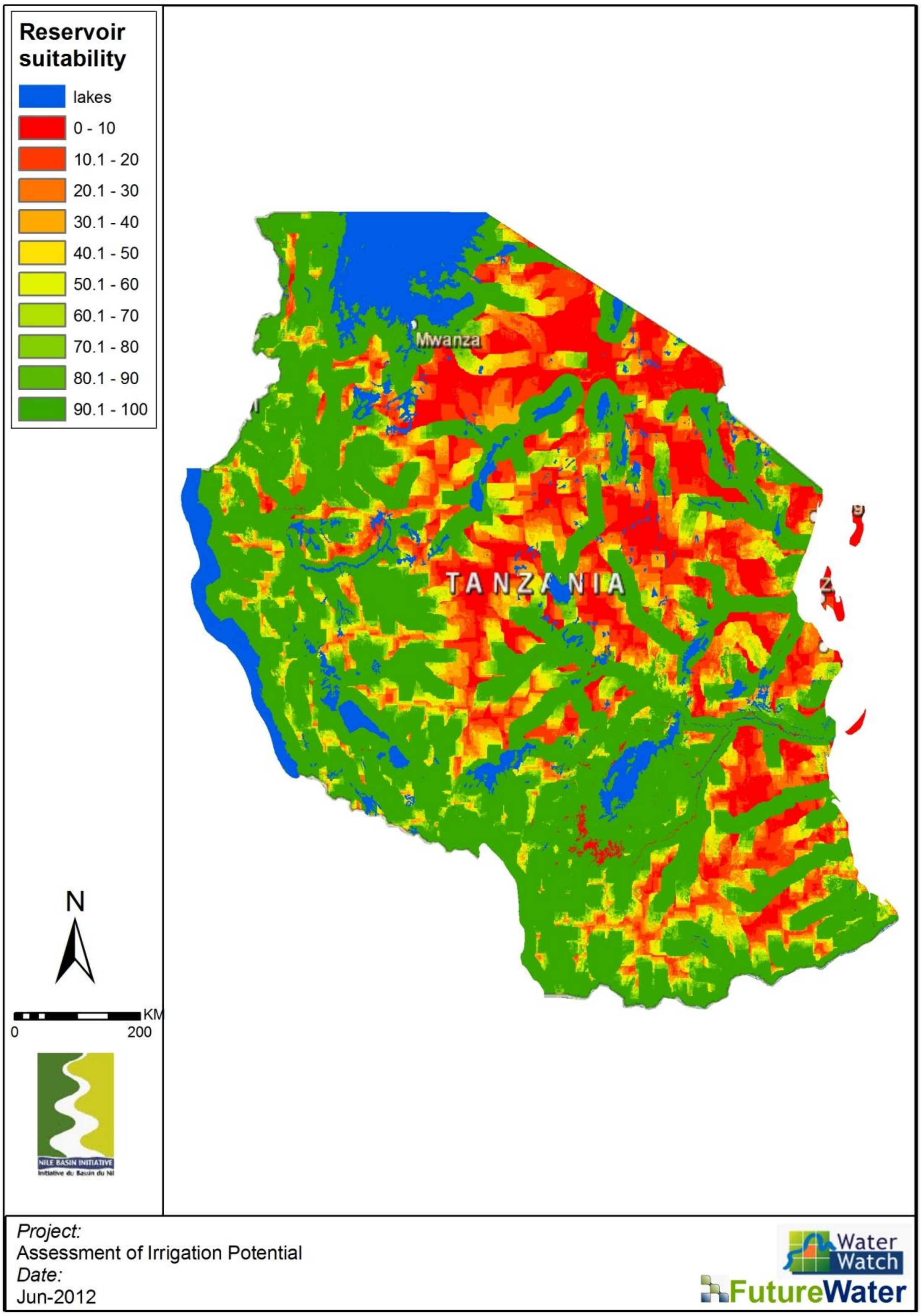



**Figure 19: Water availability for irrigation. Total coverage (top), coverage from surface water (second), coverage from ground water (third), and from potential reservoirs (bottom). (Source: study analysis).**

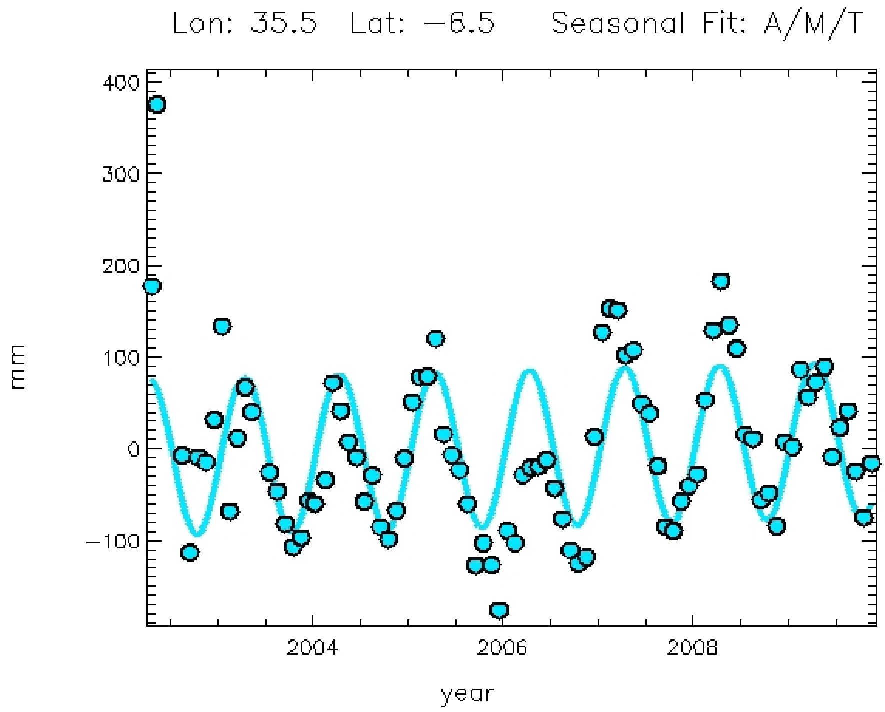



**Figure 20: Annual groundwater storage trends for Tanzania, based on GRACE satellite observations (Source: UoC, 2011).**

#### 2.2.2.2 Groundwater Trends

Large scale groundwater trends can also be observed from the GRACE satellite. This twin-satellite detects on a monthly base groundwater fluctuations over rather large areas (for details see main report). Long term groundwater trends can be seen in Figure 20. Groundwater recharge has quite some regional differences (Figure 21). Overall, groundwater recharge is South western part and quite high around Mikumi.

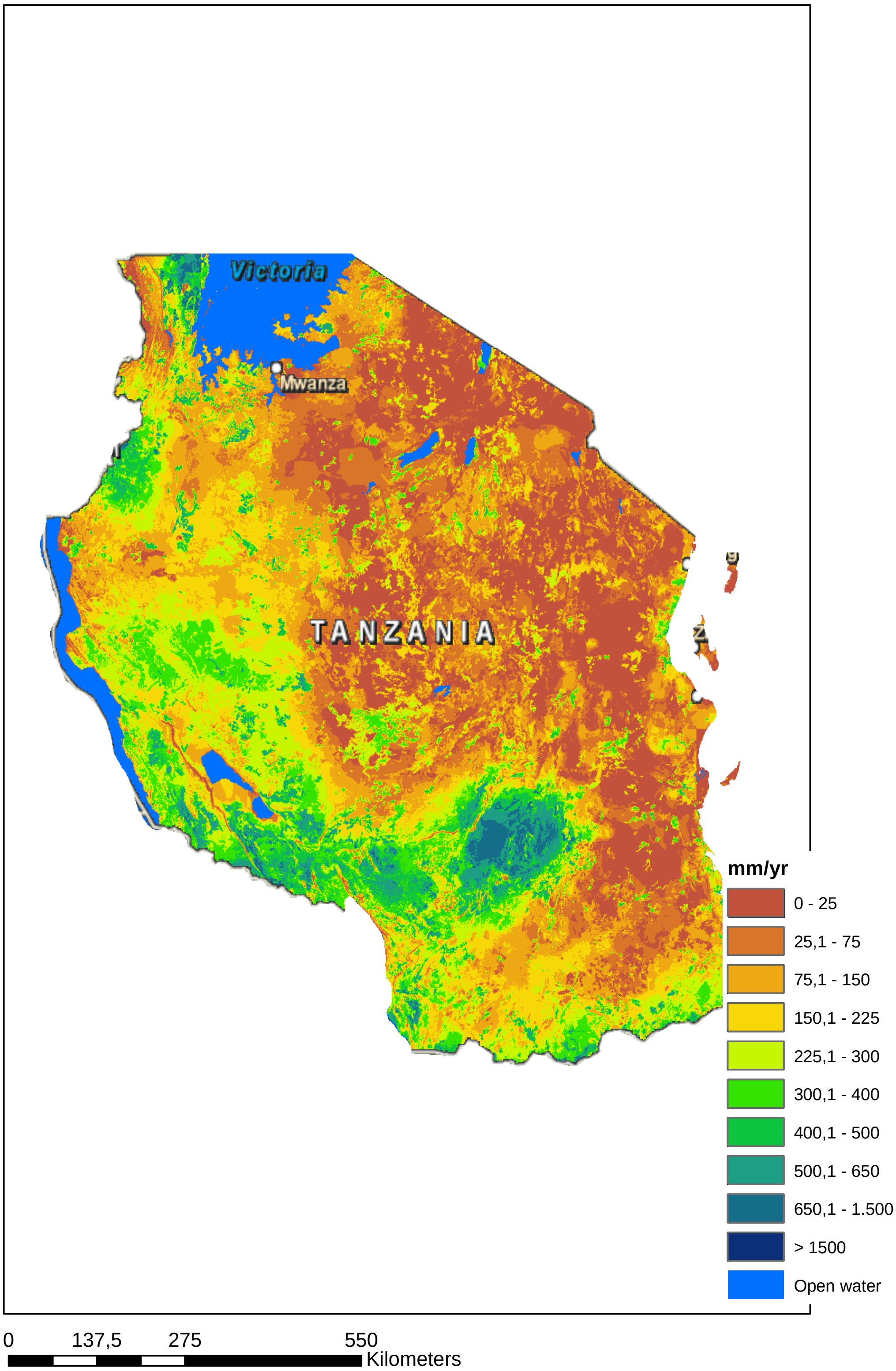
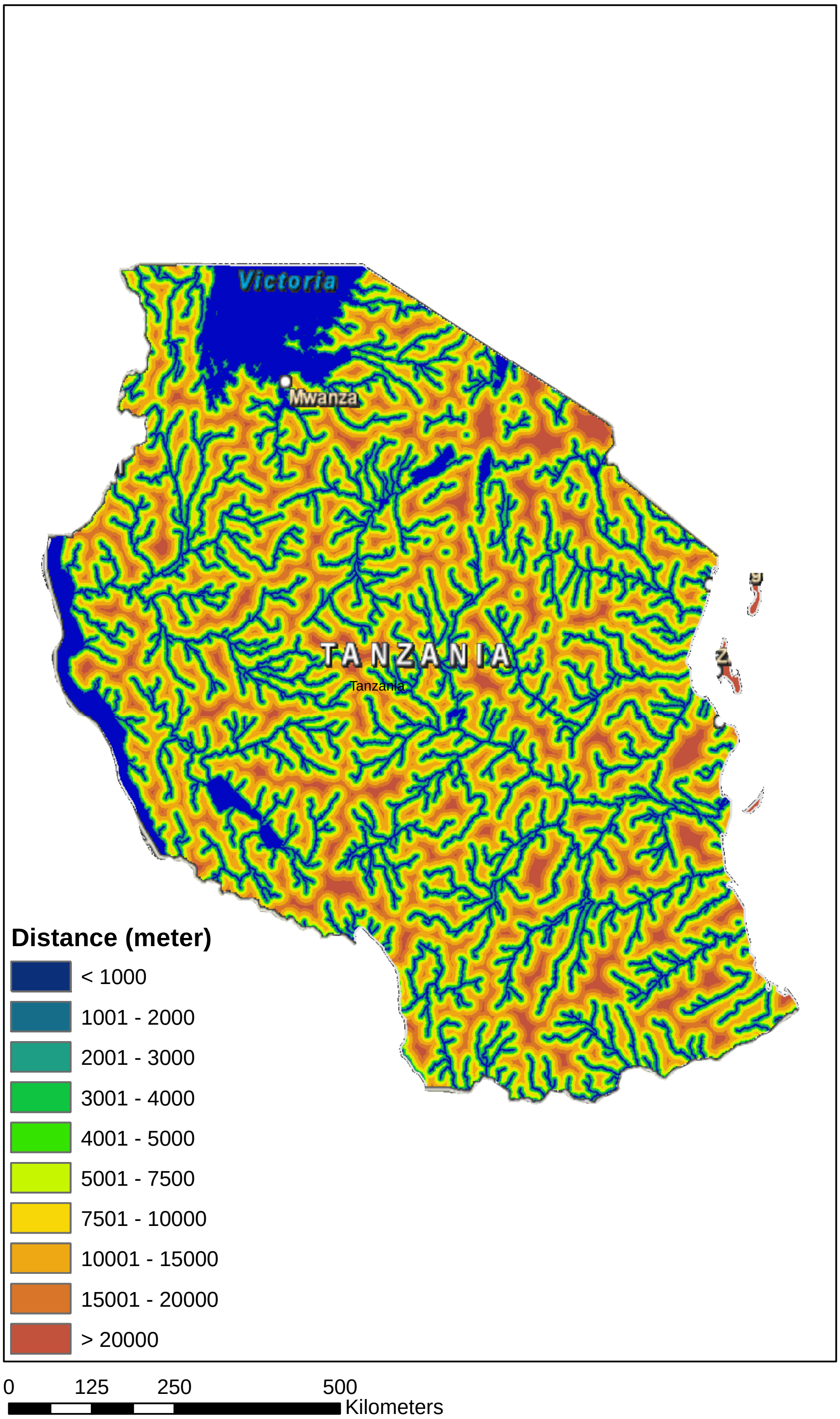
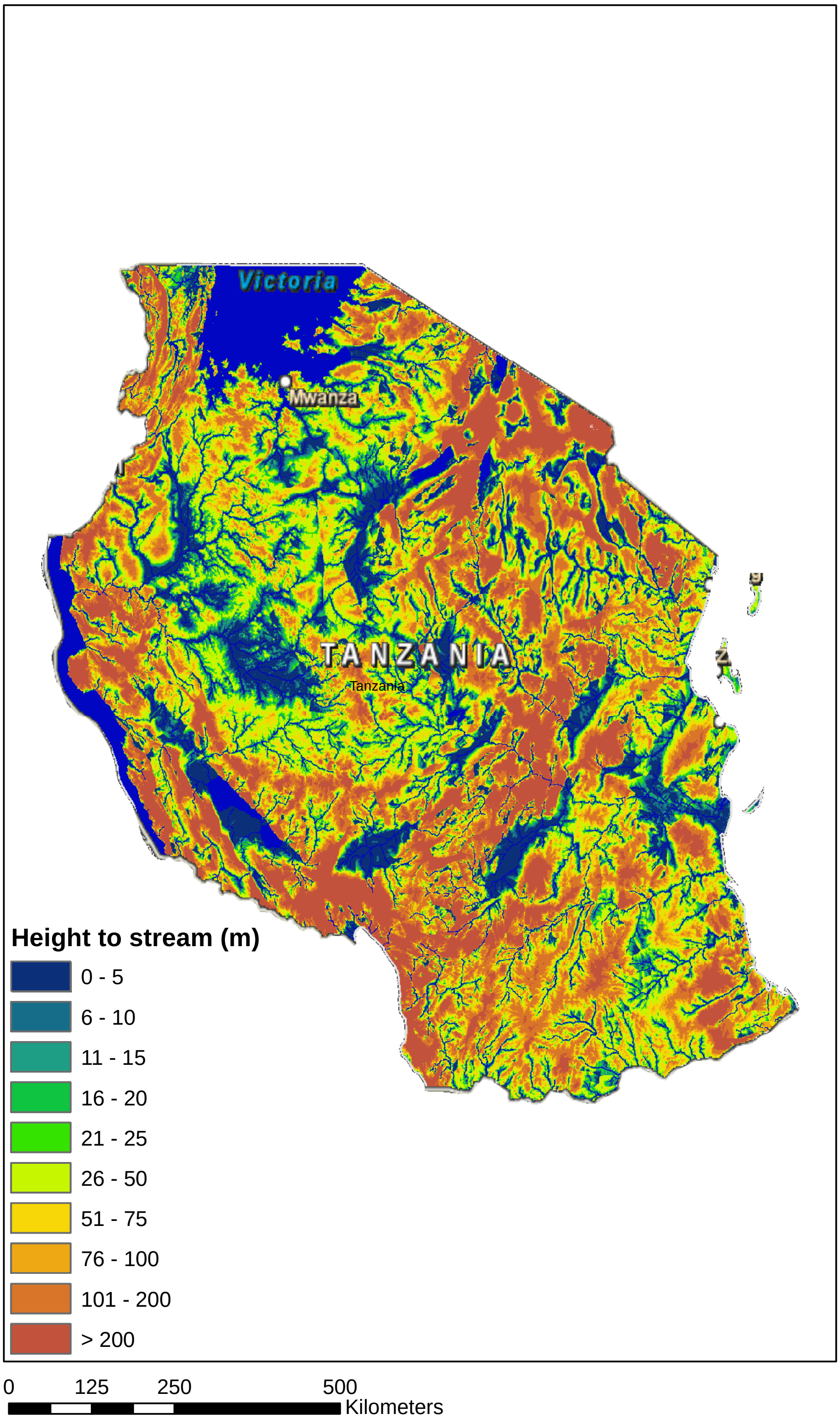



**Figure 21: Annual groundwater recharge based on NELmod.**

### *2.2.3 Access to a potential water source*

A crucial component in assessing the potential for irrigation is the distance from the potential irrigation scheme to natural course of a river, stream or lake or to an existing reservoir. Based on various distance classes and elevation this suitability in terms access to a potential water source is defined (for details see main report). The dense stream network covers most of Tanzania, and the western part south of Lake Victoria is most suitable since the height differences are not so large.


Victoria
Mwanza
TANZANIA
Tanzania
Distance (meter)
< 1000
1001 - 2000
2001 - 3000
3001 - 4000
4001 - 5000
5001 - 7500
7501 - 10000
10001 - 15000
15001 - 20000
> 20000
0 125 250 500
Kilometers


Victoria
Mwanza
TANZANIA
Tanzania
Height to stream (m)
0 - 5
6 - 10
11 - 15
16 - 20
21 - 25
26 - 50
51 - 75
76 - 100
101 - 200
> 200
0
125
250
500
Kilometers

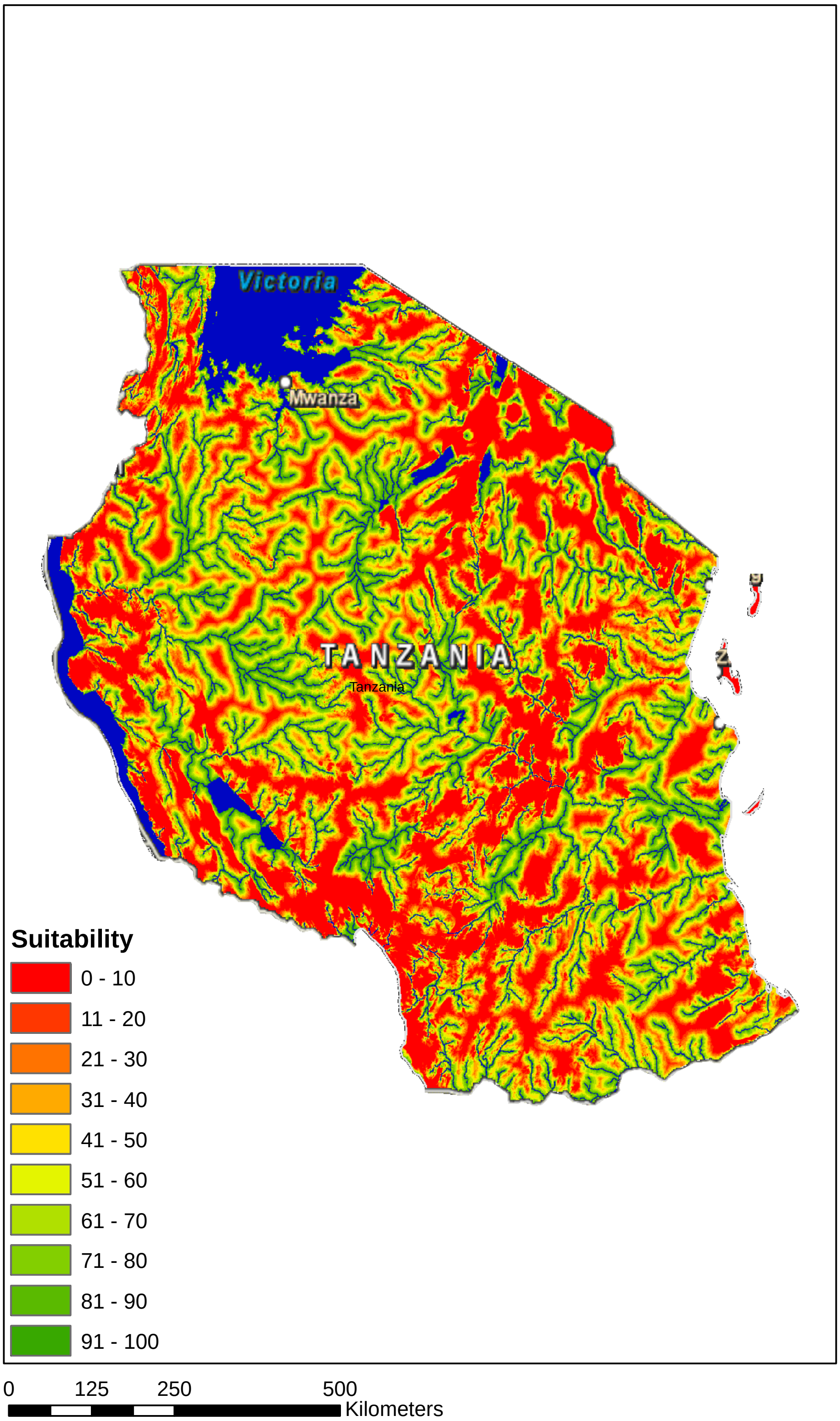



**Figure 22: Average distance to a natural stream, lake or reservoir (top), elevation above natural stream, lake or reservoir (middle), and access to water suitability score (bottom). (Source: study analysis).**

## 2.3 Land use

### 2.3.1 *Current land use*

Actual land cover based on AfriCover is shown in Figure 23. Distribution of irrigated and rainfed crops are shown in Figure 24. Specific maps for 26 crops are included in the database attached to the report.

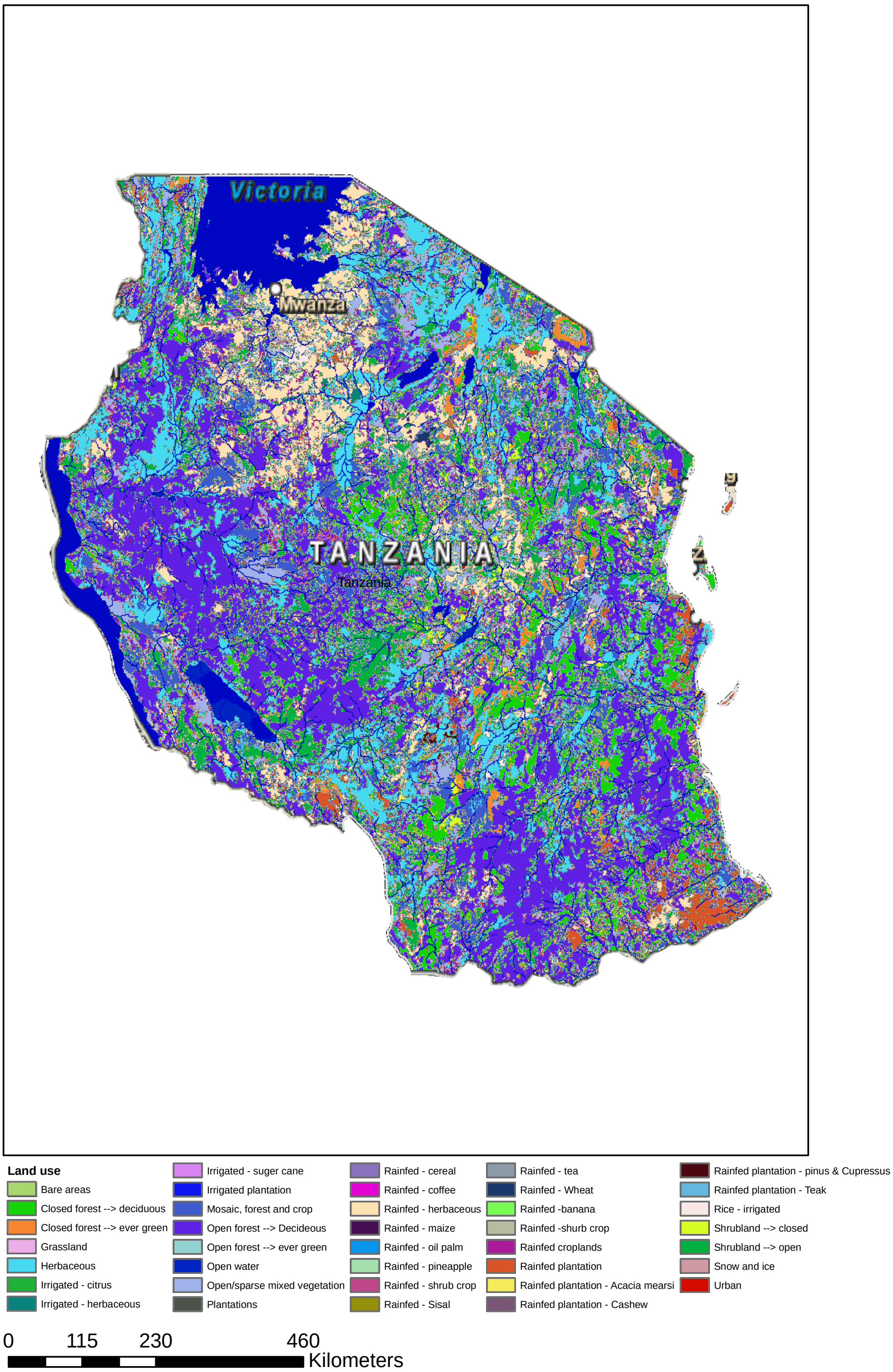
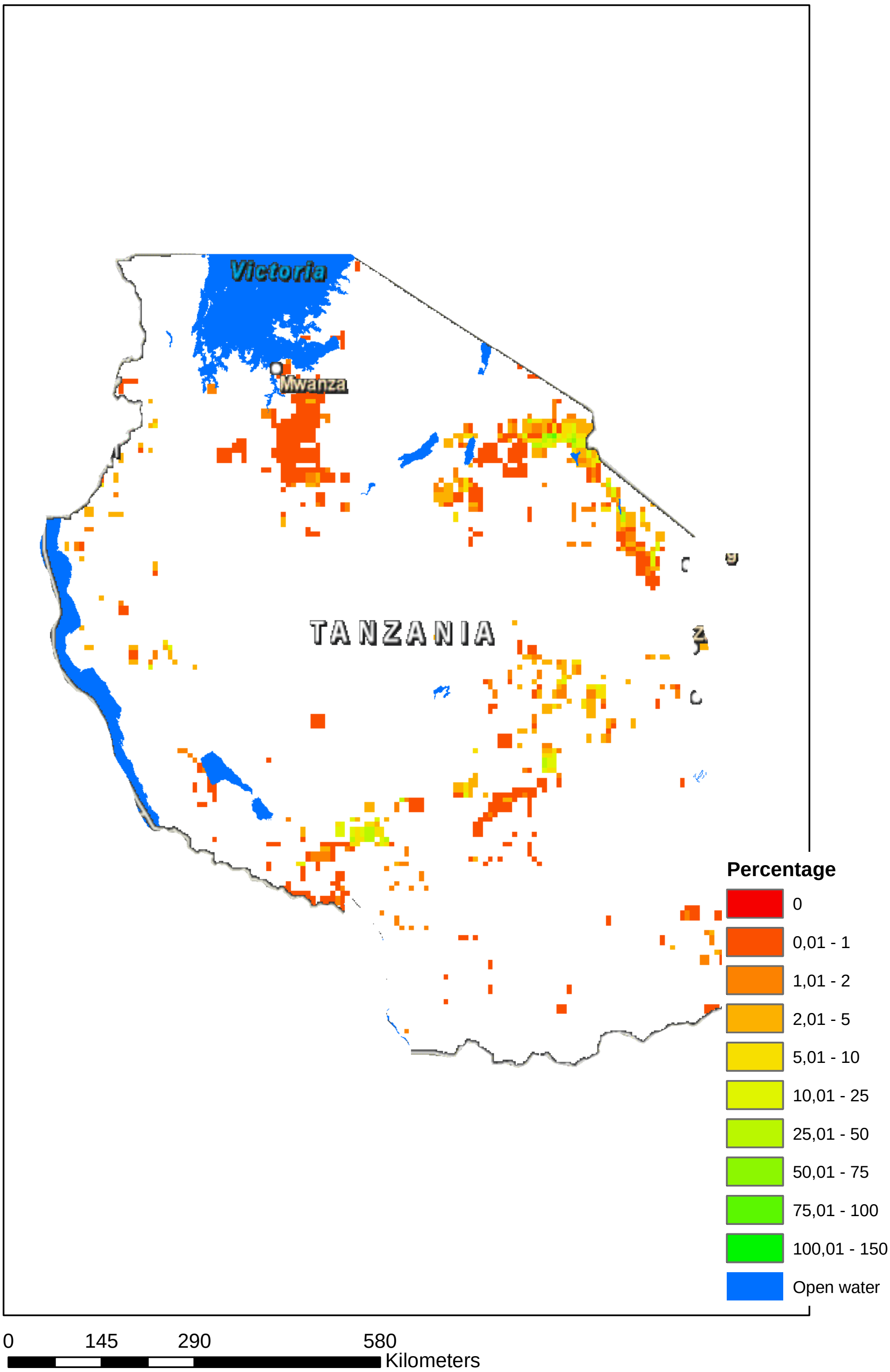



**Figure 23: Land use in Tanzania, based on AfriCover.**


Victoria
Mwanza
TANZANIA
Percentage
0
0,01 - 1
1,01 - 2
2,01 - 5
5,01 - 10
10,01 - 25
25,01 - 50
50,01 - 75
75,01 - 100
100,01 - 150
Open water
0
145
290
580
Kilometers

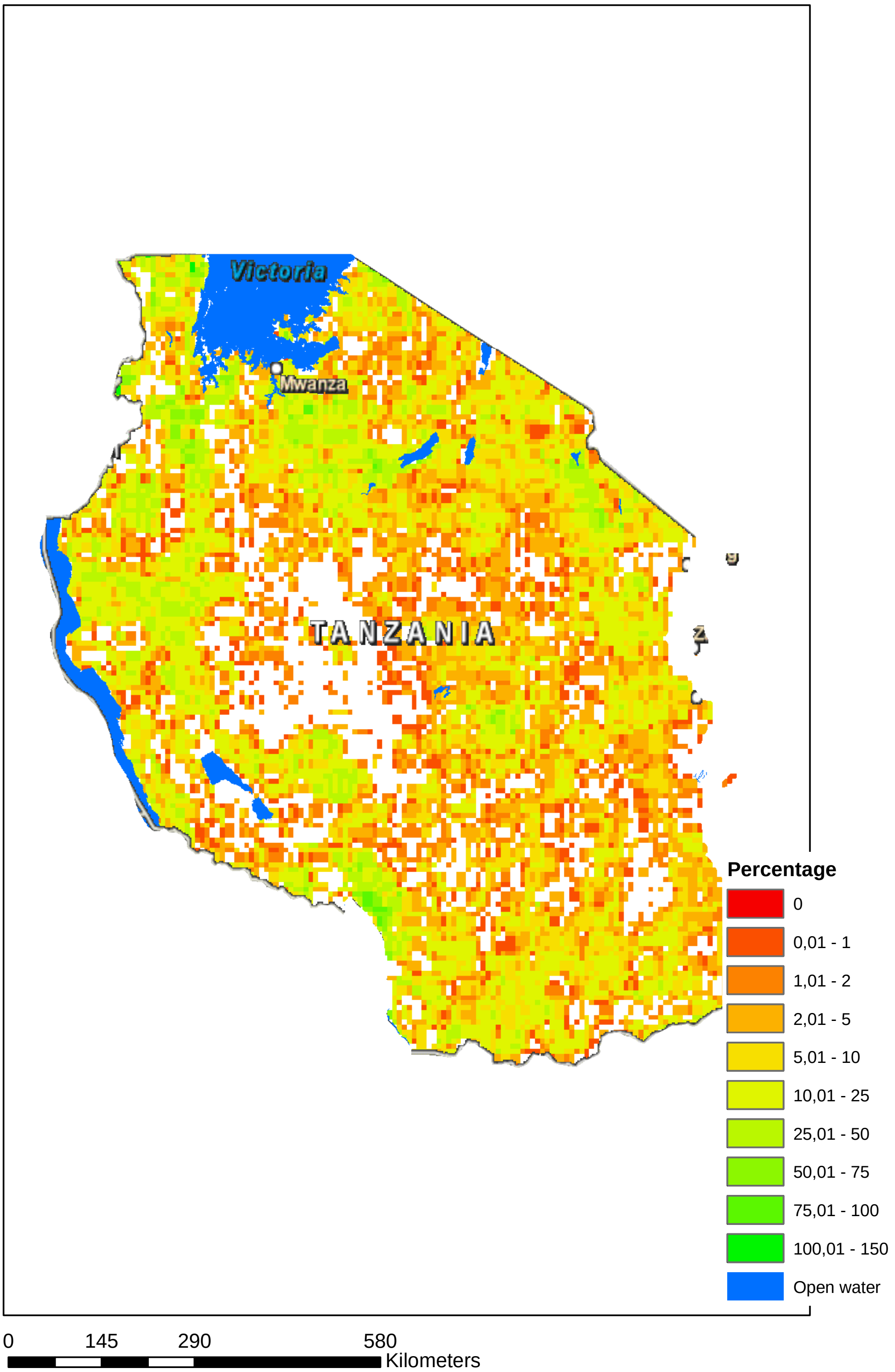



**Figure 24. Irrigated (left) and rainfed cropping intensities[1] (right) as percentage of cells of about 10 x 10 km (Source: Mirca2000).**

[1] Percentages can be above 100% as multiple cropping season might exist in one year.

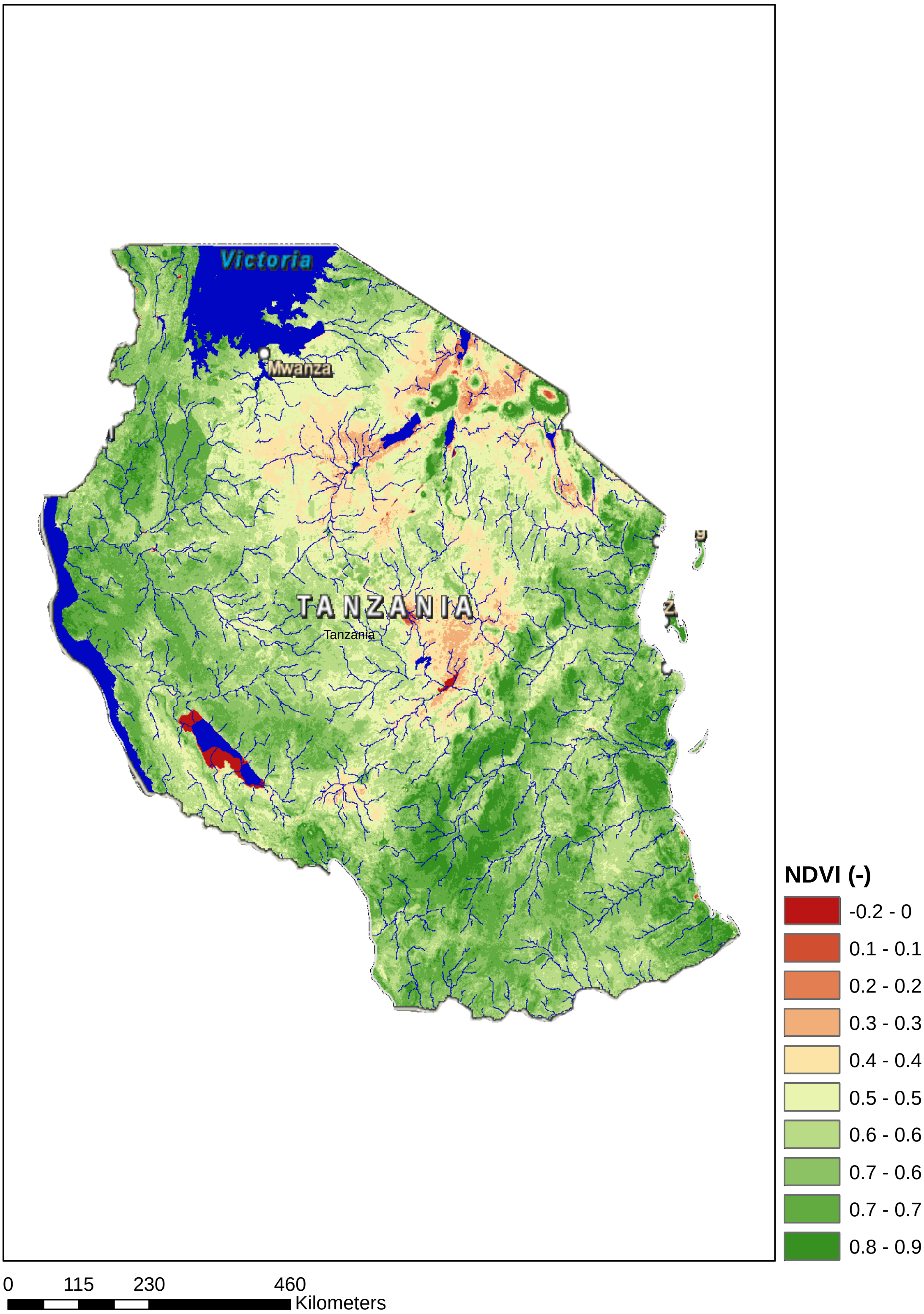
### *2.3.2 Current land productivity (NDVI)*

Current land productivity is assessed based on satellite information and is a good proxy of all integrated features like soils, slopes, management, vegetation etc. Current land productivity in the region is high and monthly variation is limited to the eastern part of the country.

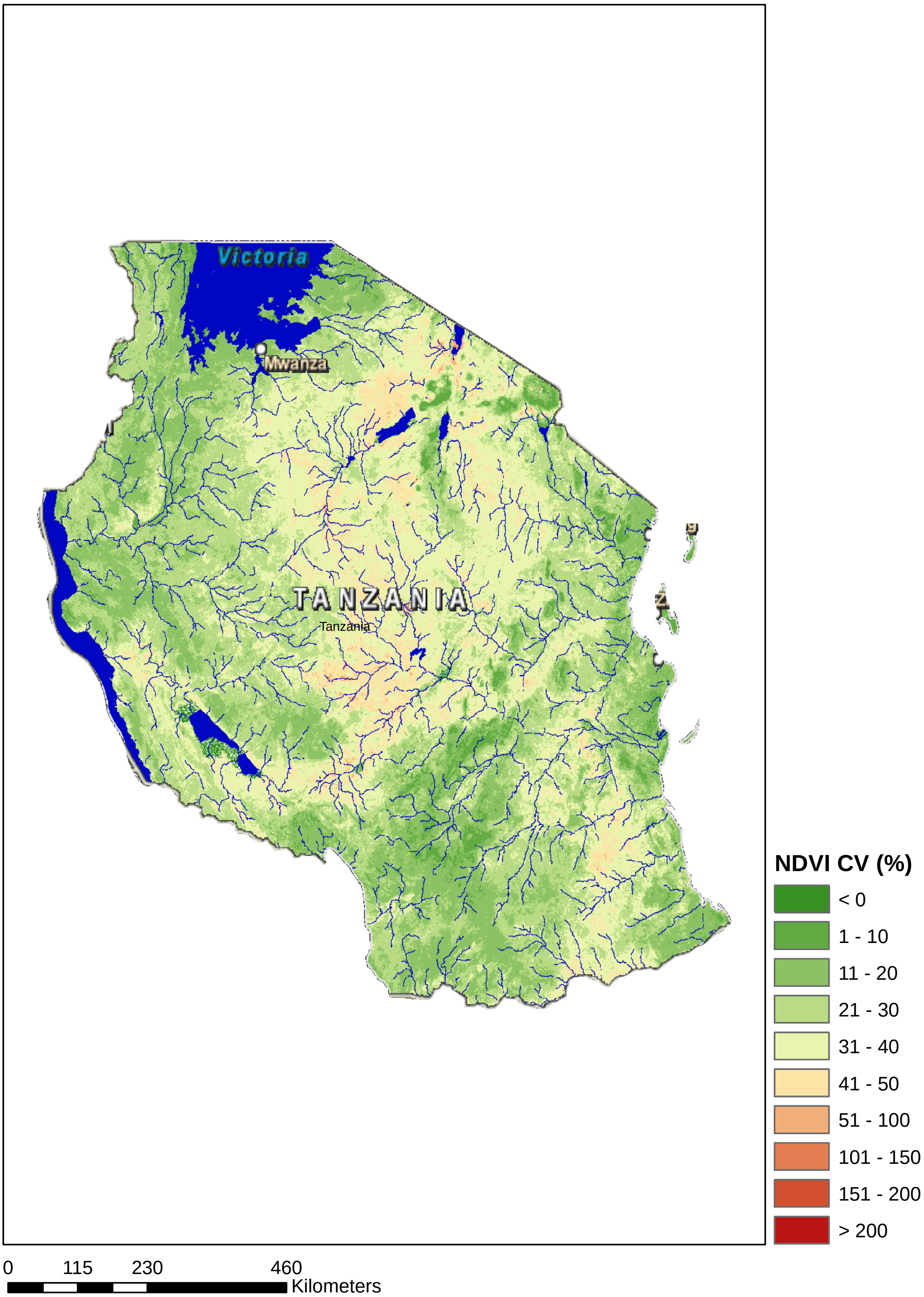
The NDVI formula is:

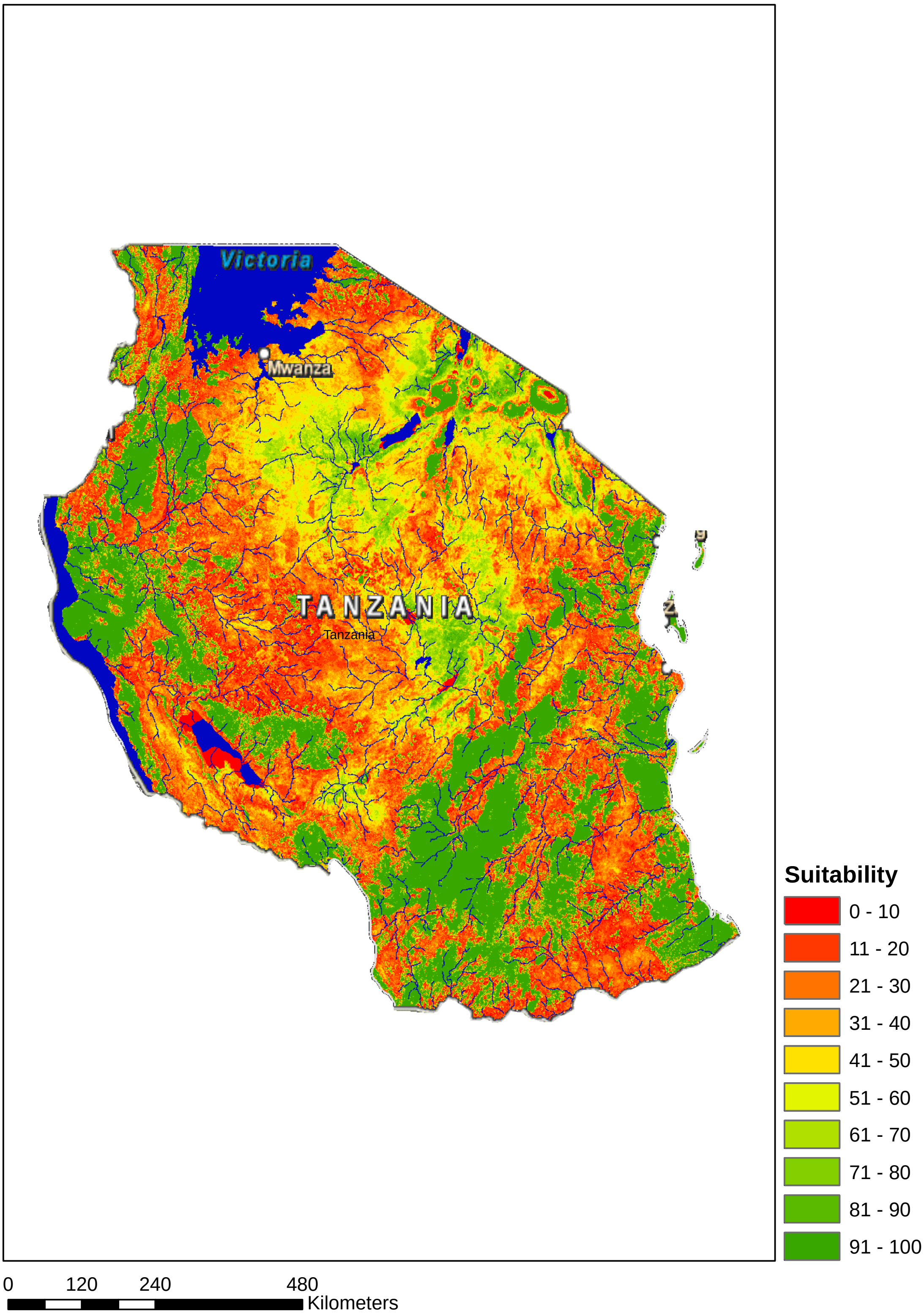
$$\frac{(NIR - RED)}{(NIR + RED)}$$

The NDVI is calculated based on remote sensing Modis images, and in more detail the Nearly InfraRed band (NIR) en de visible RED band (RED). The ratio between these two bands shows the productivity between -1 and 1. Plants absorb the red light for their photosynthesis, and reflect the NIR light.



Victoria
Mwanza
TANZANIA
Tanzania
NDVI (-)
-0.2 - 0
0.1 - 0.1
0.2 - 0.2
0.3 - 0.3
0.4 - 0.4
0.5 - 0.5
0.6 - 0.6
0.7 - 0.6
0.7 - 0.7
0.8 - 0.9
0 115 230 460
Kilometers


Victoria
Mwanza
TANZANIA
Tanzania
NDVI CV (%)
< 0
1 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 100
101 - 150
151 - 200
> 200
0
115
230
460
Kilometers


Victoria
Mwanza
TANZANIA
Tanzania
Suitability
0 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
0
120
240
480
Kilometers

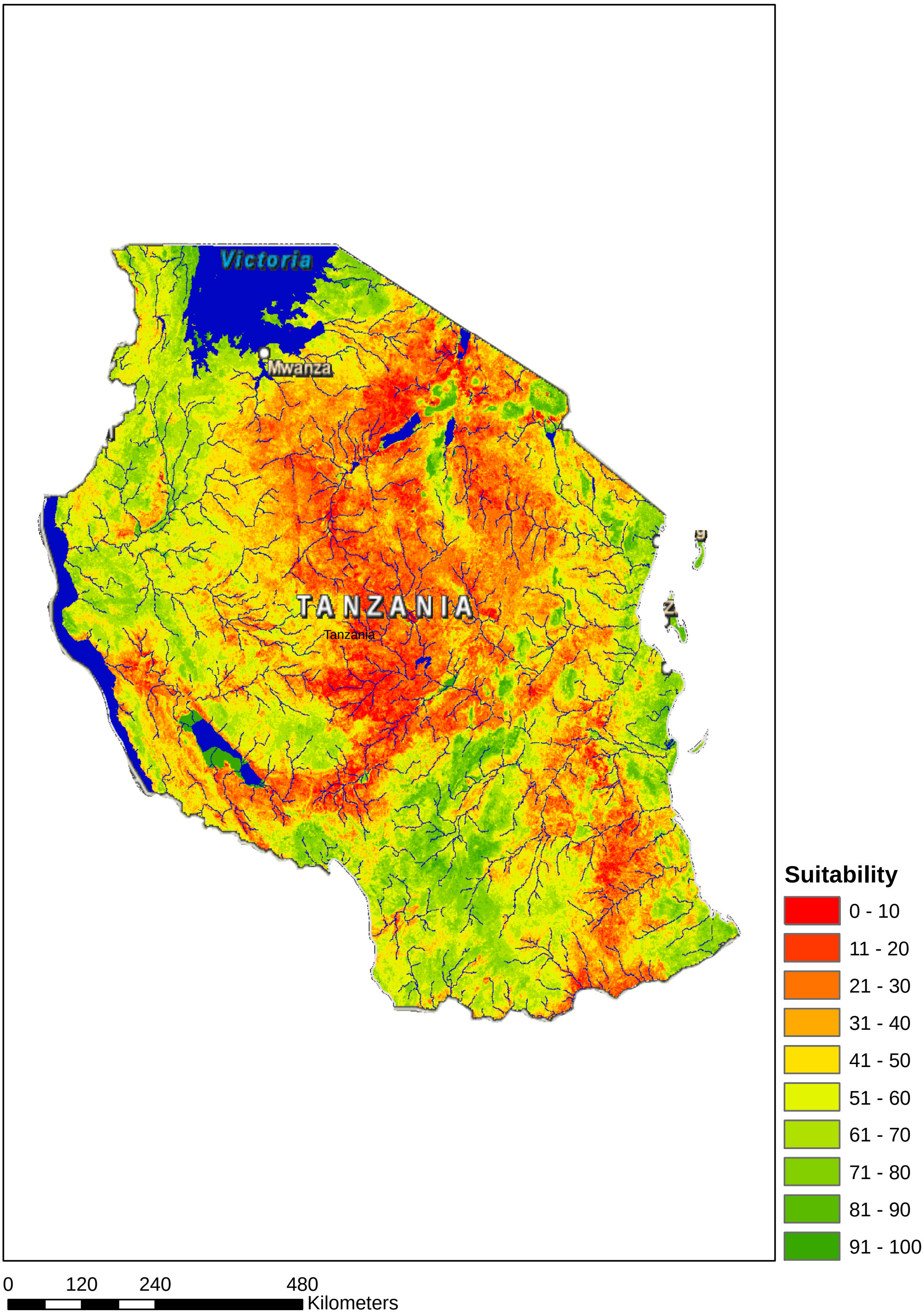



**Figure 25: Current land productivity based on NDVI. Average NDVI (top), average monthly coefficient of variation (second), and the land productivity scores based on average NDVI (third) and monthly coefficient of variation (bottom). (Source: study analysis).**

## 2.4 Agriculture

### *2.4.1 Background*

Agricultural production in Tanzania is dominated by smallholder farms (peasants), cultivating on average farm sizes of between 0.9 hectares and 3.0 hectares. About 70% of Tanzania's crop area is cultivated by hand, 20% by ox plough, and 10% by tractor. It is mainly rainfed agriculture. Food crop production dominates the agriculture economy, where 5.1 million ha is cultivated annually, of which 85% is under food crops. Women constitute the main part of the agricultural labor force. The major constraint facing the agriculture sector is the falling labor and land productivity due to poor technologies, and dependence on unreliable and irregular weather conditions. Both crops and livestock are adversely affected by periodical droughts. Irrigation holds the key to stabilizing agricultural production in Tanzania to improve food security, increase farmers' productivity and incomes, and also to produce higher value crops such as vegetables and even flowers.

Due to variations in climatic and agro-ecological conditions, different crops are grown under different farming systems. The major staples include: maize, rice, wheat, sorghum, millet, pulses (mainly beans), cassava, potatoes, bananas and plantains. The important export crops are: coffee, cotton, cashew nut, tobacco, sisal, pyrethrum, tea, cloves, horticultural crops, oil seeds, spices and flowers.

**Table 1: Area equipped for irrigation in Tanzania (FAOstat, 2010).**

| Tanzania | ha |
|---:|---:|
| 1965 | 28,000 |
| 1975 | 52,000 |
| 1985 | 127,000 |
| 1995 | 150,000 |
| 2005 | 184,000 |

### *2.4.2 Potential crop yield assessment*

Potential crop yield assessment is based on the so-called yield-gap analysis. Yield-gap is defined as the difference between the actual yield and the maximum obtainable yield. The yield-gap analysis is essential to show what might be an obtainable yield if all factors are optimal. Instead of using a so-called theoretical yield assuming that no restrictions exist, yield-gap analysis are based on realistic and attainable yields (details see main report). The analysis will therefore compare all countries involved in this study as well as the average of the continent and the highest value obtained somewhere in the world. Moreover, a trend analysis per country will indicate whether improvements can still being made.

Over the past 30 years the yield gap for Paddy and dry Beans has partly been closed. The current yields of Paddy are not yet on the level of the surrounding countries, but the dry Beans yield already exceeds the East African average. The yield development of Maize shows a similar curve as other countries, peaking just before this millennium, and decreasing from there onwards. The yield of Cassava decreases gradually and is currently at 50% of the 1979 level.

This allows for a big improvement, which may close the yield gap. Although none of yields for the five dominant crops are extremely low compared to the other countries the yield in Tanzania, for these five crops, is below the average of these seven countries. This means that there is not so much a crop specific yield gap, but more a smaller overall yield gap.

Table 2: Area harvested in ha for the 10 most dominant crops (FAOstat, 2010).

| | 1980 | 1990 | 2000 | 2005 | 2009 |
|---|---|---|---|---|---|
| Maize | 1.400.000 | 1.631.260 | 1.017.600 | 3.109.590 | 2.961.330 |
| Beans, dry | 500.000 | 410.000 | 750.000 | 1.100.000 | 1.266.870 |
| Cassava | 450.000 | 590.210 | 809.700 | 906.387 | 1.081.380 |
| Rice, paddy | 245.000 | 384.500 | 415.600 | 701.990 | 904.508 |
| Sorghum | 740.000 | 380.000 | 736.200 | 737.080 | 874.219 |
| Sweet potatoes | 189.000 | 306.540 | 407.200 | 469.110 | 680.267 |
| Coconuts | 250.000 | 302.000 | 475.525 | 656.350 | 676.821 |
| Groundnuts, with shell | 92.000 | 115.465 | 117.000 | 409.320 | 535.000 |
| Bananas | 57.000 | 63.200 | 303.500 | 322.040 | 534.354 |
| Seed cotton | 387.000 | 389.340 | 213.300 | 526.720 | 350.000 |
| Total | 4.310.000 | 4.572.515 | 5.245.625 | 8.938.587 | 9.864.749 |

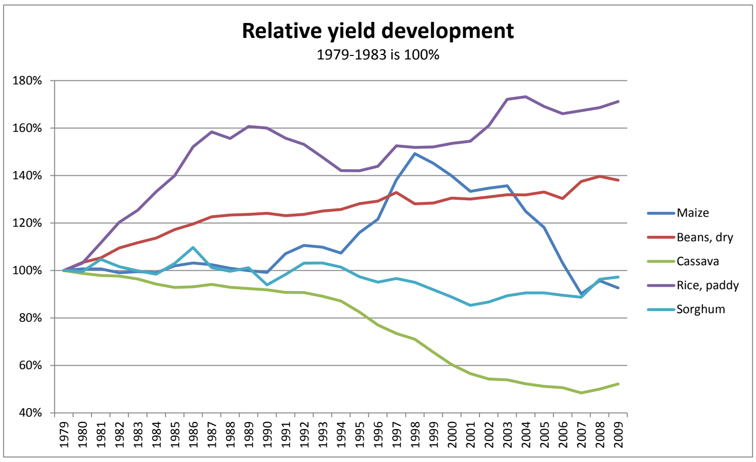



**Figure 26: Trend in yields per ha for the five most dominant crops. Average of first five years have been indexed to 100% (FAOstat, 2010).**

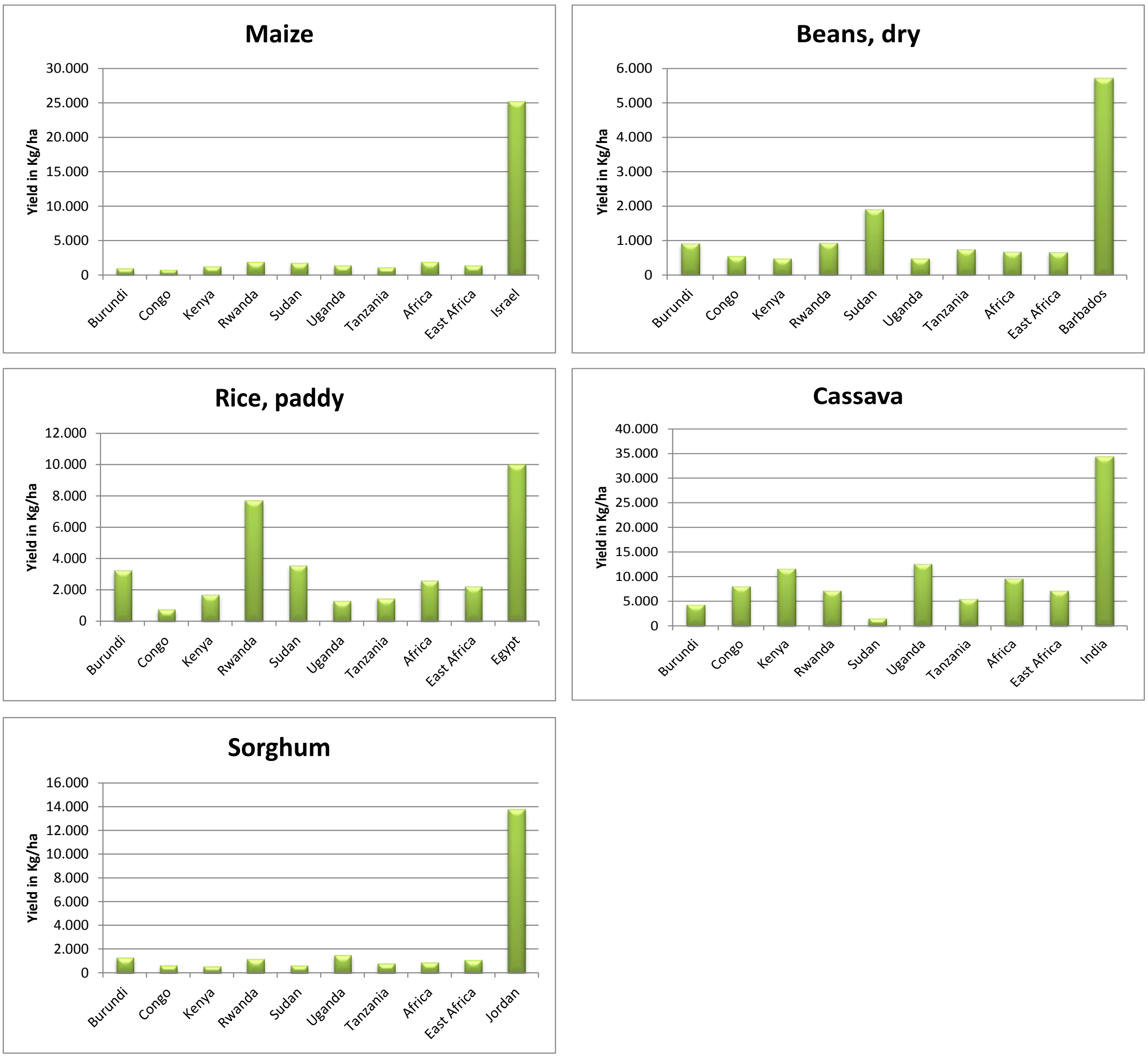
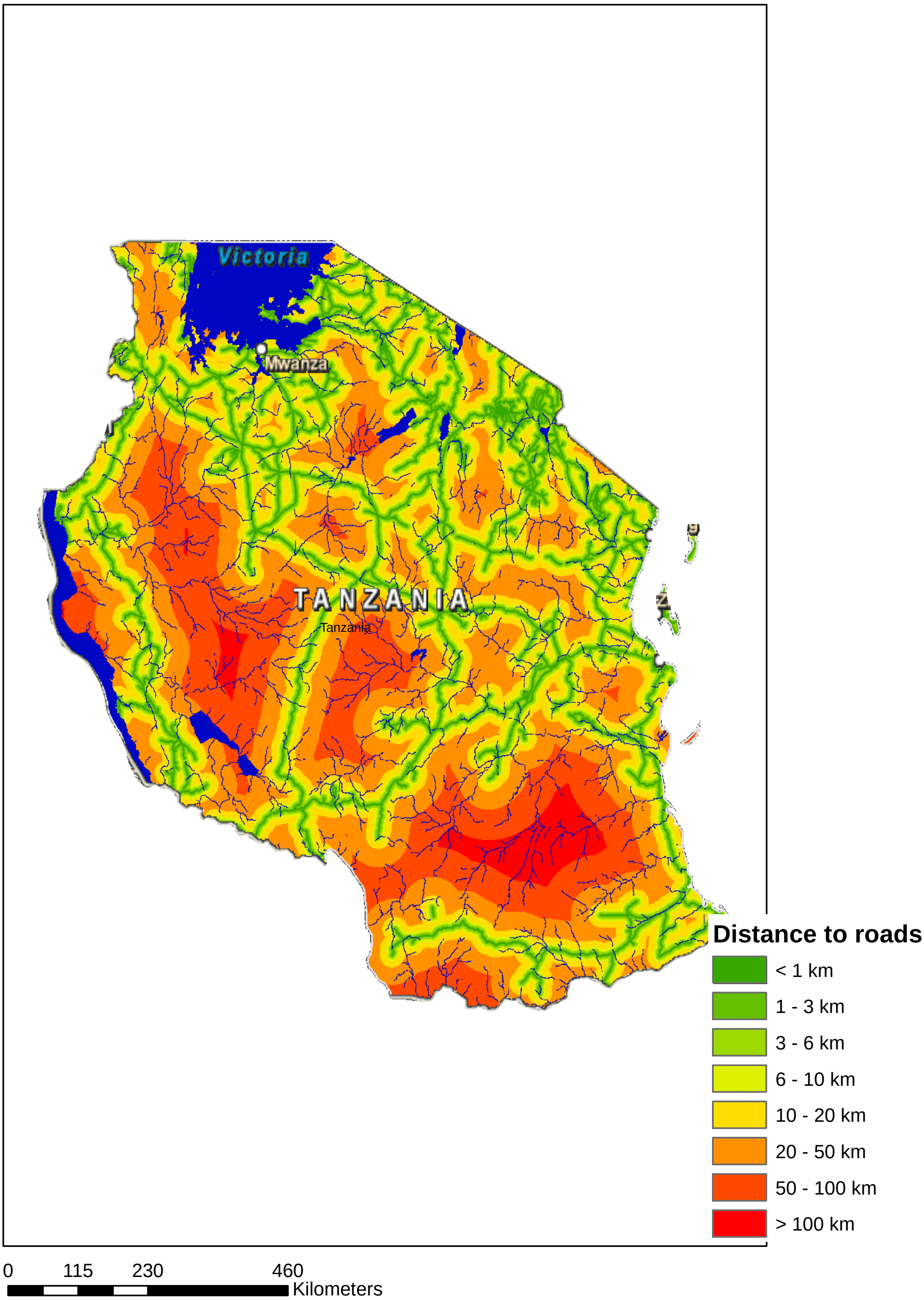



Figure 27: Regional and yields for the five dominant crops in the country (FAOstat, 2010)

## 2.5 Infrastrucutre

### *2.5.1 Access to transportation*

Access to transportation is an important factor to be considered for irrigation development. Harvested products should be transported to markets and also supply of seeds, fertilizer and machinery require close distances to transportation means. Distances to roads, railways and/or waterways are taken as input to determine the suitability in this respect (for details see main report). Tanzania’s transportation network is not very densely, and may therefore be a constraint for irrigation development.


Victoria
Mwanza
TANZANIA
Tanzania
Distance to roads
< 1 km
1 - 3 km
3 - 6 km
6 - 10 km
10 - 20 km
20 - 50 km
50 - 100 km
> 100 km
0
115
230
460
Kilometers

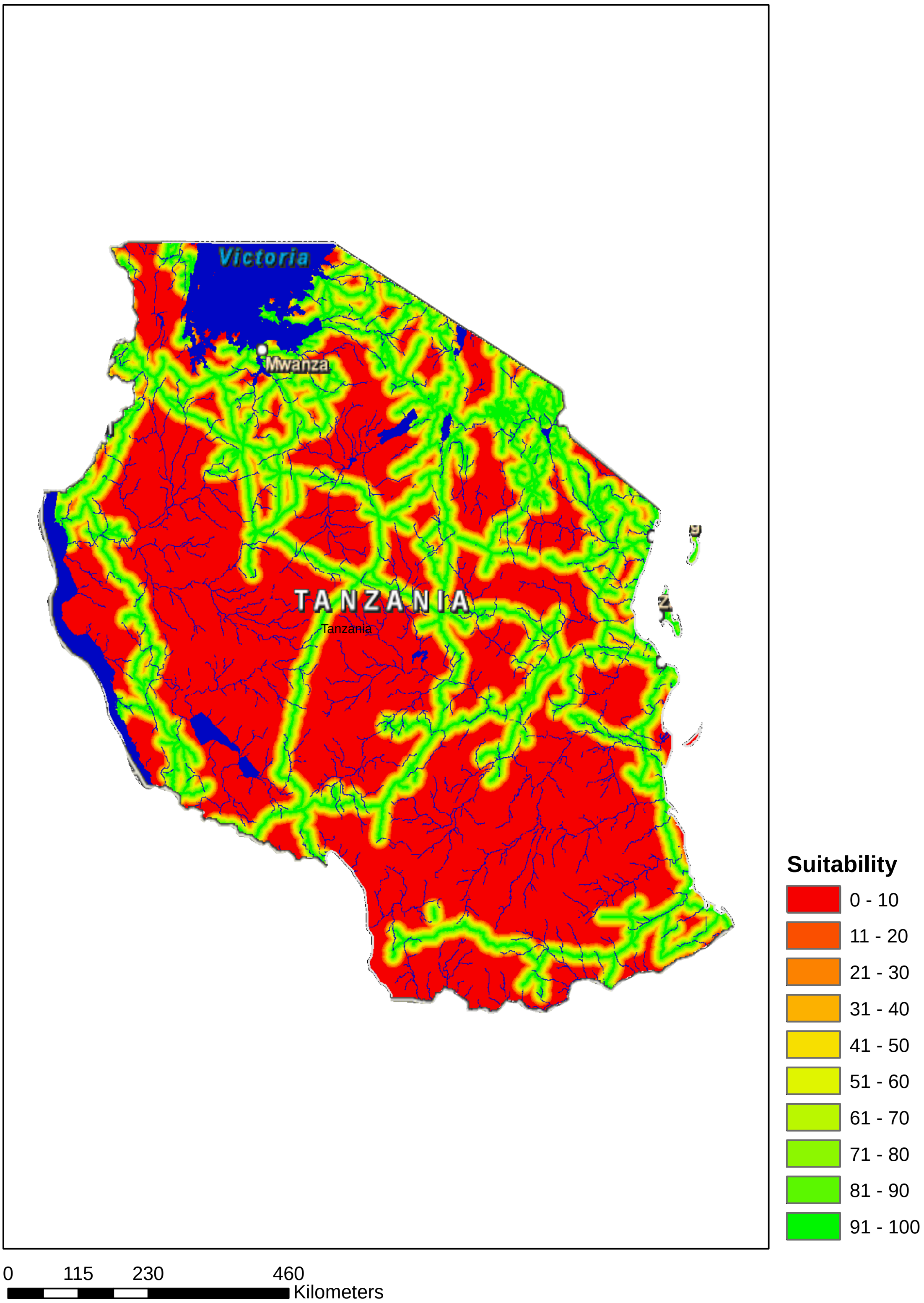
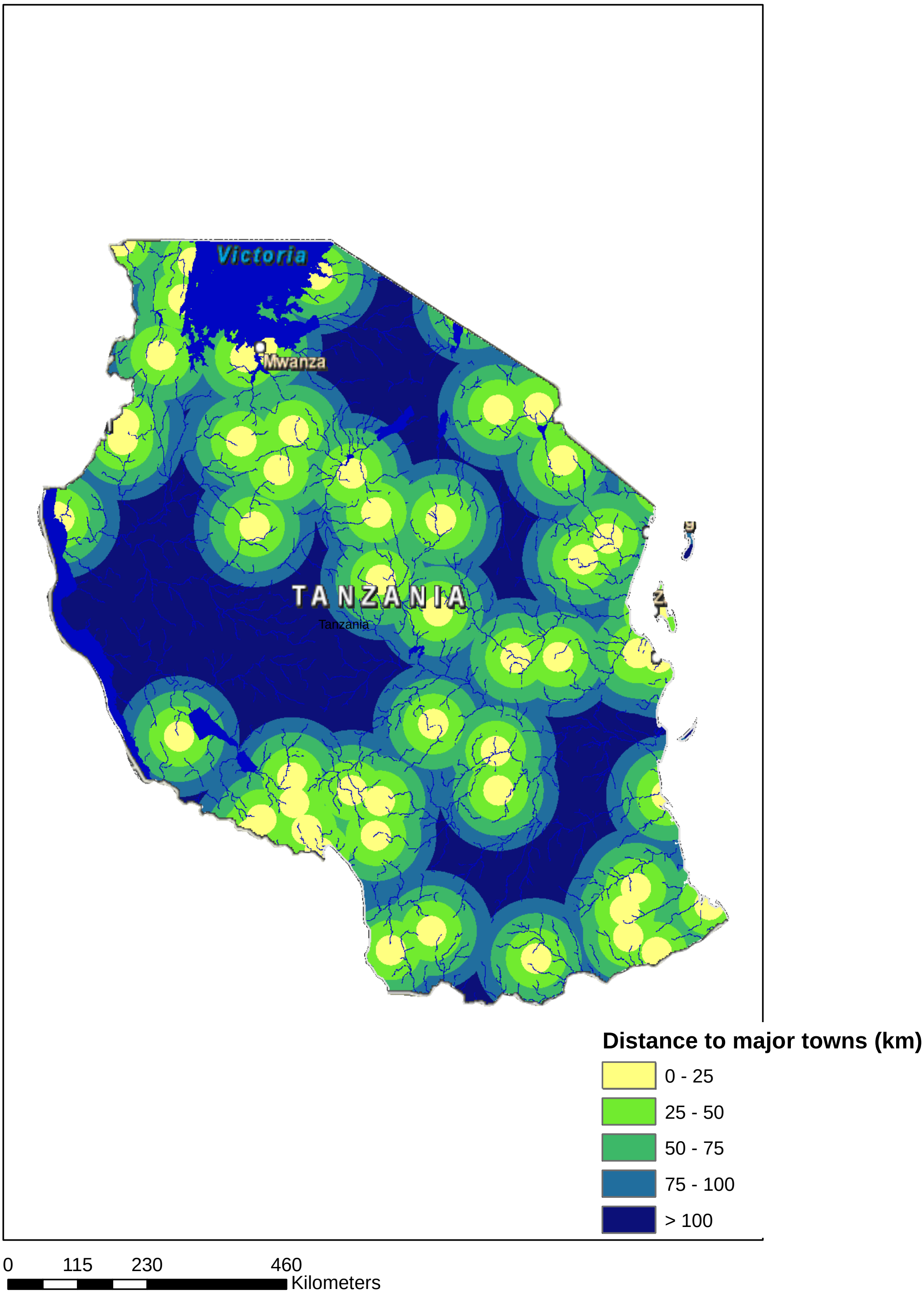
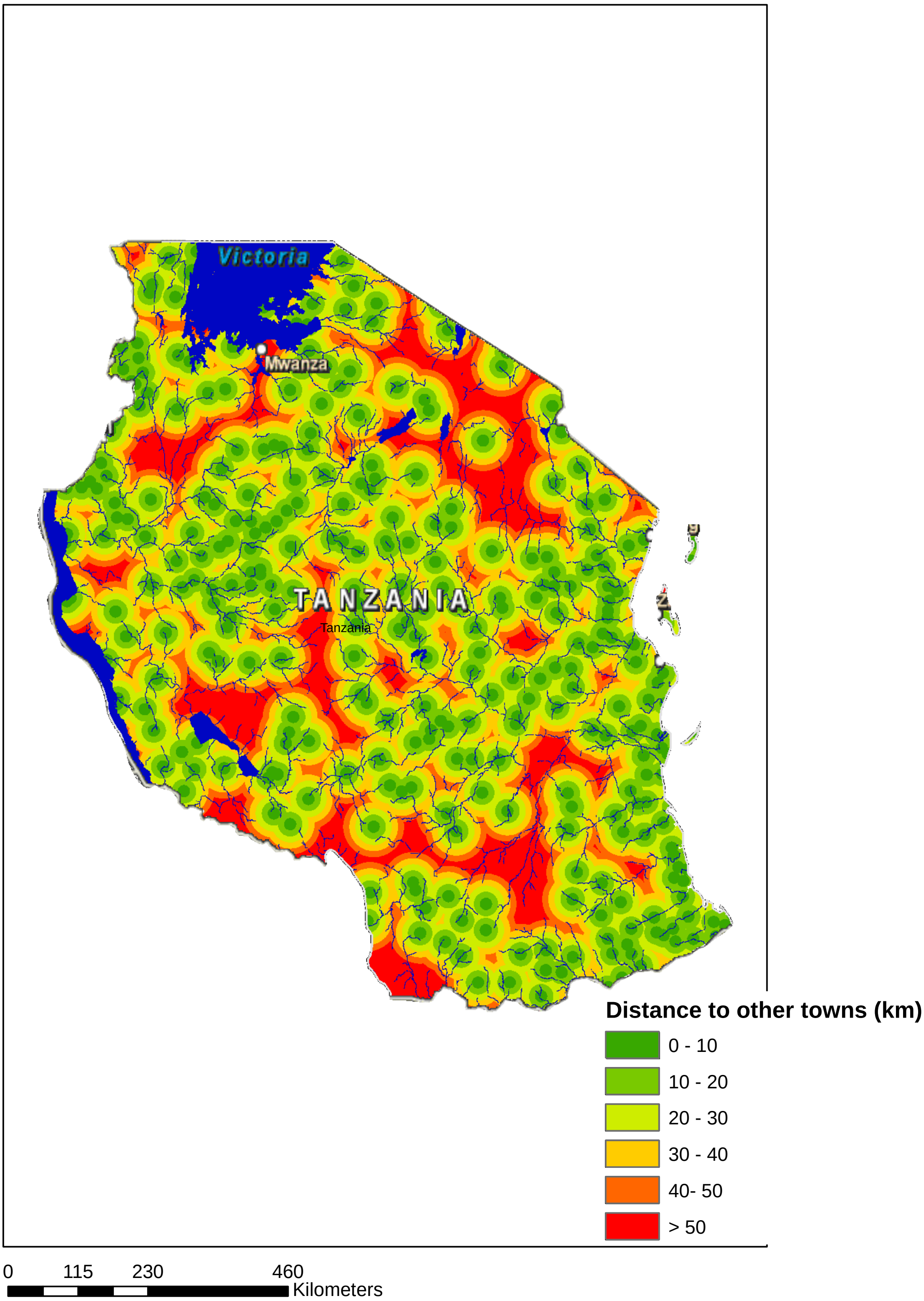



**Figure 28: Distance to transportation (top), and suitability (bottom). (Source: study analysis).**

### 2.5.2 *Access to markets*

Access to markets is an important factor if irrigated agriculture would be developed. Harvested products should be sold to the local, regional, national or world market. Distance to nearest markets is therefore an important factor to determine suitability for irrigated agriculture. Analysis is based on the distances to the nearest smaller cities and larger towns (see for details main report).




Victoria
Mwanza
TANZANIA
Tanzania
Distance to other towns (km)
0 - 10
10 - 20
20 - 30
30 - 40
40- 50
> 50
0
115
230
460
Kilometers

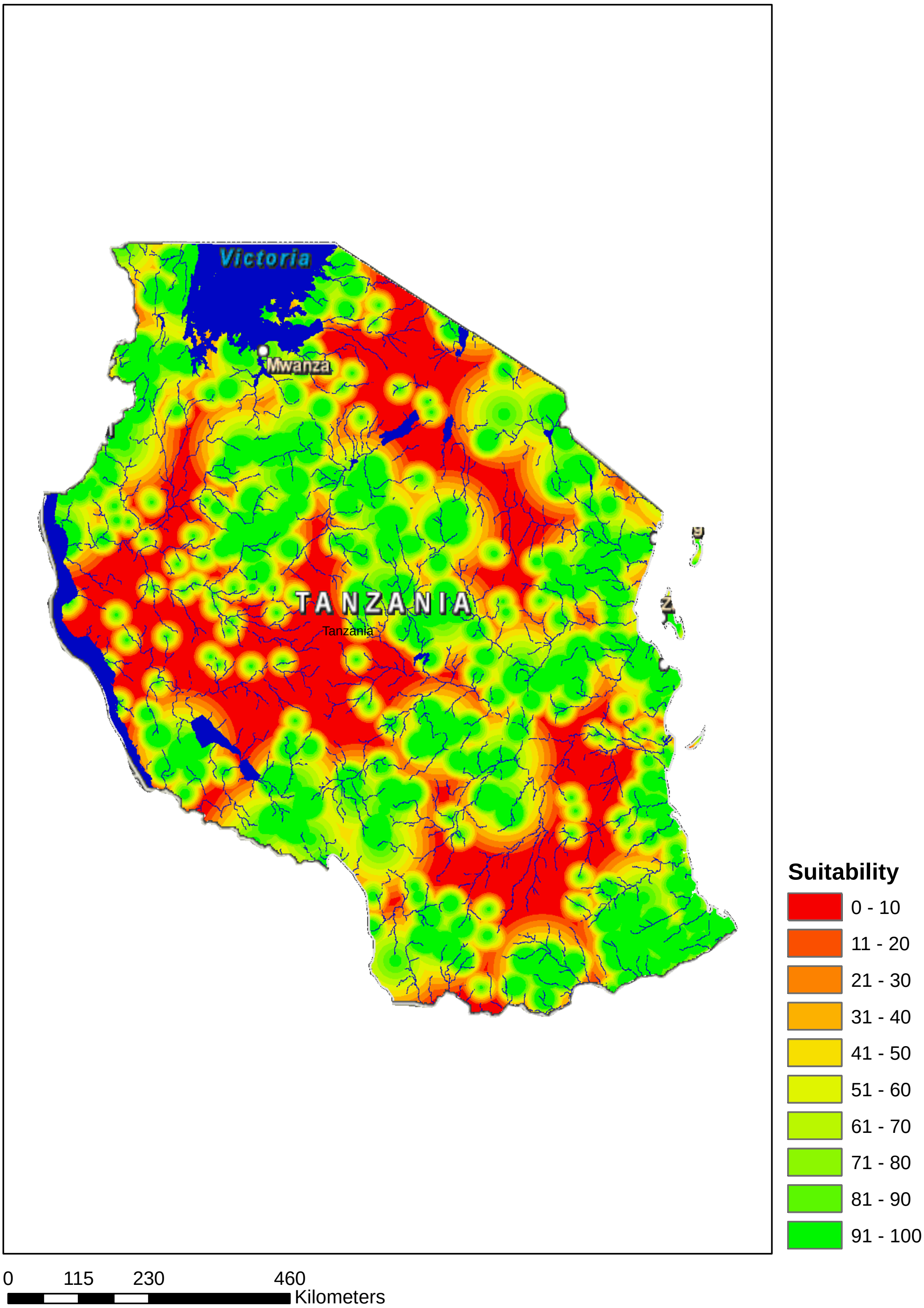



**Figure 29: Distance to major towns (top), distance to other towns (middle), and combined suitability index (bottom). (Source: study analysis).**

## 2.6 Population density

Population density should be considered in the context of irrigation. Highly-dens populated areas are not suitable for irrigation. On the contrary, areas where hardly anybody lives might face difficulties in terms of labor and markets. Population density can be observed in Figure 30.

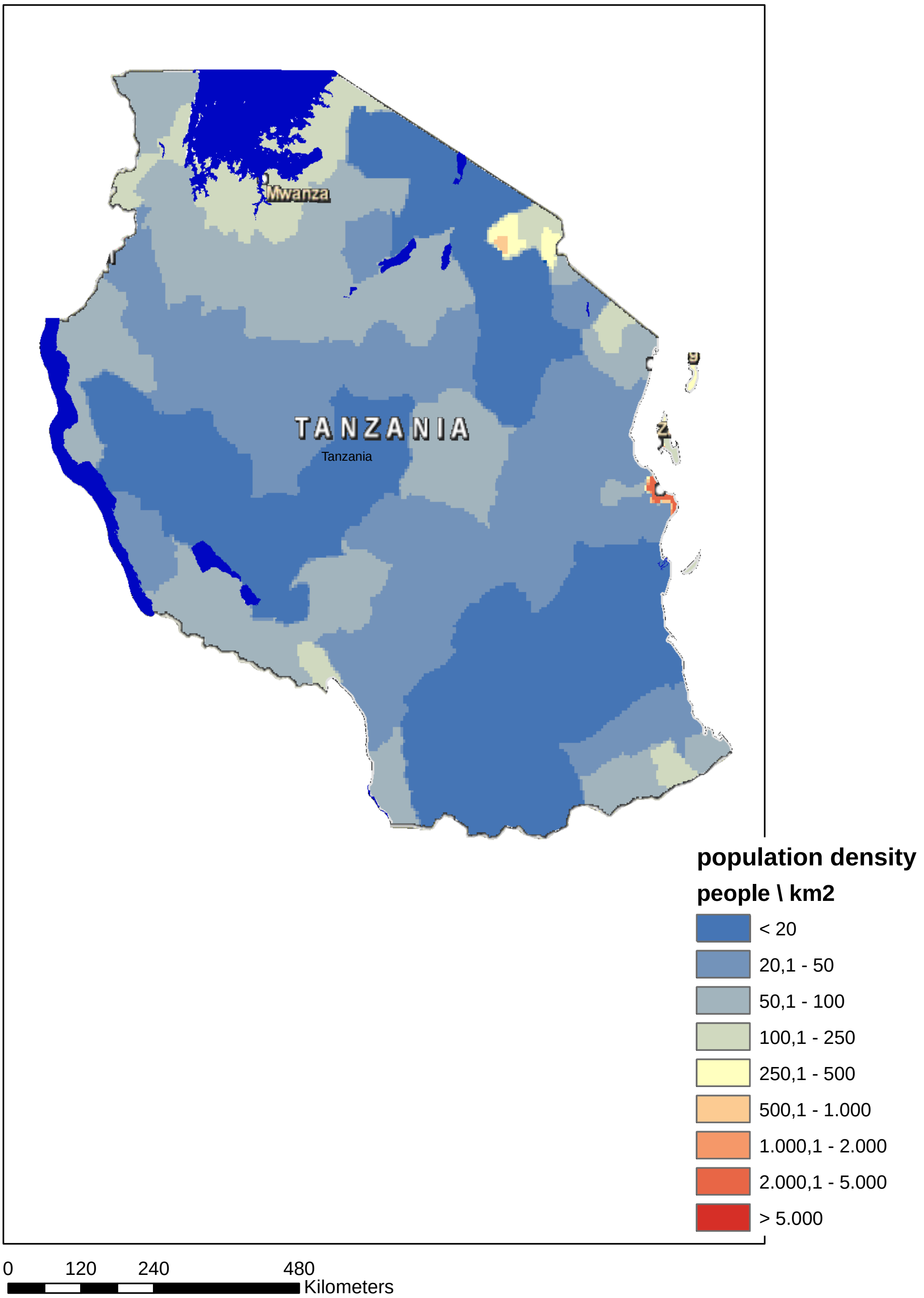



**Figure 30: Population density distribution (source: CIESIN).**

## 2.7 Institutional and legal framework

### *2.7.1 Institutional settings*

The water resources of Tanzania, comprising of surface and groundwater and water-based ecosystems such as lakes and wetlands, are essential for the sustenance and health of all human, animal and plant species. As a source of natural capital, water is a primary input for a whole array of human needs and economic development activities. Water is fundamental for food security, domestic supply and sanitation, for generation of hydropower, for industrial and mining development, for livestock, for ecology (wildlife, riverine habitats including fish, forests, swamps and marsh lands, and wetlands), for recreation and tourism, and for navigation. Many benefits accrue from harnessing and utilising water. As a sink, water sources are used as receptors for wastewater discharges from municipal, industrial and agricultural sources. Freshwater also sustains the integrity of ecosystems, which serve important ecological and hydrological functions.

The different sectors are aligning themselves in accordance with their policy objectives to achieve the Tanzania Development Vision 2025, the Millennium Development Goals, and are striving to participate fully in the National Strategy for Growth and Reduction of Poverty process. Water is one of the most important cross-sectoral resources necessary to achieving the stated objectives. However, most of the sectoral activities are highly vulnerable to the erratic nature of rainfall, floods and droughts and thus suffer from insecure water resources. The requirement for the country's water resources to meet the growing sectoral demands includes the provision of the underlying infrastructure, accompanied by commensurate wastewater treatment measures. The economy depends significantly on rain-fed agriculture, which still accounts for a 47.5% share of the GDP[1], about 85 % of total exports, and engages about 80% of the national work force. The majority of the population is still dependent upon subsistence farming, herding, and fishing, all of which are entirely dependent upon seasonal and sometimes irregular rainfall.

The current institutional framework for water resources management is inadequate in meeting the challenges of effective management of the resources and in providing an adequate mechanism for effective consultation and consensus building, and participation of stakeholders in the planning, design, operations, and management decision-making process. A number of different Government departments or agencies deal with various aspects of water resources management according to their own mandates or needs, and also their own legislative provisions, with little integration towards holistic basin-wide planning and management. In addition to this multiplicity of organisations, effective integrated water resources management is further constrained by limitations in the technical, human and financial capacities in these organisations.

The lack of an effective institutional framework for integrated water resources management has led to (National Water Sector Development Strategy 2006-2015):

- overlapping roles and responsibilities between various institutions leading to inefficient use of human and financial resources, duplication of effort, and gaps in effective management;
- inadequate cross-sectoral co-ordination between various government institutions;

[1] The Economic Survey, 2002, URT

- threats to sunk investments in major infrastructure projects;
- inadequate communication and awareness building between these institutions and local organisations and water users; and
- fragmented water resource planning and allocation, and consequent water conflicts.

The strategy for establishing a new institutional framework will be to (National Water Sector Development Strategy 2006-2015):

- implement a new institutional framework for water resources management based on autonomous basin level organisations;
- strengthen capacities of sector institutions;
- review relevant existing policy and legislative provisions to remove potential duplications and omissions, and enable effective implementation of the new institutional framework; and
- raise awareness amongst stakeholders of the new framework.

### *2.7.2 Land ownership rights*

The National Land Policy, 1995, aims to ensure a secure land tenure system, to encourage optimal land use, and to facilitate sustainable social and economic development. Land management is seen as one of the cornerstones of development policy. Land is to be publicly owned, and held by individuals only through rights of occupancy. Right of occupancy may be certificated and subject to terms and conditions (Granted Right), or customary (Deemed Right). Specific objectives of the Policy include equitable access to land, protection of existing land rights, prevention of concentration of land ownership, and promotion of land use planning and management for optimal but sustainable productivity.

As with land, water is a public asset with access controlled by rights to use, both formal and customary rights. Water supply, both quantity and quality, is influenced by the management of land. Water resources management is also influenced by the range of legislation and regulations affecting land. On the relationship of water and the growing urbanisation, both the National Land Policy and the National Human Settlement Development Policy, 2000, recognize the existence of unplanned settlements in most urban areas in Tanzania, which call for social services infrastructure upgrading such as roads, water supply and sanitation.

Unplanned settlements in rural areas can lead to significant environmental degradation, soil erosion, and pollution of streams, all of which impact on downstream and in-stream water users. These settlements also create unplanned water demands that can impact on other users who have been granted water user rights through permits. The Land and Settlement Policy (and the Forestry Policy discussed below) needs to address measures for protecting important catchment areas, recharge areas, springs, and other key water sources. It also needs to address the issue of flood prone areas and other areas vulnerable during periods of high rainfall, and consider measures for flood protection.

## 2.8 Irrigation potential

Based on information as presented in the previous sections, suitability for irrigated agriculture can be determined. Some information is more qualitative and presented as general reference to support decision making. Other information is quantitative and will be used to create maps to be used to support decisions to select areas that can be studied more in-depth

Results of the analysis are used to create an overall map of “suitability for irrigation”. These maps (determining factors) are all scaled between values of 0 (not suitable) to 100 (very suitable). Note that many of these individual maps are composed by combining various other sources. By combining this information a total suitability map per country is produced. The following maps are used to this end:

- Terrain suitability
- Soil suitability
- Water availability
- Distance to water source
- Accessibility to transportation

Based on these maps, the final score indicating suitable for irrigation can be observed in the Figure 31 and Table 3. Scores above 60% can be considered as potential suitable for irrigation, while scores above 70% can be considered as very suitable with only minor limitations. The overall suitability for the country is determined at about 14 million hectare. In order to assess what limitations are in a certain areas, information from the previous sections can be used.

The suitability map as presented should be considered as the final map for irrigation potential. This map reflects the situation for surface irrigation and non-rice crops. The database attached to the report includes the digital version of these maps allowing zooming in. Moreover, this database includes also the maps with the determining layers that can be used to explore the limitations for a specific area.

It is important to realize that the suitability map has to be considered using other (non-determining) information and maps. Moreover, other factors like expert knowledge, existing policies etc. should play an integrated role as well.

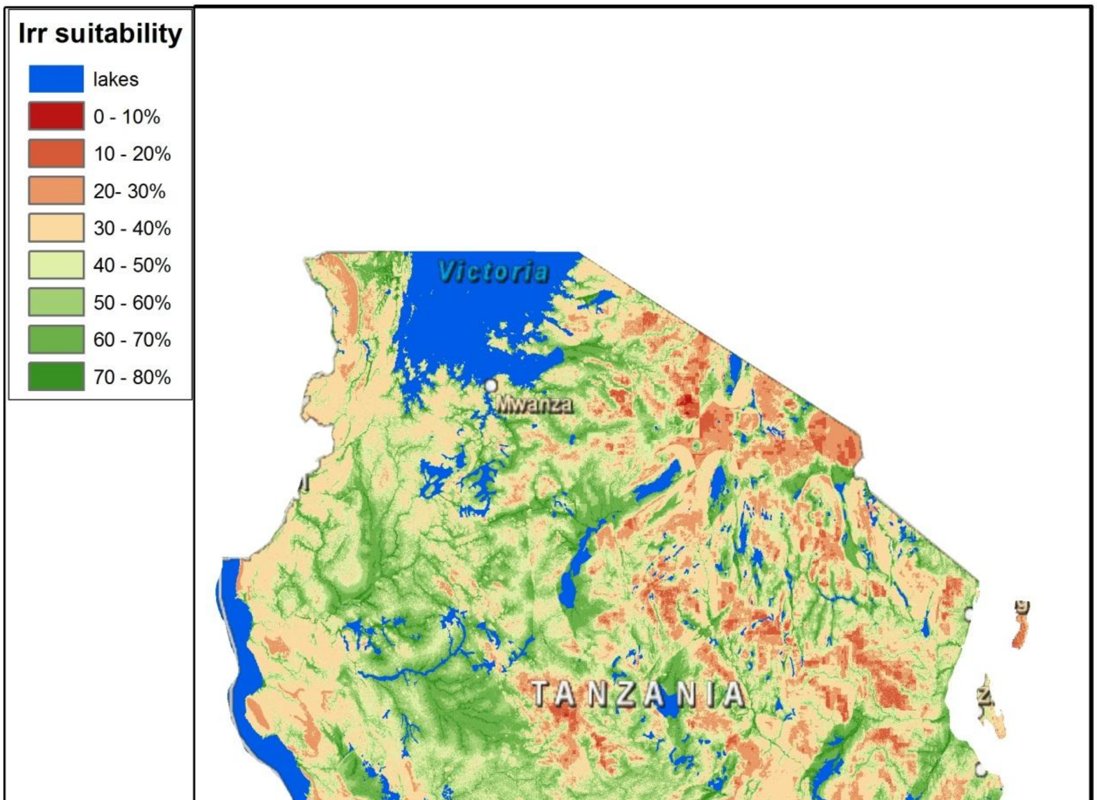



**Figure 31: Irrigation suitability score**

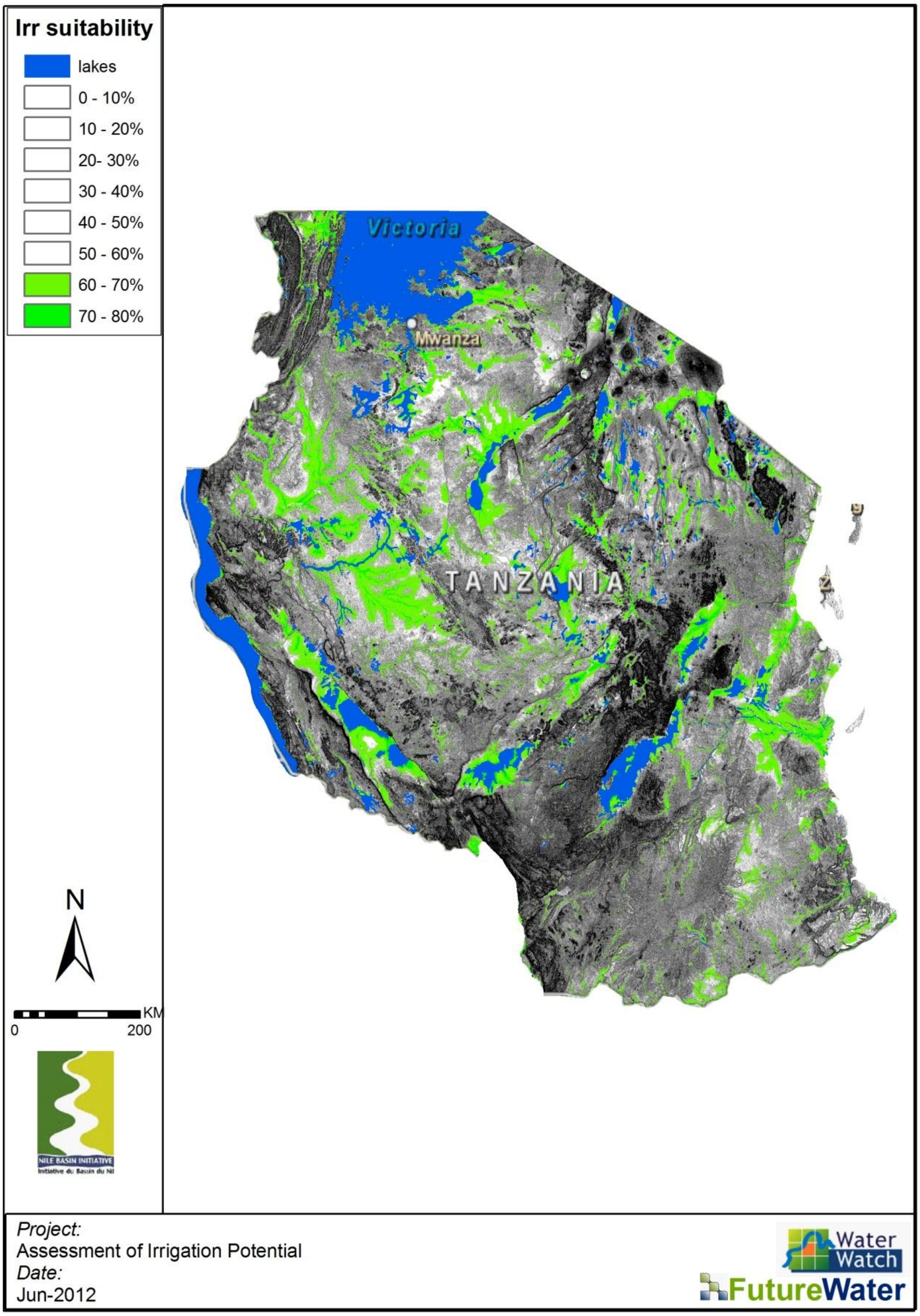



**Figure 32: Final map indicating areas suitability for irrigation.**

**Table 3. Suitability classes.**

| Suitability | Irrigation potential (ha) |
|---|---|
| 0 - 10% | 19,344 |
| 10 - 20% | 1,631,713 |
| 20 - 30% | 7,961,088 |
| 30 - 40% | 29,399,781 |
| 40 - 50% | 19,595,994 |
| 50 - 60% | 16,048,200 |
| 60 - 70% | 11,701,775 |
| 70 - 80% | 2,273,369 |
| 80 - 90% | 0 |
| 90 - 100% | 0 |
| Total >60% | 13,975,144 |

### *2.8.1 Focal areas*

Based on the results from the first phase of the irrigation potential study and the local available expert knowledge and political considerations five focal areas have been delineated on which the second phase will focus. In the following chapters these focal areas will be studied on a more detailed level, and the possibilities for irrigation development will be described. In Table 4 the names and areas are given, and in Figure 33 a map is supplied on which the focal areas are shown.

**Table 4: Focal areas Tanzania**

| | Biharamulo, Mwiruzi | Geita Plains | Katunguru | Simiyu Duma Valley | Suguti Valley |
|---|---|---|---|---|---|
| Area in ha | 3994 | 3698 | 1495 | 5284 | 4995 |


**Figure 33: Overview focal areas Tanzania**

# 3 Biharamulo focal area

## 3.1 Introduction

This chapter will describe the current state of the Biharamulo (Mwiruzi) focal area, concerning land and water resources, and will discuss the potential to develop irrigation in the area. This irrigation potential will be based on the land and water resources, the irrigation requirements, the potential crop yields and will also involve the socio-economic considerations. Based on these aspects the potential for irrigation will be described, and cost for irrigation development calculated. In Figure 34 a detailed map of the area is given. Total area is 3990 ha and is located in Kagera region.

Selection of this specific focal area was based on results of Phase 1 of this study, while final selection was the responsibility of the relevant country representatives. Results presented hereafter have been obtained from a broad range of sources: Phase 1, previous other studies and reports, modeling results, remote sensing, expert knowledge and field visits by Gaspar Damas Mashingia and supervised by Honest Prosper Ngowi and Eng. Amandus Lwena in April and May 2012.

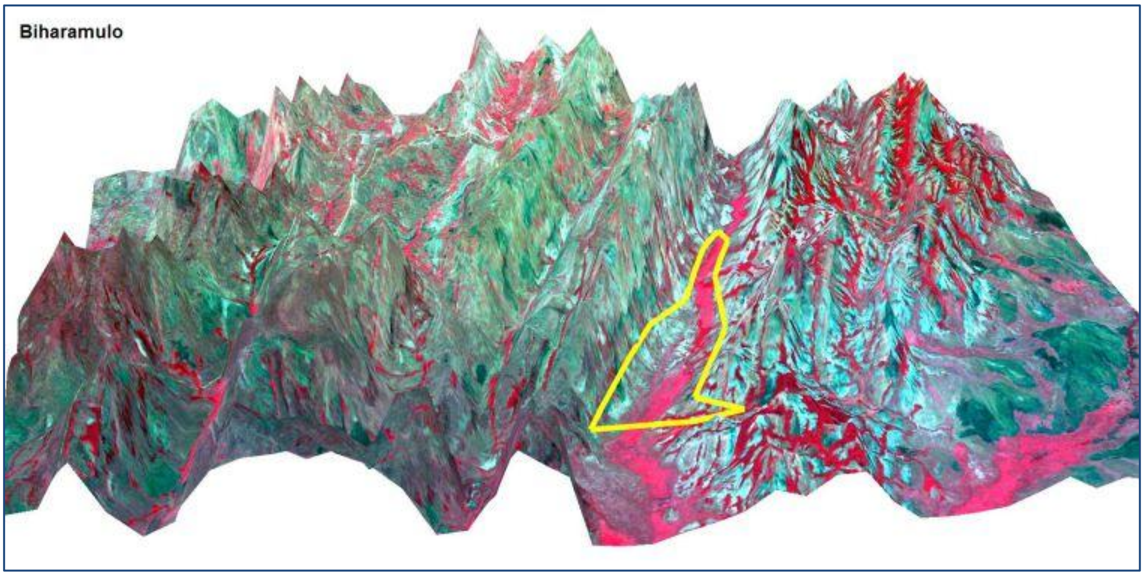
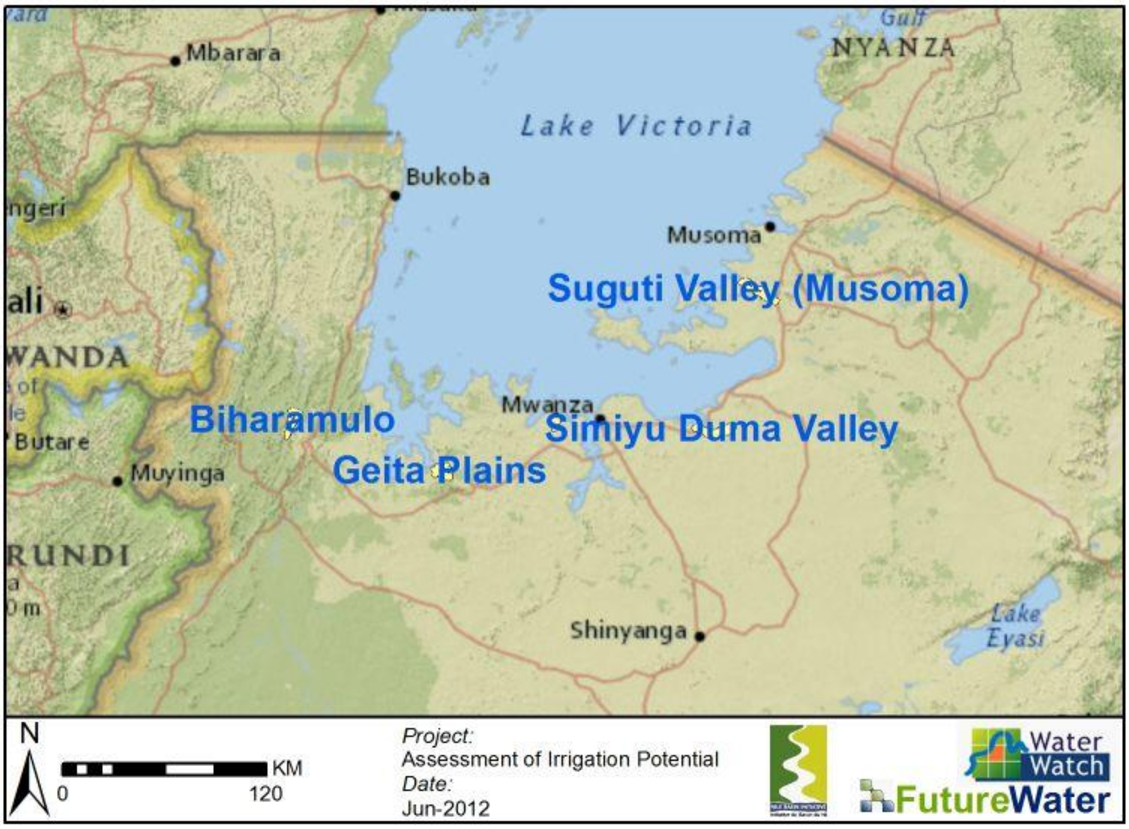



**Figure 34: 3D impression of the Biharamulo focal area, Tanzania**



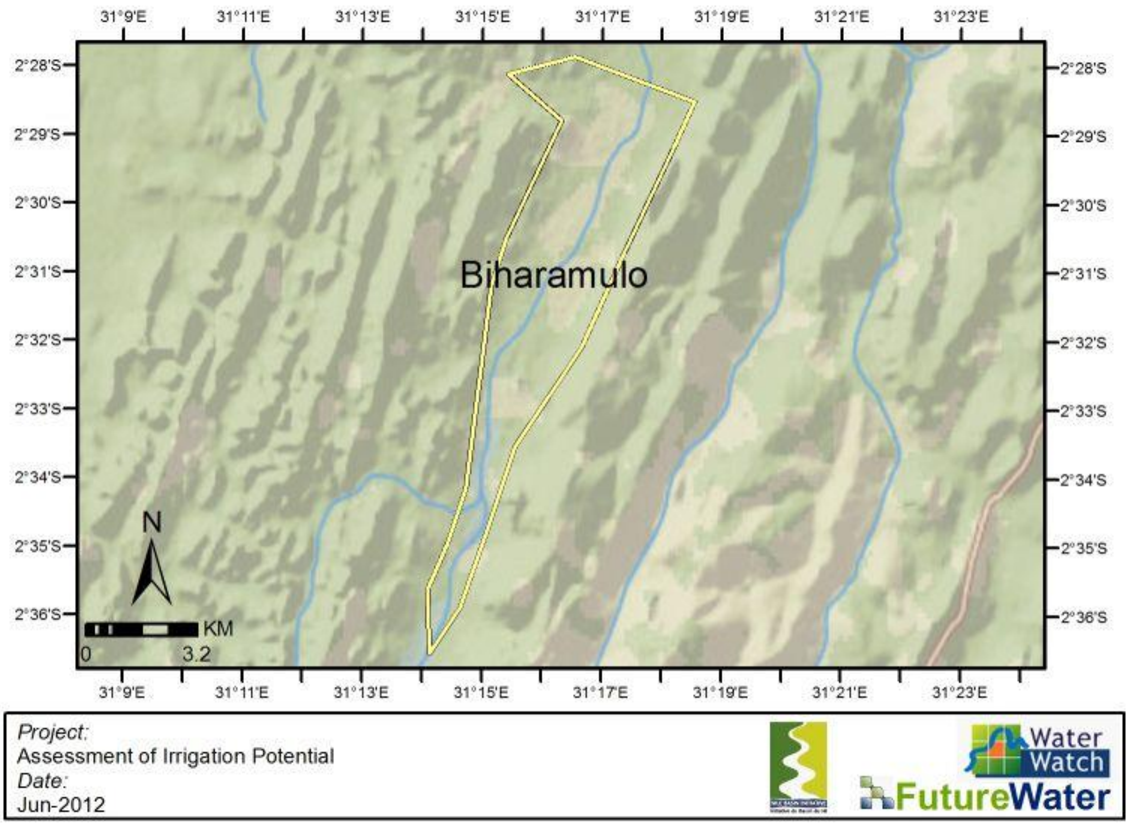




**Figure 35: Biharamulo focal area, Tanzania**

## 3.2 Land suitability assessment

### *3.2.1 Terrain*

Biharamulo is located in the Kagera region. Elevation in the focal area is around 1200 meters above sea level (MASL) and is surrounded by mountains of about 1600 MASL. Slopes in the focal area itself are limited to a few percentages, but outside the focal area slopes ranges from 25 to 50 degrees, making the risk of landslides and erosion high.

Most of the land area is not cultivated and of the natural vegetation is still intact by enlarge. The landscape is mostly covered with mosaic vegetation/croplands. The climate is classified as a tropical savanna (winter dry season), with a subtropical moist forest biozone. The focal area itself has a variety of vegetation: mixture of grassland, hyeperenia grasses, percoposio trees, shrubs, and scattered grasses and plants.

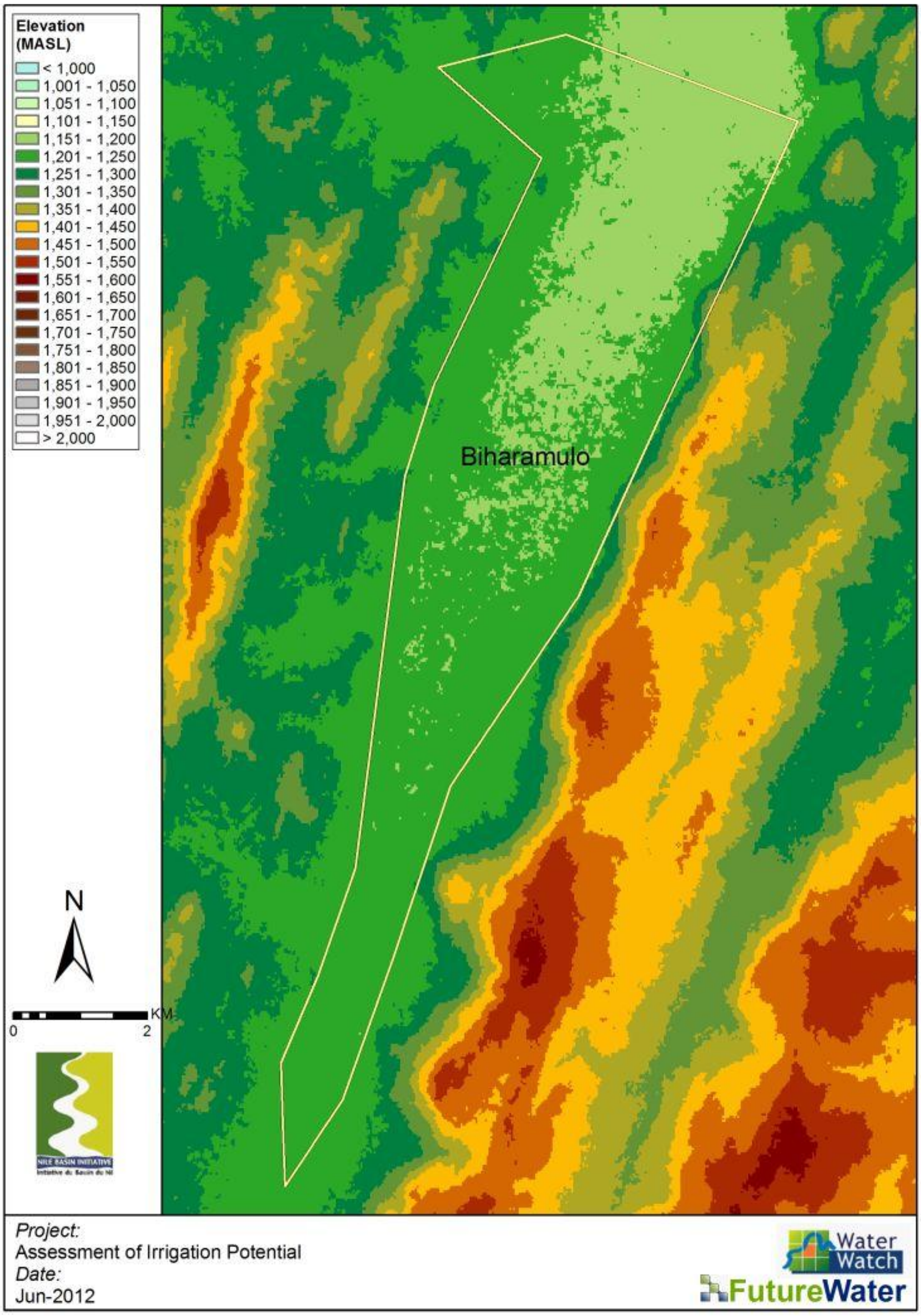



**Figure 36: DEM Biharamulo focal area. Resolution 1 arc second (+/- 30m)**

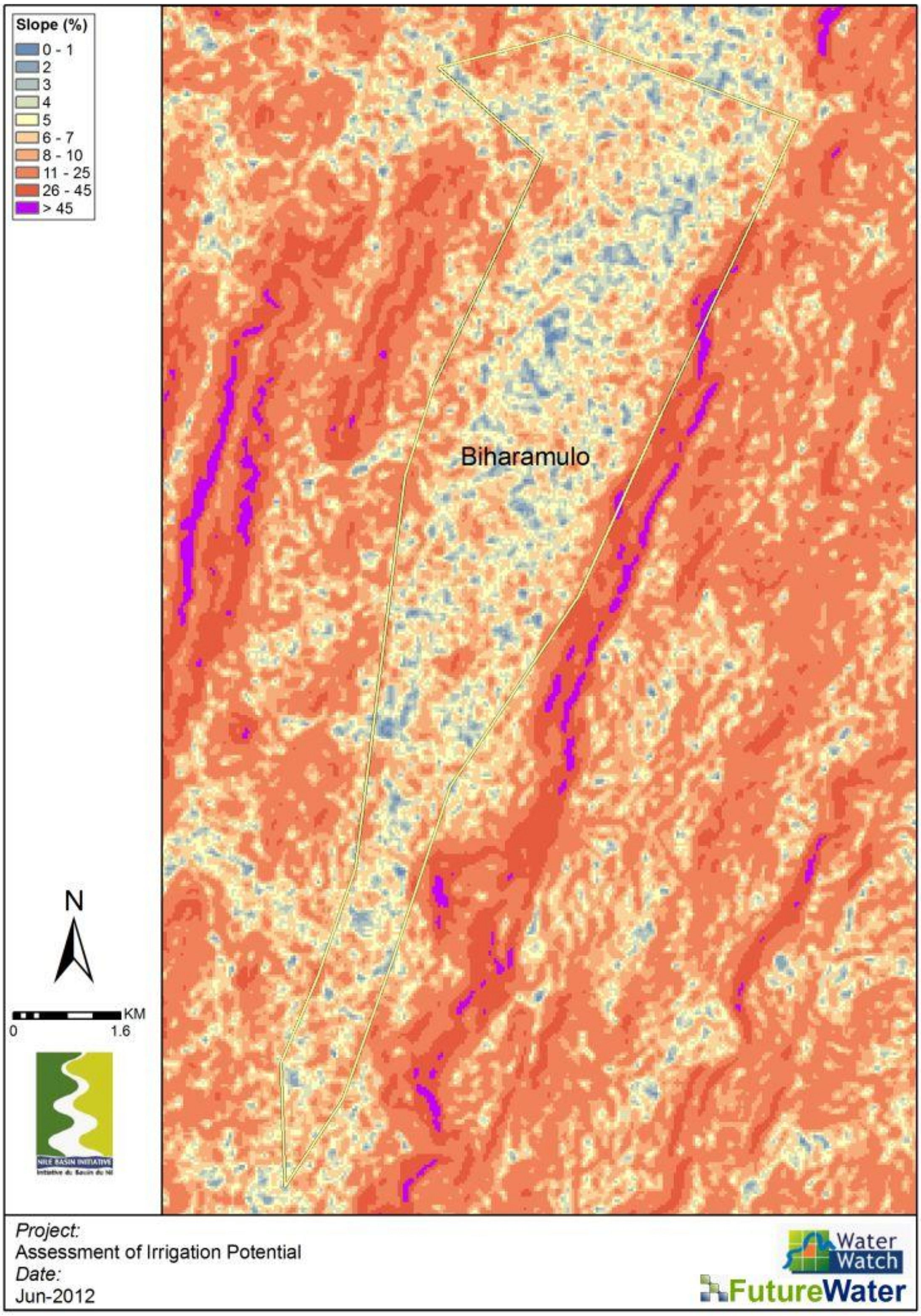


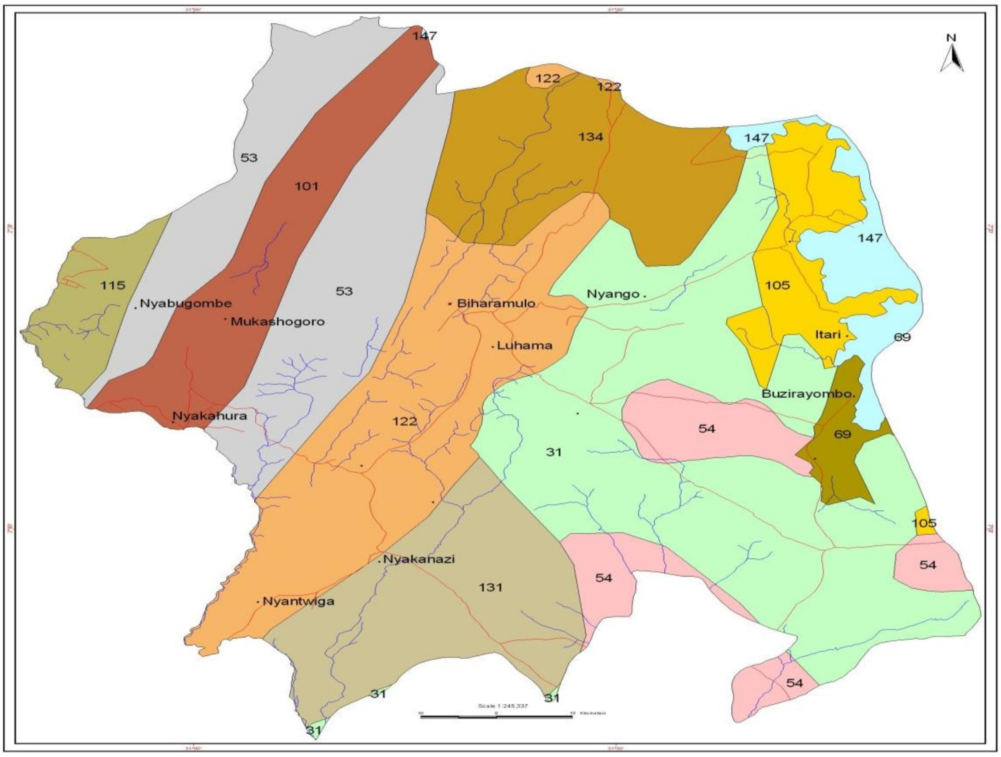

**Figure 37: Slope map Biharamulo focal area. (Source: ASTER)**

### *3.2.2 Soils*

Two major soil types can be found in the focal area: Cambisol (CMo) in the northern and eastern part, and Leptosols (LPu) in the western part of the focal area. The Cambisols generally make good agricultural land and are used intensively. Cambisols with high base saturation in the temperate zone are among the most productive soils on earth. More acid Cambisols, although less fertile, are used for mixed arable farming and as grazing and forest land. Cambisols on steep slopes are best kept under forest; this is particularly true for Cambisols in highlands. Cambisols on irrigated alluvial plains in the dry zone are used intensively for production of food and oil crops. Cambisols in undulating or hilly terrain (mainly colluvial) are planted to a variety of annual and perennial crops or are used as grazing land. Cambisols in the humid tropics are typically poor in nutrients. Cambisols with groundwater influence in alluvial plains are highly productive paddy soils.

Leptosols, sometimes referred to as Lithosols, are very shallow soils over continuous rock and soils that are extremely gravelly and/or stony. Leptosols have a resource potential for wet-season grazing and as forest land. Erosion is the greatest threat to Leptosol areas, particularly in montane regions in the temperate zones where high population pressure, overexploitation and increasing environmental pollution lead to deterioration of forests and threaten large areas of vulnerable Leptosols. Leptosols on hill slopes are generally more fertile than their counterparts on more level land. One or a few good crops could perhaps be grown on such slopes but at the price of severe erosion. Steep slopes with shallow and stony soils can be transformed into cultivable land through terracing, the removal of stones by hand and their use as terrace fronts. Agroforestry (a combination of rotation of arable crops and forest under strict control) holds promise but is still largely in an experimental stage. The excessive internal drainage and the shallowness of many Leptosols can cause drought even in a humid environment.

A more detailed soil map can be seen below including limitations and suitability of these soils is shown in the table below. Overall, soils are suitable for a wide variety of crops, although natural fertility is somewhat limited.




| Symbol | WRB soil unit | Limitations | Use and Management |
|---|---|---|---|
| 30 | Calci-Hypsodic Planosols | Strong sodicity and silinty, very low fertility | Suitable for extensive grazing and in some places wetland rice |
| 31 | Chromi-Feralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 53 | Humi-Umbric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 54 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 69 | Pellic Vertisols | Difficult workability, difficult water management | High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated cropping |
| 82 | Eutri-Pellic Vertisols | Difficult workability, difficult water management | High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated cropping |
| 101 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 105 | Eutri-Rhodic Cambisols | Vary with climate, topography, depth or stoniness | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 108 | Eutric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 115 | Humi-Umbric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 122 | Chromi-Feralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 131 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 134 | Ferralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 147 | Waterbody | | |

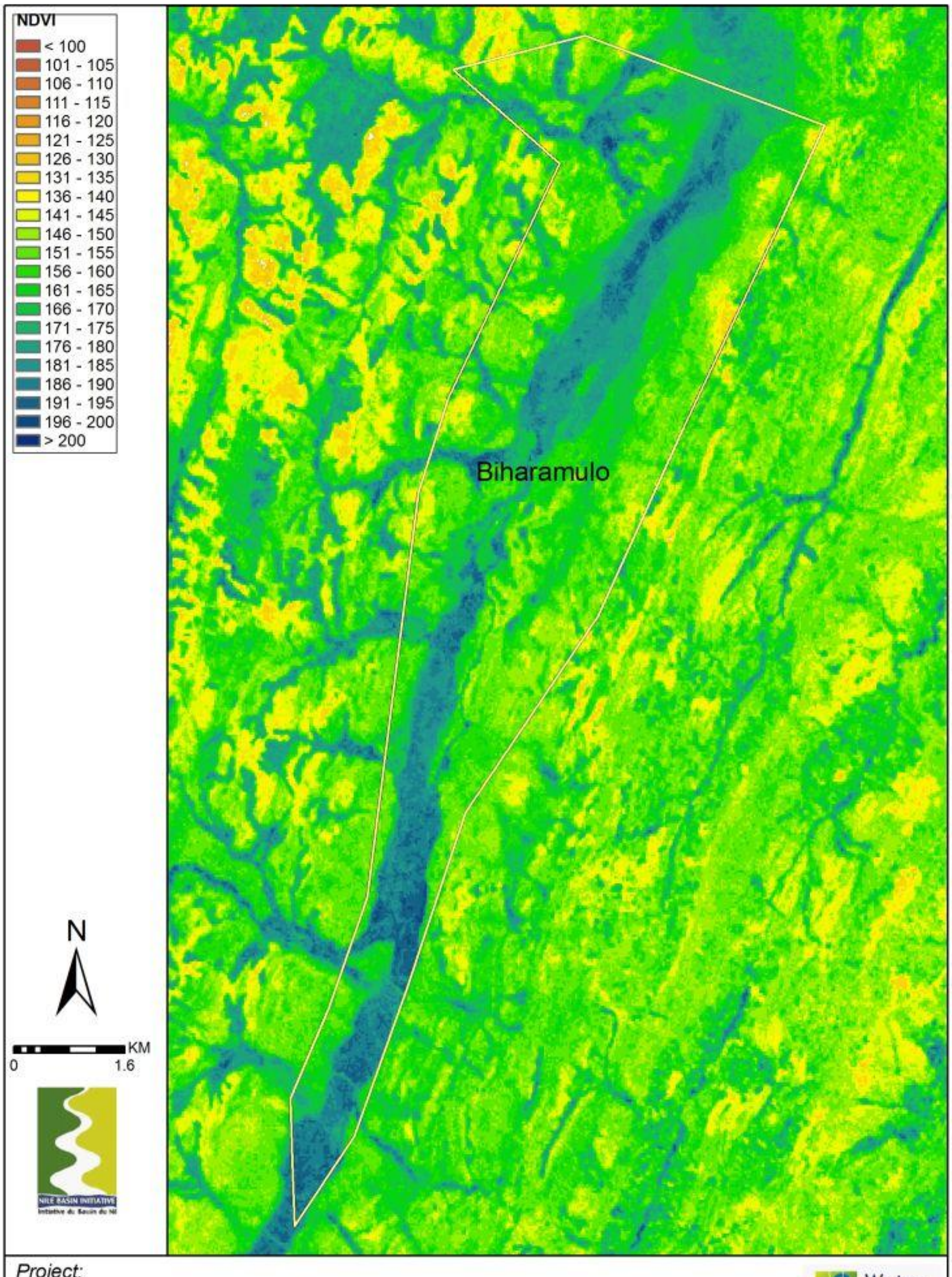
**Figure 38: Details soil map and associated limitations, use and management options for Bihalamulo focal area.**

### *3.2.3 Land productivity*

Most of the land area is not cultivated and of the natural vegetation is still intact by enlarge. The landscape is mostly covered with mosaic vegetation/croplands. The climate is classified as a tropical savanna (winter dry season), with a subtropical moist forest biozone. The focal area itself has a variety of vegetation: mixture of grassland, hyeperenia grasses, percoposio trees, shrubs, and scattered grasses and plants. During the field inventory the following estimate has been made regarding land cover:

- Percoposio trees: 40% of the area

- Shrubs: 30% of the area
- Hyperemia grass: 30% of the area




*Project:*
Assessment of Irrigation Potential
*Date:*
Jun-2012

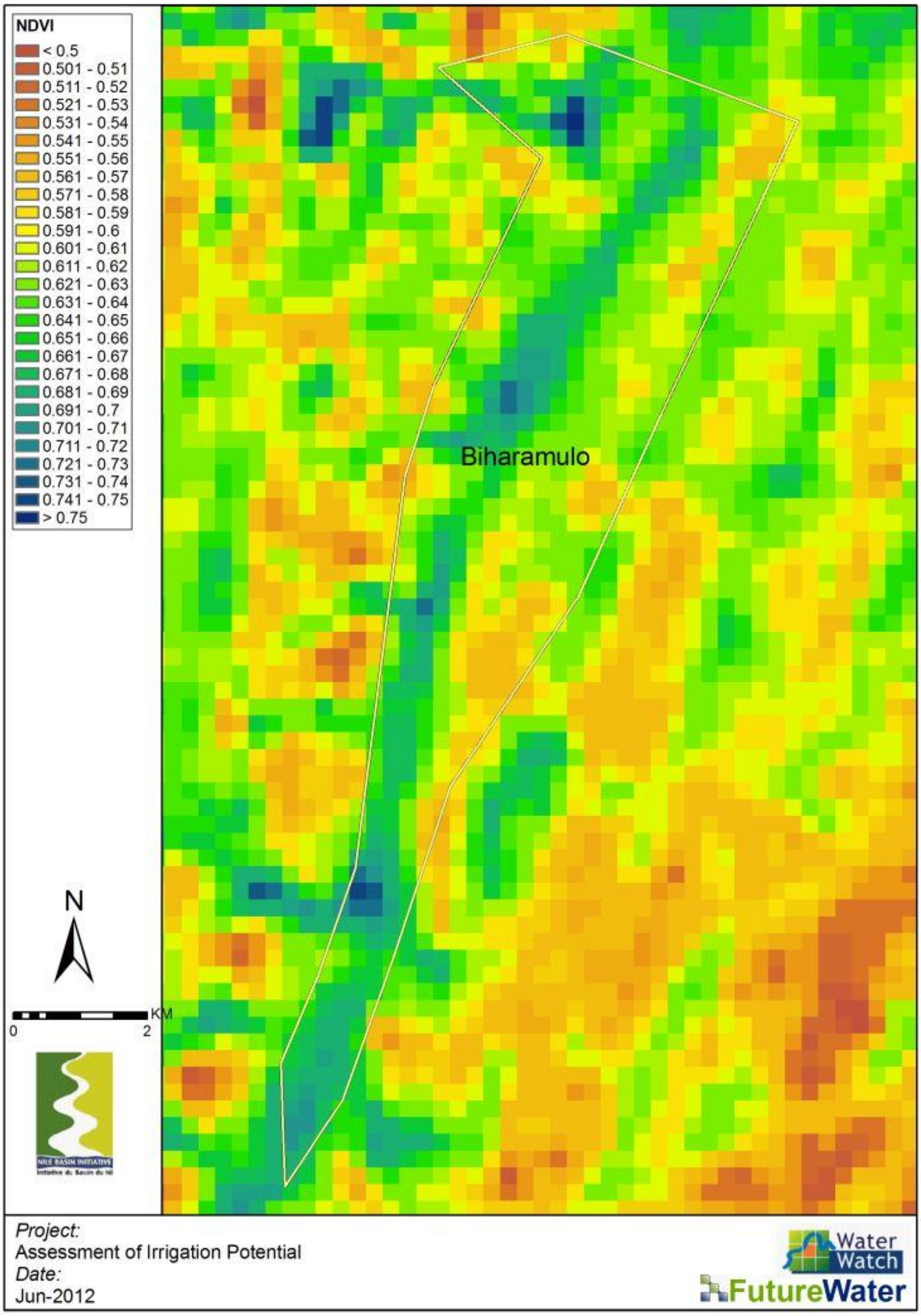



**Figure 39: Yearly average NDVI values (top) and high resolution Landsat NDVI for one day (bottom) for Biharamulo focal area.**

### 3.2.4 *Potential cropping patterns*

Currently three dominant crops can be found in the area: maize, paddy and beans. These crops are not irrigated. Other details of these crops are shown in the following table.

| BIHARAMULO | Maize | Paddy | Beans |
|---|---|---|---|
| % of this crop as of % total agriculture area | 60 | 30 | 10 |
| Date planting/seeding | Aug/sept | Oct/nov | Aug/sept |
| Date harvest | Jan/feb | Apr/june | Jan/feb |
| Average yield (kg/ha) | 1200 | 3000 | 500 |
| Maximum yield (kg/ha) | 1500 | 4000 | 600 |
| Average selling value of crop (shs/kg) | 450 | 1800 | 1500 |
| Irrigated (yes no and mm/) | No | No | No |
| Amount of growing cycles per year | one | one | one |

Regarding potential crops to be promoted in the area if irrigation will be developed, the following crops were proposed: paddy, maize, cassava, cotton and vegetables.

**Figure 40: Photograph from field inventory and assessment work**

## 3.3 Water resource assessment

### 3.3.1 *Climate*

Climate in the focal area is characterized by a humid conditions with constant annual temperatures ranging from 18 to 28$^{o}$C, for minimum and maximum temperatures respectively. Annual precipitation is about 1070 mm, while reference evapotranspiration is about 1400 mm per year. Main dry period is from June to August.

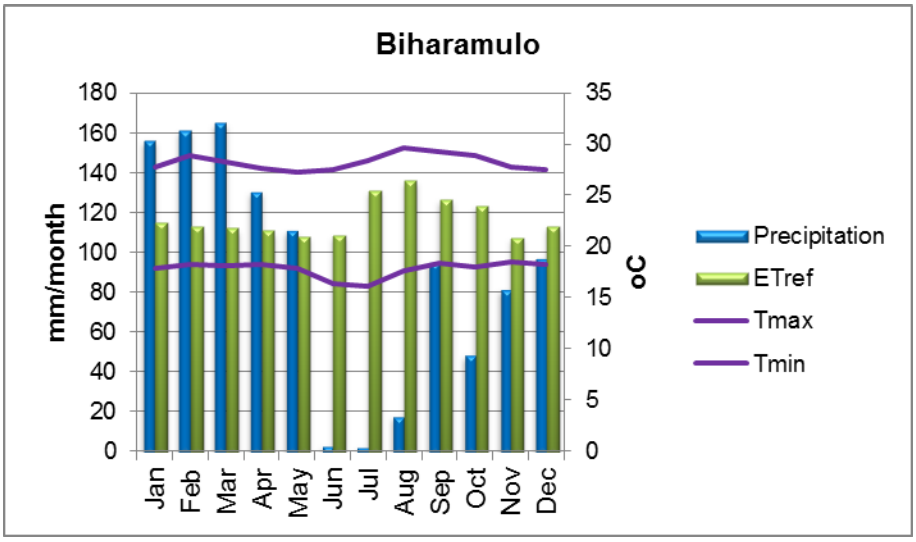


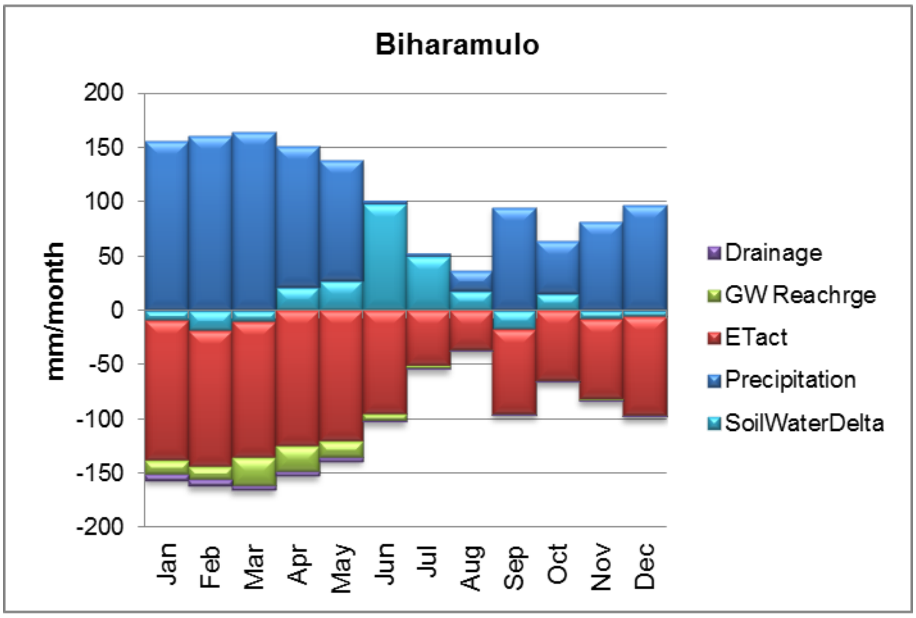

**Figure 41: Average climate conditions for the focal area.**

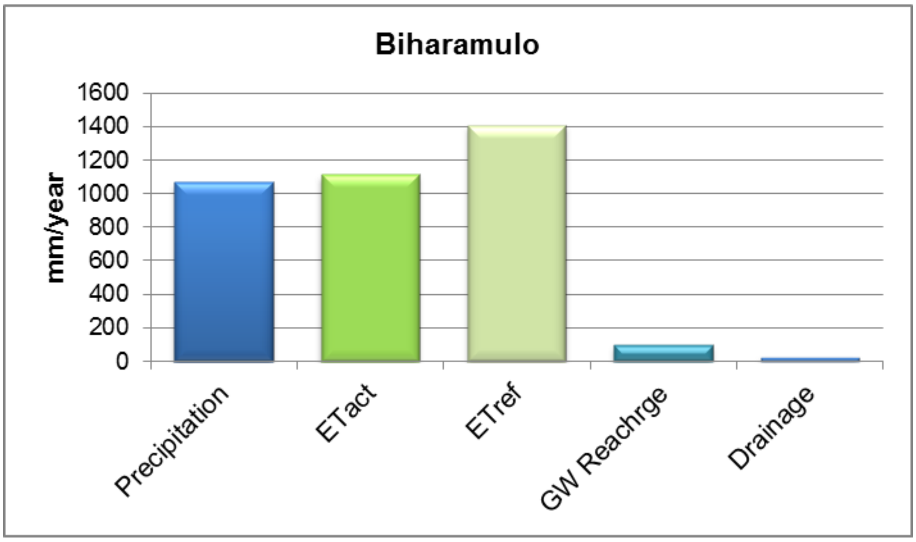
### *3.3.2 Water balance*

A very detailed high resolution model was built for NEL countries (NELmod). For a detailed description see Phase 1 report. Results from NELmod were extracted for this specific focal area and are shown below.

**Figure 42: Photograph from field inventory and assessment work**

**Figure 43: Photograph from field inventory and assessment work**



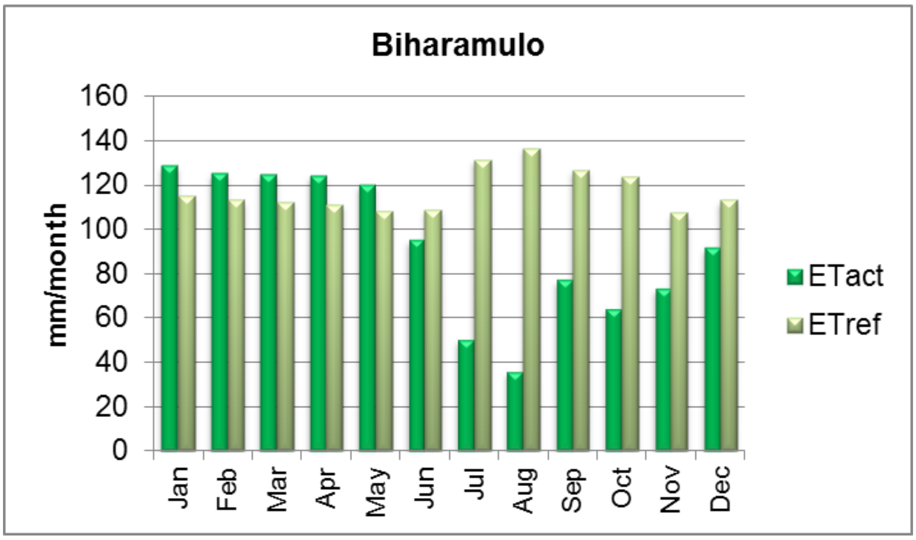
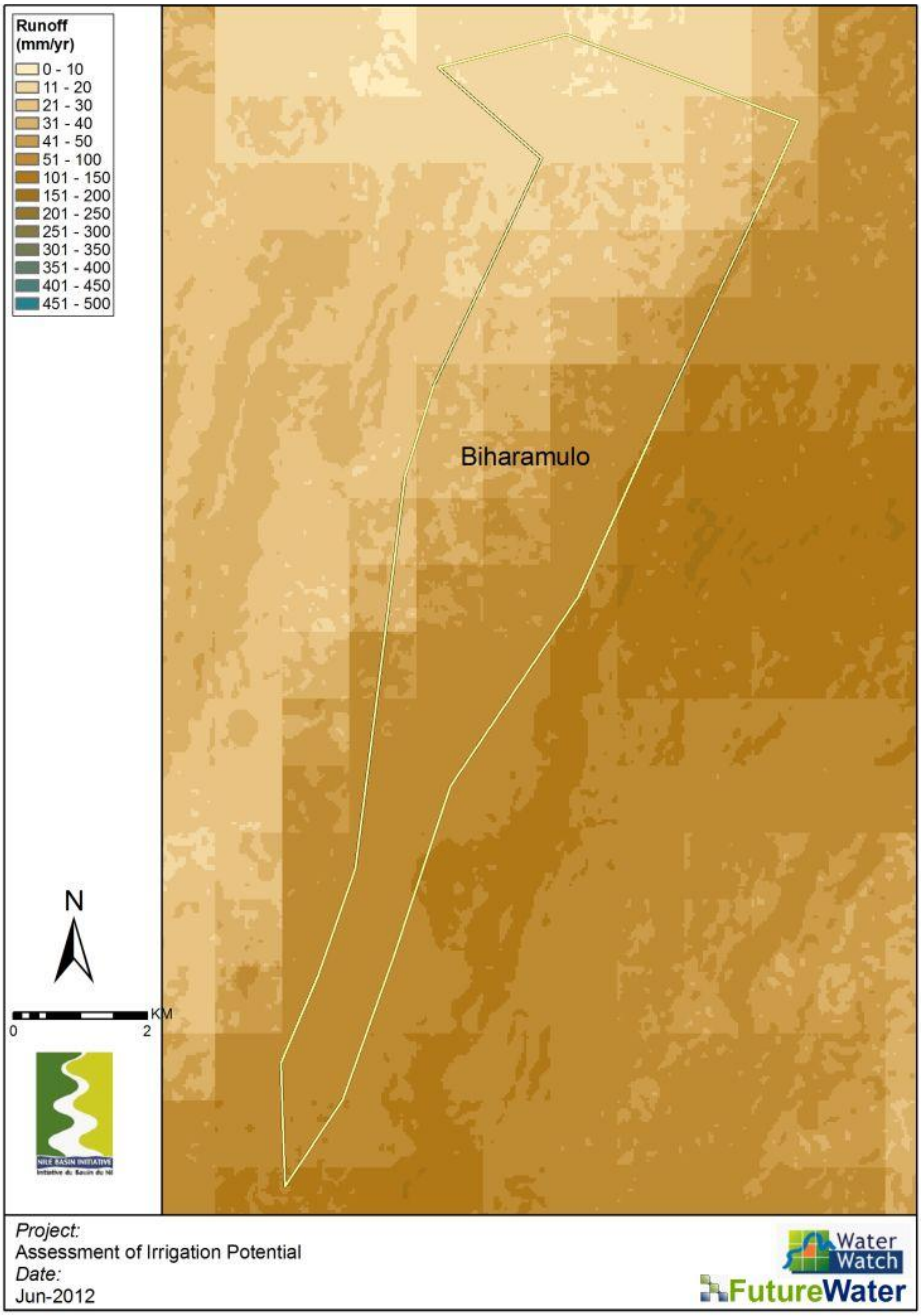
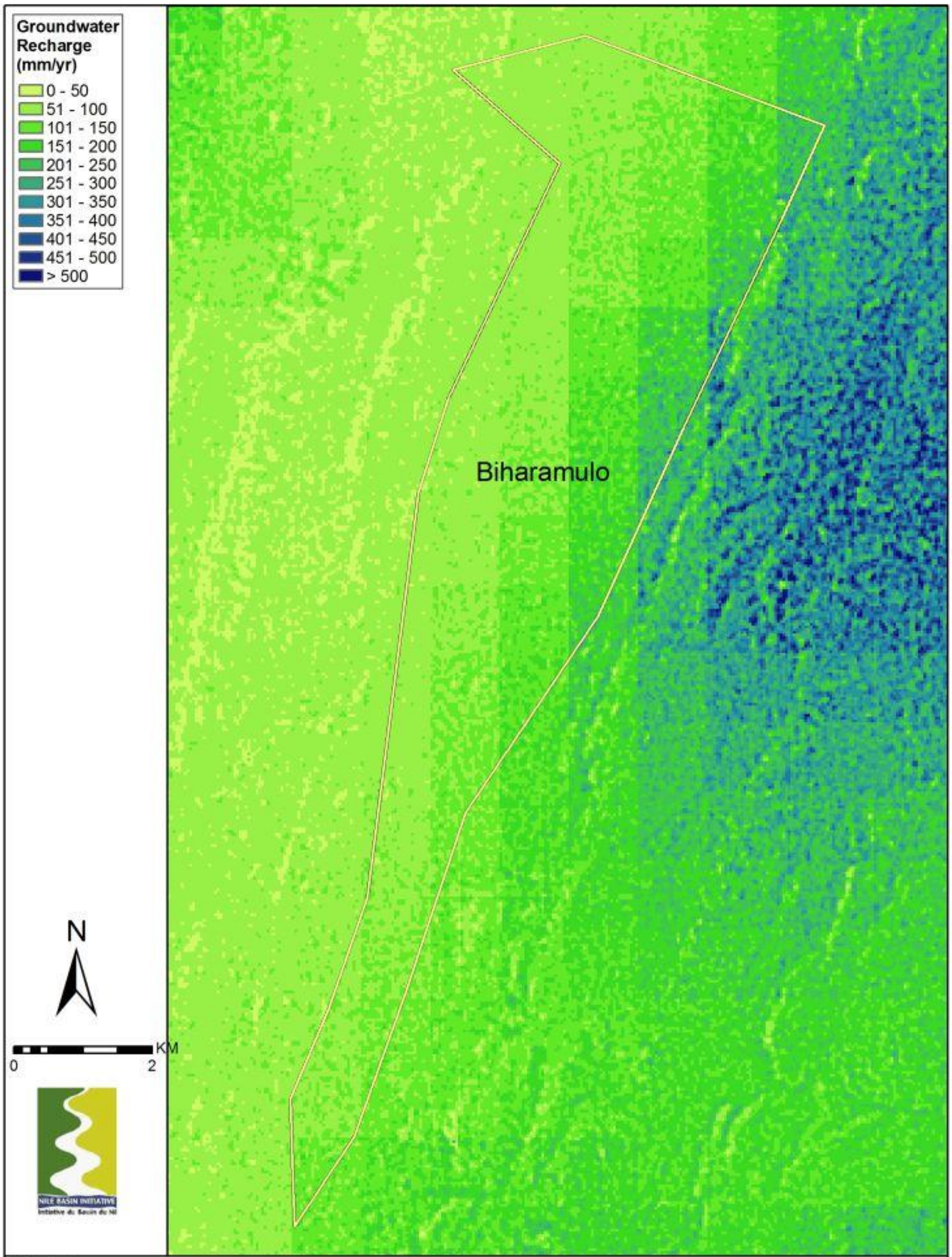




**Figure 44: Water balances for the area based on the high resolution data and modeling approach for Biharamulo focal area.**


Runoff (mm/yr)
0 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 100
101 - 150
151 - 200
201 - 250
251 - 300
301 - 350
351 - 400
401 - 450
451 - 500
Biharamulo
N
0
2
KM
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater




Project:
Assessment of Irrigation Potential
Date:
Jun-2012

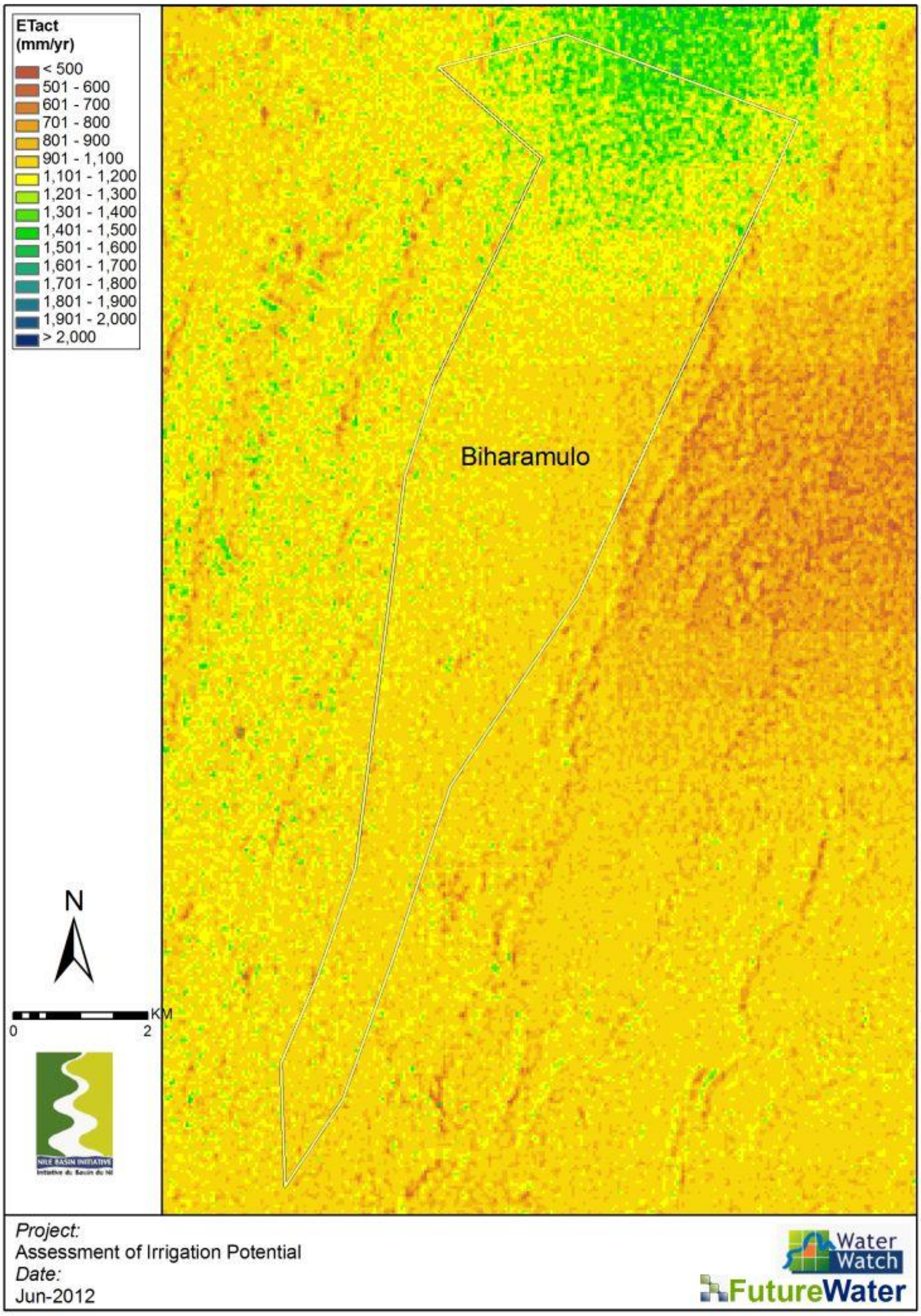



**Figure 45: Water balances for the area based on the high resolution data and modeling approach for Biharamulo focal area.**

## 3.4 Assessment of irrigation water requirements

### *3.4.1 Irrigation water requirements*

Irrigation water requirements depend on many factors such as: climatic conditions, crop, growing season, irrigation practices etc. A first estimate of irrigation requirements could be based on the difference between rainfall and reference evapotranspiration. It was however selected for this pre-feasibility assessment to provide a first estimate of irrigation needs based on the most promising crops. To this end, FAO's AquaCrop, the successor of CropWat was setup for local and crop specific conditions.

All input files and output files for AquaCrop can be found in the database attached to the reports. Note that during this pre-feasibility phase focus with AquaCrop was to obtain crop water requirements. A subsequent feasibility study could focus more on the crop yield validation and calibration components of AquaCrop.

In the table below the irrigation water requirements for each selected crop are provided based on AquaCrop calculations. All units are provided in mm per growing season for the specific crops. Note that for various crops, like vegetables and similar crops, multiple croppings per years might occur.

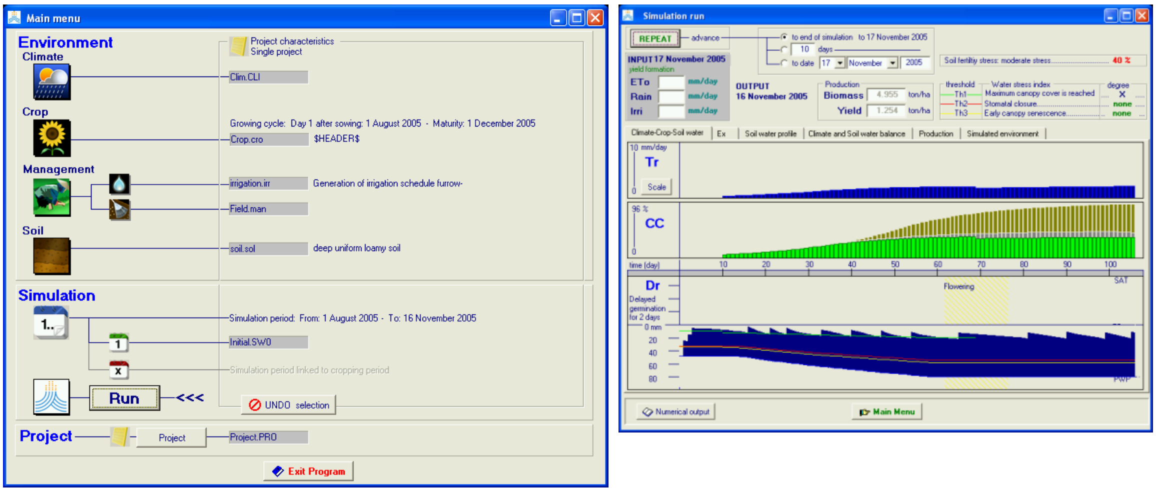



**Figure 46: Typical example of AquaCrop input and output screens.**

**Table 5: Irrigation water requirements for the selected crops in the focal areas. All units are given in mm per growing season.**

| Crop | Rain | ETref | Planting | Harvets | Rain | Irrigation | ETref | ETact |
|---|---|---|---|---|---|---|---|---|
| | === year === | | == (day of year) == | | ======== growing season ======= | | | |
| | (mm) | (mm) | | | (mm) | (mm) | (mm) | (mm) |
| Rice | 1070 | 1407 | 45 | 213 | 509 | 140 | 634 | 337 |
| Maize | 1070 | 1407 | 41 | 182 | 528 | 90 | 519 | 357 |
| Cassava | 1070 | 1407 | 349 | 167 | 785 | 110 | 669 | 544 |
| Cotton | 1070 | 1407 | 359 | 207 | 754 | 100 | 795 | 443 |
| Vegetables | 1070 | 1407 | 1 | 365 | 1075 | 90 | 1404 | 598 |

### *3.4.2 Water source and irrigation systems*

During the field visit and existing expert knowledge in the area it became clear that this focal area is suitable for irrigation from a reservoir combined with water harvesting practices. According to the District Agriculture Development Officer (DALDO) the District Agricultural Sector Investment Project (DASIP) is undertaking a detailed design for the Mwiruzi Irrigation Scheme. In this area traditional irrigation has been practiced for many years, especially in the upstream area there is a big traditional scheme of about 1000 ha irrigated from Mwiruzi River. River overflow water is diverted to the paddy farm. A summary of the irrigation potential in this area is shown in Table 6.

**Table 6: Potential for irrigation.**

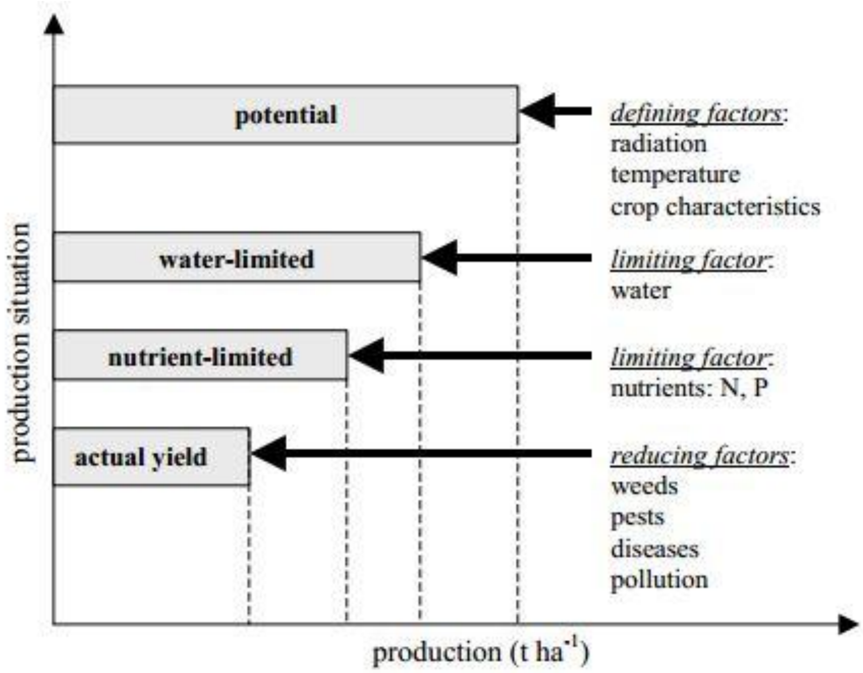
| | |
|---|---|
| *Potential irrigation sources* | River Mwiruzi |
| *Stability of water source during the year (discharge range) please note about the stability* | Not developed and thus unspecified |
| *Potential for reservoir/ water harvesting (capacity)* | Not yet |
| *Raining season (s)* | August/ September Heavy rains |
| *Amount for precipitation mm/yr ( an estimate from local and experts)* | 800mm to 1200mm |
| *Ground water levels which areas have less regimes? As from locals also* | 4m |
| *Already irrigated area (Mwiruzi overflows)* | 1000 ha |

## 3.5 Potential crop yield assessment

The yield gap describes the difference between the current yield, and the maximal possible yield. Mostly the maximal possible yield is defined as the highest yield in the world, but it can also be assessed against a regional background which makes the yield gap more realistic and the maximal yield possible to achieve under the given circumstances.

The gap between the actual yield and the potential yield can be caused by several processes. Factors which may cause that the maximal possible yield is not reached can be the water availability, the soil and the available nutrients, or yield reducing factors like diseases, weeds or pollution.

For the four proposed crops (paddy, maize, cassava, cotton and vegetables) potential crop yields are expected to be relatively high. The focal area is relatively fertile and additional irrigation might increase crop yields of these crops to higher yields compared to the country averages. Especially cassava, rice and cotton have a high potential to generate relatively high yields. Detailed analysis during a feasibility study should focus on a more in-depth analysis of the potential crop yields.



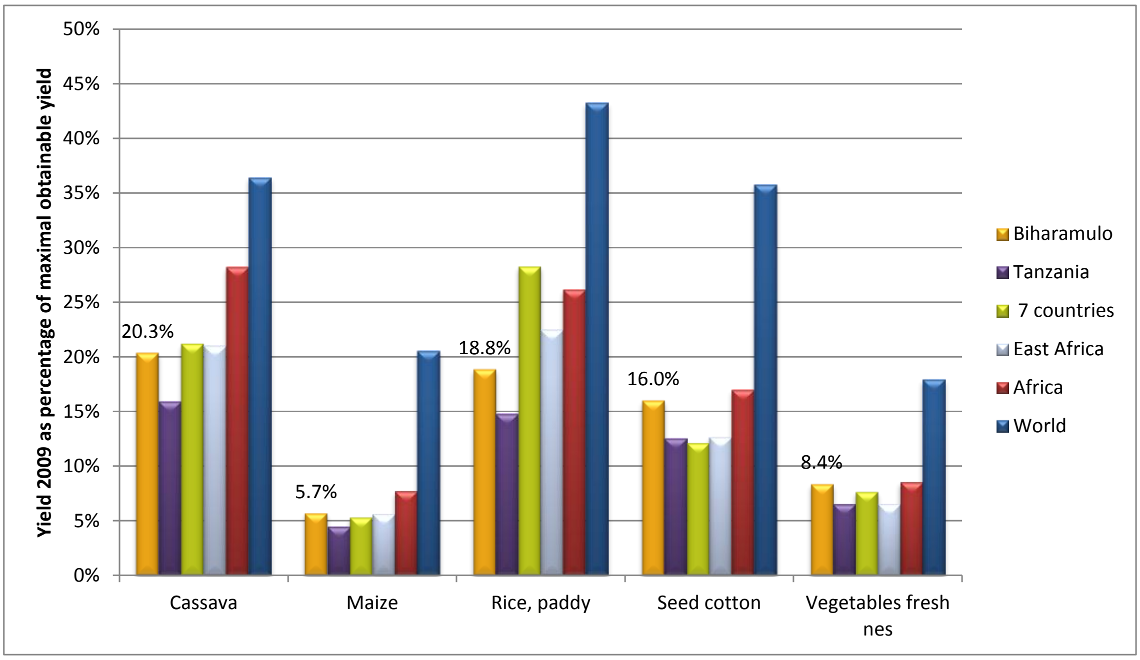




**Figure 47: Yield gap Biharamulo (source: FAOSTAT, 2010).**

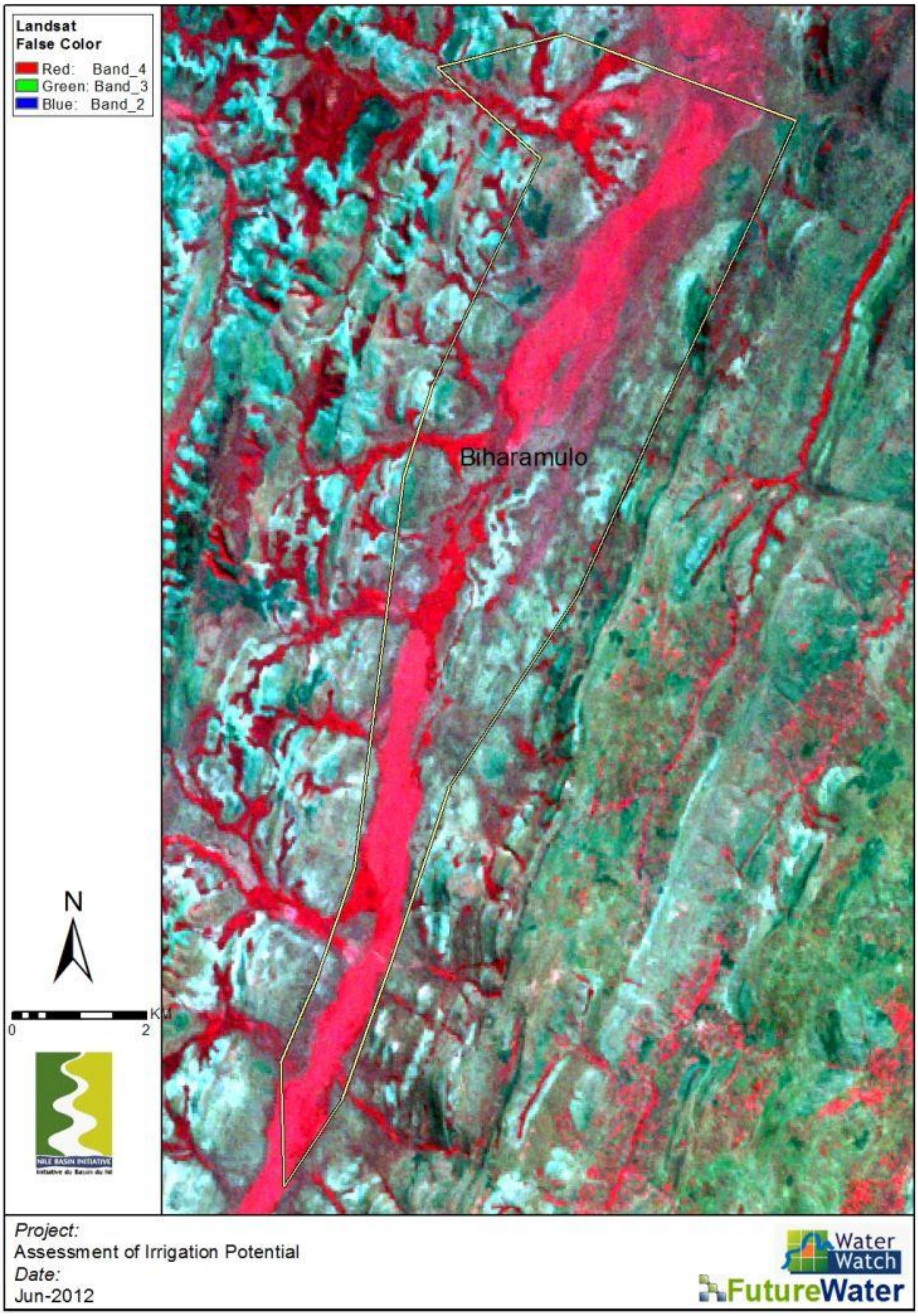



**Figure 48: Landsat False Color Composite indicating current productivity of the area for Biharamulo focal area.**

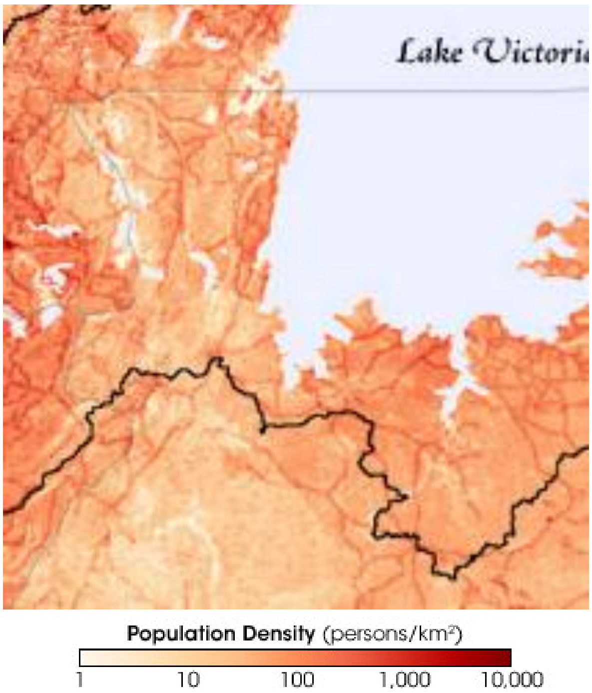



**Figure 49. Population density focal area (source: NASA Earths Observatory).**

## 3.6 Environmental and socio-economic considerations

### *3.6.1 Social and population considerations*

A first pre-feasibility assessment on the social context of the focal area has been undertaken. A field visit and additional data and information have been obtained regarding the focal area. Population density for the area is shown in the following map, while detailed concise information regarding social considerations is provided in the table.

| Focal point name | Biharamulo |
|---|---|
| Accessibility | 9km/45km |
| Population rural density area | Uknown |
| Which tribes inhabit the region? | Sukuma, Washubi, waha |
| Current welfare, unemployment, development. | 8% agriculture |
| Farmer's expertise | Low |
| Experience in agricultural cooperatives | Low |

### *3.6.2 Protected areas*

Within the focal area no protected areas are reported.

**Figure 50: Photograph from field inventory and assessment work**

## 3.7 Benefit-cost Analysis

A simplified benefit-cost analysis is undertaken for the area. Information for this is based on various sources such as FAO publications, IFPRI publications, local expertise and data. A full benefit-costs analysis has to be undertaken in a sub-sequent feasibility study for the area.

Note that this is a first-order benefit-cost analysis. A feasibility study can provide a more rigorous benefit-cost analysis, which is required before taking any implementation planning. However, the following table shows that based on this first-order analysis investments in irrigation can have a very positive impact.

Based on expert knowledge on the suitability to develop irrigation in the area scores between 1 (negative: low suitability or expensive) to 10 (positive: high suitability or low investments) have been marked. The filled radar plot below indicates the options for the focal area. Overall, the weak part of the site lies under farmers capacity, accessibility to roads, to markets and the initial investment cost. This in-turn affects access to market as farmers cannot transport their yield easily and more importantly may not fetch golden prices. However, soil suitability and water availability is a great deal for the area that will foster an increase yields.

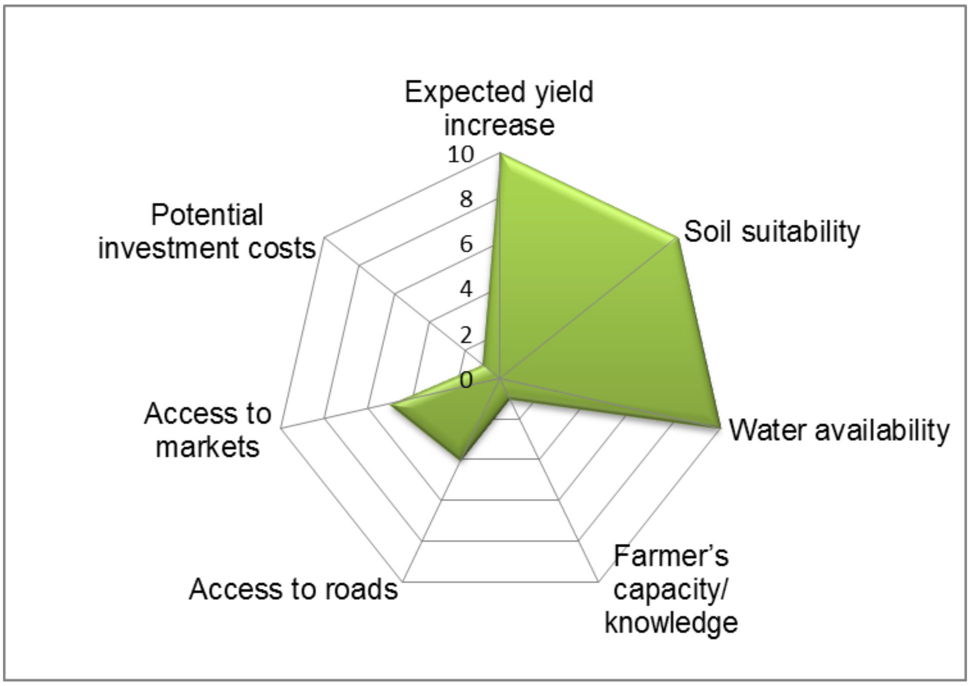



**Figure 51: Filled radar plot indicating expert knowledge score to develop irrigation in the Biharamulo focal area (1 = negative, 10 = positive). (Source: local experts and study analysis).**

**Table 7: Key factors used for the benefit costs analysis as based on field and data inventories.**

| | |
|---|---|
| Irrigation technique | Furrow, basin(majaruba) |
| Suitable area | 50ha |
| Road building requirement | Yes/9km |
| Pumping of water required | No |
| Reservoir building necessary | Yes |
| Soil improvement needed | No |

**Table 8: Benefit-cost analysis for Biharamulo area.**

| | |
|---|---|
| **Characteristics** | |
| Irrigated land (ha) | 2,500 |
| Farmers | 2,083 |
| **Investment Costs** | |
| Irrigation infrastructure (US$/ha) | 4,000 |
| Social infrastructure (US$/farmer) | 750 |
| Accessibility infrastructure (million US$) | 2.0 |
| **Operational Costs** | |
| O&M irrigation (US$/ha/yr) | 60 |
| Extension service (US$/farmer) | 15 |
| O&M roads (US$/yr) | 40,000 |
| **Summary** | |
| Initial investments (million US$) | 13.6 |
| O&M costs (million US$/yr) | 0.221 |
| Net benefits per year (million US$/yr) | 2.751 |
| IRR (Internal Rate of Return) | 22.8% |

## 3.8 Recommendations

The cost benefit analysis as presented in this report is made in the scope of a pre-feasibility study. Although based on literature, expert knowledge and rapid field assessments by local experts it can rather be seen as an indication of expected costs and benefits. As much as possible local technical, social and hydrological factors are incorporated. However it is recommended to assess the costs and benefits in more detail during a feasibility study, which can focus more in depth on the local situation.

# 4 Geita Plains focal area

## 4.1 Introduction

This chapter will describe the current state of the Geita Plains focal area, concerning land and water resources, and will discuss the potential to develop irrigation in the area. This irrigation potential will be based on the land and water resources, the irrigation requirements, the potential crop yields and will also involve the socio-economic considerations and institutional frameworks. Based on these aspects the potential for irrigation will be described, and cost for irrigation development calculated. In Figure 52 a detailed map of the area is given. Total area is 3700 ha.

Selection of this specific focal area was based on results of Phase 1 of this study, while final selection was the responsibility of the relevant country representatives. Results presented hereafter have been obtained from a broad range of sources: Phase 1, previous other studies and reports, modeling results, remote sensing, expert knowledge and field visits by Gaspar Damas Mashingia and supervised by Honest Prosper Ngowi and Eng. Amandus Lwena in April and May 2012.

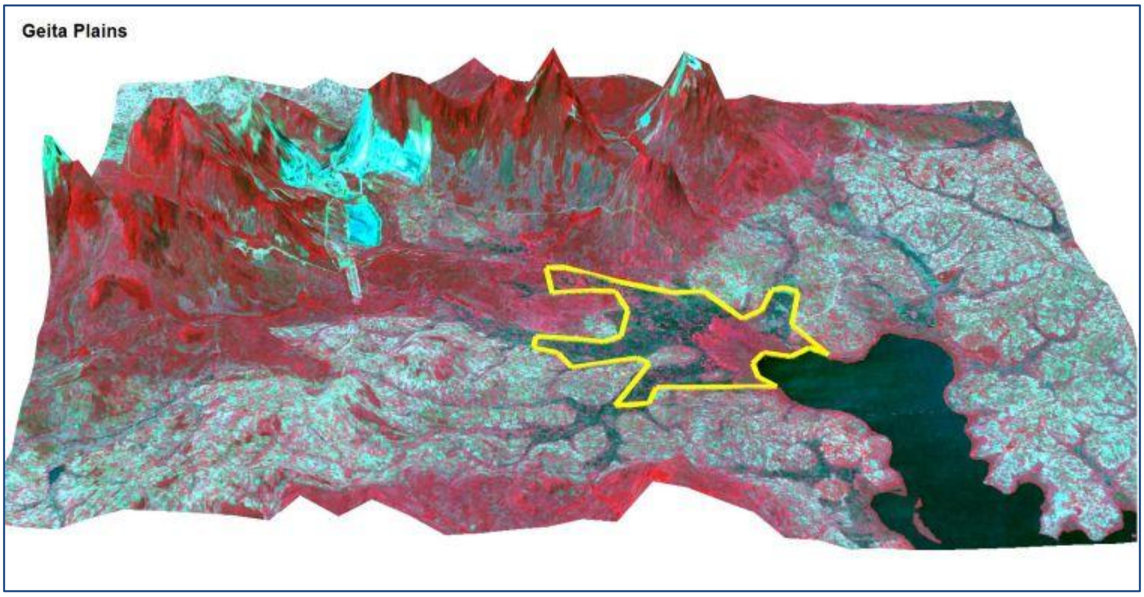
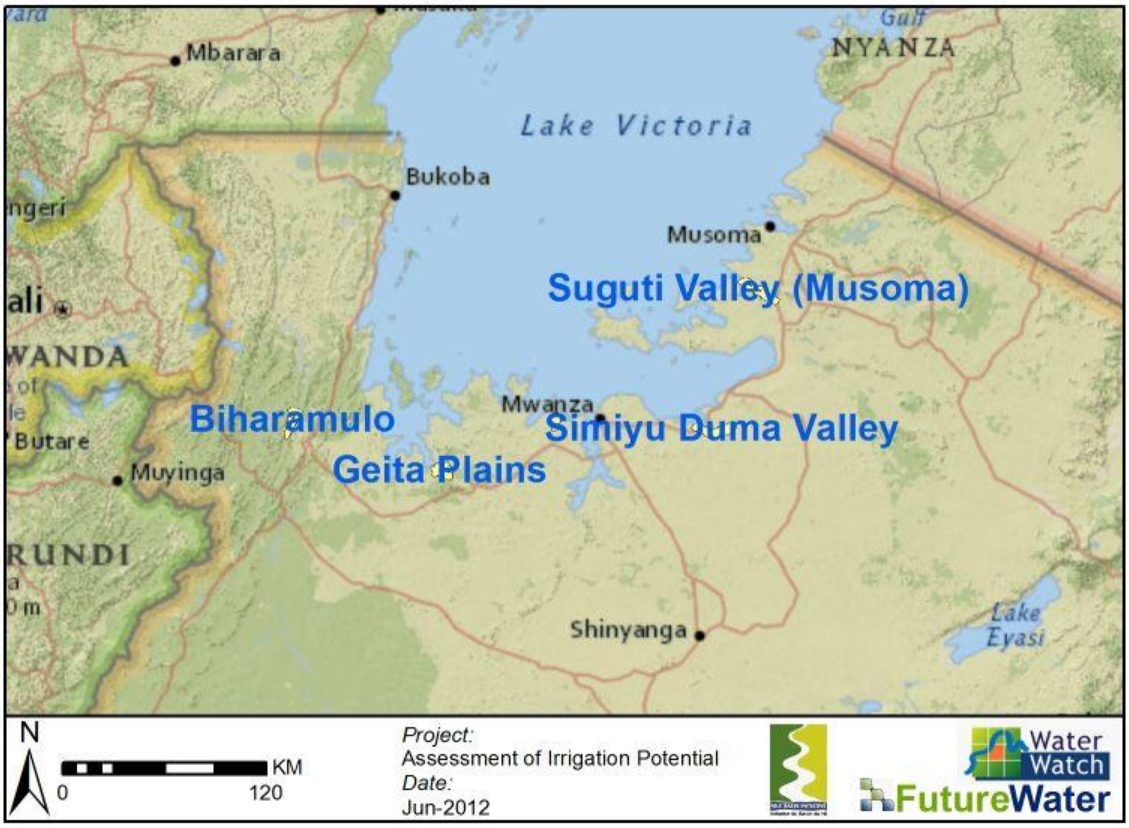



**Figure 52: 3D impression of Geita Plains focal area, Tanzania**



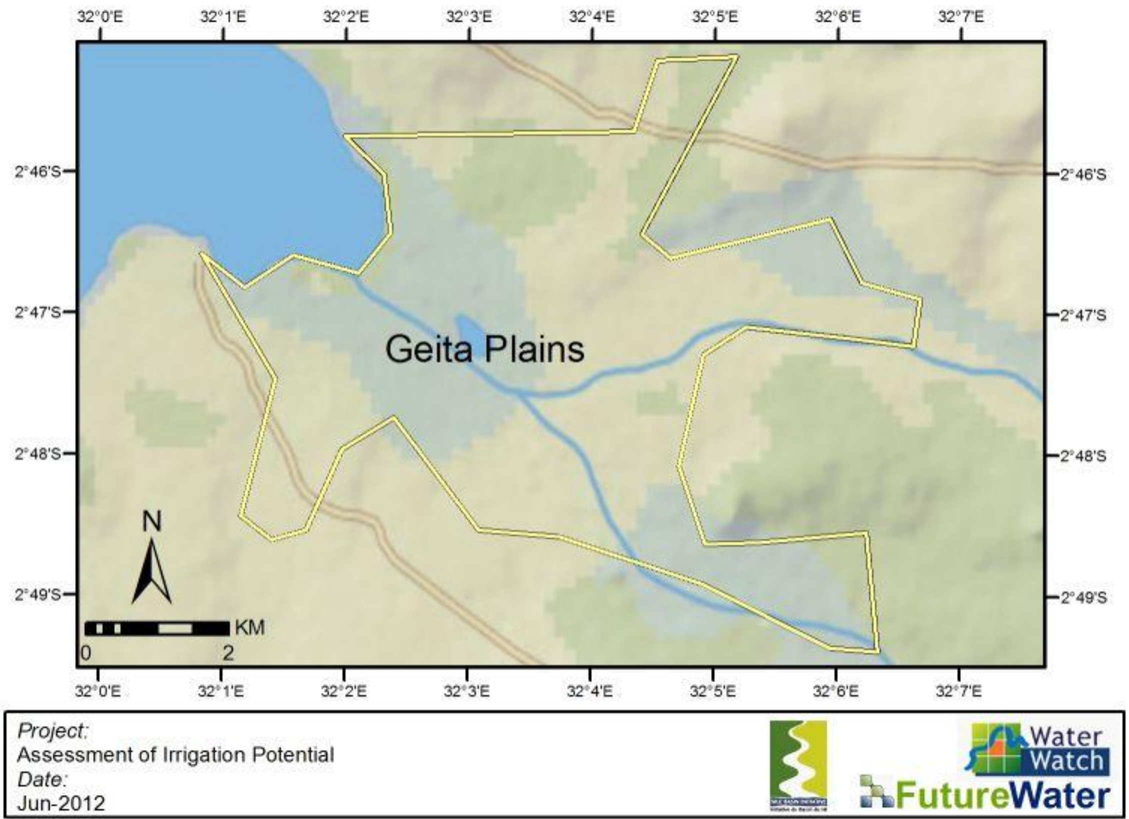




**Figure 53: Geita Plains focal area, Tanzania**

## 4.2 Land suitability assessment

### *4.2.1 Terrain*

The Geita Plains are located close to Lake Victoria. The area is very flat and average elevation is about 1130 meter above sea level (MASL). In the south and the east are some smaller mountain ridges ranging to about 1500 MASL. Average slope of the Geita Plains is only e few percentages, making the area suitable to develop irrigation.

The area is covered with medium tall grass and short grass, It has trees like acacia, grasses known by locals as Lusozy, hyperemia grasses, shrubs, brancharia species.

**Figure 54: Photograph from field inventory and assessment work**

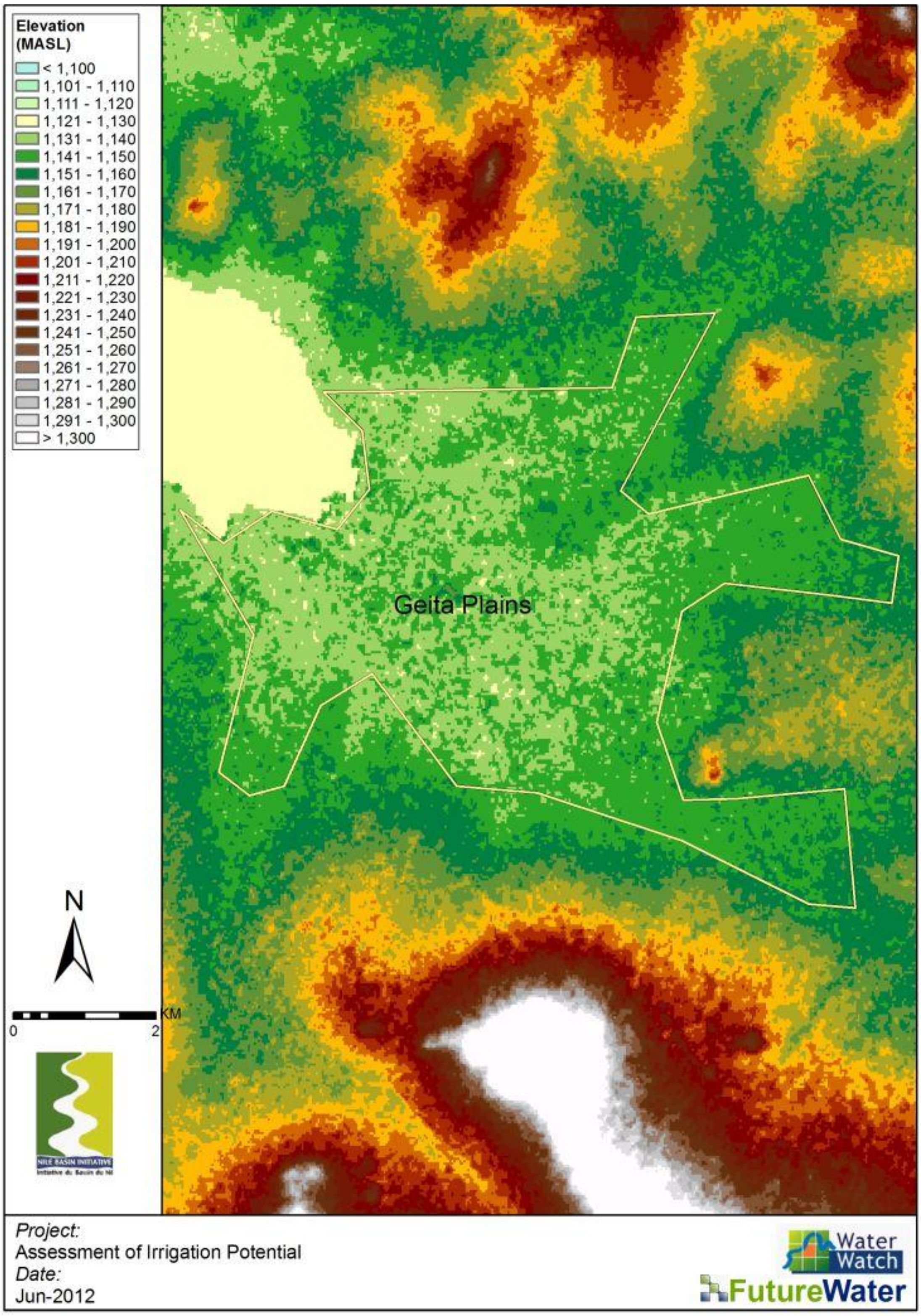



**Figure 55: DEM Geita Plains focal area. Resolution 1 arc second (+/- 30m)**

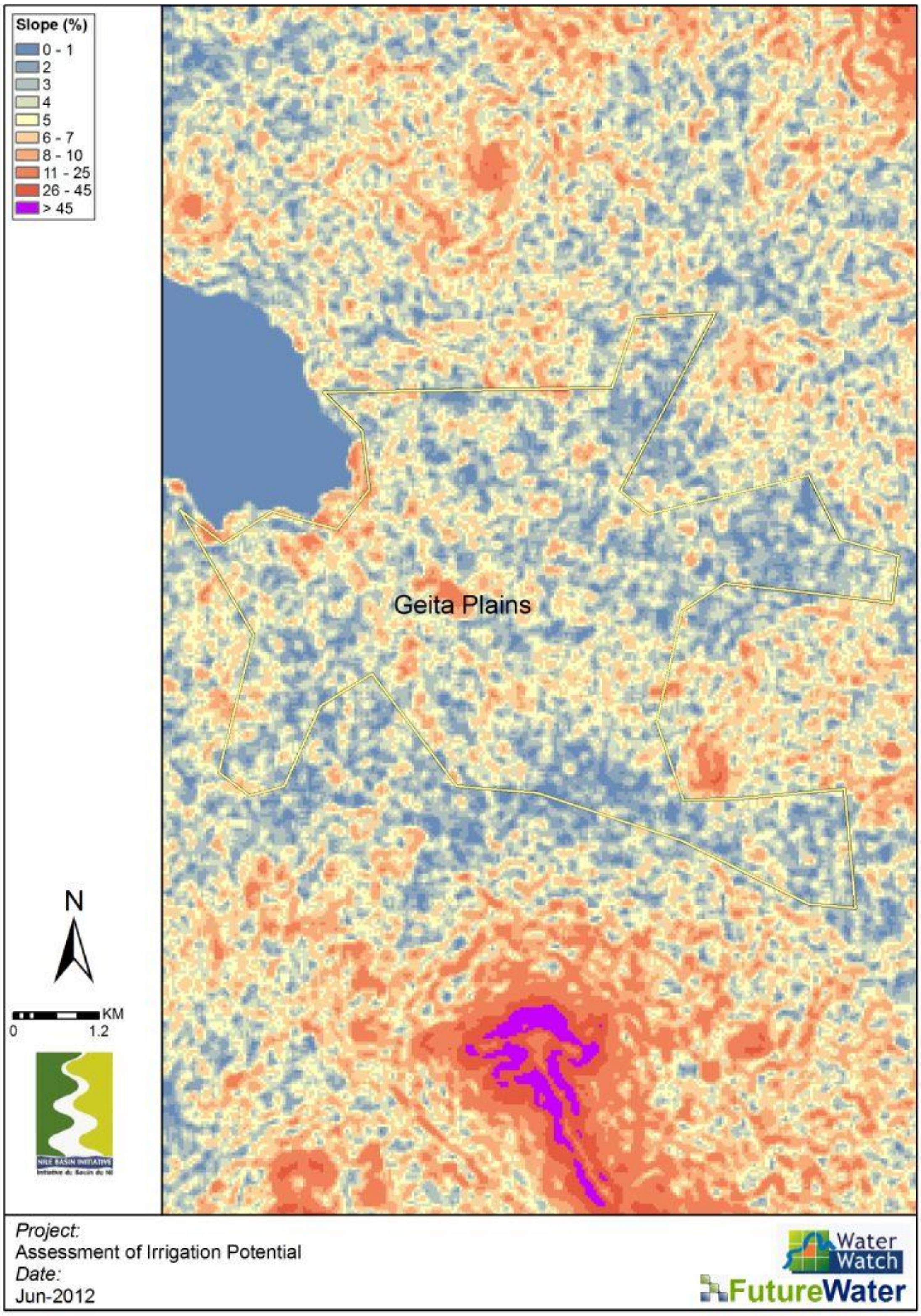



**Figure 56: Slope map Geita Plains focal area. (Source: ASTER)**

### *4.2.2 Soil*

The Geita Plains focal area has two distinct soil types: Vertisols (VRe) in the north, and Ferralsols in the south (FRr). Vertisols are churning, heavy clay soils with a high proportion of swelling clays. These soils form deep wide cracks from the surface downward when they dry out, which happens in most years. These soils have considerable agricultural potential, but adapted management is a precondition for sustained production. The comparatively good chemical fertility and their occurrence on extensive level plains where reclamation and mechanical cultivation can be envisaged are assets of Vertisols. Their physical soil characteristics and, notably, their difficult water management cause problems. The agricultural uses of Vertisols range from very extensive (grazing, collection of fuelwood, and charcoal burning) through smallholder post-rainy season crop production (millet, sorghum, cotton and chickpeas) to small-scale (rice) and large-scale irrigated agriculture (cotton, wheat, barley, sorghum, chickpeas, flax, and sugar cane). Cotton is known to perform well on Vertisols, allegedly because cotton has a vertical root system that is not damaged severely by cracking of the soil. Tree crops are generally less successful because tree roots find it difficult to establish themselves in the subsoil and are damaged as the soil shrinks and swells.

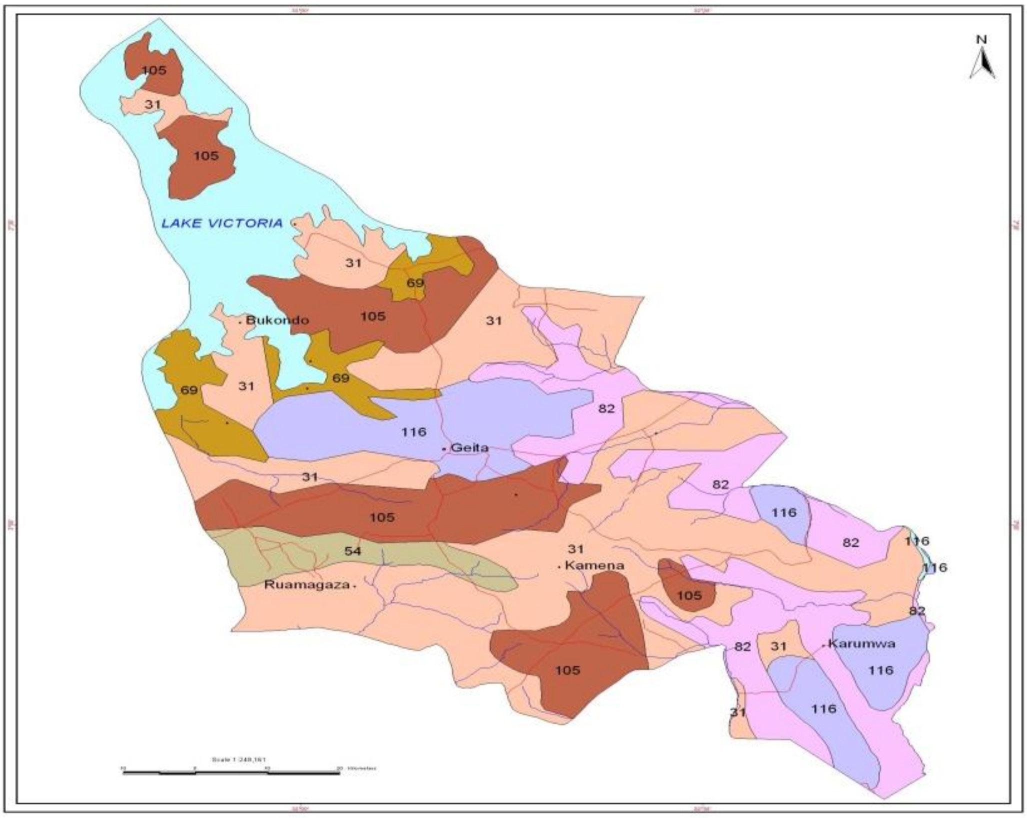
Management practices of Vertisols for crop production should be directed primarily at water control in combination with conservation or improvement of soil fertility. The physical properties and the soil moisture regime of Vertisols represent serious management constraints. The heavy soil texture and domination of expanding clay minerals result in a narrow soil moisture range between moisture stress and water excess. Tillage is hindered by stickiness when the soil is wet and hardness when it is dry. The susceptibility of Vertisols to waterlogging may be the single most important factor that reduces the actual growing period. Excess water in the rainy season must be stored for post-rainy season use (water harvesting) on Vertisols with very slow infiltration rates. One compensation for the shrink–swell characteristics is the phenomenon of self-mulching that is common on many Vertisols. Large clods produced by primary tillage break down with gradual drying into fine peds, which provide a passable seed bed with minimal effort. For the same reason, gully erosion on overgrazed Vertisols is seldom severe because gully walls soon assume a shallow angle of repose, which allows grass to become re-established more readily.

The Ferralsols, as found in the south part of Geita plains, are the classical, deeply weathered, red or yellow soils of the humid tropics. Ferralsols have good physical properties. Great soil depth, good permeability and stable microstructure make Ferralsols less susceptible to erosion than most other intensely weathered tropical soils. Moist Ferralsols are friable and easy to work. They are well drained but may in times be droughty because of their low available water storage capacity. The chemical fertility of Ferralsols is poor; weatherable minerals are scarce or absent, and cation retention by the mineral soil fraction is weak. Under natural vegetation, nutrient elements that are taken up by the roots are eventually returned to the surface soil with falling leaves and other plant debris. The bulk of all cycling plant nutrients is contained in the biomass; available plant nutrients in the soil are concentrated in the soil organic matter. If the process of nutrient cycling is interrupted, e.g. upon introduction of low-input sedentary subsistence farming, the rootzone will rapidly become depleted of plant nutrients. Maintaining soil fertility by manuring, mulching and/or adequate (i.e. long enough) fallow periods or agroforestry practices, and prevention of surface soil erosion are important management requirements.

For Ferrasol, the fertilizer selection and the mode and timing of fertilizer application determine to a great extent the success of agriculture. Slow-release phosphate (phosphate rock) applied at a rate of several tonnes per hectare eliminates P deficiency for a number of years. For a quick fix, much more soluble double or triple superphosphate is used, needed in much smaller quantities, especially if placed in the direct vicinity of the roots. Sedentary subsistence farmers and shifting cultivators on Ferralsols grow a variety of annual and perennial crops. Extensive grazing is also common and considerable areas of Ferralsols are not used for agriculture at all. The good physical properties of Ferralsols and the often level topography would encourage more intensive forms of land use if problems caused by poor chemical properties could be overcome.

During the field inventory texture data was found. The top soil depth ranges 0.0m – 0.35m, where sub grade materials below ground surface are characterized of silty sand, sand-silt mixtures (sm) and clayey sands, sandy-clay mixtures (SC). Another characteristic of the soil is that, the top soil depth ranges from 0.0m – 0.4m where sub grade materials below land surface are characterized of fine sand, silty clay mixed with whitish calcium carbonate concretion particles known as calcrete at few meters that covers across the river basin below the ground level at depth of 1.0m to 2m.

A more detailed soil map can be seen below.



| Symbol | WRB soil unit | Limitations | Use and Management |
|---|---|---|---|
| 30 | Calci-Hypsodic Planosols | Strong sodicity and silinty, very low fertility | Suitable for extensive grazing and in some places wetland rice |
| 31 | Chromi-Feralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 53 | Humi-Umbric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 54 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 69 | Pellic Vertisols | Difficult workability, difficult water management | High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated cropping |
| 82 | Eutri-Pellic Vertisols | Difficult workability, difficult water management | High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated cropping |
| 101 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 105 | Eutri-Rhodic Cambisols | Vary with climate, topography, depth or stoniness | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 108 | Eutric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 115 | Humi-Umbric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 122 | Chromi-Feralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 131 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 134 | Ferralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 147 | Waterbody | | |

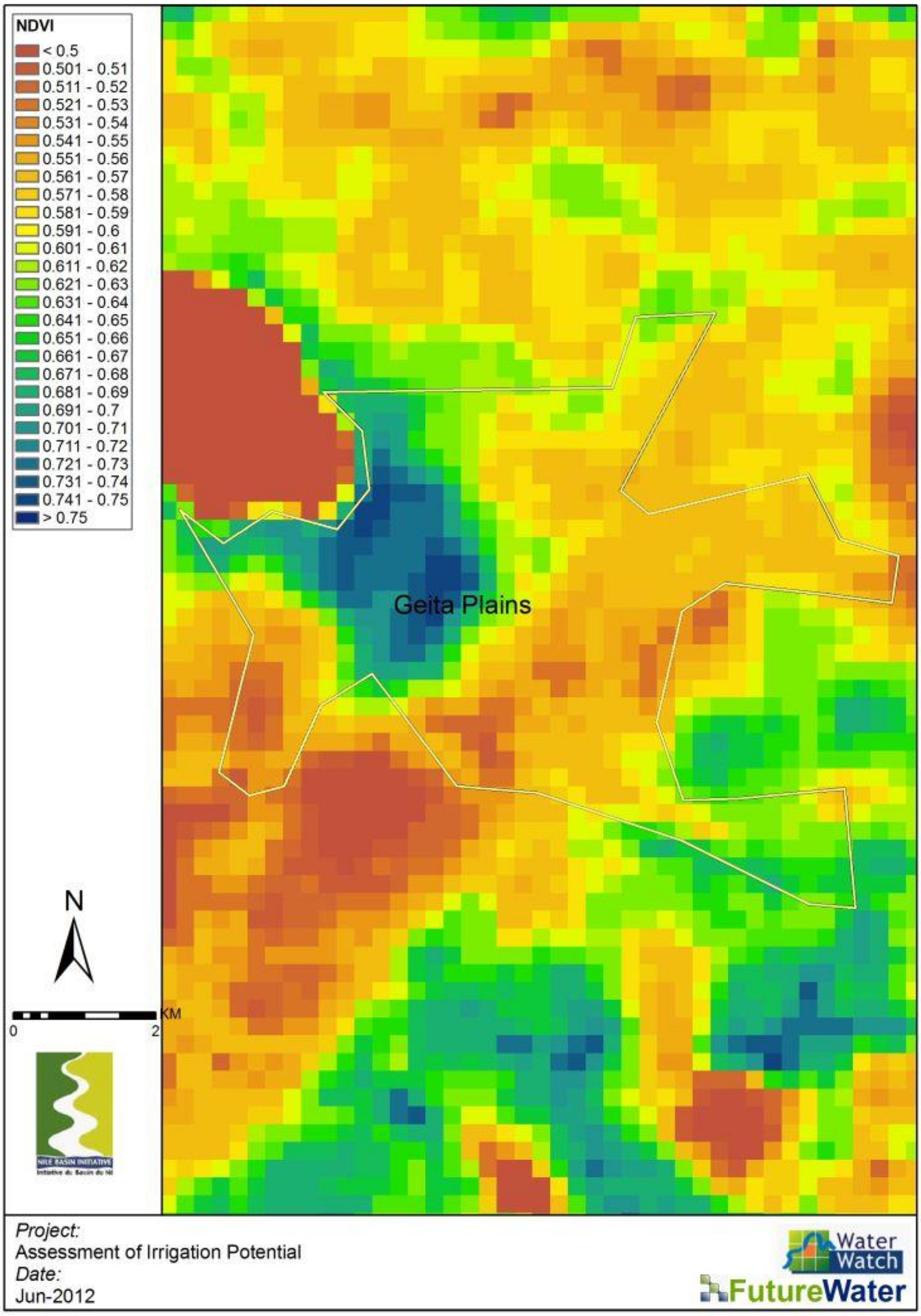
**Figure 57: Details soil map and associated limitations, use and management options for Geita Plains focal area.**

### *4.2.3 Land productivity*

The current land cover is medium tall grass and short grass, It has trees like acacia, grasses known by locals as Lusozy, hyperemia grasses, shrubs, brancharia species. During the field inventory the following land cover classes were identified:

- Shrubs at 20% of the area
- Hyperemia trees at 10% of the area
- Accacia trees at 10% of the area
- Grasses at 60% of the area

**Figure 58: Photograph from field inventory and assessment work**


NDVI
< 0.5
0.501 - 0.51
0.511 - 0.52
0.521 - 0.53
0.531 - 0.54
0.541 - 0.55
0.551 - 0.56
0.561 - 0.57
0.571 - 0.58
0.581 - 0.59
0.591 - 0.6
0.601 - 0.61
0.611 - 0.62
0.621 - 0.63
0.631 - 0.64
0.641 - 0.65
0.651 - 0.66
0.661 - 0.67
0.671 - 0.68
0.681 - 0.69
0.691 - 0.7
0.701 - 0.71
0.711 - 0.72
0.721 - 0.73
0.731 - 0.74
0.741 - 0.75
> 0.75
Geita Plains
N
0
2
KM
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater

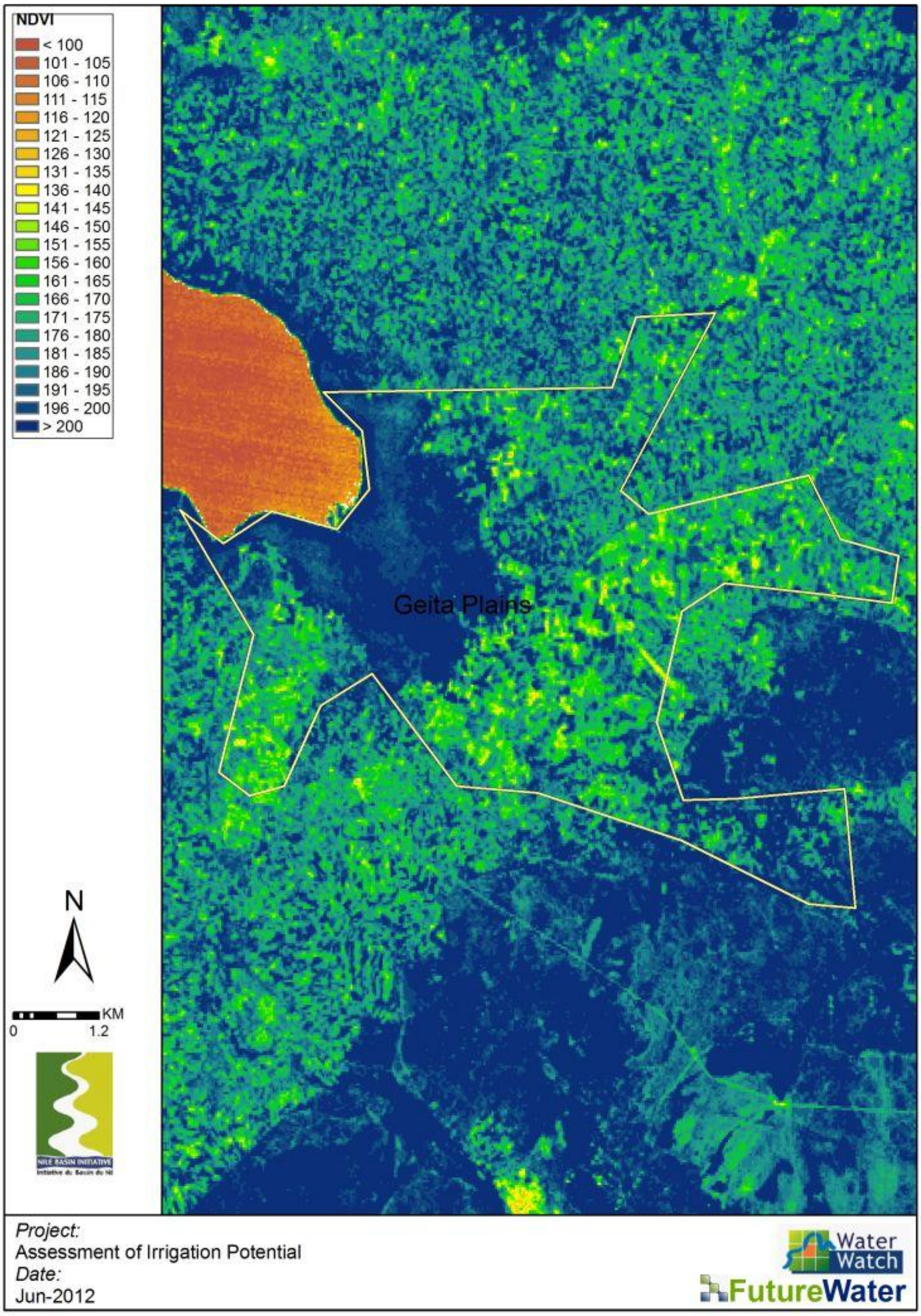



**Figure 59: Yearly average NDVI values (top) and high resolution Landsat NDVI for one day (bottom) for Geita Plains focal area.**

### 4.2.4 Potential cropping patterns

Currently the only crop found in in the area is paddy. Paddy receives in some periods and in some locations limited irrigation. Other details of the crop are shown in the following table.

| GEITA | Paddy |
|---|---|
| % of this crop as of % total agriculture area | 100 |
| Date planting/seeding | Nov/Dec/Jan |
| Date harvest | May/Jun/Jul |
| Average yield (kg/ha) | 5000 |
| Maximum yield (kg/ha) | 6000 |
| Average selling value of crop (fbu/kg) | 1500shs |
| Irrigated (yes no and mm/) | No/yes |
| Amount of growing cycles per year | one |

Regarding potential crops to be promoted in the area if irrigation will be developed, the following crops were proposed: paddy, maize, cassava, cotton and vegetables.

## 4.3 Water resource assessment

### 4.3.1 Climate

Annual rainfall in the focal area is about 1060 mm per year. Main dry period is from June to August. Overall climate in the focal area is characterized by humid conditions with constant annual temperatures ranging from 19 to 28$^{o}$C, for minimum and maximum temperatures respectively. Reference evapotranspiration is about 1460 mm per year.

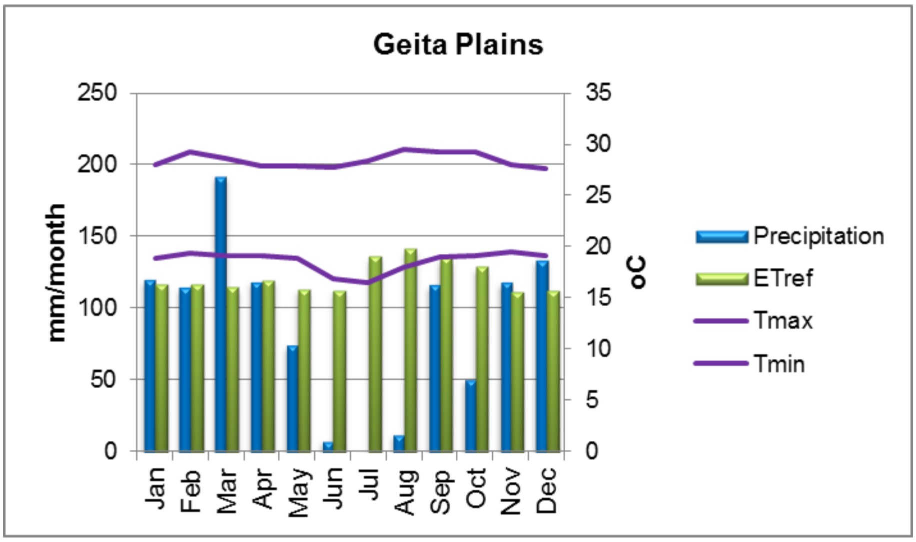



**Figure 60: Average climate conditions for Geita Plains focal area.**

### 4.3.2 Water balance

A very detailed high resolution model was built for NEL countries (NELmod). For a detailed description see Phase 1 report. Results from NELmod were extracted for this specific focal area and are shown below.

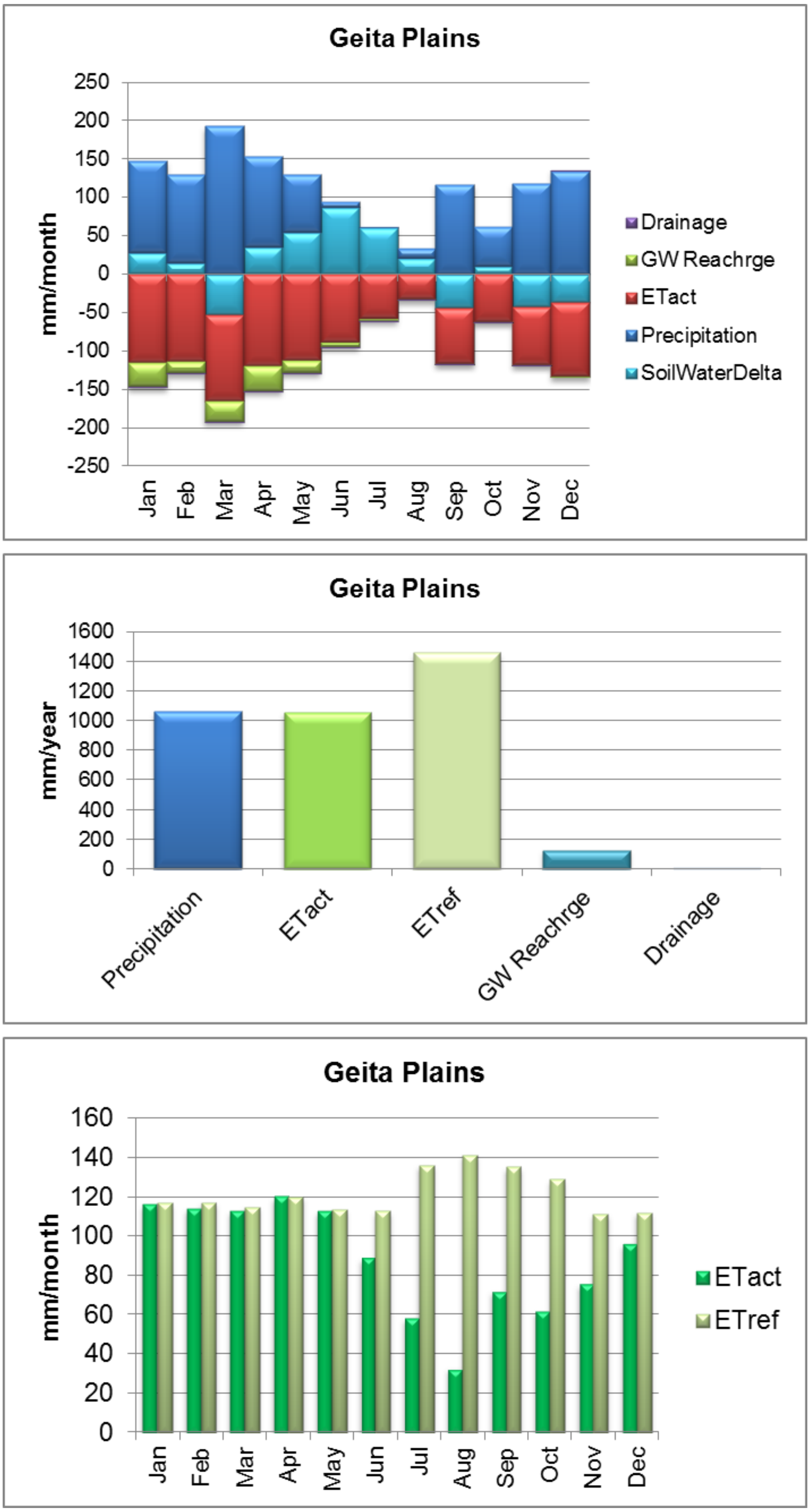
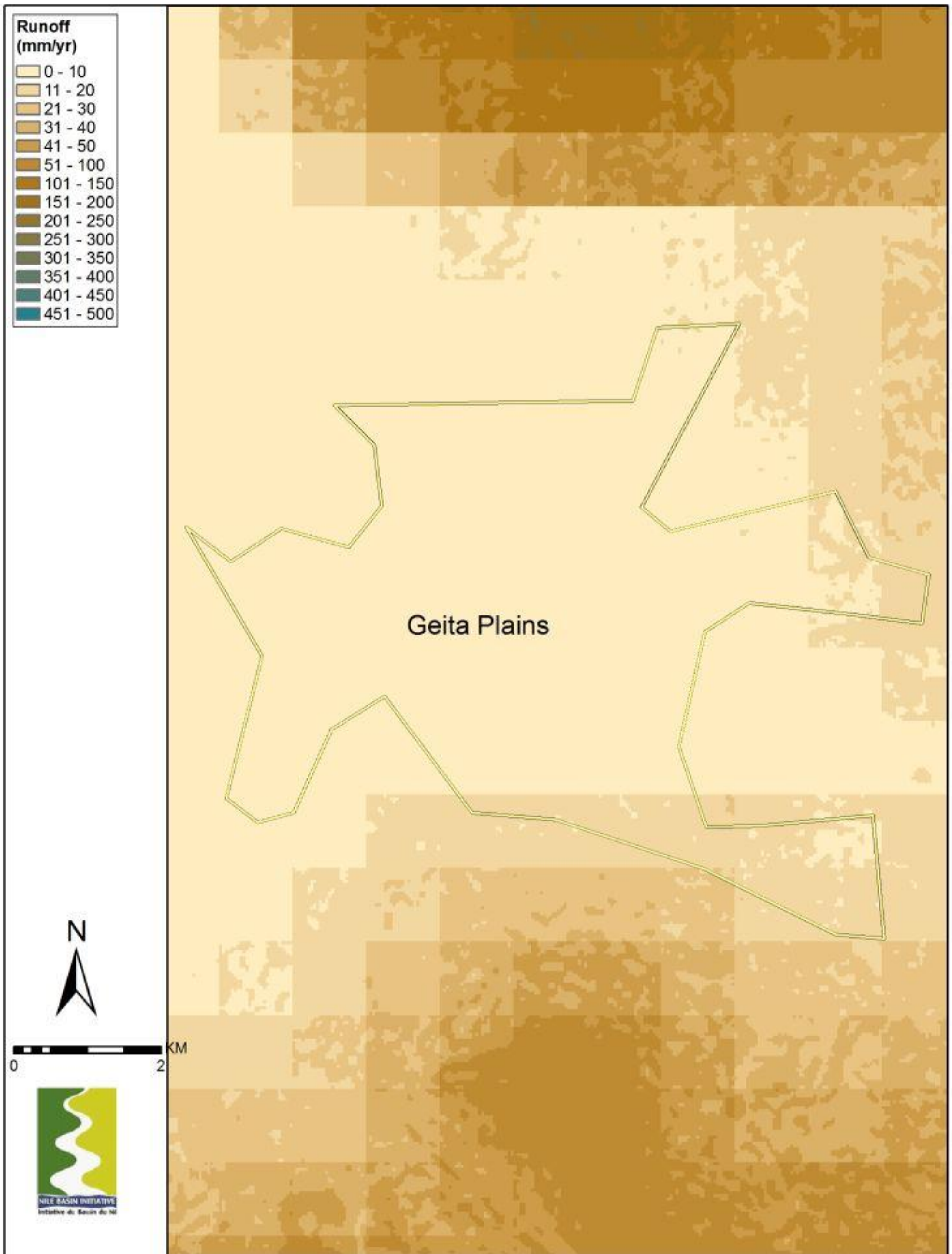
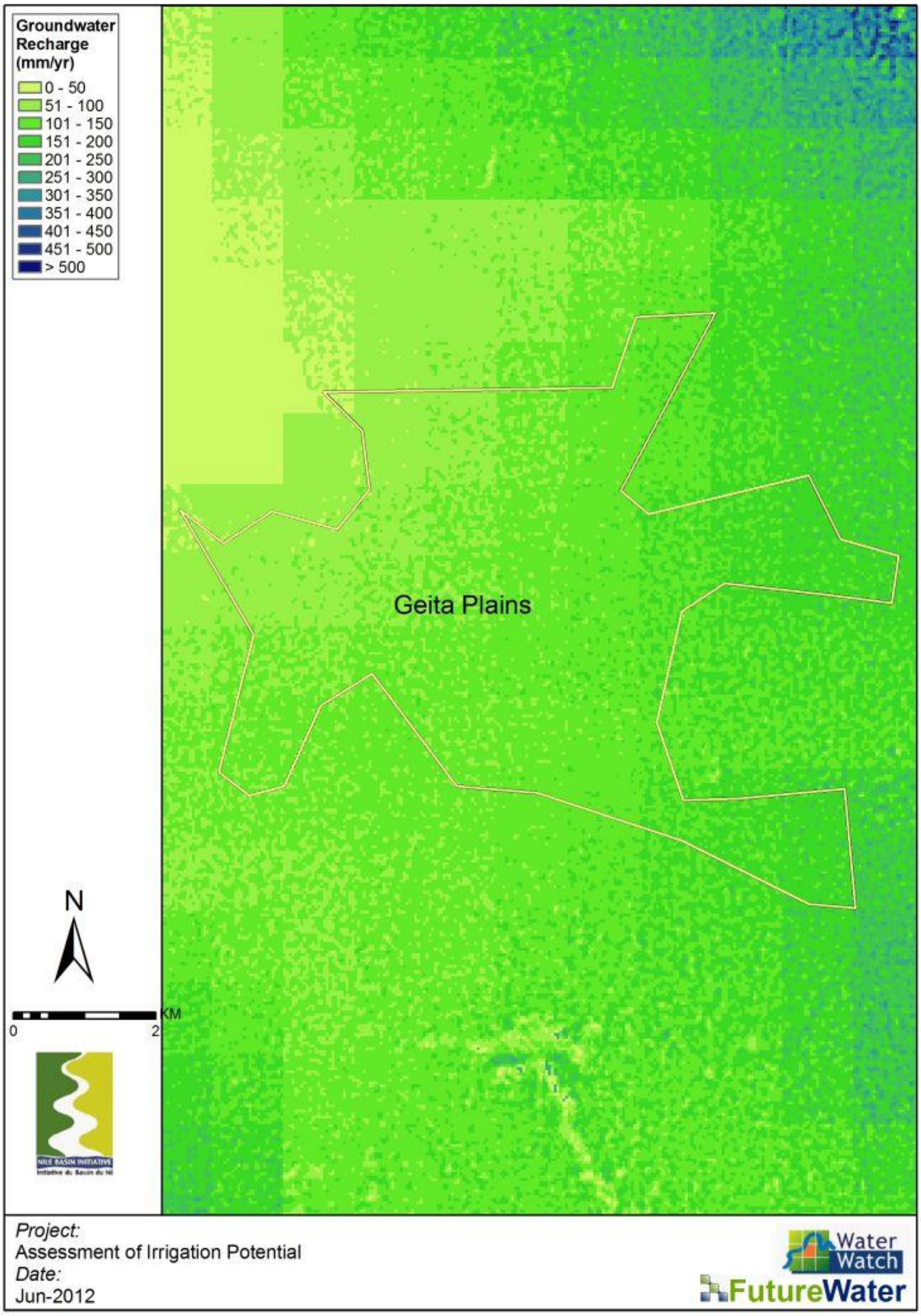



**Figure 61: Water balances for the area based on the high resolution data and modeling approach for Geita Plains focal area.**




*Project:*
Assessment of Irrigation Potential
*Date:*
Jun-2012


Groundwater Recharge (mm/yr)
0 - 50
51 - 100
101 - 150
151 - 200
201 - 250
251 - 300
301 - 350
351 - 400
401 - 450
451 - 500
> 500
Geita Plains
N
0
2
KM
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater

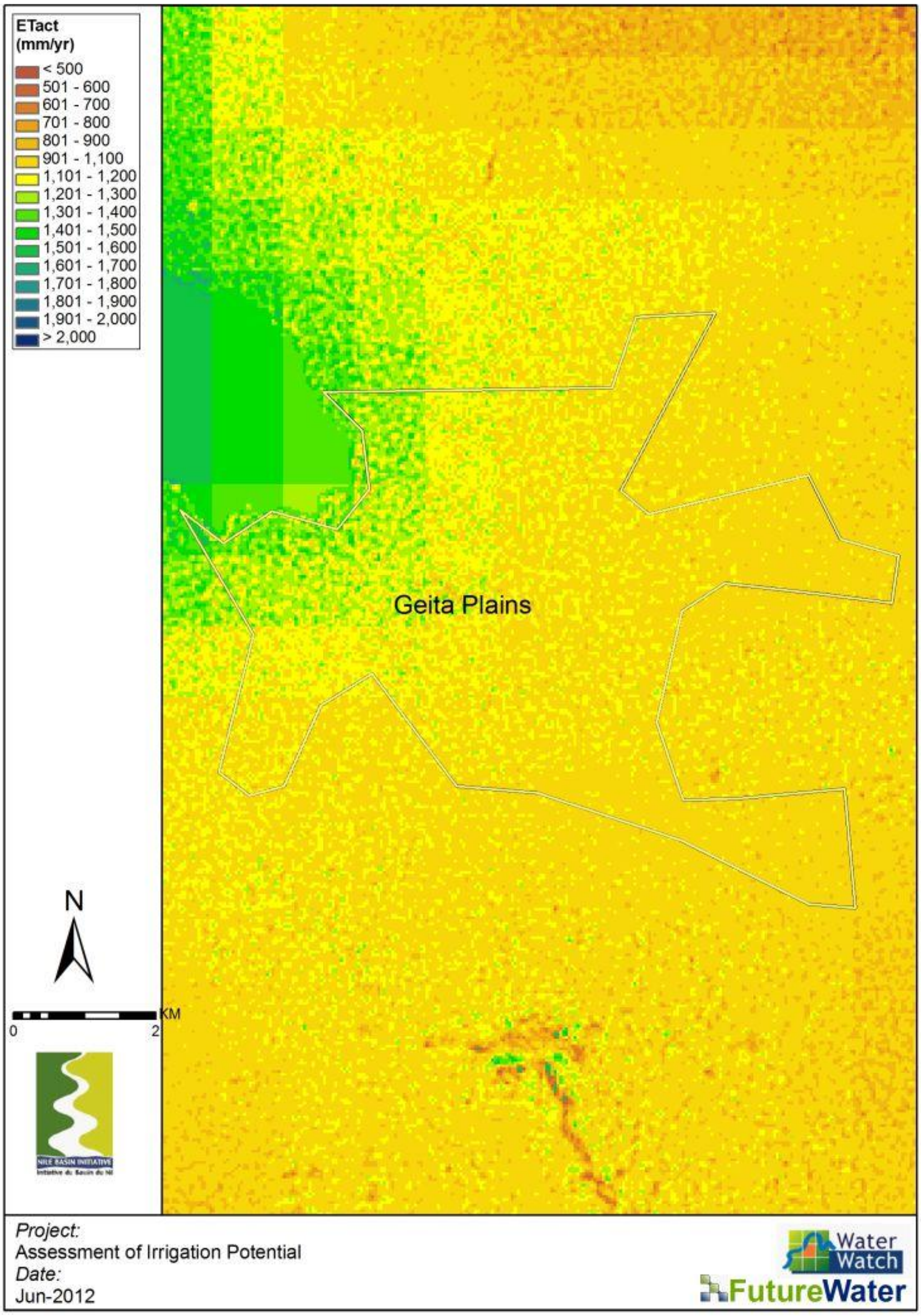



**Figure 62: Water balances for the area based on the high resolution data and modeling approach for Geita Plains focal area.**

## 4.4 Assessment of irrigation water requirements

### *4.4.1 Irrigation water requirements*

Irrigation water requirements depend on many factors such as: climatic conditions, crop, growing season, irrigation practices etc. A first estimate of irrigation requirements could be based on the difference between rainfall and reference evapotranspiration. It was however selected for this pre-feasibility assessment to provide a first estimate of irrigation needs based on the most promising crops. To this end, FAO's AquaCrop, the successor of CropWat was setup for local and crop specific conditions.

All input files and output files for AquaCrop can be found in the database attached to the reports. Note that during this pre-feasibility phase focus with AquaCrop was to obtain crop water requirements. A subsequent feasibility study could focus more on the crop yield validation and calibration components of AquaCrop.

In the table below the irrigation water requirements for each selected crop are provided based on AquaCrop calculations. All units are provided in mm per growing season for the specific crops. Note that for various crops, like vegetables and similar crops, multiple croppings per years might occur.

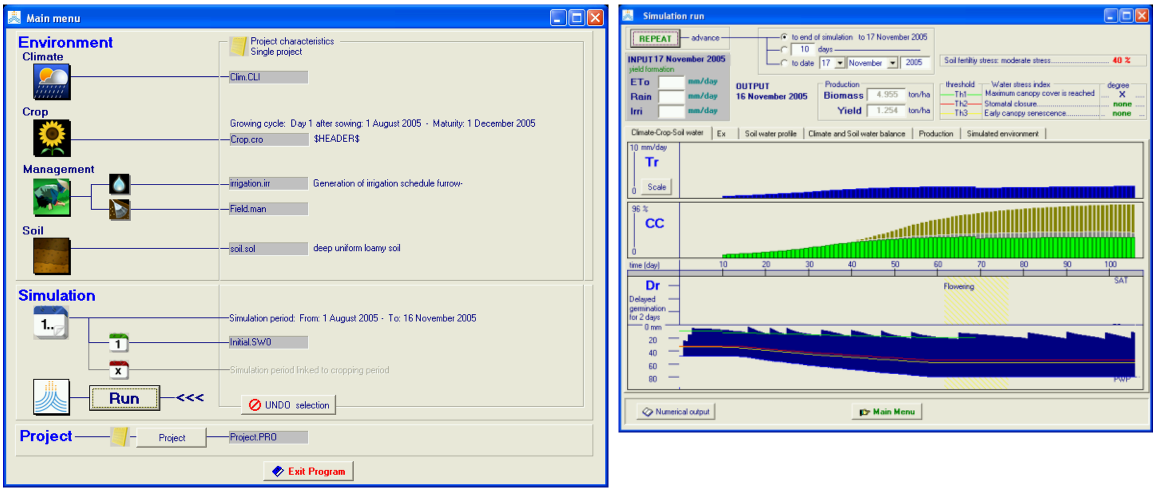



**Figure 63: Typical example of AquaCrop input and output screens.**

**Table 9: Irrigation water requirements for the selected crops in the focal areas. All units are given in mm per growing season.**

| Crop | Rain | ETref | Planting | Harvets | Rain | Irrigation | ETref | ETact |
|---|---|---|---|---|---|---|---|---|
| | === year | === | == (day of year) == | | ======== growing season | ======= | | |
| | (mm) | (mm) | | | (mm) | (mm) | (mm) | (mm) |
| Rice | 1063 | 1460 | 45 | 213 | 465 | 190 | 662 | 349 |
| Maize | 1063 | 1460 | 41 | 182 | 479 | 140 | 542 | 384 |
| Cassava | 1063 | 1460 | 349 | 167 | 697 | 140 | 693 | 513 |
| Cotton | 1063 | 1460 | 359 | 207 | 655 | 130 | 825 | 420 |
| Vegetables | 1063 | 1460 | 1 | 365 | 1066 | 100 | 1457 | 625 |

#### *4.4.2 Water source and irrigation systems*

Existing irrigation schemes are found at Nzera and Nyamboge villages. One schemes lies in the lower plain. The scheme area is 40 km from Geita township and lies north west of the town. The schemes are still not used for irrigated as it characterized with conflicts. This is however the possible site for irrigation. More detailed information as collected during the field visit:

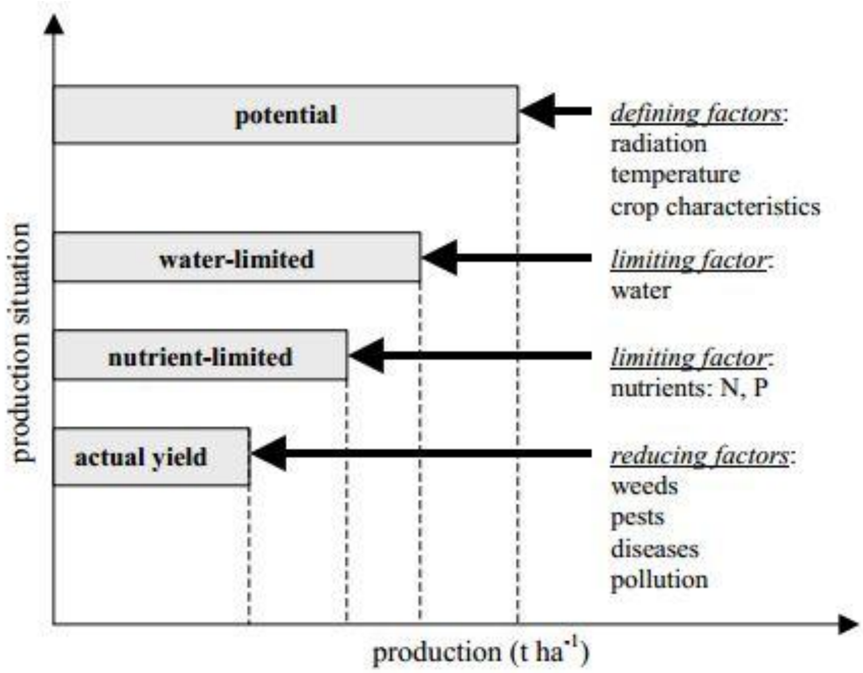
| | |
|---|---|
| *Potential irrigation sources* | River nyikonga – surface run off and water basin and streams |
| *Stability of water source during the year (discharge range) please note about the stability* | Not done to determine as there is no any control system in place |
| *Potential for reservoir/ water harvesting (capacity)* | A number of dams built – Nyamalula, Nyabulanda, luinge and Izunya. Water is abstracted and directed to the reservoirs/dams |
| *Raining season (s)* | bi-modal with the short rains in October to December. January and February are dry periods. The heavy rains occur in March to May. |
| *Amount for precipitation mm/yr ( an estimate from local and experts)* | 750mm/year – 1200mm/year |
| *Ground water levels which areas have less regimes? As from locals also* | 6m - 8m depending on the period time say dry and rain seasons |
| *Already irrigated area* | Yes |

## 4.5 Potential crop yield assessment

The yield gap describes the difference between the current yield, and the maximal possible yield. Mostly the maximal possible yield is defined as the highest yield in the world, but it can also be assessed against a regional background which makes the yield gap more realistic and the maximal yield possible to achieve under the given circumstances.

The gap between the actual yield and the potential yield can be caused by several processes. Factors which may cause that the maximal possible yield is not reached can be the water availability, the soil and the available nutrients, or yield reducing factors like diseases, weeds or pollution.

For the four proposed crops (paddy, maize, cassava, cotton and vegetables) potential crop yields are expected to be relatively high. The focal area is relatively fertile and additional irrigation might increase crop yields of these crops to higher yields compared to the country averages. Especially cassava, rice and cotton have a high potential to generate relatively high yields. Detailed analysis during a feasibility study should focus on a more in-depth analysis of the potential crop yields.



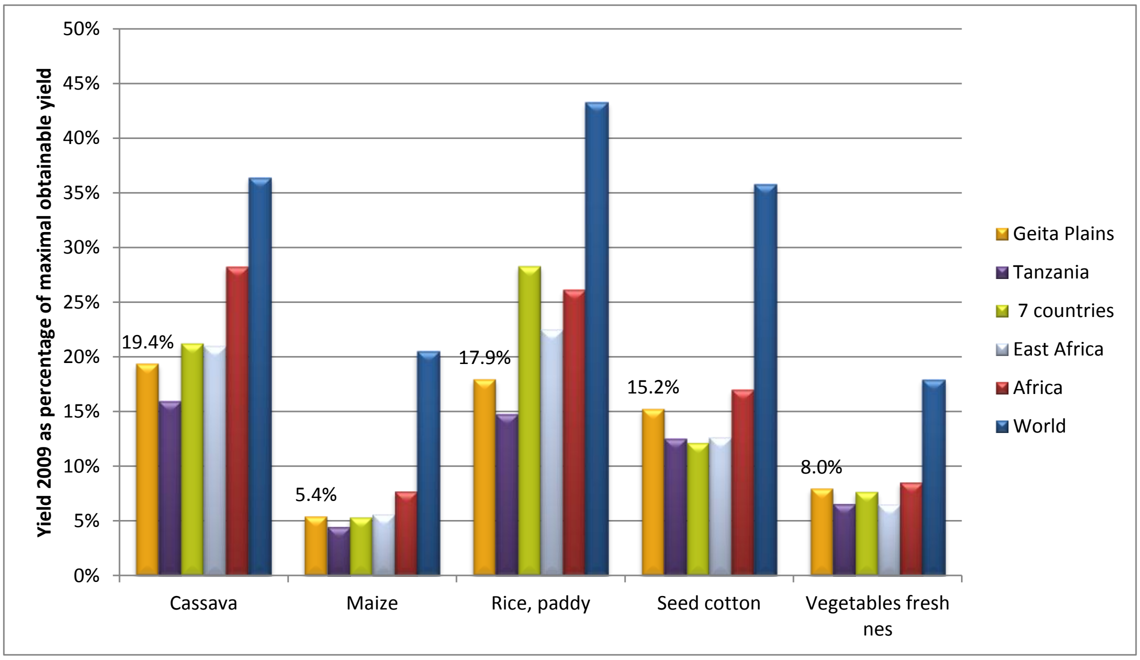




**Figure 64: Yield gap analysis (source: FAOSTAT, 2010).**

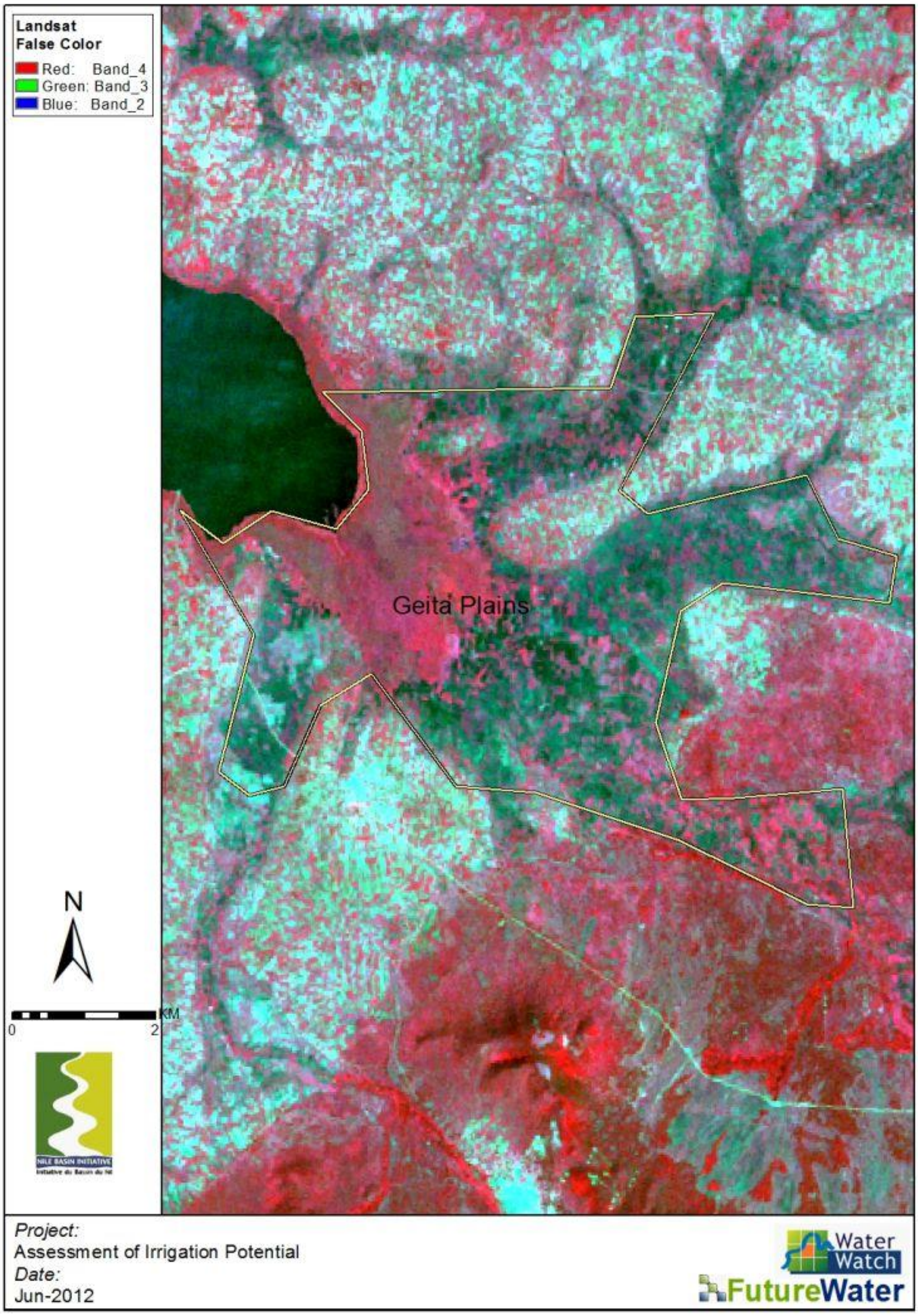



**Figure 65: Landsat False Color Composite indicating current productivity of the area for Geita Plains focal area.**

## 4.6 Environmental and socio-economic considerations

### *4.6.1 Social and population considerations*

A first pre-feasibility assessment on the social context of the focal area has been undertaken. A field visit and additional data and information have been obtained regarding the focal area. Population density for the area is shown in the following map, while detailed concise information regarding social considerations is provided in the table.

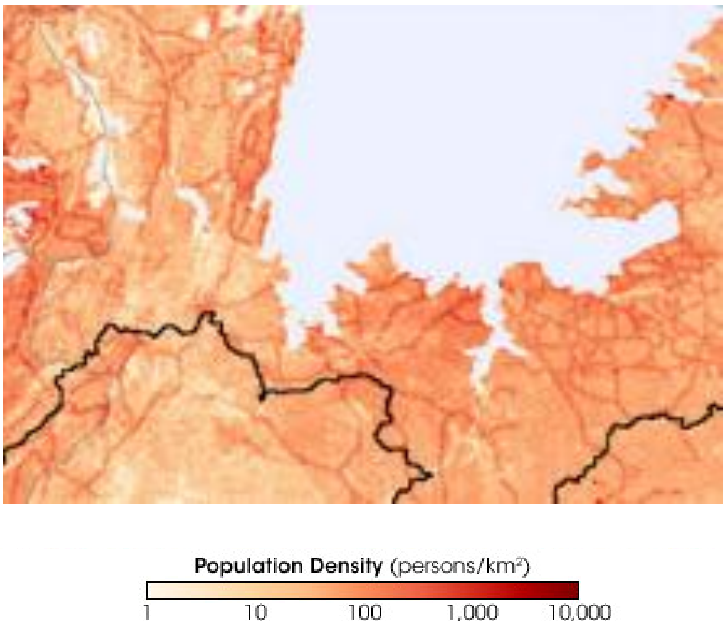



**Figure 66. Population density focal area (source: NASA Earths Observatory).**

| Focal point name | Geita |
|---|---|
| Accessibility | 1km |
| Population rural density area | - |
| Which tribes inhabit the region? | Sukuma, Zinza, Sumbwa |
| Current welfare, unemployment, development. | 5 medium |
| Farmer’s expertise | Low |
| Experience in agricultural cooperatives | middle |

### *4.6.2 Protected areas*

Within the focal area no protected areas are reported.

**Figure 67: Photograph from field inventory and assessment work .**

## 4.7 Benefit-cost Analysis

A simplified benefit-cost analysis is undertaken for the area. Information for this is based on various sources such as FAO publications, IFPRI publications, local expertise and data. A full benefit-costs analysis has to be undertaken in a sub-sequent feasibility study for the area.

Note that this is a first-order benefit-cost analysis. A feasibility study can provide a more rigorous benefit-cost analysis, which is required before taking any implementation planning. However, the following table shows that based on this first-order analysis investments in irrigation can have a positive impact.

Main assumptions for the benefit-costs analysis include:

- Irrigated land based on GIS and local experts for boundaries
- Number of farmers based on average land tenure area
- Irrigation infrastructure based on irrigation type and source
- Social infrastructure based on local expert judgment on farmers' trainings need
- Accessibility infrastructure based on generalized road conditions
- Internal Rate of Return based on 25 years
- Crop revenues based on local crop potentials and local market prices (crop, kg/ha, $/kg):
    - Rice: 6,000 kg/ha, 0.95 $/kg
    - Maize: 1,300 kg/ha, 0.29 $/kg
    - Cassava: 7,000 kg/ha, 0.28 $/kg
    - Cotton: 850 kg/ha, 0.51 $/kg
    - Vegetables: 6,000 kg/ha, 0.25 $/kg

Based on expert knowledge on the suitability to develop irrigation in the area scores between 1 (negative: low suitability or expensive) to 10 (positive: high suitability or low investments) have been marked. The filled radar plot below indicates the options for the focal area.

Overall, the focal area is good for investment. The strong area lies on the fact of roads (main road from Sengerema to Mwanza and back to Geita town. The site is somehow developed and thus making the initial investment cost less. The weak part of the site is on runoff roads. Due to the vastness of the area, a need for farm roads is of paramount importance a thing that is not available. This makes farmers ability to transport yields very difficult especially when there is rain.

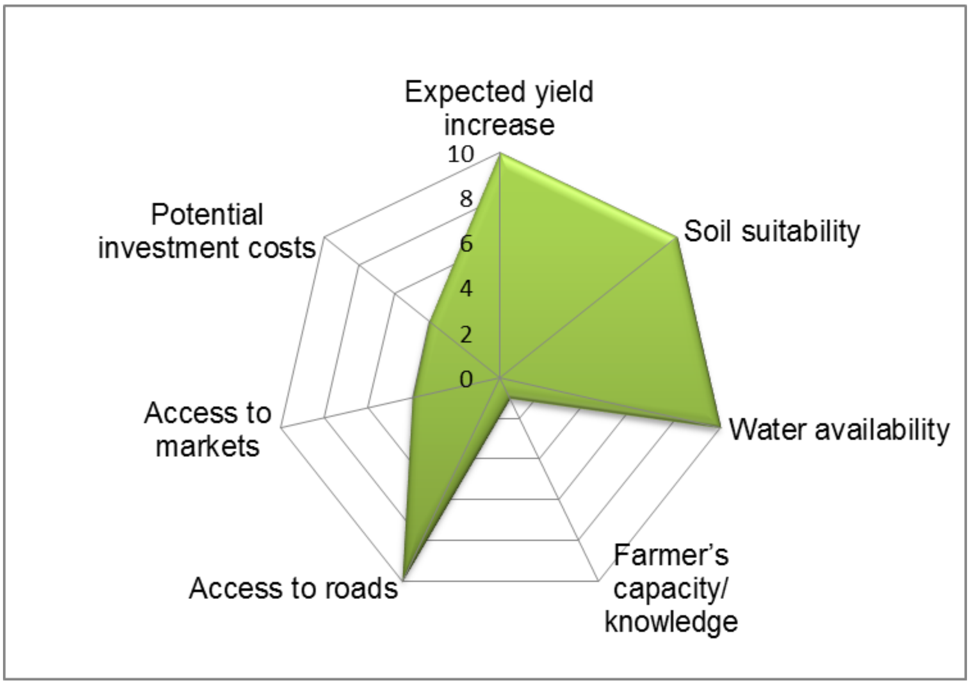



**Figure 68: Filled radar plot indicating expert knowledge score to develop irrigation in the Geita Plains focal area (1 = negative, 10 = positive). (Source: local experts and study analysis).**

**Table 10: Key factors used for the benefit costs analysis as based on field and data inventories.**

| | |
|---|---|
| Irrigation technique | Canal, gravity irrigation, furrow |
| Suitable area | 7597ha |
| Road building requirement | On farm – 2km |
| Pumping of water required | Yes |
| Reservoir building necessary | Yes |
| Soil improvement needed | somewhat |

**Table 11: Benefit-cost analysis for Geita Plains area.**

| | |
|---|---|
| **Characteristics** | |
| Irrigated land (ha) | 3,000 |
| Farmers | 4,000 |
| **Investment Costs** | |
| Irrigation infrastructure (US$/ha) | 4,000 |
| Social infrastructure (US$/farmer) | 750 |
| Accessibility infrastructure (million US$) | 1.0 |
| **Operational Costs** | |
| O&M irrigation (US$/ha/yr) | 60 |
| Extension service (US$/farmer) | 15 |
| O&M roads (US$/yr) | 20,000 |
| **Summary** | |
| Initial investments (million US$) | 16.0 |
| O&M costs (million US$/yr) | 0.260 |
| Net benefits per year (million US$/yr) | 3.593 |
| IRR (Internal Rate of Return) | 26.2% |

## 4.8 Recommendations

The cost benefit analysis as presented in this report is made in the scope of a pre-feasibility study. Although based on literature, expert knowledge and rapid field assessments by local experts it can rather be seen as an indication of expected costs and benefits. As much as possible local technical, social and hydrological factors are incorporated. However it is recommended to assess the costs and benefits in more detail during a feasibility study, which can focus more in depth on the local situation.

# 5 Katunguru focal area

## 5.1 Introduction

This chapter will describe the current state of the Katunguru focal area, concerning land and water resources, and will discuss the potential to develop irrigation in the area. This irrigation potential will be based on the land and water resources, the irrigation requirements, the potential crop yields and will also involve the socio-economic considerations and institutional frameworks. Based on these aspects the potential for irrigation will be described, and cost for irrigation development calculated. In Figure 69 a detailed map of the area is given. Total area is 1490 ha.

Katunguru is located in the Mwanza Region and lies in the northern part of Tanzania, located between latitude 10 30' and 30 south of the Equator . Longitudinally the region is located between 310 45' and 340 10' east of Green wich. Regions bordering Mwanza region are Kagera to the west, Shinyanga to the south and south east. The north east boarders Mara region. The northern part of Mwanza is surrounded by the water of Lake Victoria which in turn separates the region from neighbouring countries of Uganda and Kenya Mwanza is a relatively small region occupying 2.3 percent of the total land area of Tanzania mainland.

Selection of this specific focal area was based on results of Phase 1 of this study, while final selection was the responsibility of the relevant country representatives. Results presented hereafter have been obtained from a broad range of sources: Phase 1, previous other studies and reports, modeling results, remote sensing, expert knowledge and field visits by Gaspar Damas Mashingia and supervised by Honest Prosper Ngowi and Eng. Amandus Lwena in April and May 2012.

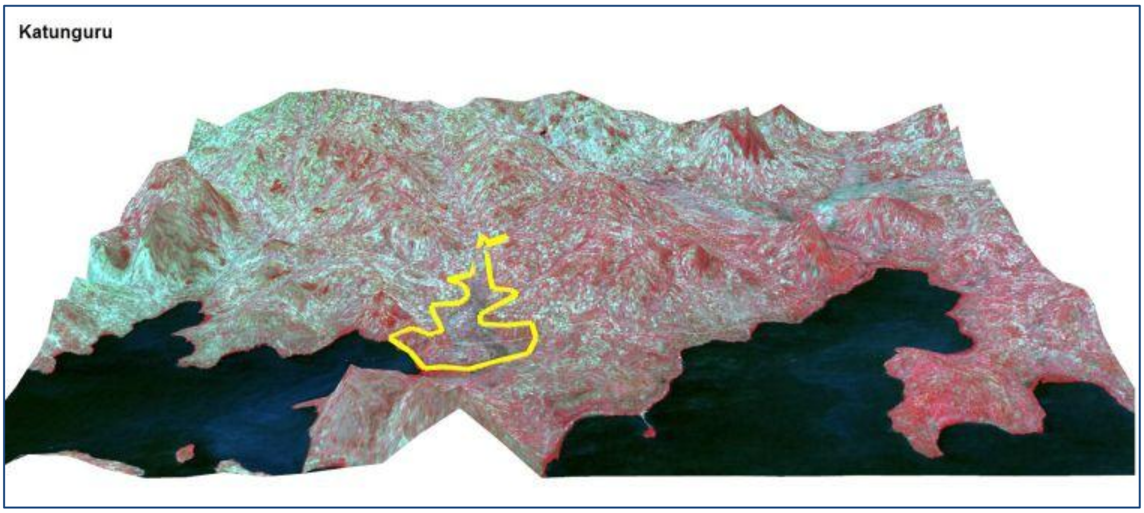



**Figure 69: 3D Impression of Katunguru focal area, Tanzania**

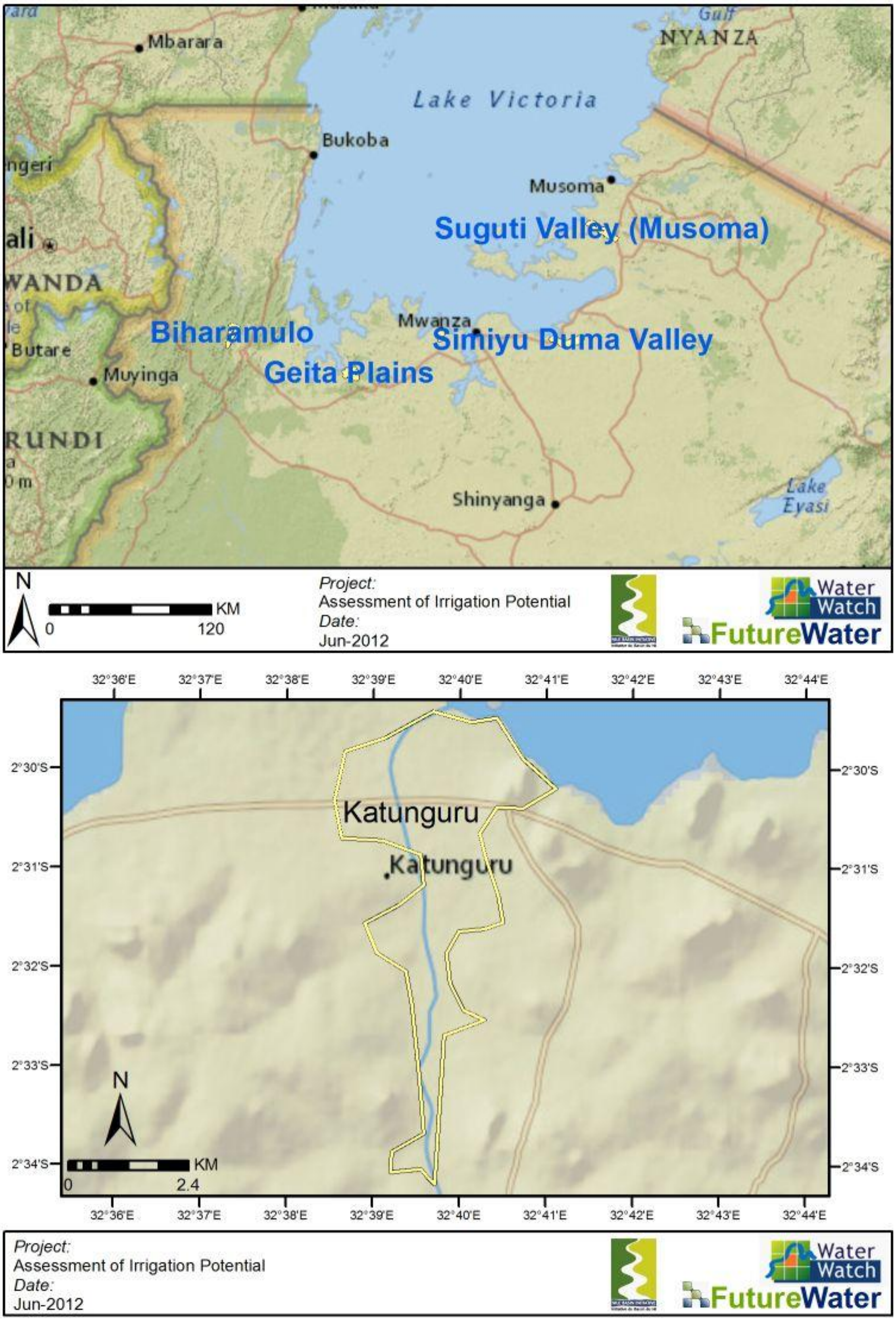



**Figure 70: Katunguru focal area, Tanzania**

## 5.2 Land suitability assessment

### *5.2.1 Terrain*

Katunguru is located at the south coast of Lake Victoria in a narrow valley surrounded by mountain ranges. The average elevation of the focal area is 1130 meter above sea level (MASL) in the north and about 1190 MASL in the south. Mountains around the focal area have elevations up to 1320 MASL. The slope in the focal area are limited to a few percentages, although in some areas slopes till 10 percentage can be found.

The area is covered by shrubs and short grasses. It is also an area where a dam construction is already taking place. Katunguru is already in use for agriculture with crops such as maize and paddy.

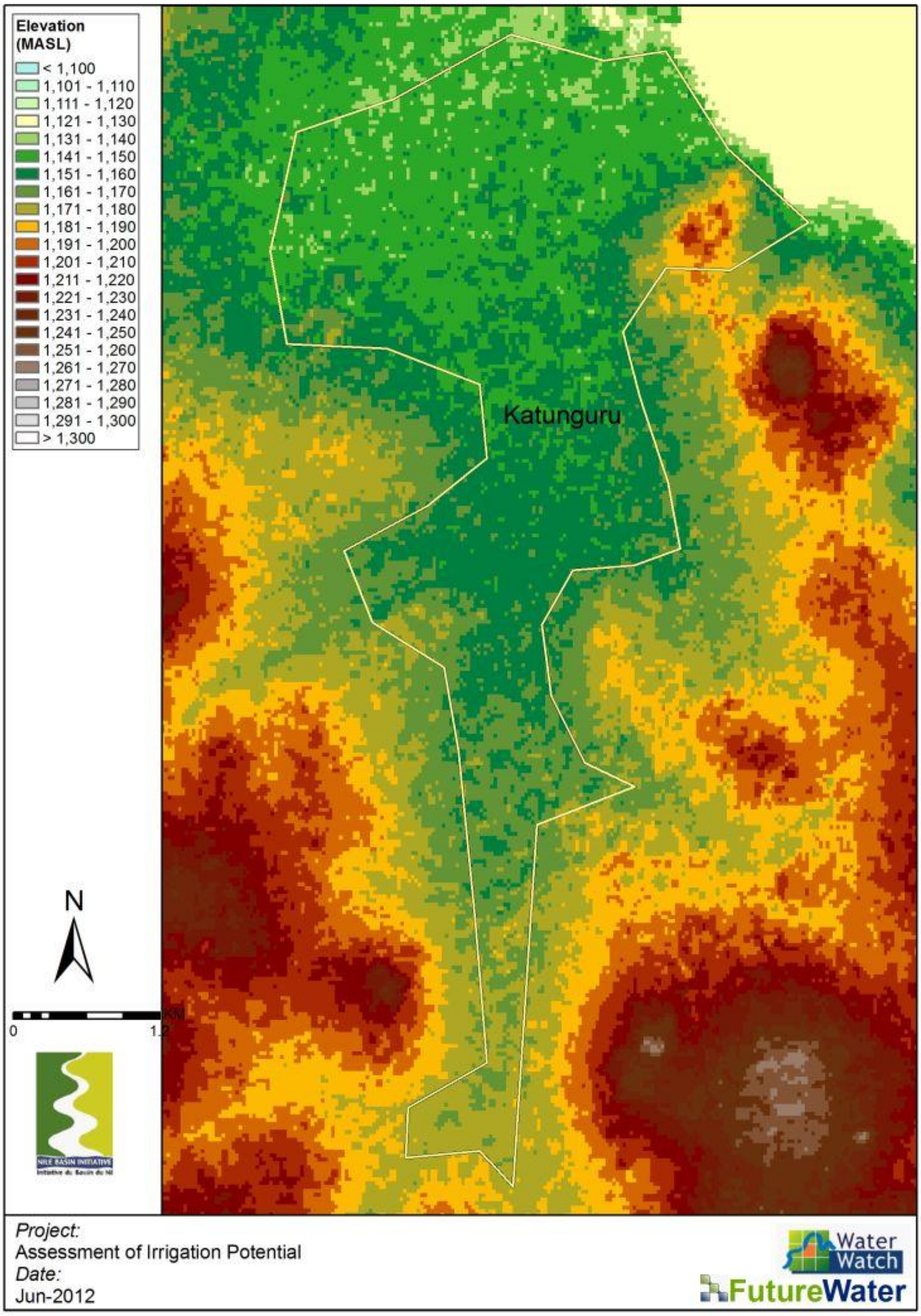



**Figure 71: DEM Katunguru focal area. Resolution 1 arc second (+/- 30m)**

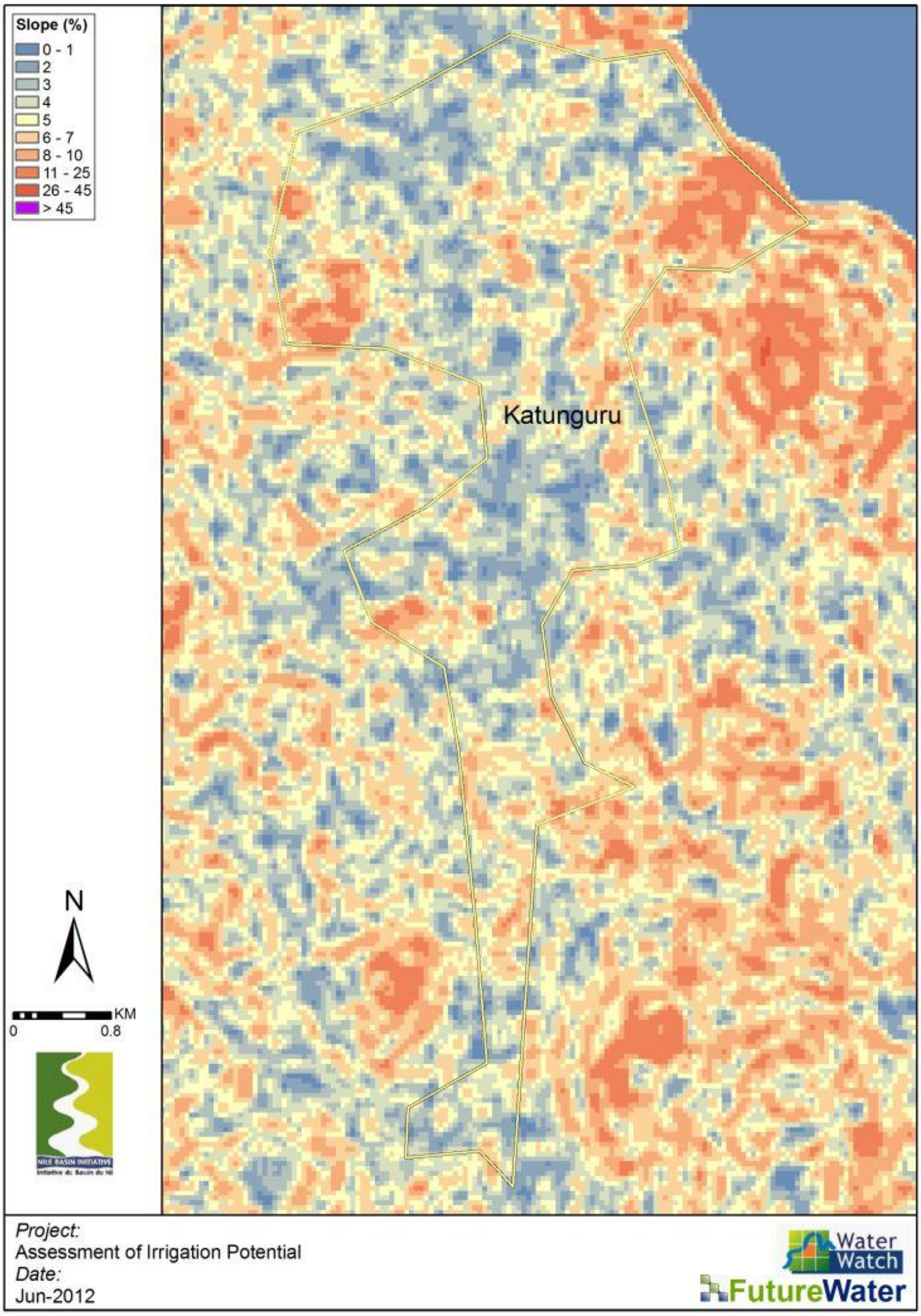


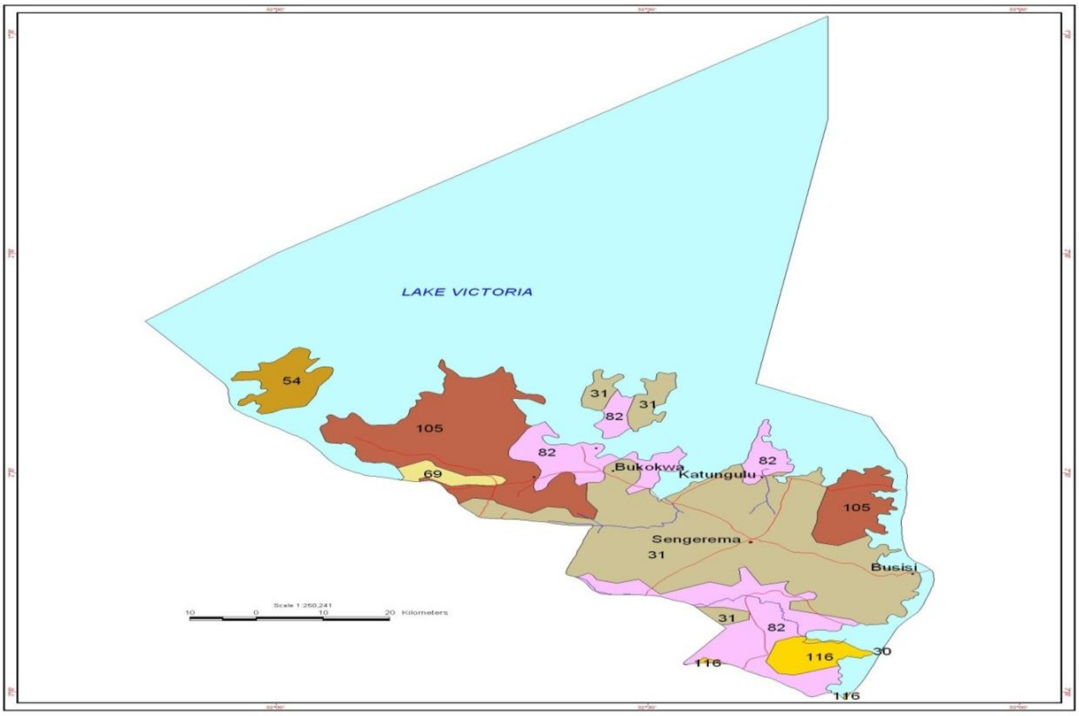

**Figure 72: Slope map Katunguru focal area. (Source: ASTER)**

### 5.2.2 Soils

In the Katunguru focal area two soil types can be found: Vertisols (VRe) in the north, and Cambisols in the south (CMo). Vertisols are churning, heavy clay soils with a high proportion of swelling clays. These soils form deep wide cracks from the surface downward when they dry out, which happens in most years. These soils have considerable agricultural potential, but adapted management is a precondition for sustained production. The comparatively good chemical fertility and their occurrence on extensive level plains where reclamation and mechanical cultivation can be envisaged are assets of Vertisols. Their physical soil characteristics and, notably, their difficult water management cause problems. The agricultural uses of Vertisols range from very extensive (grazing, collection of fuelwood, and charcoal burning) through smallholder post-rainy season crop production (millet, sorghum, cotton and chickpeas) to small-scale (rice) and large-scale irrigated agriculture (cotton, wheat, barley, sorghum, chickpeas, flax, and sugar cane). Cotton is known to perform well on Vertisols, allegedly because cotton has a vertical root system that is not damaged severely by cracking of the soil. Tree crops are generally less successful because tree roots find it difficult to establish themselves in the subsoil and are damaged as the soil shrinks and swells.

Management practices of Vertisols for crop production should be directed primarily at water control in combination with conservation or improvement of soil fertility. The physical properties and the soil moisture regime of Vertisols represent serious management constraints. The heavy soil texture and domination of expanding clay minerals result in a narrow soil moisture range between moisture stress and water excess. Tillage is hindered by stickiness when the soil is wet and hardness when it is dry. The susceptibility of Vertisols to waterlogging may be the single most important factor that reduces the actual growing period. Excess water in the rainy season must be stored for post-rainy season use (water harvesting) on Vertisols with very slow infiltration rates. One compensation for the shrink–swell characteristics is the phenomenon of self-mulching that is common on many Vertisols. Large clods produced by primary tillage break down with gradual drying into fine peds, which provide a passable seed bed with minimal effort. For the same reason, gully erosion on overgrazed Vertisols is seldom severe because gully walls soon assume a shallow angle of repose, which allows grass to become re-established more readily.

The Cambisols generally make good agricultural land and are used intensively. Cambisols with high base saturation in the temperate zone are among the most productive soils on earth. More acid Cambisols, although less fertile, are used for mixed arable farming and as grazing and forest land. Cambisols on steep slopes are best kept under forest; this is particularly true for Cambisols in highlands. Cambisols on irrigated alluvial plains in the dry zone are used intensively for production of food and oil crops. Cambisols in undulating or hilly terrain (mainly colluvial) are planted to a variety of annual and perennial crops or are used as grazing land. Cambisols in the humid tropics are typically poor in nutrients. Cambisols with groundwater influence in alluvial plains are highly productive paddy soils.



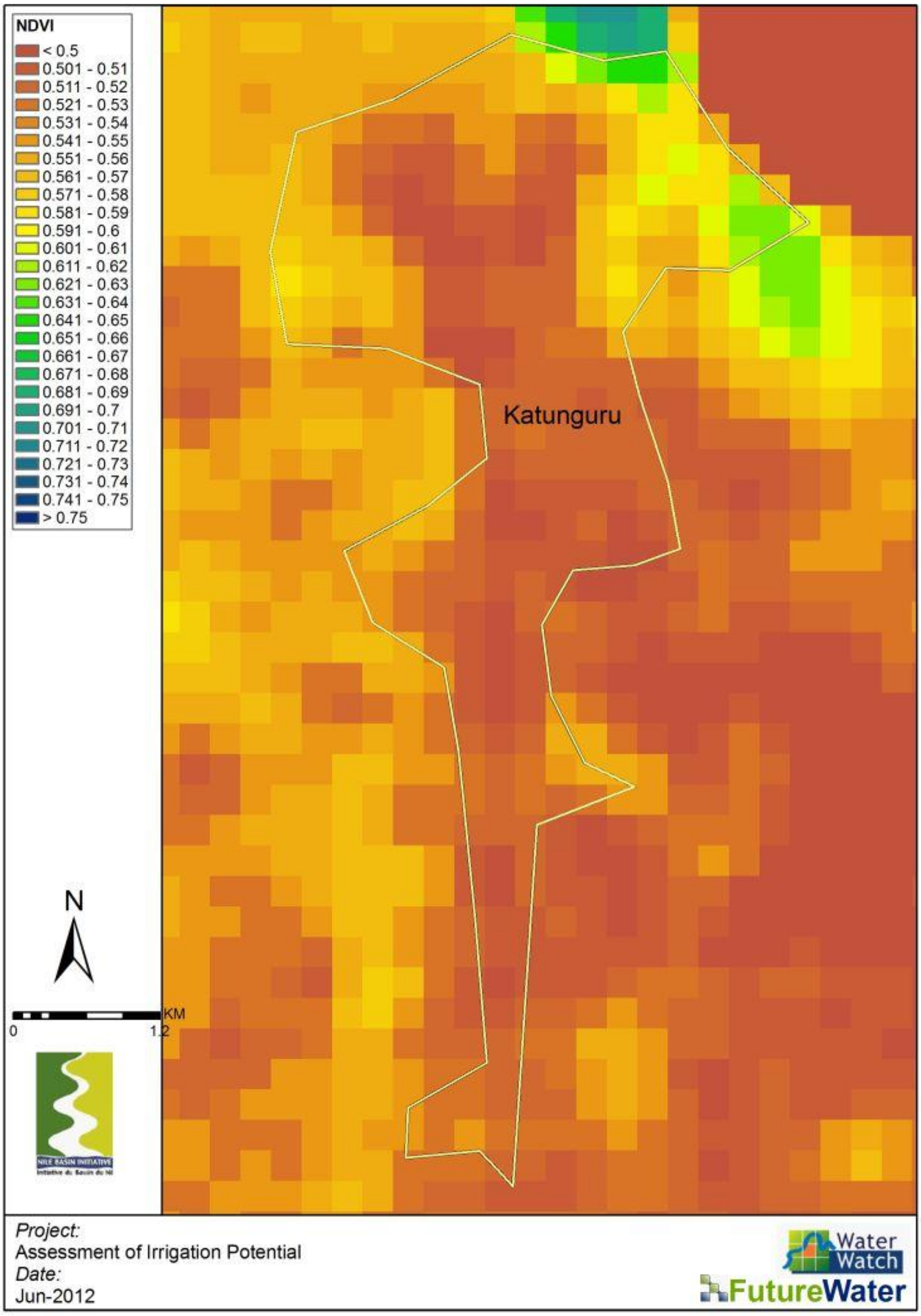

| Symbol | WRB soil unit | Limitations | Use and Management |
|---|---|---|---|
| 30 | Calci-Hypsodic Planosols | Strong sodicity and silinty, very low fertility | Suitable for extensive grazing and in some places wetland rice |
| 31 | Chromi-Feralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 53 | Humi-Umbric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 54 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 69 | Pellic Vertisols | Difficult workability, difficult water management | High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated cropping |
| 82 | Eutri-Pellic Vertisols | Difficult workability, difficult water management | High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated cropping |
| 101 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 105 | Eutri-Rhodic Cambisols | Vary with climate, topography, depth or stoniness | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 108 | Eutric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 115 | Humi-Umbric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 122 | Chromi-Feralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 131 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 134 | Ferralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 147 | Waterbody | | |

**Figure 73: Details soil map and associated limitations, use and management options for Katunguru focal area.**

### *5.2.3 Land productivity*

The focal area is covered by shrubs and short grasses. It is also an area where a dam construction is already taking place. Katunguru is already in use for agriculture with crops such as maize and paddy. The field inventory showed the following distribution of vegetation:

- shrubs at about 30% of the area
- short grass at 40% of the area
- agricultural crops cover about 30% of the area.


NDVI
< 0.5
0.501 - 0.51
0.511 - 0.52
0.521 - 0.53
0.531 - 0.54
0.541 - 0.55
0.551 - 0.56
0.561 - 0.57
0.571 - 0.58
0.581 - 0.59
0.591 - 0.6
0.601 - 0.61
0.611 - 0.62
0.621 - 0.63
0.631 - 0.64
0.641 - 0.65
0.651 - 0.66
0.661 - 0.67
0.671 - 0.68
0.681 - 0.69
0.691 - 0.7
0.701 - 0.71
0.711 - 0.72
0.721 - 0.73
0.731 - 0.74
0.741 - 0.75
> 0.75
Katunguru
N
KM
0
1.2
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater

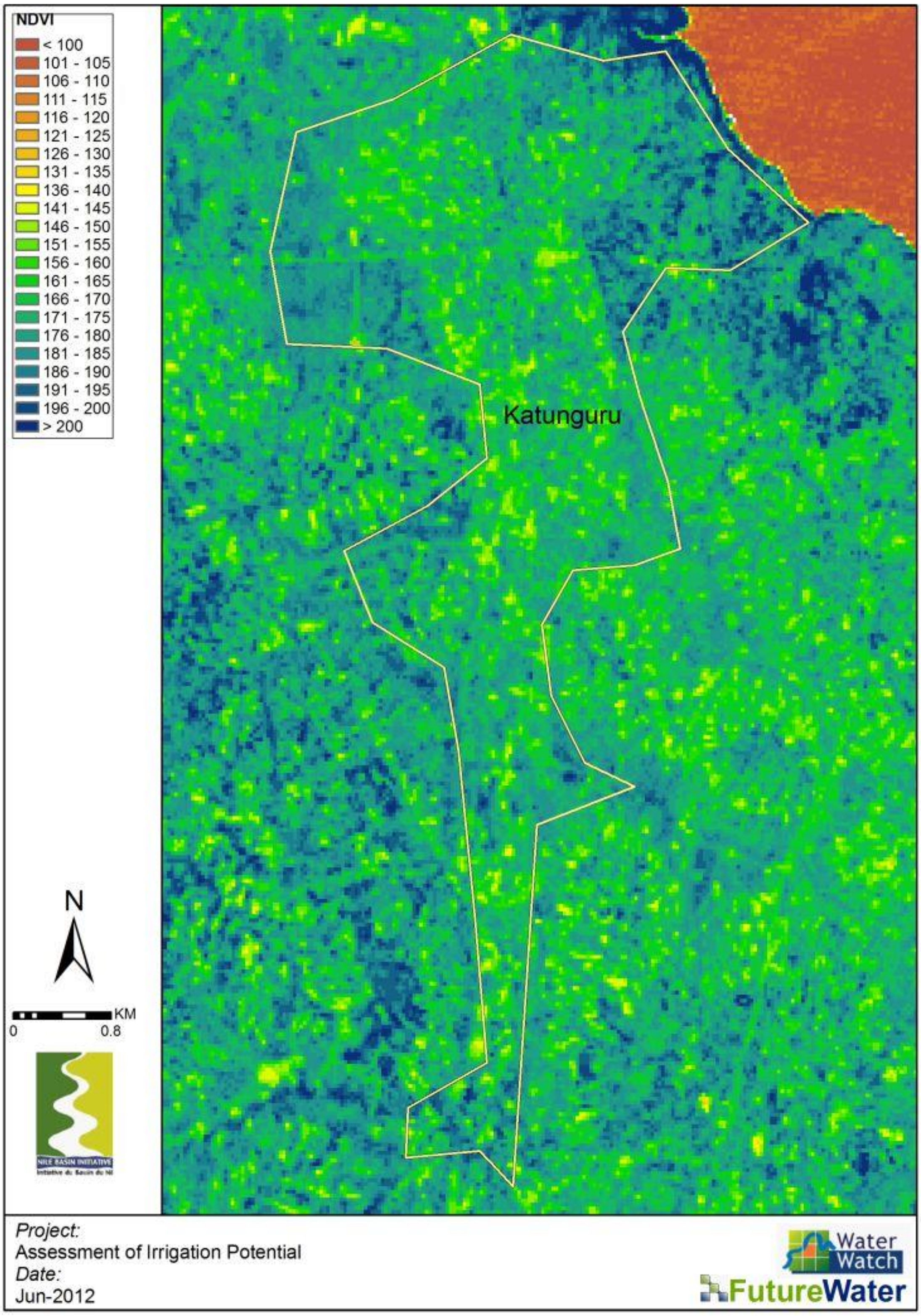



**Figure 74: Yearly average NDVI values (top) and high resolution Landsat NDVI for one day (bottom) for Katunguru focal area.**

### 5.2.4 *Potential cropping patterns*

Currently the only crop found in in the area is paddy. Paddy is grown in the area without irrigation. Other details of the crop are shown in the following table.

| KATUNGURU | Paddy |
|---|---|
| % of this crop as of % total agriculture area | 80 |
| Average yield (kg/ha) | 4500 |
| Maximum yield (kg/ha) | 5000 |
| Average selling value of crop (shs/kg) | 1300 |
| Irrigated (yes no and mm/) | No |
| Amount of growing cycles per year | one |

Regarding potential crops to be promoted in the area if irrigation will be developed, the following crops were proposed: paddy, maize, cassava, cotton and vegetables.

## 5.3 Water resource assessment

### 5.3.1 *Climate*

Katunguru focal area receives about 1130 mm annual rainfall. Main dry period is from June to August. Overall climate in the focal area is characterized by humid conditions with constant annual temperatures ranging from 19 to 29°C, for minimum and maximum temperatures respectively. Reference evapotranspiration is about 1585 mm per year.

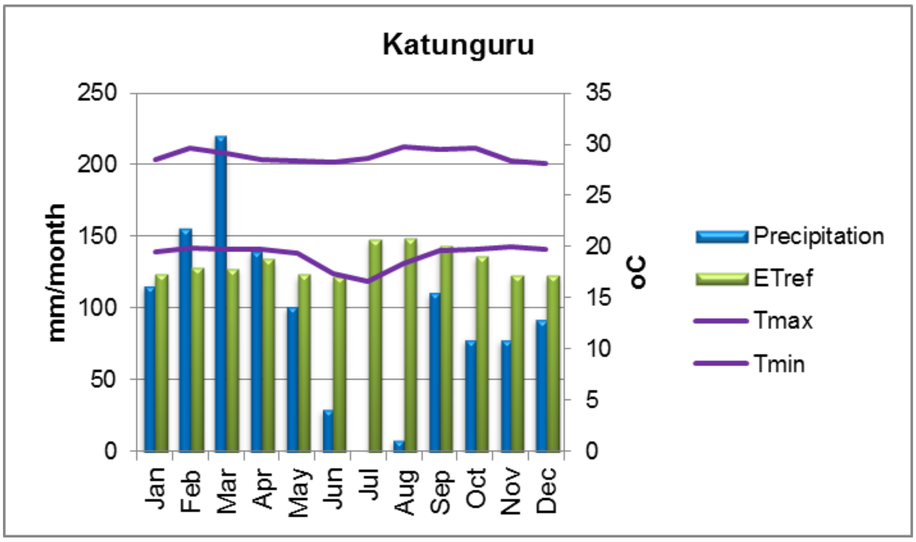



**Figure 75: Average climate conditions for the focal area.**

### 5.3.2 *Water balance*

A very detailed high resolution model was built for NEL countries (NELmod). For a detailed description see Phase 1 report. Results from NELmod were extracted for this specific focal area and are shown below.

**Figure 76: Photograph from field inventory and assessment work .**

**Figure 77: Photograph from field inventory and assessment work .**

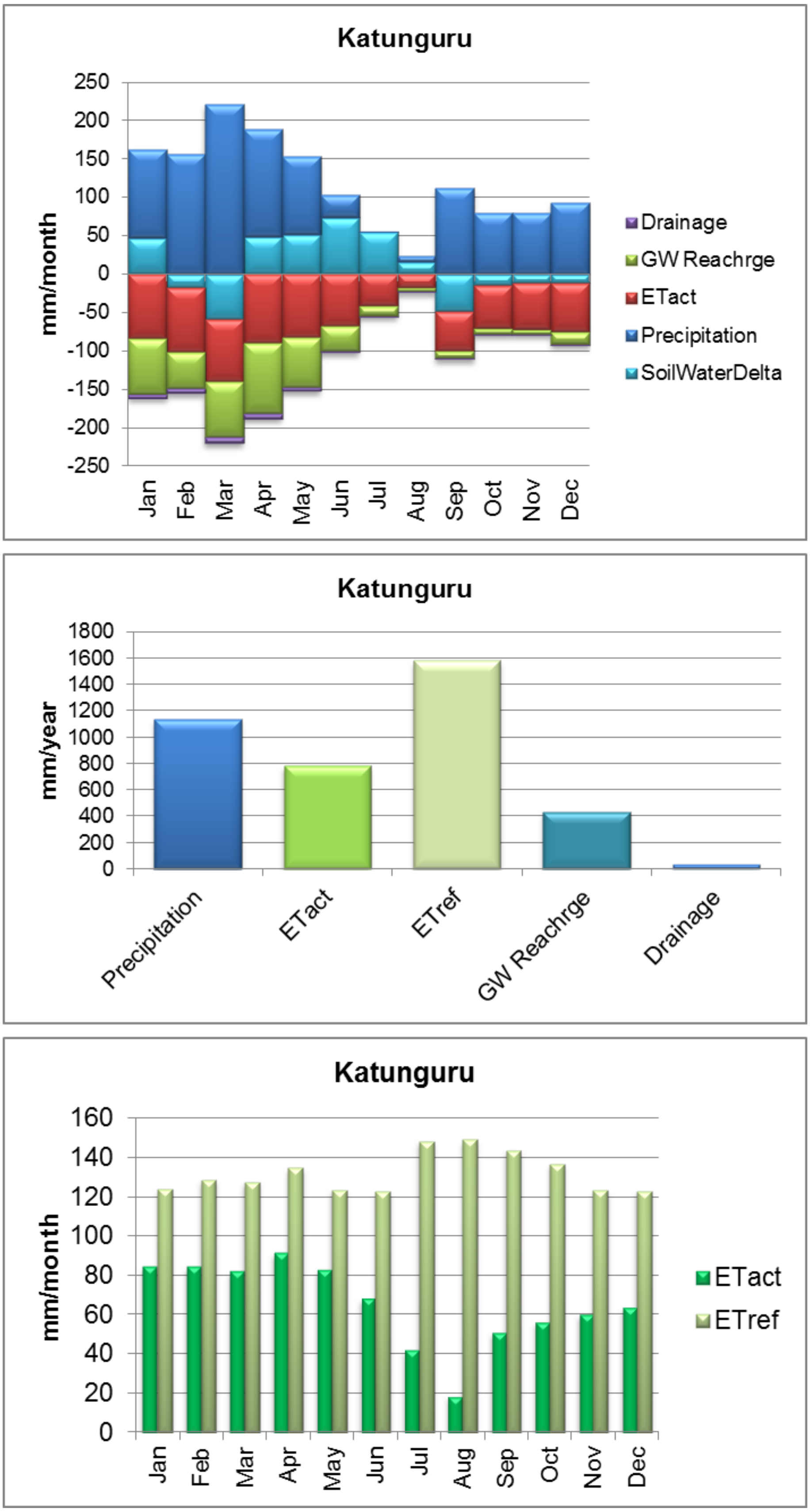
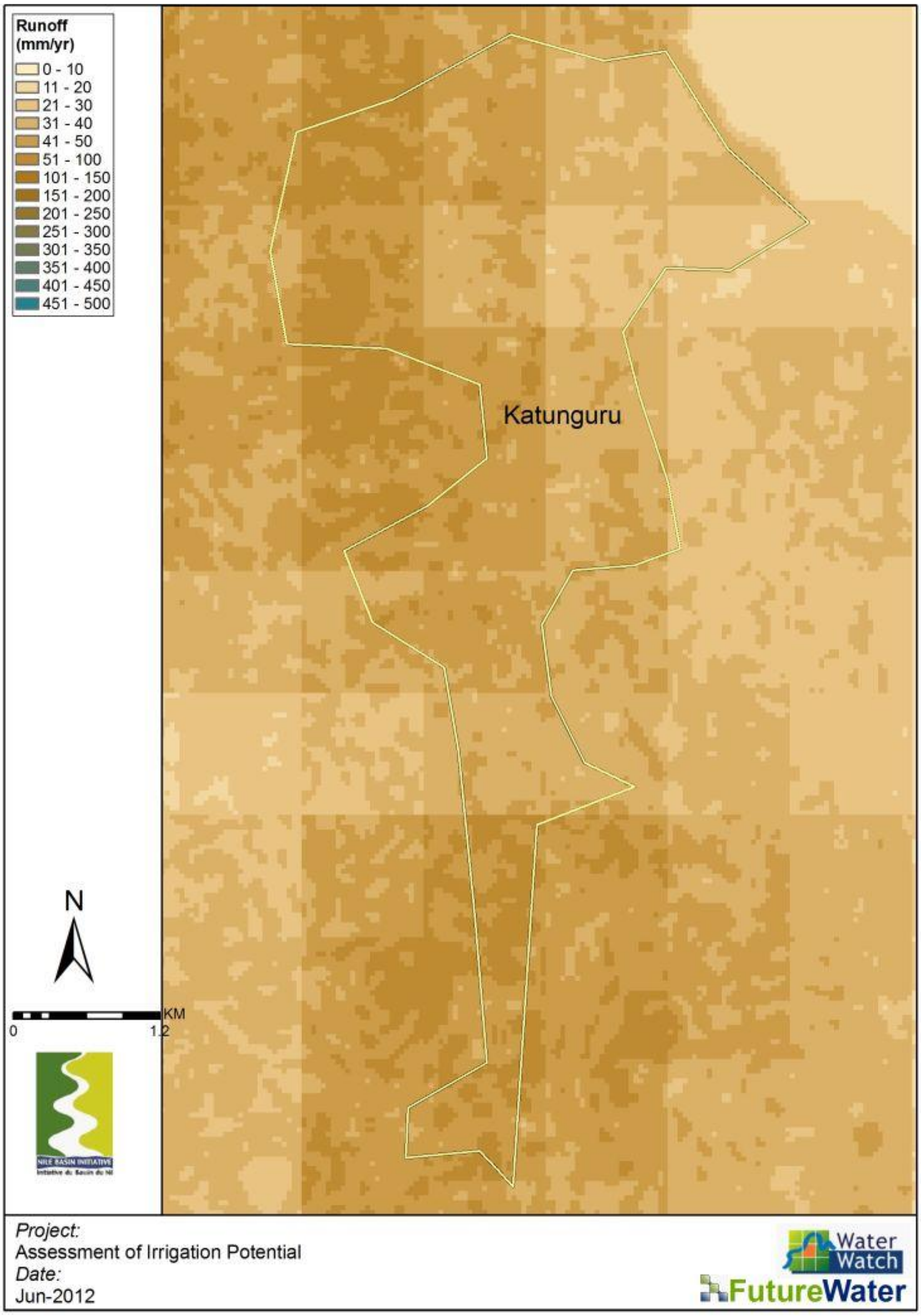
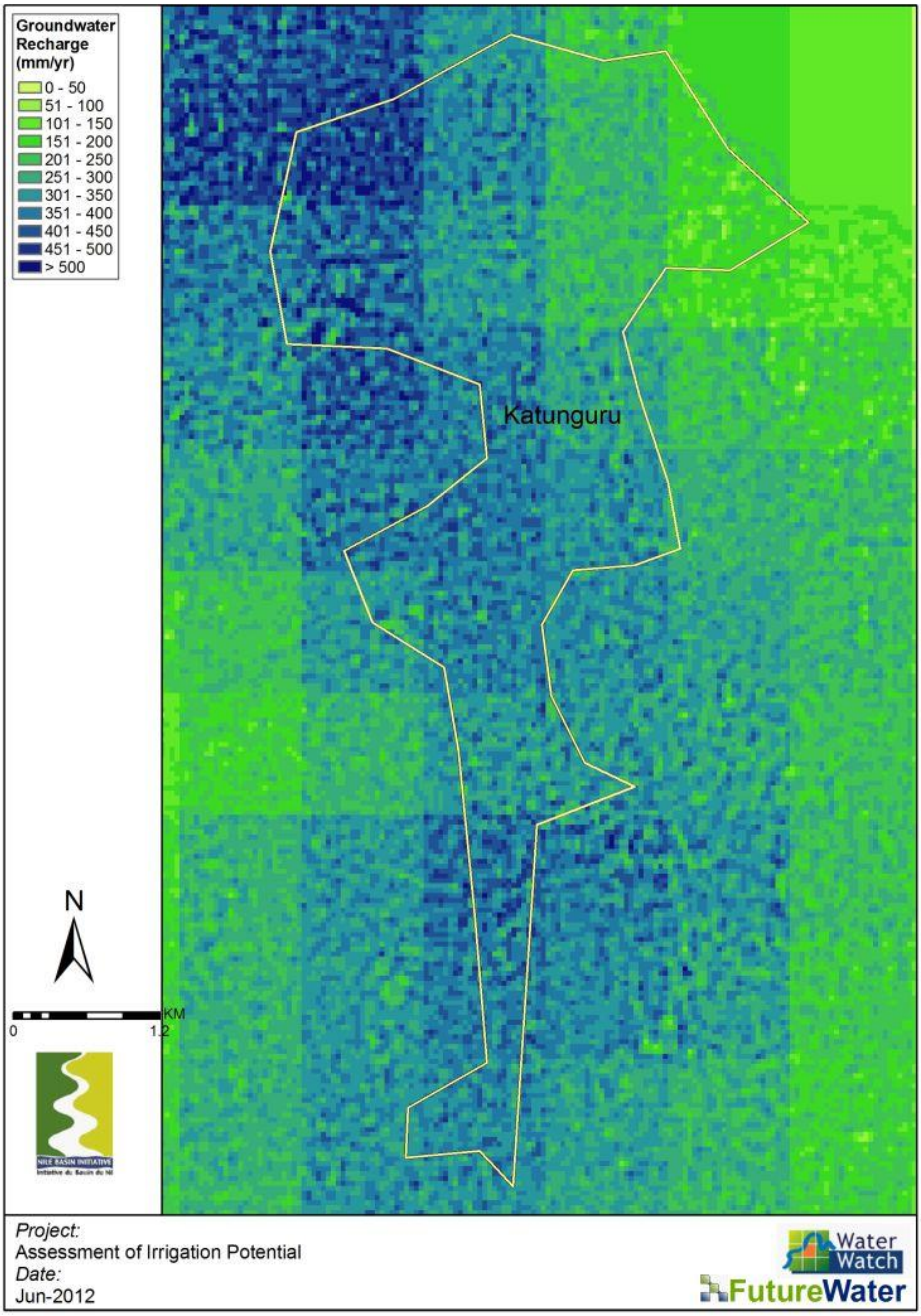



**Figure 78: Water balances for the area based on the high resolution data and modeling approach for Katunguru focal area.**


Runoff (mm/yr)
0 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 100
101 - 150
151 - 200
201 - 250
251 - 300
301 - 350
351 - 400
401 - 450
451 - 500
Katunguru
N
KM
0
1.2
Project:
Assessment of Irrigation Potential
Date:
Jun-2012


Groundwater Recharge (mm/yr)
0 - 50
51 - 100
101 - 150
151 - 200
201 - 250
251 - 300
301 - 350
351 - 400
401 - 450
451 - 500
> 500
Katunguru
N
KM
0
1.2
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater

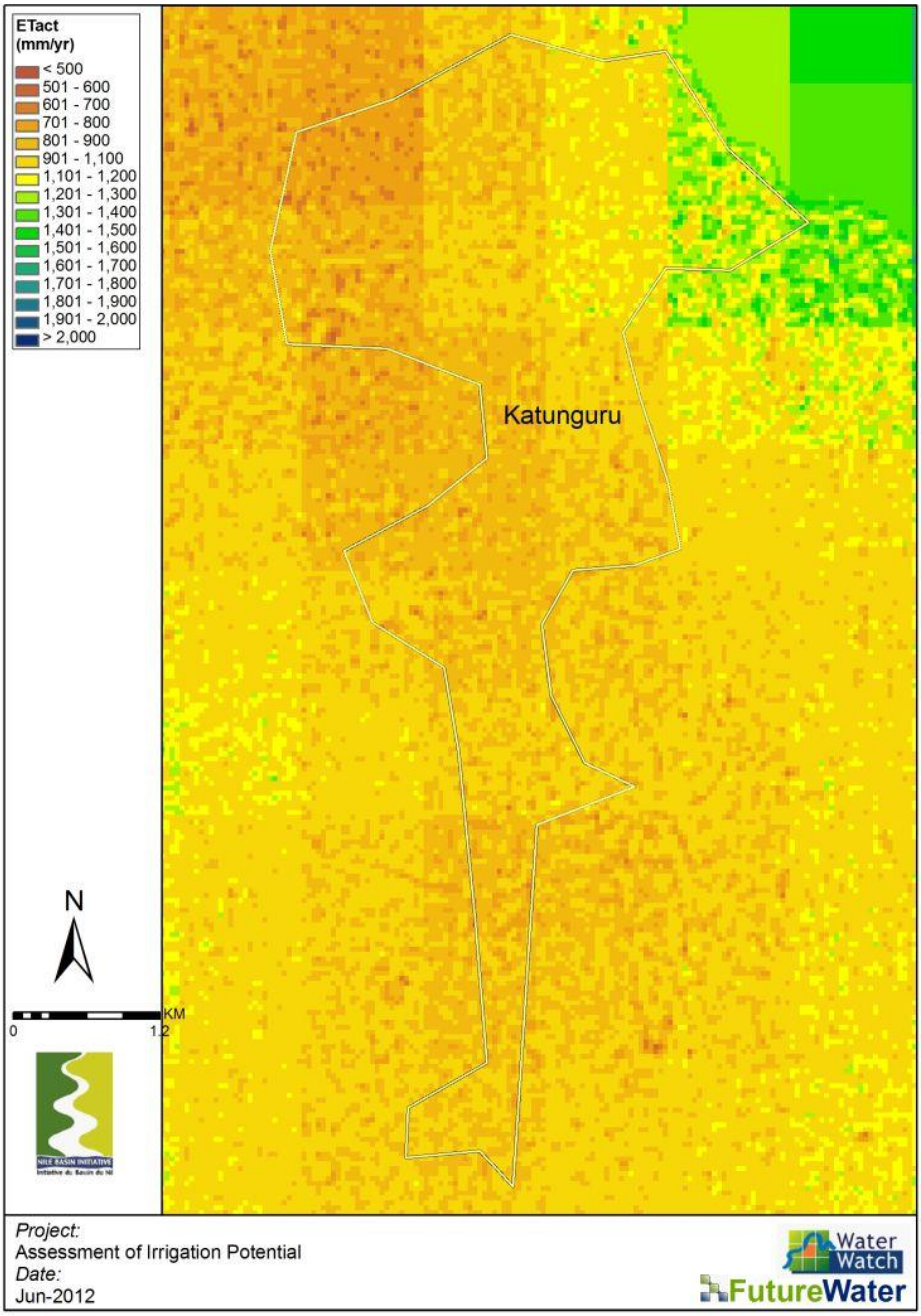



**Figure 79: Water balances for the area based on the high resolution data and modeling approach for Katunguru focal area.**

## 5.4 Assessment of irrigation water requirements

### *5.4.1 Irrigation water requirements*

Irrigation water requirements depend on many factors such as: climatic conditions, crop, growing season, irrigation practices etc. A first estimate of irrigation requirements could be based on the difference between rainfall and reference evapotranspiration. It was however selected for this pre-feasibility assessment to provide a first estimate of irrigation needs based on the most promising crops. To this end, FAO's AquaCrop, the successor of CropWat was setup for local and crop specific conditions.

All input files and output files for AquaCrop can be found in the database attached to the reports. Note that during this pre-feasibility phase focus with AquaCrop was to obtain crop water requirements. A subsequent feasibility study could focus more on the crop yield validation and calibration components of AquaCrop.

In the table below the irrigation water requirements for each selected crop are provided based on AquaCrop calculations. All units are provided in mm per growing season for the specific crops. Note that for various crops, like vegetables and similar crops, multiple croppings per years might occur.

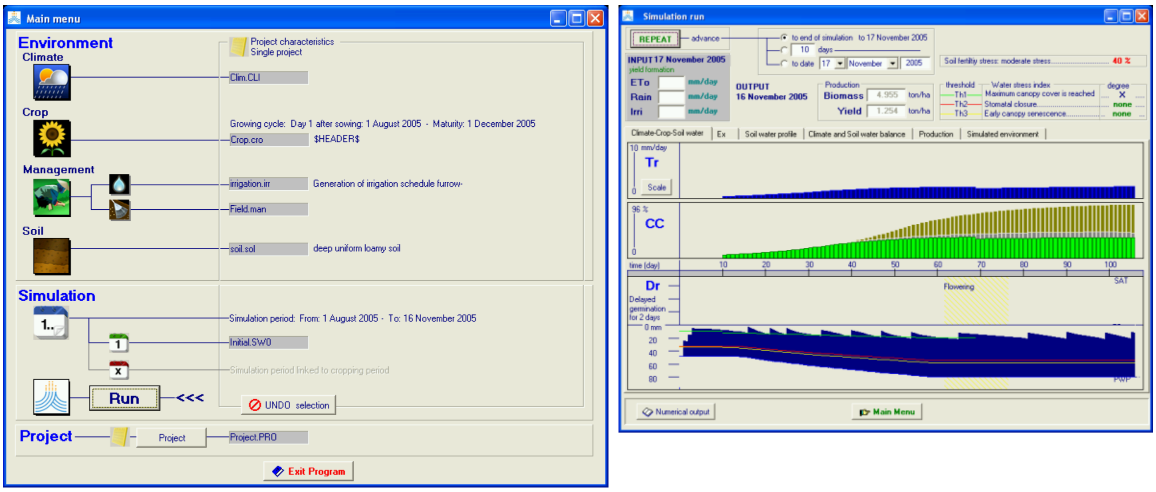



**Figure 80: Typical example of AquaCrop input and output screens.**

**Table 12: Irrigation water requirements for the selected crops in the focal areas. All units are given in mm per growing season.**

| Crop | Rain | ETref | Planting | Harvets | Rain | Irrigation | ETref | ETact |
|---|---|---|---|---|---|---|---|---|
| | === year | === | == (day of year) == | | ======== growing season | | ======= | |
| | (mm) | (mm) | | | (mm) | (mm) | (mm) | (mm) |
| Rice | 1135 | 1585 | 45 | 213 | 588 | 160 | 727 | 403 |
| Maize | 1135 | 1585 | 41 | 182 | 607 | 110 | 598 | 448 |
| Cassava | 1135 | 1585 | 349 | 167 | 804 | 160 | 759 | 616 |
| Cotton | 1135 | 1585 | 359 | 207 | 784 | 130 | 902 | 508 |
| Vegetables | 1135 | 1585 | 1 | 365 | 1138 | 110 | 1581 | 676 |

### *5.4.2 Water source and irrigation systems*

Irrigation in the focal area requires a reservoir. There are three potential inflows for the reservoir, which are Ibondo- nyamililo and Nyan'homa and Luchili. Irrigated areas nearby, or abandoned irrigation systems, started in 1974 by the Ministry of Water and Irrigation (now ministry of Agriculture). Main problem is pumping system and some breakages on irrigation canals. Farmers are unable to do irrigation thus making cultivation mainly during rainy season. The major drainage systems is from the mountains originates Sengerema hills and surface run off which drains into lake Victoria (source URT. Ministry for Local Government, Sengerema District Council, Design Report, Katunguru Dam for Irrigation, 2008). Currently, a dam is being constructed in the area. This dam has a capacity to irrigate 200 ha (NLO Tanzania and Lake Victoria/Mwanza Zonal Irrigation Engineer). Therefore, for future development this dam will require some improvement and also assess compensation event to people whose areas will be submerged.

During the field visit the following detailed information was obtained:

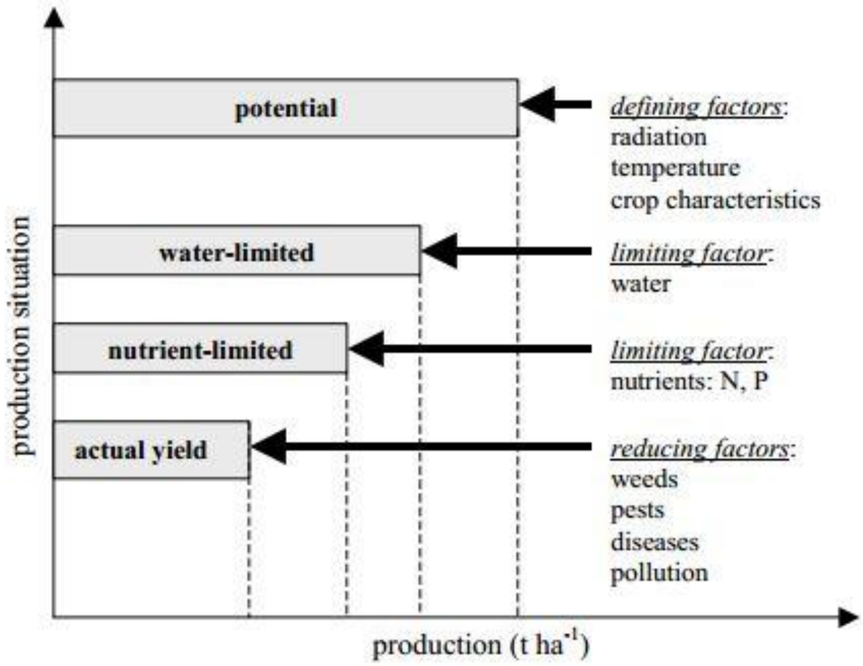
| | |
|---|---|
| *Potential irrigation sources* | reservoir |
| *Stability of water source during the year (discharge range) please note about the stability* | Range of discharge – 153m3/ha |
| *Potential for reservoir/ water harvesting (capacity)* | 3,306,497m3 |
| *Raining season (s)* | September – December – bimodal |
| *Amount for precipitation mm/yr ( an estimate from local and experts)* | 800mm – 1200mm |
| *Ground water levels which areas have less regimes? As from locals also* | 7m during dry spell and 5m during rain spell |
| *Already irrigated area* | no |

## 5.5 Potential crop yield assessment

The yield gap describes the difference between the current yield, and the maximal possible yield. Mostly the maximal possible yield is defined as the highest yield in the world, but it can also be assessed against a regional background which makes the yield gap more realistic and the maximal yield possible to achieve under the given circumstances.

The gap between the actual yield and the potential yield can be caused by several processes. Factors which may cause that the maximal possible yield is not reached can be the water availability, the soil and the available nutrients, or yield reducing factors like diseases, weeds or pollution.

For the four proposed crops (paddy, maize, cassava, cotton and vegetables) potential crop yields are expected to be relatively high. The focal area is relatively fertile and additional irrigation might increase crop yields of these crops to higher yields compared to the country averages. Especially cassava, rice and cotton have a high potential to generate relatively high yields. Detailed analysis during a feasibility study should focus on a more in-depth analysis of the potential crop yields.



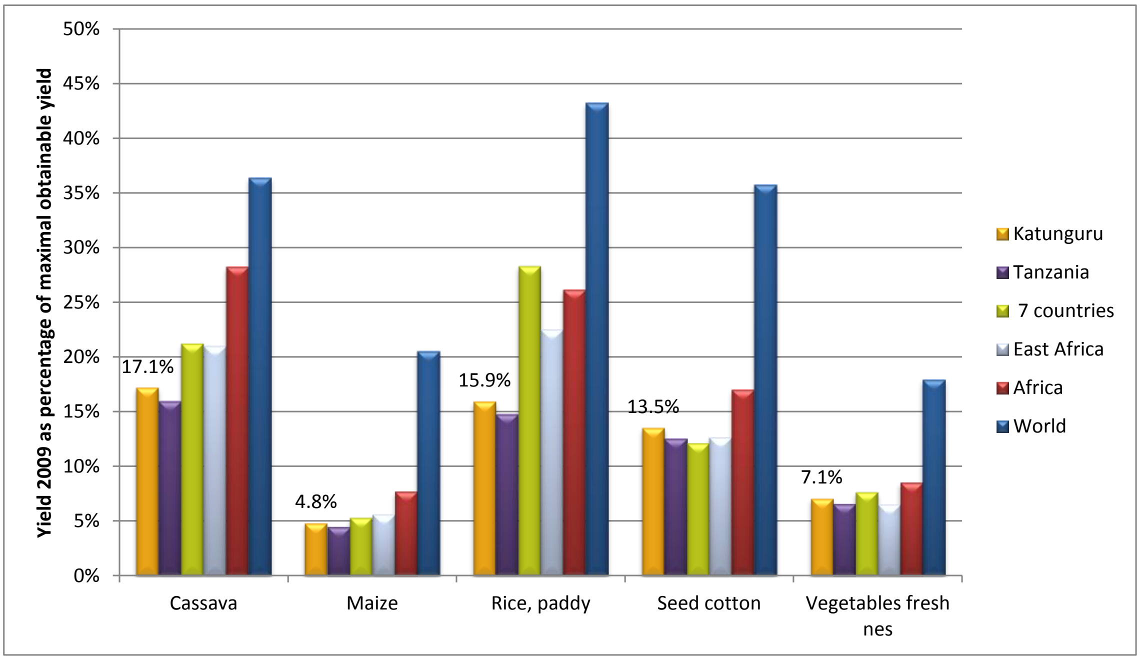




**Figure 81: Yield gap analysis (source: FAOSTAT, 2010).**

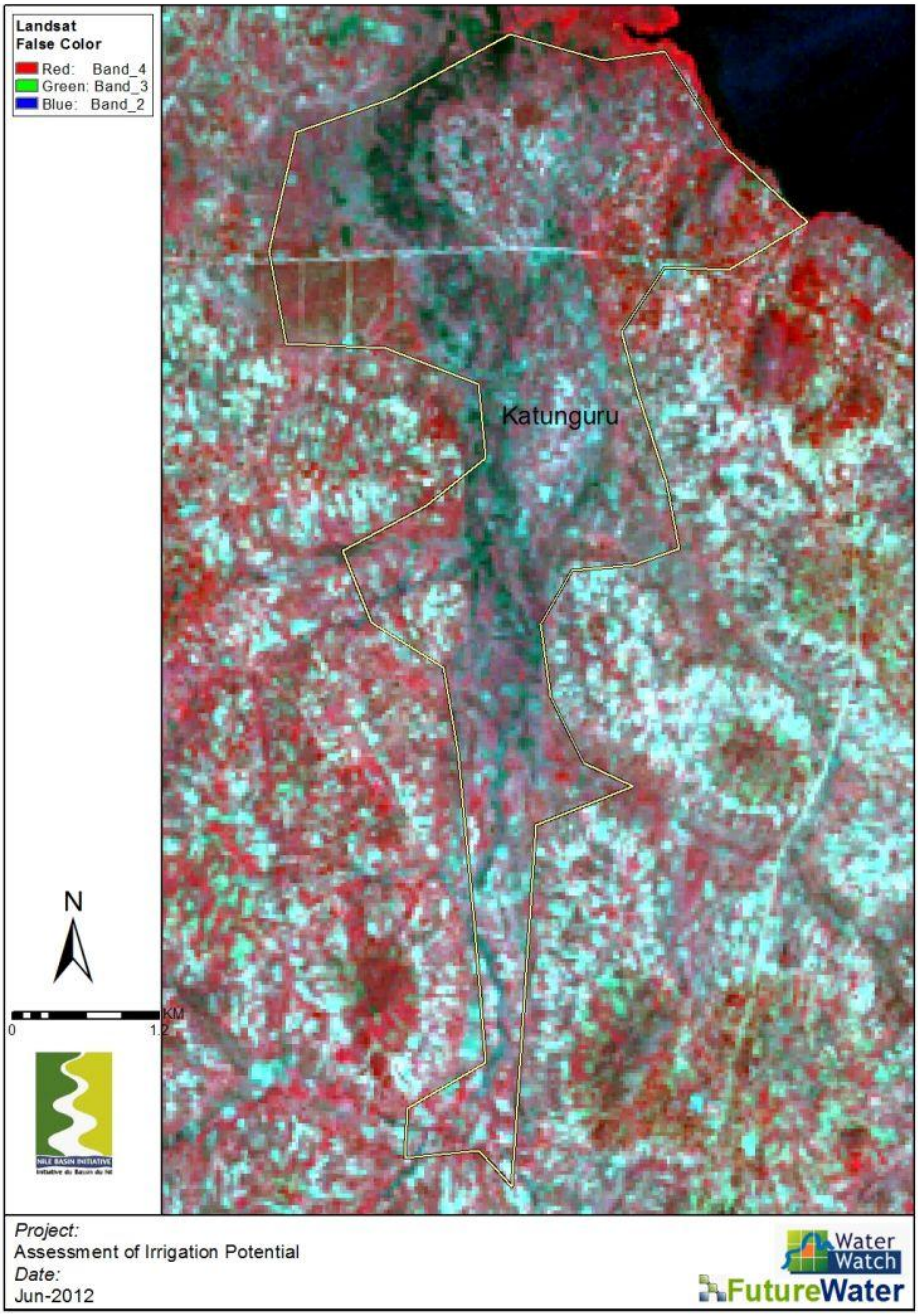



**Figure 82: Landsat False Color Composite indicating current productivity of the area for Katunguru focal area.**

**Figure 83: Photograph from field inventory and assessment work for Katunguru focal area .**

## 5.6 Environmental and socio-economic considerations

### *5.6.1 Social and population considerations*

A first pre-feasibility assessment on the social context of the focal area has been undertaken. A field visit and additional data and information have been obtained regarding the focal area. Population density for the area is shown in the following map, while detailed concise information regarding social considerations is provided in the table.

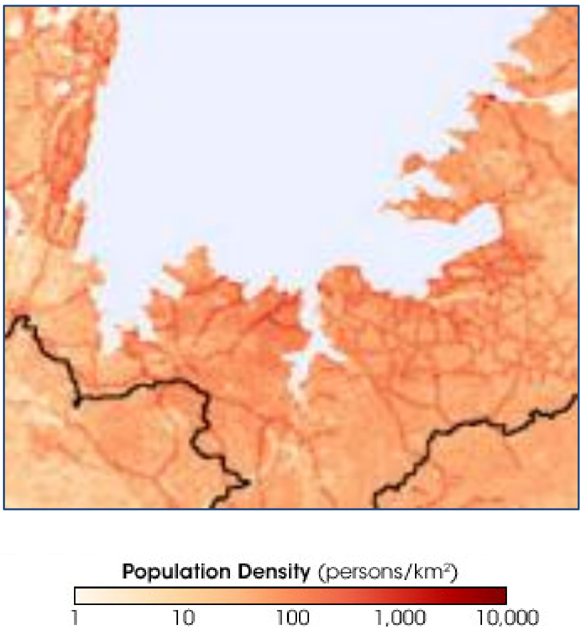



**Figure 84. Population density focal area (source: NASA Earths Observatory).**

| Focal point name | Katunguru |
|---|---|
| Accessibility | 32km/2km |
| Population rural density area | $166km^2$ |
| Which tribes inhabit the region? | Sukuma |
| Current welfare, unemployment, development. | - |
| Farmer's expertise | low |
| Experience in agricultural cooperatives | |

### *5.6.2 Protected areas*

Within the focal area no protected areas are reported.

**Figure 85: Photograph from field inventory and assessment work for Katunguru focal area.**

## 5.7 Benefit-cost Analysis

A simplified benefit-cost analysis is undertaken for the area. Information for this is based on various sources such as FAO publications, IFPRI publications, local expertise and data. A full benefit-costs analysis has to be undertaken in a sub-sequent feasibility study for the area.

Note that this is a first-order benefit-cost analysis. A feasibility study can provide a more rigorous benefit-cost analysis, which is required before taking any implementation planning. However, the following table shows that based on this first-order analysis investments in irrigation can have a small positive financial impact.

Main assumptions for the benefit-costs analysis include:

- Irrigated land based on GIS and local experts for boundaries
- Number of farmers based on average land tenure area
- Irrigation infrastructure based on irrigation type and source

- Social infrastructure based on local expert judgment on farmers' trainings need
- Accessibility infrastructure based on generalized road conditions
- Internal Rate of Return based on 25 years
- Crop revenues based on local crop potentials and local market prices (crop, kg/ha, $/kg):
    - Rice: 5,000 kg/ha, 0.83 $/kg
    - Maize: 1,300 kg/ha, 0.29 $/kg
    - Cassava: 6,000 kg/ha, 0.28 $/kg
    - Cotton: 700 kg/ha, 0.51 $/kg
    - Vegetables: 5,500 kg/ha, 0.25 $/kg

Based on expert knowledge on the suitability to develop irrigation in the area scores between 1 (negative: low suitability or expensive) to 10 (positive: high suitability or low investments) have been marked. The filled radar plot below indicates the options for the focal area.

Overall, the focal area is already halfway developed. Funding for this site is already made through the central government – District Irrigation Development Fund (DIDF). Community mobilization to contribute to the construction of the dam, topographical surveys and engineering designs done making investment costs very low. The weak part is that, soil suitability is very low due to long time land exploitation. For the past two farming seasons, farmers failed to harvest due to erratic rainfall conditions. Farmers still sale the rice (paddy) un processed which leads to very low prices. Need more training for farmers on farming with modern techniques and farming methods and saving skills.

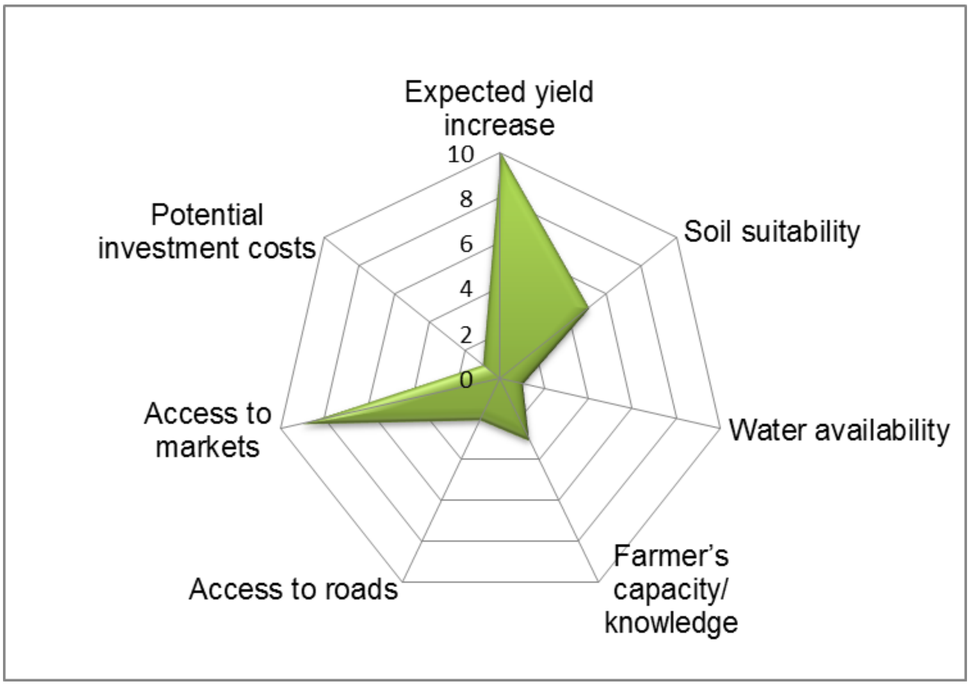



**Figure 86: Filled radar plot indicating expert knowledge score to develop irrigation in the Katunguru focal area (1 = negative, 10 = positive). (Source: local experts and study analysis).**

**Table 13: Key factors used for the benefit costs analysis as based on field and data inventories.**

| | |
|---|---|
| Irrigation technique | Border |
| Suitable area | 600ha |
| Road building requirement | 2km |
| Pumping of water required | No |
| Reservoir building necessary | Yes |
| Soil improvement needed | Substantial |

**Table 14: Benefit-cost analysis for Katunguru area.**

| **Characteristics** | |
|---|---|
| Irrigated land (ha) | 600 |
| Farmers | 600 |
| **Investment Costs** | |
| Irrigation infrastructure (US$/ha) | 4,000 |
| Social infrastructure (US$/farmer) | 750 |
| Accessibility infrastructure (million US$) | 5.0 |
| **Operational Costs** | |
| O&M irrigation (US$/ha/yr) | 60 |
| Extension service (US$/farmer) | 15 |
| O&M roads (US$/yr) | 100,000 |
| **Summary** | |
| Initial investments (million US$) | 7.9 |
| O&M costs (million US$/yr) | 0.145 |
| Net benefits per year (million US$/yr) | 0.570 |
| IRR (Internal Rate of Return) | 2.7% |

## 5.8 Recommendations

The cost benefit analysis as presented in this report is made in the scope of a pre-feasibility study. Although based on literature, expert knowledge and rapid field assessments by local experts it can rather be seen as an indication of expected costs and benefits. As much as possible local technical, social and hydrological factors are incorporated. However it is recommended to assess the costs and benefits in more detail during a feasibility study, which can focus more in depth on the local situation.

# 6 Simiyu Duma Valley focal area

## 6.1 Introduction

This chapter will describe the current state of the Simiyu Duma valley focal area, concerning land and water resources, and will discuss the potential to develop irrigation in the area. This irrigation potential will be based on the land and water resources, the irrigation requirements, the potential crop yields and will also involve the socio-economic considerations and institutional frameworks. Based on these aspects the potential for irrigation will be described, and cost for irrigation development calculated. In Figure 87 a detailed map of the area is given. Total area is 5284 ha.

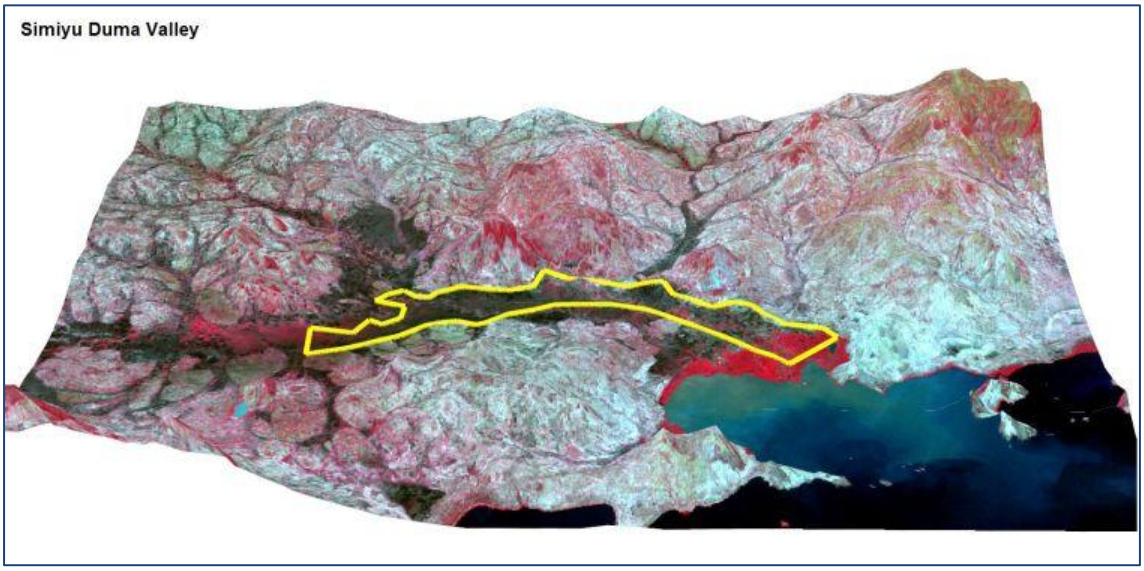



**Figure 87: 3D impression Simiyu Duma Valley focal area, Tanzania**

The focal area is located in the Mwanza Region. Mwanza Region lies in the northern part of Tanzania, located between latitude 10 30' and 30 south of the Equator . Longitudinally the region is located between 310 45' and 340 10' east of Green wich. Regions bordering Mwanza region are Kagera to the west, Shinyanga to the south and south east. The north east boarders Mara region. The northern part of Mwanza is surrounded by the water of Lake Victoria which in turn separates the region from neighbouring countries of Uganda and Kenya Mwanza is a relatively small region occupying 2.3 percent of the total land area of Tanzania mainland. Magu District (Simiyu Duma Catchment) is among the eight District in Mwanza region, the other include Kwimba, Misungwi, Sengerema, Geita, Ukerewe and the newly established District of Ilemela and Nyamagana. Magu District shares its borders with Ilemela in the west, Bunda District (Mara region) in the North, Bariadi District (Shinyanga region) in the East and Kwimba in the South. It lies within 2010, and 2050 latitudes (South of Equator) and 330 and 340 longitudes (East of Greenwich). It is 3,095 meters above sea level.

Selection of this specific focal area was based on results of Phase 1 of this study, while final selection was the responsibility of the relevant country representatives. Results presented hereafter have been obtained from a broad range of sources: Phase 1, previous other studies and reports, modeling results, remote sensing, expert knowledge and field visits by Gaspar

Damas Mashingia and supervised by Honest Prosper Ngowi and Eng. Amandus Lwena in April and May 2012.

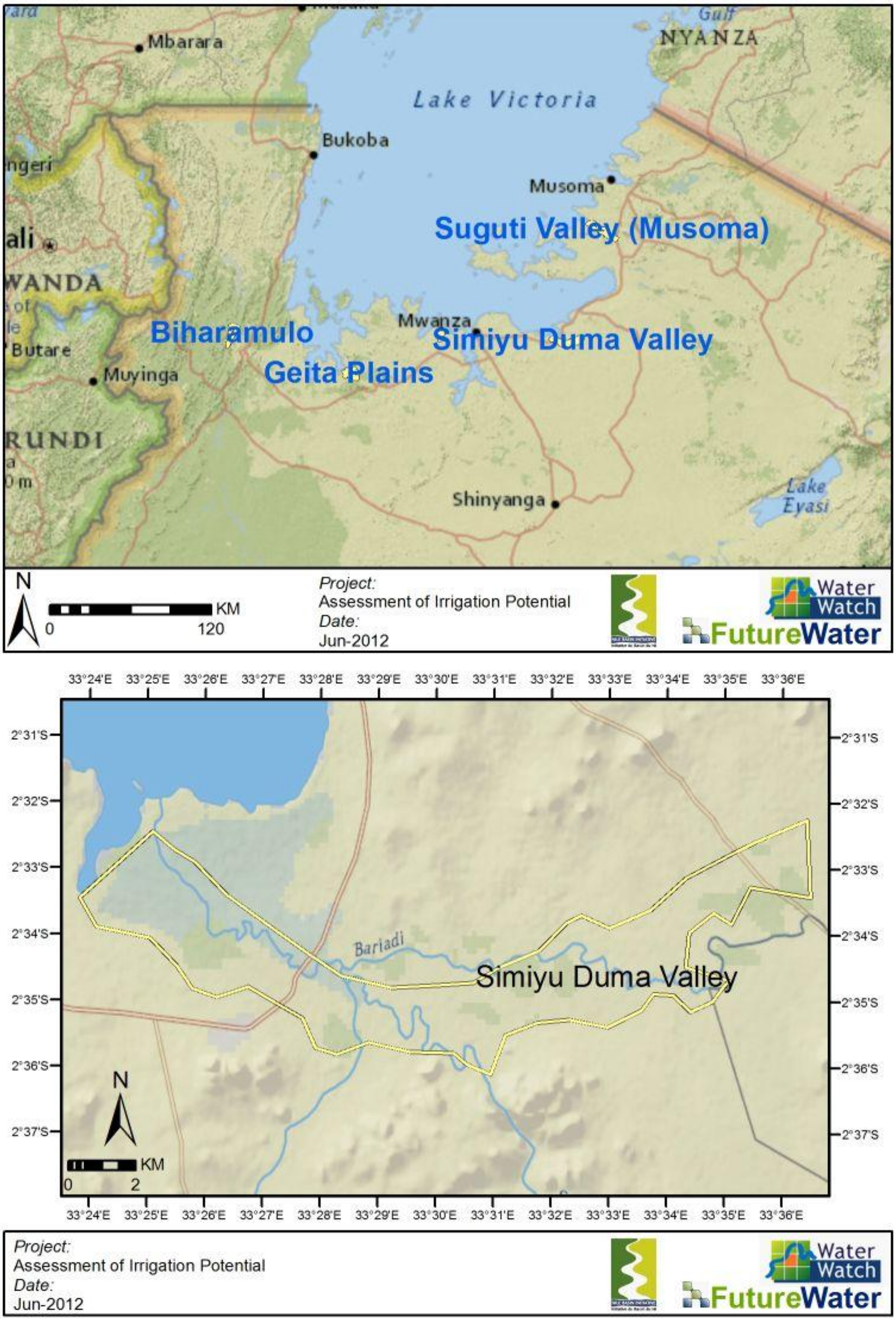



Figure 88: Simiyu Duma Valley focal area, Tanzania

## 6.2 Land suitability assessment

### *6.2.1 Terrain*

The Simiyu Duma Valley focal area is flat and slopes are lower than three percentages. Elevation of the area is about 1130 meters above sea level (MASL), with mountains in the south and the north up to about 1290 MASL.

During the field inventory is was found that the land cover is mainly short grass and long trees. Short grasses are also part of the land cover. The idea according to the government officials, the area is reserved for future forestry areas. Cultivation has bared and it is said the areas was declared since 1996 as reserve area (gazette 1996) Yet still paddy activities is still going on by small-holder farmers.

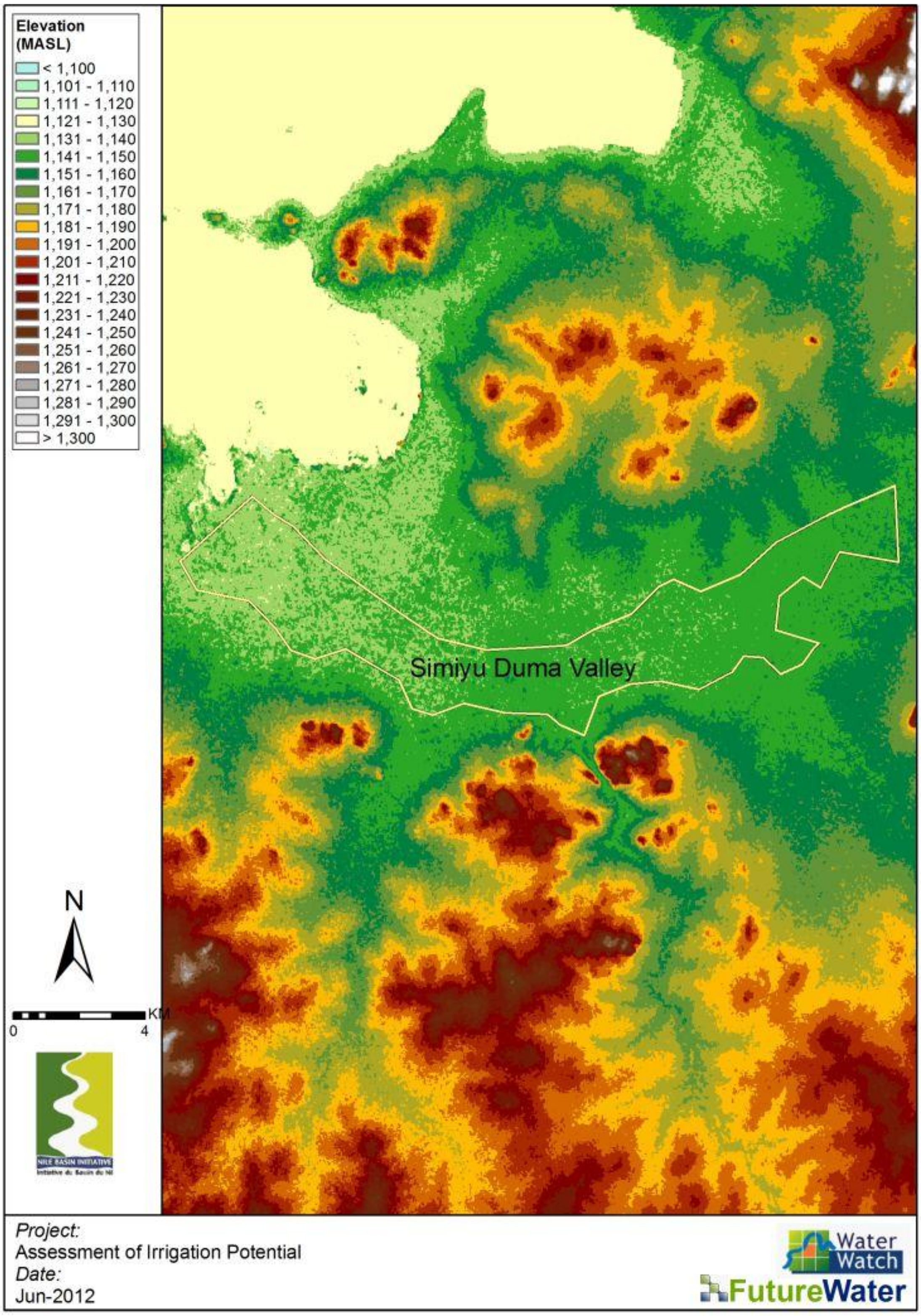



**Figure 89: DEM Simiyu Duma Valley focal area. Resolution 1 arc second (+/- 30m)**

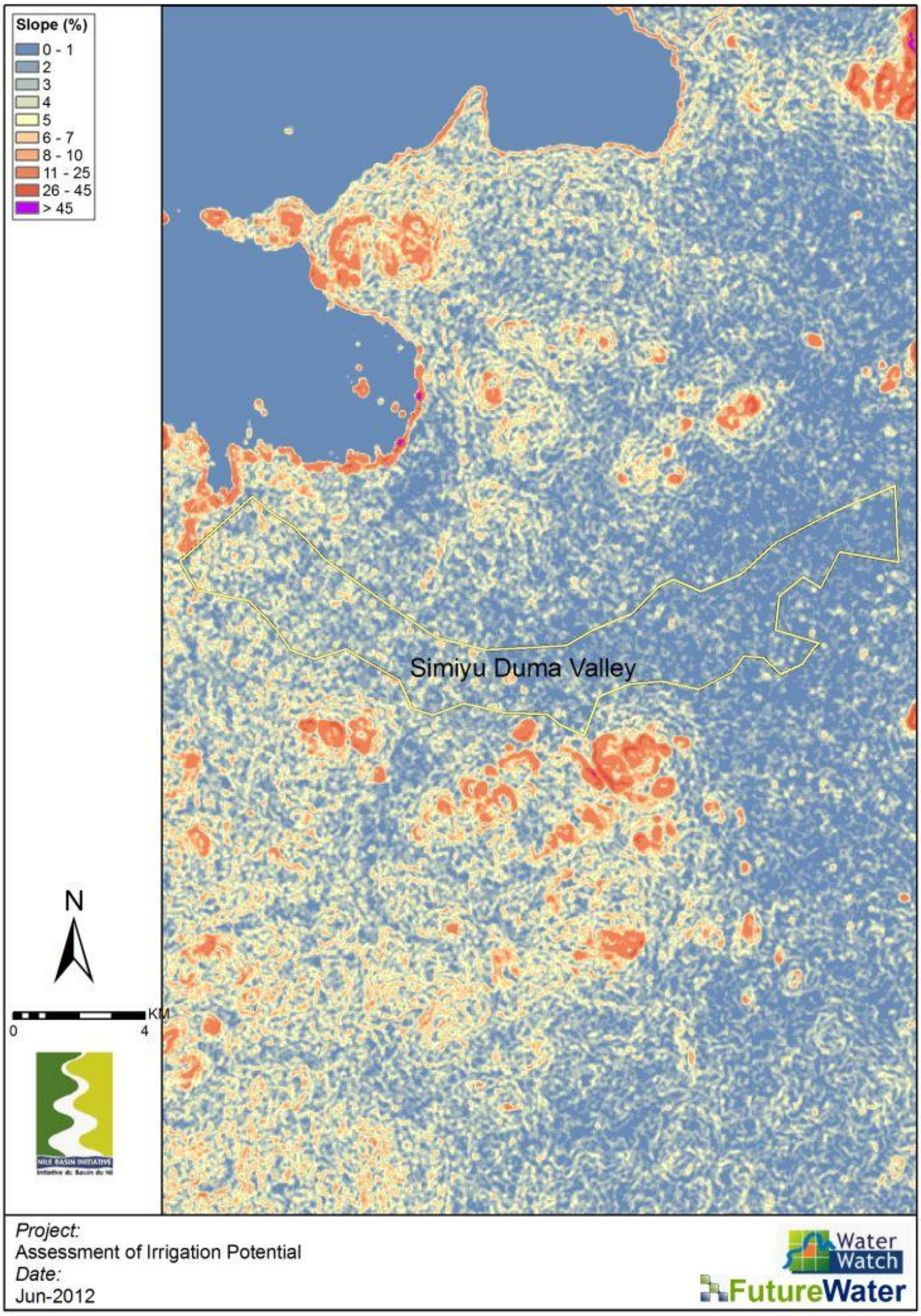
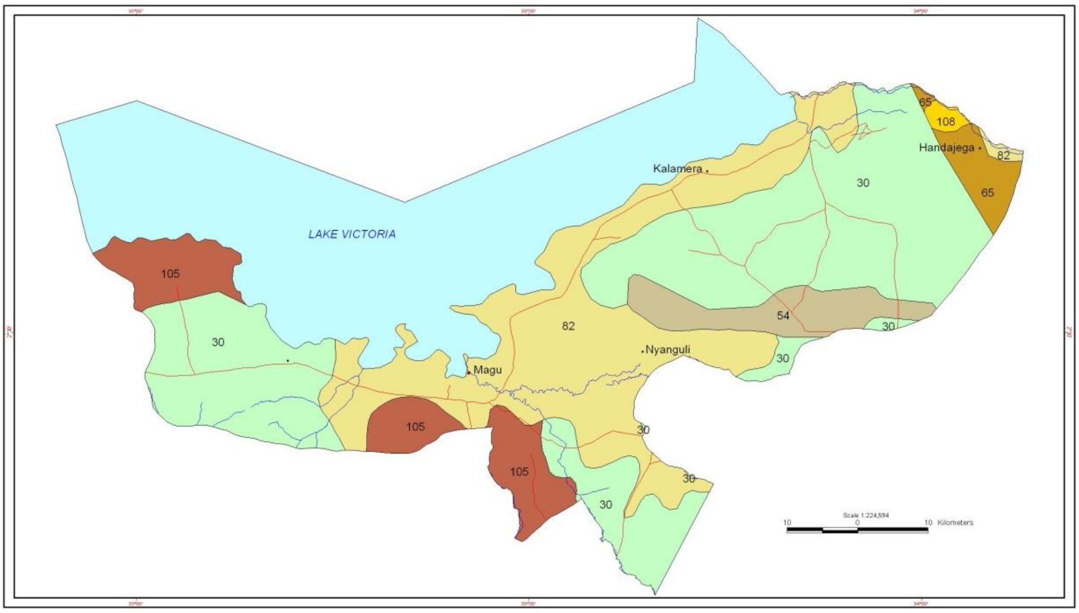



**Figure 90: Slope map Simiyu Duma Valley focal area. (Source: ASTER)**

### 6.2.2 Soil

The most dominant soil type in Simiyu Duma Valley is the Vertisols (VRe). Vertisols are churning, heavy clay soils with a high proportion of swelling clays. These soils form deep wide cracks from the surface downward when they dry out, which happens in most years. These soils have considerable agricultural potential, but adapted management is a precondition for sustained production. The comparatively good chemical fertility and their occurrence on extensive level plains where reclamation and mechanical cultivation can be envisaged are assets of Vertisols. Their physical soil characteristics and, notably, their difficult water management cause problems. The agricultural uses of Vertisols range from very extensive (grazing, collection of fuelwood, and charcoal burning) through smallholder post-rainy season crop production (millet, sorghum, cotton and chickpeas) to small-scale (rice) and large-scale irrigated agriculture (cotton, wheat, barley, sorghum, chickpeas, flax, and sugar cane). Cotton is known to perform well on Vertisols, allegedly because cotton has a vertical root system that is not damaged severely by cracking of the soil. Tree crops are generally less successful because tree roots find it difficult to establish themselves in the subsoil and are damaged as the soil shrinks and swells.

Management practices of Vertisols for crop production should be directed primarily at water control in combination with conservation or improvement of soil fertility. The physical properties and the soil moisture regime of Vertisols represent serious management constraints. The heavy soil texture and domination of expanding clay minerals result in a narrow soil moisture range between moisture stress and water excess. Tillage is hindered by stickiness when the soil is wet and hardness when it is dry. The susceptibility of Vertisols to waterlogging may be the single most important factor that reduces the actual growing period. Excess water in the rainy season must be stored for post-rainy season use (water harvesting) on Vertisols with very slow infiltration rates. One compensation for the shrink–swell characteristics is the phenomenon of self-mulching that is common on many Vertisols. Large clods produced by primary tillage break down with gradual drying into fine peds, which provide a passable seed bed with minimal effort. For the same reason, gully erosion on overgrazed Vertisols is seldom severe because gully walls soon assume a shallow angle of repose, which allows grass to become re-established more readily.




| Symbol | WRB soil unit | Limitations | Use and Management |
|---|---|---|---|
| 30 | Calci-Hypsodic Planosols | Strong sodicity and silinty, very low fertility | Suitable for extensive grazing and in some places wetland rice |
| 31 | Chromi-Feralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 53 | Humi-Umbric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 54 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 69 | Pellic Vertisols | Difficult workability, difficult water management | High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated cropping |
| 82 | Eutri-Pellic Vertisols | Difficult workability, difficult water management | High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated cropping |
| 101 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 105 | Eutri-Rhodic Cambisols | Vary with climate, topography, depth or stoniness | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 108 | Eutric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 115 | Humi-Umbric Leptosols | Shallowness, stoniness, rockiness | Low volume grazing, forestry |
| 122 | Chromi-Feralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 131 | Rhodic Ferralsols | Low natural fertility and tendency to fix phosphates | Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming |
| 134 | Ferralic Cambisols | Low natural fertility | A wide range of agricultural uses with maintenance of soil organic matter and nutrient levels |
| 147 | Waterbody | | |

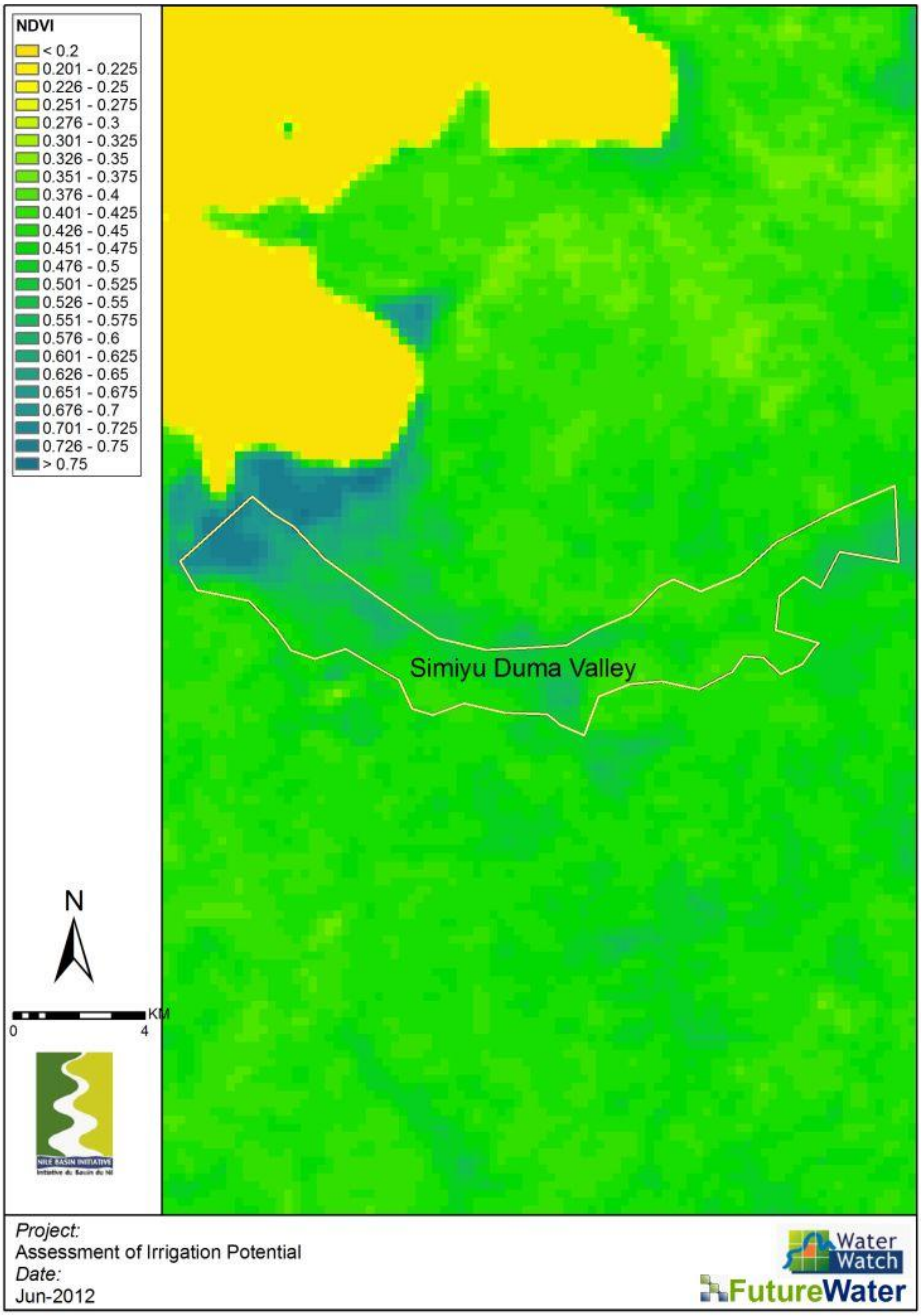
**Figure 91: Details soil map and associated limitations, use and management options for Simiyu Duma Valley focal area.**

### *6.2.3 Land productivity*

Simiyu Duma Valley focal area has a relatively high Normalized Difference Vegetation Index (NDVI), although quite some variation can be observed in the region.

Paddy activities are ongoing by small-holder farmers. However, during the field inventory it was claimed by government officials that the area is reserved for future forestry areas. Cultivation has bared and it is said the areas was declared since 1996 as reserve area (gazette 1996).

**Figure 92: Photograph from field inventory and assessment work for Simiyu Duma Valley focal area in May-June 2012.**


NDVI
< 0.2
0.201 - 0.225
0.226 - 0.25
0.251 - 0.275
0.276 - 0.3
0.301 - 0.325
0.326 - 0.35
0.351 - 0.375
0.376 - 0.4
0.401 - 0.425
0.426 - 0.45
0.451 - 0.475
0.476 - 0.5
0.501 - 0.525
0.526 - 0.55
0.551 - 0.575
0.576 - 0.6
0.601 - 0.625
0.626 - 0.65
0.651 - 0.675
0.676 - 0.7
0.701 - 0.725
0.726 - 0.75
> 0.75
Simiyu Duma Valley
N
KM
0
4
Project:
Assessment of Irrigation Potential
Date:
Jun-2012

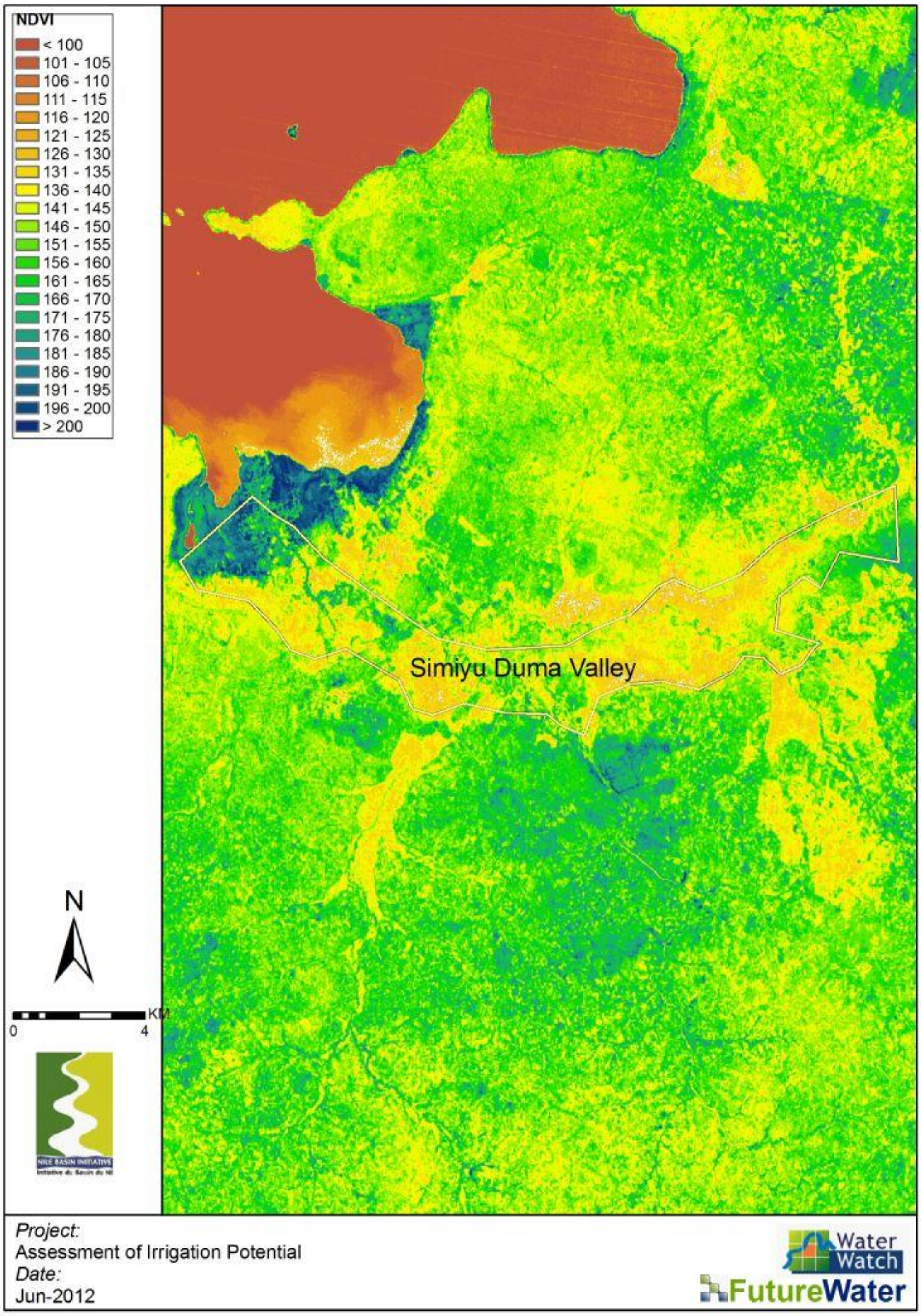



**Figure 93: Yearly average NDVI values (top) and high resolution Landsat NDVI for one day (bottom) for Simiyu Duma Valley focal area.**

### 6.2.4 Potential cropping patterns

Currently very limited agricultural activities take place; mainly some paddy. Regarding potential crops to be promoted in the area if irrigation will be developed, the following crops were proposed: paddy, maize, cassava, cotton and vegetables.

## 6.3 Water resource assessment

### 6.3.1 Climate

The focal area is relatively dry with about 830 mm annual rainfall. Main dry period starts in May and gradually rainfall increases after October-November. Annual temperatures range from 19 to 29$^{o}$C, for minimum and maximum temperatures respectively. Reference evapotranspiration is about 1600 mm per year.

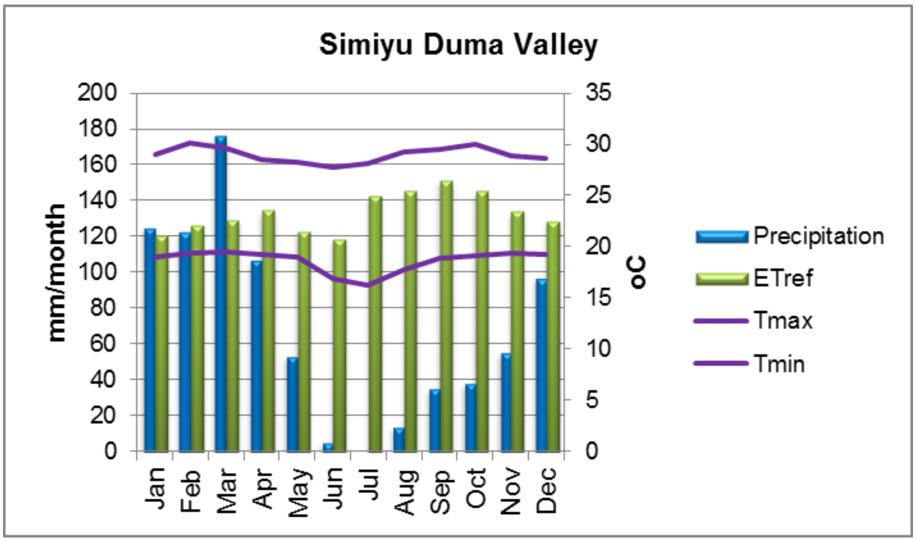



**Figure 94: Average climate conditions for Simiyu Duma Valley focal area.**

### 6.3.2 Water balance

A very detailed high resolution model was built for NEL countries (NELmod). For a detailed description see Phase 1 report. Results from NELmod were extracted for this specific focal area and are shown below.

**Figure 95: Photograph from field inventory and assessment work for Simiyu Duma Valley focal area in May-June 2012.**

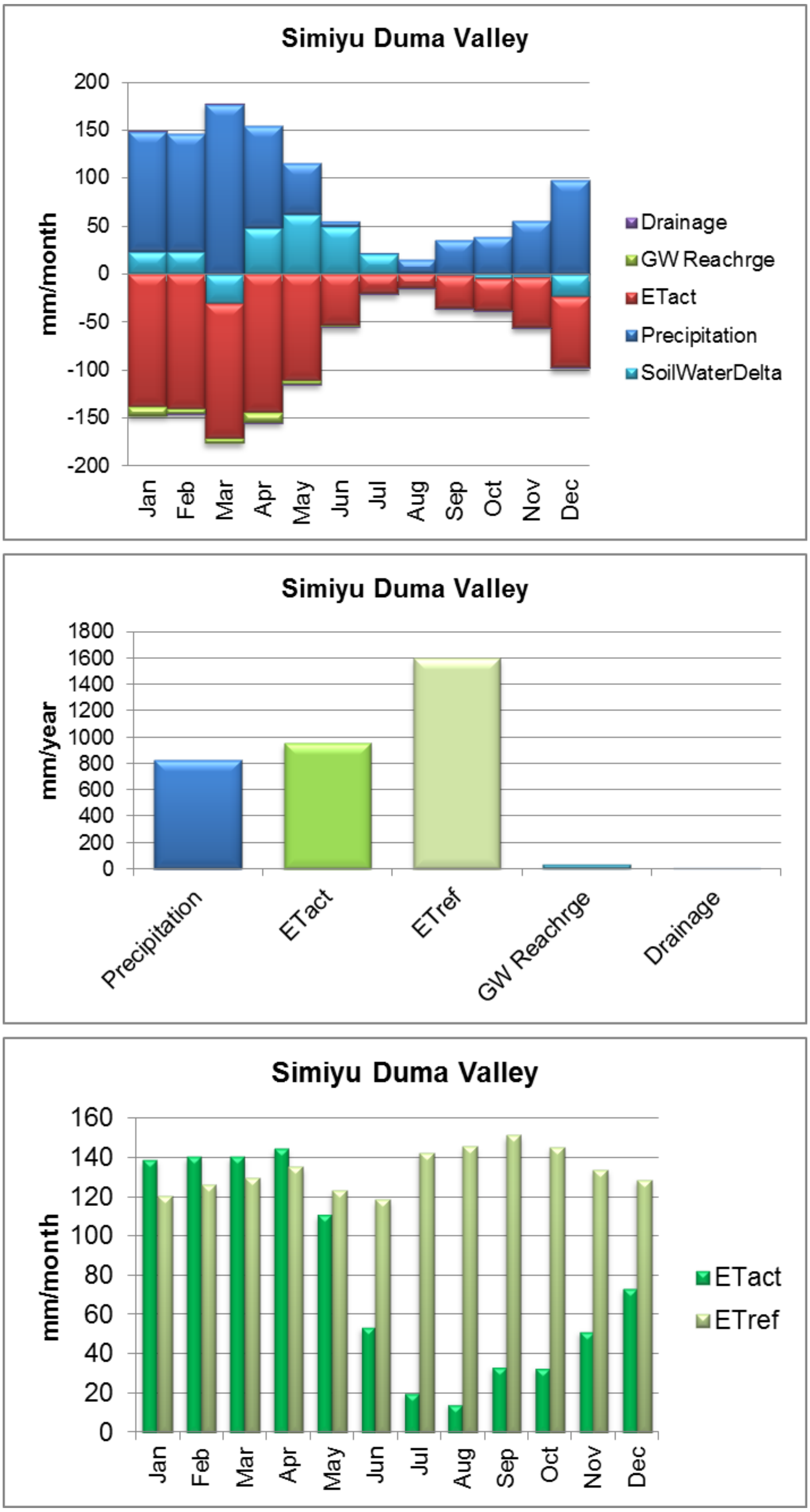
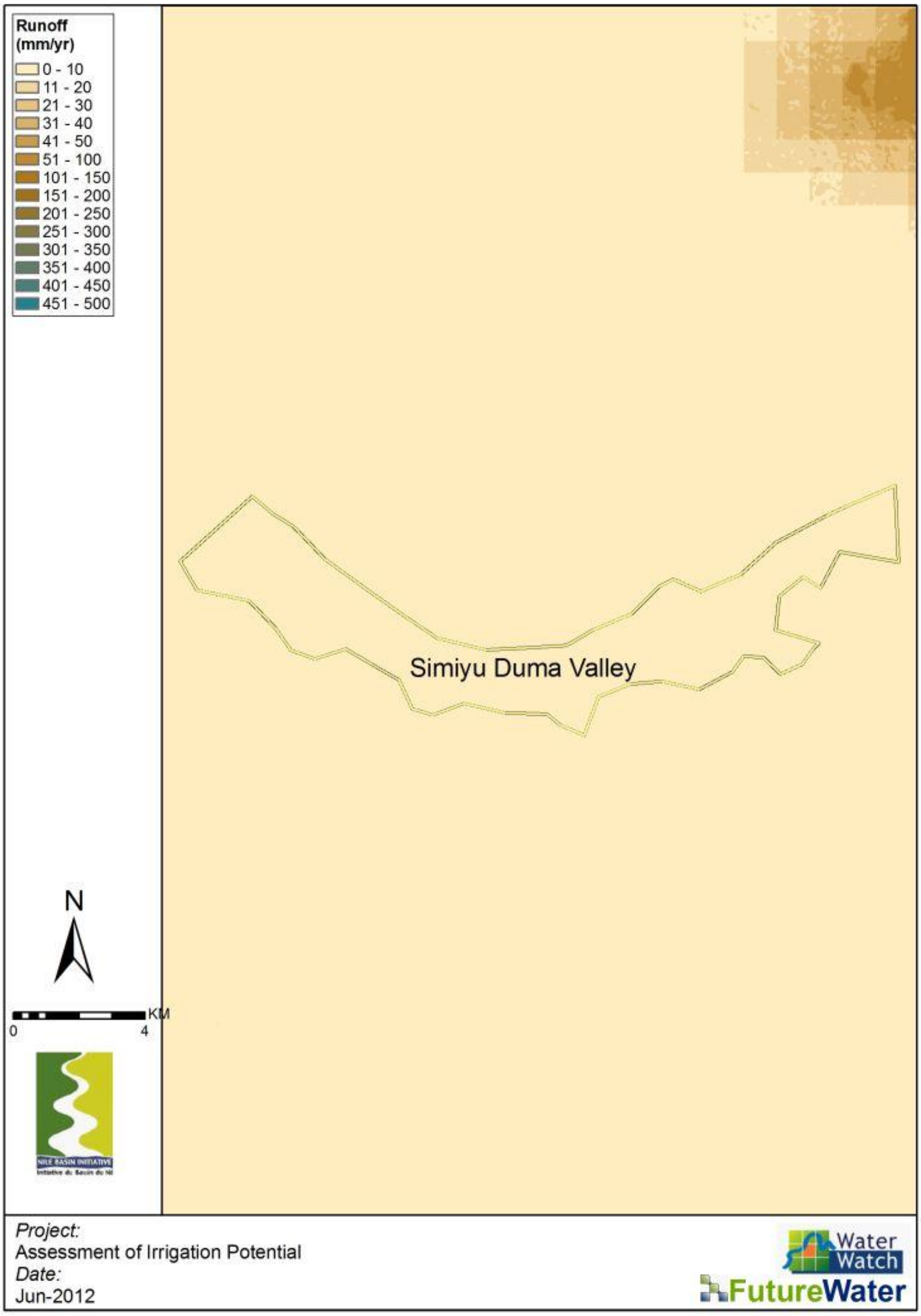



**Figure 96: Water balances for the area based on the high resolution data and modeling approach for Simiyu Duma Valley focal area.**


Runoff (mm/yr)
0 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 100
101 - 150
151 - 200
201 - 250
251 - 300
301 - 350
351 - 400
401 - 450
451 - 500
Simiyu Duma Valley
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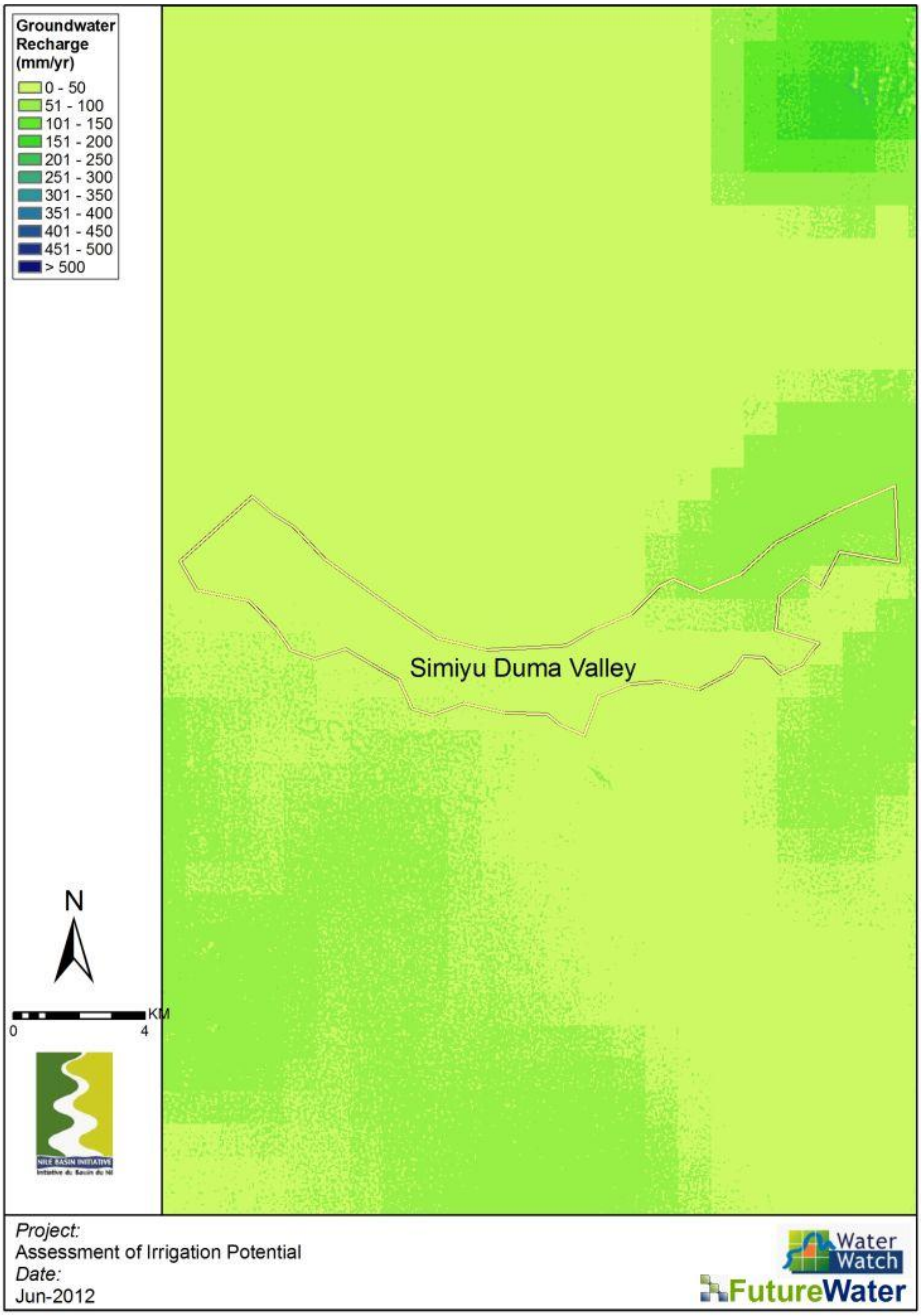
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater



Groundwater Recharge (mm/yr)
0 - 50
51 - 100
101 - 150
151 - 200
201 - 250
251 - 300
301 - 350
351 - 400
401 - 450
451 - 500
> 500
Simiyu Duma Valley
N
KM
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4
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater

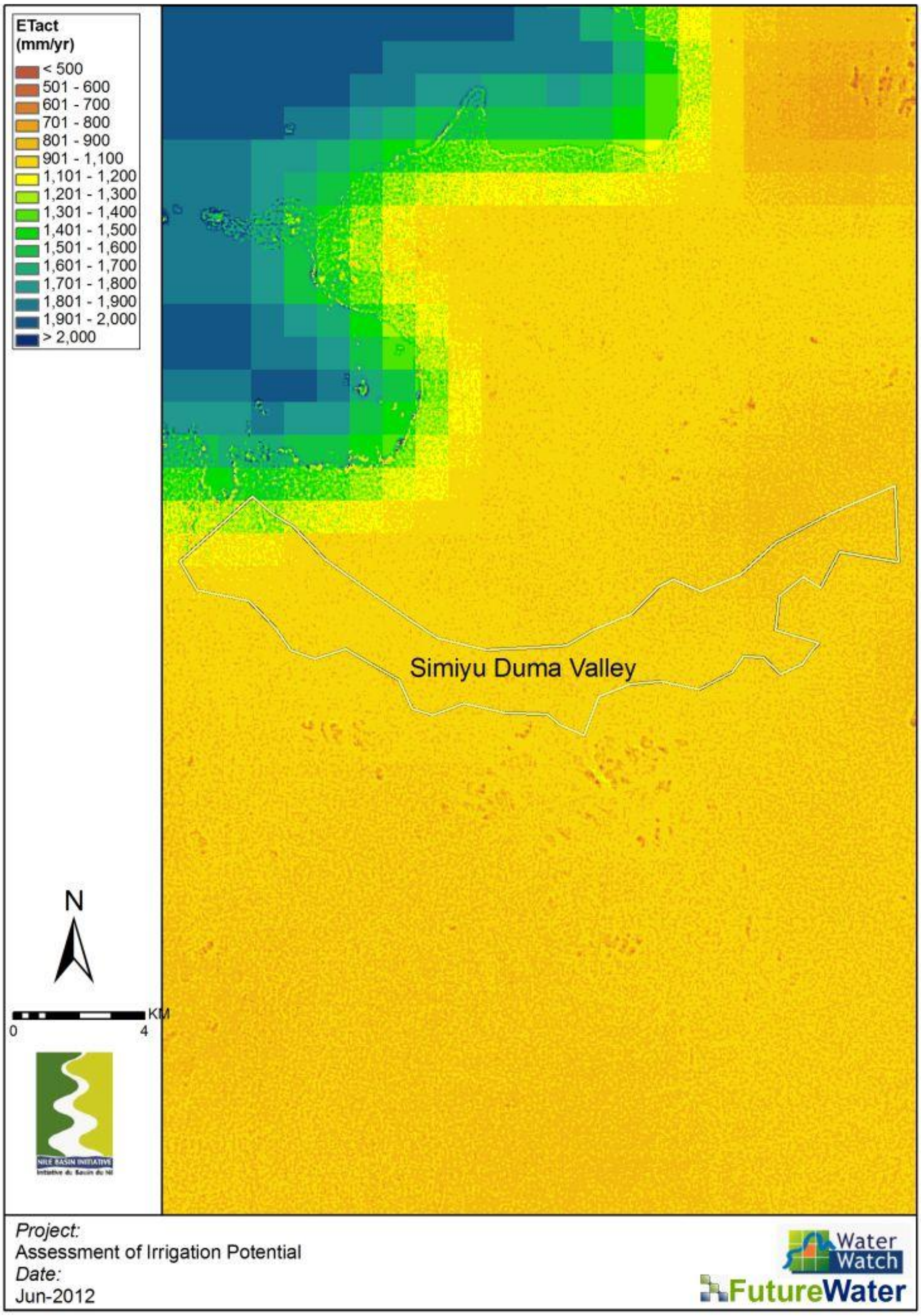



**Figure 97: Water balances for the area based on the high resolution data and modeling approach for Simiyu Duma Valley focal area.**

## 6.4 Assessment of irrigation water requirements

### *6.4.1 Irrigation water requirements*

Irrigation water requirements depend on many factors such as: climatic conditions, crop, growing season, irrigation practices etc. A first estimate of irrigation requirements could be based on the difference between rainfall and reference evapotranspiration. It was however selected for this pre-feasibility assessment to provide a first estimate of irrigation needs based on the most promising crops. To this end, FAO's AquaCrop, the successor of CropWat was setup for local and crop specific conditions.

All input files and output files for AquaCrop can be found in the database attached to the reports. Note that during this pre-feasibility phase focus with AquaCrop was to obtain crop water requirements. A subsequent feasibility study could focus more on the crop yield validation and calibration components of AquaCrop.

In the table below the irrigation water requirements for each selected crop are provided based on AquaCrop calculations. All units are provided in mm per growing season for the specific crops. Note that for various crops, like vegetables and similar crops, multiple croppings per years might occur.

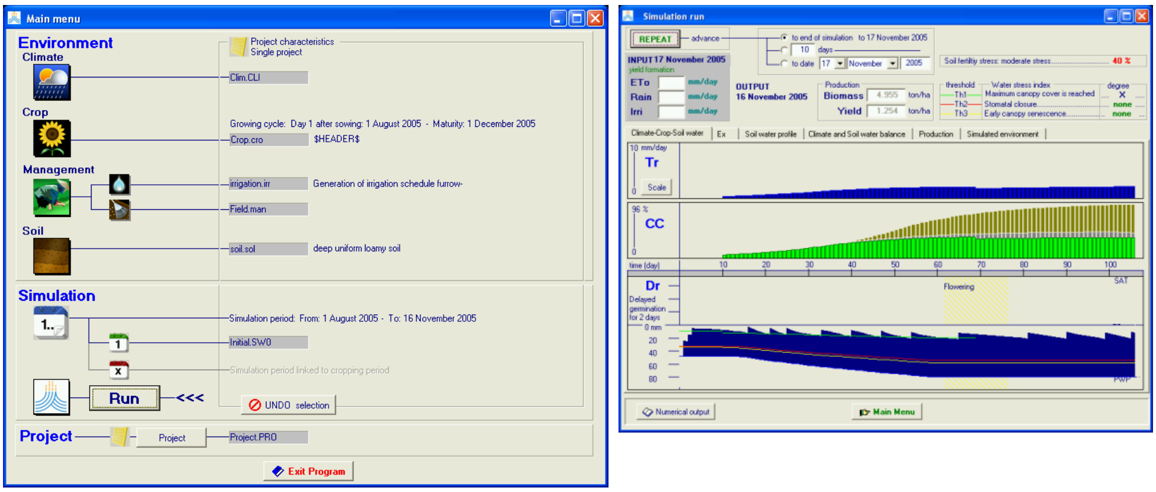



**Figure 98: Typical example of AquaCrop input and output screens.**

**Table 15: Irrigation water requirements for the selected crops in the focal areas. All units are given in mm per growing season.**

| Crop | Rain | ETref | Planting | Harvets | Rain | Irrigation | ETref | ETact |
|---|---|---|---|---|---|---|---|---|
| | === year === | | == (day of year) == | | ======== growing season ======= | | | |
| | (mm) | (mm) | | | (mm) | (mm) | (mm) | (mm) |
| Rice | 830 | 1601 | 45 | 213 | 416 | 240 | 718 | 380 |
| Maize | 830 | 1601 | 41 | 182 | 431 | 240 | 594 | 444 |
| Cassava | 830 | 1601 | 349 | 167 | 642 | 160 | 755 | 495 |
| Cotton | 830 | 1601 | 359 | 207 | 610 | 150 | 890 | 417 |
| Vegetables | 830 | 1601 | 1 | 365 | 832 | 130 | 1597 | 479 |

*6.4.2 Water source and irrigation systems*

In the focal area an abandoned irrigation system has been found. The Sawenge Irrigation Scheme is allocated in Magu District about 1 km from Magu headquarters. Sawenge scheme has total area of 150 hectares with 107 irrigators, 73 males and 34 females. This area lies to $2^0$36'10.89" and $2^0$36'41.11" latitude (South of the equator) and $33^0$ 27'35.04"and $33^0$28'18.22" longitude (East of Greenwich).The project started in 1994 by IFAD to save three villages Nyalikungu, Itumbili and Kitongo with 104 households. Paddy is the major crop that is grown in the scheme. In 1998 there was severe rainfall (El-Nino) which destroyed the project. Since that time no rehabilitation process has been undertaken.*(source – URT- regional administration and local governments Magu district council Sawenge irrigation scheme pg 8)*

Magu District lies in the drought zone area. The main food crops include cassava, maize, sorghum, sweet potatoes, paddy and legumes. Cash crop cultivated is cotton. The district has been facing shortage of food for several reasons as follows:

- Problems of drought.
- Outbreak of cassava mosaic disease virus – UgV whereby the crop has reduced production to about 90%.
- Poor technologies used by farmers e.g Use of hand hoes, fertilizers not used effectively, poor control of pests and diseases. In general the yield is low due to poor agronomic practices. The yield index for some crops is as follows – paddy 2.4 tons / ha. Sweet potatoes 1.5 tons/ha, sorghum 2 tons/ha, Cassava 1.6 tons/ha and maize 0.8/ha. *(source – URT- regional administration and local governments Magu district council Sawenge irrigation scheme)*

Additional details can be found in the following table:

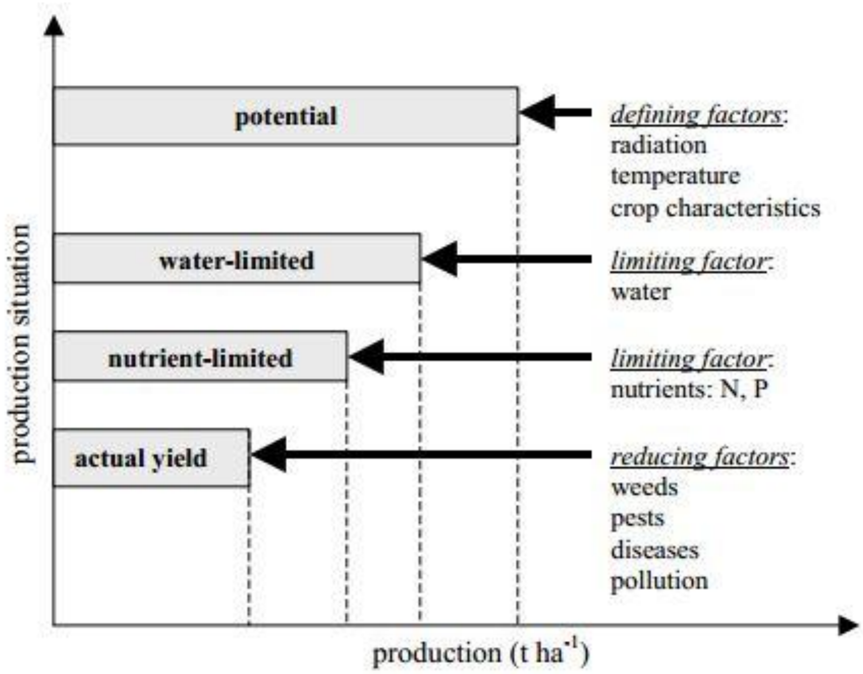
| | |
|---|---|
| *Potential irrigation sources* | Lake Victoria, Metu river, Bore-holes, charco –dam rain water harvesting |
| *Stability of water source during the year (discharge range) please note about the stability* | Stable – not countable (no information available |
| *Potential for reservoir/ water harvesting (capacity)* | No – the lake is the main source for harvesting |
| *Raining season (s)* | Short rains – Oct –dece and heavy rains March – may and Jan – Feb |
| *Amount for precipitation mm/yr ( an estimate from local and experts)* | 700 – 1000mm/year |
| *Ground water levels which areas have less regimes? As from locals also* | 70m and above , Shinoi ilungu -78 pumps in use |
| *Already irrigated area* | Yes |

## 6.5 Potential crop yield assessment

The yield gap describes the difference between the current yield, and the maximal possible yield. Mostly the maximal possible yield is defined as the highest yield in the world, but it can also be assessed against a regional background which makes the yield gap more realistic and the maximal yield possible to achieve under the given circumstances.

The gap between the actual yield and the potential yield can be caused by several processes. Factors which may cause that the maximal possible yield is not reached can be the water availability, the soil and the available nutrients, or yield reducing factors like diseases, weeds or pollution.

For the four proposed crops (paddy, maize, cassava, cotton and vegetables) potential crop yields are expected to be relatively high. The focal area is relatively fertile and additional irrigation might increase crop yields of these crops to higher yields compared to the country averages. Especially cassava, rice and cotton have a high potential to generate relatively high yields. Detailed analysis during a feasibility study should focus on a more in-depth analysis of the potential crop yields.



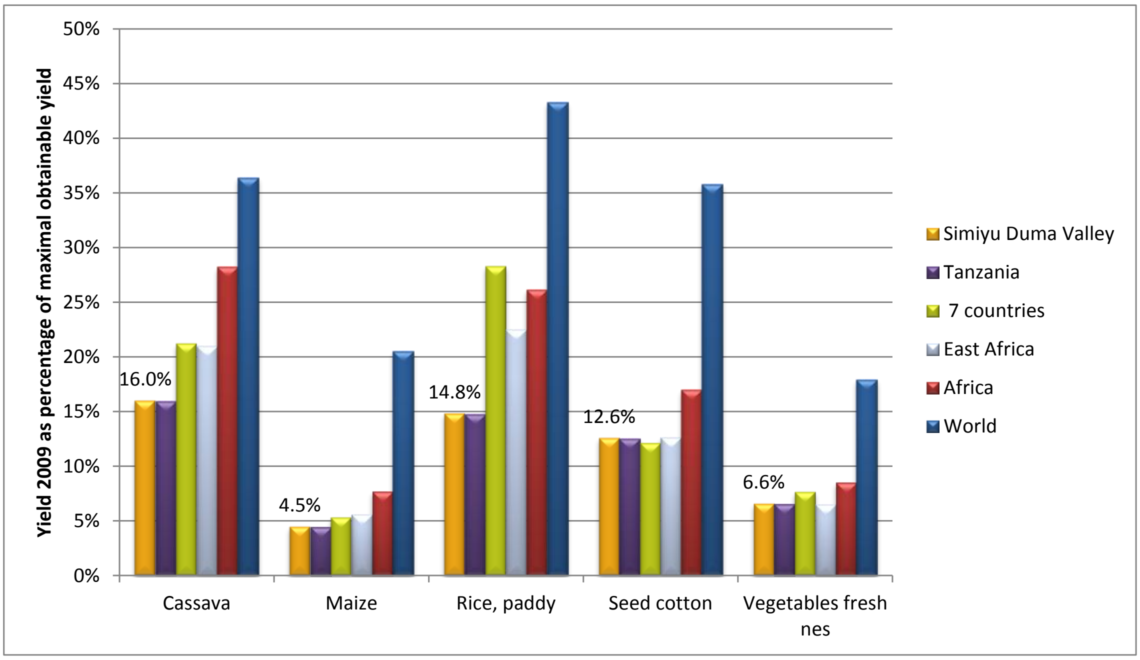



**Figure 99: Yield gap analysis (source: FAOSTAT, 2010).**

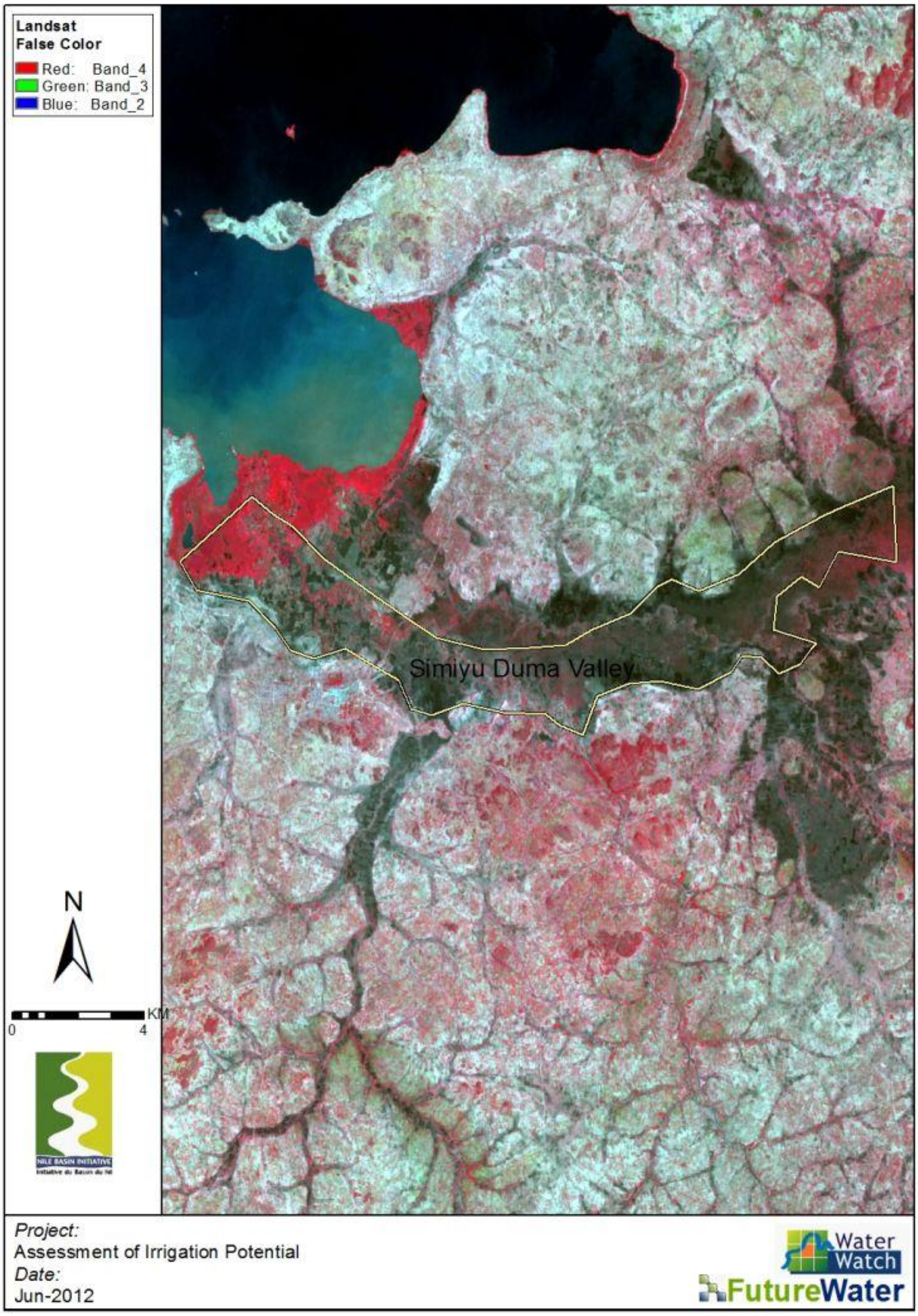



**Figure 100: Landsat False Color Composite indicating current productivity of the area for Simiyu Duma Valley focal area.**

## 6.6 Environmental and socio-economic considerations

### *6.6.1 Social and population considerations*

A first pre-feasibility assessment on the social context of the focal area has been undertaken. A field visit and additional data and information have been obtained regarding the focal area. Population density for the area is shown in the following map, while detailed concise information regarding social considerations is provided in the table.

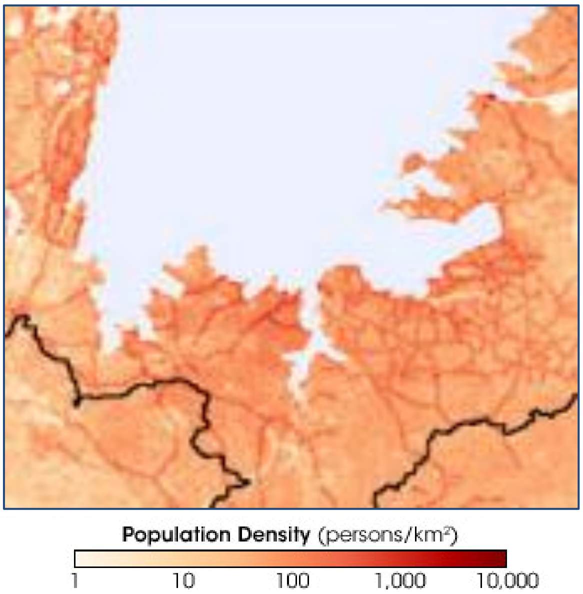



**Figure 101. Population density focal area (source: NASA Earths Observatory).**

| Focal point name | Simiyu |
| --- | --- |
| Accessibility | 2km |
| Population rural density area | - |
| Which tribes inhabit the region? | Sukuma, jita |
| Current welfare, unemployment, development. | - |
| Farmer's expertise | low |
| Experience in agricultural cooperatives | middle |

### *6.6.2 Protected areas*

It is reported during the field-inventory that the area is designated as a "forest reserve". Details on the status of this designation are yet unclear and should be taken into consideration during a possible feasibility study.

## 6.7 Benefit-cost Analysis

A simplified benefit-cost analysis is undertaken for the area. Information for this is based on various sources such as FAO publications, IFPRI publications, local expertise and data. A full benefit-costs analysis has to be undertaken in a sub-sequent feasibility study for the area.

Note that this is a first-order benefit-cost analysis. A feasibility study can provide a more rigorous benefit-cost analysis, which is required before taking any implementation planning. However, the following table shows that based on this first-order analysis investments in irrigation can have a positive impact.

Main assumptions for the benefit-costs analysis include:

- Irrigated land based on GIS and local experts for boundaries
- Number of farmers based on average land tenure area
- Irrigation infrastructure based on irrigation type and source
- Social infrastructure based on local expert judgment on farmers' trainings need
- Accessibility infrastructure based on generalized road conditions
- Internal Rate of Return based on 25 years
- Crop revenues based on local crop potentials and local market prices (crop, kg/ha, $/kg):
    - Rice: 5,000 kg/ha, 0.76 $/kg
    - Maize: 1,300 kg/ha, 0.29 $/kg
    - Cassava: 5,000 kg/ha, 0.28 $/kg
    - Cotton: 700 kg/ha, 0.51 $/kg
    - Vegetables: 5,000 kg/ha, 0.25 $/kg

Based on expert knowledge on the suitability to develop irrigation in the area scores between 1 (negative: low suitability or expensive) to 10 (positive: high suitability or low investments) have been marked. The filled radar plot below indicates the options for the focal area.

In general, the focal area is underpinned with close markets. Much more details are already hindered as the area is destined to be a "forest reserve" and no agricultural activities are permitted. Had it been not of this, the area is thought to be very potential and beneficial to both community and investors as it has a reliable market place due to its close location, well available infrastructures that need less improvements making less investments costs.

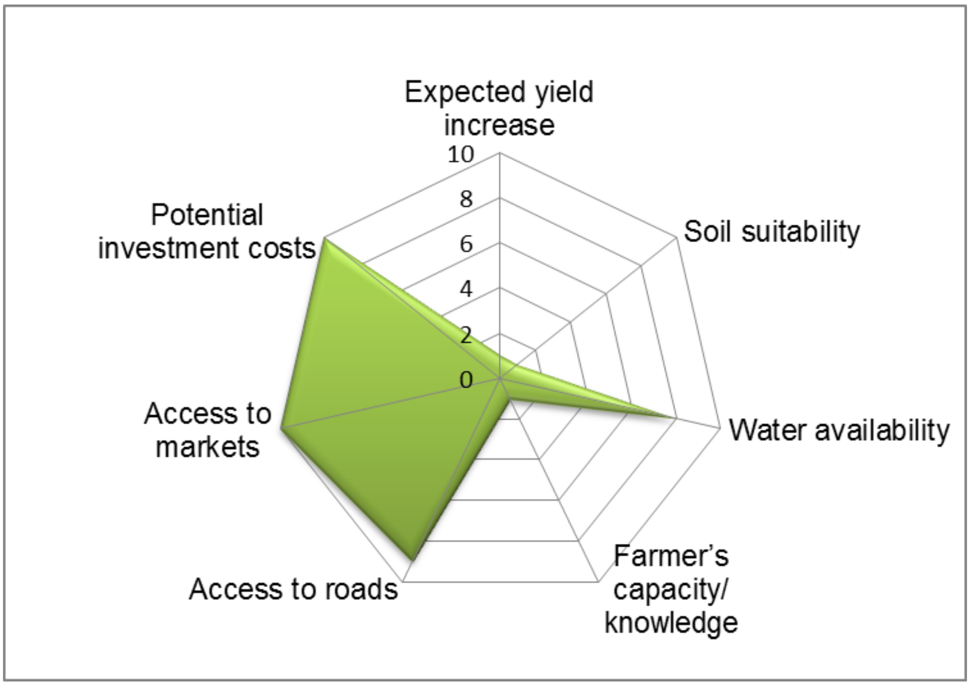



**Figure 102: Filled radar plot indicating expert knowledge score to develop irrigation in the Simiyu Duma Valley focal area (1 = negative, 10 = positive). (Source: local experts and study analysis).**

**Table 16: Key factors used for the benefit costs analysis as based on field and data inventories.**

| | |
|---|---|
| Irrigation technique | Sprinkler, Furrow, drip |
| Suitable area | 5000 ha |
| Road building requirement | No |
| Pumping of water required | Yes |
| Reservoir building necessary | Yes |
| Soil improvement needed | Extensive |

**Table 17: Benefit-cost analysis for Simiyu Duma Valley area.**

| | |
|---|---|
| **Characteristics** | |
| Irrigated land (ha) | 4,000 |
| Farmers | 2,667 |
| **Investment Costs** | |
| Irrigation infrastructure (US$/ha) | 7,000 |
| Social infrastructure (US$/farmer) | 750 |
| Accessibility infrastructure (million US$) | 1.0 |
| **Operational Costs** | |
| O&M irrigation (US$/ha/yr) | 60 |
| Extension service (US$/farmer) | 15 |
| O&M roads (US$/yr) | 20,000 |
| **Summary** | |
| Initial investments (million US$) | 31.0 |
| O&M costs (million US$/yr) | 0.300 |
| Net benefits per year (million US$/yr) | 3.451 |
| IRR (Internal Rate of Return) | 10.2% |

## 6.8 Recommendations

The cost benefit analysis as presented in this report is made in the scope of a pre-feasibility study. Although based on literature, expert knowledge and rapid field assessments by local experts it can rather be seen as an indication of expected costs and benefits. As much as possible local technical, social and hydrological factors are incorporated. However it is recommended to assess the costs and benefits in more detail during a feasibility study, which can focus more in depth on the local situation.

# 7 Suguti Valley (Musoma) focal area

## 7.1 Introduction

This chapter will describe the current state of the Suguti Valley (Musoma) focal area, concerning land and water resources, and will discuss the potential to develop irrigation in the area. This irrigation potential will be based on the land and water resources, the irrigation requirements, the potential crop yields and will also involve the socio-economic considerations and institutional frameworks. Based on these aspects the potential for irrigation will be described, and cost for irrigation development calculated. In Figure 103 a detailed map of the area is given. Total area is 4990 ha.

Selection of this specific focal area was based on results of Phase 1 of this study, while final selection was the responsibility of the relevant country representatives. Results presented hereafter have been obtained from a broad range of sources: Phase 1, previous other studies and reports, modeling results, remote sensing, expert knowledge and field visits by Gaspar Damas Mashingia and supervised by Honest Prosper Ngowi and Eng. Amandus Lwena in April and May 2012.

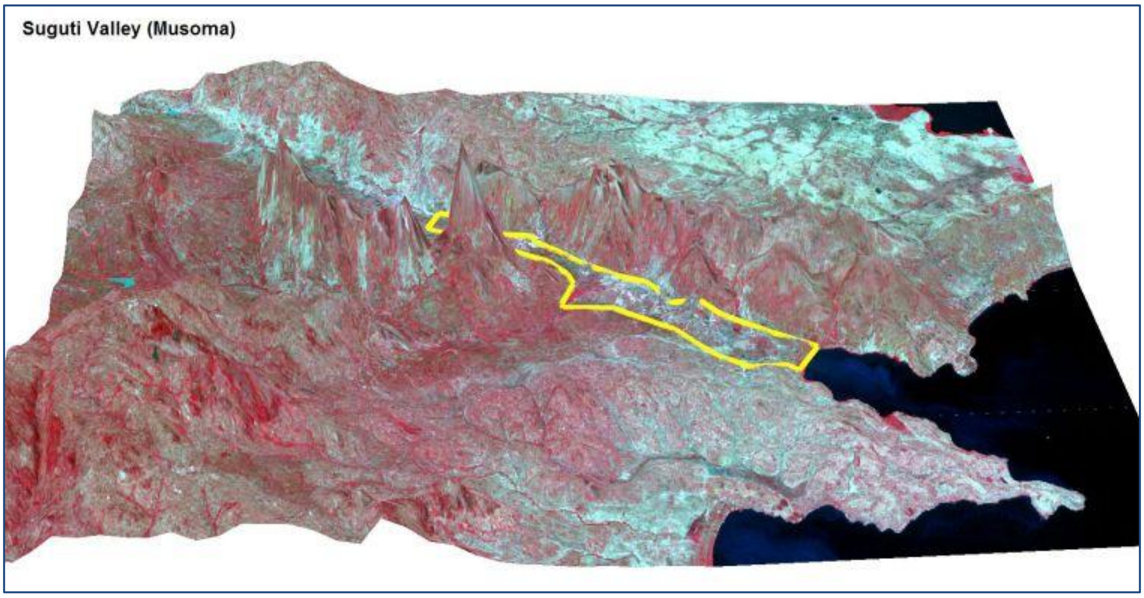



**Figure 103: 3D impression Suguti Valley (Musoma) focal area, Tanzania**

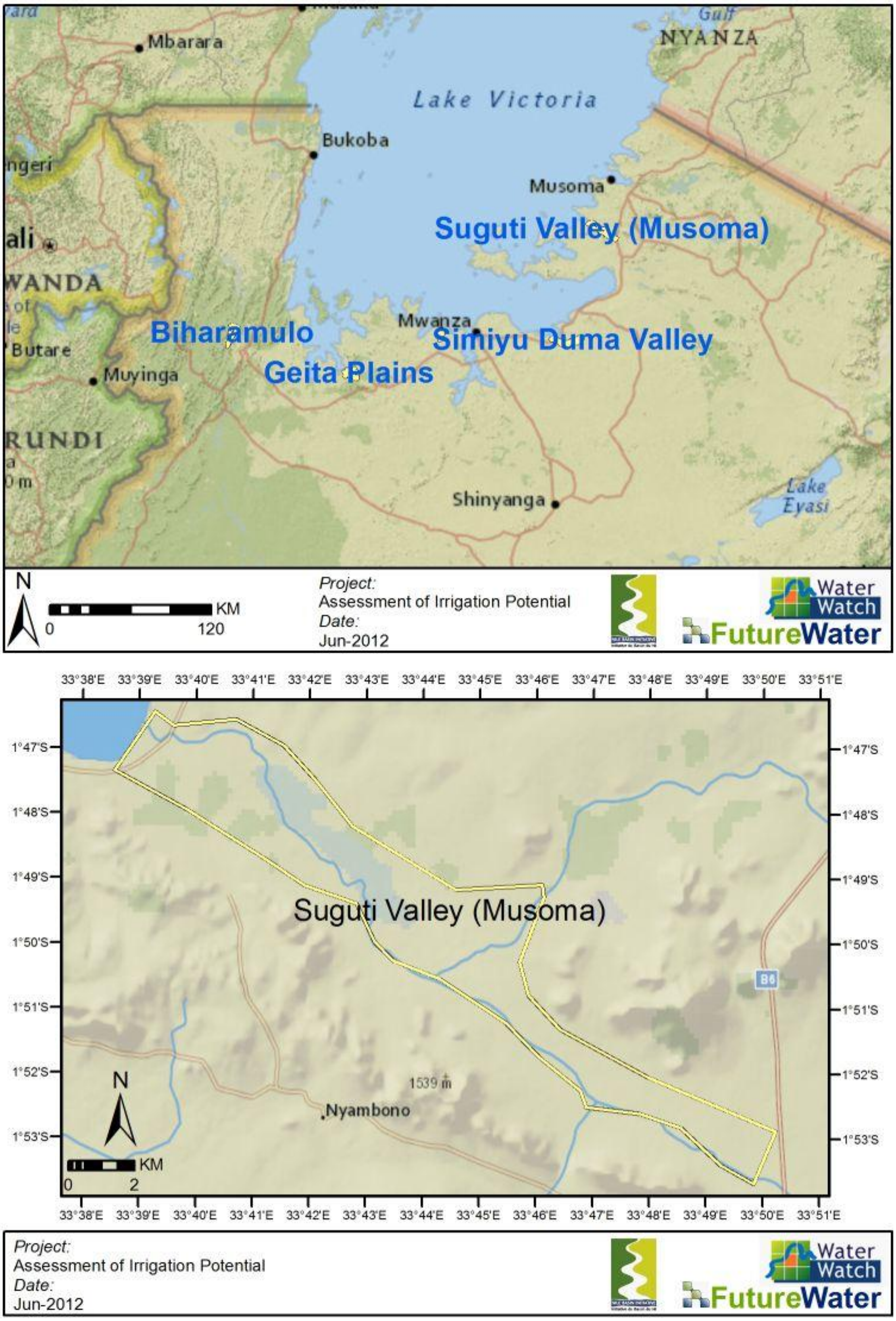



**Figure 104: Suguti Valley focal area (Musoma), Tanzania**

## 7.2 Land suitability assessment

### *7.2.1 Terrain*

Suguti Valley is located in the Musoma region just on the edge of Lake Victoria. The focal area is very flat at an elevation of about 1130 meters above sea level (MASL). The surrounding mountains are about 1500 to 1600 MASL. Slopes in the valley itself are very small, making the area suitable to develop irrigation.

Most of the land is cultivated annually. The land cover is predominantly covered by short grass with some shrubs in areas which are not cultivated during current season.

**Figure 105: Photograph from field inventory and assessment work for Suguti Valley during May-June 2012.**

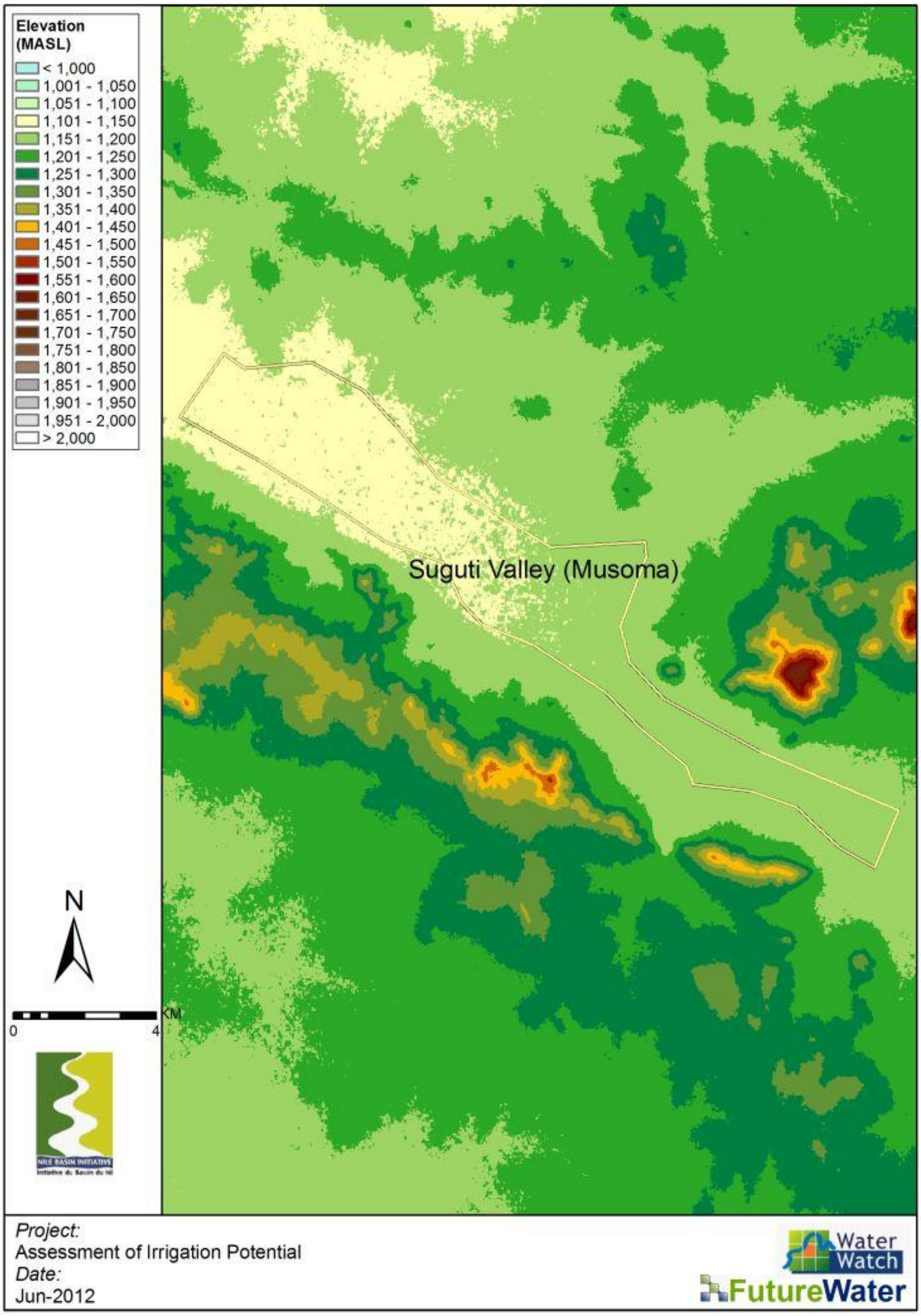



**Figure 106: DEM Suguti Valley focal area (Musoma). Resolution 1 arc second (+/- 30m)**

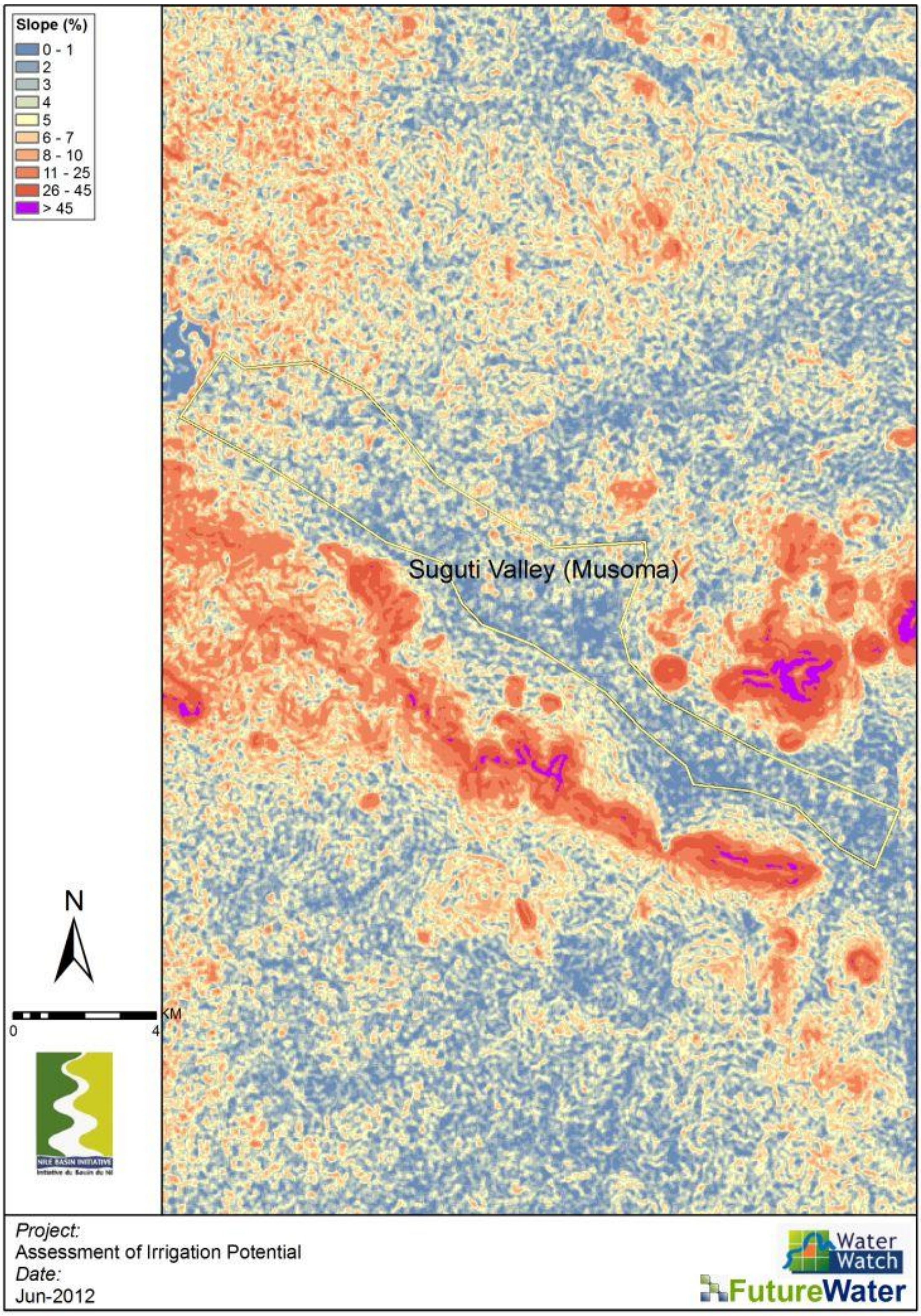



**Figure 107: Slope map Suguti Valley focal area (Musoma). (Source: ASTER)**

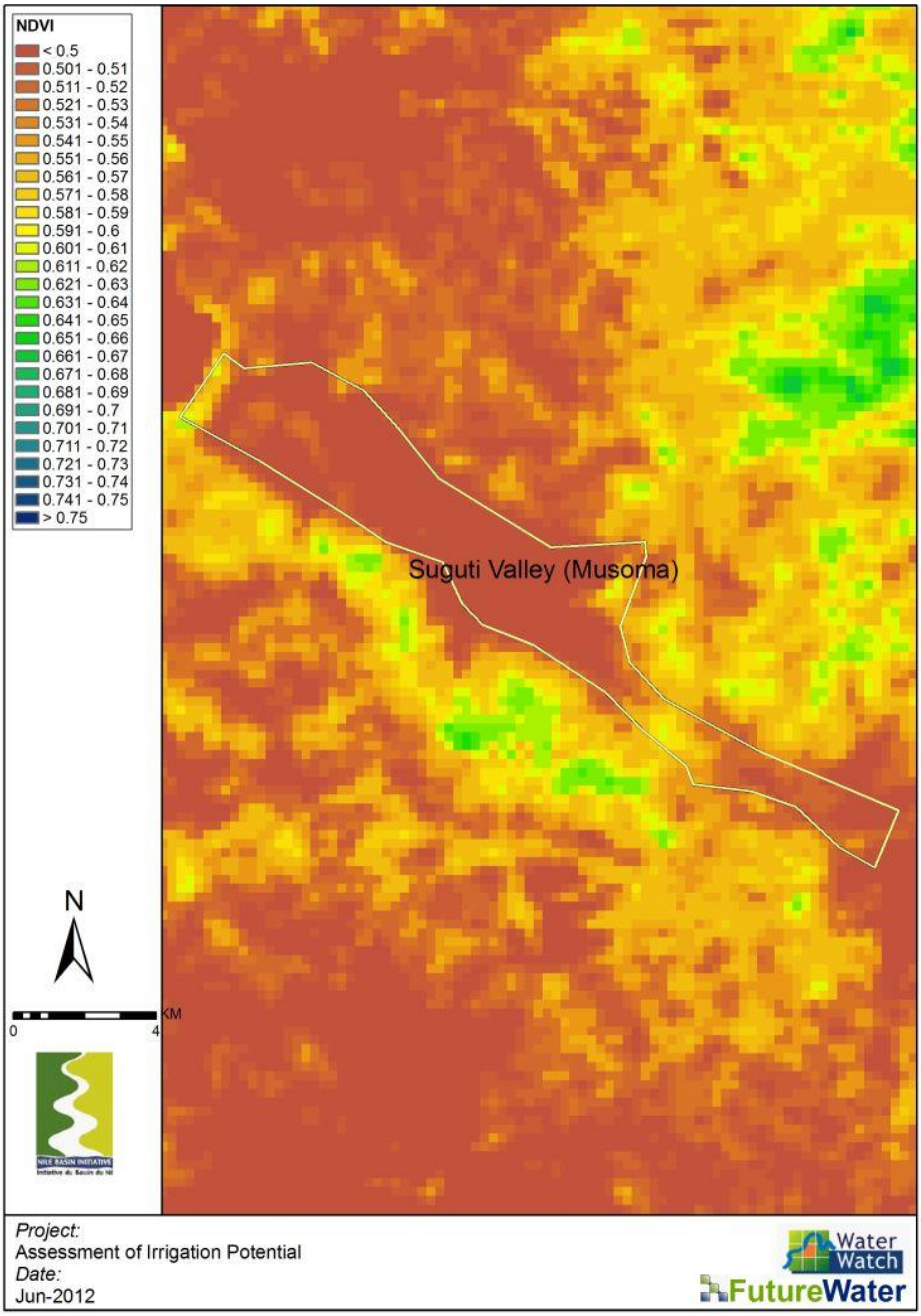
### 7.2.2 Soils

One soil type is dominant in the Suguti Valley focal area: Vertisols (VRe). Vertisols are churning, heavy clay soils with a high proportion of swelling clays. These soils form deep wide cracks from the surface downward when they dry out, which happens in most years. These soils have considerable agricultural potential, but adapted management is a precondition for sustained production. The comparatively good chemical fertility and their occurrence on extensive level plains where reclamation and mechanical cultivation can be envisaged are assets of Vertisols. Their physical soil characteristics and, notably, their difficult water management cause problems. The agricultural uses of Vertisols range from very extensive (grazing, collection of fuelwood, and charcoal burning) through smallholder post-rainy season crop production (millet, sorghum, cotton and chickpeas) to small-scale (rice) and large-scale irrigated agriculture (cotton, wheat, barley, sorghum, chickpeas, flax, and sugar cane). Cotton is known to perform well on Vertisols, allegedly because cotton has a vertical root system that is not damaged severely by cracking of the soil. Tree crops are generally less successful because tree roots find it difficult to establish themselves in the subsoil and are damaged as the soil shrinks and swells.

Management practices of Vertisols for crop production should be directed primarily at water control in combination with conservation or improvement of soil fertility. The physical properties and the soil moisture regime of Vertisols represent serious management constraints. The heavy soil texture and domination of expanding clay minerals result in a narrow soil moisture range between moisture stress and water excess. Tillage is hindered by stickiness when the soil is wet and hardness when it is dry. The susceptibility of Vertisols to waterlogging may be the single most important factor that reduces the actual growing period. Excess water in the rainy season must be stored for post-rainy season use (water harvesting) on Vertisols with very slow infiltration rates. One compensation for the shrink–swell characteristics is the phenomenon of self-mulching that is common on many Vertisols. Large clods produced by primary tillage break down with gradual drying into fine peds, which provide a passable seed bed with minimal effort. For the same reason, gully erosion on overgrazed Vertisols is seldom severe because gully walls soon assume a shallow angle of repose, which allows grass to become re-established more readily.

### 7.2.3 Land productivity

Land productivity in the area is high. Normalized Difference Vegetation Indices (NDVI) values are very high indicating good potential for irrigation. Currently most of the area is already in use for agriculture and the more natural vegetation is pre-dominantly short grasses (about 70%) and the remaining natural vegetation are small trees.


NDVI
< 0.5
0.501 - 0.51
0.511 - 0.52
0.521 - 0.53
0.531 - 0.54
0.541 - 0.55
0.551 - 0.56
0.561 - 0.57
0.571 - 0.58
0.581 - 0.59
0.591 - 0.6
0.601 - 0.61
0.611 - 0.62
0.621 - 0.63
0.631 - 0.64
0.641 - 0.65
0.651 - 0.66
0.661 - 0.67
0.671 - 0.68
0.681 - 0.69
0.691 - 0.7
0.701 - 0.71
0.711 - 0.72
0.721 - 0.73
0.731 - 0.74
0.741 - 0.75
> 0.75
Suguti Valley (Musoma)
N
KM
0
4
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater

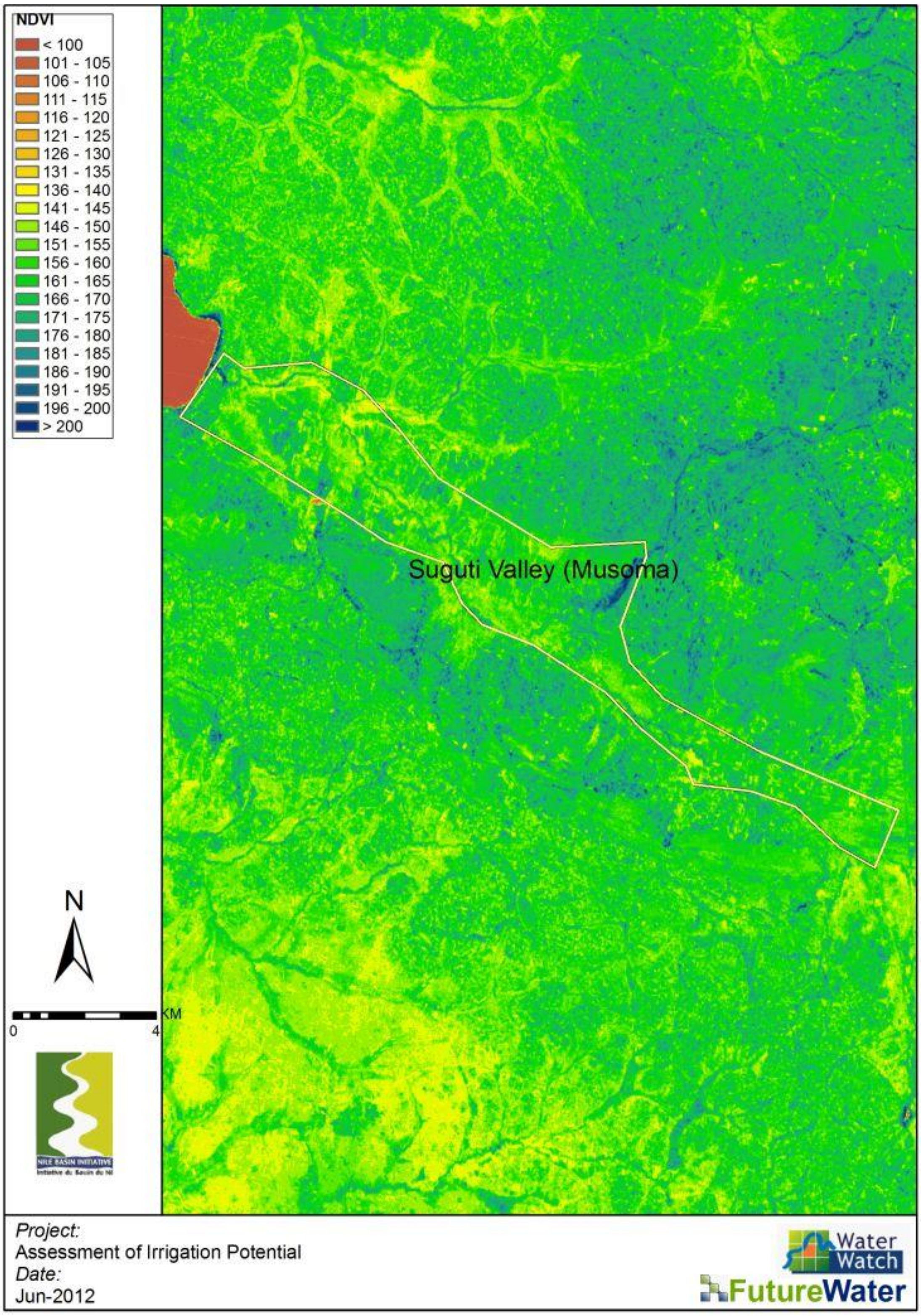



**Figure 108: Yearly average NDVI values (top) and high resolution Landsat NDVI for one day (bottom) for Sugutu Valley focal area.**

### 7.2.4 *Potential cropping patterns*

Currently three dominant crops can be found in the area: paddy, cotton and maize. These crops are not irrigated. Other details of these crops are shown in the following table.

| SUGUTI | Paddy | Cotton | Maize |
|---|---|---|---|
| % of this crop as of % total agriculture area | 40 | 40 | 20 |
| Date planting/seeding | dec | Nov | Oct/march |
| Date harvest | May | May | Feb/june |
| Average yield (kg/ha) | 2500 | 400 | 700 |
| Maximum yield (kg/ha) | 3500 | 500 | 900 |
| Average selling value of crop (fbu/kg) | 1000 shs | 800shs | 450 |
| Irrigated (yes no and mm/) | No | No | No |
| Amount of growing cycles per year | one | one | one |

Regarding potential crops to be promoted in the area if irrigation will be developed, the following crops were proposed: paddy, maize, cassava, cotton and vegetables.

## 7.3 Water resource assessment

### 7.3.1 *Climate*

Suguti Valley focal area receives about 1005 mm annual rainfall. Driest months are June, July and August.  Annual temperatures are quite constant and range from 19 to 29$^{o}$C, for minimum and maximum temperatures respectively. Reference evapotranspiration is about 1560 mm per year.

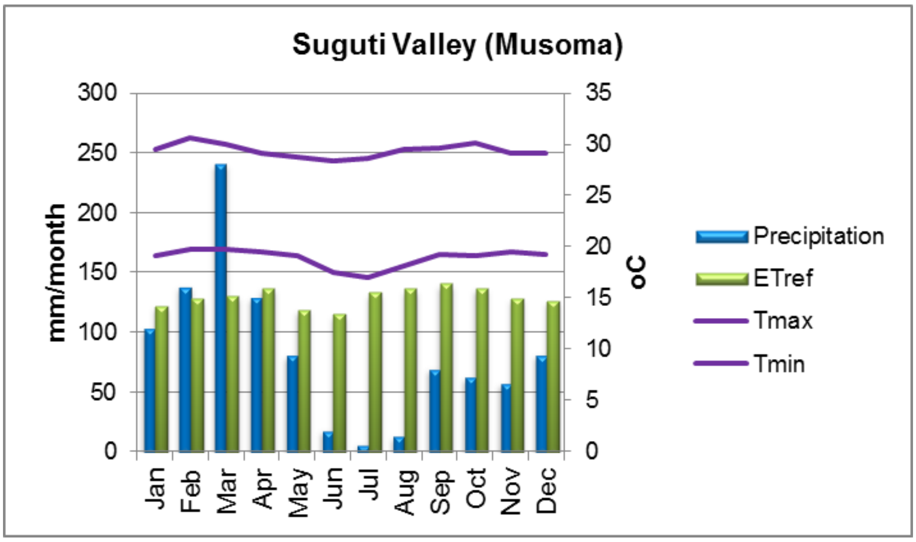



**Figure 109: Average climate conditions for Suguti Valley  focal area .**

### 7.3.2 *Water balance*

A very detailed high resolution model was built for NEL countries (NELmod). For a detailed description see Phase 1 report. Results from NELmod were extracted for this specific focal area and are shown below.

**Figure 110: Photograph from field inventory and assessment work for Suguti Valley focal area during May-June 2012.**

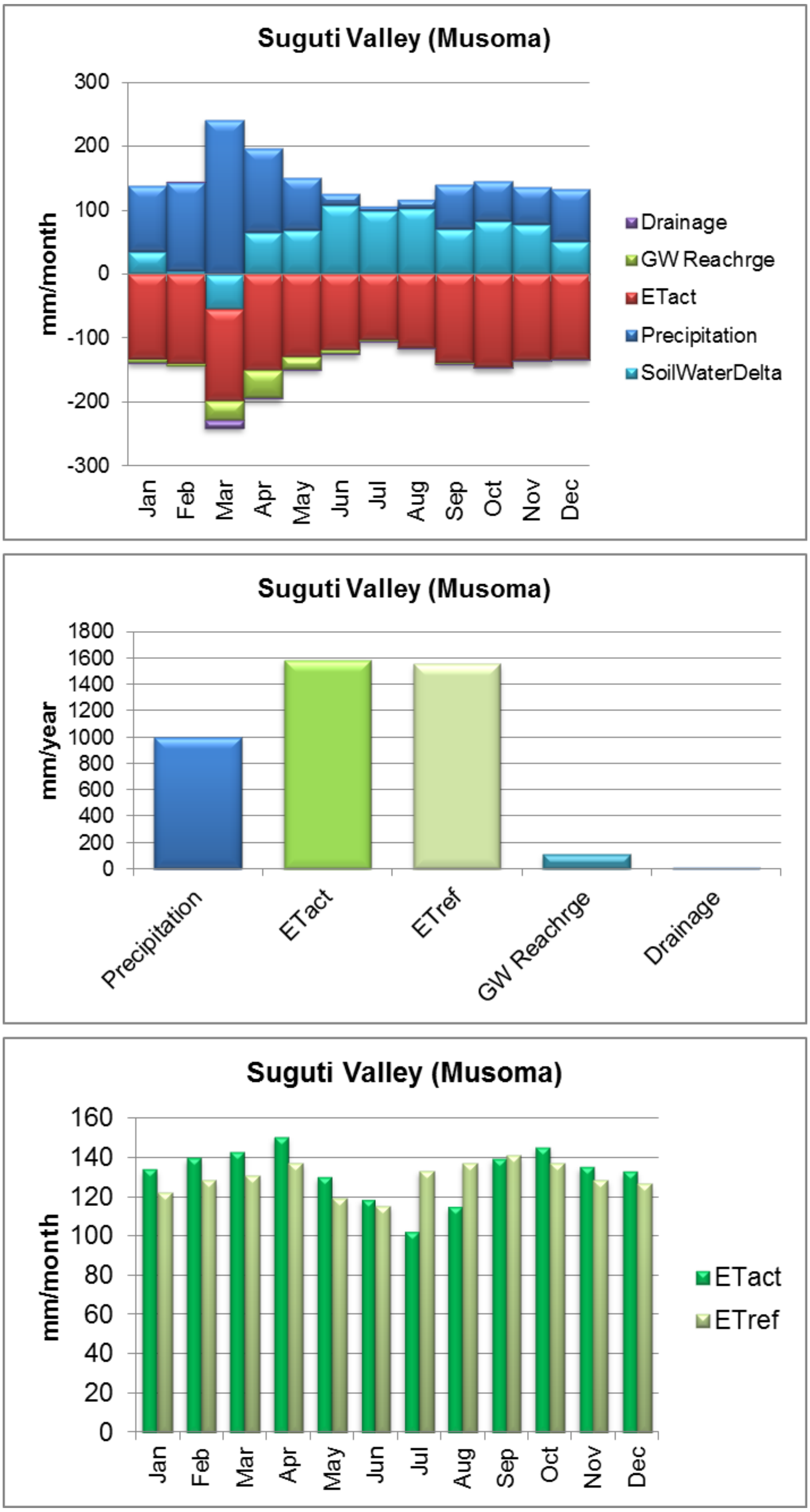
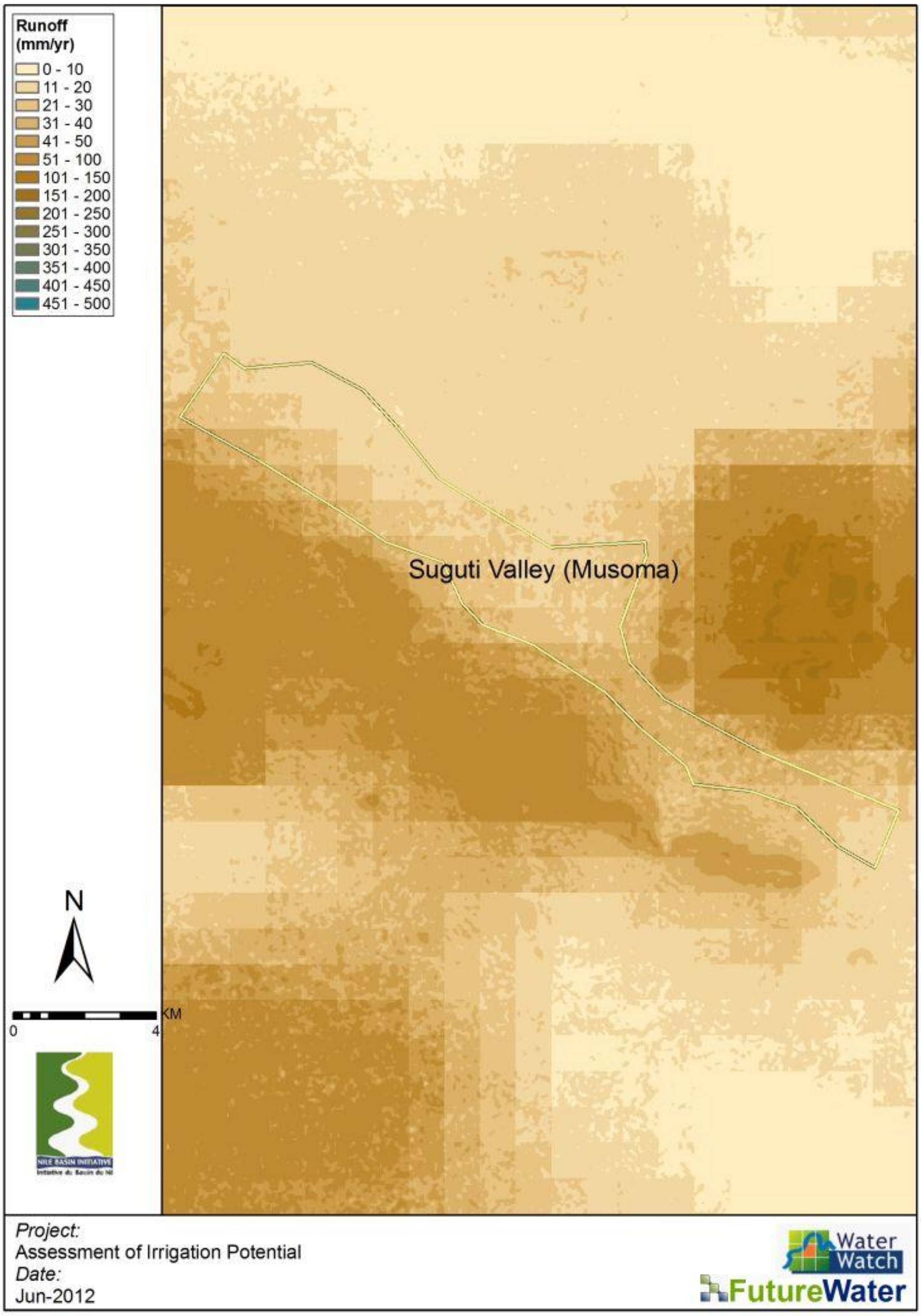
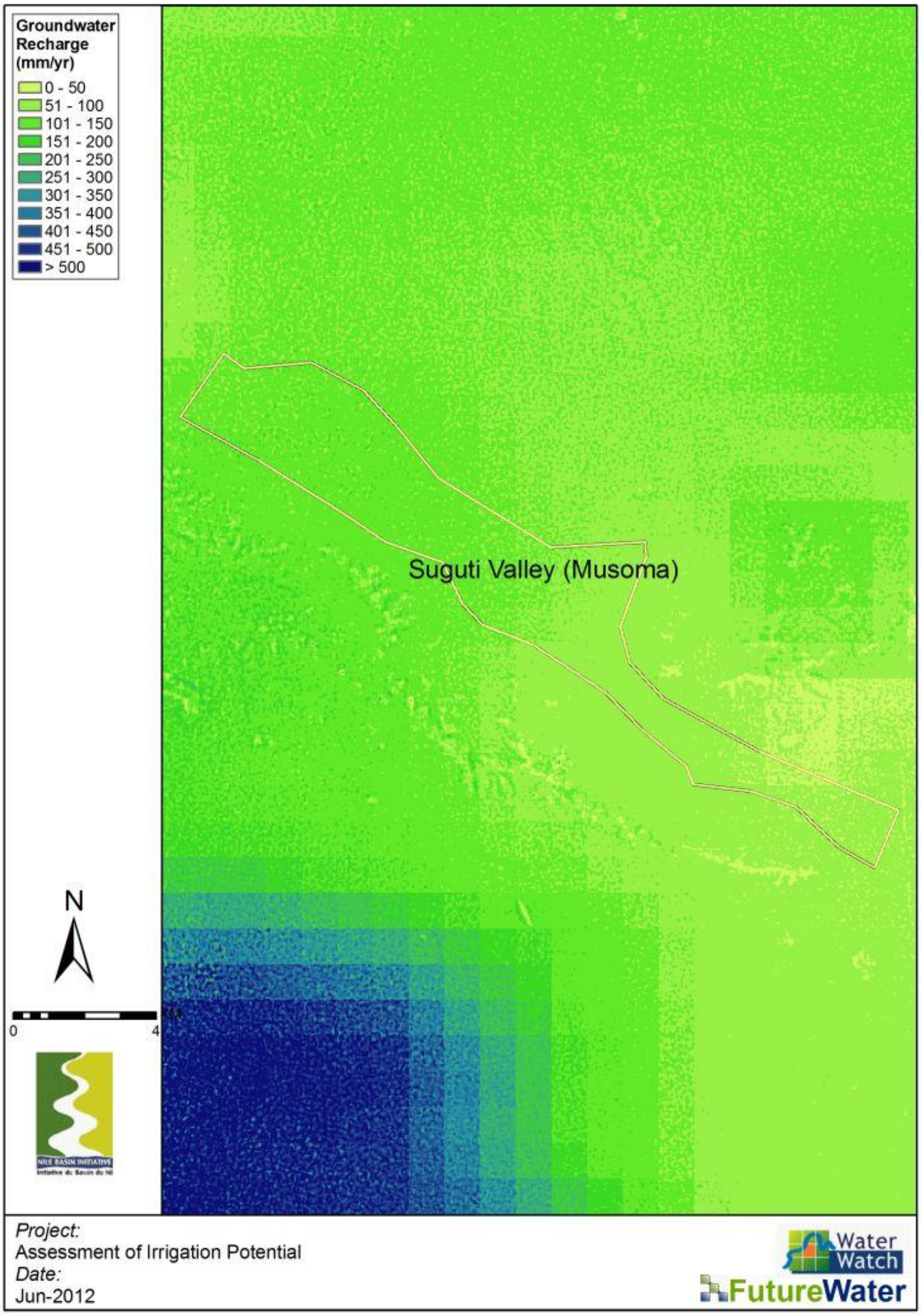



**Figure 111: Water balances for the area based on the high resolution data and modeling approach for Suguti Valley focal area.**


Runoff
(mm/yr)
0 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 100
101 - 150
151 - 200
201 - 250
251 - 300
301 - 350
351 - 400
401 - 450
451 - 500
Suguti Valley (Musoma)
N
KM
0
4
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater


Groundwater Recharge (mm/yr)
0 - 50
51 - 100
101 - 150
151 - 200
201 - 250
251 - 300
301 - 350
351 - 400
401 - 450
451 - 500
> 500
Suguti Valley (Musoma)
N
0
4
Project:
Assessment of Irrigation Potential
Date:
Jun-2012
Water Watch
FutureWater

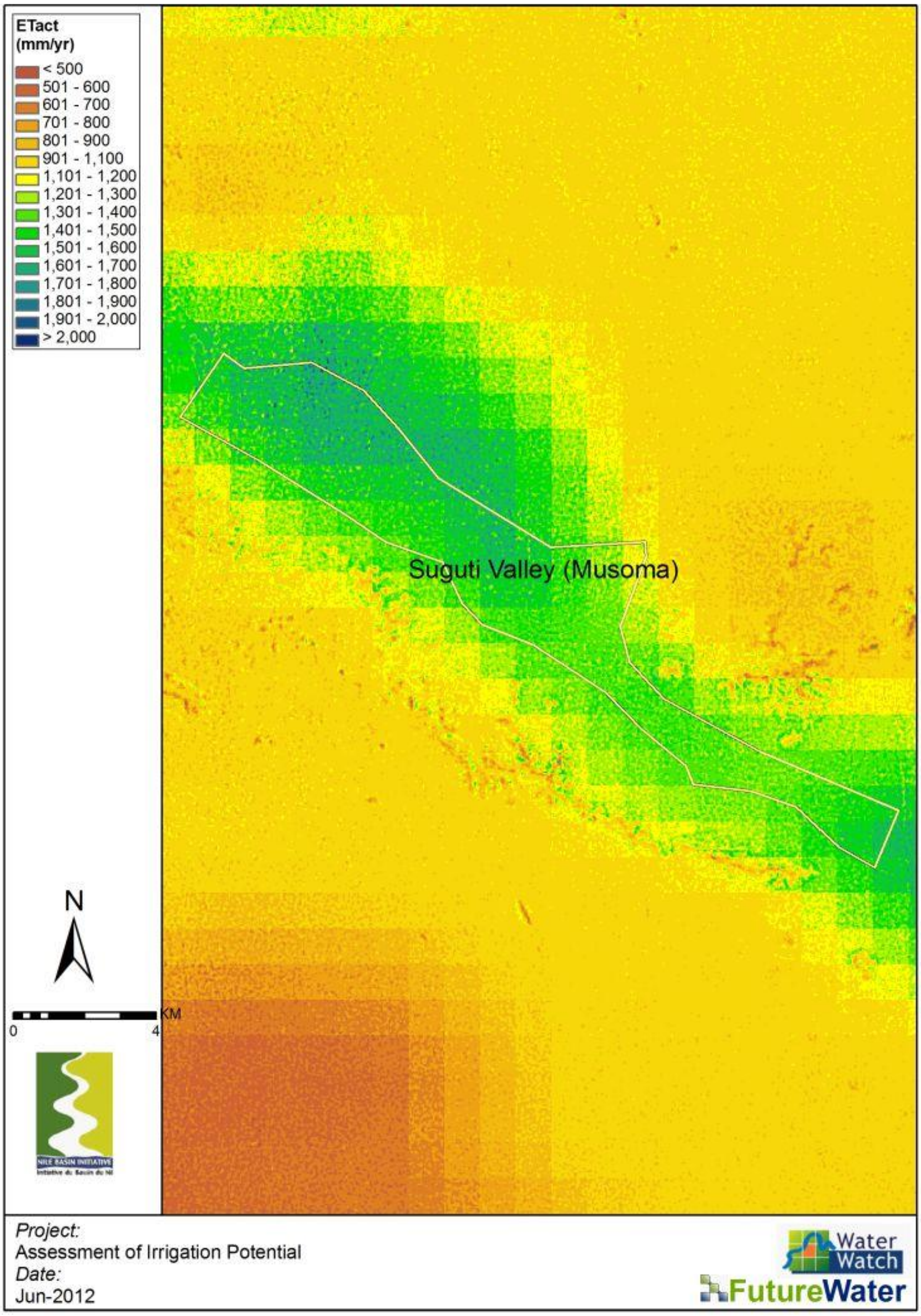



**Figure 112: Water balances for the area based on the high resolution data and modeling approach for Suguti Valley focal area.**

**Figure 113: Photograph from field inventory and assessment work for Suguti Valley focal area during May-June 2012.**

## 7.4 Assessment of irrigation water requirements

### *7.4.1 Irrigation water requirements*

Irrigation water requirements depend on many factors such as: climatic conditions, crop, growing season, irrigation practices etc. A first estimate of irrigation requirements could be based on the difference between rainfall and reference evapotranspiration. It was however selected for this pre-feasibility assessment to provide a first estimate of irrigation needs based on the most promising crops. To this end, FAO's AquaCrop, the successor of CropWat was setup for local and crop specific conditions.

All input files and output files for AquaCrop can be found in the database attached to the reports. Note that during this pre-feasibility phase focus with AquaCrop was to obtain crop water requirements. A subsequent feasibility study could focus more on the crop yield validation and calibration components of AquaCrop.

In the table below the irrigation water requirements for each selected crop are provided based on AquaCrop calculations. All units are provided in mm per growing season for the specific crops. Note that for various crops, like vegetables and similar crops, multiple croppings per years might occur.

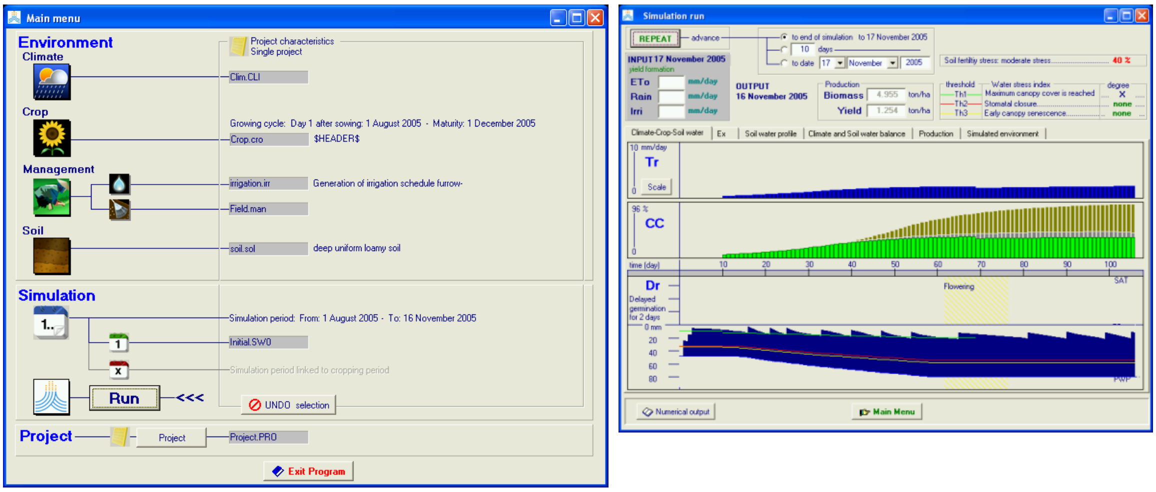



**Figure 114: Typical example of AquaCrop input and output screens.**

**Table 18: Irrigation water requirements for the selected crops in the focal areas. All units are given in mm per growing season.**

| Crop | Rain | ETref | Planting | Harvests | Rain | Irrigation | ETref | ETact |
|---|---|---|---|---|---|---|---|---|
| | === year === | | == (day of year) == | | ======== growing season ======= | | | |
| | (mm) | (mm) | | | (mm) | (mm) | (mm) | (mm) |
| Rice | 1005 | 1557 | 45 | 213 | 563 | 180 | 706 | 400 |
| Maize | 1005 | 1557 | 41 | 182 | 574 | 150 | 591 | 443 |
| Cassava | 1005 | 1557 | 349 | 167 | 751 | 190 | 757 | 569 |
| Cotton | 1005 | 1557 | 359 | 207 | 734 | 160 | 882 | 481 |
| Vegetables | 1005 | 1557 | 1 | 365 | 1005 | 130 | 1553 | 568 |

### *7.4.2 Water source and irrigation systems*

The Suguti Valley is located on the edge of Lake Victoria in a river valley. Most of the land is cultivated annually already, but irrigation is not practices yet. The river might be a potential source for water, although the reliability in flows has yet to be determined. This can be done during a possible feasibility study. Some details regarding water source and potential irrigation systems can be found in the following table:

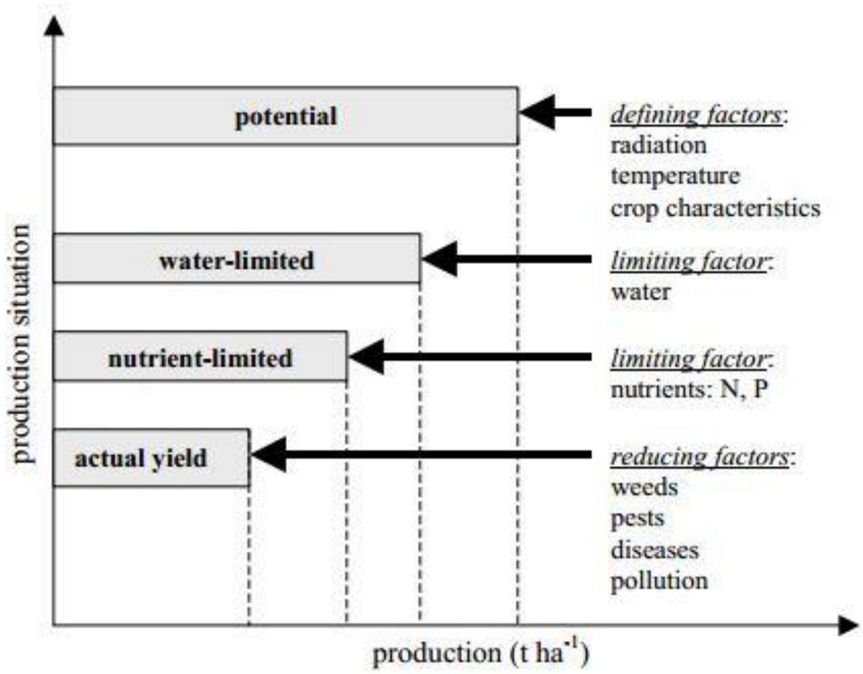
| | |
|---|---|
| *Potential irrigation sources* | River |
| *Stability of water source during the year (discharge range) please note about the stability* | Undetermined yet |
| *Potential for reservoir/ water harvesting (capacity)* | Undetermined yet |
| *Raining season (s)* | Bimodal two rain seasons |
| *Amount for precipitation mm/yr ( an estimate from local and experts)* | 600 – 700 mm |
| *Ground water levels which areas have less regimes? As from locals also* | 7000 mm |
| *Already irrigated area* | No |

## 7.5 Potential crop yield assessment

The yield gap describes the difference between the current yield, and the maximal possible yield. Mostly the maximal possible yield is defined as the highest yield in the world, but it can also be assessed against a regional background which makes the yield gap more realistic and the maximal yield possible to achieve under the given circumstances.

The gap between the actual yield and the potential yield can be caused by several processes. Factors which may cause that the maximal possible yield is not reached can be the water availability, the soil and the available nutrients, or yield reducing factors like diseases, weeds or pollution.

For the four proposed crops (paddy, maize, cassava, cotton and vegetables) potential crop yields are expected to be relatively high. The focal area is relatively fertile and additional irrigation might increase crop yields of these crops to higher yields compared to the country averages. Especially cassava, rice and cotton have a high potential to generate relatively high yields. Detailed analysis during a feasibility study should focus on a more in-depth analysis of the potential crop yields.



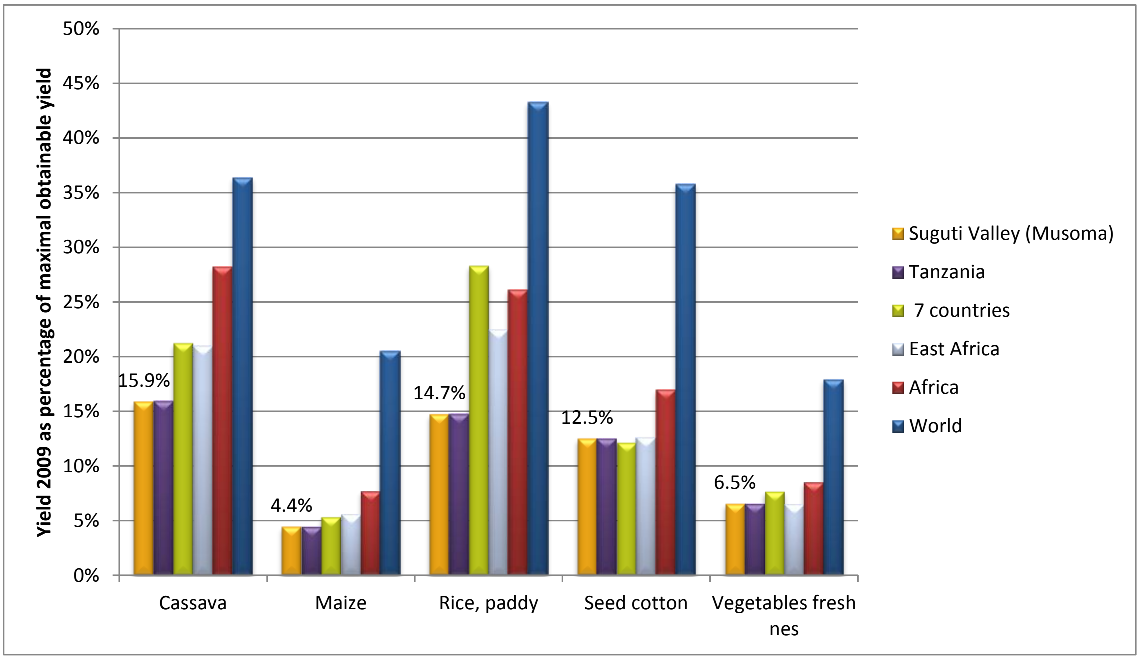



**Figure 115: Yield gap analysis (source: FAOSTAT, 2010).**

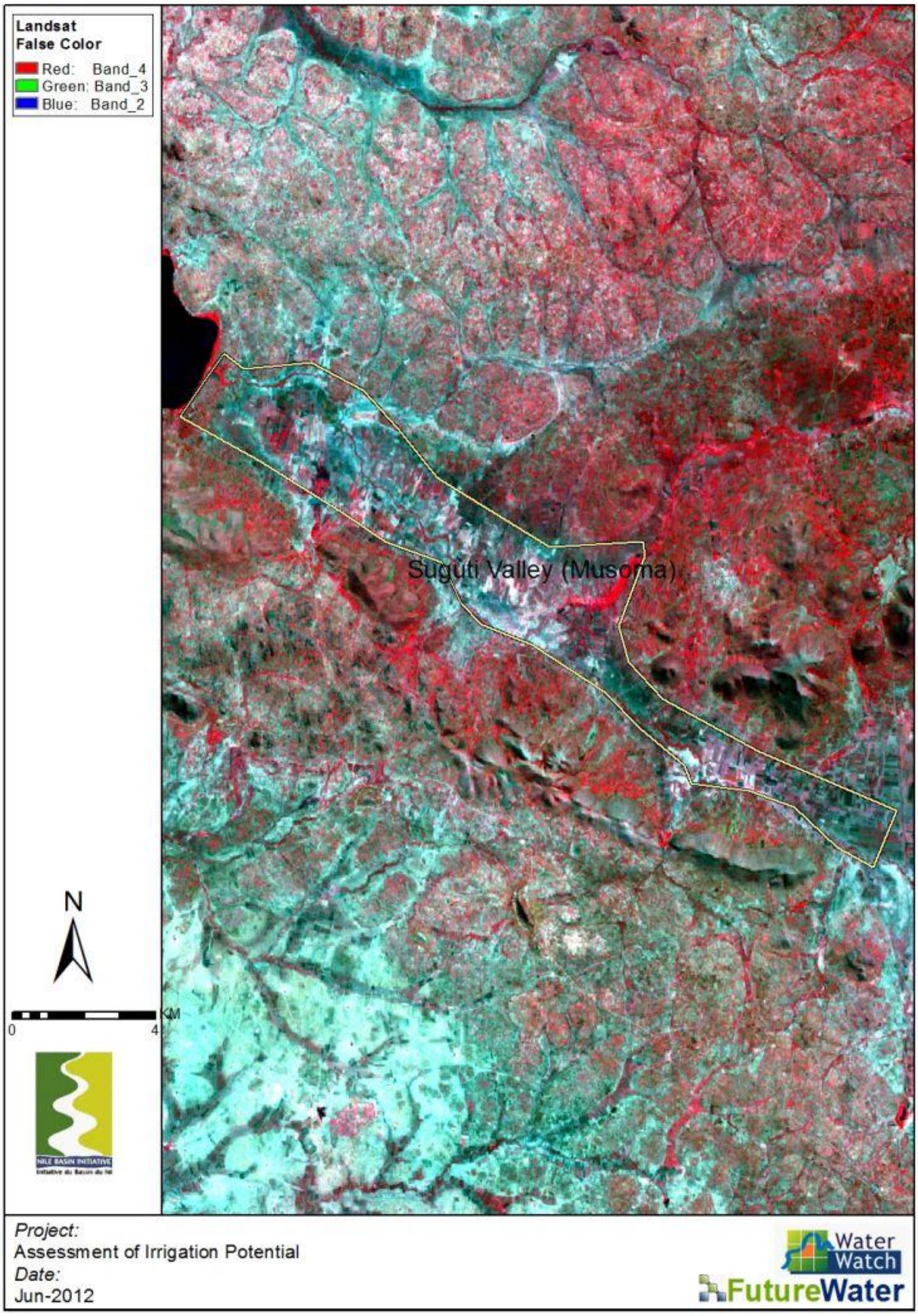



**Figure 116: Landsat False Color Composite indicating current productivity of the area for Suguti Valley focal area.**

## 7.6 Environmental and socio-economic considerations

### *7.6.1 Social and population considerations*

A first pre-feasibility assessment on the social context of the focal area has been undertaken. A field visit and additional data and information have been obtained regarding the focal area. Population density for the area is shown in the following map, while detailed concise information regarding social considerations is provided in the table.

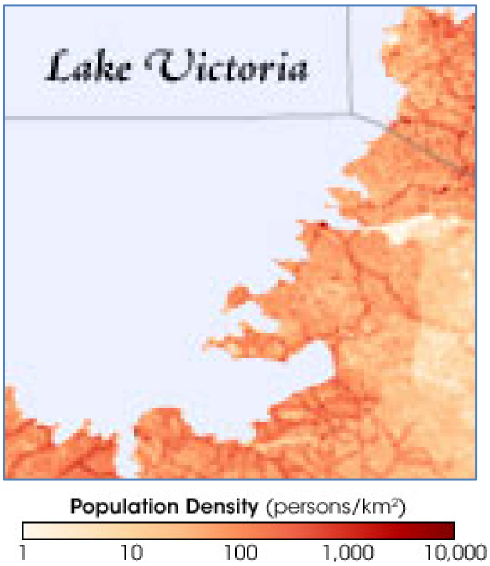



**Figure 117. Population density focal area (source: NASA Earths Observatory).**

| Focal point name | Suguti |
|---|---|
| Accessibility | 12/45km |
| Population rural density area | - |
| Which tribes inhabit the region? | Jita, kurya, luo,sukuma |
| Current welfare, unemployment, development. | 5 |
| Farmer’s expertise | low |
| Experience in agricultural cooperatives | middle |

### *7.6.2 Protected areas*

Within the focal area no protected areas are reported.

**Figure 118: Photograph from field inventory and assessment work forSuguti Valley focal area during May-June 2012.**

## 7.7 Benefit-cost Analysis

A simplified benefit-cost analysis is undertaken for the area. Information for this is based on various sources such as FAO publications, IFPRI publications, local expertise and data. A full benefit-costs analysis has to be undertaken in a sub-sequent feasibility study for the area.

Note that this is a first-order benefit-cost analysis. A feasibility study can provide a more rigorous benefit-cost analysis, which is required before taking any implementation planning. However, the following table shows that based on this first-order analysis investments in irrigation can have a positive impact.

Main assumptions for the benefit-costs analysis include:

- Irrigated land based on GIS and local experts for boundaries
- Number of farmers based on average land tenure area
- Irrigation infrastructure based on irrigation type and source
- Social infrastructure based on local expert judgment on farmers' trainings need
- Accessibility infrastructure based on generalized road conditions
- Internal Rate of Return based on 25 years
- Crop revenues based on local crop potentials and local market prices (crop, kg/ha, $/kg):
  - Rice: 3,500 kg/ha, 0.64 $/kg
  - Maize: 900 kg/ha, 0.29 $/kg
  - Cassava: 5,000 kg/ha, 0.28 $/kg
  - Cotton: 700 kg/ha, 0.51 $/kg
  - Vegetables: 5,000 kg/ha, 0.25 $/kg

Based on expert knowledge on the suitability to develop irrigation in the area scores between 1 (negative: low suitability or expensive) to 10 (positive: high suitability or low investments) have been marked. The filled radar plot below indicates the options for the focal area.

Overall, the area is attractive for investment. It has potentiality also other investments such as gold field. This is an added advantage for market growth. The weakness is that environmental is prone to be destroyed due to the mining activities. Moreover, according to the land terrain the area has a very high potential for paddy growing. The soil suitability and access to markets, its gentle slopes and flat lands where leveling is minimal hence reducing investment costs. Another weak point of the area is famer's knowledge on modern farming that is very low making the irrigation knowledge as new one ultimately requires farmers to be trained.

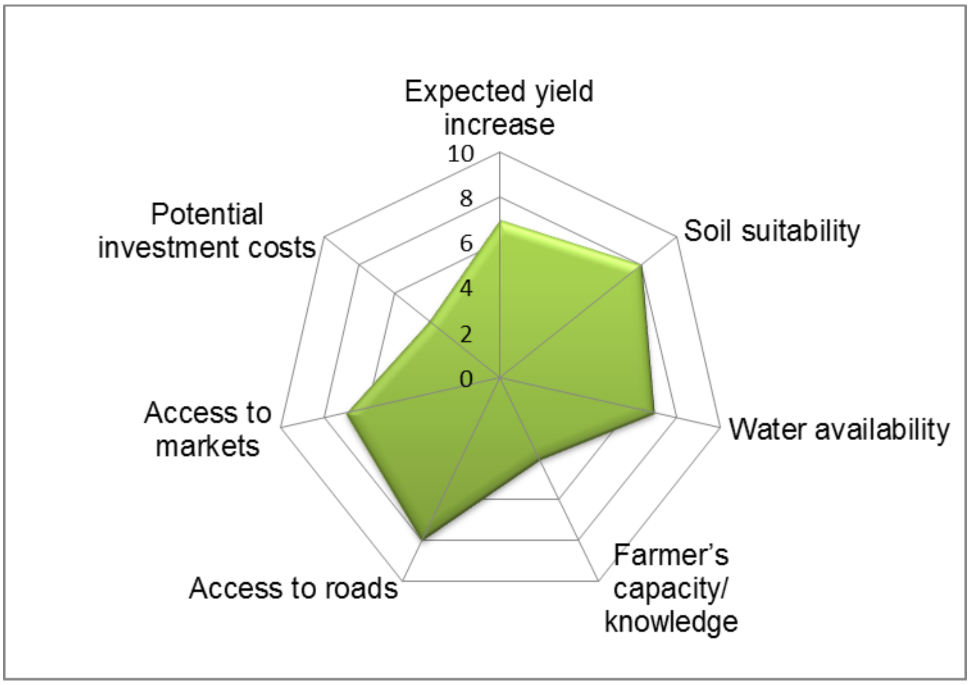



**Figure 119: Filled radar plot indicating expert knowledge score to develop irrigation in the Suguti Valley focal area (1 = negative, 10 = positive). (Source: local experts and study analysis).**

**Table 19: Key factors used for the benefit costs analysis as based on field and data inventories.**

| | |
|---|---|
| Irrigation technique | Border |
| Suitable area | 3500ha |
| Road building requirement | 20km |
| Pumping of water required | No |
| Reservoir building necessary | Yes |
| Soil improvement needed | No |

**Table 20: Benefit-cost analysis for Suguti Valley area.**

| | |
|---|---|
| **Characteristics** | |
| Irrigated land (ha) | 3,500 |
| Farmers | 2,917 |
| **Investment Costs** | |
| Irrigation infrastructure (US$/ha) | 4,000 |
| Social infrastructure (US$/farmer) | 500 |
| Accessibility infrastructure (million US$) | 1.0 |
| **Operational Costs** | |
| O&M irrigation (US$/ha/yr) | 60 |
| Extension service (US$/farmer) | 10 |
| O&M roads (US$/yr) | 20,000 |
| **Summary** | |
| Initial investments (million US$) | 16.5 |
| O&M costs (million US$/yr) | 0.259 |
| Net benefits per year (million US$/yr) | 2.304 |
| IRR (Internal Rate of Return) | 13.5% |

## 7.8 Recommendations

The cost benefit analysis as presented in this report is made in the scope of a pre-feasibility study. Although based on literature, expert knowledge and rapid field assessments by local experts it can rather be seen as an indication of expected costs and benefits. As much as possible local technical, social and hydrological factors are incorporated. However it is recommended to assess the costs and benefits in more detail during a feasibility study, which can focus more in depth on the local situation.