REPUBLIC OF MALAWI

MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT

Department of Irrigation

NATIONAL IRRIGATION MASTER PLAN AND INVESTMENT FRAMEWORK

Main Report

(Draft Final Version)

November 2014

SMEC

Local People. Global Experience.

Date: November 2014

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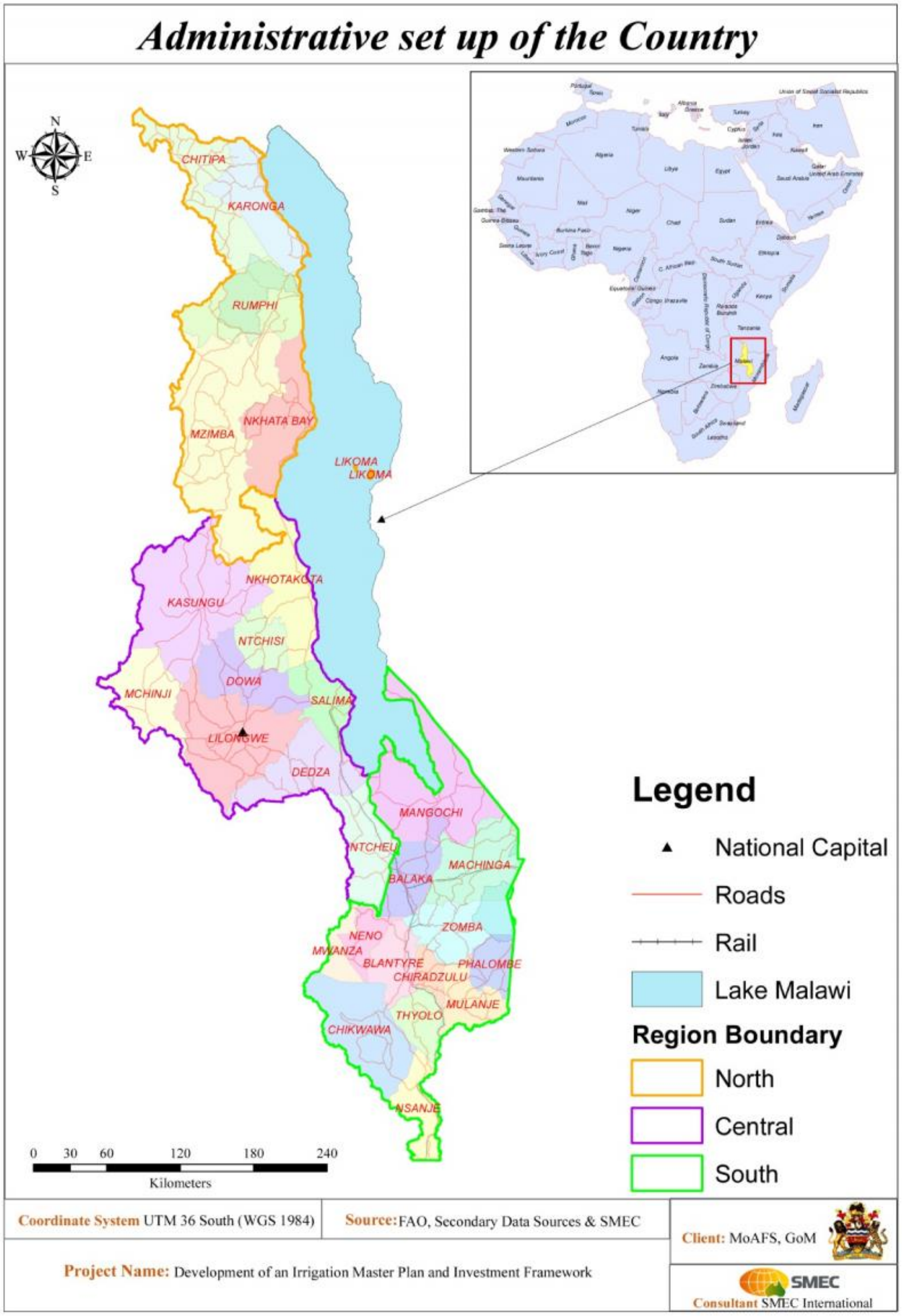
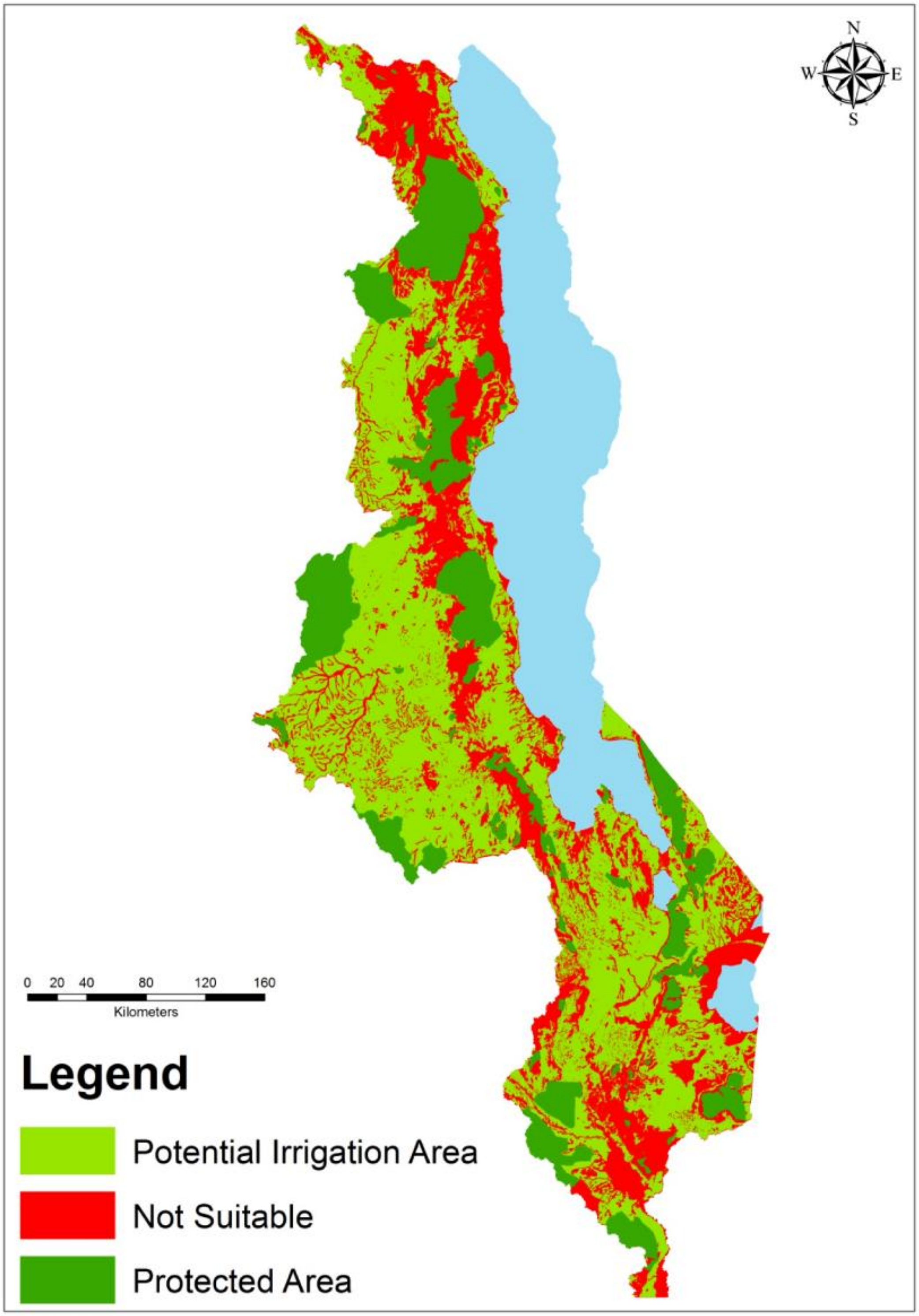
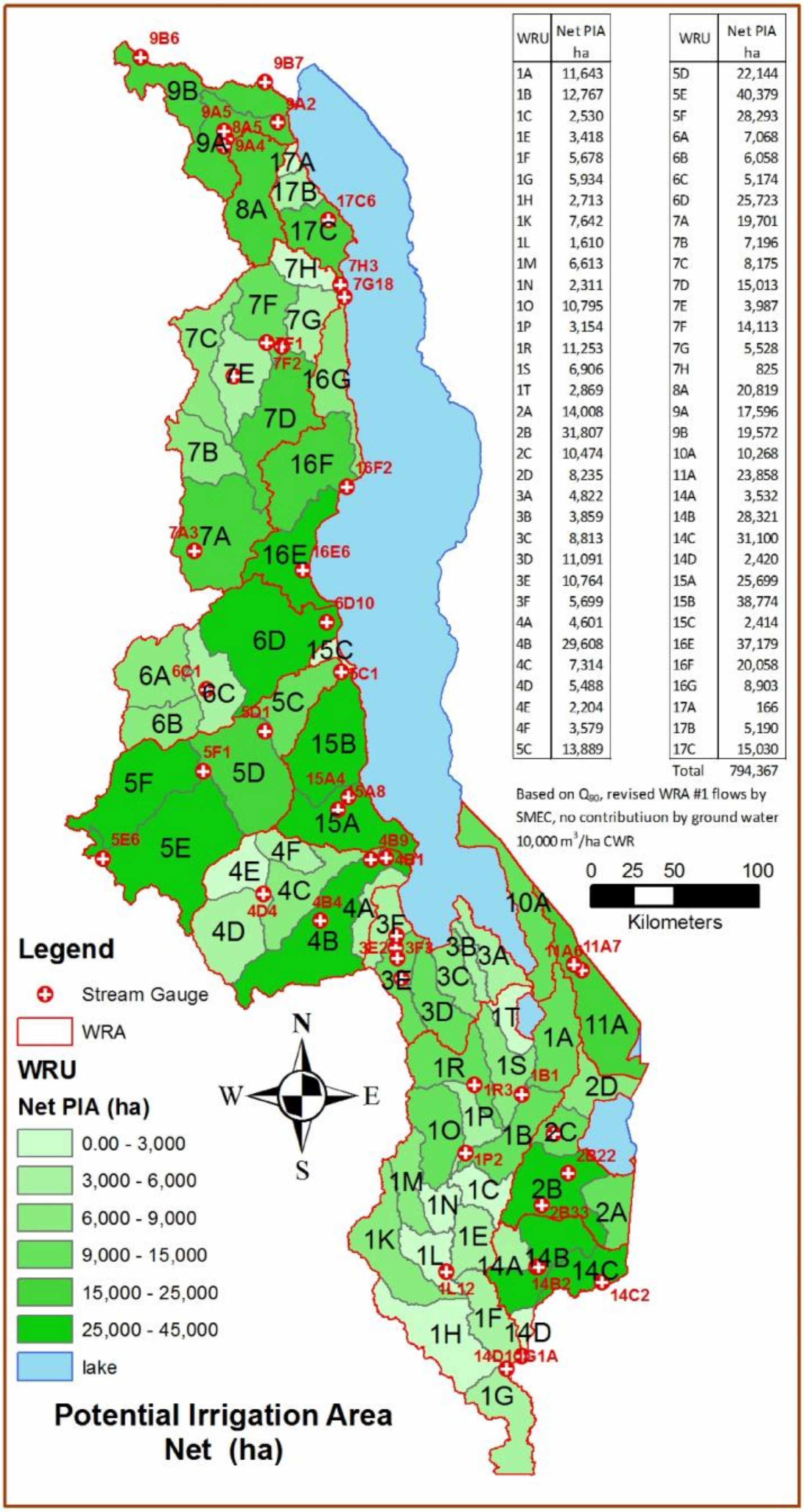
Local People. Global Experience.



Map 1: Location and Administration

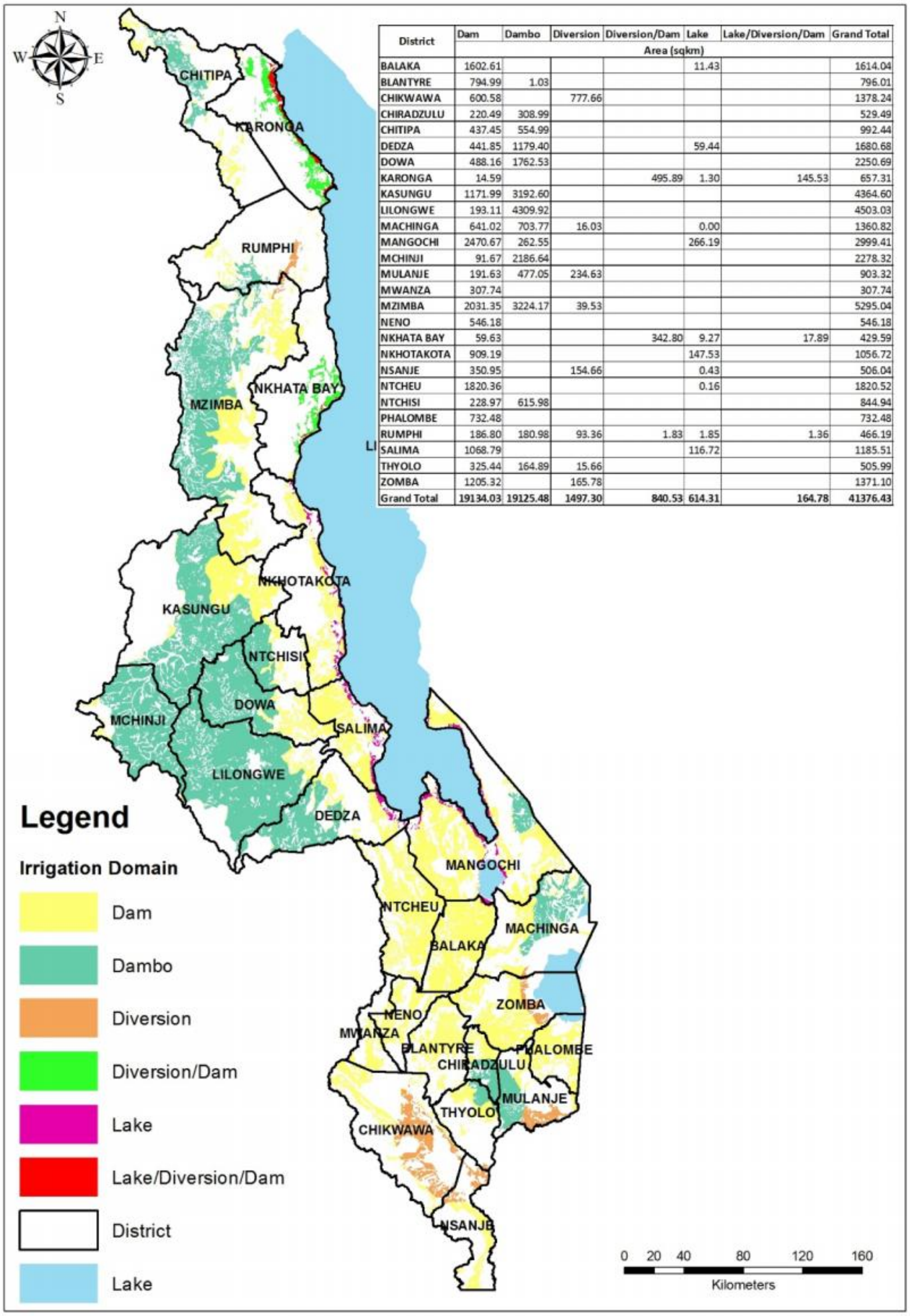


Map 2: Physical Potential Irrigation Area



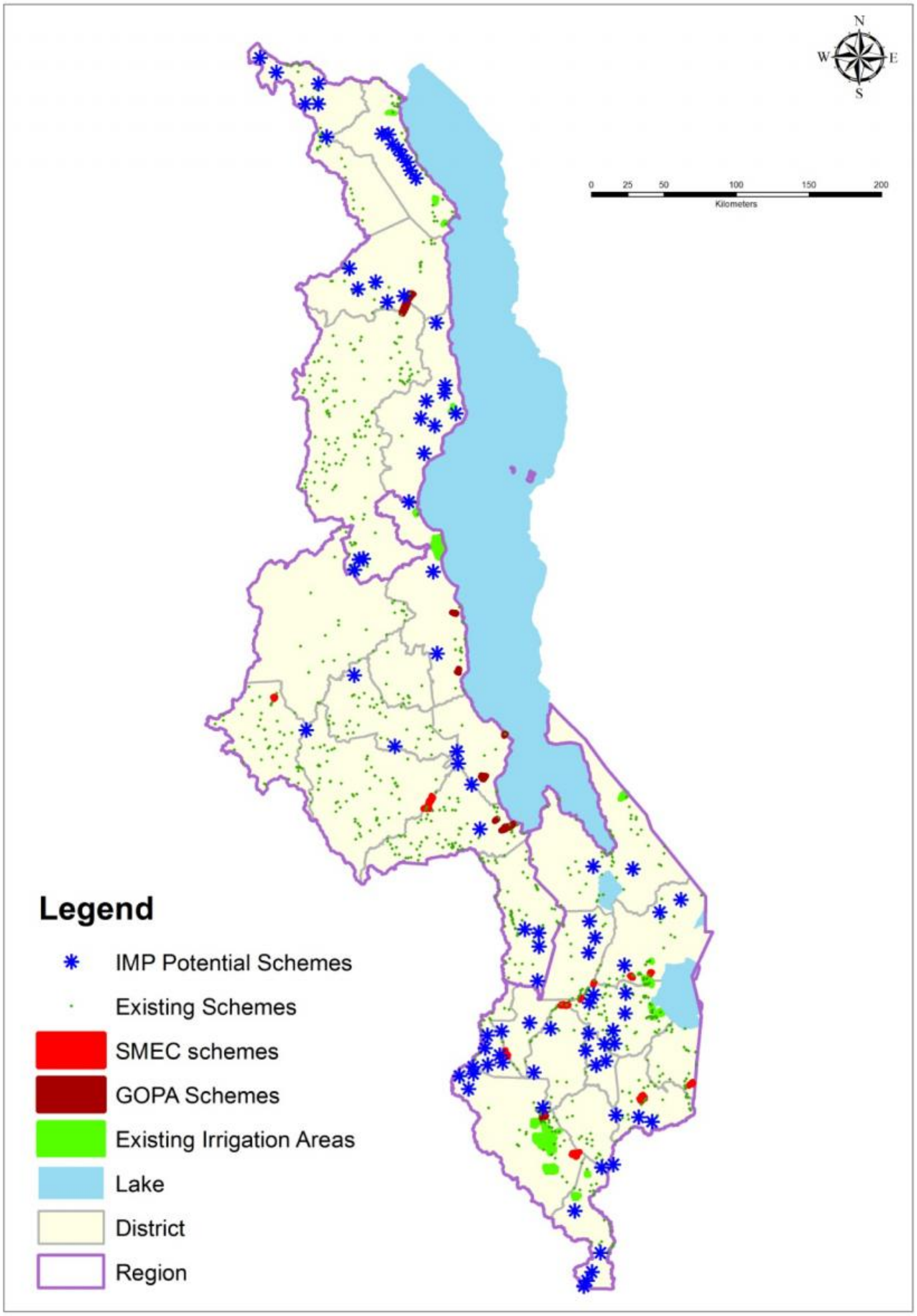
WRU	Net PIA ha	WRU	Net PIA ha
1A	11,643	5D	22,144
1B	12,767	5E	40,379
1C	2,530	5F	28,293
1E	3,418	6A	7,068
1F	5,678	6B	6,058
1G	5,934	6C	5,174
1H	2,713	6D	25,723
1K	7,642	7A	19,701
1L	1,610	7B	7,196
1M	6,613	7C	8,175
1N	2,311	7D	15,013
1O	10,795	7E	3,987
1P	3,154	7F	14,113
1R	11,253	7G	5,528
1S	6,906	7H	825
1T	2,869	8A	20,819
2A	14,008	9A	17,596
2B	31,807	9B	19,572
2C	10,474	10A	10,268
2D	8,235	11A	23,858
3A	4,822	14A	3,532
3B	3,859	14B	28,321
3C	8,813	14C	31,100
3D	11,091	14D	2,420
3E	10,764	15A	25,699
3F	5,699	15B	38,774
4A	4,601	15C	2,414
4B	29,608	16E	37,179
4C	7,314	16F	20,058
4D	5,488	16G	8,903
4E	2,204	17A	166
4F	3,579	17B	5,190
5C	13,889	17C	15,030
		Total	794,367

Map 3: Net PIA (based on physical and water resources)



District	Dam	Dambo	Diversion	Diversion/Dam	Lake	Lake/Diversion/Dam	Grand Total
	Area (sqkm)						
BALAKA	1602.61				11.43		1614.04
BLANTYRE	794.99	1.03					796.01
CHIKWAWA	600.58		777.66				1378.24
CHIRADZULU	220.49	308.99					529.49
CHITIPA	437.45	554.99					992.44
DEDZA	441.85	1179.40			59.44		1680.68
DOWA	488.16	1762.53					2250.69
KARONGA	14.59			495.89	1.30	145.53	657.31
KASUNGU	1171.99	3192.60					4364.60
LILONGWE	193.11	4309.92					4503.03
MACHINGA	641.02	703.77	16.03		0.00		1360.82
MANGOCHI	2470.67	262.55			266.19		2999.41
MCHINJI	91.67	2186.64					2278.32
MULANJE	191.63	477.05	234.63				903.32
MWANZA	307.74						307.74
MZIMBA	2031.35	3224.17	39.53				5295.04
NENO	546.18						546.18
NKHATA BAY	59.63			342.80	9.27	17.89	429.59
NKHOTAKOTA	909.19				147.53		1056.72
NSANJE	350.95		154.66		0.43		506.04
NTCHEU	1820.36				0.16		1820.52
NTCHISI	228.97	615.98					844.94
PHALOMBE	732.48						732.48
RUMPHI	186.80	180.98	93.36	1.83	1.85	1.36	466.19
SALIMA	1068.79				116.72		1185.51
THYOLO	325.44	164.89	15.66				505.99
ZOMBA	1205.32		165.78				1371.10
Grand Total	19134.03	19125.48	1497.30	840.53	614.31	164.78	41376.43

Map 4: Irrigation Domains



Map 5: Potential Irrigation Schemes

EXECUTIVE SUMMARY

Introduction

The fundamental importance of irrigation in the development of Malawi is recognised in successive national development plans. However, to date only 94, 000 hectares have been developed for irrigation despite the considerable potential that exists. The absence of a comprehensive IMP and investment framework has contributed to a fragmented and stop/go approach to irrigation development and the lower-than-expected rate of expansion. It also makes it difficult to prepare a long-term financing plan and to harmonise efforts among and between the various sources of finance (government, development partners, private sector, farmers etc.). The IMP therefore defines a development plan and financing framework to guide the expansion of the irrigation subsector over the coming years, highlighting priorities for investment and arrangements for coordination and managing implementation.

Background

Importance of Irrigation

Malawi's agricultural sector, employs about 80% of the workforce, accounts for a third of GDP and underpins national food security and exports. Irrigation plays a small but important role in the sector but has the potential to contribute much more. Only about 4% of crop land is currently irrigated but land and water resources are sufficient to more than double this amount. The total area of irrigated land stood at 94,000 ha in 2013 of which about 53% was estates and 47% smallholder. The irrigated area has been growing steadily since 2006 at the rate of around 5% per annum. Almost all of the growth has been on smallholder schemes. Overall there are around 56,600 household beneficiaries of smallholder irrigation schemes, but these represent only around 3.3% of all rural households.

The contribution of irrigation to agricultural sector GDP is in the range of 7-12%, and to the economy as a whole of between about 2% and 4%. This represents between US$ 80 million and US$ 140 million or between about US$ 850 and US$ 1,550 per irrigated hectare. Existing irrigation schemes and associated infrastructure have a replacement value of well over a billion dollars. However, the importance of irrigation is greater than shown by its contribution to GDP. Commodities produced under irrigation make up the bulk of Malawi's exports and smallholder irrigation is of particular significance to food and nutrition security, rural income generation and rural poverty reduction.

Policy and Institutional Framework

Increased investment in irrigation is consistent with Malawi's higher level development plans and aspirations articulated in Vision 2020 and the Malawi Growth and Development Strategy II (MGDS II). The Agricultural Sector-Wide Approach (ASWAp) (2011-15) presents a priority investment programme that aims to accelerate agricultural development based on the priority agricultural elements of MDGS II. Development of irrigation can make a significant contribution to the ASWAp objectives. Irrigation also occupies a prominent position in a number of sectoral and sub-sectoral strategies including: (i) the National Water Policy (2005); (ii) the Water Resources Investment Strategy (2011); (iii) the Malawi Water, Sanitation and Irrigation Sector Strategic Plan (2013); (iv) the Department of Irrigation Strategic Plan (2011-16); (v) the Draft National Irrigation Policy and

Development Strategy (2014); (vi) the National Export Strategy (2013-2018); and (vii) the Draft National Water Resources Master Plan.

Since irrigation spans a range of fields the institutional framework is necessarily diverse and poses significant coordination challenges. A holistic approach to irrigation development calls for the participation of many government institutions covering agriculture, land, water, infrastructure, transport, commerce and trade, finance, environment, training and community development; as well as farmer organisations, NGOs and the private sector. Due to financial and human resource limitations most of the relevant institutions in Malawi struggle to fulfil their mandates. This is exacerbated by frequent organisational and management changes, and lack of coordination between institutions.

Experience and Lessons Learned

Stakeholder consultations identified a number of challenges to be addressed by the IMP including: (i) land tenure issues which are seen as critical to success and sustainability; (ii) ensuring that women participate in decision making; (iii) difficulty changing the mindset of subsistence-oriented farmers; (iv) difficulty accessing financial services in rural areas; (v) lack of financial management skills of farmers and farmer organisations; (vi) inadequate funding of government support services; and (vii) marketing and transport issues. Sustainability is often an issue in smallholder schemes due to inability to collect water charges. The stakeholder consultations also emphasised the need for management of the whole catchment in order to reduce erosion and sedimentation.

A review of lessons learned from irrigation development in Sub-Saharan Africa revealed that the average cost of new irrigation schemes (including both hardware and software) was almost US$ 19,000 per ha in today's values, and for scheme rehabilitation around US$ 6,600. Economic rates of return averaged 11% for new schemes and 14% for rehabilitation, but with wide variations.

Review of lessons learned in Malawi demonstrates that Malawi can implement irrigation development successfully both large scale commercial schemes and smallholder-based approaches. There have been successes and failures in both categories, the reasons for which are fairly well understood. In particular, it has been found that successful irrigation development is much more than just designing and constructing schemes. It requires an approach which addresses diverse and often complex legal, institutional, technical, marketing, social and economic issues in a balanced and holistic manner.

Constraints

Irrigation development is unavoidably capital intensive, and has to compete with many other investment needs for the limited funding available. Farmers have very limited capacity to invest their own capital, or to borrow money for investment, and most of the investment therefore needs to come from the private sector, GoM and its development partners. The acute shortage of capital for public investment is exacerbated by the many policies, strategies and plans for irrigation development, which are only now being consolidated into a single IMP. Moreover, until now there has been no consolidated data base on existing irrigation schemes, natural resources, infrastructure and irrigation potential which can be used for systematic planning of irrigation development. A further consequence of the shortage of funding is weak institutional capacity at both central and district levels. Additionally, responsibility for irrigation is dispersed among various ministries and departments, and there have been frequent changes to institutional arrangements. Some laws and regulations affecting irrigation also need to be rationalised, especially concerning land tenure.

The performance of existing irrigation schemes also faces a number of constraints. The exceptionally large number of small irrigation schemes is difficult to service and support. Cost recovery to fund O&M tends to be weak, resulting in declining system functionality over time. Because farmers are generally not required to pay for the water they use, they tend to grow low-value staple food crops which limit economic performance. High erosion rates in catchment areas due to inappropriate agricultural practices means that dams and weirs experience very high siltation rates. There are also significant marketing challenges in a landlocked country surrounded by countries that produce similar things, and with a small (but growing) urban demand for food. In some situations irrigation has to compete with rapidly growing demand for hydro-electric power.

Opportunities

Whilst past performance of the sub-sector has been below potential, there are many opportunities which have not yet been fully realised. National and sectoral policy settings are favourable for development of irrigated agriculture. Assessment of land suitability has identified a large area of land suitable for irrigation, and the country's topography is such that many sites that could be irrigated by gravity schemes. Hydrological studies have also revealed that Malawi has sufficient un-used water to irrigate some 800,000 hectares, four years out of five, after allowing for other uses (domestic, industrial, hydropower and environmental flows). In some potential schemes it may be possible to generate hydro power to offset the costs of irrigation development, (eg. Ruo, Dwambezi Songwe).

Experience over the last 10-20 years has yielded many valuable lessons about the best approaches to irrigation development in terms of technologies, organisational structures, management systems and sustainability. The private sector has demonstrated a willingness to invest in irrigation development and there are several successful examples of outgrower schemes (eg Kasanthula, Phata and Dwangwa) associated with commercial scale plantations and processing facilities. In addition, Malawi's development partners have expressed strong interest in supporting irrigation development both financially and technically.

General Approach

The design of the IMP is based on a balanced and holistic approach which considers the constraints and opportunities within the context of national and agricultural sector development strategies. It draws on global best-practice models but is tailored to Malawi's unique social, economic, geographic, hydrological, climatic and agricultural environment. The key features of the approach include:

- The need to be results oriented and highly selective in identifying specific elements of the plan based on systematic and transparent selection procedures including a minimum 10% EIRR.
- Recognition that the IMP is more than just an aggregation of irrigation schemes that pursue hectarage targets. There are many complementary measures needed to ensure that these investments deliver the expected results, eg catchment conservation and CA.
- Employment of a variety of different strategies and approaches in pursuit of IMP objectives, reflecting the reality that no one approach is best in all circumstances.

- Differentiation of irrigation development objectives by target groups and beneficiaries ranging from smallholder subsistence-oriented households to agribusiness companies.
- Recognition of the complexity of land tenure issues, the barrier this can impose and the need to negotiate secure tenure arrangements before investment takes place, eg. MM and GBI Chikwawa.
- The need to adopt a market-led approach to improve the connectivity between irrigation farmers and the end-users of their produce, eg. MM and sugar outgrowers (Dwangwa, Kasinthula).
- The need for a long-term planning horizon which recognises that water will become increasingly scarce over the life of the IMP.
- Consideration of the financing needs of the IMP and options for procuring the necessary investment and operating funds.
- Concerns about social and environmental issues and how these should be assessed, managed and mitigated, IMP adopted the DRM-EFR using varied % for wet and dry periods.
- Sustainability issues including the need to generate revenue to finance O&M, and adoption of a whole catchment approach to prolong system life through reduced erosion and siltation rates.
- The need for institutional rationalisation and capacity development in both the public and private sectors.
- Adoption of best-practice procedures for involvement of WUAs in the design, construction and management of irrigation schemes.

Potential for Irrigation Development

Identification of Potential Irrigation Areas

The IMP identifies priorities for irrigation development over the period 2015-2035 based on a screening and selection process which begins by considering the whole country in terms of its irrigation potential, and progressively narrows down the target areas by applying different selection criteria. The first step in this process was a comprehensive biophysical assessment using a spatially-defined database and maps including the following elements:

- Administrative boundaries, Water Resource Areas (WRAs) and Water Resource Units (WRUs)
- Population and infrastructure
- Livelihood Zones
- Relief and physiography
- Soil suitability for irrigation, including erosion potential
- Existing land use, including protected areas
- Climate (temperature, rainfall,) and agro-climatic zones
- Surface and groundwater hydrology and sustainable water yields by WRA
- Cropping patterns and seasonality of water demand

The next step was to estimate the potential irrigation areas based on physical criteria (PIA_{phy}) including topography (slope), soil suitability and existing land use. This estimated PIA_{phy} to be around 4.2 million hectares (see Map 2 above) indicating that in most parts of the country availability of suitable land is not a constraint. Following this, hydrological assessment identified those parts of the country with sufficient available water to sustain irrigation by calculating the 80% reliable annual stream flow (Q_{80}) in each WRU, and deducting environmental flow and domestic water requirements. This demonstrated that in most WRUs water availability is the limiting factor, although in a few cases there is more water available than suitable land. After considering both land and water constraints the potential irrigation area (PIA) was estimated to be about 800,000 hectares, with water being the limiting factor in most parts of the country, (see Map 3 above).

The final step in assessing the potential for irrigation development was to identify and rank potential irrigation schemes (PISs) within the constraints of water availability already defined. The thirty top-ranked schemes are listed in Table 1 below.

Table 1: Top 30 Ranked Irrigation Schemes

Criterion Description	District	Area (ha)	Capital Costs (US$)	Unit Cost (US$/Ha)	EIRR (%)	Rank #
Ruo - Diversion	Thyolo/Nsanje	8,858	16,810,549	1,898	34	1
Nkawinda/Bakasala	Blantyre	560	790,000	1,411	30	2
Chilingali	Nkhotakota	1,200	2,410,000	2,008	33	3
Dwambazi	Nkhata bay/Nkhotakota	4,256	6,638,299	1,560	28	4
Mlooka	Zomba	153	730,000	4,771	14	5
Nthiramanja	Mulanje	6,381	22,419,433	3,514	21	6
Matoponi	Zomba	115	590,000	5,130	14	7
Kasano	Karonga	233	947,548	4,067	22	8
Lembani	Ntcheu	190	443,187	2,328	31	9
Nkhulambe/Wowo	Phalombe	300	1,444,000	4,813	14	10
	Total	**22,246**	**53,223,015**	**2,392**	**24**	

Criterion Description	District	Area (ha)	Capital Costs (US$)	Unit Cost (US$/Ha)	EIRR (%)	Rank #
Chipofya Diversion	Rumphi	686	2,004,275	2,922	27	11
Likabula/Kholiwe	Mulanje	628	3,947,000	6,285	11	12
Likhubula/Nthumbula	Chikwawa	419	3,410,000	8,138	12	13
Mpamba	Nkhata bay	1,266	6,137,338	4,848	20	14
Welusi	Karonga	2,722	5,210,087	1,914	34	15
Ilengo	Chitipa	3,254	13,006,491	3,997	19	16
Linga	Nkhata bay	2,434	5,759,625	2,366	31	17
Mwambazi	Nkhata bay	2,261	12,196,968	5,394	18	18
Mdenga	Balaka	294	2,119,286	7,217	11	19
Msenga	Nkhata bay	1,964	5,023,943	2,558	30	20
	Total	**15,928**	**58,815,013**	**3,692**	**21**	

Criterion Description	District	Area (ha)	Capital Costs (US$)	Unit Cost (US$/Ha)	EIRR (%)	Rank #
Chizimbi	Chikwawa	306	1,979,000	6,467	16	21
Mwenelupembe	Karonga	3,036	7,316,085	2,409	30	22
Ukanga	Karonga	5,765	13,675,680	2,372	31	23
Mtuwa	Mangochi	1,553	12,536,009	8,071	12	24
Mkulumadzi	Mwanza/Neno	321	3,070,000	9,564	10	25
Marko	Chitipa	465	2,407,218	5,177	19	26
Ngemela	Karonga	2,278	18,512,117	8,126	12	27
Mafinga Hill	Chitipa	43	244,307	5,682	15	28
Kamwanyoli	Nkhata Bay	120	968,000	8,067	12	29
Mwenilondo	Karonga	818	2,964,865	3,623	24	30
	Total	**14,706**	**63,673,282**	**4,330**	**18**	

Five types of scheme, known as irrigation domains, were identified: (i) diversion domain covering the limited areas of the country with good dry season flows; (ii) dambo domain in the plateau region; (iii) dam domain in areas downstream from good dam sites; (iv) lake domain requiring pumping; and (v) combined diversion/dam domain where there is potential for diversion but where dams are preferred, see Map 4.

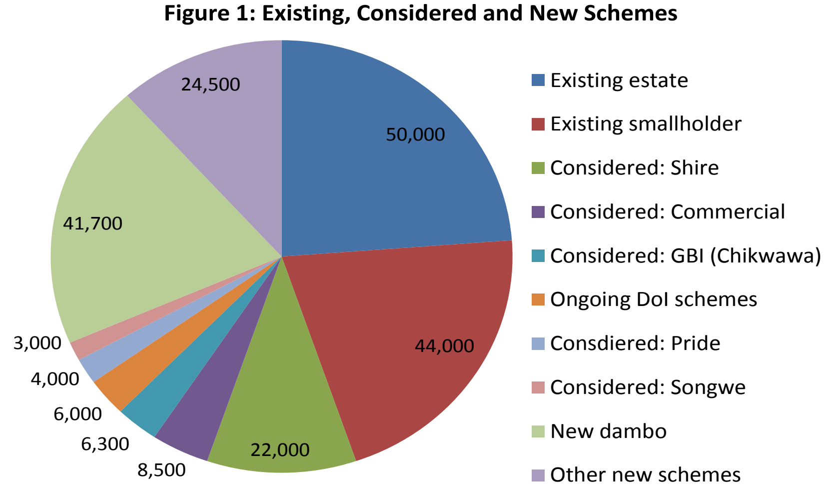
The large fluctuations between wet and dry season flows means that the potential for diversion schemes is very limited, and most suitable sites have already been developed, with the exception of the Shire and Ruo Rivers. This means that future irrigation development will have to rely mostly on dam storage. However over extensive areas of plateau there are no suitable large dam sites so dambo irrigation will remain the predominant irrigation method aided by construction of small dams, which help to retain water for multiple uses, including irrigation. Direct pumping from Lake Malawi also has limited potential if a maximum lift of 15 metres is applied (pumping more than 15 metres is generally only economic for high value crops).

The IMP recognises that in the past irrigation schemes and dam construction have been associated with land grabbing, and hence received a poor reputation. This is so bad in some parts of the country the mention of irrigation or dams has led to life threats, and clearly there is a lot of sensitisation required to help the beneficiaries become aware of the benefits of irrigation and dam storage. This approach must involve farmer participation from the conception of schemes. In addition, the catchments of all dam storage schemes and diversion schemes will be part of the financed project to implement conservation of water and land. Conservation agriculture will be a large part of the project. The training of extension workers and irrigation technicians is also a key component of the IMP.

IMP Targets

Malawi's land and water resources are such that the maximum area of irrigation land which could be developed and sustainably managed is around 297,000 hectares of which 94,000 hectares had been developed by 2013. Taking into consideration growing demand for water from other sources (domestic, industrial, hydropower, and environmental flows), the importance of selecting schemes which generate the best social and economic benefits, the likely impacts of climate change, and Malawi's capacity to finance and implement new schemes as well as manage existing ones, the IMP aims to reach a total irrigated area of 210,000 hectares by 2035, or an **increase of 116,000 hectares**. This is consistent with the allocation of water resources in the Draft Water Resources Master Plan.

Figure 1: Existing, Considered and New Schemes



The plan incorporates all existing and potential irrigation schemes in the country and includes: (i) existing schemes (formal and informal, commercial and smallholder, public and private); (ii) considered schemes (those already identified and in various stages of feasibility, design or construction); and (iii) new potential schemes (those identified and assessed during IMP preparation) see Figure 1 and Table 2.

Table 2: Existing, Considered and New Irrigation Schemes in the IMP

	Hectares	% of Total	Max Potential
Existing Schemes (2013)			
Estate	50,000	23.8	70,000
Smallholder	44,000	30.0	80,000
Sub-Total	**94,000**	**44.8**	**150,000**
Considered Schemes			
Shire Valley	22,000	10.5	22,000
Commercial estates	8,500	4.0	8,500
GBI (Chikwawa)	6,300	3.0	6,300
Ongoing DoI schemes	6,000	2.9	6,000
PRIDE schemes	4,000	1.9	4,000
Songwe River	3,000	1.4	3,000
Sub-Total	**49,800**	**23.7**	**49,800**
New Potential Schemes			
Dambo irrigation	41,700	19.9	66,000
Other new schemes	24,500	11.7	31,200
Sub-Total	**66,200**	**31.6**	**97,200**
Total	**210,000**	**100.0**	**297,000**

Should any of the considered schemes not eventuate there is scope to considerably expand the number and area of new potential schemes. The IMP has identified and completed pre-feasibility studies for some 86 potential schemes of which around 30 with a total area of almost 60,000 hectares are estimated to generate economic returns (EIRR) of 15% or greater, see Table 1.

The Master Plan

Objectives, Components and Expected Results

The logframe in the main report presents the IMP goal, objectives, outcomes and outputs together with milestone indicators to be used in monitoring progress. The overall goal of the IMP is to contribute to the MGS II objective "*to continue reducing poverty through sustainable economic development and infrastructure development*". The two key indicators of goal achievement will be: (i) the percentage of rural households below the poverty line; and (ii) the Malawi human development index.

The objectives of the IMP are to "*accelerate economic growth, reduce rural poverty, improve food security and increase exports*". These objectives recognise the multi-functional nature of irrigation investment with different development modalities addressing different objectives. The four key indicators for these objective are: (i) the percentage contribution of irrigated agriculture to GDP; (ii) the prevalence of poverty in irrigated versus rainfed areas; (iii) the percentage of food secure households in irrigated versus rainfed areas; and (iv) the value of exports derived from irrigated agriculture.

The master plan consists of four mutually supporting components including the development of selected new irrigation schemes, sustainable management of existing schemes, building the capacity of Malawi's relevant institutions and human resources, and management of master plan implementation. Each component is expected to deliver one specific outcome as follows:

Component	Expected Outcome
1. New Irrigation Development	• Area of irrigated land increased from 94,000 ha to 210,000 ha
2. Sustainable Irrigation Management	• Land and water resources efficiently and sustainably utilised
3. Capacity Building	• National capacity for irrigation development enhanced
4. Coordination and Management	• IMP efficiently and effectively managed

Phasing

The IMP will be implemented in three phases: Phase I (2015-2020), phase II (2021-2025) and Phase III (2026-2035) comprising approximately 20,000 hectares, 28,500 hectares and 67,500 hectares of new irrigation schemes in Phases I, II and III respectively. These targets comprise a combination of schemes already in the pipeline and new schemes which have been identified as part of the IMP process but are yet to undergo feasibility and design studies. Phase I will be used to consolidate existing initiatives under the IMP framework, and management arrangements, and will account for the majority of the 20,000 hectares planned for this period.

Component 1: New Irrigation Development

Component 1 will focus on the identification, design and construction of new irrigation schemes. Component 1 has six Sub-Components. Sub-Component 1.1 involves the consolidation of the existing pipeline of irrigation schemes and projects in various stages of planning and implementation under the IMP framework. The remaining five Sub-Components will develop new schemes through a planning cycle involving feasibility studies, system design, tendering and contracting, construction and commissioning as follows:

Sub-Component	Outputs
1.1 Consolidation	• Existing pipeline of schemes and projects consolidated within IMP framework
1.2 Feasibility Studies	• Feasibility studies for identified schemes completed
1.3 System Design	• Detailed irrigation system designs completed
1.4 Contracting	• Tendering and contracting for scheme construction completed
1.5 Construction	• Irrigation scheme construction completed
1.6 Commissioning	• Irrigation schemes commissioned

The annual areas of irrigation development completed and cumulative scheme completions are shown in the Figure 2.

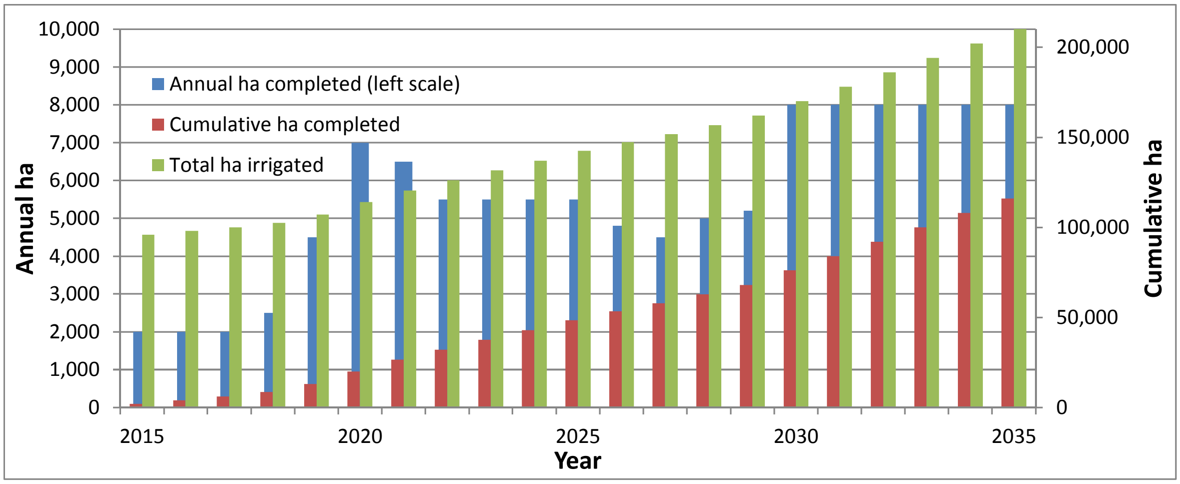


Figure 2: Irrigation Development Completed, Annual and Cumulative Hectares

The relatively large inventory of schemes currently being planned means that there is likely to be a spike in completions around 2020-2021 followed by a slum as schemes yet to be designed come on stream.

Component 2: Sustainable Irrigation Management

Component 2 will focus on the operation and management of both new and existing irrigation schemes to ensure that land and water resources are efficiently and sustainably utilised. The key requirements for sustainability will be addressed through: (i) remedial investments in schemes which are not functioning properly or are at risk of falling into disrepair: (ii) complementary measures to improve agricultural productivity and reduce soil erosion rates in catchment areas; (iii) promotion of good agricultural practices (GAPs) through farmer training in irrigation methods and climate-resilient agronomic practices; (iv) creation and/or support for community groups such as WUAs and Cooperatives to sustainably manage system O&M; and (v) the development of commercial linkages to ensure that farmers have access to the inputs they need and to profitable markets for their produce. Component 2 includes five Sub-Components as shown as follows:

Sub-Component	Output
2.1 Rehabilitation or Upgrading	• Existing schemes upgraded/ rehabilitated
2.2 Catchment Management	• Improved catchment management to reduce siltation, and improve infiltration and crop yields
2.3 Good Agricultural Practices	• Farmer skills in irrigated and rainfed crop production enhanced, e.g. CA.
2.4 Operation and Maintenance	• Satisfactory O&M of new and existing schemes
2.5 Marketing and Business Development	• Farmers have reliable access to markets

Component 3: Capacity Building

Component 3 will address Malawi's irrigation capacity constraints, specifically human resources, finance, institutional capability and the facilities and services needed to achieve the planned rate of irrigation system development and operation. The IMP will address the needs of all stakeholders in the sub-sector, and build a foundation for long-term sustainability by maximising participation of non-state actors and confining the role of government to certain well-defined areas. Component 3 has six Sub-Components as follows:

Sub-Component	Output
3.1 Institutional Rationalisation	• Lead responsibility for irrigation development assigned to a single institution, creation of IMPSC and IMPMU
3.2 Institutional Capacity	• Lead institution has adequate staff levels and budget
3.3 Human Resource Development	• Human resources for irrigation development enhanced
3.4 Standards and Accreditation	• Best-practice design, construction and operating standards widely used.
3.5 Irrigation Management	• WUAs with capacity to take responsibility for scheme O&M
3.6 IMP Financing	• Funding available to meet IMP investment targets

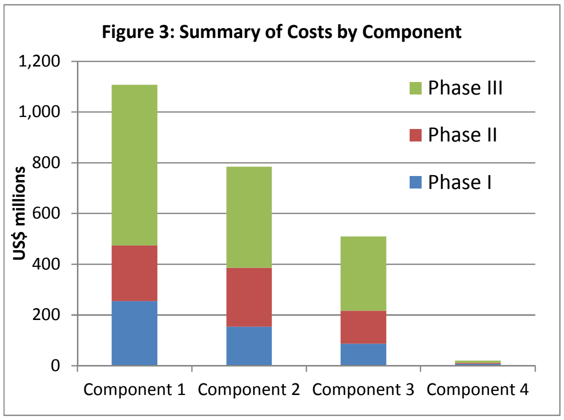
Component 4: Coordination and Management

Component 4 will develop and/or strengthen procedures for effective coordination, governance, management, monitoring and evaluation of the IMP. The transition from a fragmented project-based approach to a fully integrated master plan will require the current programmes and projects to be retrofitted into the Master Plan. The portfolio of programmes and projects will be harmonised and streamlined under a single governance framework, and a unified coordination and management structure. As new projects and programmes come on stream they will also be integrated within these governance and coordination structures. Project financing will be harmonised under the proposed National Irrigation Development Fund (NIDF), with provision for a range of financing sources, modalities and instruments. Component 4 includes four Sub-Components as shown below. Sub-Component 4.1 involves the official adoption of IMP by GoM and its integration in national development plans. Sub-Component 4.2 will be the responsibility of an IMP Steering Committee (IMPSC) and Sub-Component 4.3 will involve the creation of an IMP Management Unit (IMPMU).

Sub-Component	Output
4.1 IMP Adoption	• IMP officially adopted and integrated in national development plans
4.2 IMP Governance and Coordination	• Effective and transparent governance of IMP implementation, IMPSC
4.3 IMP Management	• Effective and efficient day-to-day management of IMP implementation, IMPMU
4.4 IMP Monitoring and Evaluation	• IMP effectively monitored and evaluated

Investment and Financing Framework

Figure 3 and Table 3 present a summary of total IMP costs by component and Phase, expressed in constant 2014 US dollars.



The total cost is estimated to be around US$ 2.4 billion of which 46% will be invested in Component 1: New Irrigation Development; 32% in Component 2: Sustainable Irrigation Management; 21% in Component 3: Capacity Building; and 1% in Component 4: Coordination and Management. Around 89% of IMP costs represent investments and 11% recurrent costs, mainly irrigation scheme O&M.

Table 3: Summary of IMP Costs by Component (US$ million)

Component	Total Cost (US$ million)				% of Total
	Phase I	Phase II	Phase III	Total	
Component 1: New Irrigation Development	255	220	634	1,108	46
Component 2: Sustainable Irrigation Management	154	232	400	785	32
Component 3: Capacity Building	87	131	292	510	21
Component 4: Coordination and Management	8	4	9	21	1
Total Irrigation Master Plan	**504**	**586**	**1,333**	**2,423**	**100**
Of which: Investment Costs	487	536	1,123	2,146	89
Recurrent Costs	17	50	278	278	11

Component 1 includes the cost of irrigation infrastructure plus 20% to cover the cost of feasibility studies, detailed design and supervision. Component 2 includes the cost of rehabilitating and/or upgrading existing schemes, as well as the investments needed for catchment management based on promotion of good agricultural practices and O&M of completed schemes. Component 3 includes capacity building investments such as increased staffing and training for DoI staff and capacity building for WUAs so that they are capable of independently operating and maintaining schemes. Component 4 includes the costs of the IMPMU and associated coordination and management activities.

Table 4 and Figure 4 present an indicative financing framework showing the expected contributions of GoM, development partners, the private sector and beneficiaries. GoM's contribution is projected to increase from 5% of the cost in Phase I to 13% by Phase III. The contribution of development partners is expected to be around US$1.3 billion declining from over 70% of the total in Phase I to around 42% in Phase III. Conversely the contribution of the private sector, through investment in commercial agriculture and outgrower schemes is expected to increase over the life of the IMP. The contribution of farmers is also expected to be significant through a ten percent share of irrigation scheme investments (mainly in kind) and financing of O&M costs.

Table 4: Indicative IMP Financing Framework by Phase

Financier	Total Cost (US$ million)				% of Total
	Phase I	Phase II	Phase III	Total	
GoM	25	54	169	248	10
Development Partners	361	342	565	1,268	52
Private Sector	79	121	331	532	22
Beneficiaries (farmers)	39	69	268	376	15
Total Irrigation Master Plan	**504**	**586**	**1,333**	**2,423**	**100**
% of Total	21	24	55	100	

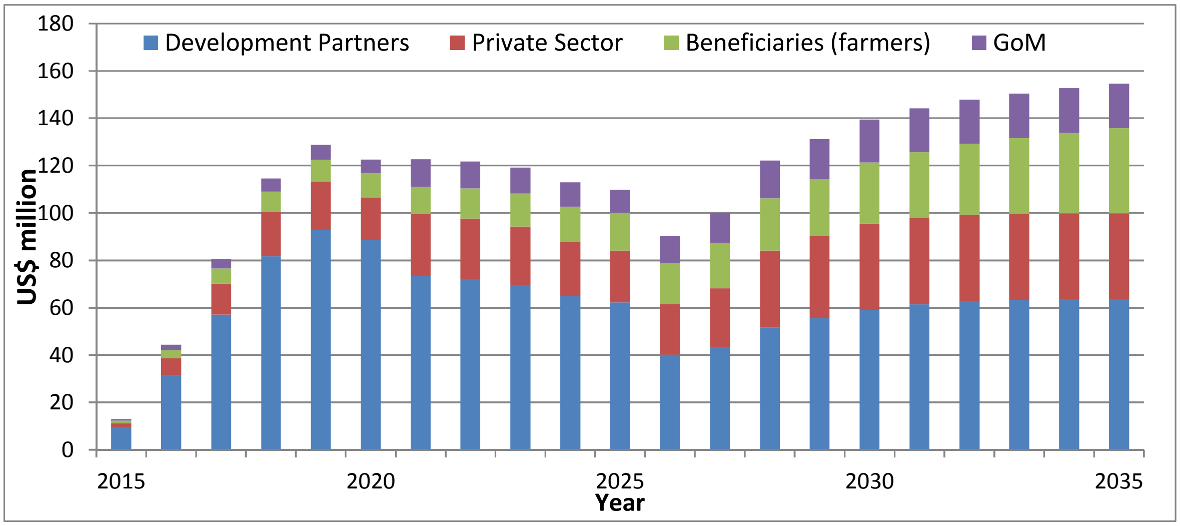


Figure 4: Indicative IMP Financing Framework by Year

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ACRONYMS AND ABBREVIATIONS

ADD	Agricultural Development Division
AfDB	African Development Bank
AISP	Agriculture Infrastructure Support Project
ASWAp	Agricultural Sector-Wide Approach
AWPB	Annual Workplan and Budget
BGS	British Geological Survey
CA	Conservation Agriculture
CARLA	Climate Adaptation for Rural Livelihoods in Agriculture
CSA	Climate-Smart Agriculture
CSM	Community Sensitisation and Mobilisation
CWR	Crop Water Requirement
DAES	Department of Agricultural Extension Services
DAS	Development Assistance Strategy
DoI	Department of Irrigation (MoAIWD)
EFA	Environmental Flow Assessment
EFR	Environmental Flow Requirement
EIRR	Economic Internal Rate of Return
ENSO	El Nino Southern Oscillation
EPA	Extension Planning Area
ESIA	Environmental and Social Impact Assessment
ESMF	Environmental and Social Management Framework
ET_0	Reference EvapotranspirationFAO Food and Agriculture Organisation
FBS	Farmer Business School
FFS	Farmer Field School
FISP	Farm Input Subsidy Programme
FSL	Full Supply Level
GAPs	Good Agricultural Practices
GBI	Green Belt Initiative
GCM	Global Circulation Model
GDP	Gross Domestic Product
GIS	Geographic Information System
GoM	Government of Malawi
ICID	International Commission on Irrigation and Drainage
IMP	Irrigation Master Plan
IMPMU	Irrigation Master Plan Management Unit
IMPSC	Irrigation Master Plan Steering Committee
IRLADP	Irrigation, Rural Livelihoods and Agricultural Development Project
ISD	Irrigation Services Division
IWMI	International Water Management Institute
JICA	Japan International Cooperation Agency
JWC	Joint Water Commission
LRCD	Land Resources and Conservation Department
M&E	Monitoring and Evaluation
MCDA	Multiple Criteria Decision Analysis
MDGs	Millennium Development Goals
MGDS	Malawi Growth and Development Strategy
MIDP	Medium Scale Irrigation Development Programme
MoAIWD	Ministry of Agriculture, Irrigation and Water Development
MoFEPD	Ministry of Finance, Economic Planning and Development
MoITPSD	Ministry of Industry, Trade and Private Sector Development
MoIWD	Ministry of Irrigation and Water Development
MoLHUD	Ministry of Lands, Housing and Urban Development
MoNREM	Ministry of Natural Resources, Energy and Mining
NES	National Export Strategy
NGO	Non-Government Organisation

NIB	National Irrigation Board
NIDF	National Irrigation Development Fund
NWRMP	National Water Resources Master Plan
O&M	Operation and Maintenance
OPC	Office of the President and Cabinet
PET	Potential Evapotranspiration
PIA	Potential Irrigation Area
PIA_{phy}	Potential Irrigation Area (physical)
PIS	Potential Irrigation Scheme
PMU	Project Management Unit
PPP	Public-Private Partnership
PRA	Participatory Rural Appraisal
PRIDE	Programme for Rural Irrigation Development
RIDP	Rural Infrastructure Development Programme
SADC	Southern Africa Development Community
SFIP	Small Farms Irrigation Project
SIVAP	Smallholder Irrigation and Value Addition Project
SMEC	Snowy Mountain Engineering Corporation
SRBDP	Songwe River Basin Development Programme
SSA	Sub-Saharan Africa
SSI	Small-Scale Irrigation
SVIP	Shire Valley Irrigation Project
SWSM&EP	Strengthening Water Sector M&E Project
TA	Traditional Authority
ToRs	Terms of Reference
ToT	Training of Trainers
TWG	Technical Working Group
ULSE	Universal Soil Loss Equation
UNDP	United Nations Development Programme
WaSWAp	Water Sector Wide Approach
WB	World Bank
WRA	Water Resource Area
WRIS	Water Resource Investment Strategy
WRU	Water Resource Unit
WUA	Water User Association
WUG	Water User Group

Weights and Measures

ha	hectare
km	kilometres
km^2	square kilometre
L	litre
l/d/c	litres/day/capita
l/s	litre/second
m	metre
m^3	cubic metre
m^3/s	cubic metres/second
masl	metres above sea level
mm	millimetre
Mm^3	million cubic metres
Q_{80}	80% reliable stream flow
Q_{90}	90% reliable stream flow
y	year
Ø	Pipe diamter

Exchange Rates (November 2014)

US$ (United States Dollars) = 470 MWK (Malawi Kwacha)

MWK 100 = US$ 0.21

1 INTRODUCTION

1.1 Overview

Malawi's Irrigation Master Plan (IMP) is a roadmap to guide future investments in Malawi's irrigation sub-sector and coordinate implementation among all stakeholders. The Plan was prepared by the Department of Irrigation (DoI) with the assistance of the Snowy Mountains Engineering Corporation (SMEC) with funding from the World Bank through the Irrigation, Rural Livelihoods and Agricultural Development Project (IRLADP). The IMP was prepared between November 2013 and December 2014 and covers the period from 2015 to 2035.

1.2 Objective of the Master Planning Process

The objective of the process as defined in the terms of reference was to develop an Irrigation Master Plan and Investment Framework to support investments in irrigation. In accordance with these ToR the integrated investment planning was based on: (i) an assessment of irrigation potential (biophysical) disaggregated by Water Resources Area (WRA) and irrigation typology; and (ii) an investment framework based on an elaboration of a typology of irrigation categories, prioritisation scorecards, implementation arrangements and required capacities, general guidelines for investment planning and environmental and social safeguards. The ToR state that the IMP and Investment Plan shall set out specific ways in which improved irrigation development and management can deliver higher incomes to smallholder and estate farmers, as well as accelerate economic growth. The Plan shall be technically, fiscally and environmentally responsive, and socially inclusive. It shall include an investment action plan, and recommend institutional arrangements that will allow accelerated and sustained irrigation development. It shall include specific programs and physical projects to be implemented. The specific objectives include:

- to verify potential areas for irrigation development opportunities in order to enable increased understanding for priorities of such development;
- to map out all potential areas for irrigation and establish the linkages that could enhance the profitability of the proposed irrigation interventions; and
- to develop prioritised irrigation development framework which will include time bound action plan and strategies for use by government and development partners as well as private sector and non-state actors.

1.3 Outline of the Master Plan

The Main Report presents the IMP in the following Sections:

Section 2 describes the history and current status of Malawi's irrigation sub-sector including the policy, regulatory and institutional framework, development constraints and opportunities, lessons learned from prior experience and presents a complete inventory of existing irrigation schemes classified by typology and location.

Section 3 describes the general approach to development of the IMP including key underlying principles and success factors, the proposed score-card methodology for ranking and selection of irrigation schemes and the approach to estimation of environmental flow allowances.

Section 4 presents a comprehensive biophysical assessment using a spatially-defined database and maps including administrative boundaries, population and infrastructure, livelihood zones, relief and physiography, soils, land use, climate, hydrology and cropping patterns.

Section 5 presents an estimate of the potential irrigation area (PIA) based on physical and hydrological criteria and identifies those parts of the country with sufficient available water to sustain irrigation development.

Section 6 describes the identification and ranking potential irrigation schemes (PISs) using the score-card methodology, within the constraints of water availability defined in Section 5 .

Section 7 defines the objectives and rationale for the IMP and outlines the four main components and the results expected from each together with targets and indicators in a logical framework format.

Section 8 provides further details on each of the IMP components and describes the proposed scheduling and implementation arrangements.

Section 9 describes the proposed investment and financing framework including the cost estimates by component and phase and an indicative framework for financing of both investment and recurrent costs.

1.4 IMP Documents

The following is a list of documents that have been produced during preparation of the IMP. These are:

Report	Date
Objectives and Context Report (Situation Analysis)	
Database of Irrigation Potential	
Proposed Irrigation Typology Report	
Irrigation Schemes Appraisal Methodology	
Irrigation Master Plan: Main Report	
Main Report Appendices:	
Appendix 1: Atlas of Maps	
Appendix 2: Agriculture	
Appendix 3: Soils	
Appendix 4: Hydrology	
Appendix 5: Inventory of Existing Schemes	
Appendix 6: Irrigation Design	
Appendix 7: Institutional Framework	
Appendix 8: Environmental Assessment	
Appendix 9: Web Page Development	
Appendix 10: Financial and Economic Analysis	

2 BACKGROUND

2.1 Overview

Malawi's agricultural sector employs about 80% of the workforce, accounts for 29% of GDP and underpins national food security. The sector is dualistic, comprising smallholder and estate subsectors. More than 90% of the rural population are subsistence-oriented farmers with customary land tenure, cultivating small and fragmented landholdings over approximately 2.3 million hectares. Average landholding has fallen from 1.5 ha in 1968 to around 0.7 ha in 2014. The great majority of crops are produced under rainfed conditions. In good years Malawi is able to produce around 3.0 million tonnes of maize, which is above the self-sufficiency level. In poor seasons, many households endure food insecurity and malnutrition particularly in the southern region. Despite the availability of improved technologies, crop productivity has only shown modest improvement because of: (i) declining soil fertility; (ii) poor access to financial services and markets; (iii) unfavourable weather; and (iv) under-resourced extension services. Post-harvest losses are estimated to be around 30% of production for maize and higher for perishable commodities. Irrigation development clearly represents one of the best opportunities to boost agricultural production and rural incomes. However, only about 4% of crop land is currently irrigated. The potential of the region is in the order of 450,000 ha, or 20%.

2.2 Situation Analysis

The history of irrigation in Malawi dates back to the 1940s when the first commercial sugar estates and sugar mills were established. In the 1960s and 1970s, GoM with financial support from donors constructed 16 smallholder irrigation schemes with a total area of 3,600 ha to increase rice production and serve as training grounds for farmers. The first smallholder sugarcane scheme was established in 1979. The largest single block small-scale irrigation scheme is the Bwanje Valley scheme (800 ha) which was constructed in 1998. In the 1990s and early 2000s, the Government focused on promotion of treadle pump technology and rehabilitation of the deteriorating structures in the 16 schemes developed earlier. Government through the Development Partners and NGOs continued with the development of smallholder irrigation as one of the strategies to fight poverty.

The total area of land developed for irrigation stood at 94,000 ha in 2013 of which about 53% was estates and 47% smallholder. The irrigated area has been growing steadily since 2006 at the rate of around 5% per annum. Almost all of the growth has been on smallholder schemes which have expanded by 143% since 2006. The smallholder sub-sector is characterised by an exceptionally large number of small schemes. There are some 38,000 smallholder schemes irrigating on average only 1.2 ha per scheme. Schemes irrigated by treadle pump and watering can generally have very small plots per beneficiary. Overall there are around 66,600 household beneficiaries of smallholder irrigation schemes, but these represent only around 3.3% of all rural households.

The large number of small schemes is very difficult to support. Gravity fed schemes average 7.6 ha, motorised schemes at 3.2 ha, treadle pumps at 1.1 ha and watering cans at 0.15 ha. To irrigate 13,000 ha using treadle pumps, more than 40,000 pumps are required at 0.3 ha per pump or about 10,000 pumps if each pump is shared by four households. These are very small schemes in economic terms but can be very significant for food security of individual households. However, there is need to change the subsistence approach to a commercial approach to empower farmers to develop to more efficient irrigation methods. Moreover it is very difficult for subsistence farmers to generate the cash needed to finance operation and maintenance (O&M).

Whilst the national accounts do not record the contribution of irrigation to GDP, it is possible to make an approximation. Agriculture represents about a third of GDP (which was US$3.7 billion in 2013), of which the great majority comes from crop production. If the contribution of irrigation is proportional to the percent of agricultural households using irrigation or to the percentage of cultivated land that is irrigated then 3-4% of agricultural GDP would be attributable to irrigation. However the productivity of irrigated land is generally 2-3 times that of rainfed land. On this basis the contribution of irrigation to agricultural sector GDP would be in the range of 7-12%, and to the economy as a whole of between about 2% and 4%. This represents between US$ 80 million and US$ 140 million or between about US$ 850 and US$ 1,550 per irrigated hectare.

Existing irrigation schemes and associated infrastructure have a replacement value of well over a billion dollars in today's values. This therefore represents one of Malawi's greatest national assets. However, there is limited information available on how well the existing schemes are operating and the likely benefits of investments to rehabilitate or augment them relative to the benefits expected from investment in new schemes.

The contribution of the agricultural sector to Malawi's exports is commonly around 90% of which the major items are produced under irrigation, especially tobacco, sugar and tea. Irrigation therefore plays a crucial role in financing Malawi's imports, with the potential to play an even greater role in the future. Horticultural crops are also largely grown under irrigation although this is mainly for the domestic market at present.

Smallholder irrigation is of particular significance to food and nutrition security, rural income generation and rural poverty reduction. Smallholder households with access to irrigation, even quite small areas, are protected to some extent against the vagaries of climatic variability and droughts, and also have the capacity to produce a much wider range of crops which help to improve the quality of their diets as well as generate year round income. This is of particular significance during the hungry season when food is scarce and food prices are at their highest. During this period many households dependent on rainfed farming are forced to sell assets to buy food or to sell their labour when they should planting and tending their own crops.

2.3 Strategies, Policies and Regulations

Since the launch of the Malawi Vision 2020 in 1998 GoM has implemented two medium term national development strategies: the Malawi Poverty Reduction Strategy (MPRS) and the Malawi Growth and Development Strategy (MGDS). MGDS II (2011-16) is the third national development strategy. It translates the goals and objectives that emerged from a nation-wide consultation process as reflected in Vision 2020. All other elements of the policy and strategic framework relating to irrigation development lie within this overarching policy framework.

Increased investment in irrigation development is consistent with Vision 2020 and MGDS II. The Agricultural Sector-Wide Approach (ASWAp) (2011-15) presents a priority investment programme for the sector that aims to accelerate agricultural growth and development based on the priority agricultural elements of MDGS II. The ASWAp is constructed around three pillars: food security and risk management; commercial agriculture, agro-processing and market development; and sustainable agricultural land and water management. Development of irrigation can make a significate contribution to all parts of the ASWAp but with a focus on Pillar 3. The ASWAp identifies the Green Belt Initiative (GBI) as the implementing agency for Pillar 3, but until now the GBI has not received sufficient funding to fulfil its mandate.

Irrigation also occupies a prominent position in a number of sectoral and sub-sectoral strategies and plans including: (i) the National Water Resources Master Plan (1986); (ii) the National Water Policy (2005); (iii) the Water Resources Investment Strategy (20011); (iv) the Malawi Water, Sanitation and Irrigation Sector Strategic Plan (2013); (v) the Department of Irrigation Strategic Plan (2011-16); (vi) the Draft National Irrigation Policy and Development Strategy (2014); (vii) the National Export Strategy (2013-2018); and (viii) the revised for the Water Resources Master Plan currently under preparation.

Malawi has a comprehensive legal and regulatory framework governing water, land, environment and commercial practices. The legislative and regulatory review conducted as part of the IMP reached the conclusion that the laws and customs that govern land tenure constitute a major impediment to irrigation development in Malawi, as well as to the development of commercial agriculture generally. Many customary landholders are reluctant to make land available for irrigation development because of fears that they will lose ownership or control of the land. Whilst such fears may not be well founded, experience has shown that concerns about land tenure can delay or prevent development if they are not addressed very early in the project planning cycle.

2.4 Institutional Framework

Since irrigation spans a range of fields the institutional framework is necessarily diverse and poses significant coordination challenges. A holistic approach to irrigation development calls for the participation of many government institutions covering agriculture, land, water, infrastructure, transport, commerce and trade, finance, environment, training and community development; as well as farmer organisations, NGOs and the private sector. Due to financial and human resource limitations most of the relevant institutions in Malawi struggle to fulfil their mandates. This is exacerbated by frequent organisational and management changes, lack of coordination between institutions, poorly defined lines of responsibility, and in some areas, deficiencies in the legal and regulatory framework. Diffusion of responsibility for irrigation development among several institutions needs to be addressed. The Water Sector-Wide Approach (WaSWAp) was created to improve coordination among and between institutions in the irrigation sub-sector, but this is not yet fully institutionalised.

2.5 Constraints and Opportunities

2.5.1 Constraints

There are a number of constraints which have limited irrigation to around 4% of the cultivated land in Malawi. Irrigation development is unavoidably capital intensive, and has to compete with many other investment needs for the limited funding available. Farmers themselves have very limited capacity to invest their own capital, or to borrow money for investment, and most of the investment therefore needs to come from GoM and its development partners. Capital shortage is exacerbated by the plethora of policies, strategies and plans for irrigation development, which are not integrated and harmonised and are only now being consolidated into a single IMP. Moreover, until now there has been no consolidated data base on natural resources, infrastructure and irrigation potential which can be used for systematic planning of irrigation development in the country. A further consequence of the shortage of funding is weak institutional capacity at both central and district levels, covering irrigation design and construction, agricultural research and extension and other areas. Additionally, responsibility for irrigation is dispersed among various ministries and departments, and there have been frequent changes to institutional arrangements. Some laws and regulations affecting irrigation also need to be rationalised, especially concerning land tenure. The predominance of customary land tenure in potential irrigation areas is a particular concern.

The performance of existing irrigation schemes also faces a number of constraints. Malawi has an exceptionally large number of small and very small irrigation schemes which are difficult to service and support. Cost recovery to fund O&M tends to be weak, resulting in declining system functionality over time. Because farmers are generally not required to pay for the water they use, they tend to grow low-value staple food crops which limits economic performance. High erosion rates in catchment areas due to inappropriate agricultural practices means that dams and weirs experience very high siltation rates. There are also significant marketing challenges in a landlocked country surrounded by countries that produce similar things, and with a small (but growing) urban demand for food. The high cost of fuel for pumping means that gravity schemes are preferred, but in some situations irrigation has to compete with rapidly growing demand for hydro-electric power.

2.5.2 Opportunities

Whilst past performance of the irrigation sub-sector has been below potential, there are many opportunities which have not yet been fully realised. Assessment of land suitability has identified a large area of land suitable for irrigation and the country's topography is such that many sites that could be irrigated by gravity schemes. Hydrological studies have also revealed that Malawi has sufficient un-used water to irrigate some 450,000 hectares, four years out of five, after allowing for other uses (domestic, industrial, hydropower and environmental flows). In some potential schemes it may be possible to generate hydro power to offset the costs of irrigation development.

National and sectoral policy settings are favourable for development of irrigated agriculture, with irrigation being a prominent feature of the national and agricultural sector development strategies. Experience over the last 10-20 years has yielded many valuable lessons about the best approaches to irrigation development in terms of technologies, organisational structures, management systems and sustainability. The private sector has demonstrated a willingness to invest in commercial agriculture, including irrigation development and there are several successful examples of outgrower schemes associated with commercial scale plantations and processing facilities, for example Kasunthula and Phata. In addition, Malawi's development partners have expressed strong interest in supporting irrigation development both financially and technically.

2.6 Inventory of Existing Schemes

Before the IMP can contemplate the future of irrigation, the present situation of schemes needs to be defined and understood. The spread of irrigation is from small watering can irrigation, through supplementary irrigation on tea estates, up to large commercial estate irrigation. The DOI together with the consultant have listed all irrigation schemes, verified their reference location, and size.

Part of the plan has been to assess the complex systems of irrigation types and reduce these down to a manageable level that would be both meaningful and manageable. A system adopted uses the already identified size categories and added the operation system, whether formal or informal, and whether private or farmer organisation. Formal schemes have had some form of engineering work performed in both design and construction of the irrigation system. Informal have had no engineering from professional bodies. Farmer organisation schemes are those handed over and operated by the farmers themselves. There are examples of schemes operated by the farmers, but on a private basis, like the cane outgrowers, which in this case are included in the private type. The list of types is given in Table 1.

Table 1: List of Irrigation Types

Type	Formal/Informal	Scale	Operation
1	Informal Schemes		
2	Formal Schemes	**Mini** < 10 ha	Farmer organisation
3			Private
4		**Small** 10-50 ha	Farmer organisation
5			Private
6		**Medium** 50-500 ha	Farmer organisation
7			Private
8		**Large** > 500 ha	Farmer organisation
9			Private

A summary of the existing schemes is given below, in Table 2. A full list of schemes with maps is given in APPENDIX 5: INVENTORY OF EXISTING SCHEMES.

Table 2: Summary of Existing Schemes by Typology and District

ISD	District	Typology									
		1	2	3	4	5	6	7	8	9	Total
Chikwawa	Chikwawa	1,870	-	-	-	-	970	-	1,755	22,000	26,595
	Nsanje	974	-	-	-	-	250	-	-	-	1,224
Blantyre	Blantyre	379	-	-	-	-	-	-	-	-	379
	Chiradzulu	13	-	-	-	-	-	-	-	-	13
	Mulanje	318	-	-	-	-	-	-	-	-	318
	Mwanza	373	-	-	-	-	-	-	-	-	373
	Neno	177	-	-	-	-	-	-	-	-	177
	Phalombe	991	-	-	-	-	-	-	-	-	991

	Thyolo	697	-	-	-	-	-	-	-	-	697
	Balaka	1,562	-	-	-	-	-	-	-	635	2,197
Machinga	Machinga	2,165	-	-	-	-	450	-	-	-	2,615
	Mangochi	2,301	-	-	-	-	-	100	-	2,350	4,751
	Zomba	4,044	-	-	-	-	400	-	1,800	-	6,244
Lilongwe	Lilongwe	6,007	-	-	-	-	-	-	-	-	6,007
	Ntcheu	3,845	-	-	-	-	-	-	-	-	3,845
	Dedza	2,467	-	-	-	-	-	-	600	-	3,067
Kasungu	Kasungu	592	-	-	-	-	-	-	-	-	592
	Dowa	3,291	-	-	-	-	-	-	-	-	3,291
	Ntchisi	494	-	-	-	-	-	-	-	-	494
	Mchinji	1,902	-	-	-	-	-	300	-	-	2,202
Salima	Salima	497	-	-	-	-	-	-	-	-	497
	Nkhotakota	3,749	-	-	-	-	-	-	1,470	6,540	11,759
Mzuzu	Mzimba	7,838	-	-	-	-	-	-	-	-	7,838
	Nkhata bay	140	-	-	-	-	320	-	-	-	460
	Rumphi	1,616	-	-	-	-	-	-	-	-	1,616
Karonga	Karonga	1,422	-	-	-	-	784	-	-	-	2,206
	Chitipa	1,942	-	-	-	-	-	-	-	-	1,942
	Total	51,666	-	-	-	-	3,174	400	5,625	31,525	92,391

Table 3: List of Existing Estate Schemes by District

District	Name of Estate	Area(ha)		Method Used	Crop	Owner
		Potential	Actual Irrigated			
Chikwawa	Illovo	30,000	22,000	Pumping Pivot, Furrow	Sugar Cane	Illovo
	Kasinthula Cane Growers Limited	3,000	1,150	Pumping Pivot, Furrow	Sugar Cane, rice	
Nsanje	Illovo, Kaombe estate	3,000	840	Centre pivot sprinkler system	Sugar Cane.	Illovo
Mulanje	Eldorado		81	Sprinkler	Tea	Tea Eastern Produce Limited
	Ruo		10	Sprinkler	Tea	do
	Chisambo		67	Sprinkler	Tea	do
	Likanga		13	Sprinkler	Tea	do
	Glenorchy		73	Sprinkler	Tea	do
	Esperanza		51	Sprinkler	Tea	do
	Lujeri		24	Sprinkler	Tea	Lujeri Tea Estates Limited
	Bloomfield		218	Sprinkler	Tea	do
	Sayama		177	Sprinkler	Tea	do
	Nampemba		102	Sprinkler	Tea	do
	Khongoni		96	Sprinkler	Tea	do
	Nsuwadzi		30	Sprinkler	Tea	do
	Mimosa		90	Sprinkler	Tea	Tea Research Foundation
Thyolo	Naming'omba		240	Sprinkler	Tea	do
	Satemwa		198	Sprinkler	Tea	do
	Satemwa		80	Sprinkler	Tea	do
	Makande		115	Sprinkler	Tea	do
	Zoa		290	Sprinkler	Tea	do
	Zoa		110	Sprinkler	Tea	do
	Gortha		85	Sprinkler	Coffee	
	Conforzi		155	Sprinkler	Tea	
	Nali farm		20	Sprinkler	Maize	
	STECO		40	Sprinkler	Maize	
Phalombe	Thuchila		20	Gravity	Maize and vegetables estate	
Dowa	Ngala	150	65	sprinkler		
	Niagara	500	100	Motorized pump	Maize, Rice, Tobacco	
Mchinji	Chichere	196	5	Drip irrigation	Maize	
	Kweza	20	7	Motorized pump		
	Wenzulo	5	2	Motorized pump		
Nkhotakota	Illovo Dwangwa	7,000	6,540	Furrow, Sprinkler Centre pivots	Sugarcane	Illovo Sugar
	Dwangwa Cane Growers Trust	2,470	1,470		Sugar cane	

Rumphi	Nkhozo	270	200	Pivot	Wheat, Beans and Paprika.	

District	Name of Estate	Area(ha)		Method Used	Crop	Remarks
		Potential	Actual Irrigated			
Dedza	Malavi		60			
	Dudu		35		Maize	
Lilongwe	Tsekwere		125			
	Dzanzi		275			
	Mitundu		550			Under Press Co.
	Lisungwi		225			do
	Mchezi		475			do
	Malowa		225		Maize, beans	
	Msunga		425			Under Press Co.
	Kakoma		520		Tobacco	do
	Kachawa		775		Tobacco	do
	Namitete		475		Maize , Tobacco	do
	Nsangwa		375			do
	Kaphiri		150			
	Kakuyu		400			Under Impala Co.
	Kapunula		500			
	Chipala		1,150		Maize , Tobacco	Under Press Co.
	Kasonjola		800			
	Khasu		725		Maize	
	Mudi		500		Tobacco	
	Chitaya		350			
	Ching'amba		125		Beans	
	Gwirize		225			Under Press Co.
	Chilikhanda		725		Maize , Tobacco	do
	Daminga		320		Tobacco	do
	Mbabvi		620			
	Lingadzi		490		Maize , Tobacco	
Balaka	Demeter	8,700	1,300	Pumping	Seed	Use Shire
	Toleza	5,400	900	Dams	Cotton	Rainwater harvesting
Zomba	Sable Farming	3,800	500	Dams	Coffee	do
Total		25,181	48,382			

Figure 1: Existing Scheme North Region

Figure 2: Existing Scheme Centre Region

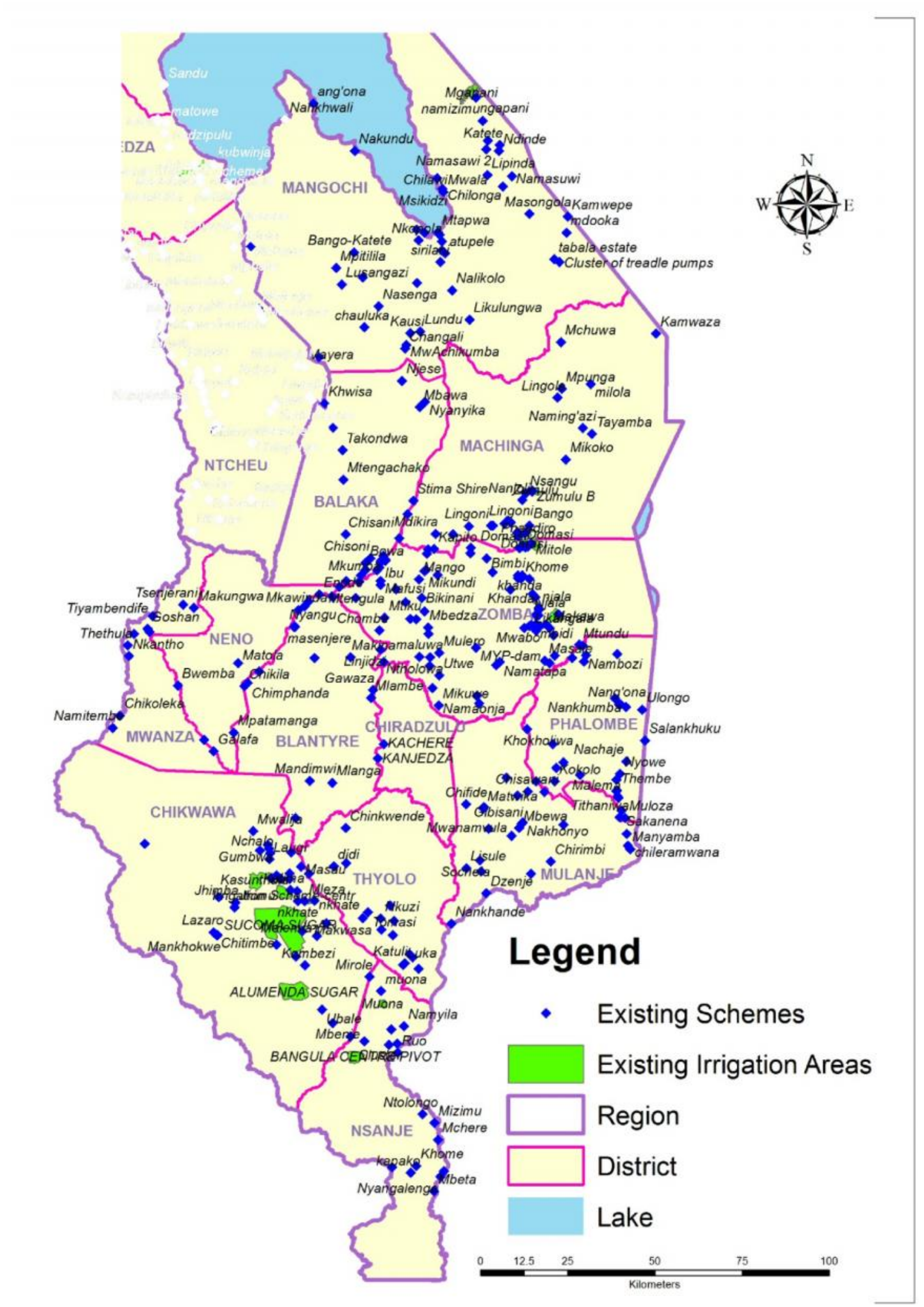

Figure 3: Existing Scheme South Region

3 FRAMEWORK APPROACH

3.1 Overview

The design of the IMP is based on a balanced and holistic approach which considers the constraints and opportunities for irrigation development within the context of national and agricultural sector development strategies. It draws on global best-practice models for irrigated agriculture but is tailored to Malawi's unique social, economic, geographic, hydrological, climatic and agricultural environment.

Irrigation is an important response to Malawi's development challenges, but one that needs to be planned concert with many other initiatives which compete for scarce financial resources. As such, irrigation development is part of the solution, but not the whole solution. It is a means to an end, not an end in itself. The IMP also recognises that the vast majority of rural households in Malawi are heavily or totally dependent on rainfed agriculture and can benefit greatly from access to even small areas of irrigated land. However the majority who will remain as rainfed farmers can also benefit through adoption of good agricultural practices in catchment areas which will extend the life of irrigation schemes. Medium and large scale commercial farmers and agribusiness companies are also expected to be important partners in the IMP. The IMP approach has a number of key features which are elaborated below and include:

- The need to be results oriented and highly selective in identifying specific elements of the plan based on systematic and transparent selection procedures.
- Recognition that the IMP is more than just an aggregation of irrigation schemes that pursue hectarage targets. There are many complementary measures needed to ensure that these investments deliver the expected results.
- Employment of a variety of different strategies and approaches in pursuit of IMP objectives, reflecting the reality that no one approach is best in all circumstances.
- Differentiation of irrigation development objectives by target groups and beneficiaries ranging from smallholder subsistence-oriented households to agribusiness companies.
- Recognition of the complexity of land tenure issues, the barrier this can impose and the need to negotiate secure tenure arrangements before investment takes place.
- The need to adopt a market-led approach to improve the connectivity between irrigation farmers and the end-users of their produce.
- The need for a long-term planning horizon which recognises that water will become increasingly scarce over the life of the IMP.
- Consideration of the financing needs of the IMP and options for procuring the necessary investment and operating funds.
- Concerns about social and environmental issues and how these should be assessed, managed and mitigated.
- Sustainability issues including the need to generate revenue to finance O&M, and adoption of a whole catchment approach to prolong system life through reduced erosion and siltation rates.
- The need for institutional rationalisation and capacity development in both the public and private sectors.
- Adoption of best-practice procedures for involvement of WUAs in the design, construction and management of irrigation schemes.
- Whilst the IMP is a national programme the spatial distribution of irrigation development will be clustered in a relatively small number of catchments with favourable land and water resources.

3.2 Results and Selectivity

The IMP is strongly results oriented and sees irrigation development as a means of progressing towards Malawi's development aspirations rather than as an end in itself. The master plan focuses on what the IMP will deliver in terms of accelerated economic growth, reduced prevalence of rural poverty, improved food security and increased exports. This will be measured against realistic and achievable goals and directly measurable development outcomes as detailed in the logframe.

The focus on results calls for a high degree of discrimination in the selection of investments through a systematic screening process in order to select the combination of irrigation schemes that will best meet the IMP objectives. Since the objectives of the IMP are multi-dimensional, so too are the criteria for selection of schemes. A structured ranking system has therefore been designed to enable the use of multiple evaluation criteria in the selection and prioritisation of irrigation investments. A review of selection methods used in a number of countries, as well as experience in Malawi under IRLADP, identified Multiple Criteria Decision Analysis (MCDA) as the preferred method of selection and prioritisation[1]. MCDA estimates a weighted average score for each of the irrigation schemes assessed to pre-feasibility level. The weighted average score for each of the criteria is used to rank in order of priority the list of irrigation investment opportunities, outlining short, medium and long term investments. This, approach is used to facilitate transparent and verifiable decision-making and prioritisation.

Economic viability is applied somewhat differently to the other criteria. All schemes are subject economic assessment and those with economic internal rates of return (EIRR) less than 10% are excluded, regardless of their overall weighted average score. In these cases economic assessment overrides the other five criteria combined. Options above the 10% threshold are scored in the same way as the other criteria.

Application of an EIRR threshold reflects that fact that average financial and economic rates of return on irrigation investments tend to be relatively low due to their capital intensity. An IWMI review[2] found that in Sub-Saharan Africa new irrigation schemes generated an average EIRR of 11% and rehabilitation investments 14%. The IWMI figures show that the per-hectare cost of new construction is generally about 75% greater than the cost of rehabilitation. However these averages conceal large variations in individual scheme performance. Systematic economic evaluation enables identification of schemes that will receive the highest priority and avoids investing in those likely to generate weak or negative returns. *E*conomic assessment of almost 100 potential schemes as part of IMP preparation produced EIRRs ranging from negative to over 50% (see Section 6.6.1).

Generally the larger schemes (over 1,500 hectares) show better results than the smaller ones with almost all of the schemes showing EIRRs of less than 10% smaller than 500 hectares. As a general rule, schemes requiring investment of more than about MWK six million (US$ 14,000) per hectare should be avoided. For mutually compatible options it is recommended to implement all schemes above the minimum EIRR threshold of 10%, working from the highest ("low hanging fruit") to the

[1] The MCDA approach is further elaborated in SMEC (July 2014) Irrigation Schemes Appraisal Methodology: IMP Report No xx

[2] Inocencio A, Kikuchi M, Tonosaki, M, Maruyama A, Merrey, D, Sally H, de Jong I (2007): Costs and Performance of Irrigation Projects: A Comparison of Sub-Saharan Africa and Other Developing Regions. Colombo, Sri Lanka: International Water Management Institute. IWMI Research Report 109

lowest, subject also to their ranking according to the other MCDA criteria. For mutually exclusive options (e.g. two schemes using the same land or water resources), the scheme with the highest EIRR of the two should be selected, other things being equal. Marginal or sub-marginal projects (with EIRRs of 8%-12%) should be re-assessed to see if there are design options that will yield better economic results.

3.3 Complementary Measures

The IMP is more than just an aggregation of irrigation schemes that pursues targets for the area of land irrigated. Whilst scheme identification, feasibility studies, design and construction are likely to account for the bulk of the IMP investments (the cost of hardware (infrastructure, equipment etc.) typically amount to around 60-70% of total irrigation investment costs) there are many complementary measures that need to be implemented to ensure that these investments generate robust financial and economic returns, whist providing safeguards against possible un-intended negative consequences. The logframe in Section 7.4 details the complementary measures proposed to ensure overall success of the programme including, but not necessarily limited to:

1. **Efficient and sustainable management of irrigation schemes** through:
    - protection of catchment areas to reduce siltation rates in irrigation structures and ensure that all members of rural communities have the opportunity to benefit from irrigation development;
    - upgrading of farmer skills in irrigated crop production;
    - ensuring satisfactory operation and maintenance (O&M) of new and existing schemes; and
    - ensuring that farmers have reliable access to markets for their produce.

2. **Enhancement of national capacity for irrigation development** through:
    - rationalisation of institutional arrangements with lead responsibility for irrigation development assigned to a single institution;
    - adequate resourcing of the lead institution with staffing levels and budget;
    - enhancement of human resources for irrigation development;
    - development and adoption of best-practice construction and operating standards;
    - support for WUAs to develop their capacity to take responsibility for scheme O&M; and
    - mobilisation of the financial resources needed to achieve the target levels of irrigation development.

3. **Efficient, and effective coordination, governance, management, monitoring and evaluation of the IMP** through:
    - Official adoption of the IMP by Government and its integration into national development plans;
    - Establishment of a coordination mechanism to harmonise the efforts of all stakeholders engaged in irrigation development;
    - The establishment of effective and transparent governance arrangements for IMP implementation;
    - Effective and efficient day-to-day management of IMP implementation; and
    - Effective monitoring and evaluation of the master plan.

3.4 Diversified Approach and Irrigation Typology

The IMP will employ a variety of different strategies and approaches in pursuit its objectives. This reflects the reality that no one approach is best for all of the four principal objectives: economic growth, poverty reduction, food security and exports. The number of possible approaches is very large and characterised by multiple criteria including: (i) scale (mini, small, medium, large); (ii) operational modality (informal, formal, semi-formal); (iii) management (private, farmer organisation, government, PPP); (iv) water source (spring, river, reservoir, lake, groundwater, wastewater etc.); (v) abstraction method (pump, gravity); and (vi) delivery system (surface, sprinkler, drip etc.). An irrigation typology which considers all of these criteria would produce a very large and un-manageable number of options. The IMP therefore adopts a streamlined approach in which schemes are characterised according to four criteria: (i) whether formal or informal; (ii) scale (small, medium, or large); (iii) operation (farmer organisation or private[3]); and (iv) water abstraction method (gravity or pump). On this basis the IMP will consider 9 different irrigation types, each suited to particular situations and each delivering a different range of benefits, see Table 1

3.5 Target Groups, Objectives and Technologies

Irrigation in Malawi is multi-functional and addresses a number of different objectives including: (i) food and nutrition security at household and national levels; (ii) rural poverty reduction; (iii) rural income generation; (iv) employment generation; (v) overall economic growth; (vi) and increased export revenue. Each of these objectives is associated with different target groups ranging from very poor and vulnerable households through to commercial estates as shown in Table 4.

Table 4: Irrigation Development Objectives by Target Group/Beneficiaries

	Target Groups/Beneficiaries			
Objectives	Poor/vulnerable households	Emerging smallholders	Semi-commercial farmers	Commercial Estates
Food Security	***	*		
Poverty reduction	***	*		
Income generation	*	**	***	***
Employment		*	**	***
Economic growth		*	**	***
Exports		*	**	***

The most appropriate irrigation technologies also vary between target groups. Poor/vulnerable households pursuing food security and poverty reduction objectives are best serviced by gravity or treadle pump schemes where cash O&M cost are minimal. Motorised pump schemes can be considered for emerging and semi-commercial farmers growing high value crops although gravity is preferred due to high pumping costs. Pressurised drip or sprinkler technologies are usually only appropriate for commercial estates growing high value cash crops.

3.6 Land Tenure

Secure land tenure is critical to the successful operation and sustainability of irrigation schemes. However, the laws and customs that govern land tenure in Malawi are complex and sensitive and are

[3] Government operation schemes have been handed over to farmer organisations or the private sector.

generally considered to constitute an impediment to irrigation development. The majority of actual and potential irrigated areas in Malawi are classified as customary land whereby it is necessary to negotiate long-term leasehold arrangements between the customary owners and the irrigation farmers, who may themselves be customary landholders. This can be a complex and time consuming process which must be done as early as possible during the planning cycle, before a decision is made to go ahead with an investment. A new land bill has been drafted to resolve some of the uncertainties about customary land ownership but this has become bogged down in the political process.

Land tenure issues have hindered, but not prevented, expansion of the irrigation sub-sector. Farmer concerns about the security of their land tenure has stopped a number of otherwise sound schemes from proceeding or has contributed to lack of sustainability of established schemes. However several projects (e.g. IRLADP) have developed approaches for dealing with the land tenure issue within the existing legal framework.

The approach to land tenure issues under IMP is to work within the existing legal, administrative and customary framework using models that have been successful on existing schemes with emphasis on early engagement with customary landholders and traditional authorities to work out durable arrangements which are acceptable to all parties. When the new land bill becomes law new solutions may become available.

3.7 Markets and Marketing

In making the transition from rainfed to irrigated farming Malawian farmers will also move from being subsistence to semi-commercial or commercial farmers. Irrigation farming is essentially a commercial activity at any level beyond subsistence/food-security garden plots of less than half a hectare. Markets and marketing are key success factors and the design of schemes will include a thorough assessment of markets and market access opportunities and constraints. This recognises that profitability is critical to sustainability and that schemes must generate sufficient cash to finance O&M over the long-term. High value crops must be grown to cover the high investment and recurrent costs of irrigation farming. Many of these are quality sensitive and/or perishable, and involve much larger marketing challenges than the traditional low-vale staple food commodities. IMP will therefore adopt a market-led approach to improve the connectivity between irrigation farmers and the end-users of their produce. Success depends on working with the entire value chain and addressing transport, storage and processing bottlenecks as well as market knowledge and skill constraints.

3.8 Planning Horizon

Irrigation is by far the largest user of water in Malawi and is likely to remain so over the IMP period. The draft National Water Resources Master Plan estimates that in the baseline year (2012) irrigation utilised 934 Mm^3 of water, representing 73% of the total 1,256 Mm^3. With the total irrigated area expected to reach 210,000 hectares by 2035 irrigation water use at the end of the IMP period is projected to reach 2,272 Mm^3, and total water use to reach 2,991 Mm^3. As a 20-year plan the IMP must consider the long-term scenarios for water supply and demand and their implications. Water available for irrigation is currently limited in some WRAs but abundant in others. However, during the life of the IMP water availability for irrigation is likely to become limiting across the whole of Malawi. Six factors will contribute to this change:

- as the largest user of water, expansion of irrigation will itself amplify the shortage of water within certain WRAs;
- population growth (expected to reach 30 million by 2030) will increase demand for domestic water as well as for food produced under irrigation;
- industrial development will increase the demand for water used in factories and mines;
- growing demand for hydro-electric power (as well as energy from other sources);
- rising temperatures will increase evaporation and transpiration rates, possibly exacerbated by lower and/or less reliable rainfall; and
- increasing environmental awareness and demand for environmental flows as well as water bodies for recreational purposes.

These scenarios have several important implications for the IMP. Schemes need to be designed according to realistic and conservative estimates of the amount of water likely to be available ten or more years ahead. Conjunctive use of water resources (e.g. agriculture combined with non-consumptive uses such as hydropower, fishing and recreation) will become increasingly important. Improved water use efficiency in agriculture using climate-smart technologies will enable irrigation to compete better with other uses of water and maximise overall returns to the nation's water resources. And the likelihood of lower basal flows in streams due to climate change and competing uses will increase the need for investment in water storage over today's levels.

3.9 Financing of Irrigation Development

The total cost of the IMP is likely to be almost US$ 2.0 billion over 20 years, or an average of around $100 million per year. Whilst the investments will be lower in the initial years and gradually expand as the rate of development accelerates, this presents a formidable financing challenge for Malawi. GoM has limited capacity to finance investments in irrigation, since the bulk of the budget is used to finance recurrent expenditure. Therefore multiple sources of finance will need to be deployed and new/innovative approaches to financing will need to be developed. Options to be considered for financing of investment costs include: (i) the GoM development budget, which is expected to grow over time, but from a low base; (ii) the principal development partners, who have already made significant commitments to irrigation investment through their respective country strategies; (iii) international investment banks and equity funds seeking exposure in emerging markets; (iv) private agribusiness companies and their financiers; and (v) farmers themselves through cost-sharing arrangements, generally involving contribution of labour or construction materials. Public-Private Partnerships may also have a role to play as well as partnerships between agribusiness and smallholder farmers in outgrower or contract farming schemes. Financing arrangements for recurrent expenditure also need to be considered including seasonal credit for crop inputs, and cost recovery to finance system O&M. Recurrent cost financing has often been overlooked in the past leading to declining system functionality.

3.10 Social and Environmental Issues

The IMP gives due consideration to environmental and social issues by assessing risks early in the planning cycle and designing appropriate mitigation measures. Initial environmental screening will be undertaken at pre-feasibility stage and will place each proposed scheme into one of three categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential impacts:

- Category A projects are considered likely to have significant adverse environmental and/or social impacts that are sensitive, diverse, or unprecedented; and may affect an area broader than the project sites or facilities. Such projects need to be subject to a full environmental and social impact assessment[4] (ESIA) which includes consideration of different design approaches that will significantly reduce impacts.

- Category B projects may have potential adverse environmental and/or social impacts, but these are site-specific and usually amenable to mitigation or reversal. Category B projects also need to undertake an ESIA with a focus on risk minimisation and mitigation measures.

- Category C projects are considered likely to have minimal or no adverse environmental or social impacts and do not need to be subject to further assessment.

According to national guidelines most IMP projects are likely to be Category A and will therefore require full ESIA at feasibility study stage. The design of all schemes will incorporate an Environmental and Social Management Framework (ESMF) which defines the risk and mitigation measures and an environmental and social impact monitoring framework. Possible negative impacts need to be weighed against positive ones, including the clear benefits of irrigation in poverty reduction, drought resilience, food security and employment in rural areas. Other possible benefits to be considered include improved dry season stream flows, flood mitigation and domestic water supply.

3.11 Sustainability

The economic justification for irrigation development is heavily dependent on sustainability with a long period of profitable operation required to amortise the heavy initial investments. Lessons learned Malawi and elsewhere have identified a number of threats to sustainability which are addressed within the IMP framework. First and foremost, to be sustainable irrigation must be profitable. This requires high cropping intensity, growing of high value cash crops and good access to farm inputs and markets. Next, a portion of the profits must be re-cycled to finance routine O&M and a sinking fund to finance major rehabilitation/repair works when the need arises. This requires competent scheme management by either private sector operators or WUAs which themselves need capacity building and support over an extended period. Schemes sometimes fail because of conflict within and between communities about access to land or water. This calls for a patient and consultative approach to the design of irrigation schemes through early community engagement to resolve issues that may later threaten sustainability.

In Malawi there is also a considerable risk to sustainability from high soil erosion rates and siltation of water storage and distribution structures. The IMP will address this risk through adoption of a whole catchment approach to sustainable land and water management in which the catchment area is an integral part of the irrigation scheme. Thus, in addition to investing in irrigation facilities, IMP schemes will also support measures to reduce erosion in catchment areas through adoption of good agricultural practices based on the principles of conservation agriculture (CA): (i) minimal soil disturbance; (ii) retention of crop residues on the soil surface; and (iii) crop rotation or intercropping.

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[4] Detailed procedures for conduct of ESIAs are provided in Appendix 8.

CA technologies can greatly reduce runoff and erosion, reduce labour inputs, and improve soil health and crop yields over time. Resilience to climate change is also enhanced through better soil moisture retention. Various approaches to CA, sometimes including agro-forestry and other soil conservation measures (grass strips, contour banks etc.) have been demonstrated successfully in Malawi but are not yet widely adopted. In addition to reduced siltation the whole catchment approach will ensure that in potential irrigation areas the whole community benefits, not just those who are allocated irrigated plots.

3.12 Institutional and Capacity Development

Provision of irrigation infrastructure often fails to deliver the intended benefits because of institutional capacity limitations. The IMP therefore incorporates an institutional and capacity-building dimension to ensure that suitable irrigation programs and projects are: (i) identified and screened according to agreed criteria; (ii) systematically appraised to determine their technical and economic feasibility; (iii) developed in cost-effective ways; and (iv) operated and maintained in a way that provides the intended benefits to farmers. The IMP therefore incorporates measures to streamline and rationalise Malawi's institutional arrangements so that responsibility for irrigation is assigned to a single institution, and that arrangements are in place for effective coordination with other institutions with responsibility for the complementary measures detailed in Section xx. Measures to strengthen institutional capacity are also proposed including filling staff vacancies, human resource development and modification of policies and procedures where needed. These proposals are based the principle that the role of Government should be confined to things that the private sector cannot do, and gives due consideration to the need for capacity building in both the private and public sectors, the latter through strengthening the capabilities of consultants, contractors and other service providers with specific skills in irrigation development. In this way the role of Government will focus on facilitation rather than direct service provision such as feasibility studies, design and construction. These will all be outsourced to private sector service providers and contractors.

3.13 Spatial Distribution

The IMP covers the whole of Malawi. At sub-national level the most meaningful planning unit is the Water Resource Area (WRA) which is equivalent to a major catchment. Previous water and irrigation studies have also used WRAs as the planning unit and DoI prefers to continue with this approach. Administrative (Regional or District) boundaries are not meaningful for water resource planning. The WRA approach is selected because WRAs fall within natural hydrological boundaries, their size is manageable, and they have somewhat homogeneous parameters within themselves. There are 17 WRAs but two are not included in the IMP because they are part of islands in Lake Malawi. The next hydrological sub-divisions are the Water Resource Units (WRUs) but there are 78 of these which is unmanageable for master planning purposes and offers no additional advantages or accuracy.

Application of the recommended selection criteria means that irrigation investment will be clustered in a relatively small number of WRAs with good water and land resources rather than evenly disbursed over the whole country. This is an inevitable consequence of Malawi's highly diverse topography and hydrology. The alternative approach of allocating resources by region or district, without regard to comparative advantage is not recommended. By focusing on the most attractive investment opportunities and avoiding sub-optimal ones the IMP will deliver the best social and economic results for Malawi as a whole.

Transboundary issues will arise in some cases where water resources are shared between Malawi and its neighbours. These will be addressed on a case-by case basis within the context of bilateral agreements for example regarding the water of the Songwe River which forms the border between Malawi and Tanzania, and the Ruo river which forms the border with Mozambique.

3.14 Institutional and Administrative Arrangements

Experience from Malawi and other countries has been used to identify best-practice arrangements for design, construction and management of irrigation schemes. Irrigation system design needs to incorporate measures for secure access to land and water based on comprehensive hydrological and land tenure assessments, the issue of water abstraction certificates and long-term land leasehold documents, and agreed measures for monitoring compliance with these. WUAs at scheme level and WUGs (also known as block committees) are crucial institutions for sustainable operation of all mulit-user irrigation schemes. The key function of WUAs is O&M. They must be registered legal entities with formal constitutions and by-laws defining their organisational structure, and procedures for ensuring transparency, accountability and social inclusion. WUAs need to be formed early in the project life-cycle to facilitate a participatory approach to irrigation system design, engender a sense of ownership among the farming community and engage them in the supervision of construction and testing. WUAs are also an important vehicle for arranging farmer contributions (in materials, cash or labour) to investment costs.

The key to financial sustainability of WUAs is the collection of water charges from members to finance O&M, land leases, administration and contributions to a reserve fund to finance major works or emergencies. There must be a clear understanding from the outset whether the water charges will be used to finance recurrent costs only or whether they are required to amortise the original investment. There are several options for calculating water charges which are discussed in detail in Appendix xx. These include: (i) crop area method based on types of crop and area irrigated; (ii) volumetric charging based on actual volume of water supplied to each farmer; and (iii) area based method based on payment of a flat rate per unit of irrigable area, irrespective of crops cultivated or volume of water supplied. The third of these methods is recommended for initial adoption, but this should not preclude crop-specific or volumetric charging to be applied in the future. Volumetric charging requires accurate metering of each farmers water use, but provides a strong incentive to use water efficiently.

To operate effectively WUAs need to have office facilities and equipment, the materials and equipment needed for routine O&M, and access to a comprehensive training and capacity building programme for members and office-bearers. Capacity building support needs to be maintained for several years at least after completion of physical works. Such support will generally be provided by the District Irrigation Office in conjunction with all of the other services required for profitable agriculture including extension services, access to inputs, financial services and market access. Experience from IRLADP suggests that WUAs need to be supported for up to five years before they are able to operate independently.

The proposed institutional and administrative arrangements will be integrated within a participatory step-by-step approach incorporating the following four implementation phases and 16 steps follows:

Phase	Step
Study and Awareness	• Step 1: Preliminary Visits • Step 2: Community Awareness Campaign • Step 3: Socio-Economic Survey and Technical Studies • Step 4: Land Acquisition, Leasing and Water Right Allocation (Milestone 1)
Design and Formation	• Step 5: Participatory Scheme Design • Step 6: Establishment of WUGs and WUA • Step 7: Preparation and Signing of Scheme Development Agreement (Milestone 2)
Capacity Building and Construction	• Step 8: WUA Capacity Building in Administrative and Financial Management • Step 9: Tender and Execution of Civil Works • Step 10: Implementation of Irrigation Extension Programme • Step 11: Preparation and Execution of Catchment Management Plan • Step 12: Capacity Building of WUGs and WUA in O&M and Water Management • Step 13: Preparation and Signing of Irrigation Management Transfer Agreement (Milestone 3)
Irrigation Management	• Step 14: WUA-Managed O&M of Irrigation System • Step 15: M&E of WUA Performance • Step 16: Agro-Economic and Environmental Assessments

For a full appreciation of the institutional aspects and the WUA's in the IMP, refer to APPENDIX 7: INSTITUTIONAL Framework

3.15 Ranking

The plan has appraised in order of priority the list of potential irrigation investment opportunities. For this, a 'score-card system' has been used for transparent and verifiable decision making and prioritization, providing guidelines for financial considerations: Only viable projects with an EIRR above 10 percent will be recommended.

3.15.1 The Multi-Criteria Decision Analysis (MCDA) method

The World Bank describes the Multi-Criteria Decision Analysis method as follows: "Among the various methods and models for MCDA, one is preferred here because of its simplicity and transparency, although it can handle complex problems with large numbers of competing alternatives. It is called the additive model within multi-attribute value theory, or the weighted-average model. It is particularly suitable for handling tradeoffs between criteria, for large numbers of alternatives, and for situations where new alternatives may from time to time be added to the list. Because of its simplicity it is easy to explain to decision makers and other stakeholders. To set up a model (a multi-criteria decision model) of this kind it is necessary to define a set of criteria and to assign a relative importance weight to each one. The model also needs a value function or scoring rule for each criterion, and in practice the formulation of the scoring rule provides the precise definition of the criterion. The scoring rule describes how a score is assigned to each alternative under each criterion, usually on a scale from zero to 100 with 100 at the preferred end of the scale. Once these elements are in place the model works by computing an overall merit index value for each alternative. The index value of an alternative is simply the weighted average of its scores. The alternatives can then be ranked to give a priority list. This prioritised list can then be used to draw up investment programme to match annual budgets or other constraints."

The World Bank indicates that in order to be ready for meaningfully ranking, investment project proposals need to be at least in the form of pre-feasibility studies containing not only financial costs but also estimated benefits.

3.15.2 Ranking Parameters Selected

The ranking parameters were selected based in the criteria used by IRLADP. The method proposed contemplates six major criteria and a number of sub-criteria. These are:

1. **Geophysical feasibility**
   - 1.1 Agro-ecological
     - 1.1.1 Area to be irrigated (incremental area)
     - 1.1.2 Soils suitability (including topography)
     - 1.1.3 Production objectives (cash crops and/or self consumption)
   - 1.2 Water Use and Sediment
     - 1.2.1 Moisture availability index
     - 1.2.2 Sedimentation problems
   - 1.3 Geotechnical Criteria
     - 1.3.1 Geology and geotechnical suitability of the site
     - 1.3.2 Availability of construction materials
   - 1.4 Engineering and other technical
     - 1.4.1 Accessibility to the intake site and to the irrigable area
     - 1.4.2 Necessity of flood protection structures
     - 1.4.3 Source of energy for water abstraction
2. **Market orientation and linkages**
     - 2.1.1 Evidence of availability of transport to markets
     - 2.1.2 Market for increased yield (road distance to major markets)
     - 2.1.3 Population of nearest market town
3. **Economic viability**
     - 3.1.1 IRR (discount rate 10%)
     - 3.1.2 Investment per hectare
     - 3.1.3 Investment per household
4. **Environmental acceptability**
     - 4.1.1 Water quality
     - 4.1.2 Modified ICID Environmental checklist
5. **Stakeholder support**
     - 5.1.1 Acceptance of the project
     - 5.1.2 Number of households to be benefitted (incremental number of households)

5.1.3 Potential conflict among water users

5.1.4 Affected households due to scheme (involuntary resettlement)

6. Land tenure systems

6.1.1 Indicative land tenure per household and minimum proposed

The description of each of these evaluation criterions and the evaluation units are described in Section 3.14.5 below.

3.15.3 The weighted average method

The World Bank line of identification of priorities method was used as the basis for the proposed methodology to be adopted in Malawi. The method indicates that once the criteria to be used for the ranking of the irrigation schemes have been determined, to set up a MCDA model it is necessary to assign a relative importance weight to each one. The practical application MCDA method for irrigation programs requires a value function or scoring rule for each criterion, and in practice the formulation of the scoring rule provides the precise definition of the criterion. The definition of each of the scoring criteria is given below, where each alternative is assigned a score range and the units of the score are clearly identified.

The computation of the merit of each criterion is determined by assigning 100 points (or 100 percent) to the highest score recorded. The other alternatives scores are calculated as a proportion of the highest.

3.15.4 Method proposed for Malawi

It is recommended grading the decisive factors (indicators) in whatever the units are given for each specific subject being assessed for the six criteria identified. This way, the indicator's grading becomes dimensionless and can be added to other indicators under the same criteria that have been estimated the same way. The percentages for each of the sub-criteria are added and compared against the total possible percentage and the weight given to each sub-criterion. The suggested weights are presented below.

3.15.5 The score-card

The score card proposed is in line with the ranking criteria given above and it is presented in the table below:

	Source	Unit	Score
1. GEOPHYSICAL FEASIBILITY			
1.1 Agro-ecological			5
1.1.1 Area to be irrigated (incremental area)	Design/Map 1	ha	
1.1.2 Soils suitability	Map 2	0 to 6 pts	
1.1.3 Export crops and/or self-consumption	Design	% cash crops	
1.2 Water Use and Sediment			10
1.2.1 Water deficit	Map 3	mm	
1.2.2 Sedimentation problems	Map 4	m^3/y	
1.3 Geotechnical Criteria			5

1.3.1 Geology and geotechnical suitability	Site	1 to 10 pts	
1.3.2 Haulage distance of construction materials	Site	0 to 5 pts	
1.4 Engineering and other technical			10
1.4.1 Accessibility to the intake site and irrigable	Site/G-map	0 to 5 pts	
1.4.2 Necessity of flood protection structures	Map 5	0 to 5 pts	
1.4.3 Source of energy for water abstraction	Site	1 to 10 pts	
2. MARKET-ORIENTATION AND LINKAGES			15
2.1.1 Road Type	G-map	0 to 5 pts	
2.1.2 Road distance to major market	G-map	Km	
2.1.3 Population of nearest Market Town	Map 6	0 to 4 pts	
3. ECONOMIC VIABILITY			15
3.1.1 EIRR	Cost	%	
3.1.2 Investment per hectare	Cost	US$/ha	
3.1.3 Investment per household	Cost/Map 6	US$/HH	
4. ENVIRONMENTAL ACCEPTABILITY			10
4.1.1 Water quality	Map 7	0 to 5 pts	
4.1.2 Simplified ICID checklist a/	Site/Map	Dif + & - Xs	
5. STAKEHOLDER SUPPORT			20
5.1.1 Acceptance of the project	Site	0 to 2 pts	
5.1.2 Number of households to be benefitted	Map 6	# families	
5.1.3 Potential conflict among water users	Site	0 to 5 pts	
5.1.4 Affected households (involuntary resettlement)	G-Map	# families	
6. LAND TENURE SYSTEMS			10
6.1.1 Indicative land tenure per household	Site	ha	

a/ International Commission on Irrigation and Drainage

3.15.6 Sensitivity to Score Weight

The weight given to the different categories will influence the ranking. To determine the influence of the weight on the ranking, a sensitivity analysis is done. Four different weights were used, giving different weights to economic, social and engineering categories. The results of the sensitivity analysis is given in report on Appraisal[5].

The results of the sensitivity show that the two highest ranks change place, the third and fourth change place, and the last four ranks remain the last four. This clearly shows that the good schemes will always be good schemes, no matter what weights are given to different criteria, and poor schemes will always be poor.

[5] Irrigation Schemes Appraisal Methodology, July 2014 (SMEC)

3.15.7 Conclusions

A broad spectrum of criteria have been selected for the ranking of schemes which represents the diverse nature of irrigation. All aspects of the national agenda are included in the ranking criteria, which makes it a useful tool for prioritising schemes. This ranking uses design data, GIS data, site investigation data and economic cost data. A sensitivity analysis shows that the weighting applied to different criteria has little influence on the ranking.

3.16 Climate Change, Vulnerability and Adaptation

Climate change challenges in Malawi include unpredictable weather patterns, heat waves, water scarcity, droughts, drying up of rivers and lakes, short rainy seasons, prolonged dry spells during rainy season, floods, landslides, reducing species diversity, low fish supplies, frequent bush fires, increased prevalence of waterborne diseases, and unstable hydroelectric power generation (AFIDEP and PAI 2012). GoM recognises that global climate change is one of the biggest challenges facing humanity and that climate change has serious implications for the development and wellbeing of the nation (GoM 2012). This section presents a brief summary of projections from recent studies concerning climate change in Malawi and the likely effect of climate change on land use, water resources and agricultural activities. It is important to account for the effect of climate change, particularly in the context of long-term plans such as the IMP which addresses crop cultivation and irrigation activities directly and significantly influenced by climate. The strategies adopted in the IMP take into consideration the implications of climate change with respect to its impacts on water availability (variability of rainfall and stream/river flow), cropping seasons, and crop selection.

3.16.1 Observed and Projected Climate Change for Malawi

Malawi has experienced a 0.9°C increase in mean annual temperatures between 1960 to 2006, accompanied by an increase in evaporation rates. This temperature increase in Malawi has occurred more quickly in the mid wet season (December-February) and more slowly during the early warm period months of September-November. The warmest and coolest periods are projected to get over 2oC warmer by the end of the 21st century (Vincent et al 2014). Months at the start of the warm period are expected to experience the greatest increase in temperature, which has implications for Malawi's traditional planning season, while temperature are also expected to increase for the cooler months of June-July (Vincent et al 2014).

Rainfall has not shown statistically significant trends in total amount, date of rainfall onset, or length of the wet season (Vincent et al 2014). Cool dry season months are projected to get drier during all but the 75th percentile, though the degree of difference is less than 1 standard deviation from current rainfall variability (Vincent et al 2014). Based on analysis of three General Circulation Models (GCMs) Atkin's (2011) projections indicated a likely wetting trend for March to May in northern Malawi and a drying trend in the south. There is uncertainty regarding potential changes in wet season rainfall in Malawi, with different GCM models projecting drier or wetter warm seasons (Vincent et al 2014). Dynamic downscaling of models project a decrease in rainfall for September to November, but statistically downscaling shows no clear trend. Given the observed variability in GCM projections for rainfall in Malawi, interpretation of change in rainfall should be in terms of direction instead of level of change (Vincent et al 2014). Box 1 present a summary of climate trends and GCM projections for Malawi. Any changes in rainfall amount and timing will have serious implications for the timing of planting in rain fed agriculture (Vincent et al 2014) and for water use in irrigated agriculture.

Box 1: Climate Change Profile for Malawi

RECENT CLIMATE TRENDS

Temperature:

- Mean annual temperature has increased by 0.9˚C between 1960 and 2006, an average rate of 0.21˚C per decade. This increase in temperature has been most rapid in DJF (wet season) and slowest in SON.
- Daily temperature observations show significantly increasing trends in the frequency hot days and nights in all seasons.

Precipitation:

- Year-to-year variability in rainfall is very strong in Malawi, making it difficult to identify long term trends. Observations of rainfall over Malawi do not show statistically significant trends. Wet-season (DJF) rainfall over Malawi in 2006 was particularly low, causing an apparent decreasing trend in DJF rainfall.
- There are no statistically significant trends in the extremes indices calculated using daily precipitation.

GLOBAL CLIMATE MODEL PROJECTIONS

Temperature:

- Mean annual temperature is projected to increase 1.1 to 3.0˚C by 2060s, and 1.5 to 5.0˚C by 2090s.
- All projections indicate substantial increases in the frequency of days and nights considered 'hot' in current climate
- All projections indicate decreases in frequency of days and nights considered 'cold' in current climate.

Precipitation:

- Projections of mean rainfall do not indicate substantial changes in annual rainfall. The range of projections from different models is large and straddles both negative and positive changes ranging from -13% to +32%. Seasonally, the projections tend towards decreases in dry season rainfall (JJA and SON), and increases in wet season rainfall (DJF and MAM).
- Overall the models consistently project increases of up to 19% by the 2090s in the proportion of rainfall that falls in heavy events in the annual average under the higher emissions scenarios. These increases mainly arise from increases in heavy events in the wet-season, DJF and MAM, and are partially offset by decreases in the dry season JJA and SON.
- Under higher emissions scenarios models consistently project increases in rainfall maxima of up to 26mm in 1-day events and up to 39mm in 5-day events by the 2090s. These rainfall maxima also generally increase in DJF and MAM, but decrease in JJA and SON.
- Model simulations show disagreements in projected changes in the amplitude of future El Niño events. Malawi's climate can be strongly influenced by ENSO, thus contributing to uncertainty in climate projections for this region.

Source: McSweeney et al 2008

3.16.2 Implications of Climate Change Agriculture in Malawi

Malawi has experienced increasing climate variability characterized by droughts, flooding, late rains, short rains and dry spells, and resulting in poor crop yields, crop failure, and an upsurge malaria and cholera (AfDB 2011). MGDS II for 2011-2016 "recognizes that population dynamics and climate change influence all aspects of sustainable development, and calls for concerted efforts to address these issues in order for the country to achieve its development objectives" (AFIDEP and PAI 2012). Rapid human population growth in Malawi has led to large scale landuse changes, particularly clearance of forested land for cultivation, weakening the natural buffers (such as forests) against variations in temperature, wind and distribution of rainfall, which is resulting in stronger effects of natural disasters such as floods and droughts (Palamuleni 2009). Landuse and land cover change associated with population growth have led to reduced infiltration capacity and less root zone water storage, thus modifying the hydrological responses in catchments which now experience increasing runoff rates, greater drainage of water during the wet season, more high-flood events, and reduced dry season base flow (GOPA and Aurecon 2014). These events impact agriculture - for example, dry spells experienced early in the wet season, while high intensity rainfall during periods of germination and crop ripening causes waterlogging all of which result in critical impacts to the production of crops (Tadross et al., 2009). Changes in dry season base flow are particularly problematic for dry season irrigation (GOPA and Aurecon 2014). Table 5 presents a few examples of potential impacts of climate change on agriculture.

Table 5: Examples of impacts on agricultural crop production from projected climate change

Event	Potential Impact
Cold periods becoming warmer and shorter; over most land areas, days and nights becoming hotter (virtually certain)	Increased yields in colder environments; decreased yields in warmer environments; increased outbreaks of new insect pests and pathogens; potential impacts on crop production
Heavy precipitation events increasing in frequency over most areas (very likely)	Damage to crops; soil erosion; inability to cultivate land owing to waterlogging of soils
Drought-affected areas increases (likely)	Land degradation and soil erosion; lower yields from crop damage and failure; loss of arable land
Intense tropical cyclone activity increases (likely)	Damage to crops

Source: Adapted from FAO 2013 (adapted from IPCC 2007 in FAO 2008)

Agriculture is the main source of livelihood for about 90% of Malawi's rural population, making their livelihoods highly vulnerable to the effects of climate change on rainfall (AfDB 2011). Malawi's economy is thus vulnerable to climate change since most of the population depends on climate sensitive agriculture and agricultural products (e.g. tobacco) are also the country's primary exports. Food security and poverty eradication efforts have been undermined by climate related hazards including droughts, dry spells, floods, and erratic rains, which have become increasingly unpredictable, intense and more frequent (AFIDEP and PAI 2012). The populations most vulnerable to climate change in Malawi includes women (particularly in female-headed households), children, the elderly, urban poor and inhabitants of lowlands or drought prone highlands (AFIDEP and PAI 2012). GoM has established the Ministry of Environment and Climate Change and issued a National Climate Change Policy to improve responses and adaptation to climate change.

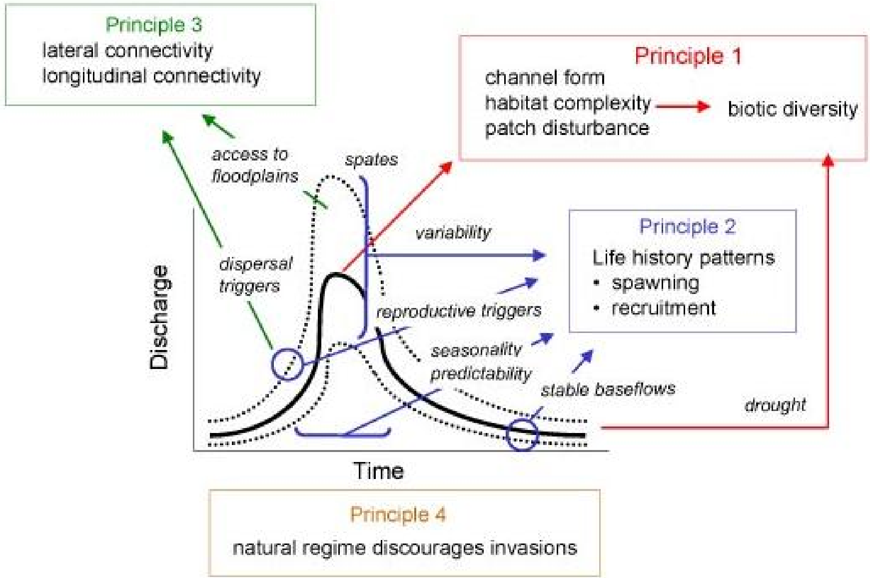
3.16.3 Climate Change Adaptation and Resilience

Adaptation to climate change requires a shift to "*agricultural production systems that are more productive, use inputs more efficiently, have less variability and greater stability in their outputs, and are more resilient to risks, shocks and long-term climate variability*" (FAO 2013). More climate resilient agriculture necessitates a change practices of land, water, nutrients, and genetic resource management, towards more efficient use and conservation (FAO 2013). Climate change mitigation will also require a reduction in greenhouse gases emitted through agricultural production activities (FAO 2013). Climate Smart Agriculture (CSA) is proposed by FAO (2013) as a means for: "(*1) sustainably increasing agricultural productivity and incomes; (2) adapting and building resilience to climate change; and (3) reducing and/or removing greenhouse gases emissions"*. CSA approaches "*identify and operationalize sustainable agricultural development within the explicit parameters of climate change… and requires site-specific assessments to identify suitable agricultural production technologies and practices"* (FAO 2013). Some recommended agricultural approaches and practices adapted to climate change are detailed in Appendix 8. In the context of irrigation planning the practice of particular interest is water resource management. Effective irrigation planning is an important component of agricultural adaptation to climate change in Malawi where rain fed agriculture is highly vulnerable to variability in the timing, intensity and amount rainfall. Irrigation must take into the consideration potential variability in surface water availability and the need to balance water extraction for irrigation use with other demands for water including environmental flows.

3.17 Environmental Flows

Environmental flows, as defined in the Brisbane Declaration (2007), "*describe the quantity, quality and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on the these ecosystems*." Alternative terms have been used to refer to environmental flow, such as in-stream flow, minimum flow, maintenance flow, ecological flow, ecological reserve, environmental reserve and riparian flow (Davis and Hirji 2003). The flow of water through river systems is a key driver of river ecosystem health and must be maintained to sustain fisheries and other sensitive organisms inhabiting the ecosystem. Environmental flows should take into consideration the natural variability of river flow, including such aspects as magnitude, frequency, duration, timing, and rate of change of flow events in rivers, as organisms inhabiting the river ecosystem are adapted to and often have developed lifecycles dependent on these natural flow features (O'Keeffe 2009).

Four key principles have been developed to describe the mechanisms that link river hydrology and aquatic biodiversity and thus potential ecological impacts of altered flow regimes (Bunn and Arthington 2002): *"(1) flow is a major determinant of physical habitat in streams, which in turn is a major determinant of biotic composition; (2) aquatic species have evolved life history strategies primarily in direct response to the natural flow regimes; (3) maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species; and (4) the invasion and success of exotic and introduced species in rivers is facilitated by the alteration of flow regimes*" (Figure 4).



Source: Australian Rivers Institute, n.d.

Figure 4: Principles describing the link between river flows, ecosystem habitat, and aquatic biodiversity

Environmental Flow Assessment (EFA) is used to estimate the quantity and timing of flows required by aquatic ecosystems. Flow regime can be categorized into four levels of flow: (1) subsistence flow, needed during drought periods for provision of minimal aquatic habitat and maintenance of tolerable water quality; (2) base flow, adequate to sustain the river's biota and abiotic components in a healthy state; (3) high flow, which remains in the river channel, washes sediment from the river bed, enhances the quality of the river following a long period of base flow, and provides habitat connectivity for organisms along the stream length; and (4) overbank flow, which connects the main river with its floodplain, restructures the channel and floodplain, transports nutrients to riparian vegetation and recharges groundwater (NRC 2005). The timing of these flows are important as floods and low flows provide environmental cues important to lifecycles of biota of the river ecosystem (NRC 2005). Environmental flows need to be set to sustain river ecological functions and to protect the services and values derived therefrom (Table 6); however, quantifying and predicting how much water can be abstracted without damaging the fisheries and ecological systems has been a challenging task.

Environmental flows need to be set by considering scientific information and in consultation with the community that use the river as a resource. Natural resource managers and development planners use environmental flow assessments to acquire EFR information needed to make informed decisions about water management that preserves ecological functions important for sustainable social and economic development. The environmental flow decision making process needs to be considered as both scientific and social (Gippel and Speed 2010). Environmental flows may need to be large if a community wishes a river to be close to natural. Safeguarded and planned releases of environmental flows is an important measure for mitigating negative impacts to river ecology caused by changes in the natural river flow. It is important to recognize that to improve and sustain river ecosystem functions and health, environmental flows need to be considered in conjunction with other environmental management and mitigation measures such as catchment management and water quality improvement (Davis and Hirji 2003).

Table 6: Valued river features protected by provision of environmental flows

Aquatic animals	Freshwater fish are a valuable source of protein; macroinvertebrates are important components of the food web	Flows to maintain physical habitat and suitable water quality, transport organic matter and nutrients, allow movement of migratory fish, and serve as life-cycle cues (e.g. floods to stimulate spawning runs)
Riparian vegetation	Stabilizes river banks, provision of food and firewood for people and habitat for animals; buffers the river against nutrient and sediment inflows	Flows to maintain soil moisture levels in river banks; floods to deposit nutrients and sediments on river banks; flows to transport and distribute seeds
River sand	Used for construction	Flows to transport and separate sand from silt and clay soils
Aquifers and groundwater	Maintain the perennial nature of rivers by providing water during the dry season	Flows to recharge groundwater (aquifers)
Floodplains	Support fisheries and flood-recession agriculture	Floods that inundate floodplains at ecologically appropriate times of the year
Aesthetics	Sounds of running water, clean streams, presence of wildlife	Flows that maintain aesthetic values
Recreation and culture	Clean water for swimming and bathing; support fisheries and other culturally important organisms.	Flows that flush sediments and algae, maintain water quality, and sustain fisheries
Ecosystem services	Maintain the capacity of aquatic ecosystems to regulate ecological processes such as water purification, flood attenuation	Flows that maintain ecosystems functioning and biodiversity
Overall environmental protection	Desire to minimize human impacts and conserve biodiversity and natural systems for future generations	Flows that maintain river health, promote water quality, sustain aquatic biodiversity, and support sustainable development

Source: Adapted from Davies and Hirji 2003

3.17.1 Environmental Flow Assessment Approaches and Methods

Multiple approaches and methods for environmental flow assessment have been developed over the years, yet there is no consensus on a single best methodology for assessing environmental flow requirements. Tharme (2003) describes the existence of around 207 different environmental flow assessment methods used in 44 countries around the world. The decision of which method to adopt is to some extent dependent on resources (i.e. financial, time, data, and human resources) available for the assessment (Lagerblad 2010). The objective of environmental flow assessment should be to relate the ecological health of a river to an environmental flow regime or to recommend a flow regime that will maintain river health.

In determining environmental flow requirements, existing river flow regimes altered by human impacts is often compared with natural flow regimes of rivers as simulated from past hydrographs (Botter *et al*. 2010). Many EFA methods are complicated processes requiring years of studies and data collection on flows and ecology, catchment assessment and stakeholder consultation (Atkins 2011). Common approaches to assessing environmental flows as reviewed by Tharme (2003) can be categorized as:

- **Hydrological**: use of hydrological data (historical monthly or daily flow records) to make (minimum) environmental flow recommendations that will maintain river health at a designated level; Hydrological methods are typically adopted for planning level environmental flow determination;
- **Hydraulic Rating**: use changes in simple hydraulic variables (e.g. water depth, velocity, wetted perimeter) across a single river cross-section as a surrogate for habitat factors that might limit selected riverine biota;
- **Habitat Simulation**: assess environmental flows from modelling the suitability of physical habitat available to selected species under different flow regimes (integrated hydrological, hydraulic and biological response data); Habitat Simulation requires input from a multidisciplinary team of scientists and sociologists in order to recommend environmental flows;
- **Holistic**: identify important flow events and the relationship between flow and ecological, geomorphological and social responses. Holistic methods incorporate elements of the hydrological, hydraulic and habitat simulation methods and requires input from a multidisciplinary team of scientists and sociologists in order to recommend environmental flows. The holistic approach attempts to consider the entire ecosystem and seeks to balance environmental flows with the water needs of users (Gippel and Speed 2010). An in-depth review of environmental flow assessments with an emphasis on the holistic approach is provided by Arthington et al. (2004).

Acreman and Dunbar (2004) grouped environmental flows methods into four classes: i) look-up tables, ii) desk-top analysis, iii) functional analysis, and iv) habitat modelling (see Table 7).

Table 7: Characteristics of environmental flow assessment methods

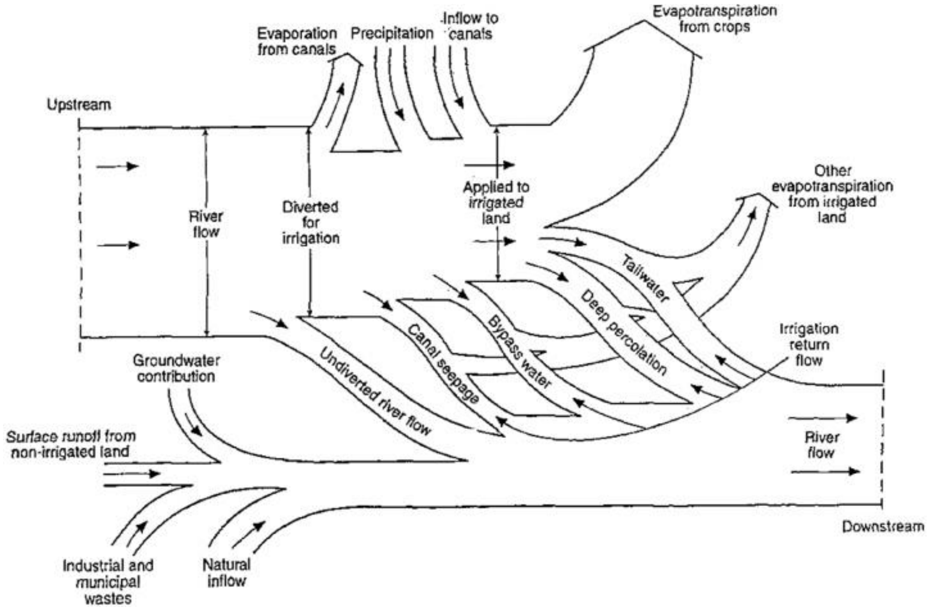
Environmental flow assessment method	Characteristics of each environmental flow assessment method
Look-up tables (e.g. Tennant Method, Flow Duration Curve Analysis (e.g. Q_{90}), Aquatic Base Flow Method (e.g. minimum monthly flow of 10 year drought period) and the 7Q10 methods)	Worldwide the most commonly applied methods to define target river flows are empirical "rules of thumb" based on simple indices; based on hydrological analysis with limited ecological considerations; based on statistical properties of the natural flow regime; an often used indicator is the Q_{95} Index, which is the flow that is equal or exceeded for 95% of the time; another indicator is the mean annual minimum flow; also the Tennant approach, which sets 10% of the mean annual minimum flow as the minimum required for poor quality of habitat and aquatic species survival, 30% is required for a satisfactory quality of habitat and aquatic species survival, and 60% for an excellent quality of habitat and aquatic species survival, This method has low confidence but is quick and easy.
Desktop analysis (e.g. Range of Variability Approach, Variable Monthly Flow Method, and Desktop Reserve Model)	Use existing data such as river flows from gauging stations and/or fish data from regular surveys; can be sub-divided into those based purely on hydrological data, those that use hydraulic information (such as channel form) and those that employ ecological data; examine the whole river flow regime rather than pre-derived statistics; maintain integrity, natural seasonality and variability of flows, including floods and low flows; long time series of data required.

Functional analysis (e.g. Building Blocks Method (BBM), Expert Panel Assessment Method, Scientific Panel Approach, Benchmarking Methodology)	Build an understanding of the functional links between all aspects of the hydrology and ecology of the river system; take a broad view and cover many aspects of the river ecosystem, using hydrological analysis, hydraulic rating information and biological data; take an integrated approach that uses a range of different experts (hydrologist, hydro-geologist and geomorphologist and biologists (e.g. aquatic entomologist, botanist, fish biologist). Consider that riverine species are reliant on basic elements (building blocks) of the flow regime, including low flows and floods that maintain the sediment dynamics and geomorphological structure of the river; expensive to collect all relevant data and to employ wide range of experts.
Habitat modelling (e.g. Physical Habitat Simulation System (PHABSIM) and Downstream Response to Imposed Flow Transformations (DRIFT))	Use data on the habitat of target species to determine ecological flow requirements; the relationship between flow, habitat and species can be described by linking the physical properties of river stretches, e.g. depth and flow velocity, at different measured or modelled flows, with the physical conditions that key animal or plant species require. Established functional relationships between physical habitat and flow are linked to scenarios of river flow; evolved from steady-state analysis of flows for given levels of habitat to time-series analysis for the entire flow regime in the river; expensive to collect the required hydraulic and ecological data; data intensive and time consuming.

Source: Dyson *et al*. 2003

3.17.2 Importance of Considering EFR for Irrigation Planning in Malawi

Extraction of irrigation water from surface waterbodies such as streams and rivers reduces the volume of flows in the stream in reaches downstream of the water extraction point, though some of the irrigation water may eventually drain back into the system further downstream (Figure 5). Irrigation using groundwater can also affect the movement of water between surface and groundwater sources and thus may also impact flows in streams and rivers; however, groundwater resources in Malawi are fairly limited and not likely to serve as a major contributor of water for large scale irrigation (Atkins 2011). Irrigation planning should take into consideration environmental flow requirements in assessing the volume and temporal availability water resources for potential irrigation. Environmental flow determines the volume of water which should be kept in the river ecosystem and thus also the amount of water that could be sustainably extracted irrigation. Environmental flow requirements thus need to be assessed and estimated for the rivers in Malawi as an important feature of water resource management and planning.



Source: FAO 1995 citing Utah State University Foundation, 1969

Figure 5: Conceptual diagram of irrigation related inflow and outflows.

Table 8: Irrigation-related actions/infrastructure impacting flows and potential consequences for aquatic ecosystem

Action	Impact on Flow	Potential Ecosystem Consequences
Irrigation flows (using the river as a conduit)	Dry-season low flows increased, and seasonal variability reduced.	Can result in higher flows in the dry season than in the wet season. Hydraulic and thermal conditions can become mismatched with life-cycle requirements, causing species to decrease in numbers and abundance. Pests are often able to take advantage of such environmental conditions and increase in abundance.
River diversion	Frequency and duration of floods reduced	Reduces habitat availability and restricts movement of aquatic animals, thus increasing competition for space and vulnerability to predation. Increases diurnal temperature fluctuations, concentrates effluents, and can lead to toxic algal blooms
Dams	Frequency and duration of floods	Flood cues that trigger fish spawning or seed germination may occur at the wrong time of the year or not at all, resulting in a failure to produce new generations of individuals. Reduced wetting of banks stresses riparian vegetation and reduces establishment of seedlings. Bank stability is weakened and soil erosion increases. Reduced flows into estuaries reduces access for marine fish using estuaries as nursery areas. Reduced flooding of riparian wetlands and floodplains causes loss of fisheries and other attributes.
Deforestation of catchment	Energy of medium/large floods increased; dry season flows decreased	Increases bank and bed erosion, which alters the available habitat for aquatic species. Reduces habitat availability in the dry season. Increases the risk of animals being washed away.
Afforestation of catchment	Wet and dry season low flows reduced and small floods attenuated	Reduces flood cues that trigger fish spawning or seed germination, and decreases wetted habitat through the year.

Source: Adapted from Davies and Hirji 2003

3.17.3 Comparison of EFA Methods for Irrigation Planning in Malawi

Several alternative methods for conducting environmental flow assessments (EFAs) in the context of the rivers in Malawi were reviewed by the consultant. The choice of EFA methods considered is influenced by the availability of resources (both human and financial) and data, as well as the objectives of the irrigation planning process. Establishing accurate ecological requirements for water resources is essential for ensuring that the prescription and allocation of water does not lead to serious environmental impacts. Given the lack of ecological and biota data needed to conduct complete holistic environmental flow assessment methods involving habitat modelling and functional analysis, readily feasible EFA assessments for Malawi are limited to hydrological approaches using look-up table and desktop analysis methods. Six hydrologically-based EFA methods, including methods adopted in Malawi's Water Resource Investment Strategy (Atkins 2011) and Water Resources Master Plan (JICA 2014), were compared by the Consultant for the rivers in the delineated water resource areas (WRAs) of Malawi (see Table 9).

Table 9: Alternative EFA methods applied to Malawi context for comparison

Environmental flow assessment method	Category of Hydrological Method	Description of the environmental flow recommended	Adopter in Malawi (context)
Tennant Method: 10% of MAF	Look-up table	10% of the mean annual minimum flow is set as the minimum required to maintain at least poor quality habitat and aquatic species survival	Northern Region Water Board;
Modified Tennant Method: 25% of MMF	Look-up table	25-30% of the MAF is estimated by some experts as the minimum flow required for satisfactory quality of habitat and aquatic species survival. Here we adopted a modified approach using 25% of mean monthly flow.	SMEC (for comparison)
Minimum Monthly Flow of the 10-Year Drought Period	Look-up table	The mean annual minimum flow is an empirical "rule of thumb" determination based on hydrological analysis.	Blantyre Water Board; Lilongwe Water Board
Flow Duration Curve Analysis Method: Q90 Index	Look-up table	Q90 is the river flow that is equalled or exceeded for 90% of the time period under consideration. Q90 index is based on hydrological analysis, specifically analysis of the statistical properties of the natural flow regime.	JICA (Water Resource Master Plan)
Desktop Reserve Model (DRM) Method	Desktop analysis	EFRs are specified based on modelled hydrological index and existing catchment condition for each WRA, with EFRs specified for dry and wet season (Table 6).	Atkins (Water Resources Investment Strategy)
Modified Variable Monthly Flow Method (VMF)	Desktop analysis	The VMF method allocates EFRs as percentages of MMF for low, intermediate and high flow seasons of the year. A modified VMF was used, where low and high flow percentages were set for each WRA to reflect the shape of the flow curve, varying the EFRs recommended by Atkins based on DRM method. Annual EFR averaged 32% of MAF, the same annual EFR average as Atkin's DRM.	SMEC (for comparison)

The methods used are listed in Table 10, and the actual monthly flows represented in

Table 10: EFA methods used for the PIA comparisons

Method	System	Curve of Flow
EFR-WRIS	Desktop Reserve Method (WRIS)	Step
10% MAF	Using Tennant 10% of mean Annual Flow for 12 months	Flat
25% MMF	Using Tennant 25% of mean Monthly Flow for 12 months	Variable
Min MF	Using the minimum Monthly Flow for 12 months	Flat
EFR-VMF	Variable Monthly Flow (VMF) (modified WRIS)	Variable
Q90 (EFR 90%)	Using the 10 year drought flow	Variable
Q93 (EFR 93%)	Using the 15 year drought flow	Variable
Q95 (EFR 95%)	Using the 20 year drought flow	Variable

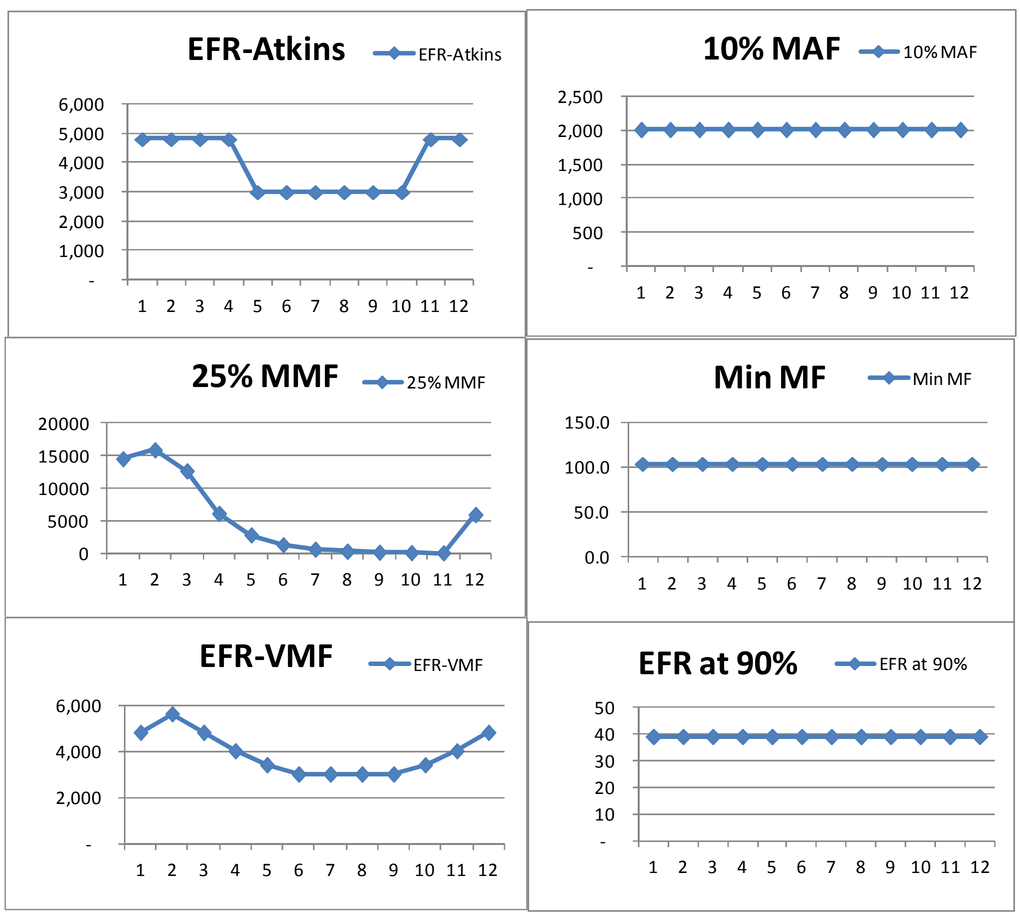


Figure 6: Plots depicting 6 methods of EFR

Based on alternative EFA methods including the Desktop Reserve method used by Atkins (top left), the Q90 method used by JICA for the Water Resource Master Plan (top right), the 10% of MAF based on Tennant's method as used by SMEC for identification of potential irrigation schemes to be included in Irrigation Master Plan (middle row, left), Minimum Monthly Flow as adopted by Lilongwe and Blantyre Water Boards (middle row, right), 25% of MMF (bottom left) and Variable Monthly Flow Method (bottom right) included as an alternative EFA methods for comparison.

The results of these assessments is given in the section 5.5.1 on PIA.

4 BIOPHYSICAL PROFILE

4.1 Overview

Any successful planning process must take into account a considerable quantity of basic data of many types. A master plan for irrigation, for example, must include not only biophysical data but administrative, social and economic data as well. It is very important to establish at an early stage how the data are to be collected and utilised so that meaningful and practical recommendations can be made. GIS, the principal tool selected for obtaining and processing data in this study, was applied in three areas:

- Data collection and storage. All electronic or physical data acquired digitally or by digitisation from paper maps were stored in a common database using a common coordinate system.
- Data conversion and mining. Much of the data that referenced geographic information was received in tabular form. Because these data were converted into map format to facilitate analysis, the IMP documents contain more maps and fewer tables.
- Data analysis. GIS allowed both stored and converted data to be combined into an explicit analysis.

4.2 Administrative & Infrastructure Data

The IMP covers the whole Nation. The administration is divided into three regions, north, central, and south. These are further dissected into eight agricultural development divisions (ADD), and then into 28 districts. The smallest unit of administration is the traditional authority (TA), and there are 208 TAs. For the purpose of registration, these TAs are divided into enumeration areas (EA) and there are 9,235 of these.

All hydrological planning in Malawi is based on the Water Resource Area (WRA), see Figure 7, since this represents individual catchments. The reasons behind selecting water catchments are that they are natural hydrological boundaries, where their size is manageable and represent homogeneous parameters within themselves. The total number of WRAs is 17 but two will not be included in the IMP because these are part of islands in Lake Malawi. The next hydrological subdivision are the Water Resource Units (WRU) and these are 78. A representation of these administrative units is given below in Figure 8, with the boundaries down to district and WRA in Figure 9.

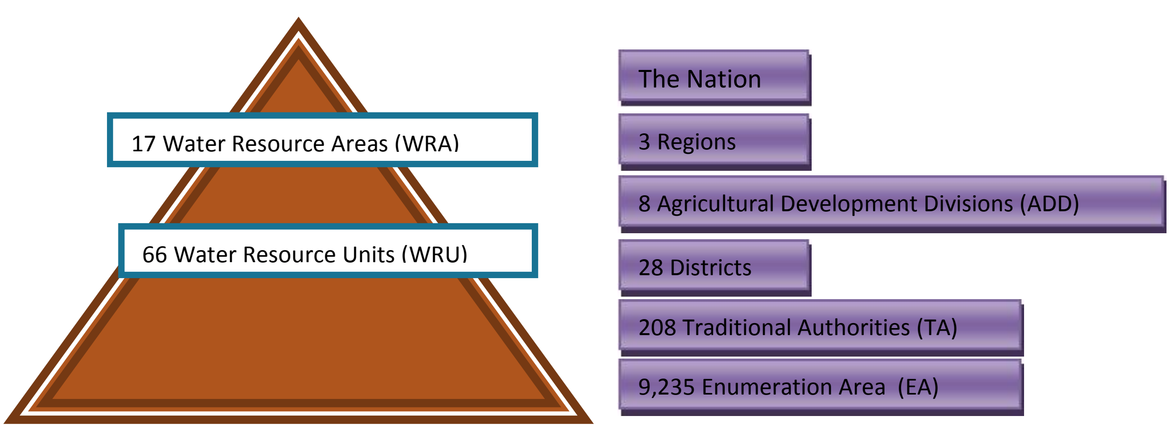


Figure 7: The Physical Planning Units

Based on the most recent census in 2008 and the annual growth rate of 2.8% the population of the country is about 15.4 million in an area of 118,000 km^2. The density and distribution of population is of prime importance in the location of irrigation schemes and because irrigation development is dependent on sufficient markets to support the financial viability. The population for each EA is available and shows the spatial distribution of population. This aspect will be used in the ranking and selection of schemes, as expanded in Section 6.6.

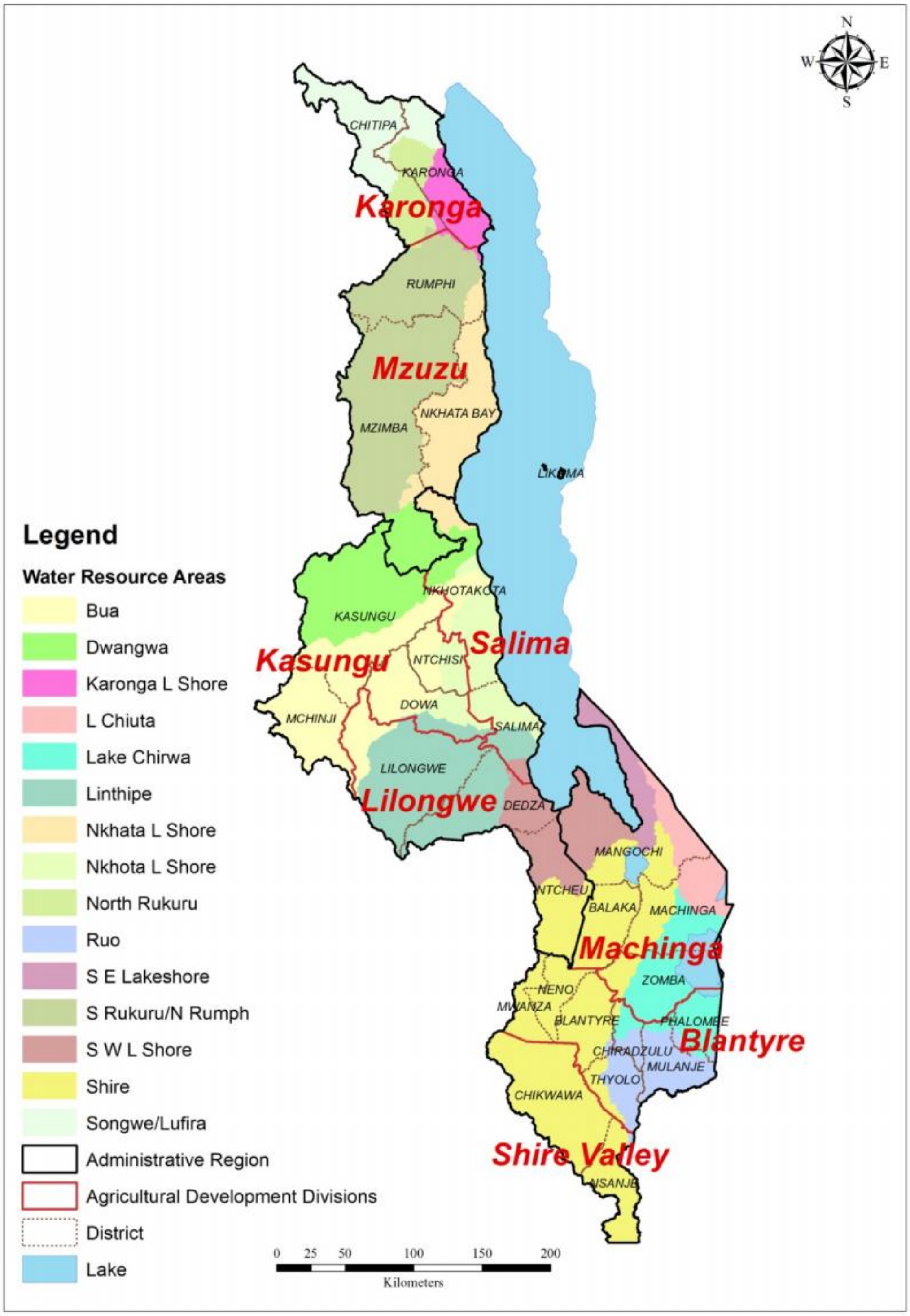


Figure 8: Region, ADD, District and Water Resource Areas, WRA (Source: MASDAP)

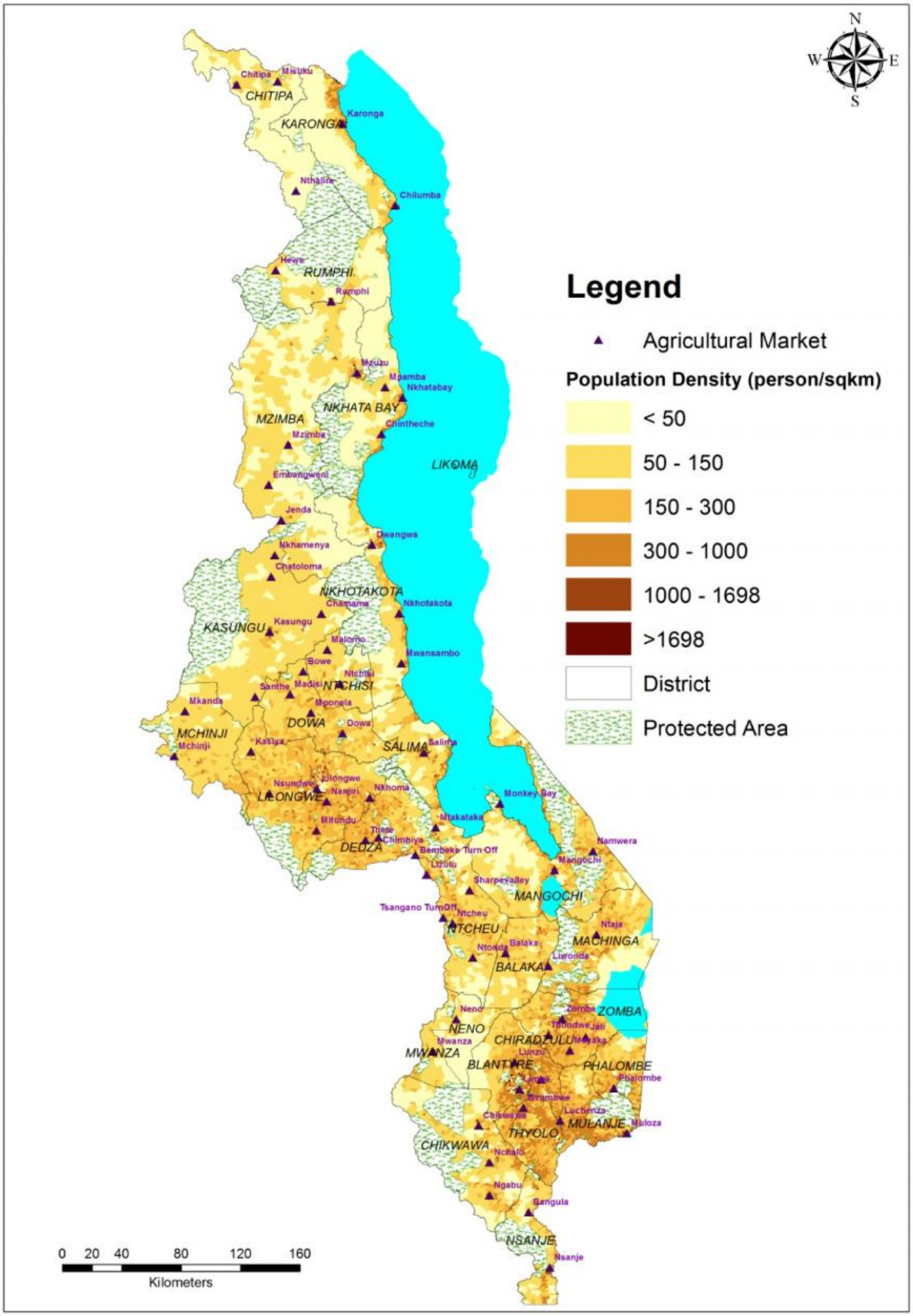


Figure 9: Population Density with Market Centres (Source: NSO, 2008)

4.3 Infrastructure

Malawi is blessed with good infrastructure in the form of a network of asphalt roads, and other roads. Self-help road construction has meant the rural roads are reaching every part of the country. In addition there is 820 km of railway lines, of which some are not functional, like the section of Mchinji. But new rail networks are being constructed connecting across the country to Mozambique coast.

There is also a network of power distribution and production. Unfortunately this aspect is lagging behind development and causing power outages. The largest consumer of power is the Illovo Sugar Estate at Nchalo and they pump all their irrigation water. However, the vast resource of water available is relatively limited because electricity, which forms the cheapest form of power, is lacking in many locations suitable for pumped irrigation.

Table 11: Road Class Length

Road Class	Length
Main Road	3,511
Secondary Road	2,804
District Road	2,560
Tertiary Road	3,874
Other Roads	78,891

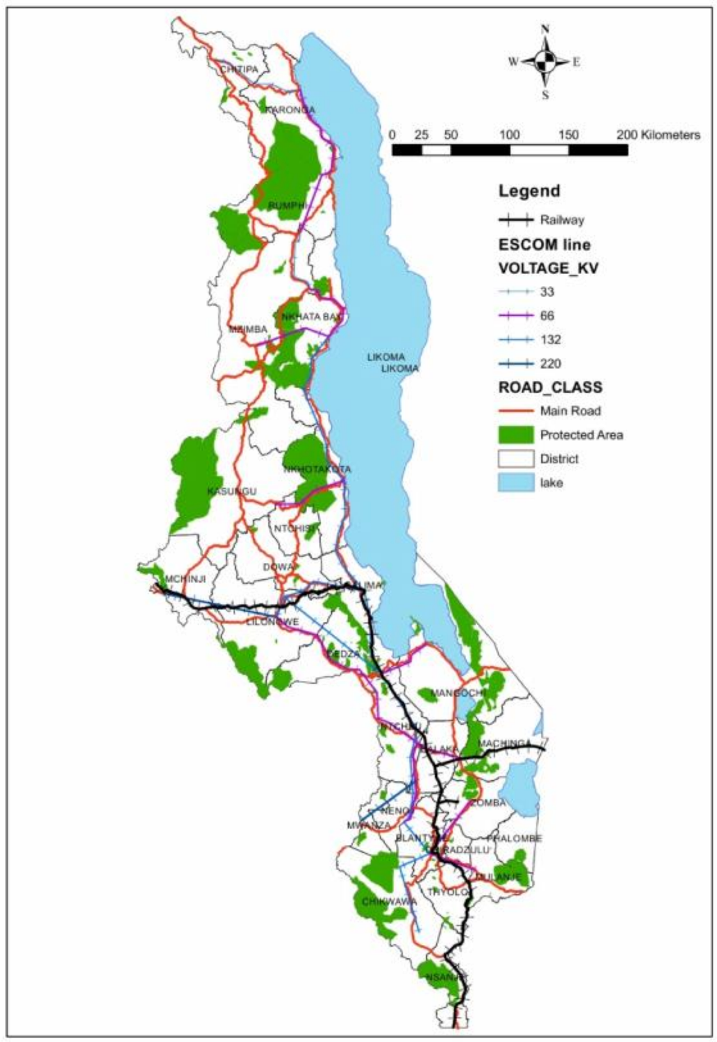


Figure 10: National Infrastructure

4.4 Livelihood Zone Descriptions

Descriptions of Zones[6] highlights the variations in climate, agriculture, income and employment. These zones harmonise well with the other zones developed later in the plan.

Table 12: Population by Livelihood Zone[7]

No.	Livelihood Zone	Population	% of total
1	Central Karonga	44,516	0.37%
2	Chitipa Millet and Maize	116,402	0.98%
3	Kasungu-Lilongwe Plain	3,236,493	27.11%
4	Lake Chilwa – Phalombe Plain	1,161,418	9.73%
5	Lower Shire Valley	648,358	5.43%
6	Middle Shire Valley	416,254	3.49%
7	Misuku Hills	36,289	0.30%
8	Mzimba Self-Sufficient	430,506	3.61%
9	Nkhata Bay Cassava	291,135	2.44%
10	Northern Karonga	111,720	0.94%
11	Northern Lakeshore	111,070	0.93%
12	Phirilongwe Hills	211,697	1.77%
13	Rift Valley Escarpment	1,167,578	9.78%
14	Shire Highlands	1,095,667	9.18%
15	Southern Lakeshore	505,979	4.24%
16	Thyolo-Mulanje Tea Estates	669,816	5.61%
17	Western Rumphi & Mzimba	139,250	1.17%
18	Not Zoned (Major Urban area)	1,543,786	12.93%
	Total	11,937,934	

Table 13: Livelihood Zone Summary

Livelihood Zone	Food Crops	Income Sources	Livestock
1. Central Karonga	Maize, Cassava, Sweet Potato	Food crops, Livestock, Other	Cattle, Pigs
2. Chitipa Millet and Maize	maize, sweet potatoes, tobacco, cassava, groundnuts, beans and finger millet.	Food crops, Livestock, ganyu	chickens, guinea fowl, goats
3. Kasungu Lilongwe Plain	Maize	Tobacco	Cattle, Goats
4. Palombe Plain/Lake Chilwa	Maize, Pulses, Rice	Other, Food crops	Goats, Pigs
5. Lower Shire Valley	Maize, Rice, Sorghum, Millet	Food crops, Cotton, Livestock sales	Cattle, Goats
6. Middle Shire Valley	Maize, Pulses, Rice	Food crops, Other, Cotton	Cattle (few), Goats
8. Mzimba Self-Suffic	Maize, Cassava	Tobacco, Food crops, Livestock	Cattle, Goats
9. Nkhata Bay Cassava Zone	Cassava, Maize	Food crops, other	Cattle (few)

[6] Malawi Baseline Livelihood Profiles, Version 1 *September 2005, Malawi National Vulnerability Assessment Committee. Sept-2005

[7] Source: NSO Population Projections and MoAIFS, Populations by EPA. Sept-2005

11. Northern Lakeshore Livelihood Zone	Cassava, maize, rice, bananas	Paddy, fishing, other	little
12. Phirilongwe Hills	Maize, Cassava, Pulses	Tobacco, cotton, Groundnuts	little
13. Rift Valley Escarpment	Maize, Groundnuts, S. Potatoes, Cassava, Rice, Cotton	Cotton, ganyu other	Goats, Cattle (few)
14. Shire Highlands	Maize, Cassava	Food crops, other	Goats
15. Southern Lakeshore	Maize, Rice	Fishing, Fishing ganyu, Fish trading	Goats
16. Thyolo Mulanje Tea Estates	Maize, Bananas	Estate work, Banana sales, Fruit and vegetables sales	Insignificant
17. Western Rumphi/Mzimba	Maize	Tobacco	Pigs

Central Karonga: A relatively productive maize and cassava zone that attracts migrant labour from other parts of the country in most years. Less dependent on maize than other northern zones. Livestock holdings, especially of cattle, are high by national standards. Cash incomes are low, however, since tobacco is not grown and the zone is far from the country's larger urban markets.

Chitipa Millet and Maize: A less productive zone as the area is susceptible to unreliable rainfall Major crops grown in the zone include maize, sweet potatoes, tobacco, cassava, groundnuts, beans and finger millet. Millet is grown using the slash and burn system, a system that is being discouraged by government and has resulted in the crop becoming no longer the second largest in the food basket. Households also keep chickens, guinea fowl, goats and, for the 'middle' and 'better-off' only, cattle. Many 'poor' households do not have goats.

Kasungu Lilongwe Plain: This is a relatively productive but undiversified maize and tobacco zone. In an average year the zone produces a surplus of food and maize, groundnuts, sweet potatoes and soya beans are sold out of the zone, mainly to Lilongwe. Tobacco is the single most important cash crop, providing the majority of income for most households and explaining why incomes in the zone are relatively high compared to elsewhere in the country.

Palombe Plain/Lake Chilwa: Like the neighbouring Shire Highlands zone, this quite densely populated zone produces roughly enough to feed itself in most years. Income generating opportunities are equally limited, so that food crops are again sold post-harvest to obtain cash, and have to be replaced by purchases later in the year. Crop production is more diversified than in the Shire Highlands, with maize, rice and pulses the main staple food crops grown.

Lower Shire Valley: This hot dry lowland zone is nonetheless relatively productive by the standards of southern Malawi. A variety of crops are grown during both the main and winter seasons, with winter crops cultivated in wetlands beside the Shire River. Cotton is the zone's major cash crop. Cattle holdings are significant in the zone. The zone benefits from good access to neighboring Mozambique, a source of relatively cheap maize in both good and bad years.

Middle Shire Valley: This is a relatively dry mid-lowland area with winter cropping and fishing along the Shire River. It is similar to a number of other southern zones in that total production at zonal level is enough to achieve rough self-sufficiency in staple food. Quite a high proportion of production is sold post-harvest by most households however, and this has to be replaced by purchases later in the year. A range of crops are grown, including cotton, but low prices limit the income from this important cash crop.

Mzimba Self-Sufficient: This is a relatively diversified zone, with food and income generated from a variety of sources. Good yields are obtained for a range of crops, of which maize and cassava are the most important. There are three main sources of income for the zone: sale of food crops, sale of livestock and sale of tobacco. Cattle holdings are significant. Tobacco is grown by most households, although in smaller quantities than elsewhere, with the result that the zone is less dependent upon this one crop than other tobacco growing areas.

Nkhata Bay Cassava Zone: With high rainfall but poor soils, cassava is the dominant crop in this zone. The zone can be characterised as "food-rich but cash-poor", since there are few sources of income available besides the sale of crops, and there is only a limited market for the bitter variety of cassava grown in the zone. Maize, rice and bananas are grown in addition to cassava, and the sale of these also contributes significantly to local incomes. Given its drought resistance, cassava plays a key role in ensuring zonal food security, with the zone attracting migrant labour from other zones which are periodically affected by food shortages.

Northern Lakeshore Livelihood Zone: The zone covers a thin strip of land with a width of approximately 5-6 km, extending from the lakeshores of Nkhata Bay Boma to the Nkhotakota-Salima boundary. Cassava, maize and rice are the major food crops in the zone. The zone also grows quite a lot of bananas, which are mostly for sale. However, the bunchy top disease has in recent years almost wiped out the banana crop in the zone. Selling paddy and fishing are the main economic activities in the area. 'Poor' households earn income from fishing ganyu for the middle or better-off. Normally, cassava and maize complement each other, with maize providing food for the first three months after harvest.

Phirilongwe Hills: The Phirilongwe Zone covers most of the upland areas of the western half of Mangochi district. Normally, the zone receives significant amounts of rainfall, 800mm to 1000mm, which frequently causes water logging and flooding problems in some years in the low-lying areas. Maize is the main staple grown while tobacco and cotton are important cash crops for the area. Groundnuts are also grown for cash, especially for poor households, whose ability to grow tobacco is limited by their lack access to inputs, especially fertilizer. Winter crop production is not very significant in the zone. In normal years, the poor and middle wealth groups obtain 50-55% and 70%, respectively, of their annual food energy requirements from their own crop production. The rest of their needs are acquired through purchases and, for the poor, through ganyu. The 'better-off' households in the zone are able to exceed their food requirements through their own production in normal years.

Rift Valley Escarpment: This zone stretches along the slopes and foot of the western rift escarpment from south-east Nkhotakota district through Dedza and Ntcheu in Central Region down to Neno district in Southern Region. It is a relatively low-lying area characterised by high temperatures, especially during the summer months of August to September. Cotton is the main cash crop in the area. The area is generally food secure with the 'poor' households being able to meet almost all (97%) their minimum food requirements with 'middle' and 'better-off' wealth getting above their minimum food requirements during normal years. Livestock, mainly goats, play a very important role as a source of income for buying food. Cattle are also important but are mainly confined to the ‘better-off’ households. The ‘poor’ households also depend heavily on ganyu to obtain cash to buy food.

Shire Highlands: Landholdings are small in this most densely populated zone in the country. The zone produces roughly enough to feed itself in most years. However, income generating opportunities are limited and many households sell quite a high proportion of their production postharvest to obtain cash, becoming heavily dependent on the market later in the year. Crop production is relatively undiversified, with quite heavy dependence upon maize supplemented to a limited extent by cassava.

Southern Lakeshore: This is the principal fishing area of Malawi, with the shallow waters to the south of the lake favouring the participation of many small scale fishermen. Fishing dominates the economy, generating income through fish sales, ganyu and trading in fish. Crop production is also important but is insufficient to cover local food requirements in most years, a situation that is made worse by the post-harvest sale of crops by many households.

Thyolo Mulanje Tea Estates: This zone is dominated by large tea estates, which generate both formal employment and casual labour for a majority of households in the zone. Landholdings for the majority are very small and the zone is a food deficit area with a high dependence upon food purchase. The zone benefits from good access to neighbouring Mozambique, a source of relatively cheap maize in both good and bad years.

Western Rumphi/Mzimbak: Cropping patterns are relatively undiversified, with a heavy reliance on just two crops; maize and tobacco. The zone produces just about enough to feed itself in an average year, so that crops sold out of the zone post-harvest have to be replaced by imports later in the year. Incomes tend to be higher than in non-tobacco-growing zones, but there is little to fall back on should the tobacco crop fail. There are above average opportunities for collecting wild foods, given the proximity to Nyika National Park and Vwaza Game Reserve. The zone also benefits from its proximity to the neighbouring Nkhatabay Cassava Zone, a potential source of employment in bad years.

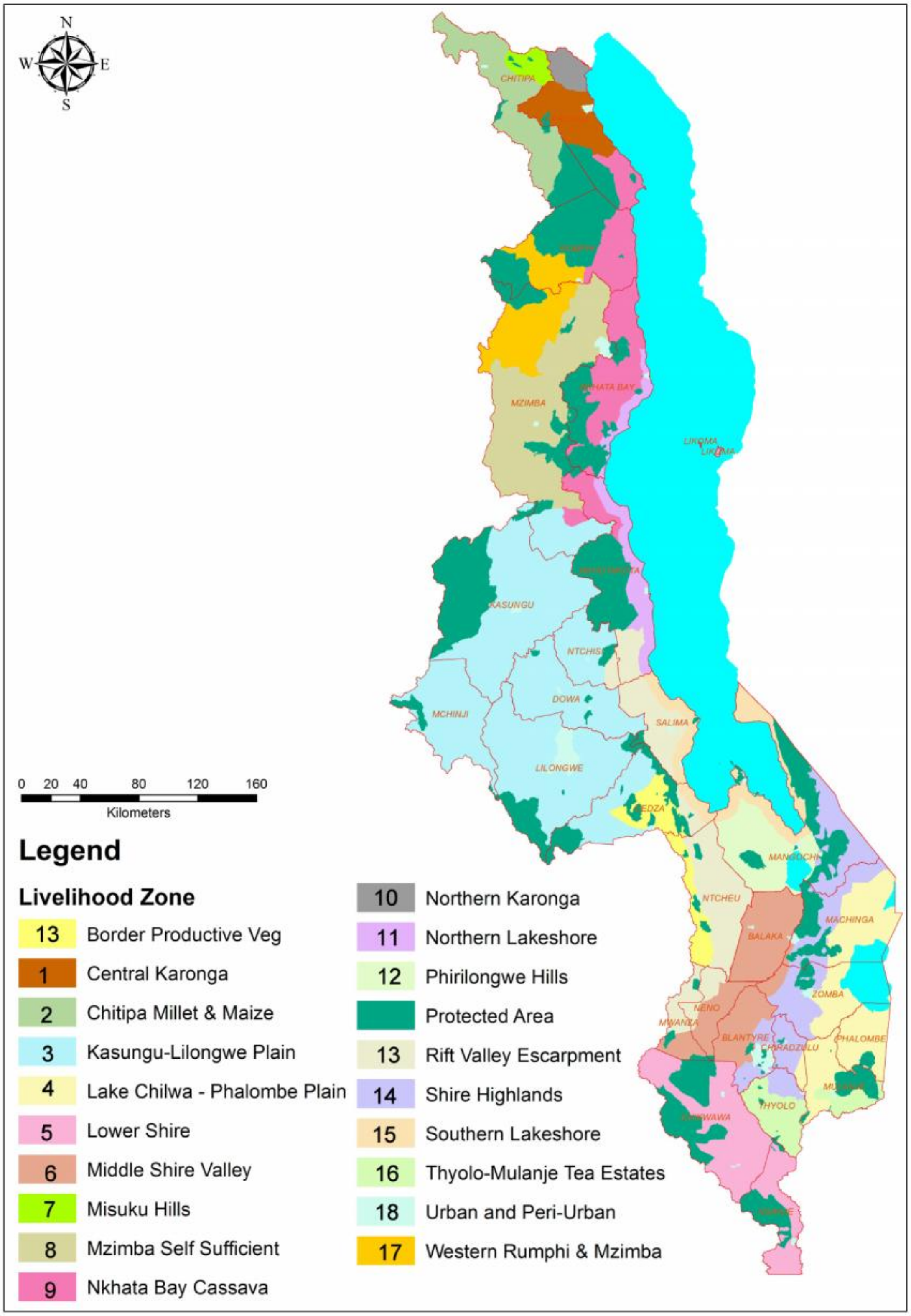


Figure 11: Livelihood Zones

4.5 Agriculture

4.5.1 General Crop Production

The main food crop is maize, which accounts for nearly 90 percent of the cultivated land, supplemented by sorghum, millet, pulses, rice, root crops, vegetables and fruits. Industrial export crops grown by smallholders include tobacco, cotton, paprika, rice, groundnuts and coffee. The main estate-grown crops are sugar, tobacco, coffee and tea. Malawi is the second largest producer of tobacco in Africa. Tobacco is an important crop that provides much of Malawi's foreign currency requirements. Maize, rice, sorghum, pearl millet and finger millet are the main cereal food crops grown by the population for food security and surplus sold along with vegetable crops like tomatoes, cabbage and fruits including citrus. Legumes such as beans, groundnuts, soya, cowpeas and pigeon peas are grown not only as food crops but also for cash. Chilli peppers (Capsicum) are an emerging cash crop for export. Root crops and tubers such as cassava, sweet potato and Irish potato are grown for food and cash crops.

4.5.2 Irrigated agriculture

Irrigated land in Malawi in 2013 stood at 94,000 hectares. Out of the total irrigated land, private estates contribute about 52.6 per cent (based on 2013 figures). While the irrigated land under private estates has grown by a mere 3% between 2006 and 2013, area under smallholders has grown by almost 150% during the same period (see Table 14). This could be enough evidence that there is more interest by the smallholders to engage in irrigated farming for economic development and food security.

Table 14: Irrigated Area by Sector in Hectares (2006 -2013)

Sector	2006	2007	2008	2009	2010	2011	2012	2013
Private Estates	48,360	48,360	48,360	48,360	51,000	48,382	49,340	50,000
Smallholder Schemes	18,210	25,114	29,640	33,249	39,000	42,181	43,182	44,209
Total	**66,570**	**73,474**	**78,000**	**81,609**	**90,000**	**90,563**	**92,522**	**94,209**

Source: Department of Irrigation Annual Report for 2013

Irrigation is done under two systems of production, estate based on freehold or leasehold tenure and smallholder farmers based on customary tenure. There has been a significant increase in smallholder irrigation over the last few years (240% in 10 years), with big jumps in 2007 through 2008. Part of this may be due to increased ability of collect data on irrigated area, but mainly due to the campaign to use treadle pumps for small holder irrigation. The distribution of technologies used in smallholder irrigation is: Treadle pumps 12,800 ha (29%), watering cans 3,100 ha (7%), motorised pumps 3,500 ha (8%), and gravity 24,700 ha (56%).

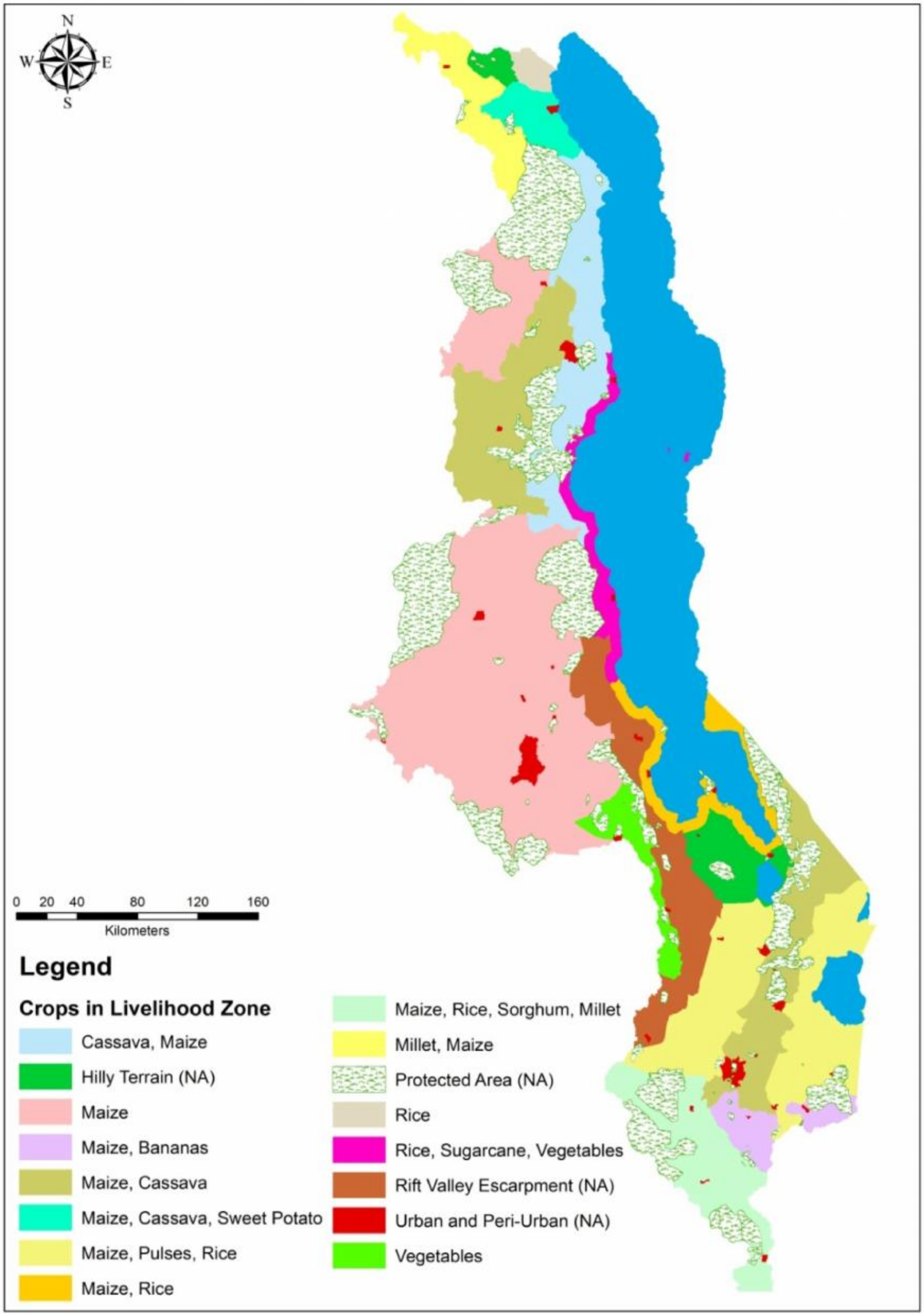


Figure 12: The Main Crops Produced Across the Seven Agro-Climatic Zones

4.5.3 Relief and Physiography

According to relief the country has been divided into five main physiographic regions (Reynolds, L; 2010), the Highlands, Escarpments, Plateaux, Lakeshore and Upper Shire Valley, and the Lower Shire Valley (Figure 13). The details are described below:

The Highlands: These consist of isolated mountains between 1,320-3,000 masl. Extensive highland plateaux are found in the Nyika, Viphya and Mulanje, while Dedza and Zomba are more isolated. Slopes can become precipitous, and soils are predominantly leached latosols.

The Escarpments: These are associated with major fault lines along the edge of the Rift Valley, running from Karonga in the north to Nsanje in the south. They are also found around the highland plateaux and mountains. Soils are predominantly thin latosols.

The Plateaux: Three quarters of Malawi consists of plateaux at elevations of 750-1300 masl. The topography is flat to rolling, with scattered rock inselbergs. The soil is deep well drained latosols on higher, with poorly drained sand and clay in the hollows. Poorly drained hollows are locally called dambos.

The Lakeshore and Upper Shire Valley: Lakeshore plains occupy 8% of the total land area, at 465-600 masl. The land is flat to gently undulating, with deep calcimorphic soils in the hollows. The upper Shire River flows through a broad flat valley. Soils are similar to those along the lakeshore. Mopanosols are found in some areas along the river.

The Lower Shire Valley: The lower Shire extends from Kapachira falls to Nsanje mostly at less than 180 masl. The river flows through two marshes with extensive areas of hydromorphic soils. To the east of the river, up to the Thyolo escarpment, soils are medium to coarse textured alluvial and colluvial. To the west there is a broad plain with vertisols and grey brown earths, rising towards the western escarpment. Some areas of saline soils are found.

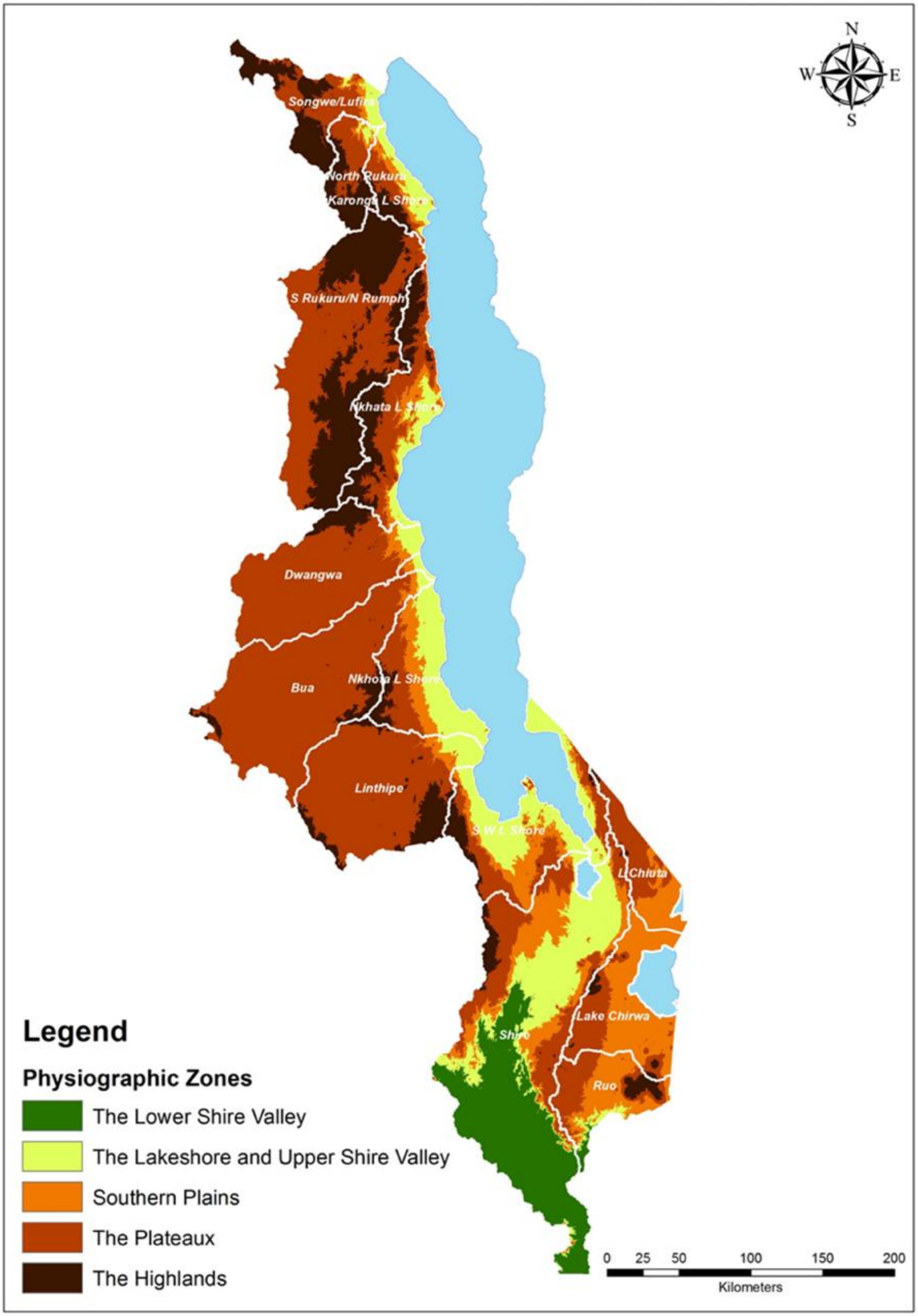


Figure 13: Physiographic/agro climatic zones (FAO,2010)

4.6 Slope

Around 42% of the country is flat or gently sloping (0-2%). Of the remainder 28% is sloping (2-6%), 14% is moderately steep (6-13%) and 16% is steep or very steep (>13%). Table 15 and Figure 14 present the distribution of various slope classes of Malawi and their area coverage.

Table 15: Slope Distribution of Malawi

Slope (%)	Description	Area (km^2)	Area (%)
0	Flat or almost flat	23,646	20
0-2	Gently sloping	26,107	22
2-6	Sloping	33,400	28
6-13	Moderately steep	16,491	14
13-26	Steep	11,319	10
>26	Very steep	7,034	6
Total		118,000	100

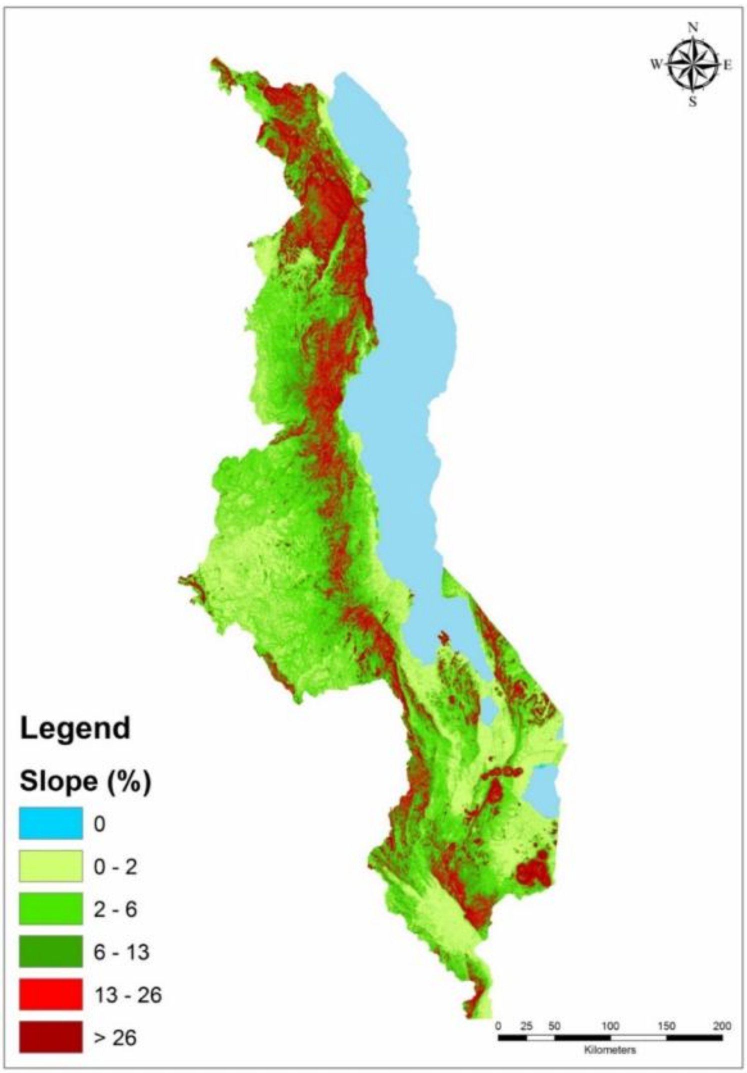


Figure 14: Slope map

Flat or almost flat (0%) land covers 20% of the country. It mostly consists of areas next to water bodies. For land management practices this class can be merged into gently sloping class (0%-2%).

Gently Sloping (0%-2%) land covers 22% of the country. It is mostly found in lower shire valley (Chirwa and Phalombe plain). The lake shore region is categorised under the same class. Flat plateau tops and dambos in Bua and Dwangwa basins also fall under the category.

Sloping (2%-6%) lands comprise 28% of total area of country. Most of the land in southern plains, upper Shire valley and plateaux consist of sloping areas with frequent undulations in terrain. The foothills of Plateaux draining to lake shore also fall under this class. Other small areas of this class are in north western Songwe Lufira basin. This category has largest areal extension in the country.

Moderately Steep (6%-13%) facets of plateaux and highlands towards foothills fall under this category. This erosion prone area consists of 14% of total area which requires basic soil conservation and afforestation techniques. Some of these areas in Ruo basin are used for tea plantation practicing terrace cultivation.

Steep (13%-26%) land makes up approximately 10% the country. This includes mountainous areas which are mostly protected for conservation. Number of national parks, protected areas and game reserves are operating to maintain those areas. These are mostly “no intervention” areas.

Very Steep (>26%) land covers 6% of the country. Prevailing land cover is mostly broadleaved deciduous forest or closed herbivorous vegetation. Similar to steep slope category these areas are also protected and “no intervention” zones.

4.7 Soils

4.7.1 General Description of Major Soil Types

The soils of Malawi have been grouped into 13 major FAO soil groups and 33 FAO soil units, though predominated by three FAO major soil types: Luvisols (22%) and Lixisols (23%) and Cambisols (17%) alone cover more than 60 % of the total area of the country. Secondary types are Fluvisols (5%) and Ferralsols (2%) cover some 7 % of the total area of Malawi. The rest of the total area of the country is covered by the rest of the eight major FAO soil types.

Table 16 summarizes the extent and distribution of the 13 major reference soil groups.

Table 16: Main Soil Types/Land types and their area distribution

	Major Soil Types/Land Types	Area	
		Km^2	%
1	Acrisols	1,646.8	1.4
2	Alisols	498.6	0.4
3	Arenosols	1,486.9	1.5
4	Cambisols	20,430.2	17.2
5	Ferralsols	2,651.2	2.2
6	Fluvisols	6,138.4	5.2
7	Gleysols	2,576.4	2.2
8	Leptosols	1,727.8	1.4
9	Lixisols	25,885.7	21.8
10	Luvisols	26,544.9	22.4
11	Planosols	859.2	0.7
12	Regosols	526.4	0.4
13	Vertisols	477.4	0.4
Sub-Total Major Soil Types		*91,450.5*	*77.2*
Miscellaneous			
14	Lakes /water body	22,743.2	19.2
15	n/a	4,286.3	3.6
16	NA	1.2	0.001
Sub-Total Land types		***27,029.5***	***22.8***
Grand Total		118,480	100.0

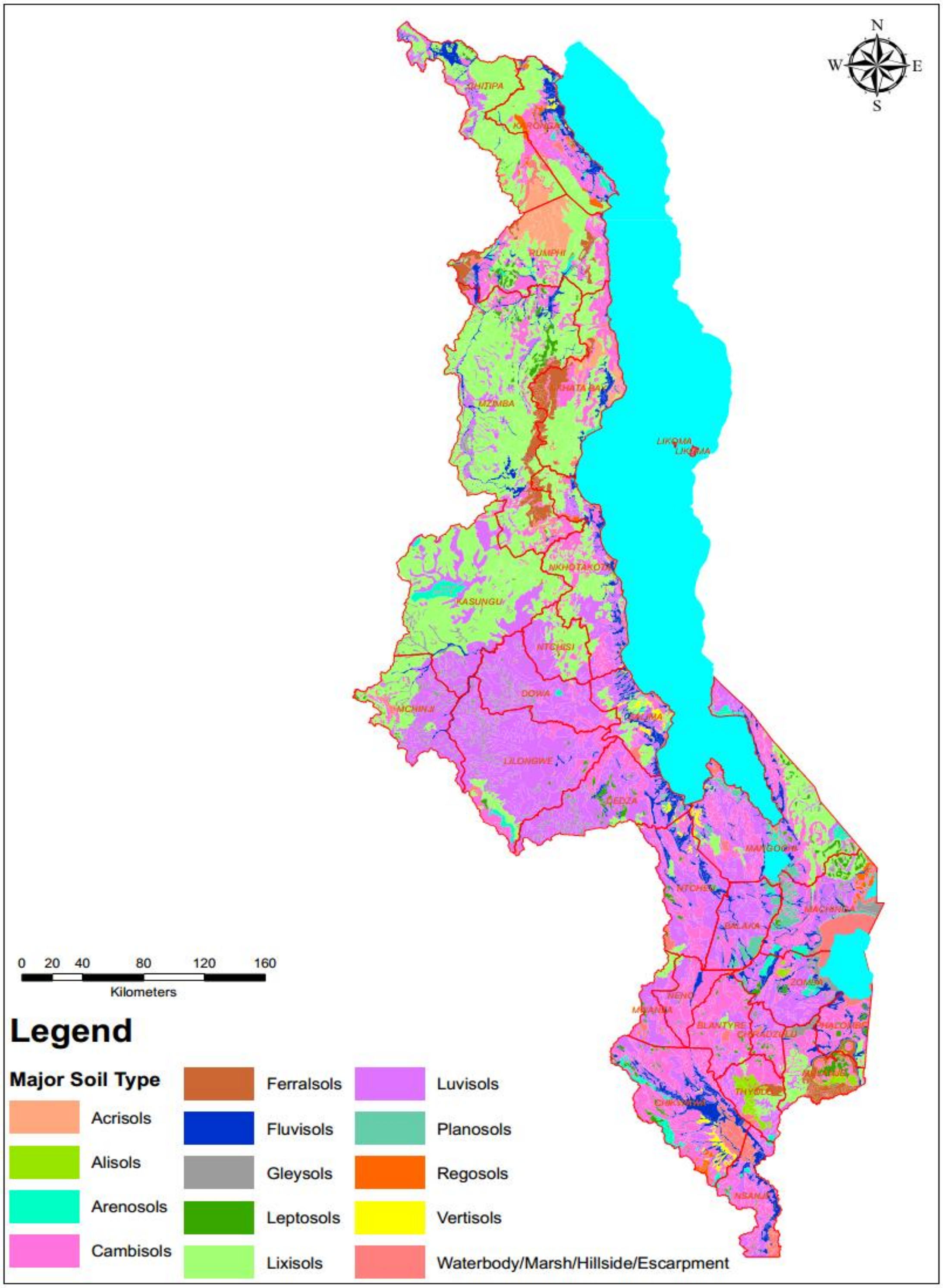


Figure 15: Major Soil Types of Malawi and their Distribution

4.8 Soil Loss

Soil erosion is widespread on cultivated land in the country, particularly on the steep slopes. Sheet and rill erosion are the dominant forms, but gully and stream bank erosion also occur. Sheet and rill erosion lead to removal of plant nutrients, decrease in soil depth, deterioration of soil structure and lowered infiltration rates. Susceptibility to erosion is highest during the beginning of the rainy season when little or no ground cover exists on cultivated land and rainfall intensities are high.

Soil erosion and sediment deposition processes are determined by four main factors: regolith type, climate, topography and land use. Although all of these factors interact with human activity to a certain extent, land use is the most manageable factor (Van Rompaey et al., 2003). For IMP soil loss has been calculated by means of Gavrilovic's method which uses the following equation:

$W = T\, H\, \pi\, Z^{1.5}$

and $T = (0.1\, T_o + 0.1)^{0.5}$

Where:

W = soil loss ($m^3/Km^2/yr$)

T_o = mean annual temperature (°C)

H = mean annual precipitation (mm)

Z = soil erosion coefficient

π = pi number

The soil erosion coefficient Z has been estimated from the soil erosion map (FAO soil database). The attributes of the map have been translated as per criteria given in Table 17 and soil loss map is presented in Figure 16.

Table 17: Value of Z as per erosion class

Erosion	Gavrilovic's Z
Slight	0.1
Slight to moderate	0.3
Moderate	0.5
Moderate to severe	0.85
Severe	1.25

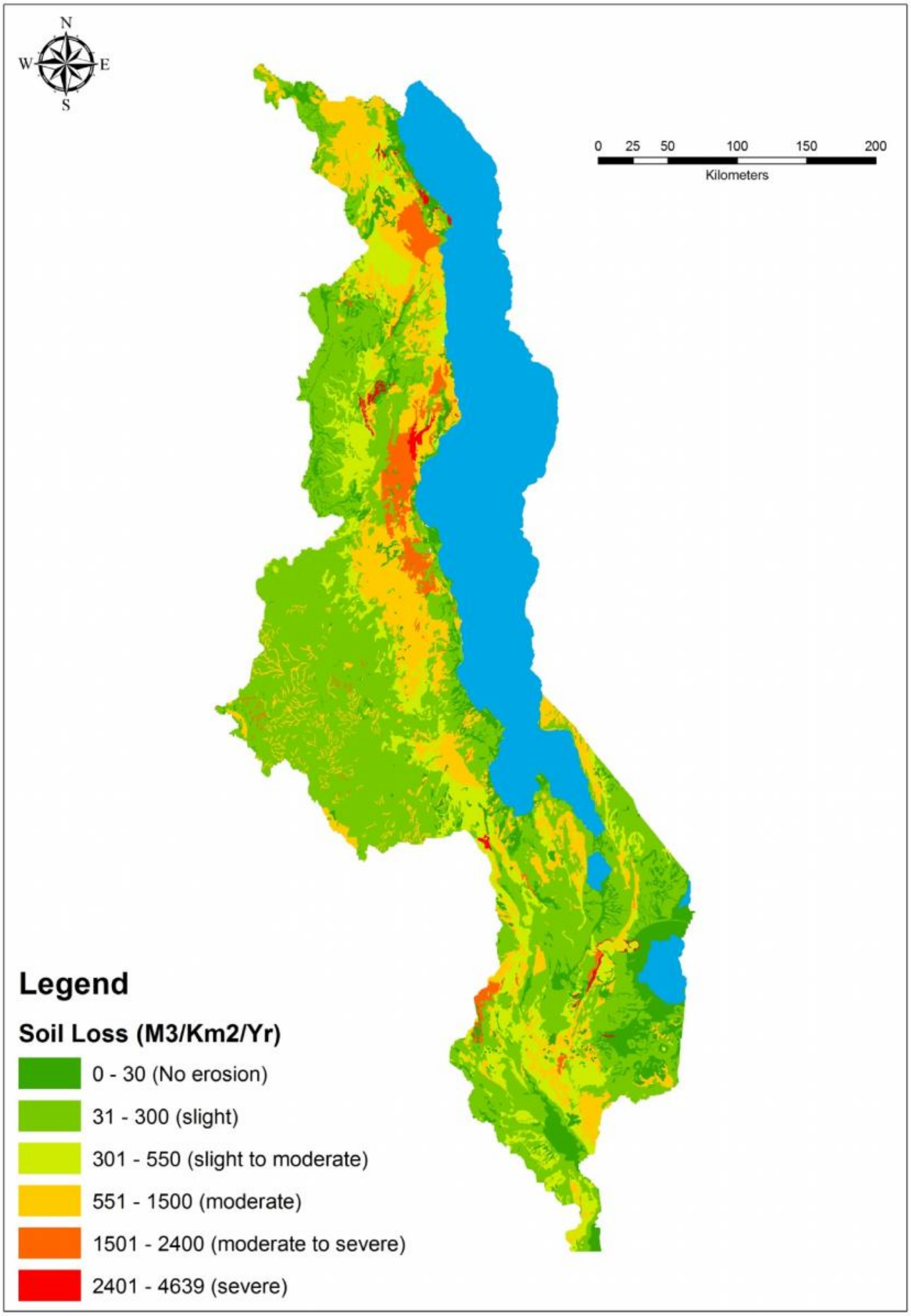


Figure 16: ***Soil Loss Map***

4.9 Land Use

The FAO Atlas of Malawi Land Cover and Land Cover Change (1990s to 2010s) was published in 2013. This database was used after validating it with random field checks/ground truthing and aggregated the classes to prepare a simplified land cover map. Forty four classes were aggregated into eight broader categories and presented in Table 18 Consolidated Areal extensions of various land use classes. Simplified land use map is shown in Figure 17 Land cover classes.

Table 18: Consolidated Areal extensions of various land use classes

Class	Area (km^2)	%
Agricultural Land	47,736	40
Shrubland/Woodland	36,055	31
Waterbodies/River	23,722	20
Plantation	4,633	4
Natural Vegetation/Forest	2,265	2
Built up Land	1,717	1
Dambo/Marsh	1,659	1
Bare Rock	213	0.18
Total	**118,000**	**100**

Agricultural land: Forty percent of total area of the country has been classified as agricultural land. Central and south regions have wider extensions of arable land compared to north. Land cover is manifestation of topography, climate and human agglomeration. Having big urban areas and demand centres in central and south region with most fertile shire plains agricultural lands are predominant land cover in these areas. According to Census 2008 report more than 80% of population in the country is engaged in primary sector of economic activity which is agriculture, forestry, fishing and mining. This shows a clear agreement to prevailing land cover in the country.

Shrubland/Woodland: The areas with mainly savannah type of vegetation to open forest woodlands come under this category. Second biggest category of land use is contributing 31% of land coverage mainly situated at undulating plains, foothills and outer fringes of forests. These areas over decades are transforming into croplands due to population growth. Mostly situated in proximity to agricultural lands these areas also serve fodder to livestock.

Waterbodies/River: Almost 20% of area falls under category of waterbodies/River including perennial, non-perennial, natural and artificial waterbodies. Lake Malawi with a mean surface area of approximately 28,760 km^2 is the third largest lake in Africa. The lake is a major source of water for lakeshore communities and plays an important role in the tourism, transport and fisheries industries. The River Shire, which is the sole outflow from the lake, also supports extensive areas of irrigation in the Lower Shire valley together with the water supply to Malawi's second largest city, Blantyre, and three hydropower schemes which together supply approximately 98% of the national electricity output (EAD 2006). The Shire River is also a major tributary of the River Zambezi, representing approximately 8% of the total catchment area.

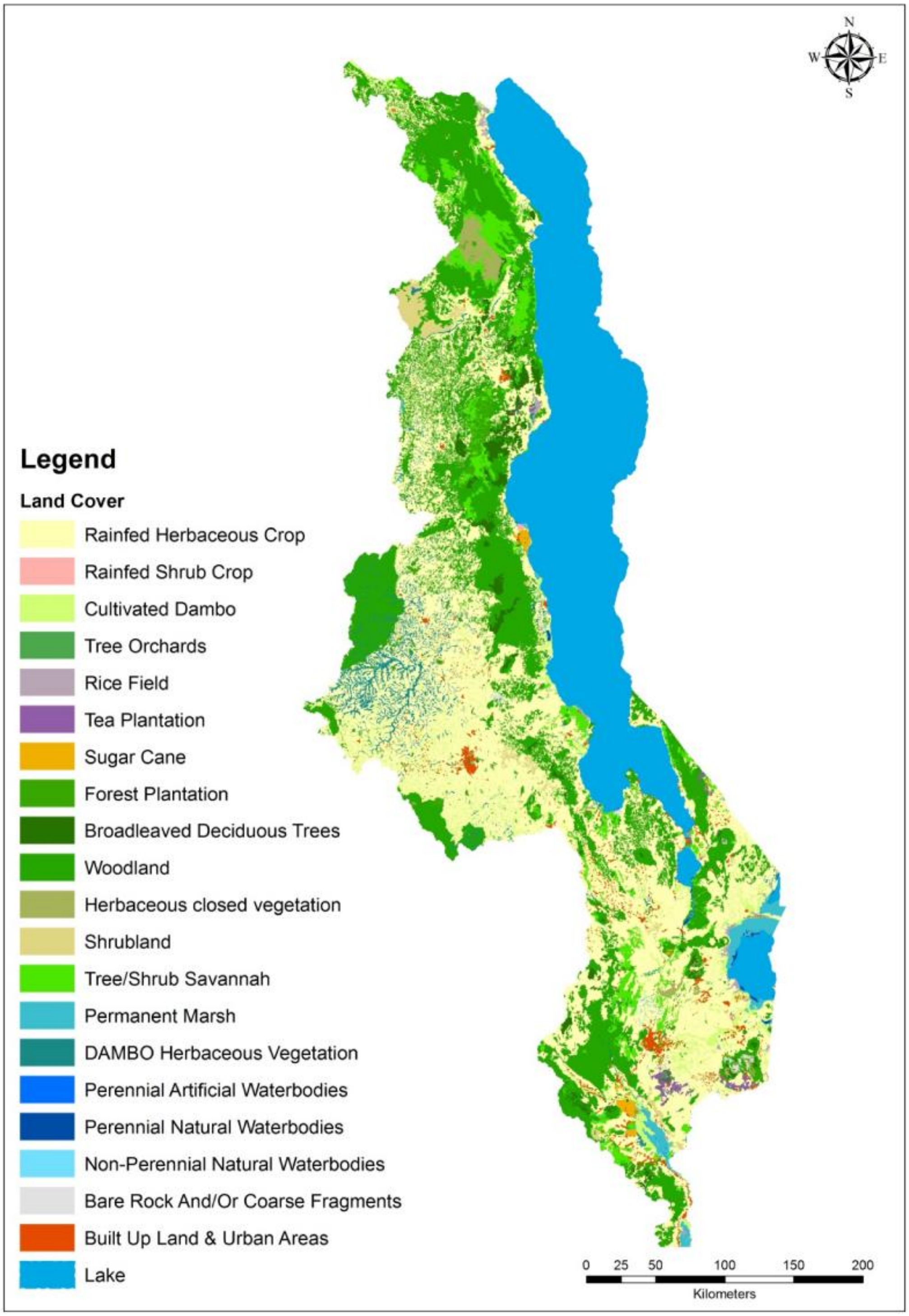


Figure 17: Land cover classes

Plantation: Plantation forest contributes 4% of area. Most of these areas are regulated and managed by the Department of Forests and promotes land management with the help of forestry.

Natural Vegetation/Forest: Very small proportion of total land is remaining with natural vegetation/Forest contributing mere 2%. As per land use statistics of 1991 Land cover study (FAO, Land Resources) Forest coverage of the country was 10%. Catchment degradation and deforestation are the key drivers for such a sharp decline of forest cover in the country.

Built up Land: Approximately 1% of the total area falls under built up land category which mostly represents urban areas. There are four big urban centres in the country Blantyre, Lilongwe, Zomba and Mzuzu. Mzuzu and Lilongwe are situated in north and central region respectively and Zomba and Blantyre in south. These are most densely populated areas reported as per 2008 census.

Dambo/Marsh Land: Predominantly found in central region plateau due to flat terrain at the top wetlands; locally called dambo; contributes to some 1% of area. They are occasionally found in north and southern plains as well. These areas are blind drainage areas, high in moisture content, are often cultivated in the country.

4.10 Climate

The climate of Malawi is tropical continental and largely influenced by the huge water mass of Lake Malawi that defines almost two-thirds of Malawi's eastern border. There are two distinct seasons: the rainy season from November to April and the dry season from May to October. The dry season may be divided into the cool dry period from May to July and the hot dry period from August to October.

Temperatures are greatly influenced by the topography and decreases with increasing altitude. The mean maximum and minimum temperatures are 28 °C and 10 °C respectively in the plateau areas, and 32 °C and 14 °C respectively in the rift valley plains. The highest temperatures occur in October/November while the lowest temperatures are experienced in June/July. Areal distribution of mean annual temperature is shown in Figure 18.

Annual rainfall in Malawi ranges from 700 to 2,400 mm with mean annual rainfall being 1,180 mm. Its distribution is mostly influenced by the topography and proximity to Lake Malawi. The highest rainfall is experienced in the high altitude and mountainous areas of Mulanje, Zomba, Dedza and the plateau of Viphya and Nyika while the lowest rainfall is experienced in the low lying areas of the Lower Shire Valley and other rain shadow areas. Due to topographic influences, rainfall at the lakeshore and escarpment is higher than on the plateau, with typical lakeshore rainfall in the range 1,500–2,000 mm per year, and values on the plateau of 700–1,000 mm, although lakeshore values can exceed 3000 mm in some places due to funnelling effects (UNDP 1986). To the north and northeast of the lake, in the Tanzanian portion of the catchment, the annual rainfall is generally higher, with a mean catchment value about 50% greater than for the catchments in Malawi. Average annual rainfall is shown in Figure 19.

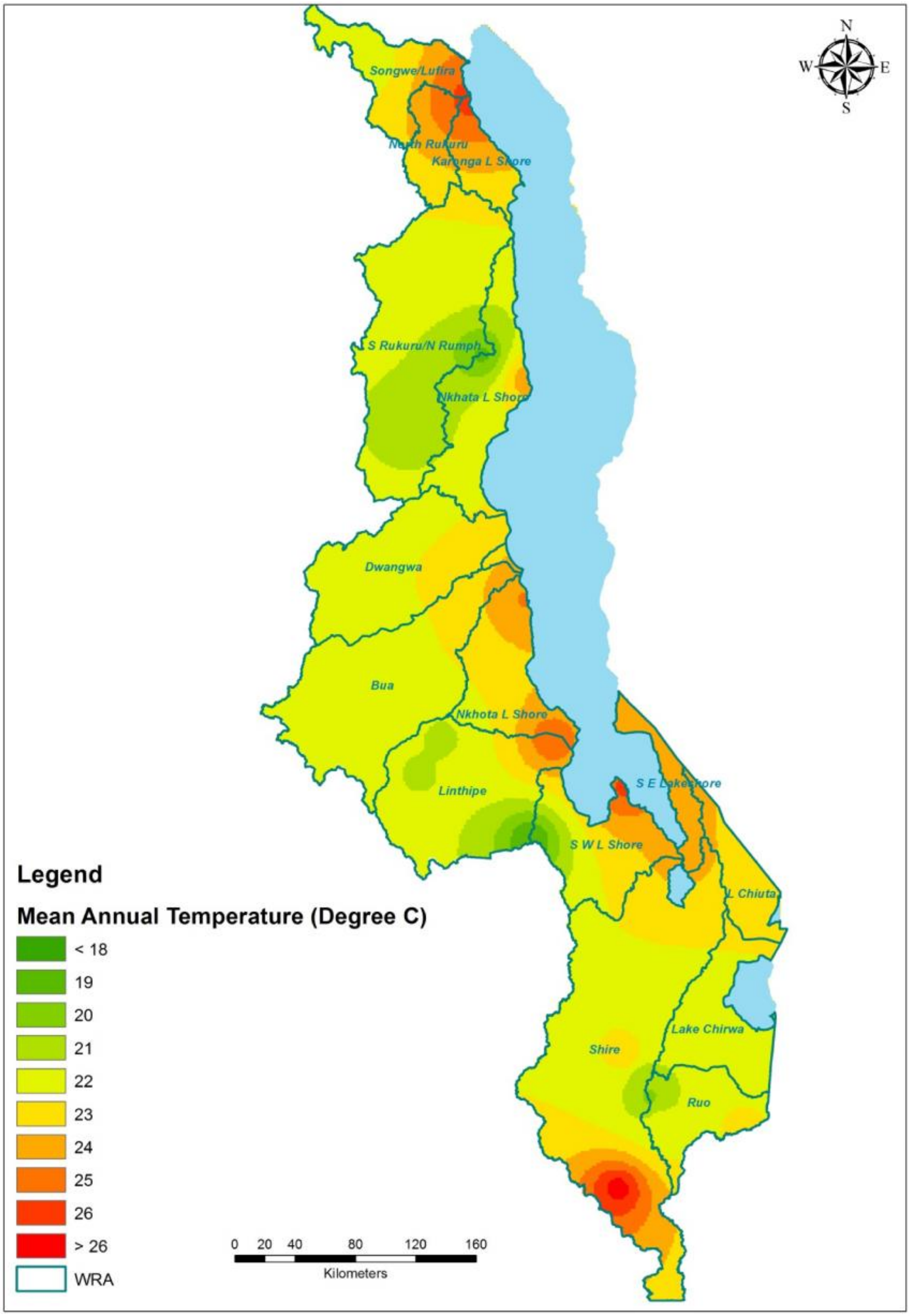


Figure 18: Temperature Map

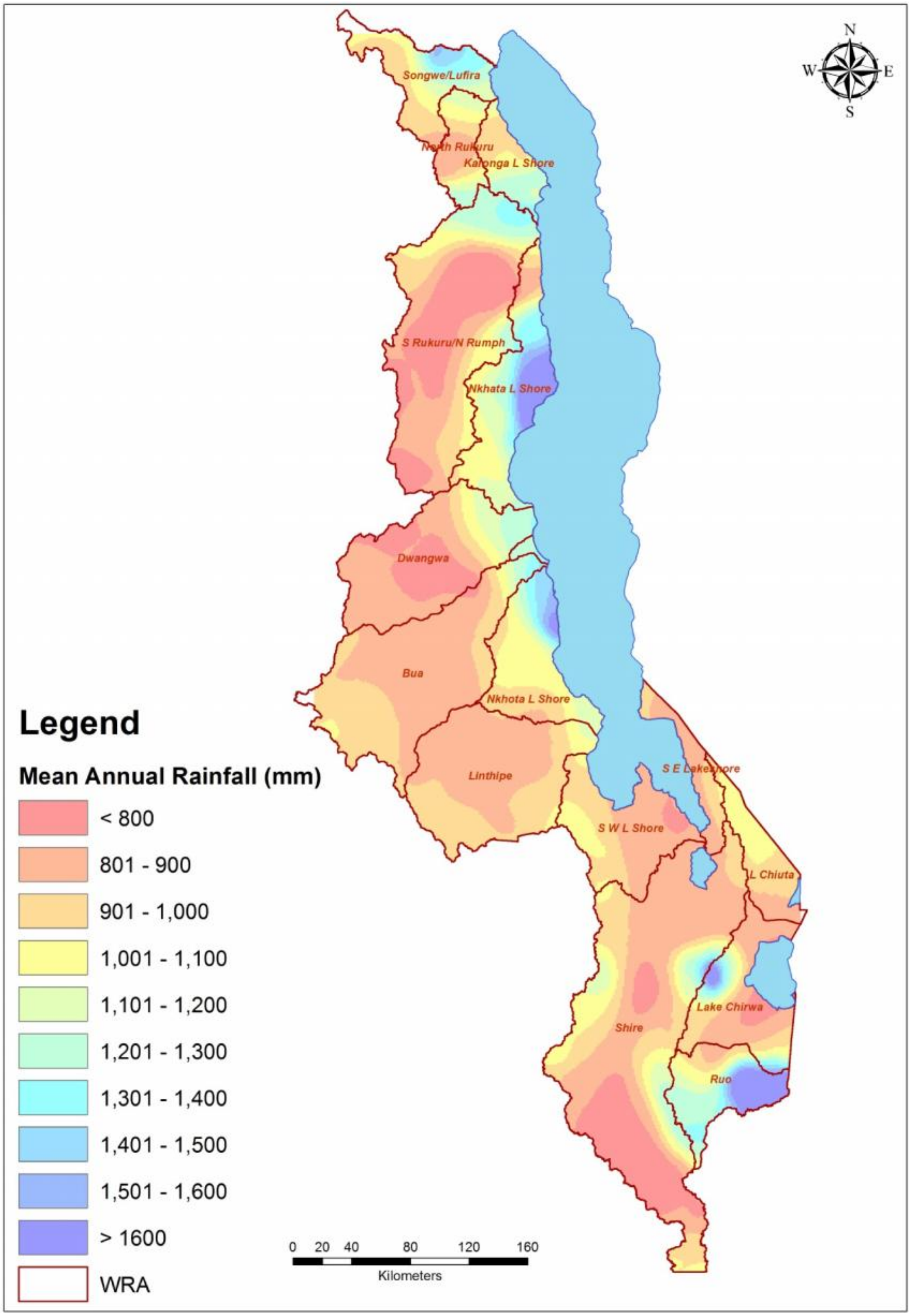


Figure 19: Rainfall distribution Map

Potential Evapotranspiration (PET) estimation has used data made available by FAO through CLIMWAT (FAO, 2010); a climatic database which provides long-term monthly mean values of climatic parameters. Like temperature, evaporation shows a strong relationship with elevation and generally decreases as elevation increases. The central plateaux show the highest evaporation rates, which gradually decreases towards northern highlands and southern mountainous regions. Areal distribution of PET has been shown in Figure 20.

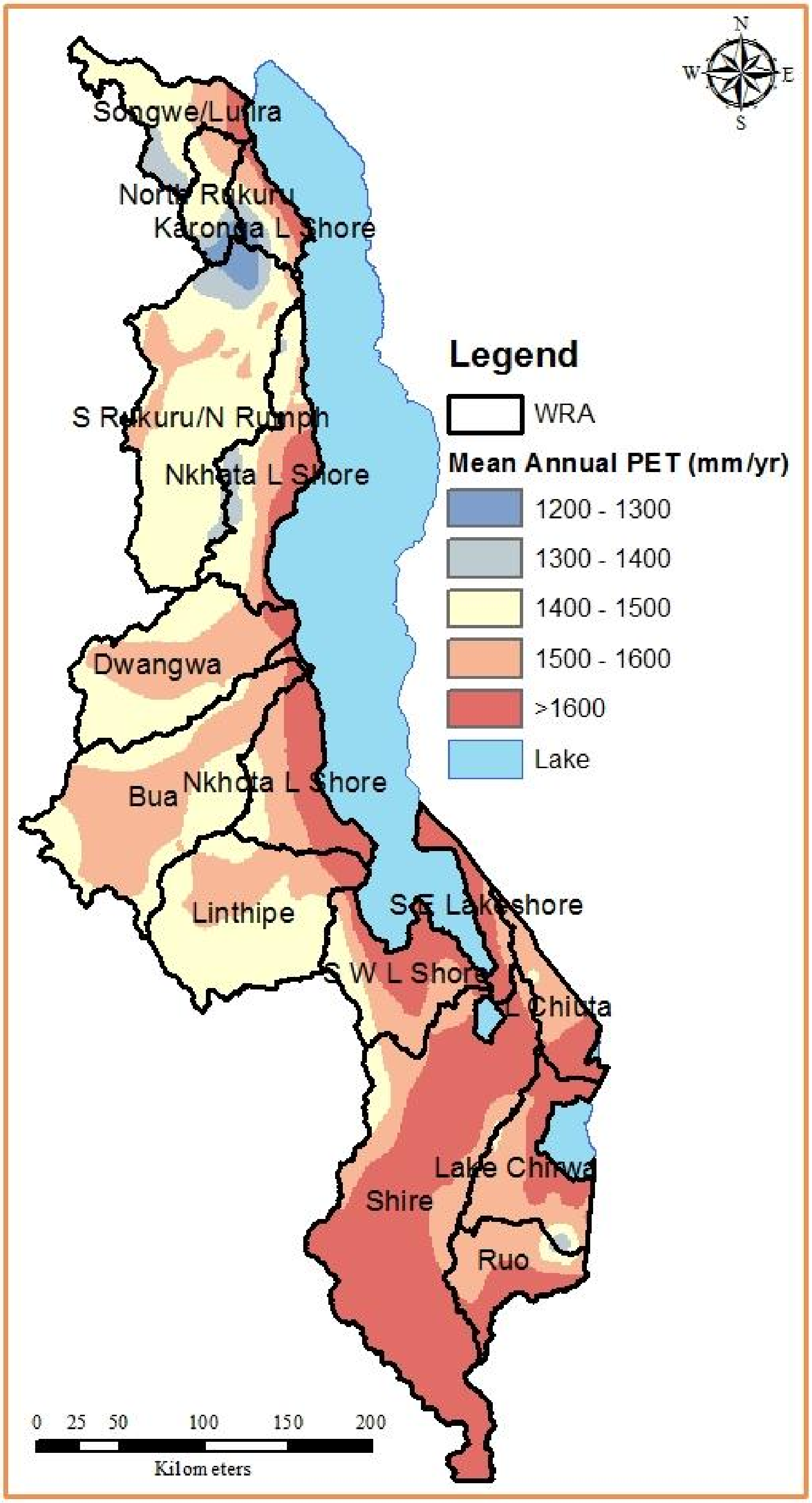


Figure 20: PET Map

4.11 Hydrology

4.11.1 Water Resources

About 94% of the land area in Malawi, as well as parts of many neighbouring countries, is part of the Zambezi River Basin which drains into the Indian Ocean in Mozambique. The remaining 6% falls within the small internal drainage basin of Lake Chilwa, lake Chitua and others. The Zambezi River Basin is the second largest in Southern African Development (second to the Congo); 8% of the basin is in Malawi.

Malawi has a large network of surface waterbodies covering about 21% of the country's total area; about 20% of this area is Lake Malawi itself. In addition to Lake Malawi, these surface waterbodies comprise a network of rivers (e.g., Shire, Ruo, Linthipe, Bua, Dwangwa, Rukuru, Songwe, etc) and other lakes such as Lake Chilwa and Lake Chiuta. The main waterbodies are shown in Figure 21 WRA and WRU Boundaries.

Most of the rivers are subject to natural seasonal flows but maintain at least some base flow (i.e. are perennial), at least in their lower reaches, throughout the dry season; their upper reaches tend to be more ephemeral in nature.

Malawi's drainage system has been divided into 17 WRAs and these are further subdivided into 78 WRUs. Despite the number and widespread nature of surface waterbodies, the availability and reliability of surface water is highly variable due to climatic extremes between the wet and dry seasons and from year to year. The national mean annual rainfall is estimated at about 1,100 mm, with the average varying from 650 mm in the Lower Shire Valley to 1,600 mm in the Northern Lakeshore Region. About 70% of the country receives 800 to 1,200 mm per year. While this is relatively good rainfall (the second highest in the SADC region), Malawi has one of the most erratic rainfall patterns in Africa and this poses one of the biggest challenges to planning irrigation development.

All previous reports and studies of the water resources show the 17 WRA, with the 78 WRU, however, this report contends that there is a need to add another WRA, that being the separation of the Shire River from the Shire Basin and all its 16 independent WRU's. This is because the WRU are totally hydrologically independent of the Shire, and cannot be grouped together with the Shire River. The Shire River drains almost the whole country, plus part of Tanzania, and in addition, it is regulated at Liwonde by the Kamuzu Barrage. This makes the Shire River a unique water source which should have its own WRA. Most of the water released at present at the barrage is used for hydro power, with some used for some 19,500 ha of irrigation.

4.11.2 Gauging Station Network

There is a dense network of river flow gauging stations in Malawi and the HYDSTRA database includes daily flow records for 164 stations. The length of the records, and the completeness and quality of the datasets are, however, highly variable. The quality and completeness of the datasets have deteriorated in the last ten to twenty years. Many stations have significant periods of missing data; furthermore, there are many sections of records that are clearly suspect where the observed hydrographs show very different patterns of flow between different parts of the record. A considerable number of stations are still missing data from the year 2000 onwards. Only 15 stations have more than five years of data available after the year 2000 and these are concentrated in WRAs 1, 3, 4, 6, 7 and 9, with the other WRAs generally having very little data available after 2000. The lack of data for the period since 2000 is of concern and needs to be addressed to ensure that future water resource planning is not jeopardised by the lack of robust hydrological data.

The data have been analysed for 45 stations to determine the 80% reliable (Q_{80}) flows. This has been determined for a unit flow in $l/s/km^2$ and an annual volume in m^3/km^2, see Figure 22. This clearly shows the areas of high dry season flows and those of low flows. The high flows are confined to the Shire River (WRA 1), Mulanje and the Ruo river (WRA 14), Nkhata Bay (WRA 16) and Karonga Lake Shore (WRA 17). The remainder of the country has low dry season flows.

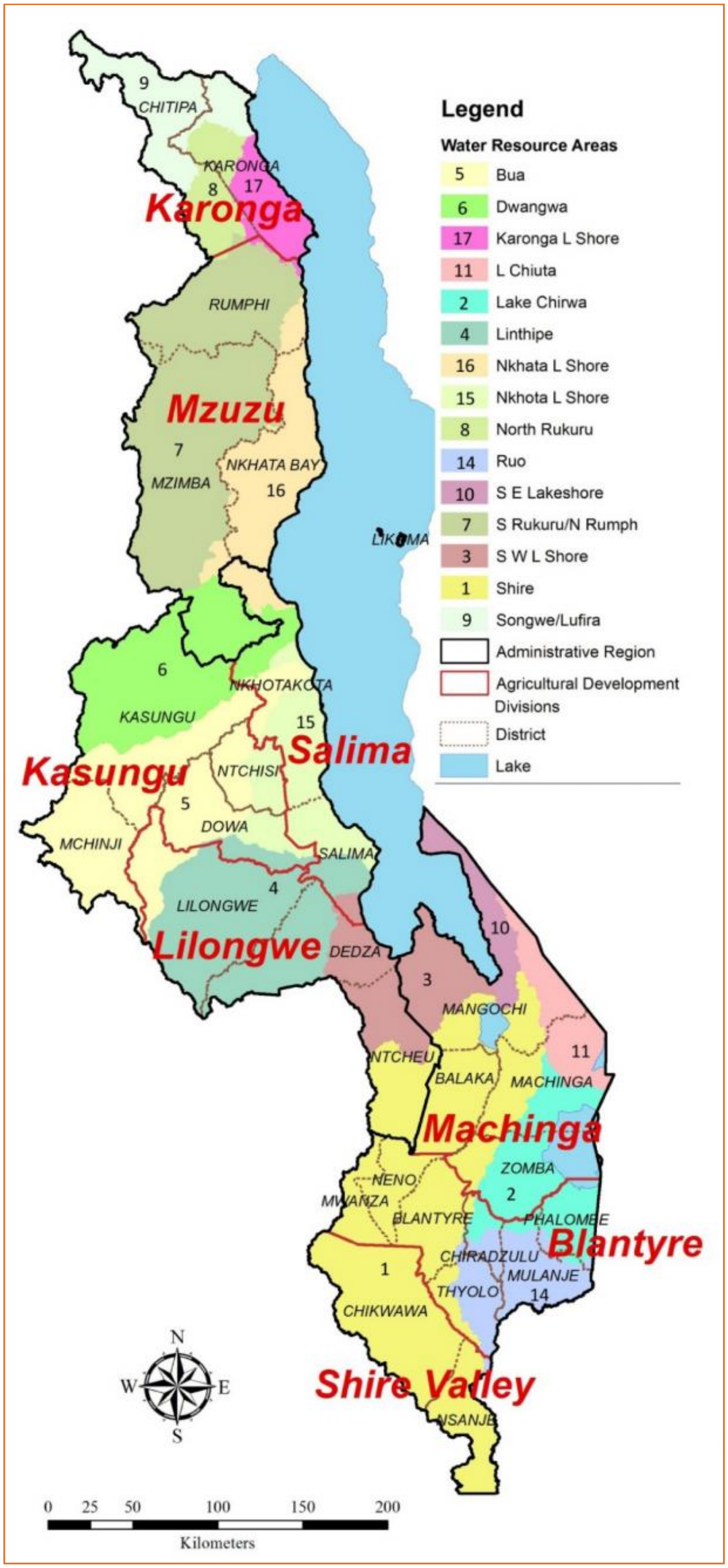
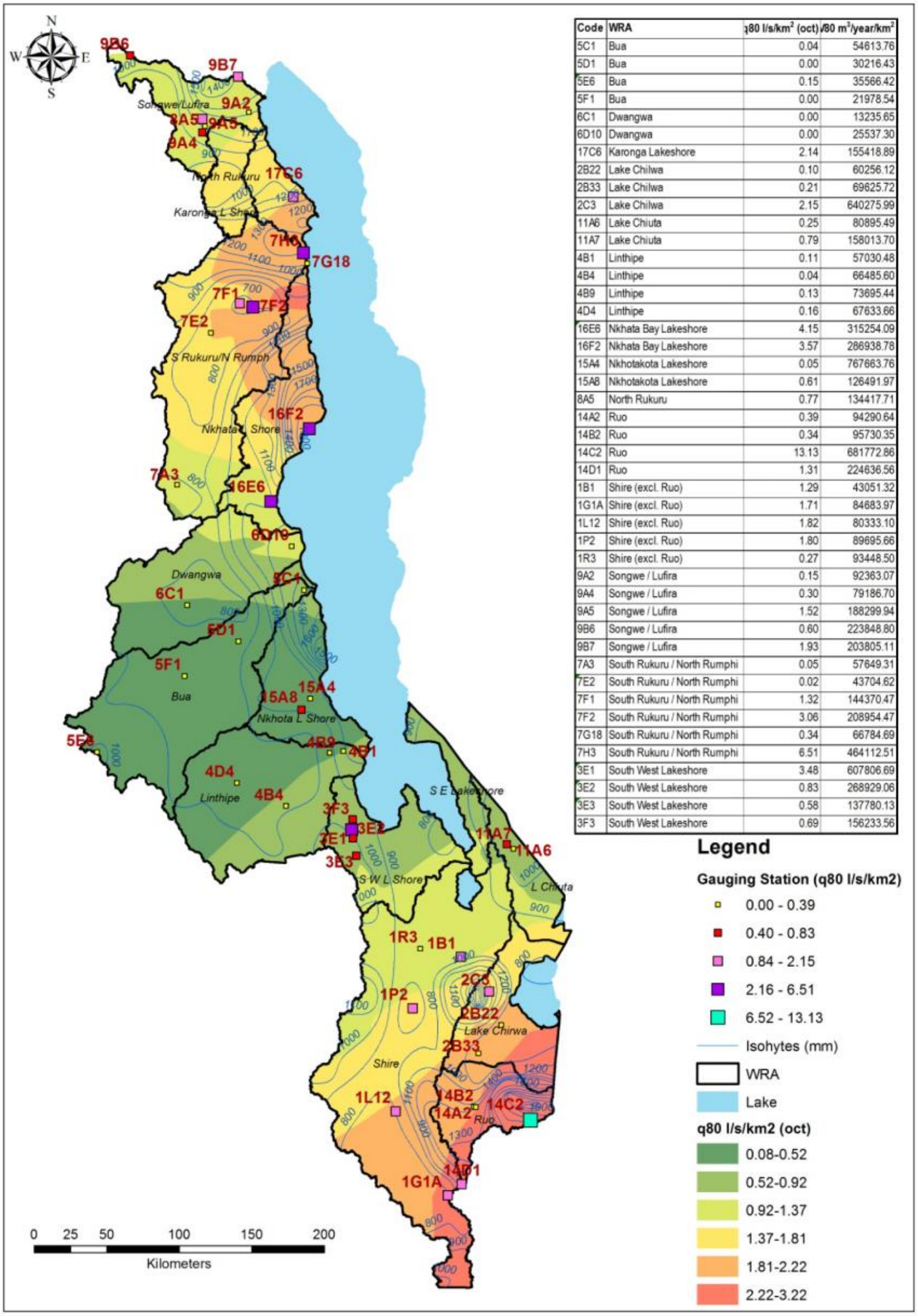


Figure 21: WRA and WRU Boundaries



Code	WRA	q80 l/s/km² (oct)	V80 m³/year/km²
5C1	Bua	0.04	54613.76
5D1	Bua	0.00	30216.43
5E6	Bua	0.15	35566.42
5F1	Bua	0.00	21978.54
6C1	Dwangwa	0.00	13235.65
6D10	Dwangwa	0.00	25537.30
17C6	Karonga Lakeshore	2.14	155418.89
2B22	Lake Chilwa	0.10	60256.12
2B33	Lake Chilwa	0.21	69625.72
2C3	Lake Chilwa	2.15	640275.99
11A6	Lake Chiuta	0.25	80895.49
11A7	Lake Chiuta	0.79	158013.70
4B1	Linthipe	0.11	57030.48
4B4	Linthipe	0.04	66485.60
4B9	Linthipe	0.13	73695.44
4D4	Linthipe	0.16	67633.66
16E6	Nkhata Bay Lakeshore	4.15	315254.09
16F2	Nkhata Bay Lakeshore	3.57	286938.78
15A4	Nkhotakota Lakeshore	0.05	767663.76
15A8	Nkhotakota Lakeshore	0.61	126491.97
8A5	North Rukuru	0.77	134417.71
14A2	Ruo	0.39	94290.64
14B2	Ruo	0.34	95730.35
14C2	Ruo	13.13	681772.86
14D1	Ruo	1.31	224636.56
1B1	Shire (excl. Ruo)	1.29	43051.32
1G1A	Shire (excl. Ruo)	1.71	84683.97
1L12	Shire (excl. Ruo)	1.82	80333.10
1P2	Shire (excl. Ruo)	1.80	89695.66
1R3	Shire (excl. Ruo)	0.27	93448.50
9A2	Songwe / Lufira	0.15	92363.07
9A4	Songwe / Lufira	0.30	79186.70
9A5	Songwe / Lufira	1.52	188299.94
9B6	Songwe / Lufira	0.60	223848.80
9B7	Songwe / Lufira	1.93	203805.11
7A3	South Rukuru / North Rumphi	0.05	57649.31
7E2	South Rukuru / North Rumphi	0.02	43704.62
7F1	South Rukuru / North Rumphi	1.32	144370.47
7F2	South Rukuru / North Rumphi	3.06	208954.47
7G18	South Rukuru / North Rumphi	0.34	66784.69
7H3	South Rukuru / North Rumphi	6.51	464112.51
3E1	South West Lakeshore	3.48	607806.69
3E2	South West Lakeshore	0.83	268929.06
3E3	South West Lakeshore	0.58	137780.13
3F3	South West Lakeshore	0.69	156233.56

Figure 22: Gauging Stations and Q_{80} Unit Discharge

4.11.3 Ground Water

Malawi is divided into three main geological zones, the rift valley area overlaid by alluvium, the plateau area composed of weathered materials, and the escarpment and mountain area of exposed basement rocks. On a broad basis, the ground water aquifers follow these three zones. The rift valley composes of quaternary alluvium, the plateau of weathered basement and the mountains and escarpment of fractured basement. The aquifer potential is highest for quaternary alluvium and lowest for fractured basement. These three zones are shown in figure below.

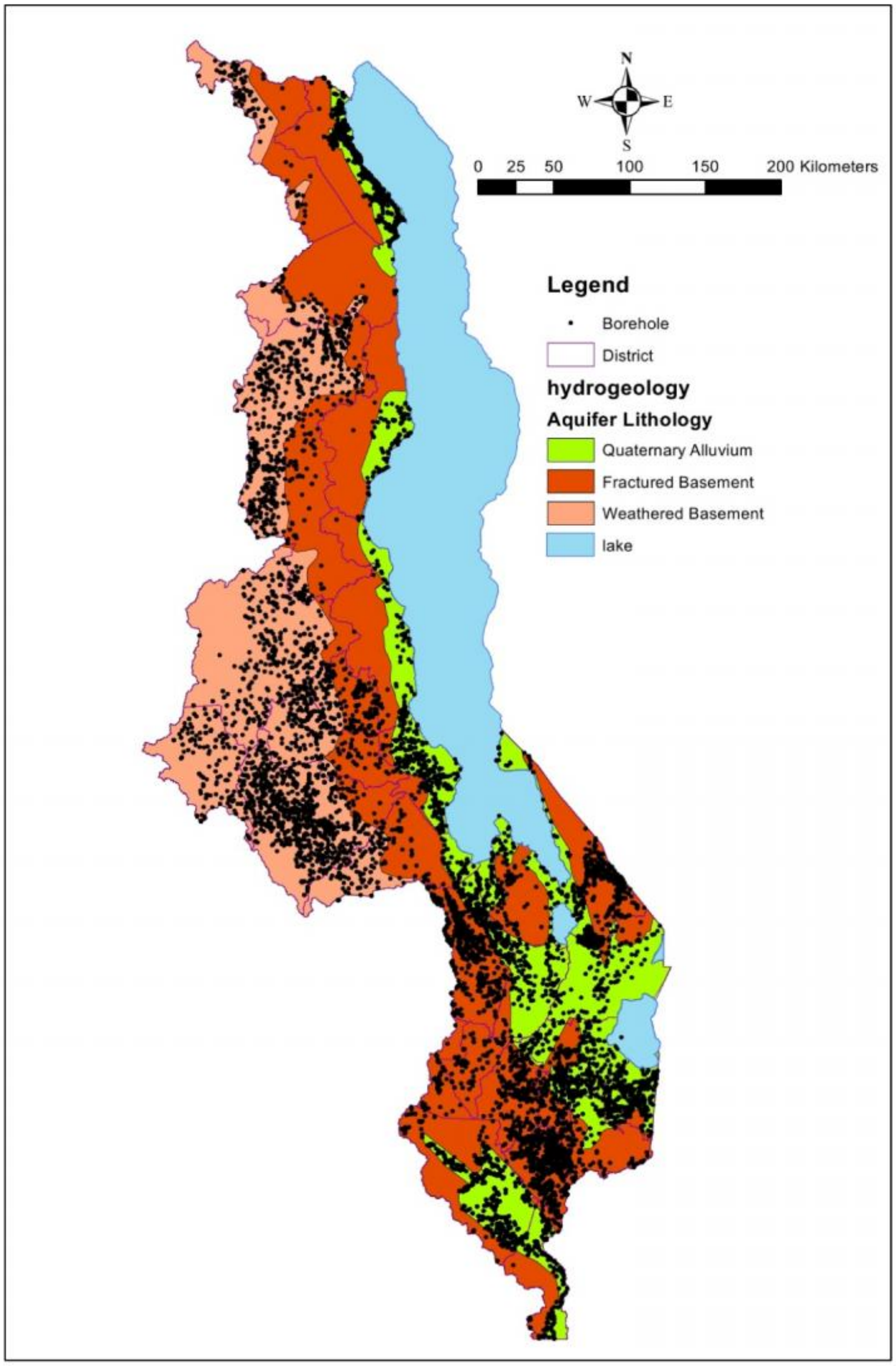


Figure 23: Ground Water Geology

The pre-1986 Malawi National borehole data base was created by seconded British Geological Survey staff initially in the form of a hard copy card index (Cardex) that was subsequently digitised during a later groundwater data project also undertaken by BGS staff. This data set was held by MoIWD and the data held in this database are regarded as being accurate. These data are fully georeferenced being located according to district/TA/village listing as well as 1:50 000 scale topographic map grid coordinates. These data have a full set of coordinates.

The yield and distribution of the borehole data has been plotted to show the distribution of these wells. They clearly show that the fractured basement is very poor yielding aquifer with few wells in this zone. Also the yield is plotted to indicate where the high potential aquifers are located, see Figure 23 Ground Water Geology.

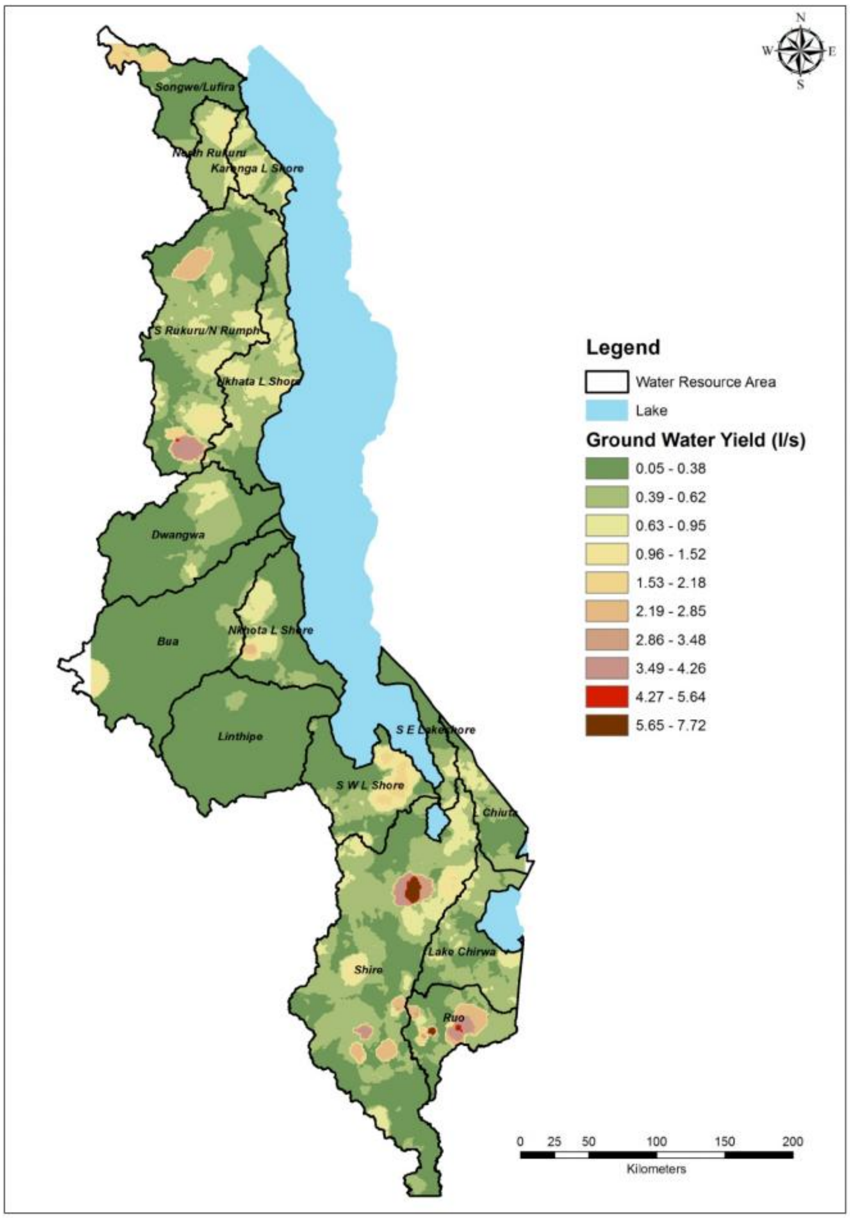


Figure 24: Ground Water Yield (l/s)

The quaternary alluvium aquifer is by far the dominant source, making up over 80% of the total yield. The other two aquifers provide about 10% each. The distribution of these groundwater resources across the WRAs is shown in Figure 25 Sustainable Yield by WRA .

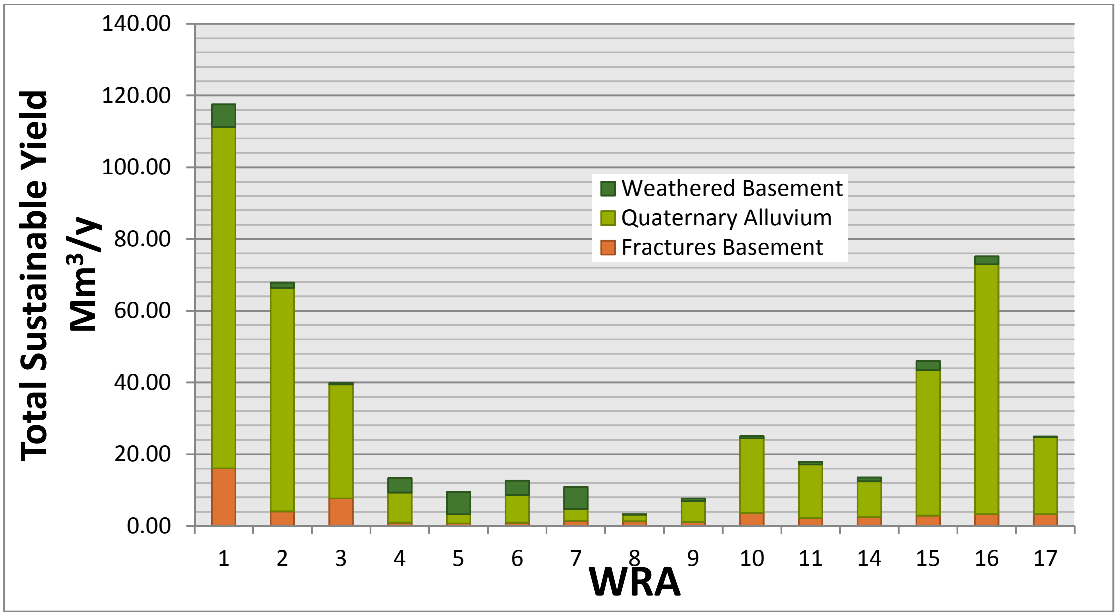


Figure 25: Sustainable Yield by WRA

Table 19: Sustainable Yield by WRA Mm³/y

WRA		Fractured Basement	Quaternary Alluvium	Weathered Basement	Total Mm³/y
1	Shire River	16.06	95.27	6.21	117.53
2	Lake Chilwa	4.02	62.42	1.46	67.89
3	South West Lakeshore	7.67	31.76	0.55	39.97
4	Linthipe	0.91	8.40	4.02	13.32
5	Bua	0.73	2.56	6.21	9.49
6	Dwangwa	0.91	7.67	4.02	12.59
7	Rukuru and Rumphi	1.46	3.29	6.21	10.95
8	North Rukuru	1.28	1.83	0.18	3.29
9	Lufira-Songwe River	1.10	5.84	0.73	7.67
10	South East Lakeshore	3.65	20.81	0.55	25.00
11	Lake Chiuta	2.19	14.97	0.73	17.89
14	Ruo River	2.56	9.86	1.10	13.51
15	Nkhotakota Lakeshore	2.92	40.52	2.56	45.99
16	Nkhata Bay Lakeshore	3.29	69.72	2.19	75.19
17	Karonga Lakeshore	3.29	21.54	0.02	24.84
	Total	**52.01**	**396.39**	**36.70**	**485.10**

The scale of the ground water resource availability is much less than that available from the surface water system. The equivalent annual average value for national surface water resources is approximately 12,829 Mm³/y. Groundwater resources in 2010, therefore at 485.1 Mm³/y, represent only 3.6 % of the total sustainable water resource available on an annual average basis.

The domestic water demand at 2035 population projections (31.0 million) will consume an estimated 775 Mm^3/y of water based on 50 l/d/c rural consumption and 120 l/d/c for the four main cities. This means that the sustainable borehole yield is insufficient to satisfy the domestic water supply, and the balance will have to come from surface water resource.

4.12 Climatic Zones

An additional use of the climate assessment is the development of agro-climatic zones. These zones have distinct crops that do better in each zone, and enable identification of indicative cropping patterns to determine scheme water requirements and economic benefits. Eight zones have been identified, described in Appendix A. These zones are shown in Figure 26. Only three cropping patterns have been developed from these eight zones. The lakeshore zones are considered as one group, the plateau zones into one group, and lowland zone has two cropping patterns, one for small farmers, and one for estates growing either sugar cane or bananas.

1. Lowlands: for Lower Shire Valley
2. Lakeshore: Low, medium and high rainfall areas.
3. Plateau: for Chilwa-Phalombe, Central and North plateau

The four cropping patterns are shown in the table below, with the percentages of the total area planted by each crop. The cropping patterns best represent what is grown locally. Vegetables cover a range of green crops while tomatoes and onions are considered separately. Cotton, groundnuts, sugar cane, beans can be considered as export crops, while rice is an import substitution crop.

Table 20: Cropping Pattern for Lowlands Zone

Cropping Pattern	Wet Season				Dry Season						Wet Season	
Maize WS				H							P	
Maize DS					P				H			
Rice WS				H							P	
Rice DS					P					H		
Cotton WS					H						P	
Groundnuts WS				H							P	
Groundnuts DS					P					H		
Vegetables DS						P				H		
Water Req. (m^3/ha)	517.5	871.8	1,369.2	888.6	448.9	377.6	660.3	1,370.7	1,761.1	902.2	0.0	439.1
	DS: Dry season		WS: Wet season								**Annual Water Req. (m^3/ha)**	**9,607**

Table 21: Cropping Pattern for Lakeshore Zone

Cropping Pattern	Wet Season				Dry Season						Wet Season	
Maize WS				H							P	
Maize DS					P				H			
Onions WS					H						P	
Onions DS					P						H	
Vegetables WS				H								P
Vegetables DS						P				H		
Groundnuts WS				H							P	
Groundnuts DS					P					H		
Beans WS			H								P	
Beans DS					P					H		
Tomatoes					P					H		
Water Req. (m^3/ha)	60.3	47.5	609.8	717.1	445.1	300.3	630.8	1,314.1	1,495.5	1,013.0	0.0	0.0
	DS: Dry season		WS: Wet season								**Annual Water Req. (m^3/ha)**	**6,634**

Table 22: Cropping Pattern for Plateau Zone

Cropping Pattern	Wet Season				Dry Season						Wet Season	
Maize WS				H							P	
Maize DS					P				H			
Onions WS					H						P	
Onions DS					P						H	
Vegetables WS				H								P
Vegetables DS						P				H		
Groundnuts WS				H							P	
Groundnuts DS					P					H		
Beans WS			H								P	
Beans DS					P					H		
Tomatoes					P					H		
Water Req. (m^3/ha)	60.3	47.5	609.8	717.1	445.1	300.3	630.8	1,314.1	1,495.5	1,013.0	0.0	0.0
	DS: Dry season		WS: Wet season							**Annual Water Req. (m^3/ha)**		**6,634**

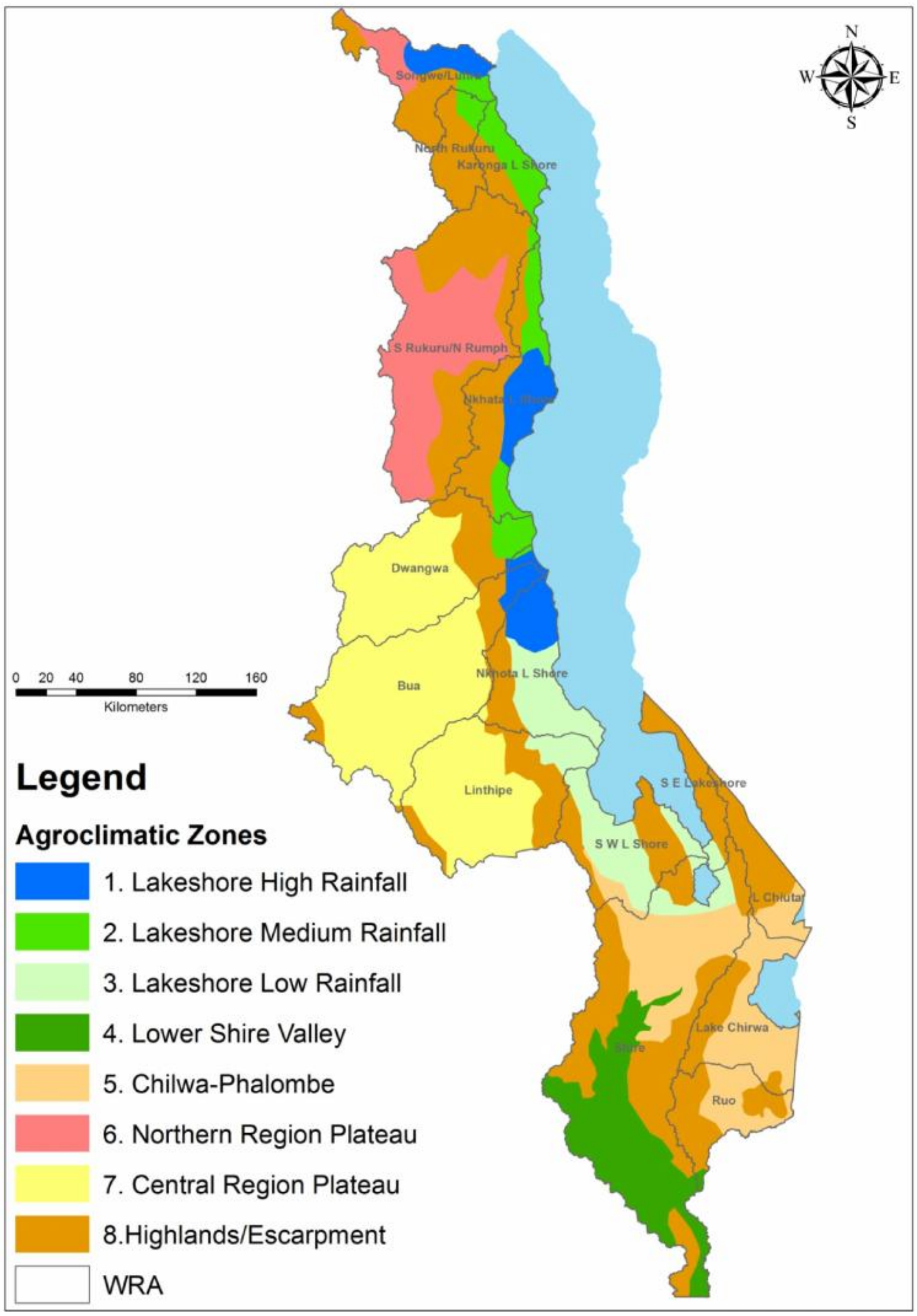


Figure 26: Climatic Zones

5 POTENTIAL IRRIGATION AREA

5.1 Methodology

The assessment of potential irrigation areas (PIA) has been divided into four phases, as shown in Figure 27.

Phase I: Estimation of general country wide PIA based on physical factors alone (PIA_{phy}). The hydrologic and climatic factors form the water resource potential. This is a general indication of potential, and a guide to the best location of irrigable areas. This is covered in detail in the report "Database of Irrigation Potential".

Phase II: Identification of Potential Irrigation Schemes (PIS's). This is based on past studies, and present studies using GIS tools and professional experience to locate schemes, as described briefly in Section 6.3.1, with full details in APPENDIX 6: **IRRIGATION DESIGN**.

Phase III: Once a list of potential schemes was compiled, the schemes were ranked against a set of criteria to determine the priority schemes for development. Schemes that were eliminated (EIRR<10%) remain in the database for future reference and possible review. See Section 6.4 for a full list of schemes, and each scheme in full detail in APPENDIX 1: **ATLAS OF MAPS**.

Phase IV: The short list of selected schemes are included in the IMP. An Action Plan was then developed to provide an investment framework.

Phase I and II are covered in the report on PIA[8], the appraisal, Phase III is covered in the report on Ranking. This report brings all three Phases I-III together into the IMP.

[8] DIMPIF –" Database of Irrigation Potential", Nov-2014 SMEC

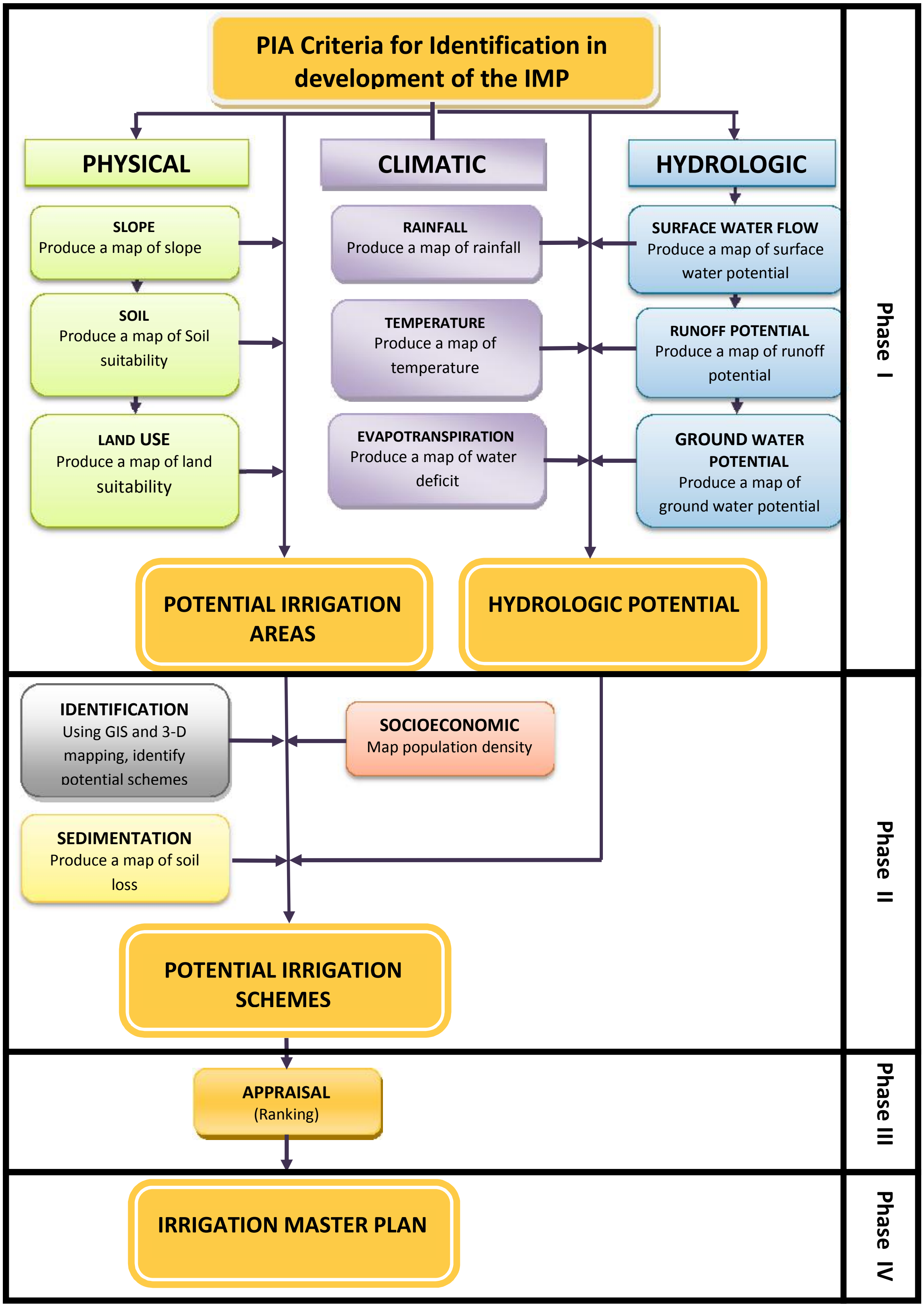


Figure 27: Flow Chart of Irrigation Master Plan Development

5.2 Physical

5.2.1 Slope

Table 23: Slope Suitability

Erosion hazard	Slight	Slight to Moderate	Moderate	Moderate to Severe	Severe
Slope %	<2	2--6	6-13	13-26	>26
Suitability	S1	S2	S3	N1	N2

S1 = highly suitable; S2 = moderately suitable; S3 = marginally suitable; N1 = unsuitable; N2 highly unsuitable

Topography is the first attribute when assessing suitability for irrigation. In this context, a slope of <13% has been used as a cut-off point for suitability. However this does not mean that irrigation cannot take place on slopes greater than 13% as many places irrigate on these slopes but with substantial land formation or mechanical irrigation. For example a centre pivot has a slope limitation of 20%. The areas of land in different slope class are shown in Table 17. The erosion hazard levels and suitability for irrigation are shown in Table 23.

5.2.2 Soils

The basis of the soil units is the UNDP/FAO (1991) detailed reconnaissance level survey carried out at a scale of 1:1,000,000 to 1:250,000. The detailed taxonomy was later brought into line with the Harmonised World Soil Database FAO/IIASA/ISRIG/ISS-OAS/JRC 2012 which identified 33 soil units. This means that the basis of soil units is broad brush, and indicative only. Every scheme will require detailed soil survey work as part of the feasibility study. Applying a range of limits for irrigated agriculture, the following table was developed for three classes of suitable land (S1, S2, and S3) and two classes of unsuitable land (N1 and N2).

Table 24: Land Use Requirements and Critical limits for Irrigated Agriculture

Land use requirements				Factor Ratings /Class of Suitability /level of yield				
Land Quality /diagnostic factors: Description	Sub Suffix	Land Characteristic	Unit	S1	S2	S3	N1	N2
Crop environmental requirement								
Moisture availability	m	AWC	mm/m	>120	120–60	<60	<60	<60
Oxygen availability	d	Soil Drainage	Class	Well	Moderate Well	Imperfect	Poor	Very Poor, Excessive,
Nutrient retention	n	CEC	Meq/ 100g soil (50cm)	>10	>10	05-Oct	<5	<5
Nutrient Availability	z	Soil reaction	pH (50cm)	5.5–7.5	5.0–5.5 7.5–8.0	4.5–5.0 8.0–8.5	<4.5 >8.5	<4.5 >8.5
Rooting condition	r	Effective soil depth	cm	>150	100–150	50–100	30-50	<30
		Surface stones and rocks	%	0–15 (non-few)	0–15 (non-few)	(15–35) common	35–55 (many)	>55 (abundant)
Toxicity/ Excess of salts	s	Salinity	%	<4	>4	>4	>4	>4
Land development and management requirement								
Workability	w	Texture / Structure	Class	SL, SiC, SiL, CL, Si, L, SCL	S, SC, SiCL	-	Cv	Cm, SiCm,
		Surface stones and rocks	%	0–15 (non-few)	0–15 (non-few)	(15–35) common	35–55 (many)	>55 (abundant)
Potential for mechanization	k	Slope	%	<2	2-6	02-Jun	Jun-13	>13
Drainage	d'	Infiltration	cm/h	0.7–3.5	3.5–6.5	0.1–0.7 6.5–12.5	<0.1 12.5–25	<0.1>25
		Depth to impermeable layer	m	>150	80-150	>80		<80
Flood hazard	f	Flooding	Occurrence	none	non-exceptional	exceptional	frequent	Severe
Erosion hazard	e		Occurrence	Slight	Slight to Moderate	Moderate	Moderate to Severe	Severe
		Slope	%	<2	2-6	6-13	13-26	>26

Class not used in Soil Suitability Mapping Criteria as data not available
Classes not used as most of these soils are already cultivated. Detailed soil surveys will determine the final suitability.

Applying the criteria that are available in the soil database, a soil suitability map was produced with the five class divisions, see Figure 28. This available data is: soil drainage, flooding, effective soil depth, texture and slope. These criteria puts the dambo soils into the unsuitable category as they have poor drainage and frequent flooding. However, it is noted that a large area of dambo soils are irrigated and included in the total existing irrigated area.

A summary of each class and the total suitable land available is given in Table 25 below, which shows that 61,253 km^2 of land is suitable for irrigation using soil classification criteria.

Table 25: Summary of Soil Suitability Class

Class	Area (km^2)	Total (km2)
S1	5,445	61,253
S2	32,530	
S3	23,278	
N1	6,663	34,484
N2	27,821	

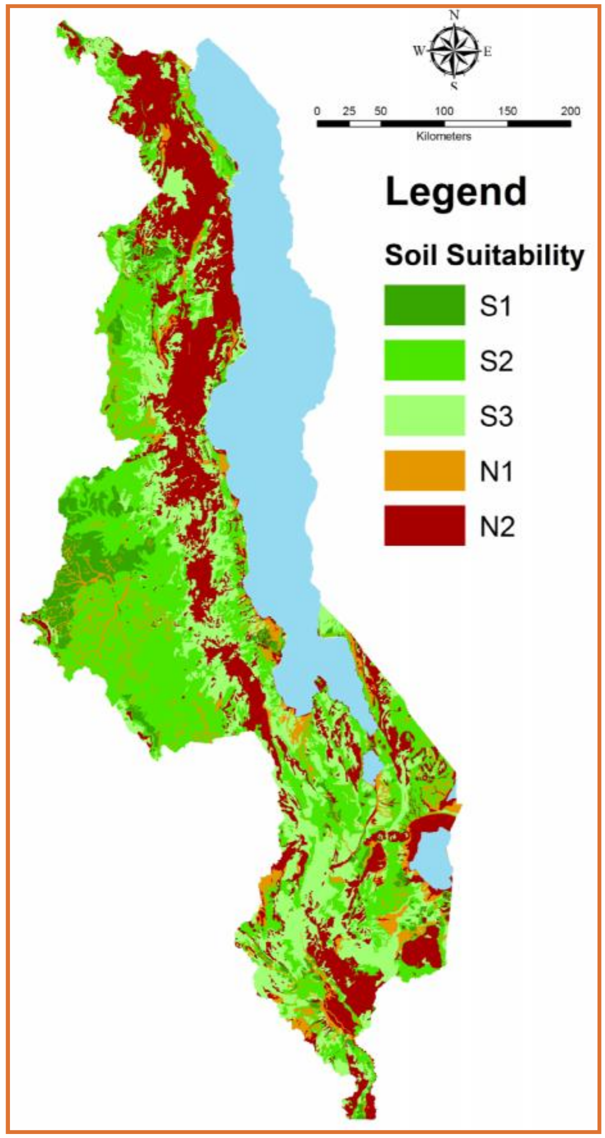


Figure 28: Soil Suitability Map

5.2.3 Land Cover Suitability:

The land use is an underlying indication of suitability. The best indication that land is suitable is if people are already cultivating and growing crops. These become suitable for irrigation. Lands with woodland, forest, and shrub savannah have been deemed unsuitable. Urban areas, rock outcrops and flooded land are also unsuitable. The land use map was taken from the Land Cover Atlas 2010, given in Figure 29 Land Use Suitability Map.

Table 26: Summary of Land Suitability Class

Class	Area (km^2)
Land Cover Suitable	58,000
Not Suitable	34,700
Lake	25,300
Total	118,000

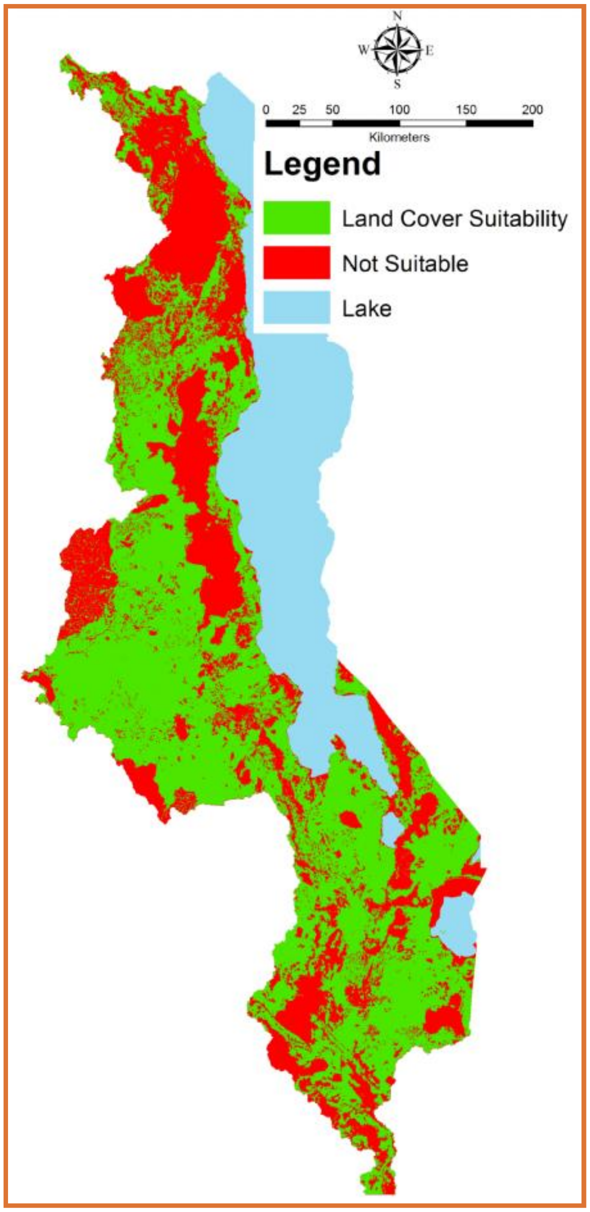


Figure 29: Land Use Suitability Map

5.3 Results of Physical Determination of PIA_{psy}

The determination of the PIA is based solely on the physical factors of slope, soils and land use, shown in Figure 30. The net area of suitable land (PIA_{phy}) after allowing for slope and land use limitations is reduced to 41,378 km^2.

The distribution of the potential irrigation areas has been determined by WRA, and given in Table 27, below. This shows that the largest catchments have the largest share of PIA; Bua (74%), Linthipe (66%), South Rukuru (49%) and Shire (51%) (percentage shown of each WRA, not national).

Table 27: WRA Distribution of PIA_{phy}

WRA	Suitability Area (km^2)		
	NS	PIA	% of WRA
Bua	3,129	7,529	71%
Dwangwa	4,613	3,138	40%
Karonga L Shore	1,570	375	19%
L Chiuta	1,157	1,286	53%
Lake Chirwa	2,279	2,289	50%
Linthipe	3,334	5,551	62%
Nkhata L Shore	4,867	665	12%
Nkhota L Shore	2,899	1,920	40%
North Rukuru	1,880	208	10%
Ruo	1,824	1,695	48%
S E Lakeshore	1,198	461	28%
S Rukuru/N Rumph	7,677	5,043	40%
S W L Shore	2,464	2,534	51%
Shire	11,300	7,611	40%
Songwe/Lufira	2,657	1,073	29%
Total	52,848	41,378	

NS = not suitable

PIA = Potential Irrigation Area

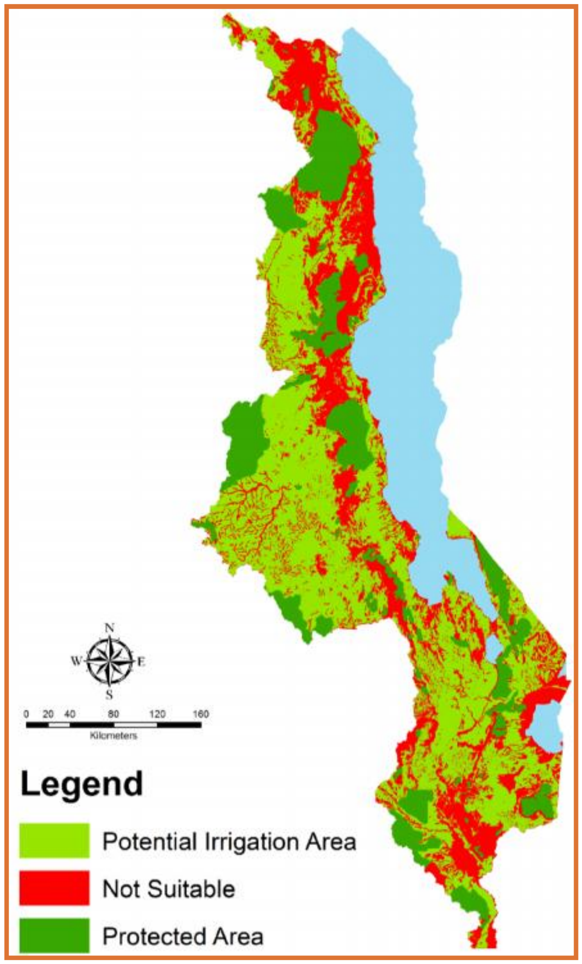


Figure 30: Potential Irrigation Area (Physical)

An irrigation potential area of 41,387 km^2 indicated that the availability of suitable land will not be a constraint to the irrigation development in the foreseeable future.

5.4 Climate

Rainfall greatly influences the amount of runoff and seasonal distribution of flows. High rainfall produce high annual river flows, see Figure 19 Rainfall distribution Map.

Temperature influences the crop water demand which determines the amount of water an irrigation area requires, see Figure 18 Temperature Map.

Crop water requirements utilise data of temperature, humidity, sunshine hours, solar radiation and wind speed (run). All these tertiary factors of climate are not used directly in the determination of potential irrigation areas, but are used to calculate other factors like evapotranspiration (ET_o). The water deficit is calculated by subtracting the effective rainfall from the ET_o. They also contribute largely to the hydrologic factors . See Figure 20 PET Map.

5.5 Hydrology

Recent studies in the water sector of Malawi have produced assessments of available water potential[9]. The WRIS did not make a final pronouncement on the potential irrigation area, based on land and water resources. Instead, it determined an irrigation area based on projections of population, water demand from various sectors, and adjusted for environment flows. The prediction for medium economic growth determined that 475,777 ha of potential irrigation area for 2035, based on 7,727 Mm^3/y.

The NWRMP took a different approach and determined the shortage of available surface water resources based on an annual growth of 5,000 ha/y, and determined the locations (by WRU) and months of shortage.

The IMP estimates the PIA based on available surface water resources and deducts domestic water demand and environmental flows. For this purpose, the NWRMP has made available stochastic generation of monthly flows for 30 years (Nov 1980 to Oct 2010). This data has been analysed to determine the 80% reliable flows (Q_{80}) used in the assessment of available water resource for irrigation. This represents the one in five year drought, or to say that four years in five will have flows exceeding the Q_{80} flow. From the Q_{80} results, the unit minimum flows for each WRU have been computed in l/s/km[2], and when represented geographically, show the areas of abundant water and those with less water, see Figure 31, and Table 28.

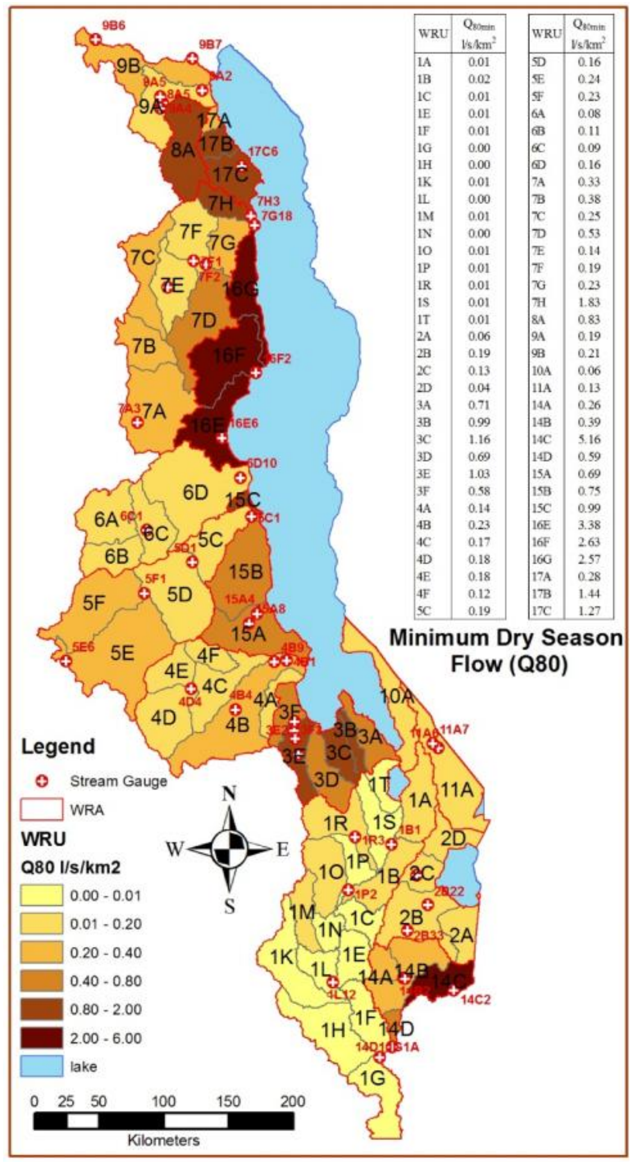


Figure 31: Minimum Dry Season Flows Q80

[9] Water Resource Investment Strategy (Atkins , April 2011) (WRIS), and National Water Resources Master Plan (JICA, October 2014) (NWRMP)

Any WRU with a minimum Q_{80} flow above 1.0 l/s/km^2 can be considered to have reasonable dry season flows, and are highlighted in Table 28.

Table 28: Q80 flows by WRU (l/s//km2)

WRU	Q_{80min} l/s/km^2	WRU	Q_{80min} l/s/km^2	WRU	Q_{80min} l/s/km^2
1A	0.01	3D	0.69	7G	0.23
1B	0.02	3E	1.03	7H	1.83
1C	0.01	3F	0.58	8A	0.83
1E	0.01	4A	0.14	9A	0.19
1F	0.01	4B	0.23	9B	0.21
1G	0.00	4C	0.17	10A	0.06
1H	0.00	4D	0.18	11A	0.13
1K	0.01	4E	0.18	14A	0.26
1L	0.00	4F	0.12	14B	0.39
1M	0.01	5C	0.19	14C	5.16
1N	0.00	5D	0.16	14D	0.59
1O	0.01	5E	0.24	15A	0.69
1P	0.01	5F	0.23	15B	0.75
1R	0.01	6A	0.08	15C	0.99
1S	0.01	6B	0.11	16E	3.38
1T	0.01	6C	0.09	16F	2.63
2A	0.06	6D	0.16	16G	2.57
2B	0.19	7A	0.33	17A	0.28
2C	0.13	7B	0.38	17B	1.44
2D	0.04	7C	0.25	17C	1.27
3A	0.71	7D	0.53		
3B	0.99	7E	0.14		
3C	1.16	7F	0.19		

5.5.1 Environmental Flow Requirement

The Q_{80} is the first step evaluation of available water for irrigation. If all this water was taken for irrigation, then downstream users would not have sufficient water and the river habitat would not be maintained. The Q_{80} must be reduced to allow for environmental flow rate (EFR). The purpose of allowing for EFR is the maintenance of ecological needs, such as flora and fauna, purification, sediment transport etc.

There are various methods of estimating the EFR, and different organizations within Malawi are using different values. For example the Lilongwe Water Board and Blantyre Water Board uses the Q_{90} flow(10 year drought) as a measure of EFR, while the Northern Region Water Board uses the Tennant method, as 10% of the mean annual flow. In the WRIS report, an alternative approach was used which is the desktop reserve method, as follows:

> *EFR assessments undertaken in South Africa which comprise detailed instream flow requirements (IFR) studies from which a desktop model has been derived provide descriptions of flow regimes that would maintain regulated river ecosystems in certain catchment conditions. Analysis of the results of these flow assessments has shown that rivers with different kinds of flow regimes were allocated different percentages of their natural flow (nMAR) to maintain the same ecological condition (Hughes and Munster, 1999). Rivers with very flashy hydrographs, for instance, were allocated less of their natural flow than rivers with stable perennial flow to maintain.*

The WRIS developed a set of percentages for wet and dry seasons for each WRA, which were hydraulically similar to those in the South African study. Different ways of determining the EFR were considered and the value greatly affects the amount of water available for irrigation.

Table 29: Comparison of Curve of Flow Associated with Different EFR Approaches

Method	System	Curve of Flow
EFR-WRIS	Desktop Reserve Method (WRIS)	Step
10% MAF	Using Tennant 10% of mean Annual Flow for 12 months	Flat
25% MMF	Using Tennant 25% of mean Monthly Flow for 12 months	Variable
Min MF	Using the minimum Monthly Flow for 12 months	Flat
EFR-VMF	Variable Monthly Flow (VMF) (modified WRIS)	Variable
Q90 (EFR 90%)	Using the 10 year drought flow	Variable
Q93 (EFR 93%)	Using the 15 year drought flow	Variable
Q95 (EFR 95%)	Using the 20 year drought flow	Variable

These different approaches are represented graphically in the Figure 32 below.

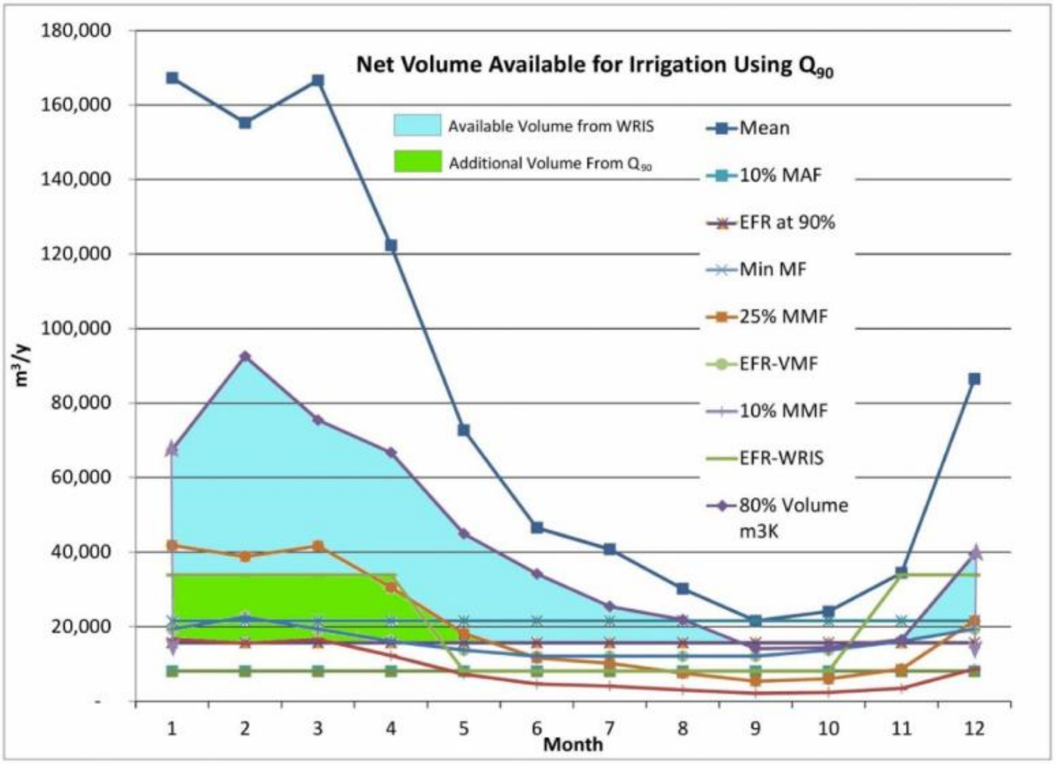


Figure 32: Monthly Flows: Q_{80} and Different EFR

The Q_{90} is based on the annual flow duration curves, and is used in most Water Boards determination of EFR in Malawi. It is applied as a fixed value for all twelve months, and therefore it does give very low values of EFR.

It is recognised that the EFRs provide only an indicative values of the ecological flow requirements for each WRA and that a single value is applied to the WRA catchment, as a whole. It is recommended that further consideration to the EFR be given that will give a higher reserve. For this the DRM method, as applied in the WRIS report could be used.

5.5.2 Population and Domestic Water Requirements

Other users of water need to be considered in determining the PIA. Apart from the EFR, another major water user is domestic water consumption. As mentioned in Section 4.11.3, ground water is the main supplier of water, but by 2035, this supply will be insufficient to meet the needs, and surface water resources will be needed. For the purpose of evaluating the national water resource available for irrigation in 2035, this IMP assumes that all the domestic consumption will be supplied by surface water. The predicted population for 2035 is 31.0 million, and the values used for rural consumption is 50 l/d/c, and for four main cities, is 120 l/d/c. This gives a total annual domestic water requirement of 776 Mm^3/y or an average for the whole country of 69 l/d/c.

Table 30: Comparison of Different Daily Domestic Water Needs

Type of supply	WHO	Uganda	Pacific	WRIS (Atkins)	NWRMP (JICA)	Average	IMP
Basic Needs	20	16	40	36	36	29.6	
Communal tap	50	50	40	50	50	48	50
House/city	100	155	100	100	80	107	120

5.6 Net PIA, and Distribution

The determination of the PIA based on physical attributes alone selects virtually all the arable land in the country as suitable. The water resources have proved to be the limiting factor in determining the PIA, and its distribution across the country.

The determination of the final PIA based on both water and physical attributes is done by calculating the Q_{80} annual flows, deducting the EFR, and deducting the domestic water requirements. Finally, in some WRU, there is more water than suitable irrigable land available, so the minimum area is determined for each WRU.

The following formula can then be applied:

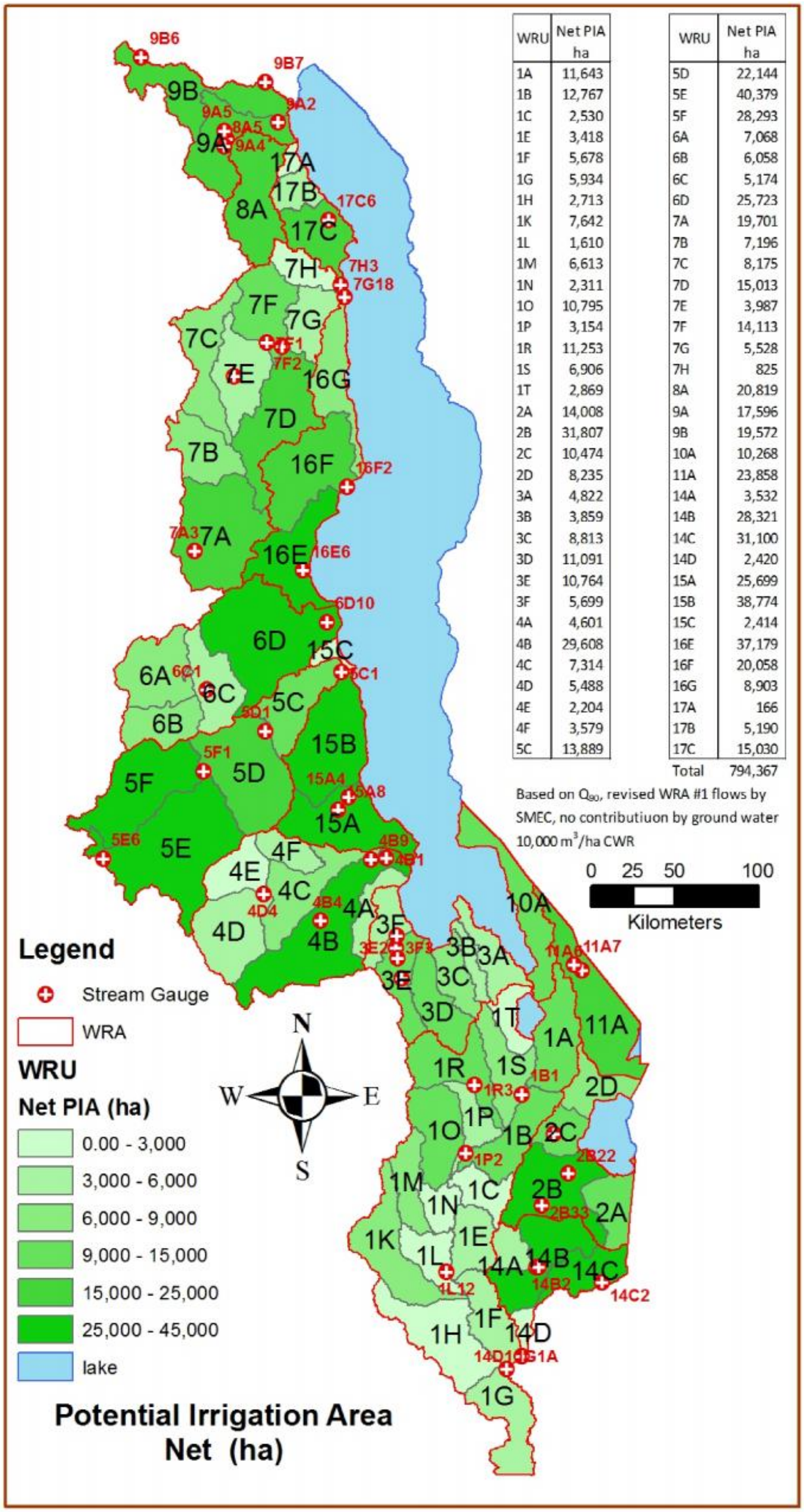
$$PIA = Min[((Q_{80} - EFR - DWR)/10{,}000), PIA_{phy}]$$

Where:
- PIA = net Potential Irrigation Area
- Min = minimum between water and land available
- Q_{80} = 80% reliable annual flow
- EFR = Environmental Flow Requirement (Q_{90})
- DWR = Domestic Water Requirement
- 10,000 = Annual water storage volume per hectare irrigated
- PIA_{phy} = Potential Irrigation Area from physical determination

It must be noted that this figure is an indicative value only, based on the criteria applied, and achieving this area is unlikely because of the distribution of both land and water. Throughout the IMP studies, it has become clear that the potential of river diversion schemes is very limited, and most of these have been developed, with the exception of SVIP and Ruo River. This means that the future of irrigation development in Malawi will have to rely mostly on dam storage. In many places there is abundant water, but finding suitable locations for storing water for irrigation is proving difficult.

Alternatives and variations of the above requirements have led to different PIA results. For example, it has been stated that 80% of rural domestic water requirements comes from ground water, and that as a consequence the figure of 50 l/d/c can therefore be reduced to 17 l/d/c. This increases the PIA by 130,000 ha. Additionally, the annual water storage requirement differs according to the climatic zones, and different values for each appropriate zone should be used. Values from 7,000 m^3/ha for Plateau, 8,000 m^3/ha for Lakeshore, and 10,000 m^3/ha for lowland mixed farming. This increases the PIA by 80,000 ha.

The total using this method and the EFR Q_{90} yields a PIA of 794,000 ha, or for purpose of national evaluation, the PIA for Malawi is 800,000 ha, see Figure 33.



WRU	Net PIA ha	WRU	Net PIA ha
1A	11,643	5D	22,144
1B	12,767	5E	40,379
1C	2,530	5F	28,293
1E	3,418	6A	7,068
1F	5,678	6B	6,058
1G	5,934	6C	5,174
1H	2,713	6D	25,723
1K	7,642	7A	19,701
1L	1,610	7B	7,196
1M	6,613	7C	8,175
1N	2,311	7D	15,013
1O	10,795	7E	3,987
1P	3,154	7F	14,113
1R	11,253	7G	5,528
1S	6,906	7H	825
1T	2,869	8A	20,819
2A	14,008	9A	17,596
2B	31,807	9B	19,572
2C	10,474	10A	10,268
2D	8,235	11A	23,858
3A	4,822	14A	3,532
3B	3,859	14B	28,321
3C	8,813	14C	31,100
3D	11,091	14D	2,420
3E	10,764	15A	25,699
3F	5,699	15B	38,774
4A	4,601	15C	2,414
4B	29,608	16E	37,179
4C	7,314	16F	20,058
4D	5,488	16G	8,903
4E	2,204	17A	166
4F	3,579	17B	5,190
5C	13,889	17C	15,030
		Total	794,367

Figure 33: Potential Irrigation Area (ha) based on available water.

6 POTENTIAL IRRIGATION SCHEMES

6.1 Irrigation Domains

Taking a holistic view of the country's potential for irrigation, there are clearly areas of homogenous characteristics that lend themselves to particular types of irrigation. There areas are defined as irrigation domains where one type of irrigation is favored over others due to the soils, topography, slopes, climate and most importantly available water. Four domains have been selected: Diversion, Dambo, Dam and Lake. There are some areas with more than one type of domain.

6.1.1 Diversion Domain

There are three areas of the country that have good dry season flows, as indicated in Section 5.6 above: Karonga Lake Shore, Nkhata Bay Lake Shore and Ruo/Mulanje area. In addition to these, there are lot of diversion irrigation schemes around Lake Chirwa using dry season flows. There is also the Shire River, which drains Lake Malawi. This river is regulated by the Kamuzu Barrage. During the years from its construction in 1967 until August 1992, the river was mostly unregulated. However, after this time the lake level lowered to the point when regulation started. The lake level reduced to such a point that flows downstream affected the ability to produce full power.

Table 31: Diversion Domain by District

Diversion Domain	Area (km^2)	% of Domain
Chikwawa	777	52%
Machinga	16	1%
Mulanje	234	16%
Mzimba	39	3%
Nsanje	154	10%
Rumphi	93	6%
Thyolo	15	1%
Zomba	165	11%
Grand Total	1,497	100%

Irrigation schemes that use perennial river flows are always selected first, as these usually provide the cheapest investment cost. The area covered by this domain is 3.6% of the total PIA_{phy}. Chikwawa, with the SVIP has the largest potential of diversion domain, followed by Mulanje and Zomba.

6.1.2 Dambo Domain

The definition of a dambo is:

"A wide low-lying gently sloping treeless grassland depression, seasonally waterlogged by seepage from surrounding high ground. It derives its fertility from accumulation of organic matter in this depression and exhibits a water table of 50-100 cm deep, from which it may drain into streams.[10]"

Dambos have been described as islands (fingers) of green surrounded by a sea of brown.

They play an important role in mitigating problems of food insecurity as the majority of small scale farmers have access to them without legal possession of acquisition. Dambos represent a major source of sustenance for many southern African countries. They are a large source of the following:

i) Fruit production, ii) Vegetable production, iii) Brick making, iv) Animal production (water and grazing), v) Fishing, and vi) Thatching grass and reeds for mats

Both the fruit and vegetable production is done using irrigation, and most the smallholder irrigation is done in dambos. The size of the dambo domain is 19,125 km^2, or 42.6% of the total PIA_{phy}.

Table 32: Dambo Domain by District

Dambo Domain	Area (km^2)	% of Domain
Blantyre	1.03	0%
Chiradzulu	308.99	2%
Chitipa	554.99	3%
Dedza	1179.40	6%
Dowa	1762.53	9%
Kasungu	3192.60	17%
Lilongwe	4309.92	23%
Machinga	703.77	4%
Mangochi	262.55	1%
Mchinji	2186.64	11%
Mulanje	477.05	2%
Mzimba	3224.17	17%
Ntchisi	615.98	3%
Rumphi	180.98	1%
Thyolo	164.89	1%
Grand Total	**19,125.48**	**100.0%**

According to McFarlane (1995) and Bullock (1995) surface water plays a minor role in Dambo hydrology. The hydrology of dambos indicated that they are a minor factor in determining base flows and dry season flows. It is the increasing deforestation of the catchment (upland area) that both

[10] Daka (1995)

flood and dry season streamflow increase[11]. Thus it is catchment conservation and conservation agriculture that are vital to the health and future sustainability of dambos and dambo agriculture.

The future of smallholder irrigation in dambos lies in maintaining the health of dambos. This means that all parties involved in smallholder irrigation must be certified in the environmentally sensitive use of dambos. The future expansion of irrigation will take place in dambos and much attention is required to develop this sustainably.

6.1.3 Dam Domain

This domain is basically what is left after the other two main domains are identified. The dam domain is located in the areas of gently rolling land surrounded by hilly land where the dams are located. The water resource availability assessment shows that most of the country requires water storage during the wet season in order to be able to irrigate during the dry season. There is sufficient water resources to irrigate over 400,000 ha, but the majority of this will come from dam storage. Every district has some amount of dam domain, with some districts having large areas of dam domain, see Table 33.

Table 33: Dam Domain by District

Dam Domain	Area (km^2)	% of Domain
Balaka	1,602.6	8%
Blantyre	795.0	4%
Chikwawa	600.6	3%
Chiradzulu	220.5	1%
Chitipa	437.4	2%
Dedza	441.8	2%
Dowa	488.1	3%
Karonga	14.6	0%
Kasungu	1172.0	6%
Lilongwe	193.1	1%
Machinga	641.0	3%
Mangochi	2,470.7	13%
Mchinji	91.6	0%
Mulanje	191.6	1%

Dam Domain	Area (km^2)	% of Domain
Mwanza	307.7	2%
Mzimba	2031.3	11%
Neno	546.2	3%
Nkhata bay	59.6	0%
Nkhotakota	909.2	5%
Nsanje	350.9	2%
Ntcheu	1820.4	10%
Ntchisi	229.0	1%
Phalombe	732.5	4%
Rumphi	186.8	1%
Salima	1068.8	6%
Thyolo	325.4	2%
Zomba	1,205.3	6%
Grand Total	**19,134.0**	**100%**

[11] Bullok (1995)

The size of the dam domain is 19,135 km², or 42.6% of the PIA_{phy}, with the majority in seven districts, Balaka, Kasungu, Mangochi, Mzimba, Ntcheu, Salima, and Zomba.

6.1.4 Lake Domain

Malawi is blessed with large fresh water bodies, and these will always attract interest in this abundant supply. However, the lake represents the lowest level of water, and ulilising this source will require pumping to a higher level to be able to irrigate. Unfortunately, the economics of pumped irrigation, using medium value crops, like vegetables and green maize, is marginally profitable. It requires high value crops to make pumping economic. In determining the size of this domain, an elevation of 15 m above lake level has been determined as the cut-off point. The size of the lake domain is 614.3 km², or 1.5% of the total PIA_{phy}.

Table 34: Lake Domain by District

Lake Domain	Area (km²)	% of Domain
Balaka	11.4	2%
Dedza	59.4	10%
Mangochi	266.2	43%
Nkhata bay	9.3	2%
Nkhotakota	147.5	24%
Nsanje	0.4	0%
Ntcheu	0.2	0%
Rumphi	1.8	0%
Salima	116.7	19%
Grand Total	614.3	100%

An additional determinate in the use of this domain is the supply of reliable cheap power, in the form of electricity. Currently there is a severe shortage of power in Malawi, and this needs to be addressed. Pumped irrigation, which usually will take the form of high technology, like drip or centre pivot requires high power demand at the right location. In the future, if Malawi invests in new power production and distribution, pumped irrigation can contribute significantly to agricultural production.

6.1.5 Diversion/Dam Domain

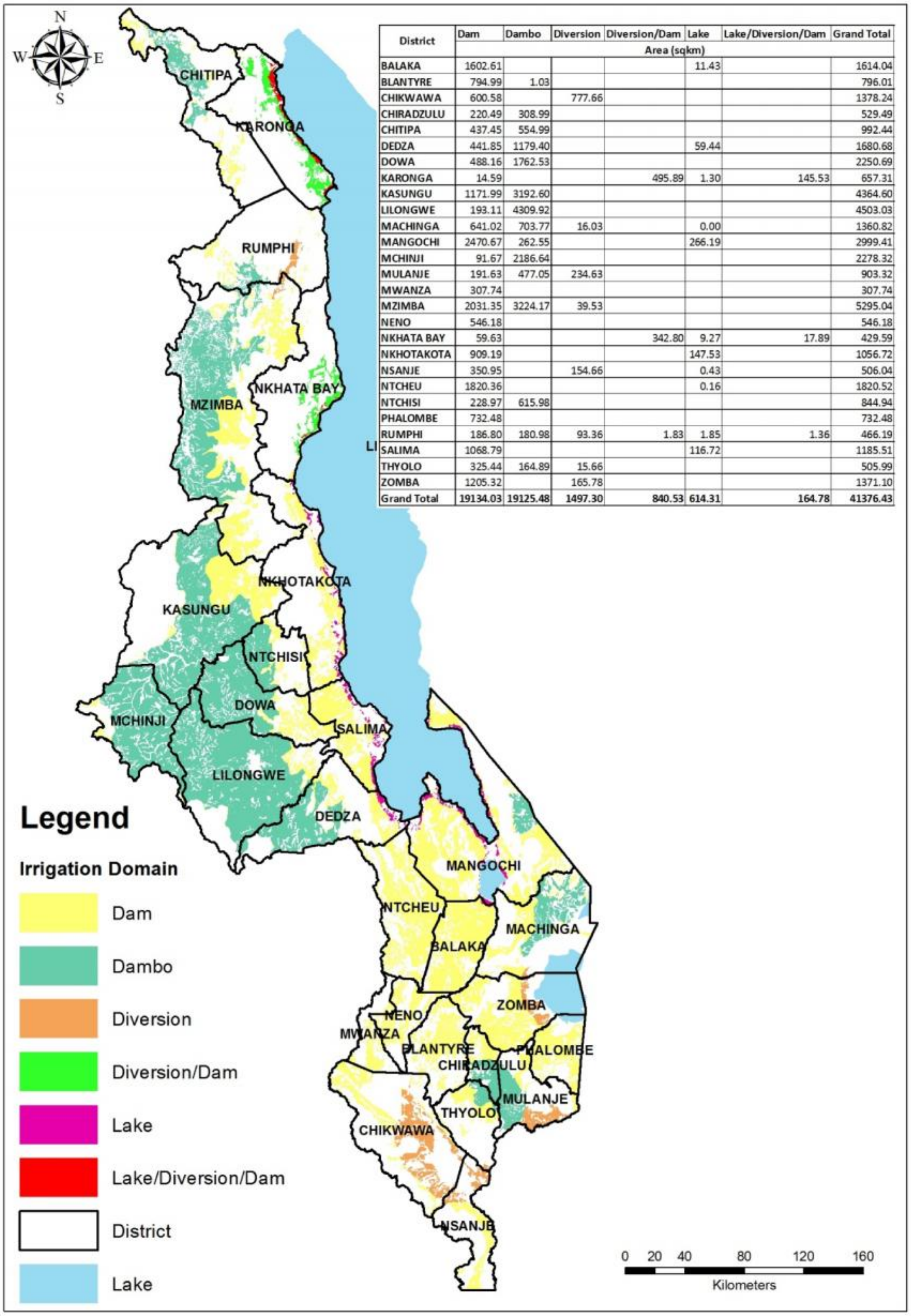
There is some overlap of domains where there is potential for diversion, but in the end dam irrigation has been selected because of increased potential from storage, and making allowance for EFR. These locations are Karonga, Nkhata Bay and Rumphi.

Table 35: Diversion/Dam Domain by District

Diversion/Dam	Area (km²)	% of Domain
Karonga	495.9	59%
Nkhata Bay	342.8	41%
Rumphi	1.8	0%
Total	840.5	100%

The size of the diversion/dam domain is 840.5 km², or 2.0% of the PIA_{phy}.

6.1.6 **Domain Summary**



District	Dam	Dambo	Diversion	Diversion/Dam	Lake	Lake/Diversion/Dam	Grand Total
	Area (sqkm)						
BALAKA	1602.61				11.43		1614.04
BLANTYRE	794.99	1.03					796.01
CHIKWAWA	600.58		777.66				1378.24
CHIRADZULU	220.49	308.99					529.49
CHITIPA	437.45	554.99					992.44
DEDZA	441.85	1179.40			59.44		1680.68
DOWA	488.16	1762.53					2250.69
KARONGA	14.59			495.89	1.30	145.53	657.31
KASUNGU	1171.99	3192.60					4364.60
LILONGWE	193.11	4309.92					4503.03
MACHINGA	641.02	703.77	16.03		0.00		1360.82
MANGOCHI	2470.67	262.55			266.19		2999.41
MCHINJI	91.67	2186.64					2278.32
MULANJE	191.63	477.05	234.63				903.32
MWANZA	307.74						307.74
MZIMBA	2031.35	3224.17	39.53				5295.04
NENO	546.18						546.18
NKHATA BAY	59.63			342.80	9.27	17.89	429.59
NKHOTAKOTA	909.19				147.53		1056.72
NSANJE	350.95		154.66		0.43		506.04
NTCHEU	1820.36				0.16		1820.52
NTCHISI	228.97	615.98					844.94
PHALOMBE	732.48						732.48
RUMPHI	186.80	180.98	93.36	1.83	1.85	1.36	466.19
SALIMA	1068.79				116.72		1185.51
THYOLO	325.44	164.89	15.66				505.99
ZOMBA	1205.32		165.78				1371.10
Grand Total	19134.03	19125.48	1497.30	840.53	614.31	164.78	41376.43

Figure 34: Map Depicting Irrigation Domain Summary for Malawi

6.2 Considered Irrigation Schemes

DOI already has many schemes in the pipeline. Some have reached detailed design stage, while others are still undergoing feasibility studies. All of these are listed as Considered Schemes, a collection of studies done in the past.

6.2.1 Songwe Scheme

The Songwe River forms the boundary with Tanzania from the Lake to the most northern tip of Malawi. After the river exits the gorge around Manolo, the river meanders and breaks its banks during the flood season. This river also forms the international boundary, and is constantly shifting its course. This and the annual flooding led to many studies aimed at reducing these problems. In the course of these studies, the hydro potential of the river was discovered, with three potential dams available for development. However, it is the Lower Songwe Dam that is put forward for first development because of its multi-purpose aspects of hydropower, irrigation and flood mitigation. A study completed by Norplan (2003) looked at the feasibility of mainly flood mitigation measures, and this was updated by the Songwe River Basin Development Programme (SRBDP), conducted by Lahmeyer and ACE consultants (April 2014). Presently funding is being sought for this Lower Songwe River Project in Tanzania and Malawi. The salient features of this project are:

- 115 m high dam, roller compacted concrete (E569,270 N8,938,430), FSL 820 m asl
- Centre Spillway, with 4 No. 11x8 m redial gates, 1,510 m^3/s capacity
- 3 Francis Turbines, total installed capacity 175 MW, 671 GWh/y
- Left Bank Feeder Canal 18.25 km commanding 3,000 ha in Tanzania
- Right Bank Feeder Canal 28.5 km commanding 2,630 ha in Malawi

			US$ M
Estimated Costs:	Lower Songwe Dam & HPP		473.3
	Left Bank Feeder	Tanzania	39.1
	Right Bank Feeder	Malawi	46.3
	Total		558.6

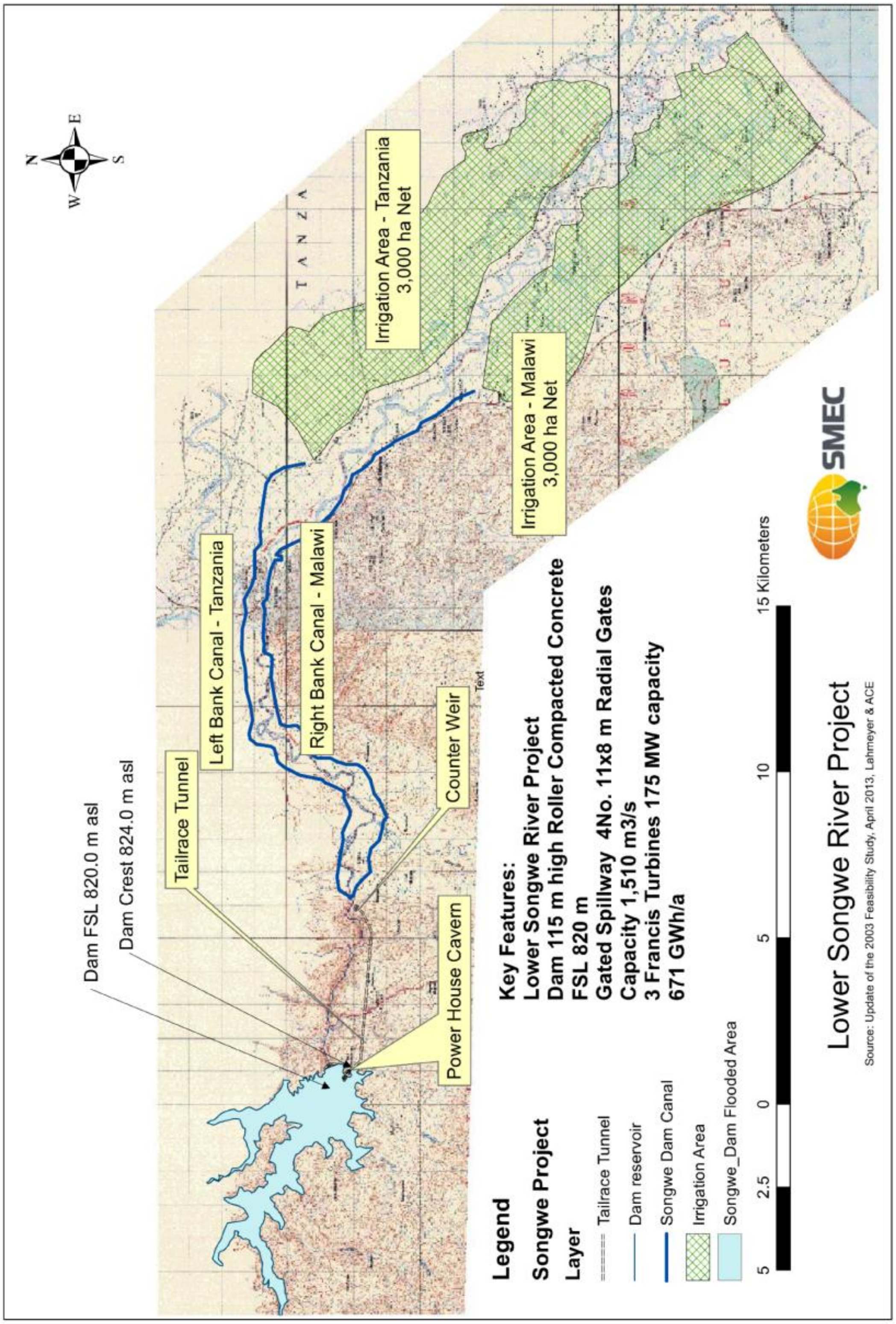


Figure 35: Lower Songwe River Project

6.2.2 RIDP II Schemes

The overall objective of the RIDP II project is to assist Malawi in becoming less dependent on rainfed agriculture, diversify cropping, enhance food security and rural incomes and reduce vulnerability to drought. This is to be achieved by the feasibility and detailed designs of irrigation schemes. In total, 10 schemes were designed and costs prepared. These are known as the GOPA Schemes, see Table 36.

Table 36: Summary of RIDP II New Schemes

No	Name	District	Irrigated Area (ha)	Source of water	No. of Beneficiaries HH	Investment Costs (M.US$)	Unit Cost (US$/ha)	EIRR %
1	Chilingali	Nkhotakota	1,200	Kaombe River	555	3.13	2,611	33
2	Lifidzi	Salima	600	Lifidzi River	488	8.06	13,433	5
3	Navikoko	Nkhotakota	150	Navokoko River	535	2.08	13,835	9
4	Kamwanyoli	Nkhatabay	120	Lwambambaza	371	1.26	10,484	12
5	Kawiya_Kadeti	Nkhatabay	55	Gomo	104	2.00	36,422	-4
6	Mwamphanzi	Chikwawa	335	Mwamphanzi	670	5.09	15,205	5
7	Lifuwu	Salima	156	Lake Malawi	254	2.44	15,627	7
8	South Rukuru	Rumphi	2,000	South Rukulu	3635	23.01	11,505	5
9	Tchanga	Dedza	154	Nadzipulu	320	1.78	11,529	9
10	Bwanje Dam	Dedza	800	Namikokwe	1777	9.39	11,737	11

These schemes locations are shown in Figure 36 RIDP II New Schemes (GOPA). All of the schemes were included in the IMP ranking assessment, with two within the top thirty. These are Chilingali #3 and Kamwanyoli, #29. The ranking results are dealt with in section 6.3.2.

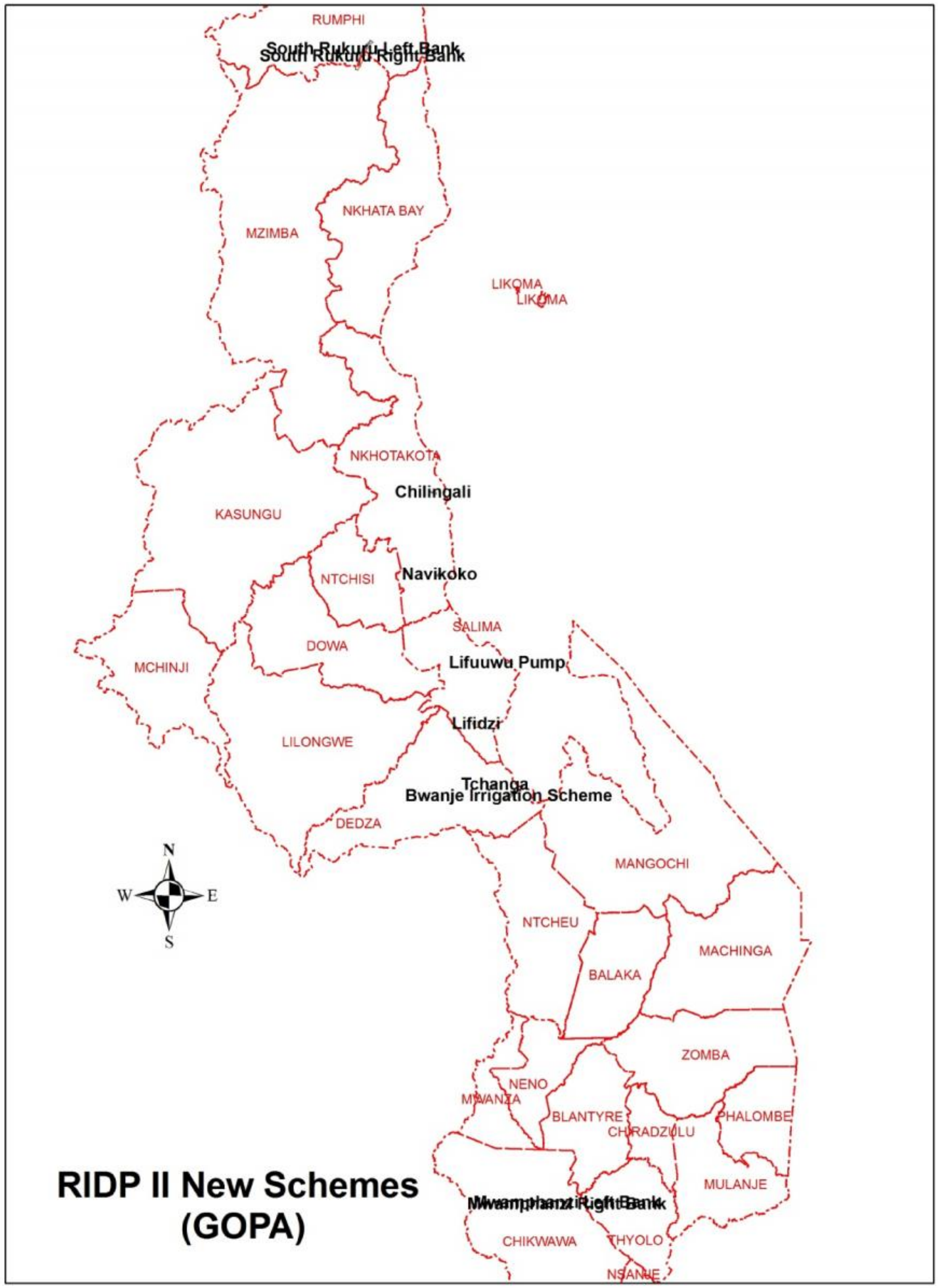


Figure 36: RIDP II New Schemes (GOPA)

6.2.3 IRLADP Feasibility Study for New Irrigation Schemes (SMEC Designs)

Within IRLADP, under the Irrigation Rehabilitation and Development and Catchment Conservation; is the activity of feasibility studies for irrigation development for selected sites covering a total of 7,000 hectares.

Twelve schemes have been included in the studies, with a total irrigated area of 4,526 ha, see Table 37 and a survey area of 6,000 ha. These schemes are included in the ranking assessment. The location is shown in Figure 36.

Table 37: Summary of IRLADP New Schemes

Name	Technology	District	Irrigated Area Ha	Total Cost	Cost /Ha
				M.US$	US$
Nkhulambe/Wowo	Gravity	Phalombe	300	2.30	7,668
Likhubula/Kholiwa	Gravity	Mulanje	820	4.60	5,616
Chizimbi	Gravity Opt. 3	Chikwawa	238	2.08	8,779
Likhubula/Nthumbula	Gravity	Chikwawa	494	2.76	5,597
Mkulumadzi_Left Bank	Gravity	Mwanza/Neno	321	3.07	5,404
Nkawinda/Bakasala	Gravity/Canalisation	Blantyre	560	0.79	1,421
Chanyungu-Mposa/Chikala	Gravity	Machinga	126	1.17	9,361
Lingoni/Mkomankhani	Gravity	Machinga	246	1.83	7,436
Matoponi	Gravity/Canalisation Opt. 1	Zomba	115	0.59	5,168
Mlooka	Gravity/Canalisation	Zomba	153	0.73	4,821
Mwelekera	Gravity	Mchinji	153	1.40	9,150
Diamphwe	Gravity	Lilongwe/Dedza	1000	8.38	8,384
Total			4,526		

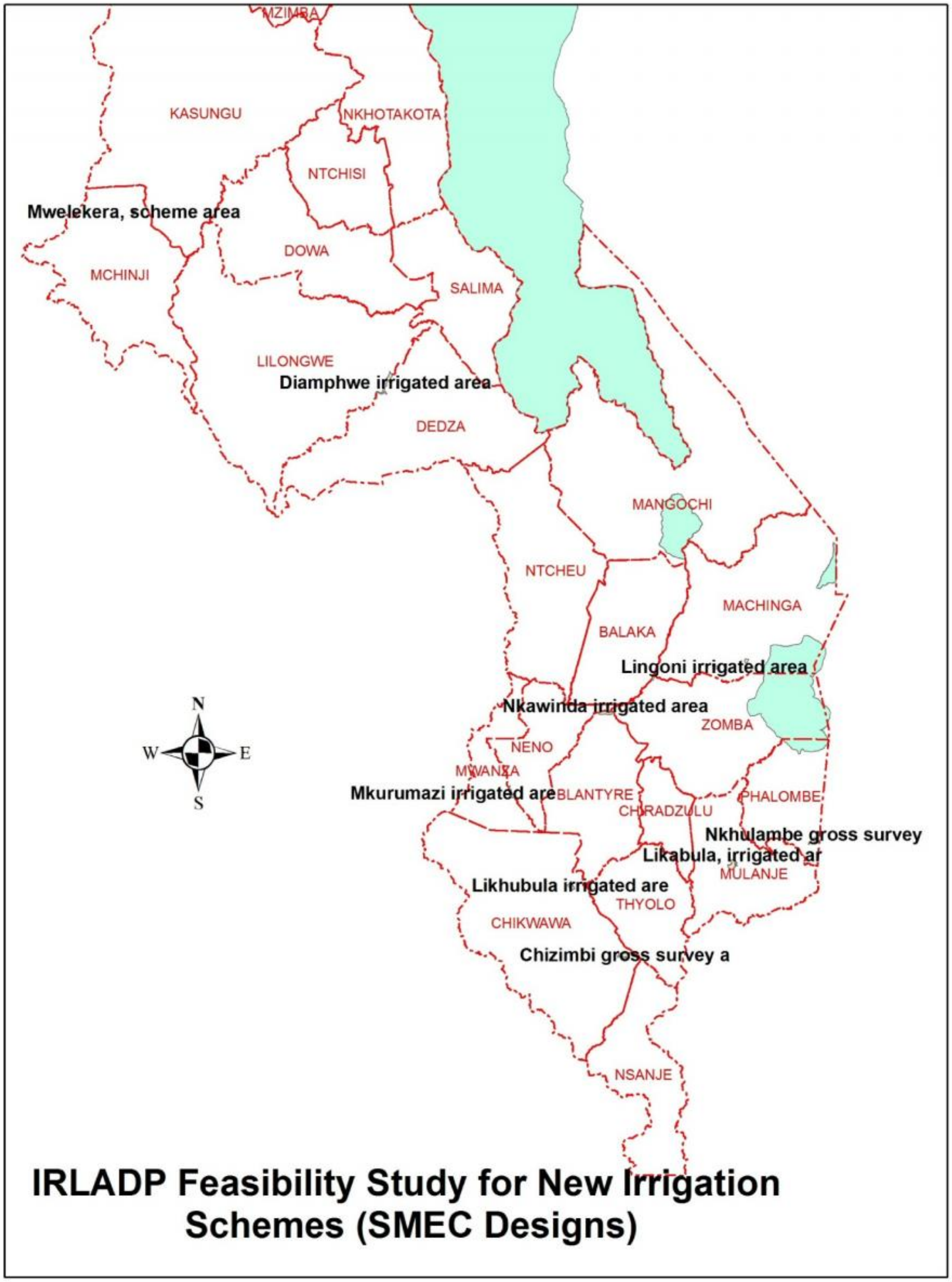


Figure 37: Location of IRLADP New Schemes

6.2.4 SMEC (water supply)

Four towns, Kasungu, Mponela, Mwanza and Chiradzulu had studies performed[12] for assessment of water supplies, with the added view to providing water for irrigation if excess was found. Storage dams were identified, with additional water available for most sites, see Table 38.

Table 38: Water Supply Sites and Irrigation Potential

No	NAME OF DAM SCHEME	Dam Height(m)	Total Storage (Mm³)	Domestic Consumption (Mm³)	Beneficiaries of Domestic Water No.	Potential Irrigation Area (ha)	Quantity for Irrigation (Mm³)	Fish Ponds (m²)	Hydro-electric Power (GWH)
KASUNGU POTENTIAL SITES									
1	Bua River at Sese	11.2	584	17.71	284,336	22,980	214	500	5.49
2	Bua River at Sese (Low dam option)	8.1	141	17.71	284,336	10,500	98	500	3.2
3	Dwangwa River at Kwengwale Vg	22.2	210	16.72	257,916	11,500	107	500	2.38
4	Dwangwa River at Lingadzi River confluence	19.4	201	17	265,377	11,300	105	500	1.6
MPONELA POTENTIAL SITES									
1	Kasangadzi River at Kanyungwi confluence	20.4	22	8.4	130,799	780	7.26	500	0.23
2	Mtiti River at Mwancheka confluence	14.9	12	8.7	144,093	305	2.84	500	0.12
MWANZA POTENTIAL SITES									
1	Mwanza at old Custom Post	38	45	8.3	132,589	1,710	15.9	500	3.9
2	Dwalibamba River at Mtoso Village	35.2	28	9	147,583	1,600	14.9	500	2.89
3	Nkulumadzi at Dwalibamba River Confluence	60.5	75	8.6	138,267	7,100	66.1	500	9.68
CHIRADZULU POTENTIAL SITES									
1	Mombezi at Mithiko Village	17.7	10	2.32	40954	140	4	500	0.43
2	Mwanje River at Mchema village	13.3	6	2.66	48468	175	2	500	0.18

12

6.2.5 IRLADP

Table 39: IRLAP Schemes

No	Scheme Name	Area (ha)	Beneficiaries/Farmers			District	EPA	River
			Male	Female	Total			
1	Domasi	500	1,255	781	2,036	Machinga	Domasi	River
2	Miyombo	10	20	23	43	Karonga	Kaporo	Motorized Pump
3	Chonanga	70	85	50	135	Karonga	Vinthukutu	Chonanga
4	Nkhwisa	210	155	212	367	Balaka	Mpirisi	Muthe
5	Kaombe	100	137	150	287	Nkhota Kota	Mphonde	Motorized Pump
Total		890			2,868			

6.2.6 Green Belt Initiative

The overall goal for GBI is the creation of wealth through increased agricultural production and productivity, enterprise development and increased exports. The specific objectives of the GBI are to: Increase production and productivity of crops, livestock and fisheries: Increased access to social infrastructure and support services; Increase agricultural exports and foreign exchange earnings; Promote diversification of crop and livestock enterprises; Increase household incomes; Improve value chain linkages and operations; Increase private sector participation in agricultural production; Add value through processing of raw materials; Reduce rural-urban migration; and Improve people's access to water for various uses.

The GBI will have seven major components: Crops, Livestock and Fisheries Development, Infrastructure Development and Rehabilitation; Land Administration; Environmental Management; Technology Development and Dissemination; Institutional Development and Capacity Building; and Agro-Processing and Marketing Development.

The programme is expected to achieve the following outputs: increased area under sustainable irrigation farming using the available abundant water resources in the country from 90, 000 ha to 1,000, 000 ha; increased productivity of crops (from the current 25% to 50%), livestock and fisheries; increased agricultural exports and foreign exchange earnings; increased crop, livestock and fisheries diversification; improved value chain linkages and operations; increased private sector participation in agricultural production; improved access to social infrastructure and support services; increased smallholder income levels and employment opportunities; improved access to water for various uses; and Existing rural growth centres rehabilitated and new ones established.

The IMP has found that the recommended PIA is limited by water resources, and is estimated at 460,000 ha, out of which 297,000 ha is a possible physical achievement.

Of the overall conception of schemes and location, the IMP has found much of an overlap, indicating that the GBI was on track in their focus, see Figure 38 GBI Conceptual Scheme Locations.

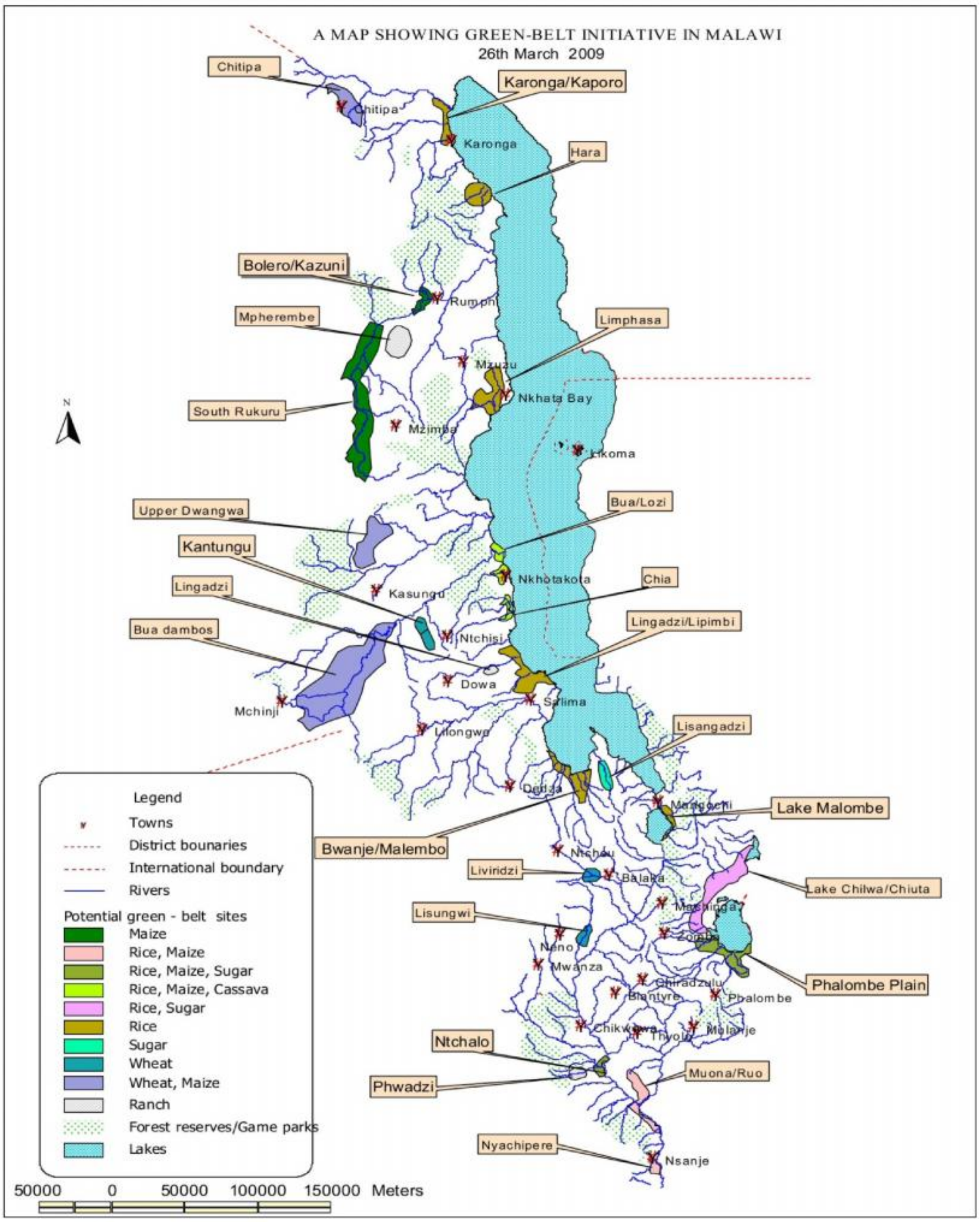


Figure 38: GBI Conceptual Scheme Locations

Due to restrictions on financing however, there are four GBI schemes that have made it through to investigation, with one reaching advanced stages of planning; One in Karonga, Salima, Mangochi and in Chikhwawa, see Figure 39 GBI Identified Scheme Locations.

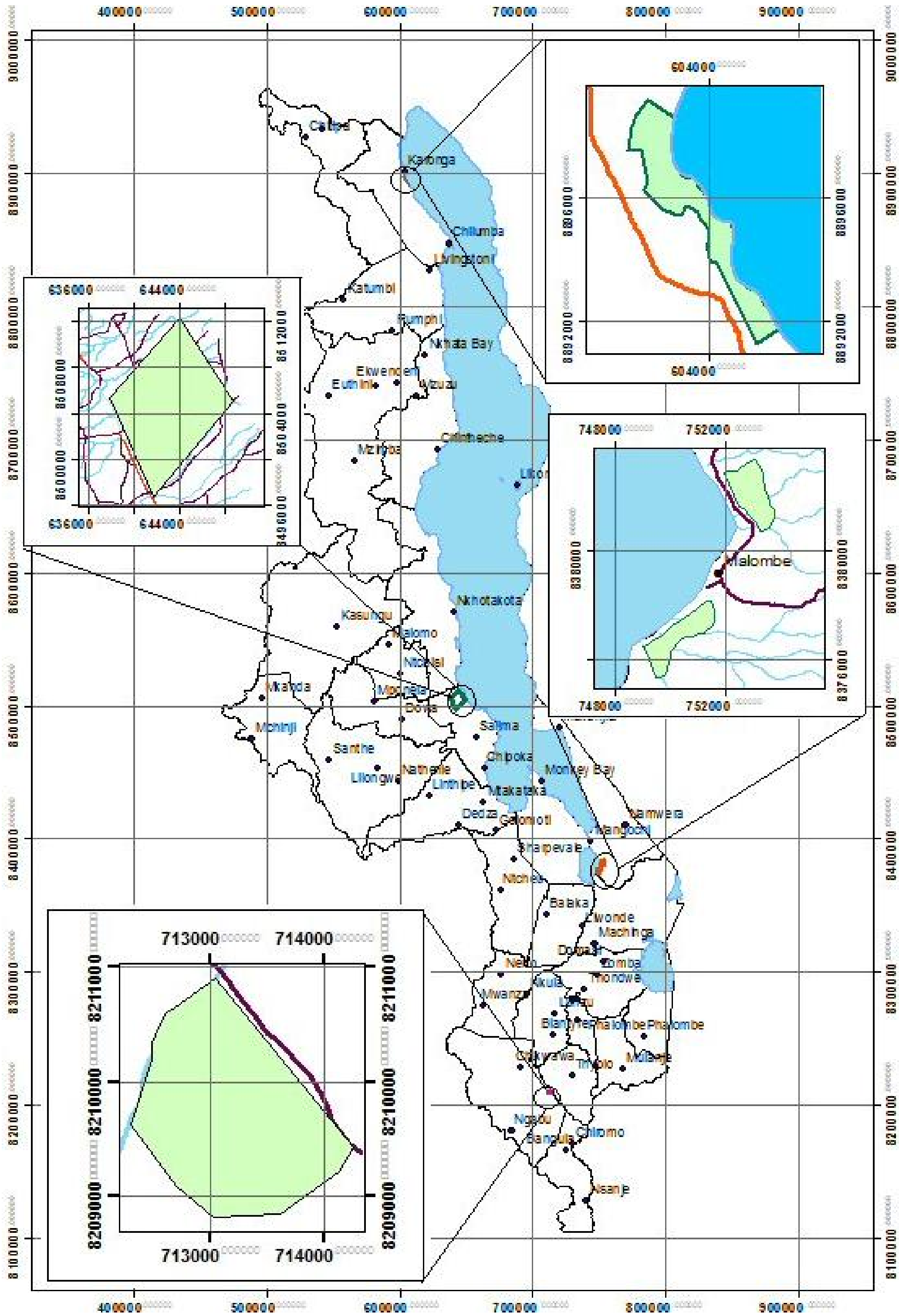


Figure 39: GBI Identified Scheme Locations

Karonga GBI Scheme

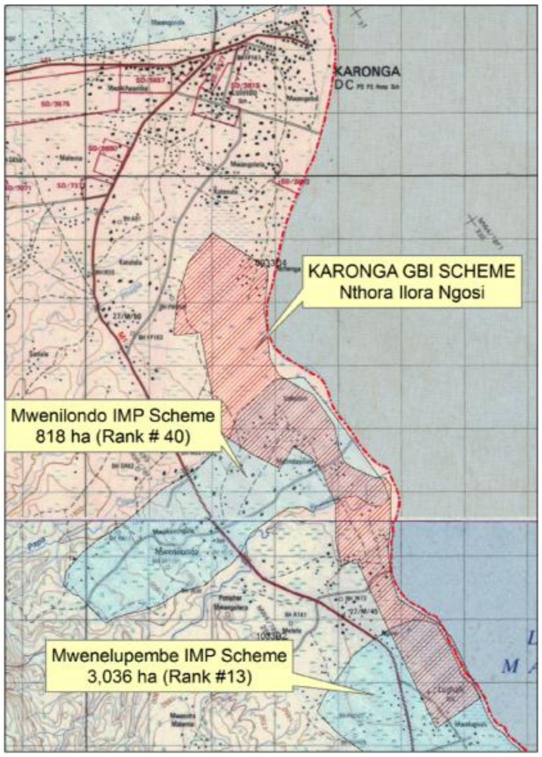


Figure 40: Karonga GBI Scheme Location

This scheme covers 778 ha just south of Karonga town, see Figure 40. This scheme is intended to be a pumped scheme. In the IMP, only high value crops are considered suitable for pumping. However, there are two IMP schemes that cover much of the intended area, and these schemes are gravity fed from storage dams. There is Mwenilondo scheme, for 818 ha, and ranked #40 in the overall assessment, with an EIRR of 23%. In the south there is Mwenelupembe scheme, which covers 3,036 ha and ranked #13 in the assessment, with an EIRR of 28%. This second scheme could be extended to cover most of the intended GBI scheme, and allow a greater range of crops to be grown.

This scheme has had baseline and map surveying completed.

Mangochi GBI Schemes

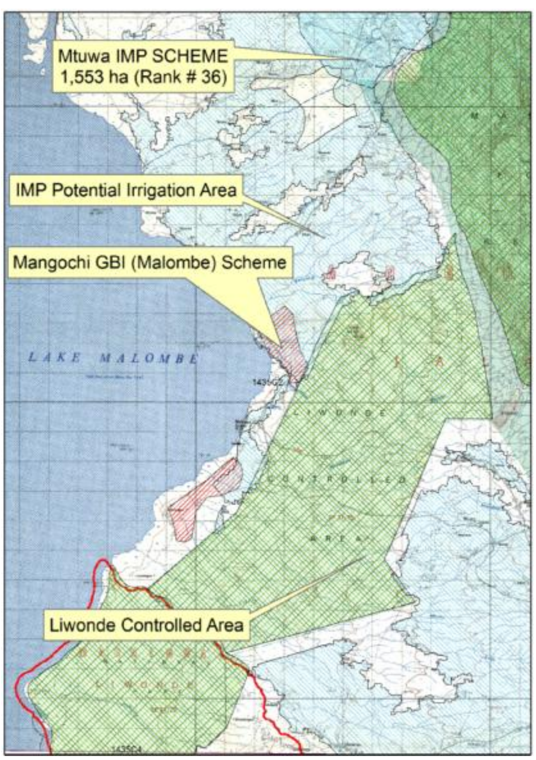


Figure 41: Mangochi GBI Scheme

The Mangochi schemes are located on the east side of Lake Malombe, sambwiched between the lake and the protected area. There areas are also intended to be pumped schemes, see Figure 41.

This scheme has had baseline and map surveying completed.

There is an IMP scheme Mtuwa close by for 1,553 ha, ranked No. 36, with an EIRR of 13%.

Chikhwawa GBI Chilongo Scheme

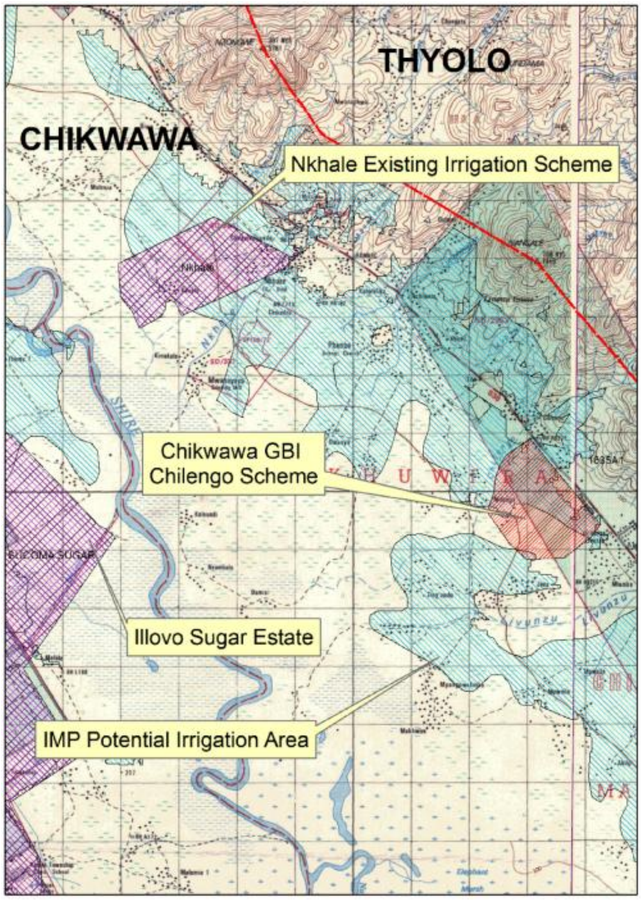


Figure 42: Chikhwawa GBI Scheme

Located between the foothills of Thyolo district and the Shire River is the Chilengo Scheme. This is close to the existing Nkhale scheme, and not far from Illovo Sugar Estate, see Figure 42.

This scheme has had baseline and map surveying completed.

Salima GBI: Chikwawa Sugar Scheme

The scheme has undergone a lot of development, as far as identifying potential investers. Key features of this scheme is that it is an estate type enterprise with sugar as the main crop and a processing plant of about 1,250 t-cane /d. It is envisaged to include 530 ha of centre pivots for smallholders, 1,000 ha for medium scale farmers. The other feature is that the core estate land will be owned by the GOM, with the operator having a management contract for 50 years, reviewed every 24 years. This arrangement is intended to maintain control of the land in the hands of the GOM, but still give the investor enough incentive to invest in the long term. Also the issues of land tenure are reduced with this arrangement. There is an extension area of about 6,500 ha.

This scheme is shown in Figure 43.

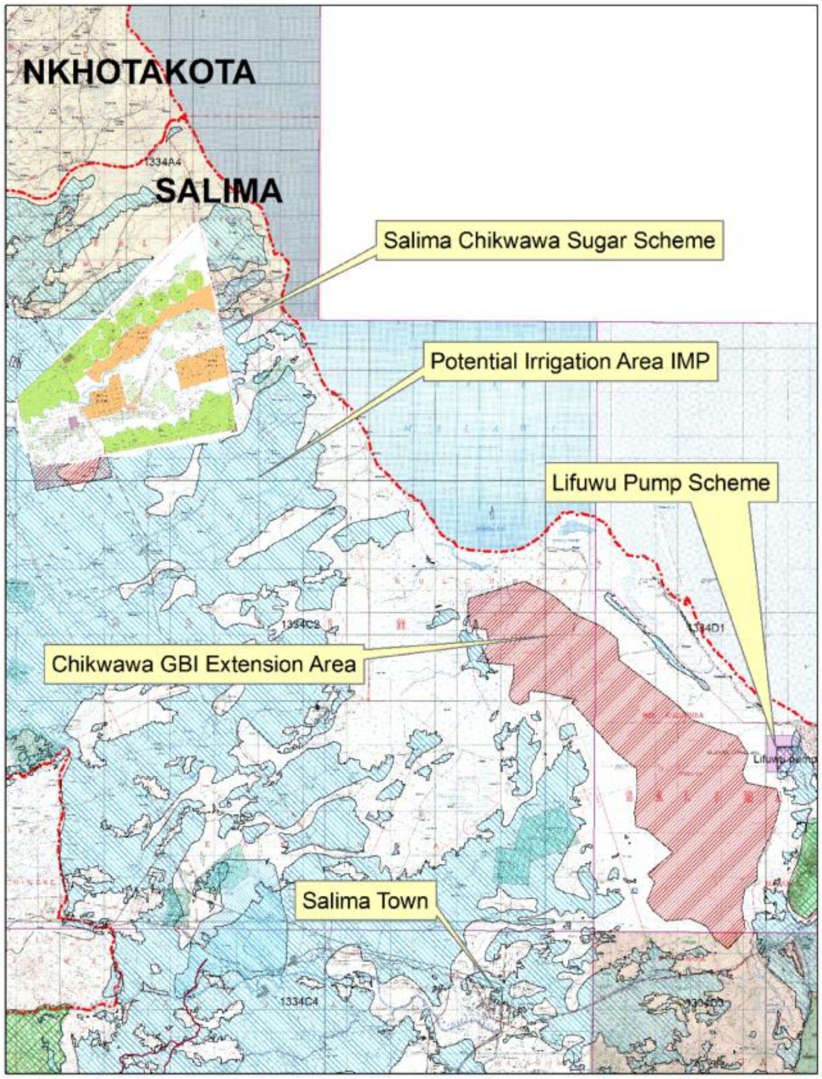


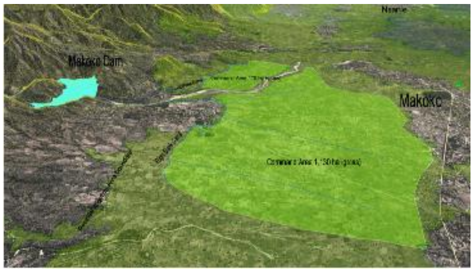
Figure 43 : Salima GBI CHikwawa Sugar Scheme

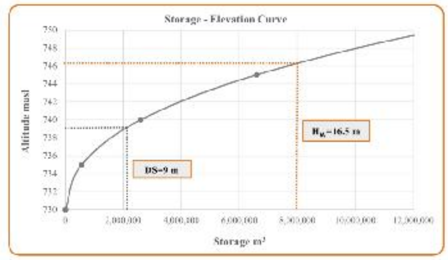
6.3 Potential Irrigation Schemes (New PIS)

6.3.1 Scheme Identification Process

Malawi has 41,387 km^2 of potential irrigable land (PIA_{phy}) but there is only enough water to irrigate 4,643 km^2 or 11.2%. Also the monthly distribution, after taking into account the EFR, means that for most of the country, storage will be required to provide irrigation water in the dry season.

The purpose of a Master Plan is to point the way forward and identify locations for developing as much of this 4,643 km^2 as possible. Having identified potential schemes, a prioritization is required to select the best schemes first. A ranking process has been developed using MCDA method and a system of score-cards to select the best schemes. Over a hundred potential sites for irrigation have been considered, with many not making it to the pre-feasibility stage. This has been done using GIS methods, with 5.0 m contours, satellite images and 3-D software to assist in locating suitable sites for water storage and river diversion. The basic process for development of the pre-feasibility schemes is as follows, (with full details given in APPENDIX 6: IRRIGATION DESIGN):





1.Locate site on 3-D image	2.Collect storage contours and determine storage—elevation curves

Soil Loss	% A	Value	Soil loss	$m^3/km^2/year$
No erosion	8%	15	1.2	0 - 30 (No erosion)
Slight	35%	166	57.925	31 - 300 (slight)
Slight to moderate	2%	426	8.51	301 - 550 (slight to moderate)
Moderate	55%	1026	564.025	551 - 1500 (moderate)
Moderate to severe	0%	1951		1501 - 2400 (moderate to severe)
Severe		3520		2401 - 4639 (severe)
	100%		631.66	

3.Determine catchment area in km²	4.From soil loss map, determine volume of sediment over 30 year life

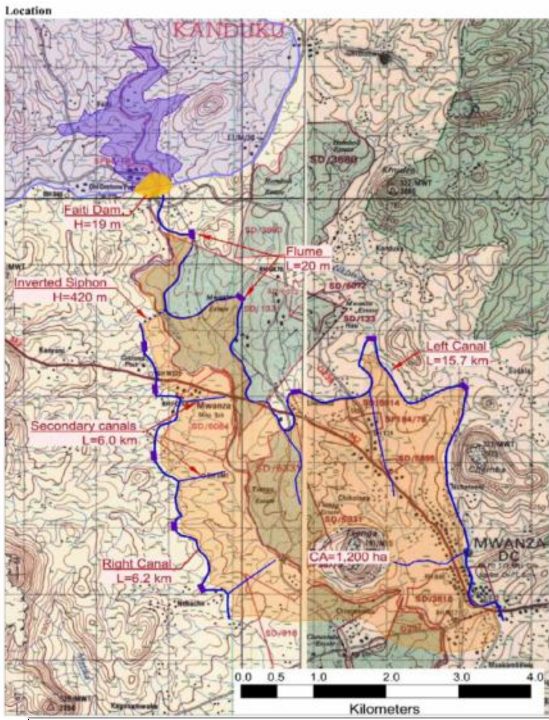
11.12 Shire at Chikwawa

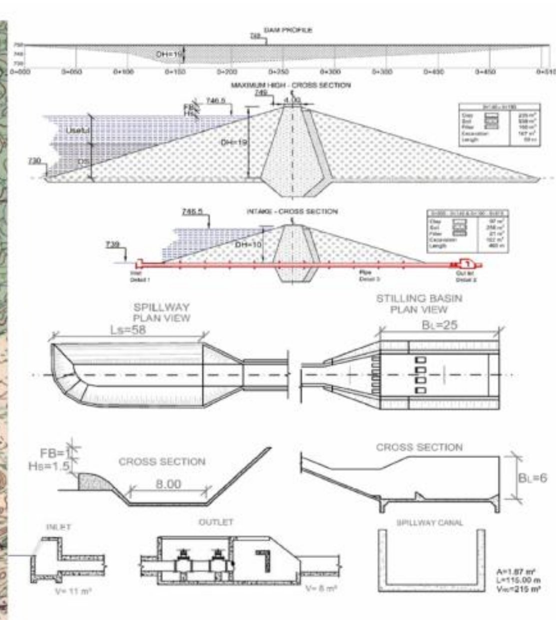
Faiti	Jan 31	Feb 28	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31	Nov 30	Dec 31
q_{80} l/s/km²	3.05	2.95	3.34	2.98	2.67	3.13	1.91	2.03	2.14	1.82	2.18	2.42
q_m l/s/km²	3.88	4.42	4.88	4.61	4.58	4.45	3.85	3.50	3.33	3.11	3.08	3.35
Q_{80} l/s	263	254	288	257	230	270	165	175	184	157	188	209
EFR l/s	34	34	34	34	34	34	34	34	34	34	34	34
Supply Q_{80} l/s	229	220	254	223	197	236	131	141	150	123	154	175
Supply V_{80} m³	613,046	533,128	681,291	577,336	526,607	611,344	350,391	377,792	389,870	329,064	400,428	469,030
											Useful volume (m³)	5,859,027
											Total Volume (Dead+Useful) (m³)	7,916,061

5.From catchment hydrological data, determine the monthly available water, after deducting the EFR	6.Available water for irrigation is run-off volume minus sediment volume

Cropping Pattern	Wet Season				Dry Season						Wet Season	
Maize WS				H							P	
Maize DS					P				H			
Rice WS				H							P	
Rice DS					P					H		
Cotton WS					H						P	
Groundnuts WS				H							P	
Groundnuts DS					P					H		
Vegetables DS						P				H		
Water Req. (m³/ha)	460.9	801.1	1,383.2	968.6	533.0	365.9	621.6	1,281.1	1,761.1	1,101.8	185.3	453.2
											Annual Water Req. (m³/ha)	9,917
											Potential Irrigation Area (ha)	591

7.From cropping pattern, determine the annual CWR, m³/ha/y	8.Determine the irrigable area from available water divided by CWR





9.Layout potential canals and irrigable area	10.Obtain costs from dam design, spillway design, canal size and structures

Description	Cost (USD)
General Facilities	198,363
Dam Construction	1,784,951
Main Canals	1,102,990
Secondary Canals	970,266
Special Infrastructure	51,062
Diversion weir	422,878
Contingency	679,577
Total Cost (USD)	**5,210,087**

Cost USD/ha **1,914**

11.Compute the unit cost in US$/ha, and the EIRR from crop margins and cost	12.Obtain ranking parameters and prioritise schemes.

Table 40: Complete List of Identified Schemes (part 1)

N°	Scheme Name	District	Coordinates		Agroclimatic	PIA	Export Crops	Soil Loss	Accessibility	Main Town Dist.	Road	Invest. Cost	Cost per ha	EIRR
			X	Y	Region	ha	%	m^3/year	to the Site	km	Type	USD	USD/ha	%
3	Kalembo	Balaka	729,152	8,358,956	Lowland	803	24%	43,584	Poor Access	37.9	Dirt	7,702,138	9,588	7.8
2	Mdenga	Balaka	733,136	8,347,555	Lowland	294	24%	14,332	Vehicle	37.0	Dirt	2,119,286	7,217	11.5
1	Naliswe	Balaka	728,672	8,337,325	Lowland	218	24%	11,476	Vehicle	7.0	Asphalt	2,446,590	11,223	5.9
5	Mpumbe	Blantyre	726,629	8,269,629	Lowland	438	24%	21,436	Poor Access	10.0	No Road	7,334,878	16,756	1.0
4	Nkalazi	Blantyre	690,910	8,254,610	Lowland	396	24%	280	Poor Access	60.4	No Road	4,104,682	10,360	6.9
6	Wilson	Blantyre	702,631	8,284,989	Lowland	2,602	24%	210,207	Poor Access	15.1	No Road	14,711,599	5,653	14.7
7	Chang'ambika	Chikwawa	639,672	8,252,287	Lowland	102	24%	2,166	Poor Access	45.1	No Road	1,725,222	16,914	0.8
8	Kunyondo	Chikwawa	649,219	8,253,742	Lowland	469	24%	62,961	Poor Access	22.7	No Road	4,278,753	9,125	8.5
9	Navaya	Chikwawa	645,784	8,243,328	Lowland	1,260	24%	96,793	Poor Access	36.4	Dirt	4,711,263	3,741	20.4
10	Nazombe	Chiladzulu/Zomba	739,784	8,274,178	Lowland	651	24%	20,772	No Access	19.5	No Road	4,547,771	6,987	11.0
12	Kadewere	Chiradzulu	740,567	8,262,561	Lowland	415	24%	14,978	Vehicle	23.6	Dirt	3,232,311	7,788	10.5
11	Masamba	Chiradzulu	733,855	8,259,487	Lowland	262	24%	8,963	Fair Access	16.4	Dirt	2,881,901	10,986	6.1
13	Mtambosimama	Chiradzulu/Zomba	728,652	8,281,479	Lowland	163	24%	8,274	Fair Access	30.8	Dirt	3,835,931	23,469	-3.2
19	Ilengo	Chitipa	513,232	8,944,631	Lowland	3,254	24%	83,157	Fair Access	30.0	Dirt	13,006,491	3,997	19.5
18	Kamanga	Chitipa	542,201	8,922,987	Lowland	1,405	24%	25,785	Poor Access	17.9	Dirt	16,590,852	11,806	5.2
17	Kenan	Chitipa	502,216	8,954,715	Lowland	1,150	24%	17,062	Vehicle	40.7	Dirt	10,902,164	9,476	8.0
86	Mafinga Hill	Chitipa	542,557	8,897,363	Lowland	43	24%	10,358	Vehicle	38.8	Dirt	244,307	5,682	14.7
15	Marko	Chitipa	542,409	8,936,773	Lowland	465	24%	151,054	Vehicle	21.0	Dirt	2,407,218	5,177	18.8
14	Mbalizi	Chitipa	548,002	8,900,175	Lowland	416	24%	69,911	Poor Access	34.8	No Road	6,262,506	15,041	2.3
16	Namasasa	Chitipa	533,308	8,925,275	Lowland	885	24%	15,916	Fair Access	7.5	Dirt	7,140,897	8,071	10.0
20	Namano	Dedza	653,805	8,422,498	Lowland	1,886	24%	60,875	Poor Access	17.6	No Road	8,266,164	4,384	18.0
76	Chaseta	Dedza/Salima	648,046	8,453,325	Plateau	435	38%	189,239	Vehicle	24.0	Dirt	13798125	31,729	-9.5
21	Kholongo	Dowa	567,135	8,528,703	Plateau	3,579	38%	319,857	Fair Access	2.0	Dirt	20,588,176	5,753	12.1
22	Ngulula	Dowa	595,001	8,479,742	Plateau	426	38%	10,587	Fair Access	13.2	No Road	6,176,478	14,484	0.9
26	Kasano	Karonga	590,900	8,901,970	Lakeshore	233	12%	48,118	Vehicle	30.1	Gravel	947,548	4,067	22.4
25	Kasimba	Karonga	605,830	8,876,970	Lakeshore	253	12%	2,426	Fair Access	35.0	Dirt	2,228,721	8,808	11.2
23	Mwaipungu	Karonga	599,865	8,887,466	Lakeshore	183	12%	1,815	Poor Access	30.7	No Road	2,399,221	13,094	5.9
24	Mwawembe	Karonga	593,215	8,895,152	Lakeshore	222	12%	4,482	No Access	16.9	No Road	5,545,641	25,023	-2.8
30	Mwenelupembe	Karonga	603,400	8,882,865	Lakeshore	3,036	12%	61,107	No Access	32.2	No Road	7,316,085	2,409	30.4
27	Mwenilondo	Karonga	597,580	8,891,599	Lakeshore	818	12%	19,931	No Access	23.0	No Road	2,964,865	3,623	24.2
28	Ngemela	Karonga	586,000	8,902,270	Lakeshore	2,278	12%	861,320	No Access	20.3	No Road	18,512,117	8,126	12.3
31	Ukanga	Karonga	617,578	8,860,728	Lakeshore	5,765	12%	462,631	Fair Access	15.0	No Road	13,675,680	2,372	30.7
29	Welusi	Karonga	609,500	8,871,660	Lakeshore	2,722	12%	98,539	Fair Access	41.7	Dirt	5,210,087	1,914	33.8
32	Kwilasya	Machinga	753,388	8,328,589	Lakeshore	349	12%	54,752	Poor Access	17.8	No Road	9,083,903	26,028	-2.7
35	Mtuwa	Mangochi	759,758	8,396,292	Lakeshore	1,553	12%	68,138	Fair Access	16.2	Dirt	12,536,009	8,071	12.4
34	Ngaka	Mangochi	731,890	8,396,863	Lakeshore	561	12%	88,625	Poor Access	13.0	No Road	6,023,632	10,737	8.5
33	Pangani	Mangochi	792,264	8,373,741	Lowland	344	24%	8,689	Poor Access	21.7	No Road	7,356,946	21,417	-2.1

Table 41: Complete List of Identified Schemes (part 2)

N°	Scheme Name	District	Coordinates		Agroclimatic	PIA	Export Crops	Soil Loss	Accessibility	Main Town Dist.	Road	Invest. Cost	Cost per ha	EIRR
			X	Y	Region	ha	%	m^3/year	to the Site	km	Type	USD	USD/ha	%
37	Lichenya	Mulanje	771,329	8,220,289	Lowland	1,249	24%	22,431	Fair Access	11.0	Dirt	7,618,786	6,099	13.7
36	Namputa	Mulanje	763,138	8,223,873	Lowland	610	24%	13,269	Vehicle	9.0	Gravel	6,527,960	10,696	6.5
38	Nthiramanja	Mulanje	747,636	8,225,221	Lowland	6,381	24%	457,464	Vehicle	7.0	Asphalt	22,419,433	3,514	21.3
42	Faiti	Mwanza	658,835	8,280,165	Lowland	610	24%	68,568	Fair Access	10.0	Dirt	5,672,347	9,301	8.2
40	Kagonamwake	Mwanza	657,288	8,271,438	Lowland	109	24%	10,263	Vehicle	6.6	Dirt	3,739,206	34,318	-8.5
41	Mkhanamphere	Mwanza	669,402	8,261,353	Lowland	186	24%	9,436	Poor Access	24.1	Dirt	5,109,886	27,461	-5.3
39	Nguleta	Mwanza	659,058	8,259,796	Lowland	69	24%	11,749	Vehicle	19.9	Dirt	1,609,203	23,209	-3.1
43	Nteka	Mwanza	667,379	8,266,493	Lowland	132	24%	12,703	No Access	16.0	No Road	3,999,601	30,393	-6.7
44	Tsingulani	Mwanza/Chikwawa	648,904	8,258,440	Lowland	208	24%	24,207	Fair Access	25	Dirt	3,752,577	18,025	0.1
45	Zidala	Mwanza/Neno	668,796	8,283,004	Lowland	1,041	24%	281,701	Fair Access	23.2	Dirt	7,056,673	6,779	12.3
48	Bwanamudoko	Mzimba	572898	8,610,489	Lowland	1,014	24%	243,216	Fair Access	27.0	Dirt	9060786	8,935	8.7
46	Lupenga	Mzimba	567,180	8,601,465	Lowland	404	24%	40,100	Fair Access	17.5	Dirt	3,713,768	9,187	8.4
47	Perete Phiri	Mzimba	570,428	8,608,682	Lowland	729	24%	125,036	Fair Access	21.5	Dirt	6,659,570	9,133	8.4
54	Chindevu	Nkhata bay	616,833	8,717,828	Lakeshore	1,809	12%	73,972	Fair Access	27.0	No Road	13,437,242	7,428	13.5
57	Linga	Nkhata bay	615,102	8,681,841	Lakeshore	2,434	12%	93,917	Vehicle	6.1	Dirt	5,759,625	2,366	30.7
49	Lizunkhuni	Nkhata bay	623,634	8,771,911	Lakeshore	106	12%	14,156	No Access	42.0	No Road	1,777,352	16,843	2.8
50	Mpamba	Nkhata bay	629,376	8,723,163	Lakeshore	1,266	12%	23,494	Vehicle	16.5	Asphalt	6,137,338	4,848	19.8
53	Msenga	Nkhata bay	612,969	8,706,024	Lakeshore	1,964	12%	867,845	Vehicle	33.7	Dirt	5,023,943	2,558	29.5
52	Mteperera	Nkhata bay	637,098	8,709,289	Lakeshore	1,658	12%	67,536	Fair Access	11.8	Dirt	11,725,870	7,071	14.2
55	Mwambazi	Nkhata bay	629,780	8,728,832	Lakeshore	2,261	12%	165,437	Vehicle	40.0	Dirt	12,196,968	5,394	18.2
56	Ngazi	Nkhata bay	622,556	8,700,862	Lakeshore	2,946	12%	1,774,903	Poor Access	15.3	Dirt	5,090,657	1,728	35.3
51	Dwambazi	Nkhata bay/Nkhotakot	604,774	8,648,254	Plateau	4,256	38%	846,207	Fair Access	20.1	Gravel	6,638,299	1,560	28.4
58	Msindwa	Nkhotakota	621,575	8,600,157	Lakeshore	462	12%	95,984	No Access	24.8	No Road	4,757,603	10,298	9.1
62	Chididi	Nsanje	736,864	8,130,191	Lowland	312	24%	24,534	Poor Access	47.9	No Road	10,616,498	34,022	-8.3
64	Kanjedza	Nsanje	697,070	8,230,250	Lowland	583	24%	159,668	Fair Access	14.6	Dirt	6,475,660	11,109	6.0
63	Makoko	Nsanje	730,972	8,116,910	Lowland	579	24%	43,532	Fair Access	16.7	Dirt	8,731,578	15,088	2.2
61	Mankhokwe	Nsanje	727,615	8,111,005	Lowland	143	24%	9,567	Fair Access	29.2	Dirt	1,863,813	12,990	4.1
60	Nsabwe	Nsanje	737,668	8,189,019	Lowland	116	24%	15,309	Poor Access	35.0	No Road	3,324,811	28,689	-5.9
65	Nyathana	Nsanje	719,100	8,159,130	Lowland	739	24%	52,433	Vehicle	13.6	Dirt	8,125,073	10,994	6.1
66	Kuyenda	Ntcheu	694,300	8,350,968	Lowland	127	24%	6,791	Vehicle	25.0	Dirt	4,248,146	33,350	-8.0
67	Lembani	Ntcheu	687,960	8,288,921	Lowland	190	24%	49,251	Vehicle	48.5	Dirt	443,187	2,328	30.9
68	Lisungwi	Ntcheu	693,330	8,317,823	Lowland	333	24%	42,441	Fair Access	12.0	Dirt	5,519,451	16,570	1.1
69	Matsimbe	Ntcheu	684,588	8,353,441	Lowland	481	24%	38,066	Vehicle	13.0	Asphalt	5,978,319	12,440	4.6
70	Tsikulamowa	Ntcheu	694,552	8,341,523	Lowland	700	24%	30,836	Vehicle	15.1	Dirt	12,918,757	18,456	-0.2

Table 42: Complete List of Identified Schemes (part 3)

N°	Scheme Name	District	Coordinates X	Coordinates Y	Agroclimatic Region	PIA ha	Export Crops %	Soil Loss m^3/year	Accessibility to the Site	Main Town Dist. km	Road Type	Invest. Cost USD	Cost per ha USD/ha	EIRR %
71	Chipofya Diversion	Rumphi	581,795	8,800,095	Lowland	686	24%	297,111	Vehicle	26.0	Dirt	2,004,275	2,922	27.5
73	Chisimika	Rumphi	563,757	8,809,541	Lowland	597	24%	23,316	Vehicle	32.0	Dirt	12,429,504	20,805	-1.7
74	Katuwa	Rumphi	569,459	8,795,126	Lowland	1,242	24%	55,389	Fair Access	7.3	Dirt	11,286,091	9,088	8.5
75	Mnyongani	Rumphi	601,418	8,790,487	Lowland	1,686	24%	88,551	Vehicle	14.5	Dirt	16,332,606	9,689	7.7
72	Zyalunga	Rumphi	589,870	8,786,114	Lowland	558	24%	11,104	Vehicle	8.9	Dirt	9,074,372	16,267	1.3
77	Mphinzi	Salima	638,697	8,467,879	Lowland	1,911	24%	1,005,928	Vehicle	23.4	Dirt	19753464	10,338	6.9
78	Pisawene	Salima	637,791	8,476,016	Lowland	1,924	24%	1,209,087	Vehicle	25.1	Dirt	24107104	12,530	4.5
79	Ruo - Diversion	Thyolo/Nsanje	743,653	8,194,506	Lowland	8,858	24%	1,151,057	Fair Access	39.3	Dirt	16,810,549	1,898	34.0
81	Dzaone	Zomba	745,595	8,283,476	Lowland	331	24%	32,518	Fair Access	23.8	Dirt	5,361,047	16,209	1.4
85	Kanache	Zomba	754,193	8,309,240	Lowland	208	24%	23,561	Vehicle	15.0	Dirt	8,732,683	41,984	-12.0
83	Kazembe	Zomba	729,102	8,302,615	Lowland	712	24%	62,682	Poor Access	28.7	No Road	16,587,733	23,299	-3.1
80	Makhaula	Zomba	746,712	8,274,549	Lowland	297	24%	9,086	Fair Access	33.0	Dirt	5,237,990	17,629	0.3
84	Makwangwala	Zomba	732,150	8,308,173	Lowland	2,048	24%	266,224	Poor Access	41.0	Dirt	11,624,335	5,675	14.7
82	Maole	Zomba	753,865	8,295,413	Lowland	461	24%	50,627	Fair Access	10.1	Dirt	6,214,916	13,473	3.6
IRLADP	Chanyungu Mposa	Machinga	770,866	8,323,994	Plateau	126	38%	2,189	Fair Access	40.0	Asphalt	1,170,000	9,286	6.1
IRLADP	Chizimbi	Chikwawa	722,512	8,199,751	Lowland	306	24%	3,496	Fair Access	38.0	Gravel	1,979,000	6,467	15.5
IRLADP	Diamphwe	Lilongwe/Dedza	614,397	8,436,275	Plateau	1000	38%	329,471	Fair Access	18.0	Asphalt	8,380,000	8,380	7.5
IRLADP	Likabula/Kholiwe	Mulanje	767,462	8,236,271	Plateau	628	38%	1,197	Fair Access	20.5	Asphalt	3,947,000	6,285	11.0
IRLADP	Likhubula/Nthumbula	Chikwawa	697,079	8,230,138	Lowland	419	24%	386,173	Fair Access	5.0	Asphalt	3,410,000	8,138	12.3
IRLADP	Lingoni	Machinga	759,198	8,231,946	Plateau	246	38%	12,373	Fair Access	25.8	Gravel	1,830,000	7,439	8.9
IRLADP	Matoponi	Zomba	723,473	8,306,804	Plateau	115	38%	0	Poor Access	46.0	Gravel	590,000	5,130	13.6
IRLADP	Mkulumadzi	Mwanza/Neno	670,194	8,270,109	Lowland	321	24%	517,203	Fair Access	11.7	Asphalt	3,070,000	9,564	10.1
IRLADP	Mlooka	Zomba	732,158	8,317,292	Plateau	153	38%	0	Fair Access	24.8	Asphalt	730,000	4,771	14.5
IRLADP	Mwelekera	Mchinji	510,534	8,513,952	Plateau	153	38%	91,231	Fair Access	21.8	Gravel	1,400,000	9,150	6.4
IRLADP	Nkawinda/Bakasala	Blantyre	713,837	8,301,871	Plateau	560	38%	0	Fair Access	56.0	Asphalt	790,000	1,411	29.5
IRLADP	Nkhulambe/Wowo	Phalombe	797,567	8,244,953	Plateau	300	38%	73	Poor Access	32.0	Gravel	1,444,000	4,813	14.4
RIDP	Bwanje Dam	Dedza	663,754	8,416,057	Lakeshore	800	12%	0	Fair Access	16.3	Asphalt	7,223,000	9,029	10.8
RIDP	Chilingali	Nkhotakota	639,400	8,575,700	Lakeshore	1200	12%	29,852	Fair Access	2.4	Asphalt	2,410,000	2,008	33.1
RIDP	Kamwanyoli	Nkhata Bay	631,266	8,716,264	Lakeshore	120	12%	26,475	Fair Access	6.8	Gravel	968,000	8,067	12.4
RIDP	Kawiya_Kadeti	Nkhata Bay	624,489	8,694,352	Lakeshore	55	12%	8,365	Fair Access	4.4	Asphalt	1,541,000	28,018	-3.6
RIDP	Lifidzi	Salima	652,747	8,457,703	Plateau	600	38%	186,787	Fair Access	19.1	Asphalt	6,200,000	10,333	4.9
RIDP	Lifuwu pump	Salima	671,000	8,488,000	Lakeshore	156	12%	0	Fair Access	27.4	Asphalt	1,875,000	12,019	7.0
RIDP	Mwamphanzi	Chikwawa	699,201	8,224,883	Lowland	355	24%	17,213	Fair Access	9.6	Asphalt	4,152,000	11,696	5.4
RIDP	Navikoko	Nkhotakota	637,311	8,530,933	Lakeshore	150	12%	132,148	Fair Access	5.7	Asphalt	1,596,000	10,640	8.6
RIDP	South Rukuru	Rumphi	598,525	8,780,015	Lowland	2900	24%	734,186	Fair Access	21.3	Asphalt	30,769,000	10,610	4.6
RIDP	Tchanga	Dedza	663,107	8,427,976	Lowland	154	24%	53,843	Fair Access	1.2	Gravel	1,366,000	8,870	8.8

A full list of these PIS is given in Table 41 with a summary in Table 43 and also located in

Figure 44.

A full set of detailed information of each scheme is given in the Appendix 1, Atlas of Maps.

A full description of the irrigation parameters used in the pre-feasibility designs is given in Appendix 6, Irrigation Design

Table 43: Summary of New PIS

	District	PIA (ha)	Cost (US$)	Unit Cost (US$/ha)
CENTRE	Dedza	5,464	28,952,622	5,299
	Dowa	426	6,176,478	14,484
	Ntcheu	1,831	29,107,860	15,894
	Salima	4,270	57,658,693	13,504
	Nkhotakota	462	4,757,603	10,298
	Sub Total	**12,454**	**126,653,257**	**10,170**
NORTH	Chitipa	7,619	56,554,437	7,423
	Karonga	15,511	58,799,965	3,791
	Mzimba	2,148	19,434,124	9,050
	Nkhata bay	18,700	67,787,293	3,625
	Rumphi	4,769	51,126,849	10,721
	Sub Total	**48,747**	**253,702,668**	**5,205**
SOUTH	Balaka	1,315	12,268,014	9,330
	Blantyre	3,436	26,151,159	7,610
	Chikwawa	1,830	10,715,238	5,854
	Chiradzulu	1,492	14,497,914	9,719
	Machinga	349	9,083,903	26,028
	Mangochi	2,458	25,916,587	10,545
	Mulanje	8,240	36,566,179	4,438
	Mwanza	2,355	30,939,494	13,138
	Nsanje	2,558	42,119,846	16,466
	Thyolo/Nsanje	8,858	16,810,549	1,898
	Zomba	4,057	53,758,704	13,250
	Sub Total	**36,948**	**278,827,587**	**7,546**
	Total	98,149	659,183,512	6,716

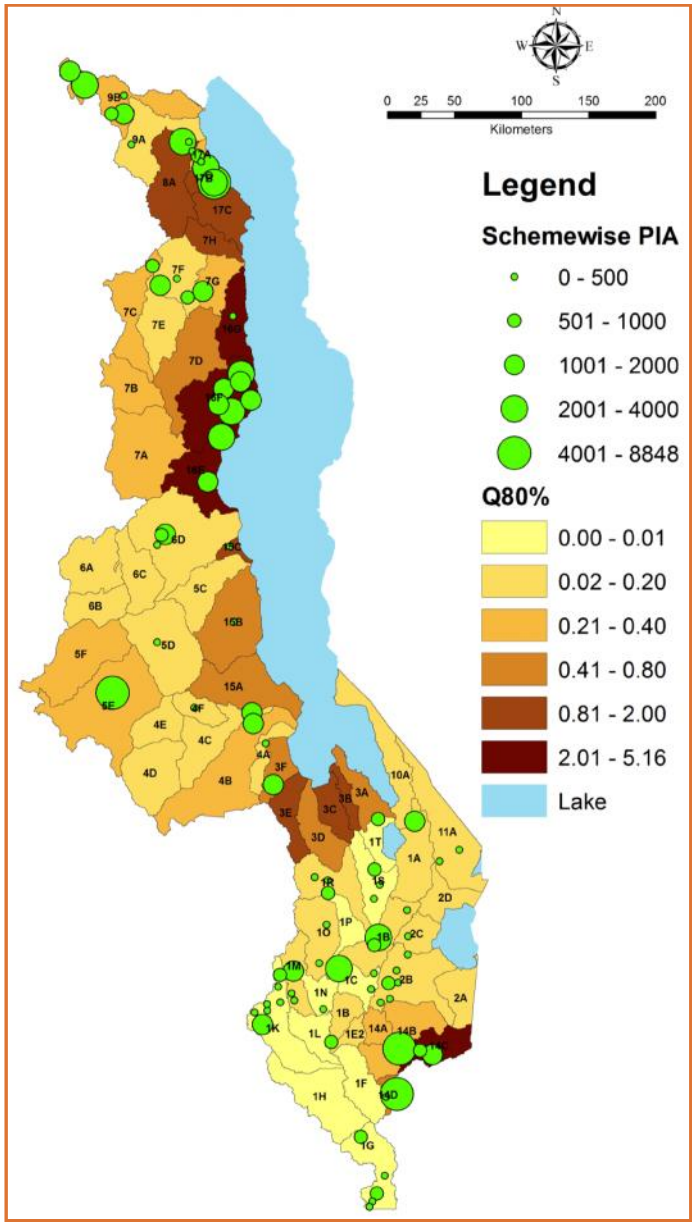


Figure 44: Location Map of New PIS

6.4 Economic Assessment and Ranking of Schemes

The 86 potential irrigation schemes for which pre-feasibility studies were undertaken were subject to economic assessment. The details are given in Appendix 10, Financial and Economic Analysis. Different financial and economic models were used for schemes in the lowlands, lakeshore and plateau because of the different crops and cropping patterns grown in these areas. The results of the economic assessment were used in the multi-attribute ranking analysis to select the preferred schemes in order of priority. The number, location and size of the schemes assessed is shown in Table 44.

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Table 44: Number, Location and Size of Schemes Subject Economic Assessment

Zone	No of Schemes	Gross Area (ha)	ha/scheme
Lowlands	61	56,572	927
Lakeshore	21	32,881	1,565
Plateau	4	8,696	2,174
Total	86	98,149	1,141

The economic assessment was undertaken using standard benefit-cost analysis methodology. The **investment costs** include: (i) estimated costs of irrigation infrastructure (hardware) based on the concept level designs shown in Appendix xx; (ii) an allowance of 20% of the hardware cost to finance feasibility studies, detailed design and supervision of construction; and (iii) an estimate of the soft investments (WUA formation and support, farmer training, extension, marketing etc.) required to achieve a satisfactory level of system performance based on the average ratio between hard and soft investments in irrigation schemes in Africa. **Recurrent costs** used in the analysis include the cost of O&M at 2.5% of the irrigation infrastructure cost, and on-farm cost of inputs and labour for crop production. **Benefits** include the farmgate value of agricultural production plus the value of produce used for subsistence consumption. All costs and benefits were estimated in financial prices initially and then converted to economic values using standard conversion factors for labour, traded and non-traded goods. The value of environmental and social benefits were not quantified in the analysis. The results are summarised in Table 45 below:

Table 45: Summary of Economic Analysis for 86 Schemes

	EIRR > 10%	EIRR < 10%	All Schemes
No of Schemes	51	35	86
Percent of schemes	59	41	100
Gross area (ha)	84,330	13,820	98,150
Percent of gross area	86	14	100
Gross area per scheme (ha)	1,653	395	1,141
Total investment ($million) a/	639	288	927
Total investment ($/ha)	$7,580	20,840	$9,440

a/ Including both hard and soft investments

Table 45 shows that 51 (59%) of the schemes assessed are expected to generate EIRRs >10%. However, because the better schemes also tend to be the larger ones (with some exceptions) these schemes account for 86% of the gross irrigated area. The schemes above 10% EIRR averaged 1,653 ha compared to those below 10% which averaged 395 ha. The average investment costs were estimated to be US$ 7,580/ha and US$ 20,840/ha for schemes above and below 10% EIRR respectively.

Table 45 divides the 51 schemes above 10% EIRR into five cohorts, and demonstrates that there are about 30 potential schemes expected to generate EIRRs of 14% or better. These have a total gross area of around 66,000 hectares representing an investment of some US$417 million.

Table 46: Summary of Economic Analysis for Schemes Ranked by EIRR

Scheme Ranking a/	Total Gross ha	Cumulative ha	$million Investment	Cumulative Investment	Investment $/ha	EIRR %	
						From	To
1-10	32,860	32,860	157	157	4,790	26.8	33.6
11-20	20,210	53,070	142	299	7,040	18.4	24.6
21-30	13,000	66,070	118	417	9,090	14.0	18.4
31-40	9,440	75,510	107	524	11,320	12.0	14.0
41-51	8,820	84,330	114	639	12,930	10.0	12.0
Total/average	84,330		639		7,580	10.0	33.6

a/ Based on EIRR, highest to lowest, including only schemes >10%

Figure 45 below shows the relationship between the investment cost per hectare and expected EIRR. If only hardware investments are considered schemes costing up to around US$13,000 per hectare can generate EIRRs of 10% or better. However to allow for the necessary soft investments, estimated to be around US$2,700/ha on average, the total hardware investment should not exceed around US$ 10,000 per hectare.

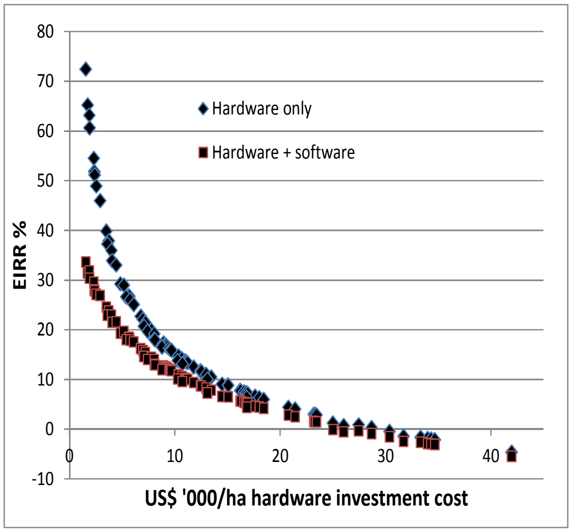


Figure 45: Investment Cost/ha vs EIRR

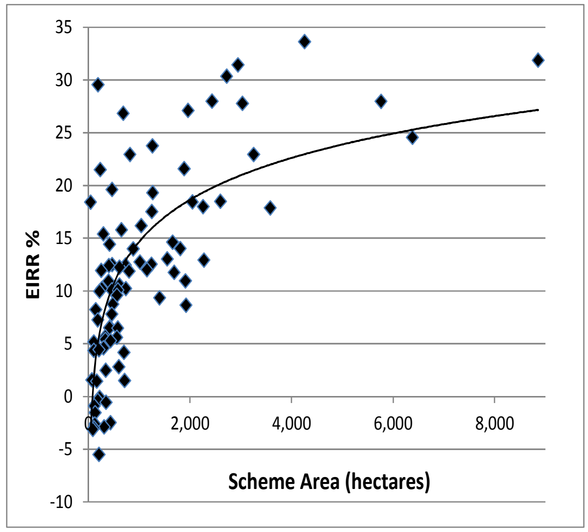


Figure 46: Scheme Area vs EIRR

Figure 46 shows that in general larger schemes tend to generate better economic returns than smaller ones. The best ten schemes ranked by EIRR average over 3,000 hectares each, whereas the bottom ten schemes average only 2,010 hectares.

Table 47: Summary of Top 30 Ranking Results

Criterion Description	District	Area (ha)	Capital Costs (US$)	Unit Cost (US$/Ha)	EIRR (%)	Rank #
Ruo - Diversion	Thyolo/Nsanje	8,858	16,810,549	1,898	34	1
Nkawinda/Bakasala	Blantyre	560	790,000	1,411	30	2
Chilingali	Nkhotakota	1,200	2,410,000	2,008	33	3
Dwambazi	Nkhata bay/Nkhotakota	4,256	6,638,299	1,560	28	4
Mlooka	Zomba	153	730,000	4,771	14	5
Nthiramanja	Mulanje	6,381	22,419,433	3,514	21	6
Matoponi	Zomba	115	590,000	5,130	14	7
Kasano	Karonga	233	947,548	4,067	22	8
Lembani	Ntcheu	190	443,187	2,328	31	9
Nkhulambe/Wowo	Phalombe	300	1,444,000	4,813	14	10
	Total	**22,246**	**53,223,015**	**2,392**	**24**	

Criterion Description	District	Area (ha)	Capital Costs (US$)	Unit Cost (US$/Ha)	EIRR (%)	Rank #
Chipofya Diversion	Rumphi	686	2,004,275	2,922	27	11
Likabula/Kholiwe	Mulanje	628	3,947,000	6,285	11	12
Likhubula/Nthumbula	Chikwawa	419	3,410,000	8,138	12	13
Mpamba	Nkhata bay	1,266	6,137,338	4,848	20	14
Welusi	Karonga	2,722	5,210,087	1,914	34	15
Ilengo	Chitipa	3,254	13,006,491	3,997	19	16
Linga	Nkhata bay	2,434	5,759,625	2,366	31	17
Mwambazi	Nkhata bay	2,261	12,196,968	5,394	18	18

Mdenga	Balaka	294	2,119,286	7,217	11	19
Msenga	Nkhata bay	1,964	5,023,943	2,558	30	20
	Total	**15,928**	**58,815,013**	**3,692**	**21**	

Criterion Description	District	Area (ha)	Capital Costs (US$)	Unit Cost (US$/Ha)	EIRR (%)	Rank #
Chizimbi	Chikwawa	306	1,979,000	6,467	16	21
Mwenelupembe	Karonga	3,036	7,316,085	2,409	30	22
Ukanga	Karonga	5,765	13,675,680	2,372	31	23
Mtuwa	Mangochi	1,553	12,536,009	8,071	12	24
Mkulumadzi	Mwanza/Neno	321	3,070,000	9,564	10	25
Marko	Chitipa	465	2,407,218	5,177	19	26
Ngemela	Karonga	2,278	18,512,117	8,126	12	27
Mafinga Hill	Chitipa	43	244,307	5,682	15	28
Kamwanyoli	Nkhata Bay	120	968,000	8,067	12	29
Mwenilondo	Karonga	818	2,964,865	3,623	24	30
	Total	**14,706**	**63,673,282**	**4,330**	**18**	

6.4.1 Discussion of Ranking Assessment

The ranking process has been performed on all considered schemes and new identified PIS. The following criteria were applied, using the ranking criteria numbering:

- (1.1.3) **Export crops** used the cropping pattern to determine a percentage of export crops, Lowland 24%, plateau 38% and lakeshore 12%.
- (1.3.1 and 1.3.2) **Geotechnical suitability** and availability of materials was based on the soils found in the project area, using clay, sand, and rock with the following percentage weighting respectively: 80%, 15%, 5%.
- (1.4.3) **Source of energy** was not used as pumping was not part of the water source. In addition, the lack of available electricity supply means that electricity will not be a major source for the near future until more power plants are constructed.
- (2.0.0) **Market Orientation** was done using distance to major markets using GIS methods, and this worked well.
- (4.1.2)**ICID environmental checklist** was not possible to assess this data, and therefore not used.
- (5.1.1) **Acceptance of project**, this data was also not assessed in any meaningful manner, as it requires much data collection and community surveys.
- (5.1.3) **Potential conflict** among water users: this data was also not assessed in any meaningful manner, as it requires much data collection and community surveys.
- (6.1.1)**Indicative land tenure** per household: it was not possible to determine this in any meaningful way, and therefore not used.

All of the ranking criteria will be covered in detail during the feasibility studies.

For the top 30 schemes, the first 10 cover 22,200 ha, costs US$53.2 Million , average $2,400/ha and an average 24% EIRR. The second 10 cover 16,000 ha, costs US$58.8 Million, an average $3,700/ha, and an average 21% EIRR. The final 10 schemes cover 14,700 ha, costs US$63.7 Million, at an average $4,300/ha with an average 18% EIRR.

Therefore the top schemes cover a larger area, cost less, and have the highest economic returns.

These schemes are plotted by ADD to indicate location, catchment boundaries and irrigation area.

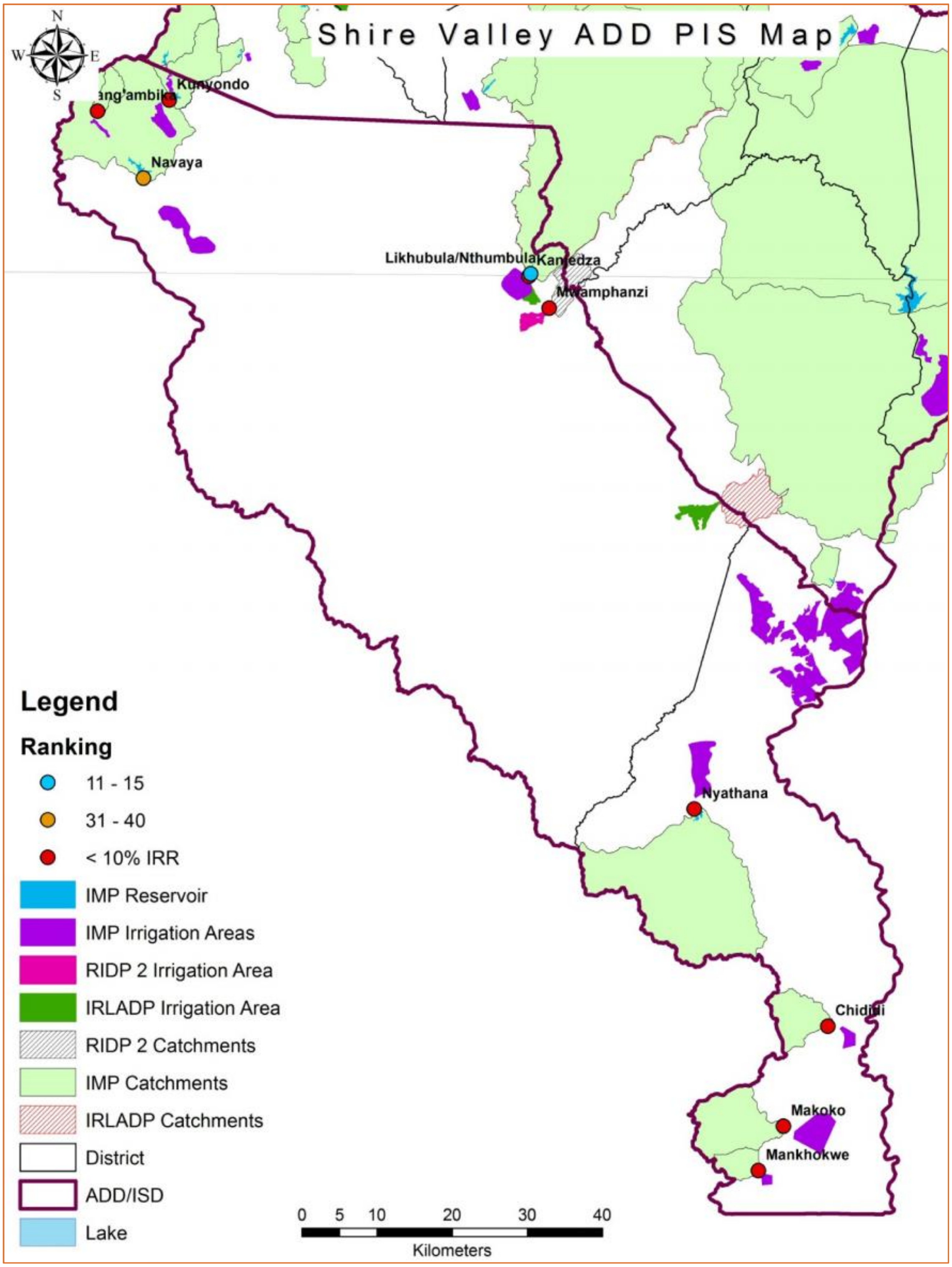


Figure 47: PIS for ADD Shire

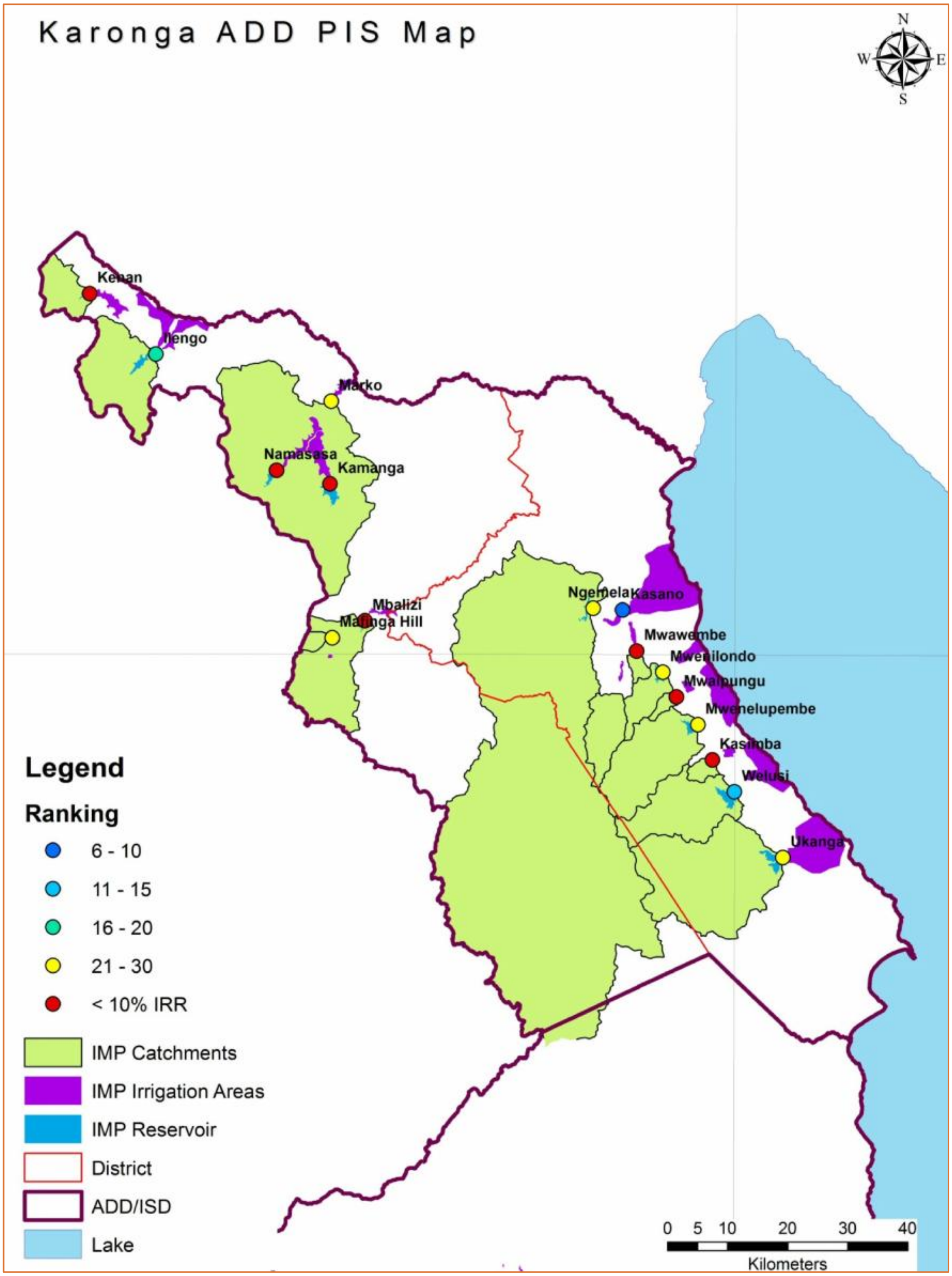


Figure 48: PIS for ADD Karonga

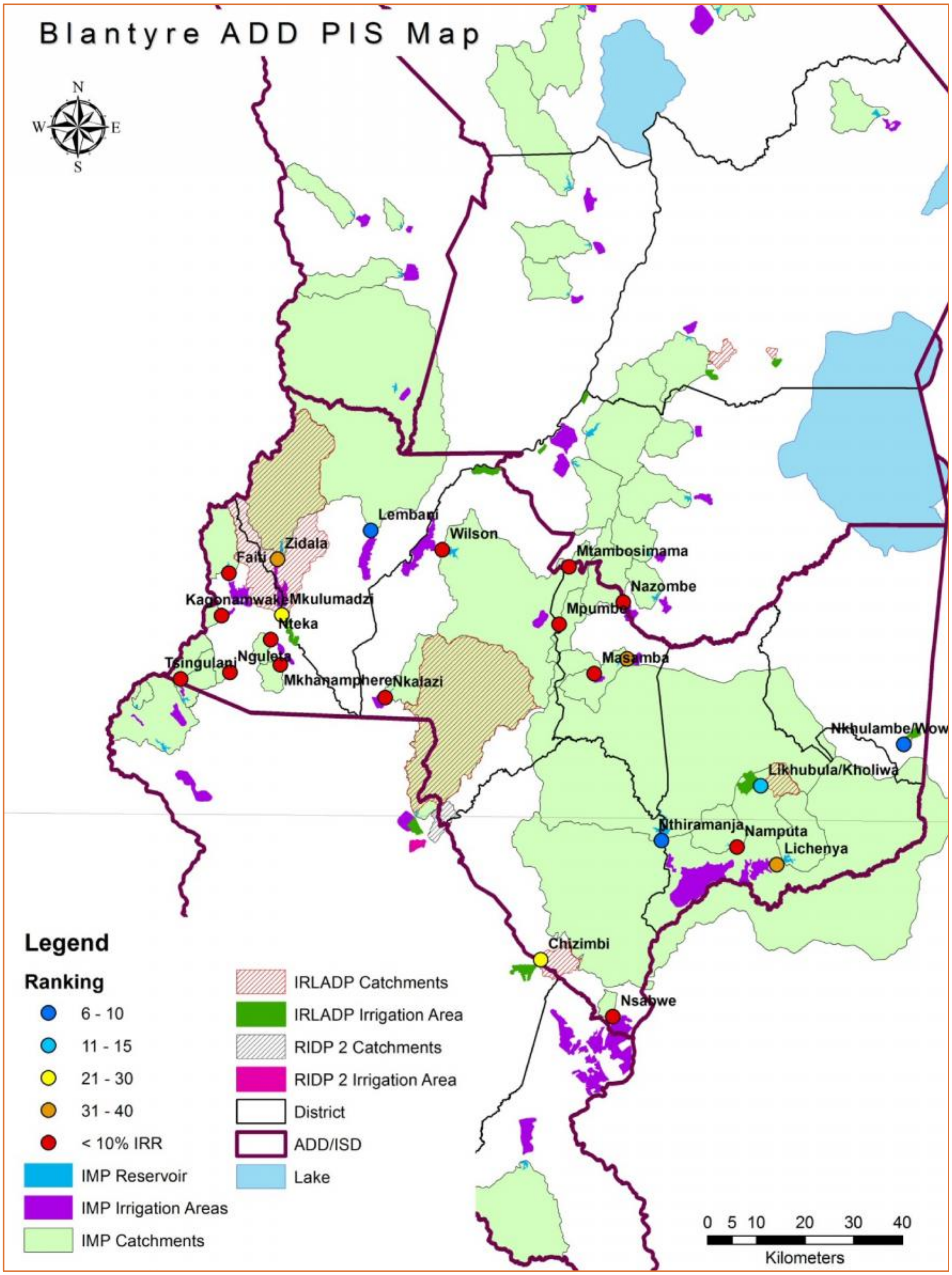


Figure 49: PIS for ADD Blantyre

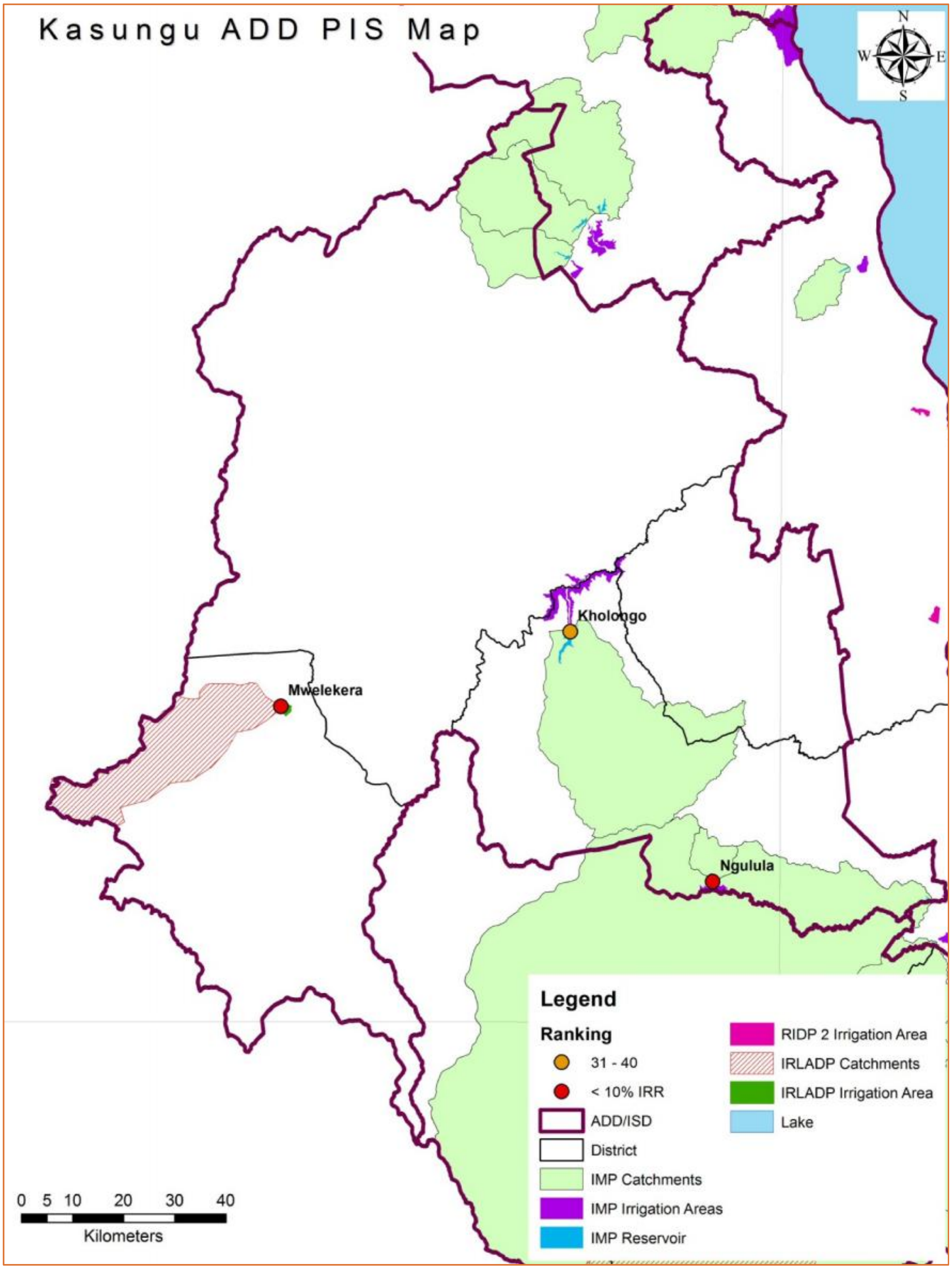


Figure 50: PIS for ADD Kasungu

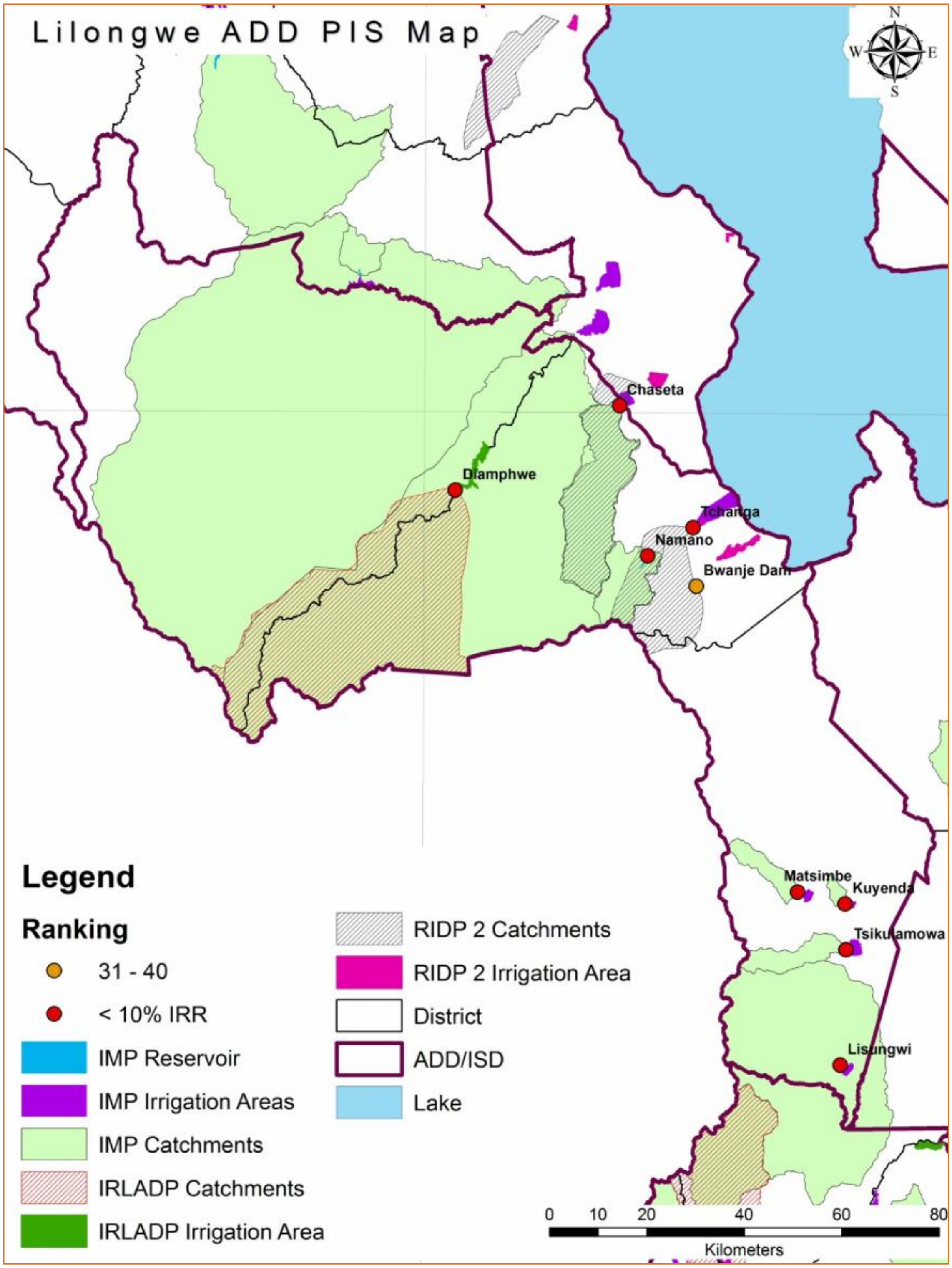


Figure 51: PIS for ADD Lilongwe

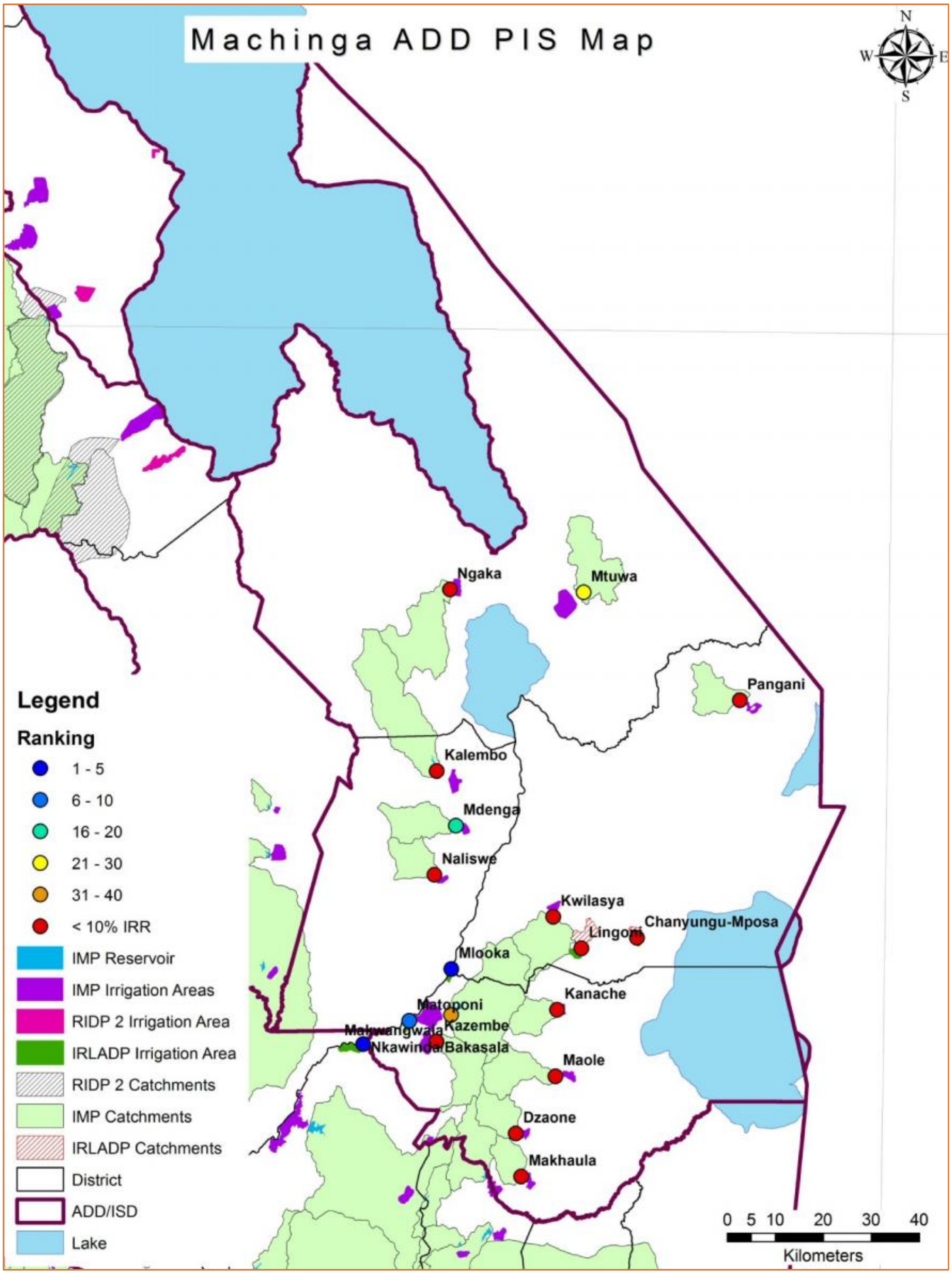


Figure 52: PIS for ADD Machinga

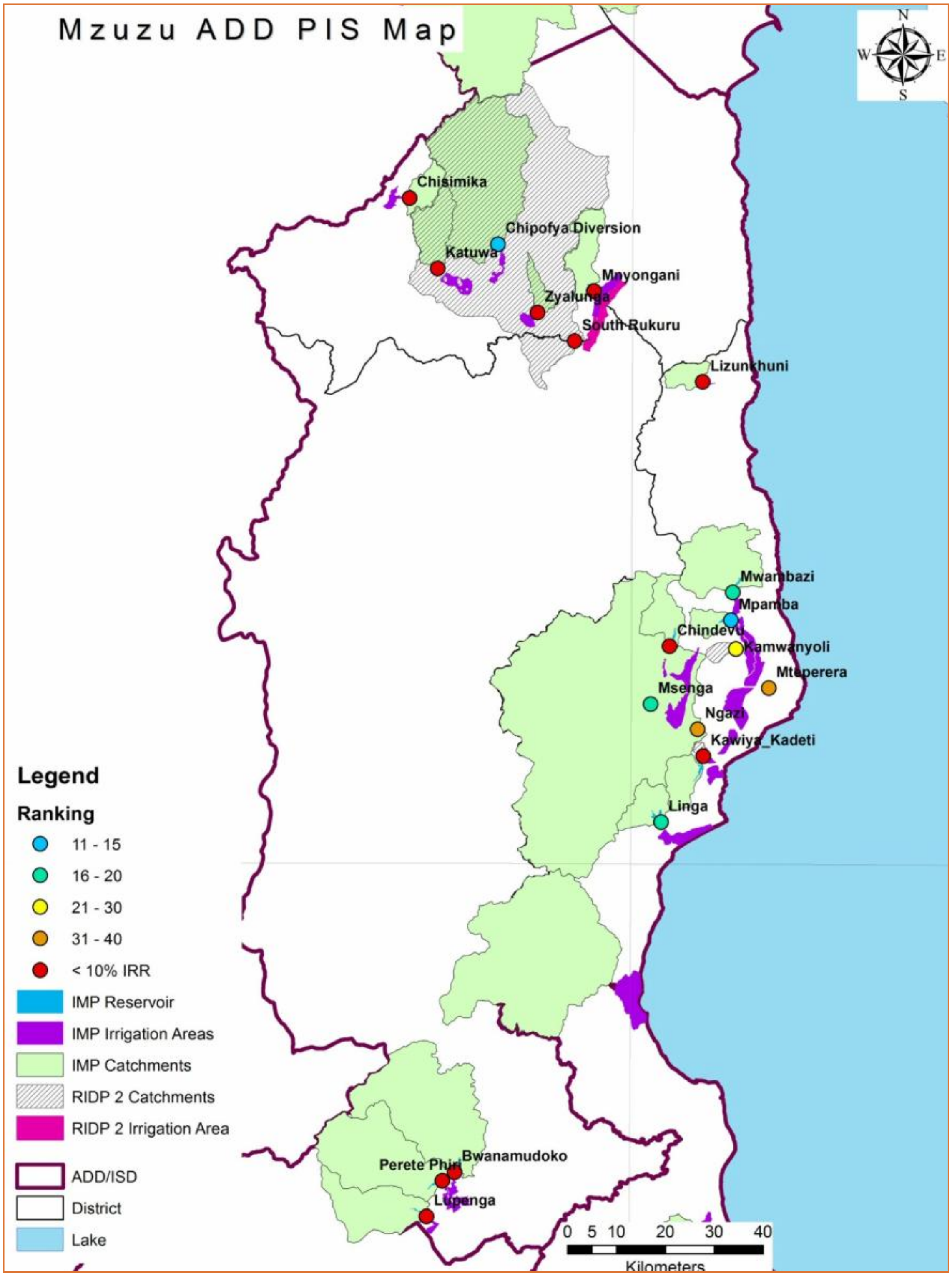


Figure 53: PIS for ADD Mzuzu

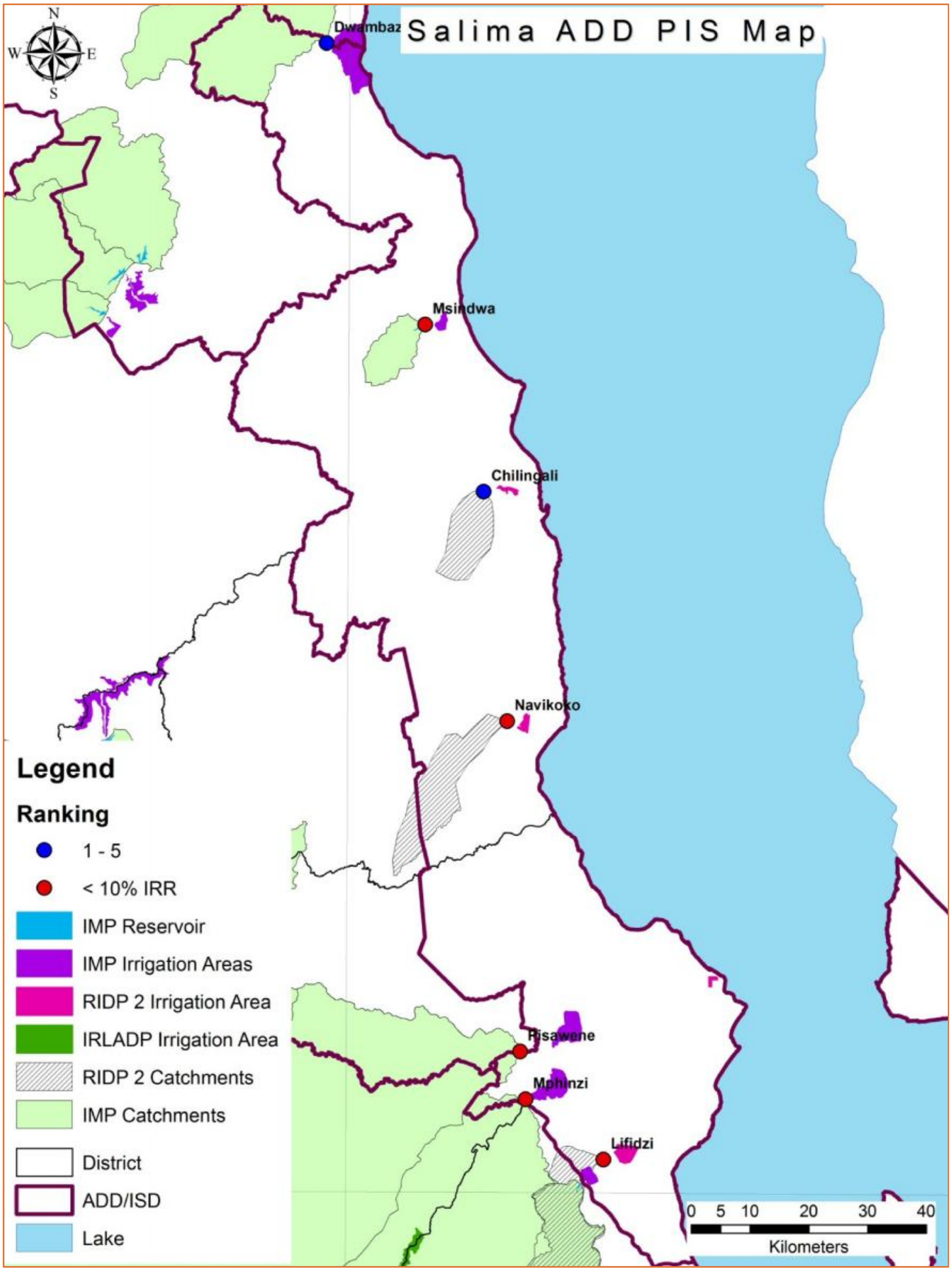


Figure 54: PIS for ADD Salima

6.5 PIS's of Specific Merit

There are a number of schemes that deserve mention as they have already received consideration, or have features of importance, like hydro potential and also trans-boundary schemes. Of these the major one is SVIP, which has been in the pipeline for many years now. There are a number of potential schemes along the Ruo River bordering with Mozambique, and some cluster of schemes in Karonga and Nkhata Bay area.

6.5.1 Shire Valley Irrigation Project (SVIP)

The main purpose is to provide gravity fed irrigation for about 52,000 ha in the Shire Valley, below Chikwawa township. Currently there is about 20,000 ha of pumped irrigation, all growing sugar for the Illovo Sugar Factory. The sugar estate is currently the largest consumer of power in the country, and removing it from the grid would free up considerable power for other users. Additionally, extracting water from the Shire River has tremendous annual maintenance problems with the intake channels need maintaining, plus the high wear on the impellers, and the pumping of sediment into the canals. These problems would largely be removed by supplying the Illovo Estate with gravity fed irrigation.

The objectives of the SVIP are to sustainably increase agricultural productivity and incomes for targeted households in the districts of Chikwawa and Nsanje in the Shire Valley by establishing market-linked smallholder farming ventures and professionally operated irrigation service.

Table 48: Potential Areas for SVIP

Name	Area (Gross ha)
New Area	33,140
Kasunthula	1,758
Sucoma	12,430
Phata Outgrowers	300
Sande Ranch (Illovo)	460
Kaombe Ranch	860
Alumenda	3,439
Total	52,387

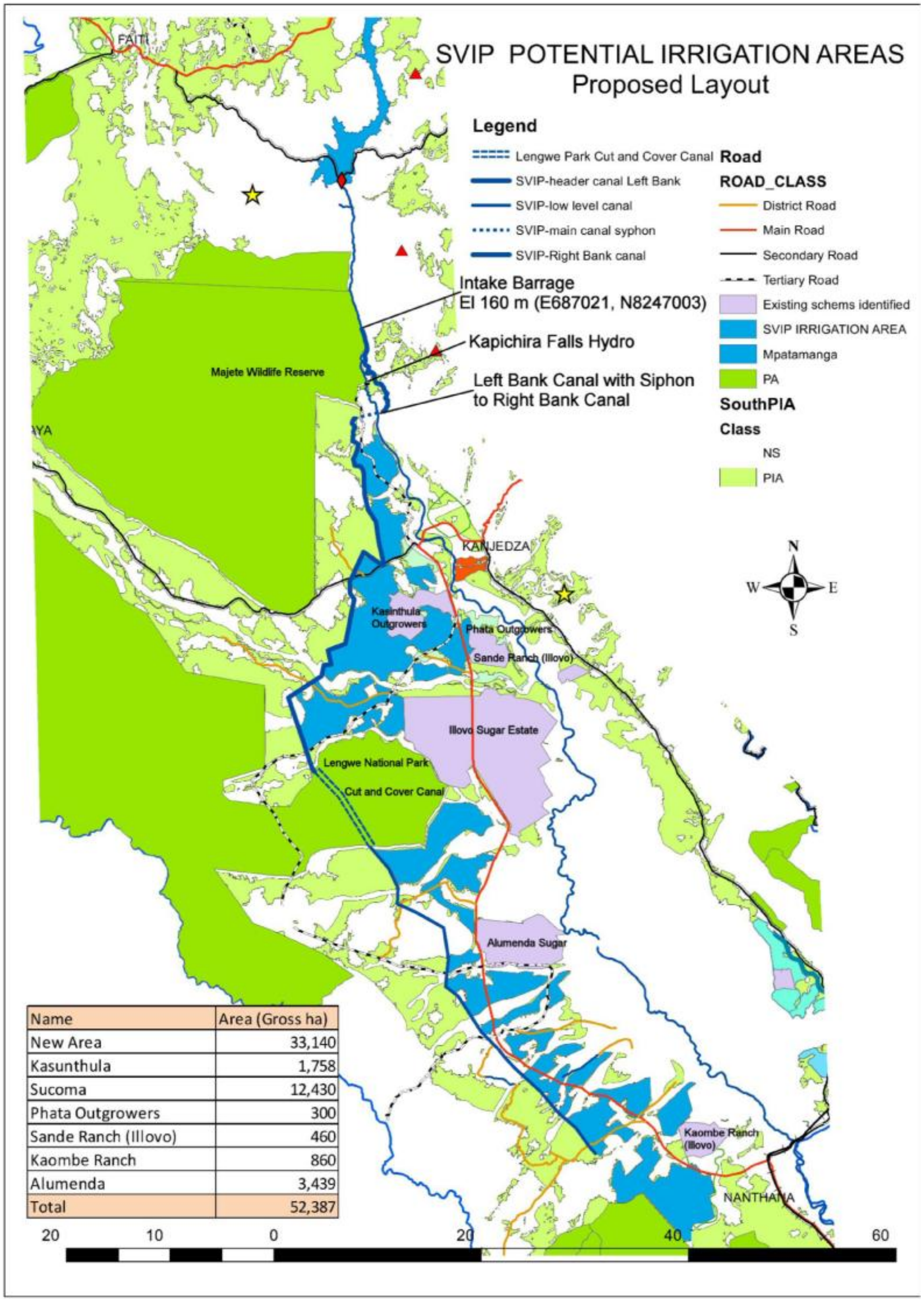
Since the 1980's the GOM has shown interest in developing this project, but there are significant challenges. There is competing interest in the water supply with Kapachira Hydro plant and environmental challenges with two protected area; 1) Majete Wildlife Reserve, and 2) Lengwe National park. Both of these have potential solutions as outlined below.

A recent study by Norplan[13] has shown that in this case of low head power generation, the best use of water is to develop irrigated agriculture. In cases of high head, power becomes more competitive, see comparison in Section 6.5

The use of an offtake at Kapichira is deemed too low to be able to irrigate the most land, and it is best to place the intake upstream of the hydro plant. However, the canal should be placed on the right bank (west side) of the Shire, but this would then effectively block access of the wildlife reserve to the Shire River. An alternative proposal would be to run the canal on the left bank (east side), at

[13] Study on water availability Shire River Final Report, Norplan April 2013

an elevation of 160 m (located at E687021, N8247003, some 5.2 km upstream of Kapichira), and run this past the power station. Once past, a desilting basin would be located, to reduce the sediment load, and eject it into the river downstream of the power station. The canal would then be brought back to the right bank through a three barrel siphon, and then continue down to the irrigation area. The layout of the project is given in Figure 55, below.



Name	Area (Gross ha)
New Area	33,140
Kasunthula	1,758
Sucoma	12,430
Phata Outgrowers	300
Sande Ranch (Illovo)	460
Kaombe Ranch	860
Alumenda	3,439
Total	52,387

Figure 55: Shire Valley Irrigation Project Layout

To reach the lower part of the project, the canal has to pass through the Lengwe National Park. There is no way around this, and a possible solution here is a cut-and-cover culvert canal. Once complete, this canal would be invisible to the park, but would be able to supply water at strategic locations for the wildlife. Inspection manholes would be required for maintenance.

Current projects underway for the SVIP is a feasibility study, and M&E for the whole valley.

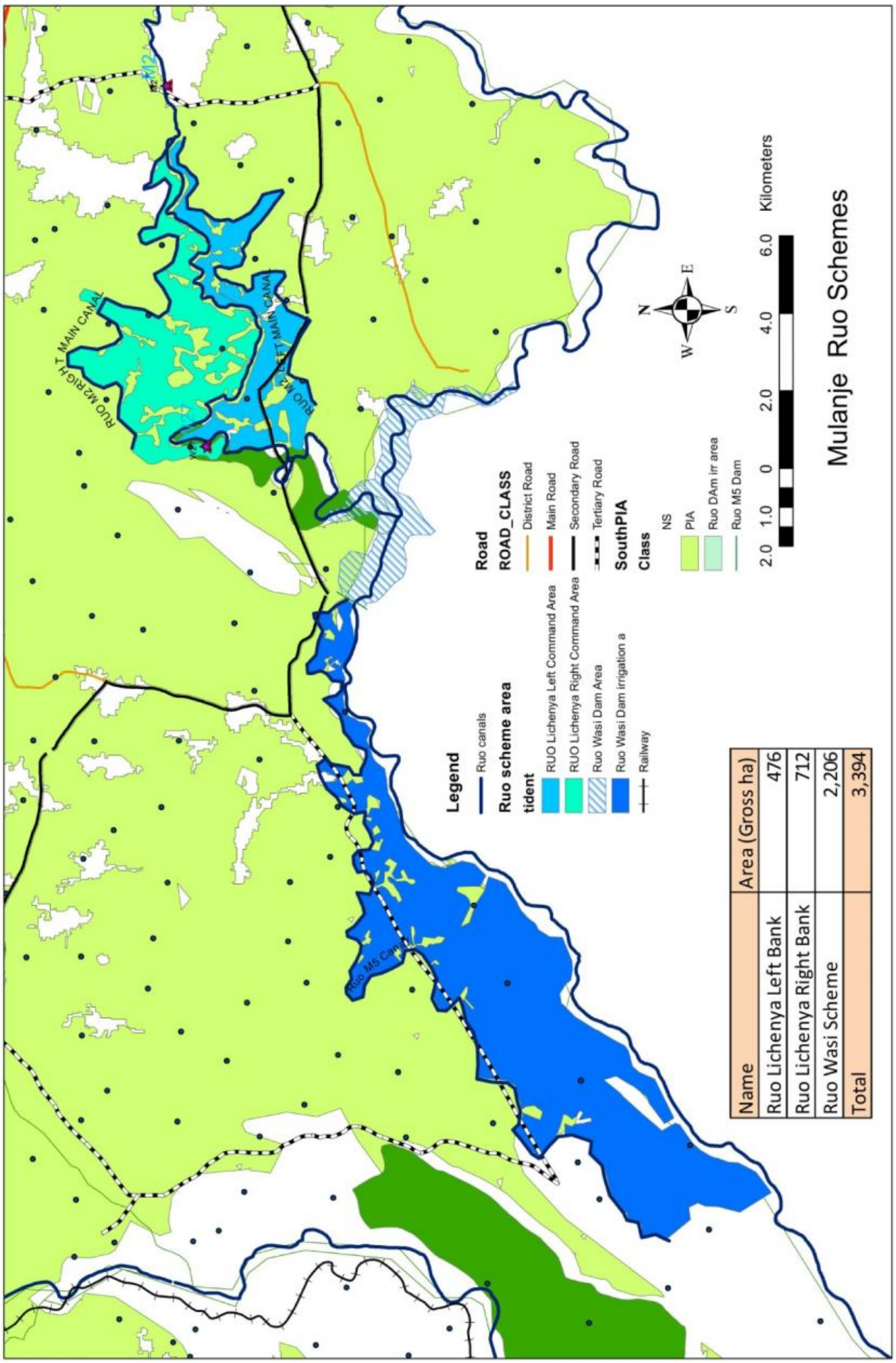
6.5.2 Ruo River

The Ruo River and WRA 14 has been the attention of schemes for a long time not only because of the high dry season flows but also because of the flooding caused by the river. In addition, there is the hydro potential of 20 to 40 MW of generation at Zoa Falls, plus many other locations for dams and hydro generation. In November 2003, a Joint Water Commission (JWC) was set up between Malawi and Mozambique to look specifically at the Ruo River, but this has become dormant. With this IMP, attention is again focused on this water resource. It has three major contributions, hydro power, irrigation and flood mitigation possibilities, and just some of these are highlighted in this plan.

Mulanje-Ruo Schemes: In the upper Ruo River, in Mulanje District there are two potential schemes. One, the Lichenya River has the potential to irrigate about 1,000 ha with a diversion weir on rock foundation at the edge of the tea estate. The second one is located on the Ruo by the village of Wasi (E 761955, N 8216805). Here a dyke intrusion cuts across the river, which has broken through to create a natural dam location. This site would store 113.5 Mm^3 and inundate 12.5 km^2 with a height of 30 m. A right bank canal could irrigate 2,200 ha with a length of 24.9 km. These schemes are shown in Figure 56 Mulanje-Ruo Schemes

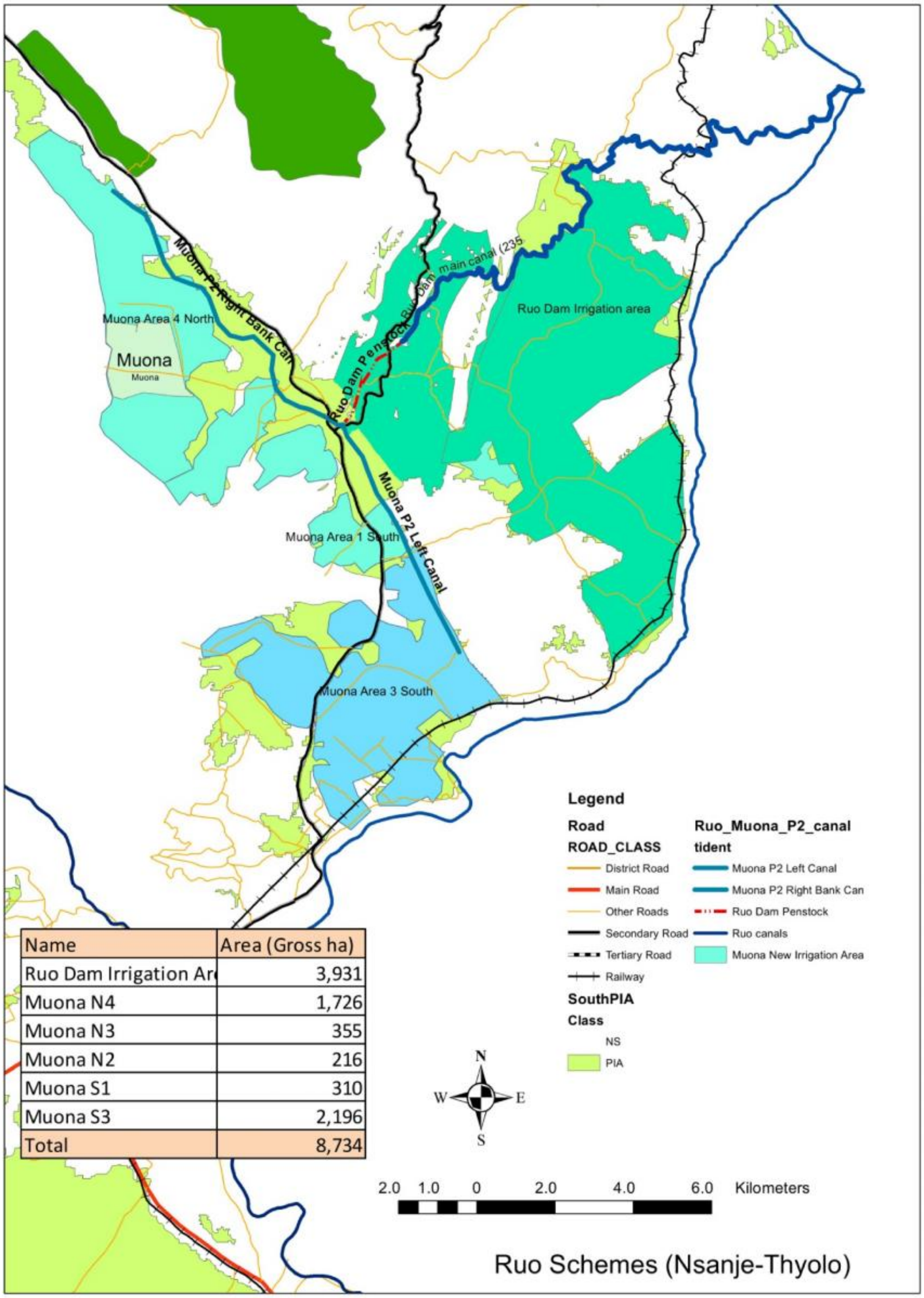
Ruo Dam Scheme: Lower down, the Zoa Falls represents an opportunity for multi-purpose functions, of hydro power plus irrigation. The irrigation canal would have to be located downstream of the power station so as not to reduce its capacity. For this reason a lower barrage could be located or an intake located in the tailwater of the hydro station, depending on its arrangement. The FSL of the main canal would be located at an elevation of 234.7 m (E 743653, N8194506). Further investigation is required for the best route and alignment of this main canal. Its command area is in the order of 10,000 ha and has a discharge 10 m^3/s. An alternative diversion for this canal could be a dam located 3.6 km downstream (E745418, N8191831). Here a dam height of 60 m to elevation 270 m, with water stored during the dry season. The potential hydro at this location would have a head of 80m (a 20 m drop below the dam) and could generate about 9MW.

The canal would run for 16 km before irrigating an area of 4,800 ha (gross), in Thyolo and Nsanje districts, with six secondary canals on the left bank (east side). At the end of the 25.7 km canal the elevation is at 219.4 m. The second main area of irrigation is located on the banks of the Shire River, and would command the existing Muona Irrigation scheme. In this area is 4,800 ha (gross, including Muona), and the canal commanding this area would have an FSL elevation of 76.1 m. Representing a drop of 143.3 m. Allowing for friction (through 2.7 km penstock) and tailwater loss, the estimated head for power is 127 m. With a flow of 4.0 m^3/s, the power generated is about 4.0 MW. The arrangement of canals, dams and irrigation area is shown in Figure 57 Ruo Dam Scheme.



Name	Area (Gross ha)
Ruo Lichenya Left Bank	476
Ruo Lichenya Right Bank	712
Ruo Wasi Scheme	2,206
Total	3,394

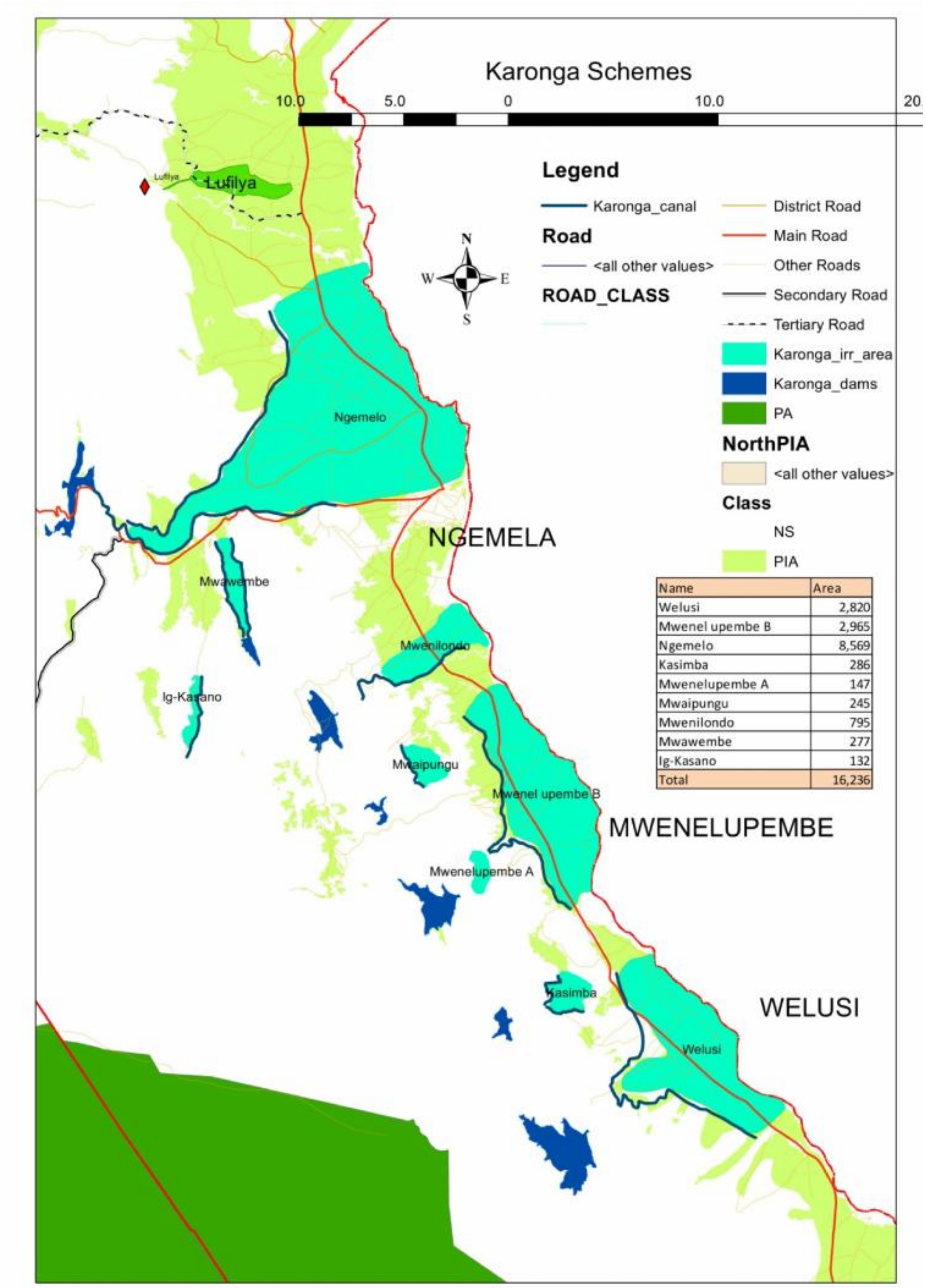
Figure 56: Mulanje-Ruo Schemes



Name	Area (Gross ha)
Ruo Dam Irrigation Ar	3,931
Muona N4	1,726
Muona N3	355
Muona N2	216
Muona S1	310
Muona S3	2,196
Total	8,734

Figure 57: Ruo Dam Scheme

Karonga Schemes: In the north a lot of rivers exit the hills through narrow gorges which are good sites for dam storage. These locations have been identified and developed into potential schemes, as shown in Figure 58 Karonga Schemes. Although these schemes are in the domain for diversion systems because of the high dry season flows, the high EFR means that dry season diversion flows are small and a combination of storage and diversion is required to maximise the irrigation potential. There are 9 schemes with command areas from 183 ha to over 5,000 ha. The two smallest schemes have unit costs of over $10,000/ha, while the six largest schemes have a unit cost of less than $3,600/ha. This represents a considerable potential for irrigation development.



Name	Area
Welusi	2,820
Mwenel upembe B	2,965
Ngemelo	8,569
Kasimba	286
Mwenelupembe A	147
Mwaipungu	245
Mwenilondo	795
Mwawembe	277
Ig-Kasano	132
Total	16,236

Figure 58: Karonga Schemes

Nkhata Bay Schemes: The second northern domain with good water potential is around Nkhata Bay. There is already the Limphasa scheme operating with a command of about 320 ha. There are nine schemes with only one below 1,000 ha, which has a unit cost of $16,800/ha and will be discarded. The rest have very low unit costs, all less than $8,000/ha. These are shown in Figure 59.

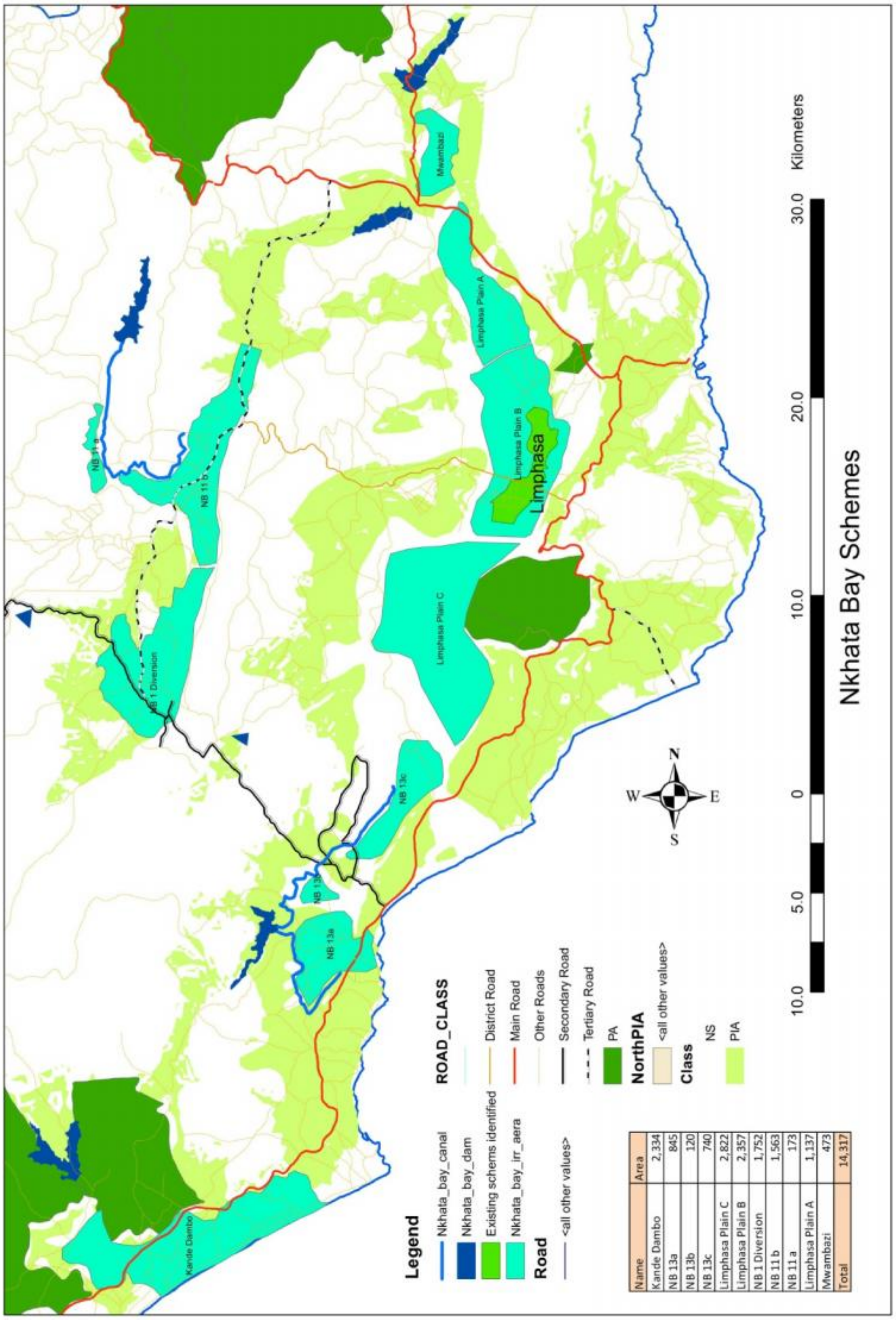


Figure 59: Nkhata Bay Schemes

6.5.3 Dambo Irrigation:

The dambo domain is the location where most of the smallholder irrigation takes place, and therefore should receive focused attention in the IMP. Most of this irrigation is informal, and is predicted to remain this way for the life of the IMP. There are two particular aspects of dambo irrigation that are an integral part of the IMP: i) informal dambo irrigation with attention on sustainable agriculture, and ii) formal irrigation with small dams (< 5.0m) and small irrigation systems. Both aspects must include catchment conservation measures incorporating conservation agriculture, and are included in the IMP budgeting.

Informal dambo irrigation, when combined with catchment conservation needs to monitored by certified irrigation technicians. There technicians will be trained and certified by the Board of Engineers, which will include three levels of accreditation: Technician, Associate Engineer, and Chartered Engineer. The technicians will be trained in participatory approach to development, CA, irrigation basics, hydraulic basics, and environmental aspects of dambo health. This person will be at the forefront of promoting sustainable irrigation in the dambo areas. All NGOs involved in irrigation should have a certified technician before engaging in irrigation.

Dambo irrigation using small dams has been tried many times in the past, and failures are mostly due to the lack of beneficiary participation. Many dams built over 30 years ago have never been used because the beneficiaries were not involved from the start, and regard the structure as not belonging to them. This approach must change if there is to be the significant increase in dambo and smallholder irrigation in the future under the IMP.

One approach to the formal dambo schemes is small dams less than about 3.0 m. One such example is Khafi Irrigation in Dowa District, where about 15 ha of land is irrigated from the small dam, see Figure 62. In this scheme, the dam height is about 3.0 m, there is a left and right bank canal starting from a 200 mm Ø pipe outlet, into a canal running for about 600 m. There is degradation of the spillway control and also the spillway channel. Lessons to be learnt from this scheme are:

- Involve the beneficiaries from the start
- The spillway control and channel could be vertical control steps from reinforced concrete
- The dambo centre should be uncultivated to keep ecology in tact
- The canal could be either 200 mm Ø pipe, or small lined canal not too deep.
- Irrigation can be done by gravity on downhill side, or by treadle pumps on uphill side
- Multiple small dams can be constructed to utilise about 38% of the dambo wetland
- With multiple dams, about 4.7% of total catchment area can be irrigated

Using a slightly larger dam with maximum height of between 5.0-10.0 m, bigger dams can be constructed to store water. There would be less dams in total, but the result would be similar. This is indicated in four catchments in the Lilongwe Plateau area, for WRU # 4B, 5D, 5E and 5F, which have had preliminary detailed location of dams, and included in the scheme list. For example, for the Dua-Dambo area, a total of 31 dams are proposed, in addition to those already existing. The potential water available is sufficient to irrigate about 17,000 ha from a catchment area of 391,300 ha, representing 4.3% of catchment area. The proposed location and example of Bua Dambo scheme is given in Figure 62.

Table 49: Potential Dambo Irrigation Area, by Plateau

Plateau	Domain PIA_{phy}				PIA_{net}
	km²	Ha	3.1%	4.7%	
Lilongwe	13,247	1,324,707	41,066	62,261	77,386
Mzimba	3,405	340,515	10,556	16,004	36,077
Chitipa	555	55,499	1,720	2,608	10,490
Mulange	951	95,094	2,948	4,469	16,616
Machinga	966	96,632	2,996	4,542	11,657
	19,124	1,912,446	59,286	89,885	152,226

Considering all potential Dambo domains, there is 1,912,446 ha in the main plateau areas (excluding 100 ha in Blantyre). Using a 4.7% yield, the dambo irrigation area is about 90,000 ha. Using the water resources available after deducting EFR and domestic water requirements, the total available is 152,226 ha. This figure is achievable, even in the life of the IMP.

The design of the dambo irrigation has been done looking at topography, original water course, spillway design and pumping potential. The average unit cost is estimated at about US$ 3,000/ha, not accounting for catchment conservation.

An example of the dambo dam design is shown in Figure 62.

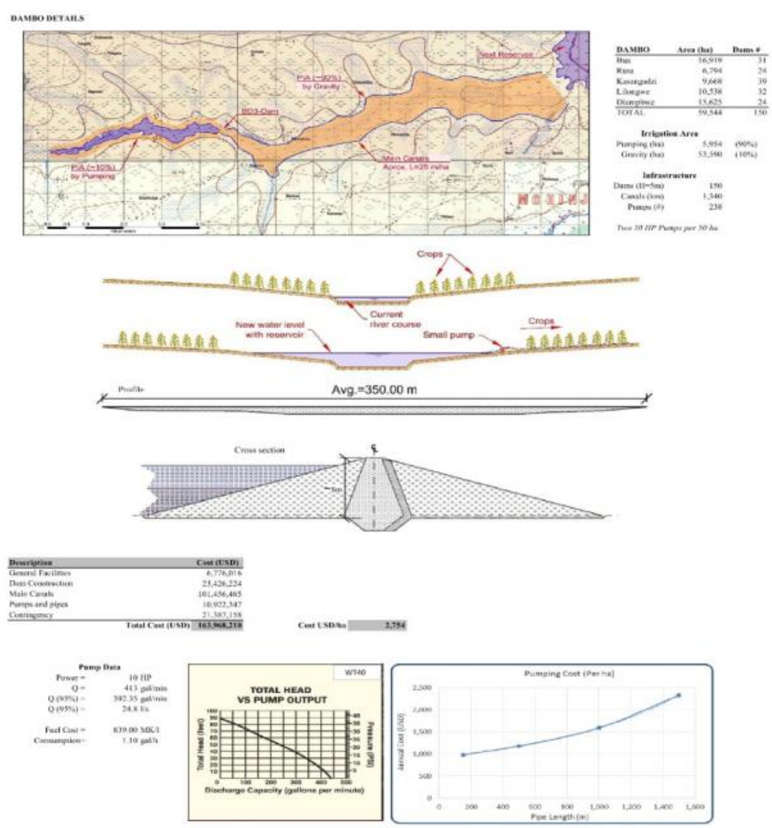


Figure 60: Example of Dambo Dam Design

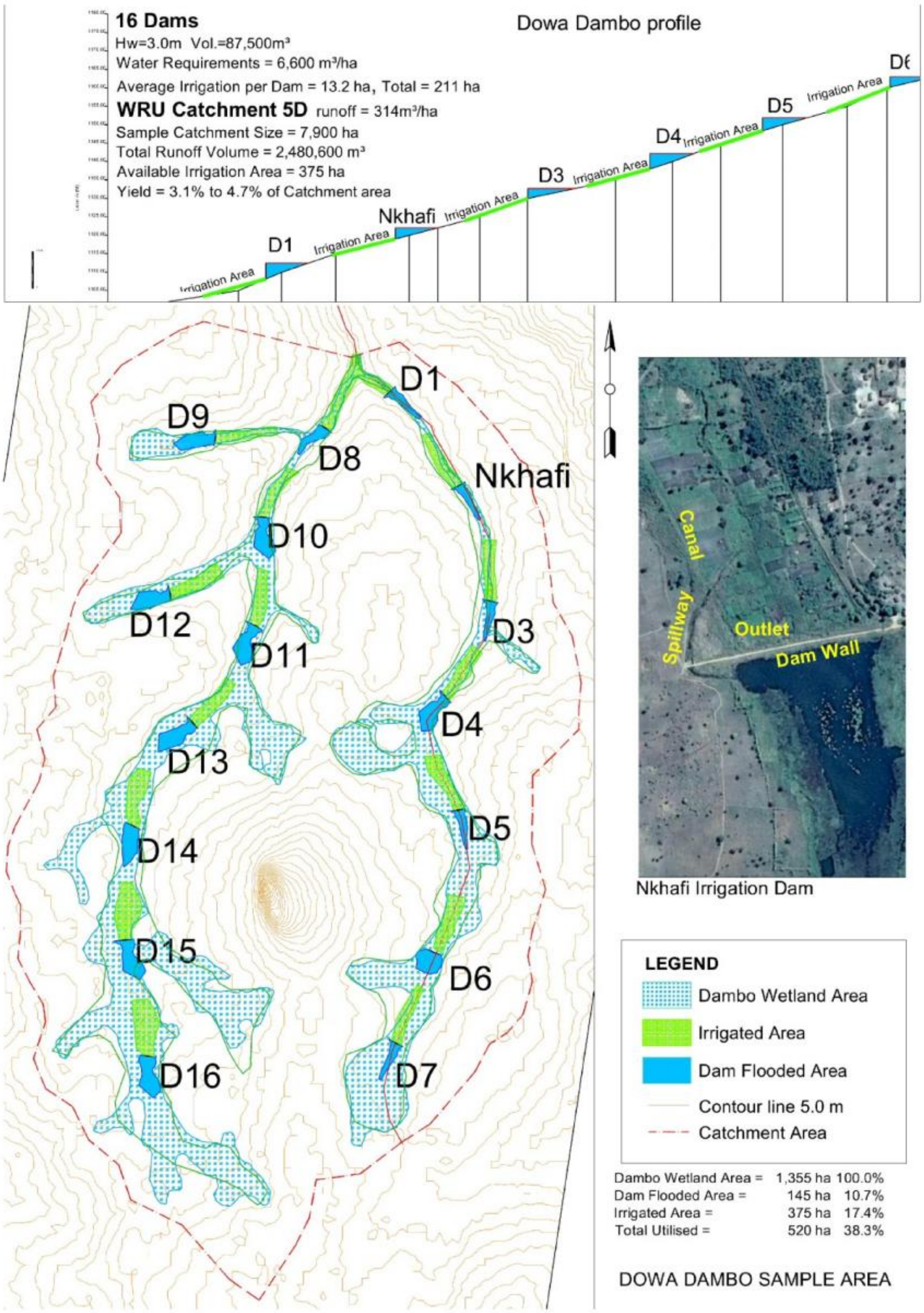


Figure 61: Dowa Dambo Area (Nkhafi Irrigation Scheme)

IRRIGATION MASTER PLAN AND INVESTMENT FRAMEWORK

Location

Scheme	Bua-Dambo	Region	Central
District	Lilongwe-Mchinji-Kasungu-Dowa		

Code	Coordinates East	Coordinates North	Reservoir Area (m²)	Code	Coordinates East	Coordinates North	Reservoir Area (m²)	Code	Coordinates East	Coordinates North	Reservoir Area (m²)
BD-1	492,525	8,471,592	606,309	BD-12	533,798	8,459,261	916,447	BD-23	549,723	8,490,672	1,613,649
BD-2	517,514	8,466,112	7,133,019	BD-13	530,364	8,464,786	617,628	BD-24	553,296	8,487,000	845,511
BD-3	519,566	8,480,922	1,105,458	BD-14	503,082	8,478,586	428,029	BD-25	557,651	8,481,324	708,557
BD-4	502,847	8,470,009	348,323	BD-15	511,080	8,479,982	448,716	BD-26	562,653	8,482,404	543,909
BD-5	514,836	8,468,868	770,374	BD-16	540,174	8,456,573	171,294	BD-27	548,104	8,507,240	3,271,281
BD-6	537,535	8,441,747	349,679	BD-17	538,995	8,459,477	190,802	BD-28	534,542	8,508,749	1,261,435
BD-7	536,766	8,446,807	459,048	BD-18	541,998	8,476,120	343,797	BD-29	556,847	8,504,478	297,288
BD-8	541,402	8,449,071	292,587	BD-19	537,445	8,479,103	853,569	BD-30	553,684	8,511,674	565,579
BD-9	537,004	8,449,832	293,463	BD-20	533,512	8,491,133	12,866,870	BD-31	551,578	8,518,774	638,782
BD-10	536,491	8,436,035	147,561	BD-21	523,919	8,490,966	1,629,898				
BD-11	535,865	8,456,168	239,160	BD-22	552,235	8,483,853	355,246				

Dambo A (km²) = 3,913.0

Soil Loss (m³/km²/yr) = 241
Service life (yr) = 30
Dead Storage (DS) (m3) = 28,347,924

Total Reservoir A (m²) = **40,313,268**
Reservoir H (m) = **4.0**
Total Reservoir V (m³) = **161,253,072**

5E6 Bua at Michinji

Bua-Dambo	Jan 31	Feb 28	Mar 31	Apr 30	May 31	Jun 30	Jul 31	Aug 31	Sep 30	Oct 31	Nov 30	Dec 31
q_{80} l/s/km²	2.66	4.46	2.37	0.68	0.75	0.86	0.67	0.46	0.15	0.15	0.13	0.41
q_m l/s/km²	4.33	5.61	5.09	3.17	2.04	1.74	1.47	1.21	0.72	0.72	0.77	2.15
Q_{80} l/s	10,411	17,465	9,264	2,679	2,946	3,383	2,613	1,795	604	604	518	1,601
EFR l/s	947	947	947	947	947	947	947	947	604	604	518	947
Supply Q_{80} l/s	9,465	16,518	8,318	1,732	1,999	2,437	1,666	848	0	0	0	655
Supply V_{80} m³	25,350,267	39,960,636	22,278,280	4,489,608	5,354,584	6,315,445	4,463,360	2,271,316	0	0	0	1,753,677

Useful volume (m³) **112,237,173**

Agrocimatic Region Plateau

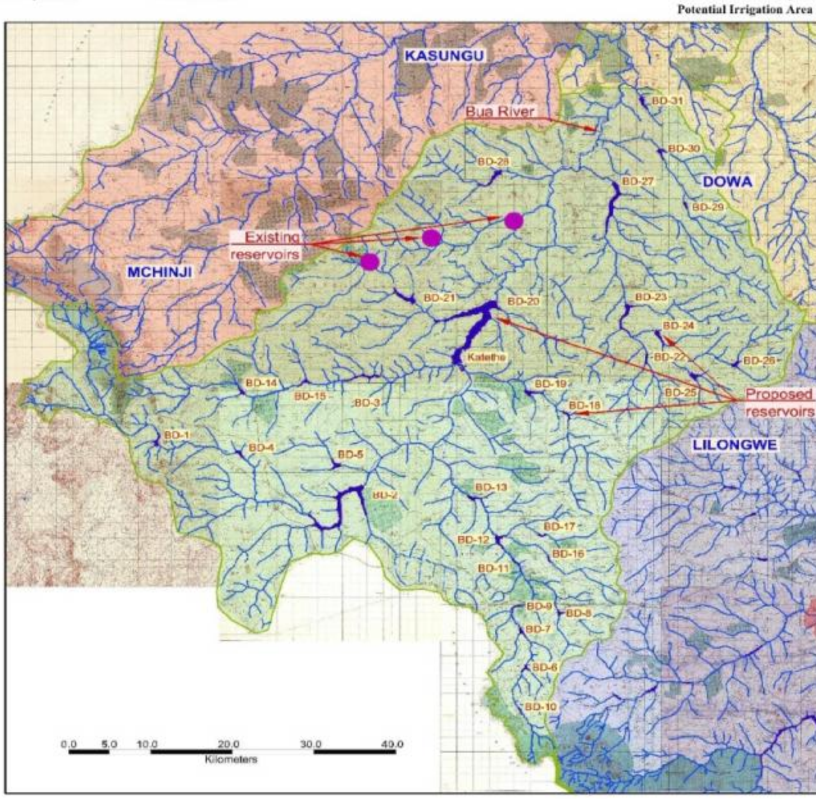
Total Volume (Dead+Useful) (m³) **140,585,097**

Cropping Pattern	Wet Season				Dry Season						Wet Season	
Maize WS				H							P	
Maize DS					P				H			
Onions WS					H						P	
Onions DS					P						H	
Vegetables WS				H								P
Vegetables DS						P				H		
Groundnuts WS				H							P	
Groundnuts DS					P					H		
Beans WS			H								P	
Beans DS					P					H		
Tomatoes					P					H		
Water Req. (m³/ha)	60.3	47.5	609.8	717.1	445.1	300.3	630.8	1,314.1	1,495.5	1,013.0	0.0	0.0

DS: Dry season WS: Wet season

Annual Water Req. (m³/ha) 6,634
Potential Irrigation Area (ha) 16,919

Location



SMEC

Figure 62: Bua Catchment Dambo Dam Location

6.6 Multi-Purpose Schemes (Hydro Power)

6.6.1 General

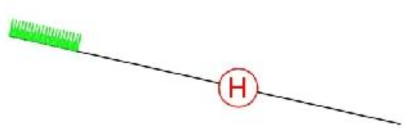
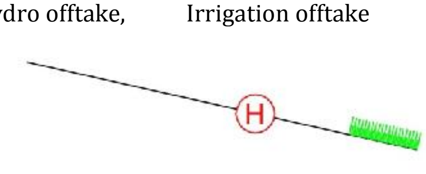
Nearly 95% of Malawi's electricity supply is provided by hydropower from cascaded plants located on the Shire River and a mini hydro on the Wovwe River, which constitute a interconnected system. Total installed capacity of these hydropower plants is 282.5 MW.

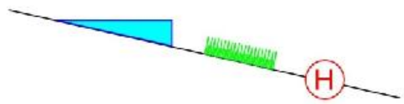
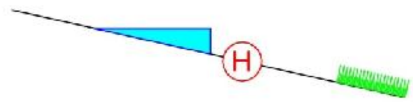
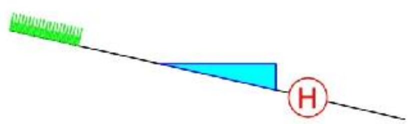
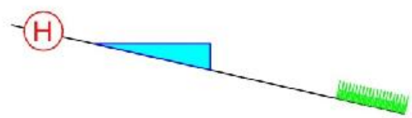
Tremendous environmental degradation in Malawi has negatively affected the operation and efficiency of the existing power generating plants. A major challenge in the operation of the electric power system is its polarized nature, whereby all the major power generating plants are concentrated in the southern region of the Country and long transmission lines feed load centres in the central and northern regions of the Country.

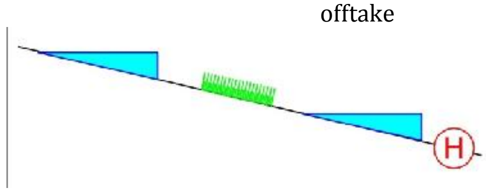
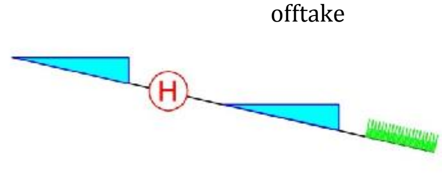
Growing demand for power in the central and northern regions, as industrial and mining prospects open up and the expansion of the grid through the Malawi Rural Electrification Programme (MAREP),has put considerable constrain on the limited generation capacity. This has thus discouraged would-be investors in both the industrial and mining sectors in the country from seriously considering investing in the country due to the unavailability of reliable and secure power supply.

In some circumstances a decision has to be made on whether to allocate water to irrigation or power generation. Generally this will apply to dry season stream flows since these are limiting for both power generation and irrigation scheme utilisation. Table 50 summarises all eight of the possible scenarios classified according to whether the irrigation offtake is above or below the hydro station, whether dam(s) exist, and their location relative to hydro stations and irrigation offtake points.

Table 50: Competition and Synergies Between Hydro Power and Irrigation

	Irrigation Offtake Above Hydro-Station	Irrigation Offtake Below Hydro Station
Run-of-river	• Irrigation reduces dry season flow to hydro station • Example: Shire River with irrigation offtake above Kapichira hydro station, • Possible South Rukuru plus Fufu Hydro	• Hydro station has no effect on availability of water for irrigation • Power generated can be used for pumping • Example: Shire River with irrigation offtake below Kapichira
	Scenario 1 Irrigation offtake, Hydro offtake 	Scenario 2 Hydro offtake, Irrigation offtake 
	Directly competitive	**Neutral or complementary**

Hydro and irrigation downstream from dam	• Dam increases dry season flow for irrigation • Irrigation may reduce dry season flow to hydro station • No competition if dam storage adequate to supply dry season flows for both • Example: South Rukuru with dam(s) in upper catchment, plus Fufu	• Dam increases dry season flow for both irrigation and hydro • Example: Proposed Songwe River scheme
	Scenario 3 Dam, Irrigation offtake, Hydro offtake 	Scenario 4 Dam, Hydro offtake, Irrigation offtake 
	May or may not be competitive	**Complementary (multi-purpose)**
Hydro and irrigation upstream/ downstream from dam	• Irrigation has no effect on hydro power generation provided dam has sufficient storage to maintain dry season flow to power station • Example: South Rukuru without dam(s) in upper catchment plus Fufu	• Use of water for power generation has no effect on availability for dry season irrigation • Example: Potential Dwambasi Irrigation
	Scenario 5 Irrigation offtake, Dam, Hydro offtake 	Scenario 6 Hydro offtake, Dam, Irrigation offtake 
	Mainly neutral	**Neutral**

Cascade of dams	• Upper dam increases dry season flow for irrigation • No competition if lower dam storage adequate to supply dry season flows for hydro • Example: Rumphi Schemes plus FuFu Dams	• Upper dam increases dry season flow for hydro power • Both dams contribute to increased dry season flow for irrigation • Example: Chimugonda plus Dwambezi Irrigation
	Scenario 7 Dam, Irrigation offtake, Dam, Hydro offtake 	Scenario 8 Dam, Hydro offtake, Dam, Irrigation offtake 
	May be competitive	**Complementary (multi-purpose)**

In all scenarios where water for irrigation is diverted below hydro power stations the effects on irrigation water availability are neutral or complementary as shown in the right hand side of Table 45. For run-of-the-river schemes below hydro power stations (Scenario 2) electricity generated may be used for pumping, and there will be a net gain in electricity supply provided the pump lift is no more than about 60% of the power generating head[14]. Where there is dam storage upstream of the power station (Scenario 4) and the irrigation offtake is downstream of the power station (Scenario 4), agriculture will generally benefit from improved volume and reliability of dry season flows – such configurations are multi-purpose with potential for cost sharing between power generation and agriculture. The same is true of Scenario 8 where the upper dam increases dry season flow for hydro power and both dams increase flows to agriculture. Scenario 6 where the power station us upstream of both the dam and the irrigation offtake are neutral for both.

In all of the scenarios on the left hand side of Table 45 where irrigation offtake is above a hydro power station there is potential for competition in water use. However, there is only one scenario where irrigation and hydro power are necessarily competitive. This is Scenario 1 where in a run-of-the-river situation there is potential to divert dry season flows for irrigation upstream of a power station. Under this Scenario a decision must be made on the most productive use of the water. In Scenario 3 where the irrigation offtake is below a dam but above a power station, irrigation may limit the availability of water for power generation if the dam cannot supply the dry season flow needed by both. In Scenario 5 where irrigation water is diverted above a dam which supplies a power station further downstream, irrigation will have no effect on power generation provided that dam has sufficient capacity to supply the power station all year round. Scenario 7 poses even less of a threat to hydro power provided both dams have adequate capacity.

In competitive situations such as Scenario 1 and in some cases under Scenarios 3, and 7 the decision on optimum allocation of water needs to be based on the productivity of a cubic metre of dry season water availability for irrigation and power generation. This in turn depends on: (i) the amount of head available for power generation; (ii) the value of electricity; and (iii) the net value of agricultural production after accounting for all costs, including where necessary, pumping. A recent study[15] on competitive uses of water in the Shire Valley concluded that irrigation is likely to give better economic returns than low head hydro power generation, although this depends in large measure on how electricity is valued, whether by the cost of alternative power generation which varies greatly between coal and diesel powered generators, or loss of economic output from non-availability of power, known as the cost of unserved energy (CUE).

Table 50 shows a range of scenarios estimating the net economic gain or loss from diverting water from hydropower generation to irrigation at head levels ranging between 25m and 300m and electricity values ranging from US$ 0.10 to US$ 1.00 per kWh. Existing power stations in the Shire River have heads ranging from 39m (Tedzani) to 55m (Kapichira) with the total cascade amounting to 151m. The head of the proposed Lower Fufu power station is 225m. The economic value of electricity can be considered in several ways. The retail price of electricity (currently around US$ 0.085 (MWK 40/kWh)) is not considered a good guide since peak demand exceeds supply at this

[14] Assuming 80% efficiency for both power generating turbines and pumping. On this basis a power station with 50 m of head would generate enough power per m^3 to lift the same volume of water about 30m.

[15] NORPLAN (April 2013) Study on Water Availability for Irrigation and Hydropower Production on Shire River at Kapichira Falls. Report prepared for the Ministry of Water Development and Irrigation, Shire River Basin Management Program (Phase1)

price indicating that electricity is worth more than US$ 0.085 /kWh. A better measure of the value of hydro-power is the cost of electricity generation by alternative means, normally diesel fuel in Malawi. This is estimated to cost around US$ 0.77/kWh in financial terms or US$ 0.37/kWh in economic terms, after deducting the tax component of the diesel fuel price. It is also possible to consider the value of energy in terms of CUE which is a measure of the productivity lost from non-availability of energy. CUE is clearly above the financial cost of alternative power generation (US$ 0.77/kWh) since many businesses are prepared to incur this expenditure to supply their energy needs.

Table 51: Net Economic Gain/Loss from use of Water for Irrigation vs Hydro-Power

Head	Value of Power Generated (US$/kWh) a/									
(m)	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
25	12.5	12.0	11.5	11.0	10.5	10.0	9.5	9.0	8.5	8.0
50	12.0	11.0	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0
75	11.5	10.0	8.5	7.0	5.5	4.0	3.5	1.0	-0.5	-2.0
100	11.0	9.0	7.0	5.0	3.0	1.0	-1.0	-3.0	-5.0	-7.0
125	10.5	8.0	5.5	3.0	0.5	-2.0	-4.6	-7.1	-9.6	-12.1
150	10.0	7.0	4.0	1.0	-2.0	-5.1	-8.1	-11.1	-14.1	-17.1
175	9.5	6.0	2.5	-1.0	-4.6	-8.1	-11.6	-15.1	-18.6	-22.1
200	9.0	5.0	1.0	-3.0	-7.1	-11.1	-15.1	-19.1	-23.1	-27.1
225	8.5	4.0	-0.5	-5.1	-9.6	-14.1	-18.6	-23.1	-27.6	-32.1
250	8.0	3.0	-2.0	-7.1	-12.1	-17.1	-22.1	-27.1	-31.1	-37.1
275	7.5	2.0	-3.6	-9.1	-14.6	-20.1	-25.6	-31.1	-36.6	-42.1
300	7.0	1.0	-5.1	-11.1	-17.1	-23.1	-29.1	-35.1	-41.1	-47.1

a/ Based on dry season river flow of 10m3/second

In Table 51 the green areas show the situations in which it is clearly better to use dry season stream flows for irrigation, and the red areas where it is clearly better to generate electricity. The diagonal boxed area in the chart represents marginal situations where there is no clear advantage one way or the other. Table 51 shows that for low head hydro schemes, say less than 50m, it generally better to use dry season stream flows for irrigation. Hydro-schemes above 200m head generally produce better economic benefits than use of this water for irrigation. If electricity is valued using the alternative generation cost method (US$ 0.37/kWh) irrigation will clearly be better for heads of up to about 100m, and power generation clearly better for heads over 200m. Using the CUE valuation method power generation will be better for all but low-head hydro power schemes.

6.6.2 Dwambazi-Chimugonda Hydro Power

The Dwambazi River forms the boundary between Nkhotakota and Nkhata Bay Districts. Previous studies have identified the hydro potential of this river, called Chimugonda[16].

These studies have located a potential dam site upstream of the Chitape River in Nkhotakota district with a FSL of 915 masl. Two alternative headrace tunnels were proposed with the first powerhouse

[16] 1986 National Water Resources Master Plan

1998 Power Development Study, Lahmeyer/Knight Piesold located close to the Lake shore, and the second on the Mtazi River in Nkhata Bay district. Studies during the IMP have identified the lakeshore area of the Dwambazi River as suitable for irrigation. There is already an informal irrigation taking place close to the lake shore. The river is perennial and has the potential to irrigate 4,256 ha without storage. However, with the proposed hydro power project, this irrigation potential could be in jeopardy.

This is a situation where there is potential for cooperation and win-win between hydro power and irrigation. The tailrace of Alt A could be located in a position to still be able to command the potential area of irrigation. The tailrace of Alt B is located upstream of the proposed diversion headworks, and would utilise the water from the hydro plant. In addition, here is potential for another dam close to the exit of the river from the hills. This could be used for hydro power and storage for irrigation. These aspects are shown in Figure 63.

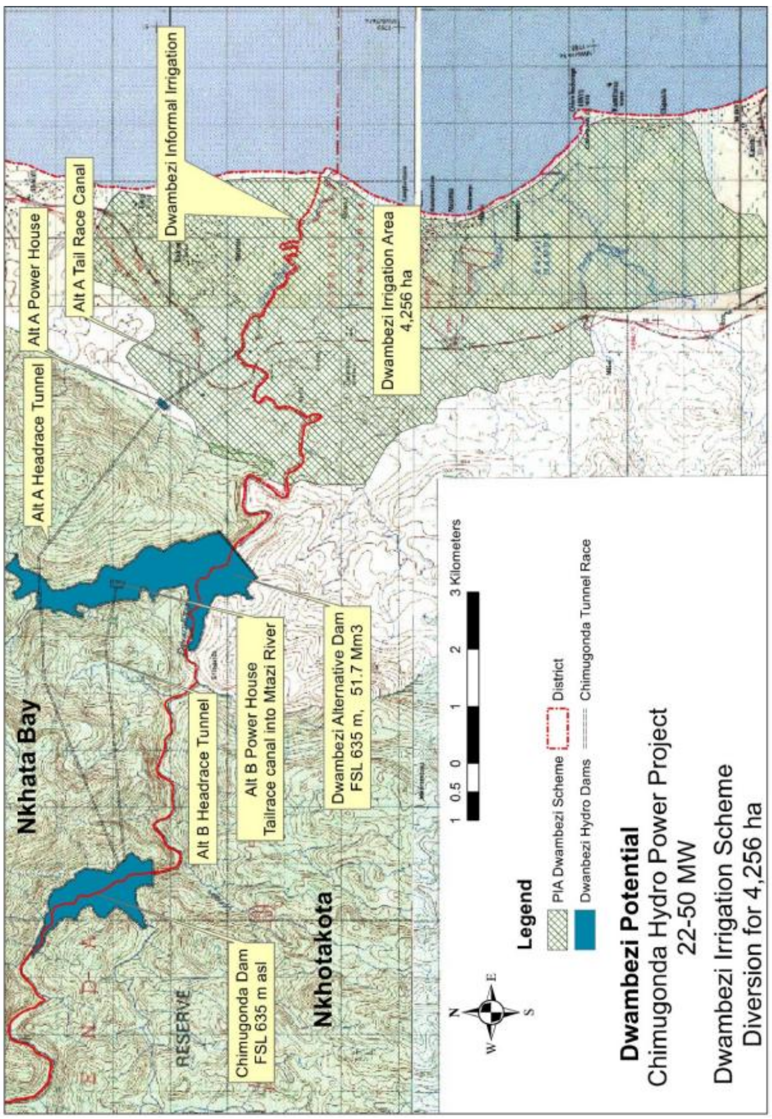


Figure 63: Dwambazi Potential

6.6.3 **Tchanga**

RIDP II covered the feasibility and detailed design on a number of irrigation schemes, one of which was Tchanga, located along the lake shore, in Dedza District. The potential irrigated area is 154 ha. During the identification of potential schemes, a dam site was located in the plateau of Dedza that could store 19.9 Mm^3 which is sufficient to irrigate 1,886 ha. This dam is located on the Nadzipulu River, also the iver where the Tchanga diversion weir is located. It is therefore suggested that the original Tchanga scheme is extended to accommodate the extra water to serve 1,886 ha, and to also include the existing informal irrigation along the lake shore. In addition, there is a large head, at least 528 m drop from the dam to the lower plain, which could be utilised to generate power in the order of 4 MW. This would require a headrace tunnel of some 4.9 km. This arrangement is shown in Figure 64.

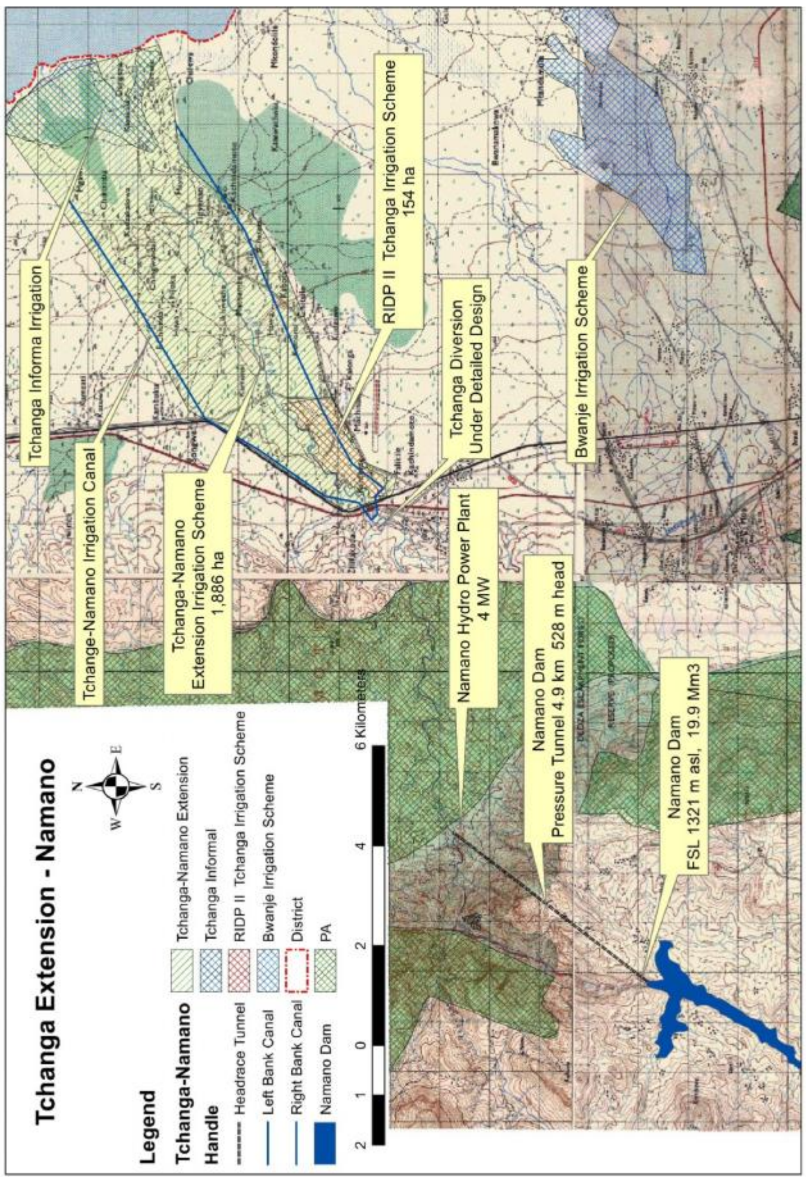


Figure 64: Tchanga Extension – Namano and Hydro Power

6.6.4 South Rukuru – Fufu Hydro Power

The Fufu Hydroelectric Power Project on the South Rukuru River in Rumphi District has been identified as one of the least cost options for the expansion of the power generation system and increasing access to electricity by the rural communities in the north and centre regions. Also the South Rukuru River is also the potential for irrigation one of the largest schemes in the north, and is in direct competition with the hydro power project, as it consumes some of the required water for power generation.

However, during the IMP preparation, a number of dam locations were identified which would store the wet season flows for use in the dry season, but still allow the flow required for the hydro power project to be released. One of these schemes, Mnyongani, overlaps the South Rukuru Left bank command area, and would supply water for 1,686 ha of irrigation. There is also the potential to increase the storage capacity in these dams to allow water to be released into the South Rukuru River, and still allow the Right Bank canal to command its 1,900 ha, without disruption of the hydro plant generation.

A total of 4,769 ha can be irrigated from the five schemes, with a storage capacity of 44.6 Mm^3. Therefore there is capacity for the co-existance of the Fufu Hydro power project along with considerable irrigation potential. The hydrology and available water resources needs to studied in more detail, looking at the whole South Rukuru basin and all storage potential before a definitive answer can be made. These schemes are listed in Table 52, with the layout of all schemes in Figure 65.

Table 52: Identified Irrigation Schemes for Rumphi District

District	Scheme Name	PIA (ha)	Storage Volume (Mm^3)	FSL (m asl)	IRR %	Ranking #
Rumphi	Chipofya Diversion	686	0		27%	5
Rumphi	Zyalunga	558	5.69	1182	6%	58
Rumphi	Chisimika	597	6.44	1322	3%	58
Rumphi	Katuwa	1,242	13.59	1283	13%	30
Rumphi	Mnyongani	1,686	18.85	1103	12%	34
	Total	4,769	44.6			
	South Rukuru Scheme				11%	31
	Left Bank (17.2 km)	1,000				
	Right Bank (23.0 km)	1,900				

6.6.5 Other Rumphi Hydro Power Projects

There have been suggestions of two further hydro power projects in Rumphi District. The first is located in the narrow gorge, right at the proposed location of the South Rukuru diversion weir, where the main road crosses the river (E597364, N8780004), by Njakwa. This hydro dam would almost flood out almost the entire town of Rumphi, plus about 4,000 ha of agricultural land. The projected power development is in the order of 15MW.

The second suggestion is a dam located at the Vuku Vuku Falls, downstream of Phwezi by 4.0 km, (E 616600 , N 8799569). The dam would flood almost the entire Henga Valley, for about 5,000 ha, and cover much of the proposed irrigation schemes of South Rukuru and Mnyongani. The projected power development would be 20-40 MW. Both these dam locations are shown in Figure 66.

The economic loss of about 9,000 ha of agricultural land is unacceptable, especially for the small hydro potential of just 35-55 MW. Therefore these potential hydro power projects should be removed from the list for good.

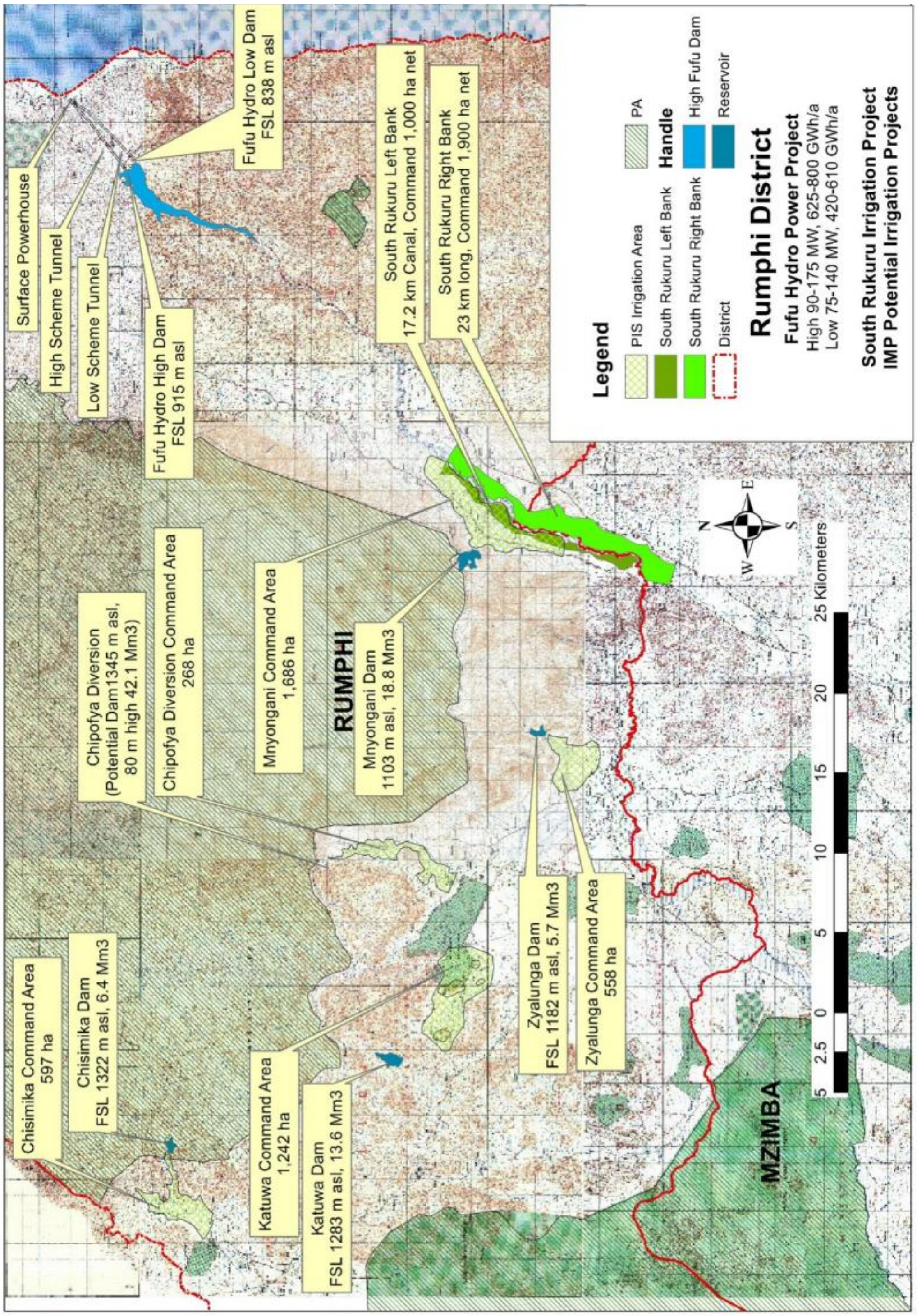


Figure 65: Rumphi District Water Projects

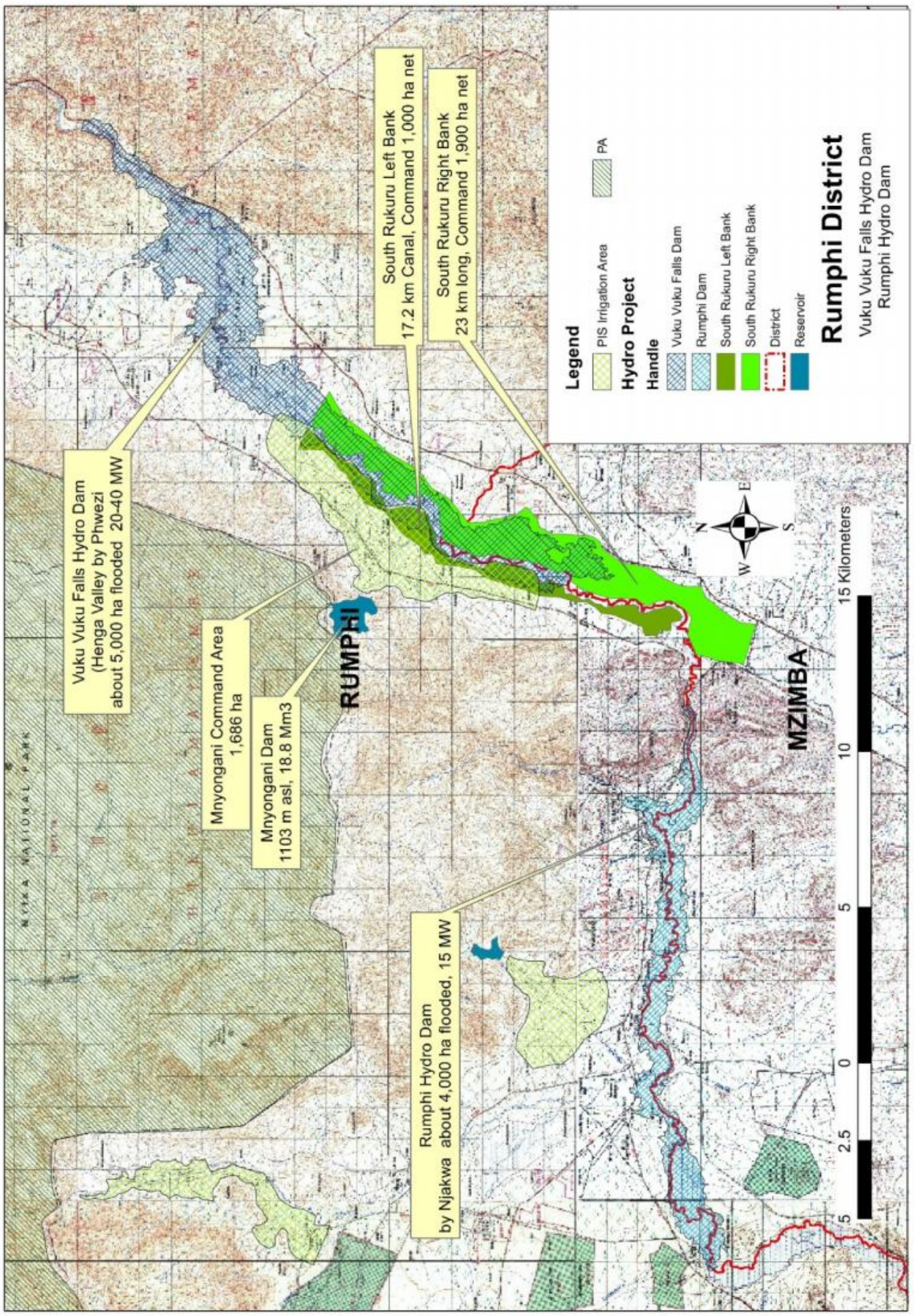


Figure 66: Alternative Rumphi Hydro Power Projects

6.6.6 Summary of Hydro versus Irrigation

A number of schemes involve both hydro power plants and irrigation. In some cases they are complementary, see Section 6.5.1 for a discussion of the alternatives. In some cases they can be competitive and consideration should be give to the most economical use of the water. The above discussions are not meant to be definitive or the last word, but to highlight the issues involved.

In the case of Fufu, this is a high head hydro power, and therefore usually has higher economical value. There is also direct competition for water, and alternatives for water supply should be studied. This can be in the form of alternative schemes, or water storage for irrigation. This will be the subject of further studies.

In the case of SVIP, this is a low head hydro power. The study by Norplan found that the economical value of water for irrigation was higher than the hydro energy and therefore water should be used for irrigation.

The major untapped source of hydro power is the Ruo River on the border with Mozambique. There are at least four hydro sites on this river with two large irrigation areas, Wasi and Ruo-Diversion in Thyolo-Nsanje areas. Below, in Table 53, is a list of schemes involving hydro power and irrigation. There are other instances not included in this list, and some of the identified schemes could also include hydro power when full feasibility studies are carried out.

Table 53: Selection of HPP and irrigation Schemes

Scheme	Power (MW)	Irrigation Area (ha)	Type	Prefered Option
Songwe	175	5,630	complementary	both
Dwambezi	22-50	4,256	complementary	both
Tchanga [/a]	4	1,900	complementary	both
FuFu/South Rukuru	75-140	2,900	competitive	Fufu
Ruo Wasi Dam[/a]	3	1,000	complementary	both
Zoa Falls	20-40	8,700	complementary	both
SVIP	64	42,320	competitive	SVIP

[/a]estimated power, not based on extensive study

7 RATIONALE AND OBJECTIVES OF THE IMP

7.1 Rationale

The fundamental importance of irrigation in the development of Malawi is recognised in successive national development plans including the current MGDS II. However, to date only 94, 000 hectares have been developed for irrigation despite the considerable water resources and irrigable land that exist. The absence of a comprehensive IMP and investment framework has contributed to a fragmented and stop/go approach to irrigation development and the lower-than-expected rate of expansion.

The development of an IMP calls for a systematic and holistic approach to planning. There have been a number of studies conducted on irrigation development interventions but they have been inadequate in scope and coverage to constitute a comprehensive irrigation planning and investment framework. The absence of an IMP has led government and development partners to support isolated feasibility studies for specific irrigation investments without the benefit of a unifying objective, strategy or implementation framework. Consequently Malawi does not have an overarching framework for investments in irrigation, despite the importance of irrigation development in national and sectoral development plans. The absence of such a framework makes it difficult to prepare a long-term financing plan and to harmonise efforts among and between the various sources of finance (government, development partners, private sector, farmers etc.). Integration of the IMP within the ASWAp framework is therefore a key element of the approach and will ensure an appropriate balance between irrigation and other dimensions of agricultural sector development.

Malawi has both a great need for irrigation development and great potential. The country is heavily dependent on rainfed agriculture and highly vulnerable to both short-term rainfall variability and long-term climate change. During the last decade national maize production averaged 2.9 million tonnes, above the self-sufficiency level of around 2.5 million tonnes, but varied between 1.2 million tonnes in 2004-05 and 3.9 million tonnes in 2010-11. Most rural households grow only one crop per year, and are underemployed during the long dry season when no crops are grown. The result is fragile national and household food security and persistent high levels of poverty and malnutrition in a context of rapidly growing population (projected to reach 30 million by 2035) and food demand. A very small fraction of agricultural land is irrigated although irrigation has the potential to increase yields substantially and provide at least two crops per year, thereby generating attractive financial and economic returns as well as assuring sustained food security. Complementary investment in rainfed agriculture in catchment areas has the potential to further improve returns through initiatives such as conservation agriculture, drought tolerant crop varieties, improved agronomic practices, integrated soil fertility management, catchment management and improved access to weather and climate information.

Although the pace of irrigation development has been disappointing many lessons have been learned to guide the approach in future. Recent experience demonstrates that Malawi can implement irrigation development successfully both large scale commercial schemes and smallholder-based approaches. There have been successes and failures in both categories, the reasons for which are fairly well understood. In particular, it has been found that successful irrigation development is much more than just designing and constructing schemes. It requires an approach which addresses diverse and often complex legal, institutional, technical, marketing, social and economic issues in a balanced and holistic manner. Other lessons learned and their implications for the IMP are summarised in Box 2 below.

Box 2: Lessons Learned from Recent Experience

- Malawi's large number of small and micro irrigation schemes place heavy demands on supporting institutions and suggests that larger schemes, or at least clustering of small and micro schemes may deliver better outcomes.
- Irrigation places heavy demands on Malawi's capacity to finance its development aspirations. However, impact assessments demonstrate that smallholder irrigation can be an effective instrument for sustainable poverty reduction.
- Malawi's major development partners are the main source of finance for irrigation investments. Outside the sugar and tobacco sectors, private investment in irrigation has been limited.
- Irrigation development is very demanding on institutional and human resources calling for an approach where government focuses its resources on a coordinating and facilitative role.
- Institutional responsibilities for irrigation development have been unstable. The lack of clear/stable lines of responsibility has not been conducive to the development of the irrigation sub-sector.
- Early stakeholder consultation and sensitisation is important to create understanding and confidence, make farmers aware of what they are expected to contribute, and to build ownership and commitment. In particular, land tenure issues must be addressed early in the life of a project.
- A "whole catchment" approach is key to the sustainability of irrigation schemes.
- Generally gravity schemes have performed better than pump schemes in terms of costs and sustainability.
- Malawi has limited capacity to undertake high quality irrigation system design, making it necessary to source design expertise internationally. There is also a shortage of competent and well-financed construction contractors.
- Multiple cropping with high value crops and due attention to marketing issues is essential to generate economic returns which justify the high level of investments in irrigation systems.

Malawi has no shortage of land suitable for irrigation. Whilst there are currently abundant un-used water supplies in some WRAs and in the country as a whole, the draft Water Resources Master Plan (2015-35) demonstrates that the amount of water available for irrigation will become limiting in some seasons and some WRAs during the life of the IMP when the requirements for hydro-power, domestic and industrial use, and environmental flows are considered. Irrigation will remain by far the largest user of water in the country, which highlights the importance of water use efficiency in irrigation as a major pillar of water resource management. Upgrading or augmentation of existing schemes and proper attention to O&M can achieve significant improvements in irrigation efficiency, making more water available for further expansion and/or alternative water uses. This will become more important as temperatures rise and crop water consumption increases, possibly in combination with increased rainfall but increased evapotranspiration leading to increasing drought frequency.

Exports are an important objective for the semi-commercial and commercial farming sub-sectors. The contribution of the agricultural sector to Malawi's exports is commonly around 90% of which the major items are produced under irrigation, especially tobacco, sugar and tea. Irrigation therefore plays a crucial role in financing Malawi's imports, with the potential to play an even greater role in the future and which could make a significant contribution to overall economic growth and employment.

Irrigation also offers opportunities for diversification of agricultural production and a shift towards higher value products. The rainfed sub-sector is dominated by production of food staples including maize, groundnuts, pulses and root crops, reflecting smallholder farmers' primary concern with household food security. Irrigation greatly increases the range of potential crops and includes some high value options such as green maize and vegetables grown in the dry season.

Water storage and regulatory structures designed primarily for irrigation can also generate significant benefits in terms of domestic water supply, fisheries/aquaculture and flood protection.

Low and declining size of landholdings is also a significant element of the rationale for irrigation development. Around half of all rural households have less than 0.7 hectares of rainfed crop land which is insufficient to provide a year-round supply of staple food and leaves little capacity to generate cash income. Access to even a small area of irrigated land can dramatically improve the food security of such households and provide significant nutritional benefits through dietary diversification.

The private sector has shown that it is prepared to invest in irrigation development for production of cash crops on commercial estates, including outgrower schemes in some cases. Attracting further investment from the private sector, possibly through public-private partnerships (PPPs), will be essential to meet the cost of the IMP, estimated to be around US$ x billion. The proposed large scale developments in the Shire Valley will need to be substantially private-sector funded, leaving GoM and development partner resources free to finance medium, small and micro-scale schemes.

The overall goal of the irrigation sub-sector[17] is to contribute to sustainable economic growth and development by enhancing irrigated agricultural production for improved national and household incomes, food and nutritional security. The broad objectives include:

- increase land under sustainable irrigation farming;
- extend cropping opportunities and facilitate crop diversification under both total and supplemental irrigation;
- create an enabling environment for irrigated agriculture;
- optimise government investment in irrigation development;
- enhance capacity for irrigated agriculture in the public and private sectors; and
- promote a business culture in the small-scale irrigated agriculture sector.

Whilst the importance of irrigation is not questioned, it is recognised that development of the sub-sector is not the whole solution to Malawi's agricultural sector challenges. The great majority of

[17] Department of Irrigation Strategic Plan 2011-16

rural households and the bulk of food production currently comes from rainfed agriculture where there is potential for low-cost improvements in agricultural technologies and productivity. Irrigation development is unavoidably capital intensive when compared with rainfed agriculture, but it is seen as part of the solution which complements investments in rainfed agriculture, livestock, fisheries and forestry.

7.2 Objectives, Components and Expected Results

The logical framework (logframe) shown in Section 7.4 presents the IMP goal, objectives, outcomes and outputs together with milestone indicators to be used in monitoring progress, the means of verification, and important risks and assumptions underlying the design of the master plan.

The logframe shows that the **overall goal** of the IMP is to contribute to the MGS II objective "*to continue reducing poverty through sustainable economic development and infrastructure development*". The two key indicators of goal achievement will be: (i) the percentage of rural households below the poverty line; and (ii) the Malawi human development index.

The development **objectives** of the IMP are to "accelerate economic growth, reduce rural poverty, improve food security and increase exports". These objectives recognise the multi-functional nature of irrigation investment with different development modalities addressing different objectives. The four key indicators for assessing the achievement of these objective are: (i) the percentage contribution of irrigated agriculture to GDP; (ii) the prevalence of poverty in irrigated versus rainfed areas; (iii) the percentage of food secure households in irrigated versus rainfed areas; and (iv) the value of exports derived from irrigated agriculture.

The master plan has four **components**, each expected to deliver one specific outcome:

Component	Expected Outcomes
1. New Irrigation Development	• Area of irrigated land increased from 94,000 ha to 210,000 ha
2. Sustainable Irrigation Management	• Land and water resources efficiently and sustainably utilised
3. Capacity Building	• National capacity for irrigation development enhanced
4. Coordination and Management	• IMP efficiently and effectively managed

Component 1 will focus on the identification, design and construction of new irrigation schemes up to a maximum of 210,000 hectares as envisaged in the Draft Water Resources Master Plan. This represents an average development rate of almost 6,000 hectares per annum which is considered to be at the upper end of Malawi's capacity to develop new irrigation schemes. Performance of Component 1 will be assessed according to two key performance indicators:

- Records of irrigated land area by WRA, district and irrigation typology.
- Investment cost per irrigated hectare.

Component 2 will focus on the operation and management of both new and existing irrigation schemes to ensure that land and water resources are efficiently and sustainably utilised. Performance of Component 1 will be assessed according to three key performance indicators:

- Cropping intensity (%) on irrigated land – a measure of the efficiency with which irrigation land is used, with a maximum of 200% representing all land cropped in both wet and dry seasons.
- Volume (m^3) of water used per irrigated hectare – a measure of water use efficiency.
- Volume (m^3) of water used per kg of crop (for cane ton water/ton cane) – a measure of water use efficiency.
- Net value of production per irrigated hectare and per m^3 of water – a measure of economic efficiency.

Component 3 will address Malawi's irrigation development capacity constraints, specifically human resources, finance, institutional capability and the full range of facilities and services needed to achieve the planned rate of irrigation system development and operating standards defined in Components 1 and 2. Performance of Component 3 will be assessed according to a single key performance indicator:

- Hectares of irrigation schemes designed, constructed and operating satisfactorily (defined as a cropping intensity of at least 170%).

Component 4 will develop and/or strengthen procedures for effective coordination, governance, management, monitoring and evaluation of the IMP over the 20-year life of the programme with emphasis on the first ten years. Performance of Component 4 will be assessed according to:

- The performance of IMP implementation relative to rolling annual workplan and investment framework targets.

7.3 Targets and Indicators

Component 1 targets are specified in terms of the annual amounts of land developed for irrigation with the aim of increasing from 94,000 ha to 210,000 ha over twenty years. In view of the long lead-times involved in conducting feasibility and design studies and scheme construction, and the need to build national capacity, the annual targets are expected to increase gradually from the current (last five year average) level of around 4,000 ha per annum to reach around 6,000 ha per annum after 7-10 years.

There are also target levels of investment per hectare developed to avoid the risk of pursuing the area targets regardless of cost. The target is for at least half of the irrigated area to be developed for an investment of less than US$ 10,000 per ha and for no scheme to cost more than US$ 15,000 per hectare. This will ensure that the best schemes are given the priority they deserve, and that all irrigation investments achieve the hurdle of 10% economic internal rate of return (EIRR).

Component 2 targets concern the need to achieve satisfactory levels of operational and economic efficiency on both existing and new irrigation schemes in order to generate satisfactory financial and economic outcomes. Again, this aims to avoid the risk that of over-emphasising the investment part of the Master Plan without due consideration to operational issues. Three operational efficiency targets have been defined:

- Cropping intensity on irrigated land is maintained at a minimum of 170% from the third year of scheme operation onwards.

- The amount of water used (m^3) per irrigated hectare does not exceed design estimates by more than 10% and in no case should irrigation efficiency be less than 50%.

- The average net value of production should be at least US$ 2,750 per irrigated hectare (gross margin/ha) and at least US$ 0.20 per m^3 of water used.

Component 3 targets concern enhancement of the level of national capacity for irrigation development. Since capacity is multi-dimensional it is not possible to define a single quantifiable target for capacity enhancement. The proposed target for Component 3 is therefore a combination of the Component 1 target for irrigation scheme development and the Component 2 targets of operational efficiency, and is defined as:

- Hectares of irrigation schemes designed and constructed (within the Component 2 investment cost thresholds) and operating satisfactorily (according to the Component 3 efficiency criteria).

Component 4 does not have specific and measurable targets of its own since is measure of performance is the degree to which the targets of Components 1-3 are achieved, their timeliness and cost effectiveness.

7.4 Logical Framework

Results Hierarchy	Milestone Indicators a/	Means of Verification	Risk and Assumptions
Goal: Contribute to MGS II objective "to continue reducing poverty through sustainable economic development and infrastructure development"	• % of rural households below the poverty line • Malawi human development index	• Poverty assessments in periodic integrated household surveys • Annual MGDS II monitoring reports • MDG monitoring reports	• National development plans will continue to give high priority to rural and agricultural development
Development Objective: Accelerate economic growth, reduce rural poverty, improve food security and increase exports	• Contribution of irrigated agriculture to GDP (%) • Prevalence of poverty in irrigated vs rainfed areas • % of food secure households in irrigated vs rainfed areas • Value of exports derived from irrigated agriculture	• Disaggregation of agricultural sector GDP into irrigated and rainfed sub-sectors • Periodic integrated household surveys • National export statistics	• GoM maintains policy settings that favour allocation of resources to development of the irrigation sub-sector • Irrigation farmers have secure tenure of land and access to the required amounts of water
Component 1: New Irrigation Development			
Outcome 1: Area of irrigated land increased from 94,000 ha to 210,000 ha	• Records of irrigated land area by WRA, district and irrigation typology • Investment cost per irrigated hectare	• DoI annual reports showing annual and cumulative No. of schemes and irrigated area	• Water Resources Master Plan allocates sufficient water to irrigate 210,000 ha • Customary landowners are prepared to make land available
Output 1.1: Existing pipeline of schemes and projects consolidated within IMP framework	• Annual and cumulative areas of land developed for irrigation under pipeline schemes and projects	• Database maintained by IMP Management Unit (IMPMU) and DoI annual reports	• Resources are available to maintain irrigation database
Output 1.2: Feasibility studies for identified schemes completed	• No. and area of schemes with feasibility studies (including benefit/cost analysis) completed	• Feasibility study reports and DoI annual reports	• Suitably qualified consultants are recruited to complete feasibility studies
Output 1.3: Detailed irrigation system designs completed	• No. and area of schemes fully designed and costed	• System design documents and DoI annual reports	• Suitably qualified consultants are recruited to complete designs
Output 1.4: Tendering and contracting for scheme construction completed	• No. and value of irrigation construction contracts awarded	• Tender and contract documents and DoI annual reports	• GoM and donor procurement procedures do not delay contract awards

Results Hierarchy	Milestone Indicators a/	Means of Verification	Risk and Assumptions
Output 1.5: Irrigation scheme construction completed	• No. and area of schemes that have completed construction	• Certificates of completion and DoI annual reports	• Capacity of contractors sufficient to construct average 6,000 ha/year to acceptable standards
Output 1.6: Irrigation schemes commissioned	• No. and area of new schemes commissioned and operating • No. of farmer beneficiaries growing irrigated crops	• DoI annual reports	• Procedures are in place for land allocation and system operation
Component 2: Sustainable Irrigation Management			
Outcome 2: Land and water resources efficiently and sustainably utilised	• Cropping intensity (%) on irrigated land maintained at >170% • m^3 of water per irrigated ha no more than 10% above design estimates and irrigation efficiency >50% • Net value of production per irrigated ha >US$ 2,750 and per m^3 of water > US$ 0.20	• Annual reports for each scheme on cropping patterns, water use, production and sales of agricultural commodities	• Farmers are prepared to use water-efficient irrigation methods and grow high value crops.
Output 2.1: Existing schemes upgraded/rehabilitated	• Records of upgraded schemes by irrigated area, WRA, district and irrigation typology	• DoI annual reports on scheme upgrades and costs	• Benefit-cost analysis demonstrates that upgrading/rehabilitation is a worthwhile investment • Farmers are prepared to contribute to costs
Output 2.2: Improved catchment management to reduce siltation	• % of land in catchments cultivated using good agricultural practices (GAPs) • Siltation rate in dams and irrigation structures	• MoAIWD records on adoption rate of GAPs in scheme catchments • DoI estimates of capacity loss in dams and irrigation structures	• The majority of farmers in catchment areas are willing to adopt sustainable GAPs which reduce erosion rates
Output 2.3: Farmer skills in irrigated crop production enhanced	• No. of extension workers (Govt and NGO) receiving training of trainers (ToT) • No. of farmer person-days of training provided	• MoAIWD and NGO staff training records • MoAIWD farmer training records	• MoAIWD Extension Department is able to provide the required ToT and farmer training services

Results Hierarchy	Milestone Indicators a/	Means of Verification	Risk and Assumptions
Output 2.4: Satisfactory O&M of new and existing schemes	• No. of WUAs established and collecting water charges to finance O&M	• Annual reports and accounts of WUAs	• WUAs and WUA members are committed to take full responsibility for O&M
Output 2.5: Farmers have reliable access to markets	• % of irrigation farmers satisfied with market access	• Farmer satisfaction surveys	• Access to markets is given due consideration in selection of schemes
Component 3: Capacity Building			
Outcome 3: National capacity for irrigation development enhanced	• Hectares of irrigation schemes designed, constructed and operating satisfactorily (CI >170%)	• DoI annual reports	• Irrigation sub-sector stakeholders recognise the importance of capacity building
Output 3.1: Lead responsibility for irrigation development assigned to a single institution	• GoM funding for irrigation development is channelled through one institution	• GoM budget and annual audit reports	• GoM is prepared to rationalise leadership of irrigation development
Output 3.2: Lead institution has adequate staff levels and budget	• Number of established and vacant staff positions • Allocation to irrigation at least x% of agriculture budget	• Staffing records • Annual financial reports	• GoM and development partners are able to provide the necessary funding for staff and operations
Output 3.3: Human resources for irrigation development enhanced	• No. of diploma, bachelor and masters graduates in irrigation engineering and related fields	• Graduation records • GoM, private sector and NGO employment statistics	• Training institutions area able to increase the number of students in irrigation-related courses
Output 3.4: Best-practice design, construction and operating standards widely used	• Irrigation guidelines, standards and codes of practice prepared and maintained • Accreditation scheme for contractors, consultants and service providers established	• Documents and resource materials prepared and disseminated to stakeholders • Records of numbers and qualifications of individuals accredited	• Contractors, consultants and service providers accept the need for standardisation and are prepared to undergo accreditation
Output 3.5:WUAs with capacity to take responsibility for scheme O&M	• No. of WUA members and office-holders trained and competent to manage schemes	• DoI training records • Minutes of WUA meetings and financial records	• GoM maintains policy of delegating responsibility for scheme management to WUAs
Output 3.6: Financial resources mobilised to achieve target levels of irrigation investment	• Rolling five year funding commitments by financier (GoM, donors, private sector etc.) • Annual and cumulative spending	• TWG monitoring of financial commitments and disbursements • GoM budget and accounts • Country assistance strategies of	• GoM maintains CAADP target of 10% of budget to agriculture • Private sector is prepared to engaged in PPPs for irrigation

Results Hierarchy	Milestone Indicators a/	Means of Verification	Risk and Assumptions
	on irrigation investments	development partners • Project financing agreements and disbursement records	• Development partners continue to support irrigation investment
Component 4: Coordination and Management			
Outcome 4: IMP efficiently and effectively coordinated, governed, managed, monitored and evaluated	• Performance of IMP implementation relative to rolling annual workplan and investment framework targets	• Annual workplans and budgets • Annual reports showing planned/actual performance	• Enabling (policy, legal and regulatory) environment is conducive to IMP implementation
Output 4.1: IMP officially adopted and integrated in national development plans	• Cabinet-level adoption of IMP by GoM and integration in the MGDS and ASWAp	• Cabinet minutes • MGDS and ASWAp documents	• Irrigation development continues to receive high priority in national and sectoral plans
Output 4.2: Effective and transparent governance of IMP implementation	• Creation of multi-stakeholder IMP Steering Committee (IMPSC) to oversee IMP implementation	• TWG meeting attendance records and minutes	• MoAIWD and development partners continue to support the ASWAp and its TWGs
Output 4.3: Effective and efficient day-to-day management of IMP implementation	• IMP Management Unit (IMPMU) takes full responsibility for IMP implementation	• Semi-annual and annual IMPMU reports	• Responsible ministry is prepared to delegate implementation responsibility to the IMPMU
Output 4.4: IMP effectively monitored and evaluated	• Comprehensive M&E system designed and fully operational	• Semi-annual and annual M&E reports • Periodic independent external reviews of IMP implementation	•

a/ All indicators to be gender disaggregated

8 COMPONENTS OF THE IMP

8.1 Overview

Figure 67 presents an overview of the IMP. It consists of four mutually supporting components including the development of selected new irrigation schemes, sustainable management of existing schemes, building the capacity of Malawi's relevant institutions and human resources, and management of master plan implementation.

The IMP will be implemented in three phases: Phase I (2015-2020), phase II (2021-2025) and Phase IIi (2026-2035) comprising approximately 20,000 hectares, 28,000 hectares and 70,000 hectares of new irrigation schemes in Phases I, II and III respectively. These targets comprise a combination of schemes already in the pipeline and new schemes which have been identified as part of the IMP process but are yet to undergo feasibility and design studies. Phase I will be used to consolidate existing initiatives under the IMP framework, and management arrangements, and will account for the majority of the 20,000 hectares planned for this period.

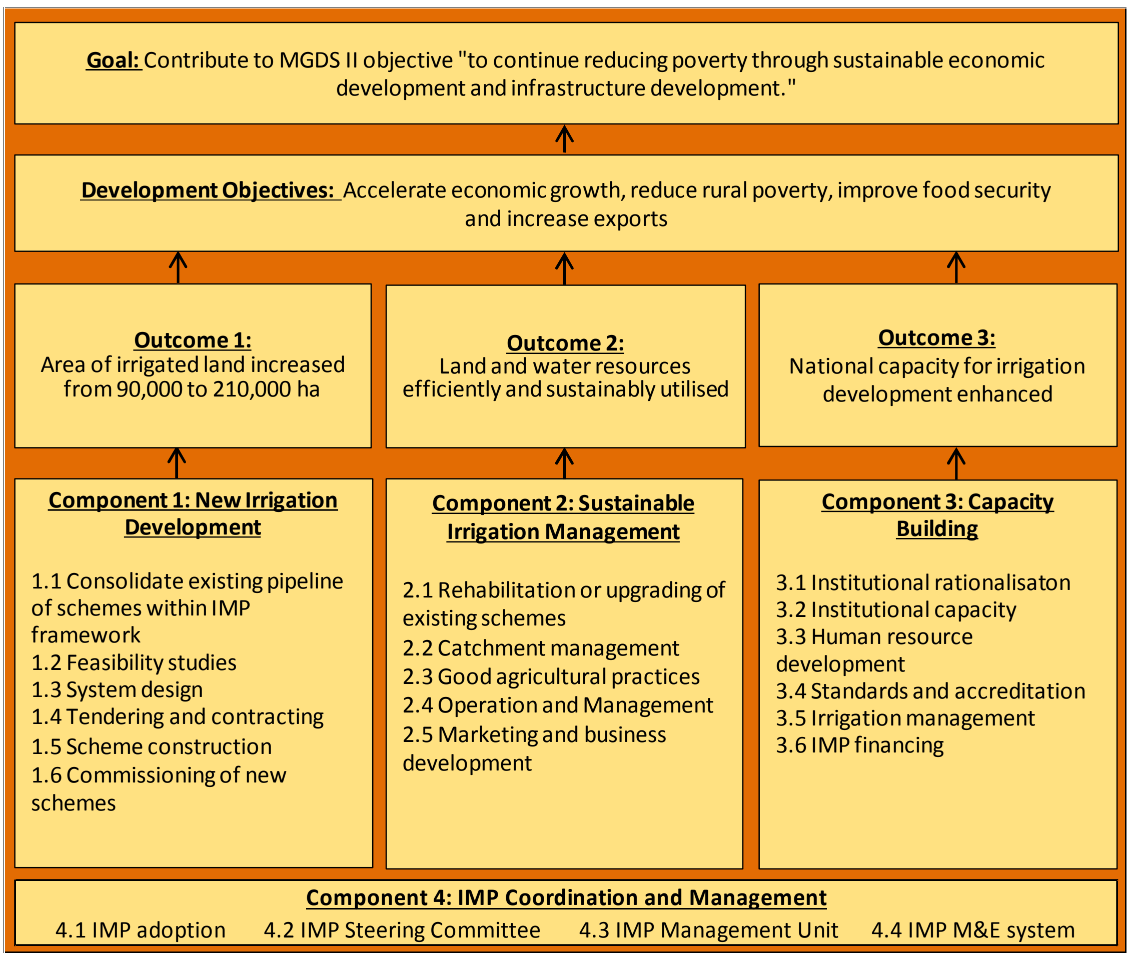


Figure 67: Overview of the Irrigation Master Plan

8.2 Component 1: New Irrigation Development

Assessment of irrigation potential in Chapter 5 reveals that Malawi's land and water resources are such that the maximum area of irrigation land which could be developed and sustainably managed is around 297,000 hectares of which 94,000 hectares had been developed by 2013. Taking into consideration growing demand for water from other sources (domestic, industrial, hydropower, and environmental flows), the importance of selecting schemes which generate the best social and economic benefit streams, the likely impacts of climate change, and Malawi's capacity to finance and implement new schemes as well as manage existing ones, the IMP aims to reach a total irrigated area of **210,000 hectares by 2035**, or an increase of 116,000 hectares over the IMP period, equal to around 5,500 hectares/year. This is consistent with the allocation of water resources among the various competing uses outlined in the Draft Water Resources Master Plan.

Component 1 includes six Sub-Components as shown in Table 54 below. Sub-Component 1.1 involves the consolidation of the existing pipeline of irrigation schemes and projects in various stages of planning and implementation under the IMP framework. The remaining five Sub-Components will develop new schemes through a planning cycle involving feasibility studies, system design, tendering and contracting, construction and commissioning.

Table 54: Component 1: New Irrigation Development

Sub-Component	Output	Milestone Indicators
1.1 Consolidation	• Existing pipeline of schemes and projects consolidated within IMP framework	• Annual and cumulative areas of land developed for irrigation under pipeline schemes and projects
1.2 Feasibility Studies	• Feasibility studies for identified schemes completed	• No. and area of schemes with feasibility studies (including benefit/cost analysis) completed
1.3 System Design	• Detailed irrigation system designs completed	• No. and area of schemes fully designed and costed
1.4 Contracting	• Tendering and contracting for scheme construction completed	• No. and value of irrigation construction contracts awarded
1.5 Construction	• Irrigation scheme construction completed	• No. and area of schemes that have completed construction
1.6 Commissioning	• Irrigation schemes commissioned	• No. and area of new schemes commissioned and operating • No. of farmer beneficiaries growing irrigated crops

Implementation of new programmes and projects will take place in parallel with Sub-Component 1.1 to build a balanced and mutually supporting portfolio of irrigation investments across the country. This will include a combination of hard and soft components, and a balance between different types of irrigation investment which address the different dimensions of the IMP objectives. The portfolio will integrate the four main initiatives currently under design: (i) MIDP II which will focus on capacity building; (ii) PRIDE which will invest in smallholder irrigation schemes; (iii) SVIP which will involve major investments in the Shire Valley comprising both commercial and smallholder schemes; and the Songwe River Hydro-Power and Irrigation Scheme on the border between Malawi and Tanzania.

New schemes identified during the IMP design will be subject to a systematic process of feasibility studies (Sub-Component 1.2), detailed system design (Sub-Component 1.3); tendering and contracting (Sub-Component 1.4), construction (Sub-Component 1.5) and commissioning (Sub-Component 1.6). This process will be overseen by the IMP Steering Committee (IMPSC – see Sub-Component 4.2) and coordinated by the IMP Management Unit (IMPMU – see Sub-Component 4.3) and will employ best-practice design, construction and operating standards to be developed under Sub-Component 3.4. Schemes will include large scale commercial farms such as those proposed under SVIP, often with associated outgrower arrangements; medium scale commercial farms; smallholder schemes and informal dambo irrigation development as described in Section xx.

8.3 Component 2: Sustainable Irrigation Management

The IMP recognises Malawi's mixed track record with regard to sustainability of irrigation schemes and the lessons learned from recent experience. Planning new schemes under Component 1 will respond to the sustainability challenge by employing a screening/selection process that includes sustainability criteria, early community engagement and participatory approaches to system design, and use of simple irrigation technologies with affordable recurrent cost regimes. Under Component 2, the key requirements for sustainability of both new and existing schemes will be addressed through: (i) remedial investments in schemes which are not functioning properly or are at risk of falling into disrepair: (ii) complementary measures to improve agricultural productivity and reduce soil erosion rates in catchment areas; (iii) promotion of good agricultural practices (GAPs) through farmer training in irrigation methods and climate-resilient agronomic practices to enhance productivity and profitability, and generate the cash incomes needed to finance system O&M; (iv) creation and/or support for community groups such as WUAs and Cooperatives which have the capacity to sustainably manage system O&M on a cost recovery basis; and (v) the development of commercial linkages to ensure that farmers have access to the inputs they need and to reliable and profitable markets for their produce. Component 2 therefore includes five Sub-Components as shown in Table 55 below.

Table 55: Component 2: Sustainable Irrigation Management

Sub-Component	Output	Milestone Indicators
2.1 Rehabilitation or Upgrading	• Existing schemes upgraded/ rehabilitated	• Records of upgraded schemes by irrigated area, WRA, district and irrigation typology
2.2 Catchment Management	• Improved catchment management to reduce siltation	• Percent of land in catchments cultivated using good agricultural practices (GAPs) • Siltation rates in dams and irrigation structures
2.3 Good Agricultural Practices	• Farmer skills in irrigated and rainfed crop production enhanced	• No. of extension workers (Government and NGO) receiving training of trainers (ToT) • No. of farmer person-days of training provided
2.4 Operation and	• Satisfactory O&M of	• No. of WUAs established and collecting

Sub-Component	Output	Milestone Indicators
Maintenance	new and existing schemes	water charges to fiancé O&M
2.5 Marketing and Business Development	• Farmers have reliable access to markets	• Percent of irrigation farmers satisfied with market access

Sub-Component 2.1: Rehabilitation and/or Upgrading of Existing Schemes

Rehabilitating existing schemes can generate attractive social and economic returns due to the lower level of investment compared to new schemes. The key to success is to identify the reason(s) why rehabilitation is needed and ensure that these are addressed in order to avoid repeating the cycle of deterioration and rehabilitation. In Malawi there is usually a combination of social, organisational and technical factors underlying the need to rehabilitate and work should only proceed when there is broadly-based stakeholder consensus on the nature of the problems and how to solve them to ensure future sustainability.

The causes of declining functionality of irrigation schemes in Malawi include: (i) ambiguities or misunderstandings about the legal responsibility for O&M; (ii) recurrent budget constraints on Government-operated schemes; (iii) poor design and construction standards leading to high O&M costs; (iv) reluctance of farmers to accept responsibility for O&M, particularly on Government or former Government schemes; (v) disputes over access to land and water and legal responsibility for O&M; (v) market access problems limiting cash generation to finance O&M, exacerbated by the tendency to grow low-value staple food crops; and (vi) natural disasters such as floods which can cause major damage to structures and equipment. Sustainable rehabilitation requires these causes to be identified and addressed within the context of a well-planed rehabilitation investment framework.

Under the IMP the inventory of irrigation schemes in the country will be systematically screened to identify those in need of rehabilitation and/or upgrading, and select the best candidates using the same multi-attribute ranking criteria as for new schemes. In most cases rehabilitation will involve a combination of hard (physical) and soft (organisational) investments both designed case-by-case. Participatory methods will be used to develop rehabilitation plans which beneficiaries are prepared to contribute to (in cash or kind) and accept responsibility for. Particular attention will be given to the legal and institutional arrangements for financing and ongoing operation of rehabilitated schemes, with consideration of opportunities for partnerships with the private sector. It is recognised however, that in cases where stakeholders are not prepared to address the root cause of the problem that sustainable rehabilitation is not possible and the best approach is to do nothing.

In many cases rehabilitation also offers opportunities for upgrading or augmentation to create a scheme that is better than the original one. Where dry season cropping is limited by water availability increased storage capacity and/or reduced distribution losses (eg by lining canals) can greatly improve overall performance. Upgrading of functional schemes can also offer opportunities to improve system performance by use of improved technologies and operating procedures and conversion of informal to formal schemes.

The IMP target for irrigation rehabilitation is estimated to be xxx hectares during Phase I. This target will be refined once the inventory of existing schemes has been assessed to identify priorities for rehabilitation.

Sub-Component 2.2: Catchment Management

IMP will work with entire catchments, not just the irrigated portion downstream of dams and diversion structures. The rationale for this approach is to reduce erosion and siltation rates in irrigation systems and ensure that entire rural communities benefit, not just the households who have access to irrigated plots. Each of the selected schemes will therefore incorporate sustainable land and water management practices in its catchment area including the rehabilitation of degraded lands using the hotspot approach[18]. Landholders in the catchment areas will be engaged to develop participatory catchment management plans to promote benefit-sharing through improving soil and water conservation and hence productivity for the rainfed areas whilst ensuring water security and protecting irrigation infrastructure.

Catchment management activities to be promoted include: (i) conservation agriculture (CA) techniques to reduce runoff and improve crop yields; (ii) replanting or natural regeneration of forested areas; (iii) vegetated bunds for erosion control; (iv) tree nurseries and woodlots to provide fuelwood and reduce rates of deforestation; (v) reduced cultivation of land along riverbanks; and (vi) appropriate water harvesting technologies. All of these will support smallholder rainfed farmers to adopt sustainable intensification and climate-resilient farming systems whilst reducing sedimentation rates and extending the life of irrigation schemes.

Sub-Component 2.3: Good Agricultural Practices

Successful irrigation development depends on the adoption of intensive cash crop production in irrigated areas as well as sustainable intensification of agriculture in the catchment areas based on CA and integrated soil and water management regimes. Both of these require farmers to adopt improved agricultural practices. This calls for a well-coordinated farmer training effort to complement the investments in irrigation system development.

Crop intensification will be enabled by sensitisation and building the capacity of farmers and farmer groups, the dissemination of proven appropriate technologies, timely supply of farm inputs (seed, fertilsers and agro-chemicals) and establishing linkages between farmers and markets (see Sub-Component 2.5). Schemes implemented under the IMP framework will incorporate measures to sustainably enhance agricultural productivity on both irrigated and rainfed lands using simple and affordable GAPs that are suitable for smallholder adoption and will help to bridge the gap between actual and potential yields.

Farmers will be trained to adopt GAPs that sustainably improve crop yields, improve soil health, reduce erosion rates, and enable greater crop diversification and commercialisation. IMP schemes will also support farmers in obtaining access to the inputs needed to employ GAPs including tools, equipment, seeds, fertilisers, financial services and post-harvest storage and handling facilities. The focus will be on simple but effective ways of improving productivity and the benefits of producing

In most catchment areas a high proportion of the silt load comes from a relatively small number of severely degraded sites known as hotspots. Focusing erosion control measures on these hotspots is a highly effective means of reducing siltation rates.

high value cash crops in irrigated areas and climate-resilient GAPs in the catchments. IMP schemes will employ a range of approaches and methodologies to promote the adoption of GAPs including:

- **Farmer Group Development** involving the formation, sensitisation and capacity building of farmer groups in both irrigated and rainfed areas. This will employ participatory methods to strengthen the organisation and management capacity of farmer groups including the formation of formal associations (WUAs) and cooperatives.

- **Training for Technical Staff** of DoI, the Department of Agricultural Extension (DAES) and other technical departments of MoAIWD to improve their knowledge of irrigated and rainfed agronomy, and climate-resilient GAPs based on the principles of CA, as well as enhancement of their extension and communication skills.

- **Improved Extension Services** based on low-cost farmer-to-farmer extension networks which have proven successful under IRLADP and other programmes in Malawi and are widely used by NGOs. This involves engagement of lead farmers who are responsible for overseeing demonstration plots on farmers' fields and the organisation of field days, farmer field schools (FFSs) and farmer business schools (FBSs) to raise awareness and understanding of GAPs. Lead farmers will be provided with training in management of demonstration plots and basic agronomy and GAPs especially including CA methods, and enhancing their communication skills.

- **Extension Programme Management:** Under IMP schemes service providers (including but not limited to NGOs) will be engaged to coordinate and support the proposed farmer-to-farmer extension network. The service providers will recruit and supervise field officers and lead farmers in the conduct of demonstrations, field days and FFSs.

The adoption of GAPs requires more than just awareness raising and training. Many farmers in Malawi are aware of improved technologies and prepared to adopt them, but are discouraged from doing so because of the non-availability of un-affordability of key inputs. IMP schemes will therefore facilitate the establishment of linkages between WUAs/rainfed farmer groups and agro-dealers for access to the inputs needed for GAPs. Other complementary activities may include seed multiplication and distribution by contract seed growers, improved post-harvest management, and livelihood diversification options such as aquaculture and small livestock.

Sub-Component 2.4: Operation and Maintenance

O&M is not a significant concern on larger scale commercial or outgrower schemes, or on micro-scale dambo schemes using very basic technology. However, inadequate O&M is the most common reason for under-performance or failure of smallholder irrigation schemes in Malawi. The IMP therefore incorporates institutional and financing arrangements to provide assured access to land and water and the O&M regimes needed for long-term sustainability. WUAs are the central pillar of this approach.

IMP smallholder schemes will establish a WUA for each scheme as the legal mechanism to transfer irrigation management responsibilities to smallholder farmers. These responsibilities include representation of users, O&M of the system and ownership of the irrigation facilities. WUAs will be formed early in the project life-cycle to facilitate active participation of members in all phases of design and development. WUAs will be formed as private, non-profit, self-supporting, independent entities solely for operation, maintenance and management of irrigation systems. The WUAs will have four main functions: (i) ensuring equitable allocation of land and water resources among members; (ii) collection of water charges and membership fees; (ii) O&M of the irrigation systems; and (iv) resolution of conflicts over access to land and water or other issues. Experience has shown that WUAs can be effective in performing these functions but only after an extended period of support and capacity building.

WUAs have up to a three-tier organisational structure; one for each level of tertiary, secondary and main canal. Membership of WUAs is automatic for all water users holding land in the scheme. Each member has an equal voting right in elections and decision-making. The WUAs have (i) a General Assembly composed of all members; (ii) an Executive Board for day-to-day management; (iii) a Board of Trustees for overseeing the WUA's affairs; and (iv) a Water Jury for resolution of disputes.

IMP schemes will support the formation or strengthening of WUAs. Implementation of rehabilitation and development works will only be carried out after the formation of WUAs. The operationalisation of WUAs will go through three stages: (i) identification and planning; (ii) organisation and preparation; and (iii) formation and establishment/strengthening. These arrangements will be built into the design of all smallholder irrigation schemes developed under the IMP in order to ensure satisfactory and sustainable O&M.

Sub-Component 2.5: Marketing and Business Development

Agricultural commercialisation is essential for successful and sustainable irrigation development at all levels above micro-scale dambo schemes which are essentially about food and nutrition security. This is because it is necessary to generate cash income to finance system O&M and provide an adequate return on investment. The greatest challenges are in smallholder schemes where there is a need to forge mutually beneficial linkages between farmer groups/cooperatives and the commercial agribusiness sector. Outgrower and contract farming arrangements are attractive options, but these generally only work well for industrial crops where there is a single marketing channel.

Detailed recommendations for marketing and business development interventions are provided in Appendix 10. These are based on experience and lessons learned from IRLADP[19] and other irrigation projects in Malawi and provide clear guidance on how marketing challenges should be addressed under the IMP framework. The approach recognises that as well as converting rainfed farmers to irrigation farmers they also need to make the transition from subsistence-oriented to commercial agriculture. This transitional process must be integrated within the overall irrigation development package, not added on later as an afterthought. The IRLADP experience highlights the key success factors with respect to marketing in irrigation scheme development. These include:

- Marketing issues need to be addressed very early in the design of an irrigation scheme or project. From project concept state there should be a clear vision of what the scheme is going to produce and how it will be marketed. This vision should be based on a thorough analysis of marketing opportunities and constraints, so that marketing issues are adequately addressed as part of the software investment.

[19] Posthumus H, Baltissen G, Mweninguwe R, Jan Veldwisch G, and Beekman W (October 2014) Documenting Lessons Learnt of the Irrigation, Rural Livelihoods and Agricultural Development Project

- A marketing plan should be developed in close consultation with the proposed beneficiaries and the local commercial sector before construction begins.

- Market access should be one of the key selection criteria for identification of priority schemes under the IMP. Investment in schemes with poor market access, in remote areas without all-weather roads should be given lower priority.

- Farmer Business Schools (FBSs) have proven effective in changing the mindset of smallholder farmers and improving their marketing and commercial skills. In particular FBSs help farmers to increase awareness of market opportunities and requirements beyond their immediate vicinity.

- Some form of farmer group is usually involved in successful marketing so that produce can be aggregated into saleable parcels that attract interest from buyers. This can be an informal farmer-based organisation (FBO) or a registered cooperative. However the performance of FBOs and cooperatives has been mixed and capacity building support needs to be provided over an extended period.

- Marketing is not an appropriate function for WUAs. WUAs should focus only on collection of fees and O&M of the system.

- Investment in storage, handling and processing (value adding) facilities (eg rice mills) can greatly improve marketing, but only if there are well-planned arrangements for ownership, operation and cost recovery.

- Efforts to improve marketing services provided by MoAIWD centrally and in the districts have met with limited success due to high staff turnover and budget constraints. Developing stronger linkages between farmers, farmer groups and the private sector based on commercial incentives to all parties, is a more sustainable approach.

The design of IMP schemes will incorporate appropriate marketing and business development arrangements based on the above elements including, where relevant, partnerships with micro-finance institution(s) to facilitate the adoption of agricultural practices that require access to financial services. The approach will consider the whole value chain from input suppliers to end users, and the role of smallholder farmers within these value chains. Designing smallholder schemes will involve selection of commodity value chains including: (i) analysis and mapping of value chains – based on the commodities demanded by the market and selected by the smallholder groups; (ii) selection of commodities considered to be most commercially viable for smallholder farmers; and (iii) formulation of action plans prescribing interventions to address specific market access challenges. This will help to establish or strengthen commercial/market linkages for smallholder farmers, including securing contract arrangements.

8.4 Component 3: Capacity Building

The various policies, strategies and plans relating to irrigation development in Malawi consistently acknowledge capacity constraints and the need for further capacity building. This need is also reflected in the assistance strategies of Malawi's development partners. Most donor-supported irrigation programmes include capacity building elements, and in several cases are primarily concerned with capacity building[20]. Despite these efforts there remains a large capacity deficit which will be addressed as an integral part of the IMP.

The capacity challenge is accentuated by the large number of small irrigation schemes in the country, the fragmented approach to irrigation development with many programmes and projects competing for the same resources, and ongoing fiscal constraints which limit the ability of government to develop and retain capacity. Efforts to build capacity have also tended to focus on professional level staff in Government institutions and overlook the capacity needs of non-state actors. Since Government institutions have difficulty in recruiting and retaining well-qualified staff, capacity tends to be lost as quickly as it is developed. This suggests that the IMP should adopt a new approach to capacity building by addressing the specific needs of all stakeholders in the sub-sector as shown in Table xx below, and laying a foundation for long-term sustainability by maximising participation of non-state actors and confining the role of government to certain well-defined areas.

Table 56: Roles and Capacity Needs of Various Stakeholders

Stakeholders	Roles and Principal Capacity Needs
Central Government Ministries (MoAIWD, MoLHUD, MoNREM, MoIT, MoFEPD etc.)	• Policies, planning and strategies • Legal and regulatory supervision • Research and extension • Financing and budgetary control • M&E
District Administrations	• Local-level support for irrigation schemes • Catchment management
Traditional Authorities	• Land allocation and land tenure • Dispute resolution
Farmer Organisations, WUAs, Cooperatives etc.	• Participatory planning of irrigation schemes • Equitable distribution of land and water • Operation and maintenance of irrigation schemes
Training Institutions – Universities, and Technical/Vocational Colleges	• Training of irrigation professionals • Training of technicians
Consultants and Contractors	• Irrigation feasibility and design studies • Construction of irrigation schemes
Professional Institutes (e.g. Board of Engineers)	• Preparation of guidelines, standards and codes of practice • Registration/accreditation of professionals
Agribusiness Enterprises	• Input supplies (agro-dealers) • Market linkages – domestic and export • Agro-processing
Financial Institutions (banks and micro-finance institutions)	• Financial services for farmers and agribusiness enterprises

Component 3 includes six Sub-Components as shown in Table xx below. Sub-Component 3.1 involves rationalisation of Malawi's institutions so that responsibility for irrigation development is assigned to a single national-level institution, and that all GoM funding for irrigation development is channelled through one institution. The remaining five Sub-Components address the various dimensions of

[20] For example, the JICA-supported MIDP II and the EU-supported Component 2 of RIDP II.

capacity including staffing levels and budgets, human resources, standards and accreditation, management of irrigation schemes and financing of the IMP investments.

Table 57: Component 3: Capacity Building

Sub-Component	Output	Milestone Indicators
3.1 Institutional Rationalisation	• Lead responsibility for irrigation development assigned to a single institution	• GoM funding for irrigation development is channelled through one institution
3.2 Institutional Capacity	• Lead institution has adequate staff levels and budget	• No. of established and vacant staff positions • Annual budget allocations
3.3 Human Resource Development	• Human resources for irrigation development enhanced	• No. of diploma, bachelor and masters graduates in irrigated engineering and related fields
3.4 Standards and Accreditation	• Best-practice design, construction and operating standards widely used.	• Irrigation guidelines, standards and codes of practice prepared and maintained • Accreditation scheme for irrigation professionals established
3.5 Irrigation Management	• WUAs with capacity to take responsibility for scheme O&M	• No. of WUA members and office-holders trained and competent to manage schemes
3.6 IMP Financing	• Funding available to meet IMP investment targets	• Rolling five-year funding commitments by financier (GoM, donors, private sector) • Annual and cumulative spending on irrigation development

Sub-Component 3.1: Institutional Rationalisation

Diffusion of responsibility for irrigation development among several institutions needs to be addressed. Due to financial and human resource limitations most of the relevant institutions in Malawi struggle to fulfil their mandates. This is exacerbated by frequent organisational and management changes, and lack of coordination between institutions.

Malawi has two institutions with responsibility for irrigation development: (i) DoI which is a department of MoAIWD; and (ii) the GBI Secretariat which is hosted by the Office of the President and Cabinet (OPC) but has never been officially recognised or gazetted as an instrument of Government, and has limited access to budgetary resources. The dispersal of human and financial resources between these two institutions causes confusion, duplication and inefficiency. Rationalisation of this situation is key to the IMP which embodies a single set of objectives, a single investment framework and needs to be spearheaded by a single institution. It is also important to achieve a greater degree of strategic alignment between the irrigation sub-sector and the overall agricultural sector strategy and investment as defined in the ASWAp. The recent re-integration of DoI into the agriculture ministry is a step in the right direction, but full strategic alignment requires recognition of the IMP as an integral part of the ASWAp.

Sub-Component 3.2: Institutional Capacity

As a signatory to the Maputo Declaration and the Malawi CAADP Compact GoM is committed to allocating at least ten percent of its budget to the agricultural sector. However, the Farm Input

Subsidy Programme (FISP) utilises a large portion of the sector's allocation, leaving limited resources to finance staffing and other recurrent expenditure in MoAIWD, and almost nothing for capital expenditure. Consequently many programmes (including GBI) remain un-funded or heavily dependent on external resources and there is a high level (around 50%) of vacant staff positions. The IMP will address this institutional capacity issue in several different ways: (i) by DoI assuming a facilitatory role, allocating its available resources on policy, planning and oversight activities and avoiding direct involvement in irrigation system development; (ii) by reducing overhead costs through the institutional rationalisation recommended in Sub-Component 3.1; and (iii) by procuring additional funding from external sources via the proposed National Irrigation Development Fund (NIDF) under Sub-Component 3.6.

Sub-Component 3.3: Human Resource Development

The IMP includes a comprehensive and sustained programme of human resource development (HRD) to address critical skill shortages which limit overall sector performance. The HRD effort will be broad in scope to embrace all of the stakeholder groups and include training at different levels ranging from technical and vocational skills normally provided by the Technical Colleges under the auspices of the Technical, Entrepreneurial and Vocational Education and Training Authority (TEVETA); to university course for engineers, agriculturists, hydrologists, sociologists, accountants etc. This will very likely call for capacity building in the training institutions themselves to allow for increased student numbers and the introduction of special courses for irrigation-related skills. A detailed HRD programme will be developed as part of a comprehensive training needs assessment.

In the immediate future Malawi will continue to be heavily dependent on internationally-sourced and funded expertise for feasibility and design studies. However, joint ventures between international and national consulting firms should be encouraged (or mandatory) to accelerate the development of local expertise.

Sub-Component 3.4: Standards and Accreditation

A number of evaluations point to the poor quality and time or cost over-runs of work undertaken by consultants and contractors on irrigation design and construction. This is attributed to lack of specialised skills and experience in hydrology, irrigation engineering and related fields, as well as the absence of an agreed set of standards for irrigation design, construction and operation. Under the IMP a set of standards will be developed covering micro, small and medium scale irrigation schemes including design and construction protocols, sample designs for different types of scheme, and detailed instructions to users. Large scale schemes will be designed according to international best-practice standards. The Malawi Board of Engineers will become the agency responsible for accrediting technicians and engineers in terms of their knowledge of and ability to apply the irrigation standards.

Sub-Component 3.5: Irrigation Management

Irrigation management is one of the important soft investments that will accompany the hard investments in irrigation infrastructure. Experience in Malawi and elsewhere has demonstrated the benefits of investing in irrigation management, or alternatively the costs of not investing adequately, which can result in sub-optimal utilisation of schemes and poor sustainability. The IMP will adopt a balanced approach to irrigation which aims to optimise utilisation of both land and water resources, and in both the irrigated and catchment areas by building the capacity of farmer-based irrigation management institutions.

The irrigation management challenge is greatest on small and medium schemes occupied by smallholder farmers. Micro-scale (dambo) schemes are relatively easily managed by small groups of farmers operating simple low cost equipment. Commercial schemes (with or without outgrowers) are also usually well managed. Government-operated schemes have not performed well and have largely been handed over to farmers to manage. Experience has shown that the management capacity of WUAs, cooperatives or other forms of farmer organisation is critical for efficient operation and sustainability of smallholder schemes.

IMP smallholder schemes will follow best-practice guidelines for capacity building in irrigation management including the following:

- Community sensitisation and mobilisation (CSM) represents the start of activities in a new scheme. This will involve the conduct of Participatory Rural Appraisal (PRAs) in potential scheme villages to develop awareness and agree on an action plan. The CSM methodology, forming and training CSM teams, conducting village PRAs and preparing consolidated action plans will be adopted from IRLADP procedures.

- Formation of a WUA for each scheme as the legal vehicle for irrigation management by smallholder farmers. The WUA mandate includes representation of water users, O&M of the system and ownership of the irrigation infrastructure. WUAs will be formed prior to the start of construction in order to facilitate active participation of their members in all phases of design and development. Experience has shown that WUAs require a sustained period (several years at least) of support and capacity building before they are able to operate independently.

- Capacity building for WUAs (or similar organisations) under IMP schemes will include: (i) development of rules, procedures and constitution; (ii) registration as a legal entity; and (iii) enabling the WUA to take charge of its administrative and management responsibilities to operate the system. WUA leaders will also be trained to monitor the performance of contractors to ensure timely completion of high quality irrigation infrastructure in line with the design.

Sub-Component 3.6: IMP Financing

Implementation of the IMP calls for a systematic approach to mobilising financial resources to support a rolling medium-term (five-year) investment framework. This will replace the current haphazard and unpredictable financing arrangements involving multiple projects and programmes, each funded from different sources under a diverse assortment of financing arrangements. This tends to produce an erratic stop/go pattern of irrigation development driven largely by the availability of funding, rather than a master plan investment framework. Formulation of the IMP is itself an important requirement for defining the financing needs of the irrigation sub-sector and building the capacity to manage a medium term investment framework. Such a framework will accommodate a range of different financing sources, modalities and instruments including various combinations of the following:

Sources	Modalities	Instruments
• Private sector • Investment banks • Beneficiaries (farmers) • Government • Donors • IFIs (WB, AfDB, IFAD etc. • NGOs	• Project finance • Programme finance • Pooled funding with earmarking • Pooled funding • Budget support • PPPs	• Grants • Loans • Equity investments

GoM's preferred financing modality is pooled (basket) funding through the creation of a National Irrigation Development Fund (NIDF). The establishment of NIDF is authorised by the Irrigation Act (2001) and is advocated in Draft National Irrigation Policy and Development Strategy (NIPDS, 2014). The Irrigation Act also authorises the National Irrigation Board to oversee implementation and coordination of irrigation including administration of the NIDF. The objective of the NIDF[21] is to effectively mobilise financial resources to be used by public, private and civil society organisations for sustainable irrigation development. The expected results are: (i) irrigation development in Malawi is funded and implemented in a timely manner without funding gaps; (ii) private sector investment in sustainable irrigation development enhanced; and (iii) irrigation development in Malawi has attracted an increase in funding from development partners and private sector. Detailed design of the NIDF is part of the terms of reference for EU-supported technical assistance to DoI due to be launched in early 2015 and will address the legal setup of the Fund and operational policies and guidelines.

Detailed design of the NIDF should take note of the ASWAp experience as well as lessons learned from pooled/basket funding schemes in other countries of the region. These have not been universally successful. The Malawi ASWAp includes a range of funding modalities from which potential financiers can choose including discrete, earmarked and pooled funding arrangements and various hybrid arrangements including parallel and co-financing. This offers options to financiers who prefer not to pool their funds, or whose policies require strict earmarking in order to ensure traceability of expenditure.

8.5 Component 4: Coordination and Management

The transition from a fragmented project-based approach to a harmonised portfolio of programmes and projects is one of the key themes of the IMP, and will require the current programmes and projects shown in Figure xx to be retrofitted into the Master Plan framework under Component 4, supported by institutional rationalisation and capacity building under Component 3. To the extent possible, subject to the various project financing agreements and in consultation with the development partners, the existing portfolio of programmes and projects will be harmonised and streamlined under a single governance framework, and a unified coordination and management structure. As new projects and programmes come on stream they will also be integrated within

[21] GOPA and Aurecon (February 2013): Guidelines on the National Irrigation Development Facility (NIDF): Mandate, Guiding Principles, Interventions, Institutional and Operational Arrangements. Technical Assistance to the Rural Infrastructure Development Programme – Component II (RIDP II), Malawi

these governance and coordination structures with provision for project-specific Project Management Units (PMUs). Project financing will be harmonised under the proposed NIDF, with provision for a range of different financing sources, modalities and instruments.

IMP Phasing

The IMP will be implemented in three phases: Phase II (2015-2020), phase II (2021-2025) and Phase II (2026-2035). Phase I will be used to consolidate existing initiatives under the IMP framework, and management arrangements, and will account for the majority of the 20,000 hectares of development planned for this period. Ongoing projects that will be completed during Phase I include:

Project/Programme		Completion
Agriculture Infrastructure Support Project	AISP	2015
Climate Adaptation for Rural Livelihoods in Agriculture	CARLA	2015
Rural Infrastructure Development Programme, Phase II	RIDP II	2016
Small Farms Irrigation Project, Phase II	SFIP II	2017
Smallholder Irrigation and Value Addition Project	SIVAP	2018
Strengthening Water Sector M&E Project	SWSM&EP	2018
Shire River Basin Management Project, Phase I	SRBMP I	2019

As the above group of projects comes to completion four new projects currently under various stages of preparation will be launched. In 2015 these include Phase II of the JICA-supported Medium Scale Irrigation Development Programme (MIDP II) and the IFAD-supported Programme for Rural Irrigation Development (PRIDE). In 2016 it is expected that the major investment phase of the Shire Valley initiative will begin with the launch of the Shire Valley Irrigation Project with funding from the World Bank and others amounting to some US$ 340 million. Also in 2016 the Songwe River Hydropower and Irrigation Scheme, which is currently under detailed design, will be ready for implementation. Malawi's 50% share of the cost of is estimated to be around US$ 47 million.

As shown in the lower part of Figure 69 below Phase I will also be used to design a new generation of schemes and projects, most of which will be implemented during Phase II (2021-25) or beyond. Prioritisation of schemes for development will be based on the multi-criteria ranking system described in Section xx with the highest ranked schemes implemented first.

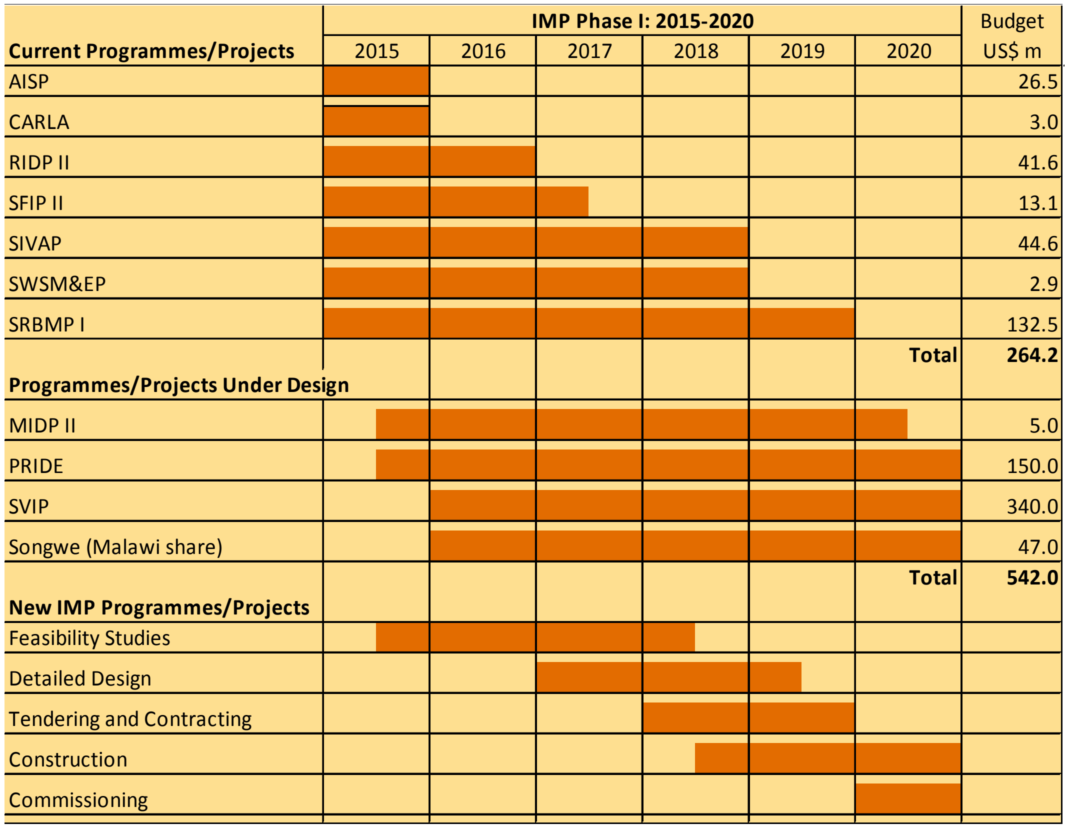


Figure 68: Major Programmes and Projects, IMP Phase 1: 2015-2020

Component 4 includes four Sub-Components as shown in Table 58 below. Sub-Component 1.1 involves the official adoption of IMP by GoM and its integration in national development plans. The remaining Sub-Programmes describe the proposed arrangement for overall governance and coordination of the master plan, as well as its management, monitoring and evaluation.

Table 58: Component 4: Coordination and Management

Sub-Component	Output	Milestone Indicators
4.1 IMP Adoption	• IMP officially adopted and integrated in national development plans	• Cabinet-level adoption of IMP by GoM and integration into the MGDs and the ASWAp
4.2 IMP Governance and Coordination	• Effective and transparent governance of IMP implementation	• Creation of multi-stakeholder steering committee (IMPSC) to oversee IMP implementation
4.3 IMP Management	• Effective and efficient day-to-day management of IMP implementation	• IMP Management Unit (IMPMU) takes full responsibility for IMP implementation
4.4 IMP Monitoring and Evaluation	• IMP effectively monitored and evaluated	• Comprehensive M&E system designed and fully operational

Sub-Component 4.1: IMP Adoption

Once finalised and approved by MoAIWD the IMP will be submitted for Cabinet-level endorsement by GoM. Subsequently the IMP will be integrated within all national and sectoral development plans as they are developed or updated. The plan will be integrated into Malawi's higher level development plans articulated in Vision 2020 and MGDS II. The IMP will also be incorporated within the ASWAp as well as a number of sectoral and sub-sectoral strategies and plans including: (i) the National Water Resources Master Plan (2014); (ii) the National Water Policy (2005); (iii) the Water Resources Investment Strategy (2011); (iv) the Malawi Water, Sanitation and Irrigation Sector Strategic Plan (2013); (v) the Department of Irrigation Strategic Plan (2011-16); (vi) the Draft National Irrigation Policy and Development Strategy (2014); and (vii) the National Export Strategy (2013-2018).

Sub-Component 4.2: IMP Governance and Coordination

Since irrigation spans a range of fields the governance framework is necessarily diverse and poses significant coordination challenges. The IMP will involve participation of institutions covering agriculture, land, water, infrastructure, transport, commerce, finance, environment, training and community development; as well as farmer organisations, NGOs and the private sector. Improved coordination among the development partners supporting water, irrigation, agriculture and related sectors is also needed. The Development Assistance Strategy (DAS) provides the framework for coordination and utilisation of development assistance in Malawi with emphasis on monitoring targets and indicators of national development strategies. The DAS defines strategies for increasing development efficiency and effectiveness in pursuit of the MGDS objectives through the Paris Declaration principles: ownership, alignment, harmonisation, management for results and mutual accountability.

Governance and coordination responsibilities will be assigned to an IMP Steering Committee (IMPSC) chaired by the Permanent Secretary of the ministry/department with lead responsibility for irrigation (currently DoI) and including representatives of all stakeholder groups. These governance and coordination responsibilities are similar to those assigned to the National Irrigation Board (NIB) under the Irrigation Act (2001) and it is therefore proposed that the IMPSC will operate under the authority of the NIB, and be financed through the NIDF. The responsibilities of the IMPSC are detailed in Box 3.

Box 3: Responsibilities of the Irrigation Master Plan Steering Committee

- Strategic direction and oversight of IMP implementation to ensure that it remains focussed on its goal and development objectives.
- Ensuring alignment (or re-alignment) of the IMP with higher level national policies and strategies.
- Coordination between the IMP and related sectoral strategies, programmes and projects.
- Monitoring the efficiency and effectiveness or resource utilisation on IMP initiatives to ensure optimal use of resources.
- Assisting with the resolution of strategic level issues and risks.
- Overseeing periodic review of IMP implementation and approving proposals for re-alignment or re-orientation to improve effectiveness.
- Coordinating the financing of IMP investments among the different sources of funding, funding modalities and financing instruments to ensure optimal deployment and utilisation

of resources.

- Making major decisions on investment programmes and projects in terms of their consistency with the IMP investment framework.
- Supervising the work of the IMP Coordination Unit (see Sub-Component 4.3) including review and approval of its annual workplan and budget and annual reports.

Sub-Component 4.4: IMP Management

Management of the IMP will be the responsibility of the IMP Management Unit (IMPMU) to be hosted within the department/ministry with lead responsibility for irrigation, and financed through the NIDF. Under the oversight of the IMPSC the Management Unit will facilitate the pipeline of irrigation investment programmes and projects which make up the IMP investment framework, but will not have direct project implementation responsibilities. The implementation of projects, programmes and individual irrigation schemes will each be managed by their respective project management units (PMUs) to be financed from project funds which may themselves be channelled through the NIDF. The responsibilities of the IMPMU are detailed in Box 4.

Box 4: Responsibilities of the IMP Management Unit

- Prepare the IMP AWPB and submit it the IMPSC for approval.
- Maintain a register of all programmes and projects in the irrigation sub-sector, their stage of planning or implementation and financing arrangements.
- Administer the NIDF by procuring funds from different sources and allocating them to eligible investments in accordance with the goal and objectives of the IMP.
- Coordinate the financing of the IMP investment pipeline by informing potential financiers of investment opportunities and proponents of various schemes about the availability of finance.
- Provide a "one-stop-shop" for proponents of irrigation scheme development including assistance for obtaining regulatory approvals and permits.
- Undertake monitoring, evaluation and reporting on implementation of the IMP (see Sub-Component 2.4).
- Prepare and disseminate standards for the design and construction of irrigation schemes and oversee an accreditation programme for irrigation technicians and professionals.
- Act as Secretariat to the IMPSC by arranging meetings, agendas, minutes and ensuring follow-up on decision made by the IMPSC.
- Liaise with development partners and the private sector to ensure a harmonised and coordinated approach to implementation of the IMP.
- Provide a knowledge management and communication service to fully inform all irrigation sub-sector stakeholders about important findings and lessons learned.

Sub-Component 4.5: IMP Monitoring and Evaluation

M&E is an essential element of IMP management whose purpose is to keep track of implementation performance to enable informed decision-making, undertake periodic reviews and updates of the IMP, facilitate learning and knowledge management, and assess the social and economic impact of IMP investments relative to alterative use of resources. This will be used to inform the higher level national social and economic indicators embodied in the MGDS and the ASWAp as well as for annual performance evaluations and major strategic reviews at the end of Phases I and II.

M&E at master plan level will involve meta-analysis of data collected at project and programme level, and will not engage in primary data collection or analysis. It will aggregate and analyse information to enable assessment of IMP achievements at impact and outcome and levels. Four impact level indicators will be monitored: (i) percent contribution of irrigated agriculture to GDP; (ii) prevalence of poverty in irrigated versus rainfed areas; (iii) percent of food secure households in irrigated versus rainfed areas; and (vi) the value of exports derived from irrigated agriculture. All of these indicators will be estimated from secondary data sources. There will be seven performance indicators at outcome level:

1) Area of irrigated land by WRA, district and irrigation typology
2) Investment cost per irrigated hectare
3) Cropping intensity on irrigated land
4) Volume of water used per irrigated hectare
5) Net value of production per irrigated hectare
6) Hectares of irrigated schemes designed, constructed and operating satisfactorily
7) Overall performance of the IMP relative to rolling annual workplan and investment framework targets

The use of a limited number of impact and outcome indicators is intended to create a simple and practical M&E system based on the things it is essential to know, and which can accommodate the limitations of M&E systems to source primary data at project and district levels. This recognises that whilst the capacity building initiatives under Component 3 will improve M&E capacity over time, the resources available for M&E will always be limited. The detailed design of the M&E system to be undertaken during the first year of the IMP needs to recognise these limitations.

9 INVESTMENT FINANCING FRAMEWORK

9.1 Overview

This Section presents a summary of the estimated costs of implementing the IMP by Component, and an indicative financing framework. Details are provided in the tables at the end of this Section with further explanation given in Appendix 10. All costs are in constant 2014 US$ values. The cost estimates are built on the proposed schedule of irrigation infrastructure development and supporting investments over the life of the Master Plan.

9.2 Irrigation Infrastructure Investment

Table 54 shows the proposed schedule of infrastructure investments and their estimated costs, excluding allowances for feasibility studies, design, supervision, or other soft investments needed to make the schemes work effectively. The schemes are shown in eight different categories totalling 116,000 hectares as follows:

- Dambo Schemes: small or micro scale schemes of a few hectares or less generally operated by motorised or treadle pumps – 41,700 ha to be completed.
- New Schemes: newly identified IMP schemes which have been subject to pre-feasibility level assessment and ranked according to the multi-criteria decision analysis tool – 24,500 ha to be completed.
- Shire Valley Schemes to be implemented during the second phase of the Shire Valley project beginning around 2016 – 22,000 ha to be completed.
- Commercial schemes undertaken independently by private enterprise investors – 8,500 ha to be completed.
- GBI schemes planned but not yet financed – 6,300 ha to be completed.
- Other ongoing DoI schemes currently in various stages of design and implementation and likely to be completed during the first few years of Phase I – 6,000 ha to be completed.
- PRIDE schemes – 4,000 ha to be completed.
- Malawi's share of the Songwe River Scheme currently under detailed design but not yet financed – 3,000 ha to be completed.

Table 59 below shows that the total cost of irrigation infrastructure investment over the life of the IMP is estimated to be US$ 923 million or around US$ 8,000 per hectare completed. About 23% of the infrastructure investment will take place during Phase I (six years), 20% in Phase II (five years) and 57% in Phase III (ten years). Irrigation infrastructure represents the largest single investment in the IMP amounting to almost 40% of the total cost. The annual areas of irrigation development started and completed and cumulative scheme completions are shown in Figure 70.

Table 59: Estimated Cost of Irrigation Infrastructure Investments (US$ million)

Investment Cost	Phase 1	Phase II	Phase III	Total	%
New Schemes	26	50	222	298	32
SVIP	31	50	181	262	28
Dambo	20	30	85	134	15
Commercial	16	20	41	77	8
GBI	31	32	0	63	7
PRIDE	39	1	0	40	4
Songwe	30	0	0	30	3
Ongoing DoI	20	0	0	20	2
Total	212	183	528	923	100
% of Total	23	20	57	100	

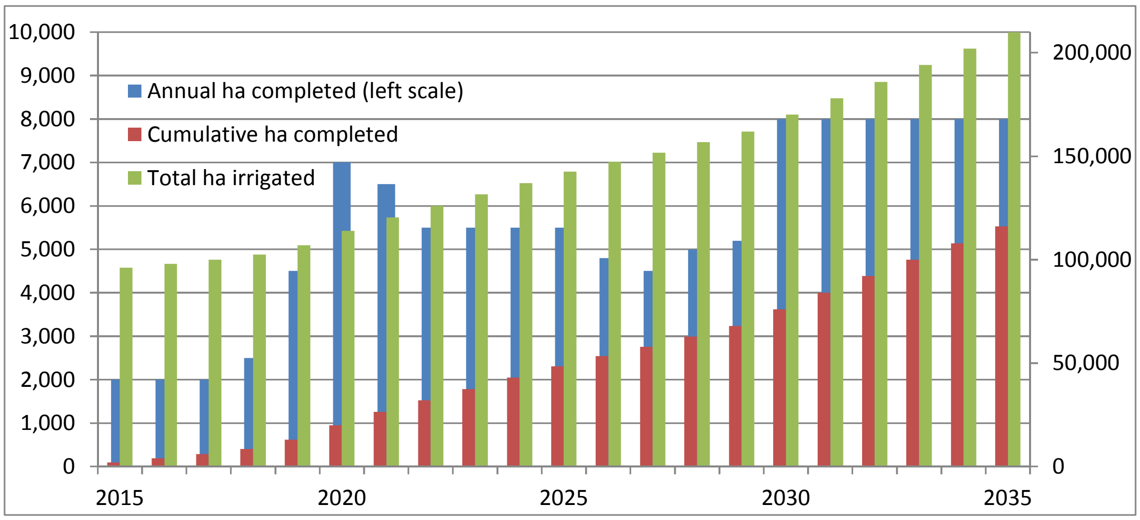


Figure 69: Irrigation Development Completed, Annual and Cumulative Hectares

9.3 IMP Costs by Component

Table 60 presents a summary of total IMP costs by component and Phase. The total cost is estimated to be around US$ 2.4 billion of which 46% will be invested in Component 1: New Irrigation Development; 32% in Component 2: Sustainable Irrigation Management; 21% in Component 3: Capacity Building; and 1% in Component 4: Coordination and Management. Around 89% of IMP costs represent investments and 11% recurrent costs, mainly irrigation scheme O&M.

Table 60: Summary of IMP Costs by Component (US$ million)

Component	Total Cost (US$m)				% of Total
	Phase I	Phase II	Phase III	Total	
Component 1: New Irrigation Development	255	220	634	1,108	46
Component 2: Sustainable Irrigation Management	154	232	400	785	32
Component 3: Capacity Building	87	131	292	510	21
Component 4: Coordination and Management	8	4	9	21	1
Total Irrigation Master Plan	**504**	**586**	**1,333**	**2,423**	**100**
Of which:					
Investment Costs	487	536	1,123	2,146	89
Recurrent Costs	17	50	211	278	11

Component 1 includes the cost of irrigation infrastructure as detailed in Section 9.2 plus 20% to cover the cost of feasibility studies, detailed design and supervision.

Component 2 includes the cost of rehabilitating and/or upgrading existing schemes, as well as the investments needed for catchment management based on promotion of good agricultural practices and O&M of completed schemes.

Component 3 includes capacity building investments such as increased staffing and training for DoI staff and capacity building for WUAs so that they are capable of independently operating and maintaining schemes.

Component 4 includes the costs of the IMPMU and associated coordination and management activities.

9.4 Financing Framework

Table 61 presents an indicative financing framework showing the expected contributions of GoM, development partners, the private sector and beneficiaries. GoM's contribution is projected to increase from 5% of the cost in Phase I to 13% by Phase III. The contribution of development partners is expected to be around US$1.3 billion over the life of the IMP declining from over 70% of the total in Phase I to around 42% in Phase II. Conversely the contribution of the private sector, through investment in commercial agriculture and outgrower schemes is expected to increase over the life of the IMP. The contribution of farmers is also expected to be significant through a ten percent share of irrigation scheme investments (mainly in kind) and financing of O&M costs through the WUAs.

Table 61: Indicative IMP Financing Framework

Financier	Total Cost (US$m)				% of Total
	Phase I	Phase II	Phase III	Total	
GoM	25	54	169	248	10
Development Partners	361	342	565	1,268	52
Private Sector	79	121	331	532	22
Beneficiaries (farmers)	39	69	268	376	15
Total Irrigation Master Plan	**504**	**586**	**1,333**	**2,423**	**100**
%of Total	21	24	55	100	

Table 62: Schedule of Irrigation Investments

Irrigation Investments				IMP Phase I 2015-2020						IMP Phase II 2021-2025					IMP Phase III 2026-2035										Total			
				2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Phase I	Phase II	Phase III	Total
Dambo		Start	ha		1,000	1,500	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,500	2,700	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	8,500	10,000	29,200	47,700
$'000/ha		Complete	ha				1,000	1,500	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,500	2,700	3,000	3,000	3,000	3,000	3,000	3,000	4,500	10,000	27,200	41,700
3.0	Year 1	20%	$m	0.0	0.6	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.5	1.6	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8				
	Year 2	60%	$m		0.0	1.8	2.7	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	4.5	4.9	5.4	5.4	5.4	5.4	5.4	5.4	5.4				
	Year 3	20%	$m			0.0	0.6	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.5	1.6	1.8	1.8	1.8	1.8	1.8	1.8				
	Year 4	0%	$m				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 5	0%	$m					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Total	100%	$m	0.0	0.6	2.7	4.5	5.7	6.0	6.0	6.0	6.0	6.0	6.0	6.3	7.3	8.2	8.8	9.0	9.0	9.0	9.0	9.0	9.0	19.5	30.0	84.6	134.1
PRIDE		Start	ha	1,000	2,000	1,000																			4,000	0	0	4,000
$'000/ha		Complete	ha					1,000	2,000	1,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,000	1,000	0	4,000
10.0	Year 1	10%	$m	1.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 2	20%	$m		2.0	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
4,000 ha	Year 3	50%	$m			5.0	10.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 4	10%	$m				1.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 5	10%	$m					1.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Total	100%	$m	1.0	4.0	10.0	13.0	8.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.0	1.0	0.0	40.0
SVIP		Start	ha		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	5,000	5,000	20,000	30,000
$'000/ha		Complete	ha						1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	2,000	2,000	2,000	2,000	2,000	2,000	1,000	5,000	16,000	22,000
10.0	Year 1	10%	$m	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0				
	Year 2	20%	$m		0.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0				
	Year 3	50%	$m			0.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0				
	Year 4	10%	$m				0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0				
	Year 5	10%	$m					0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0				
	Total	100%	$m	0.0	1.0	3.0	8.0	9.0	10.0	10.0	10.0	10.0	10.0	10.0	11.0	13.0	18.0	19.0	20.0	20.0	20.0	20.0	20.0	20.0	31.0	50.0	181.0	262.0
Songwe		Start	ha		1,500	1,500																			3,000	0	0	3,000
$'000/ha		Complete	ha				1,500	1,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,000	0	0	3,000
10.0	Year 1	20%	$m	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 2	40%	$m		0.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
3,000 ha	Year 3	40%	$m			0.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 4		$m				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 5		$m					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Total	100%	$m	0.0	3.0	9.0	12.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0	30.0

Table 63: Schedule of Irrigation Investments(Continued)

				IMP Phase I 2015-2020						IMP Phase II 2021-2025					IMP Phase III 2026-2035										Total			
Irrigation Investments				2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Phase I	Phase II	Phase III	Total
GBI		Start	ha		1,000	1,000	1,000	1,000	1,000	1,000	300														5,000	1,300	0	6,300
$'000/ha		Complete	ha						1,000	1,000	1,000	1,000	1,000	1,000	300	0	0	0	0	0	0	0	0	0	1,000	5,000	300	6,300
10.0	Year 1	10%	$m	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 2	20%	$m		0.0	2.0	2.0	2.0	2.0	2.0	2.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
6,300 ha	Year 3	50%	$m			0.0	5.0	5.0	5.0	5.0	5.0	5.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 4	10%	$m				0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 5	10%	$m					0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Total	100%	$m	0.0	1.0	3.0	8.0	9.0	10.0	10.0	9.3	7.6	3.5	1.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0	31.7	0.3	63.0
Commercial		Start	ha	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	3,000	2,500	5,000	10,500
$'000/ha		Complete	ha					500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	1,000	2,500	5,000	8,500
10.0	Year 1	10%	$m	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
	Year 2	20%	$m		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1				
3,000 ha	Year 3	50%	$m			2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5				
	Year 4	10%	$m				0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
	Year 5	10%	$m					0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
	Total	100%	$m	0.5	0.6	3.1	3.6	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	15.8	20.3	40.6	76.7
Ongoing DoI		Start	ha	2,000																					2,000	0	0	2,000
$'000/ha		Complete	ha	2,000	2,000	2,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,000	0	0	6,000
10.0	Year 1	20%	$m	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 2	50%	$m		10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
6,000 ha	Year 3	30%	$m			6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 4	0%	$m				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Year 5	0%	$m					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Total	100%	$m	4.0	10.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	20.0
New Schemes		Start	ha		500	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	4,500	5,000	25,000	34,500
$'000/ha		Complete	ha						500	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	2,500	2,500	2,500	2,500	2,500	2,500	500	5,000	19,000	24,500
10.0	Year 1	10%	$m	0.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5				
	Year 2	20%	$m		0.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0				
	Year 3	50%	$m			0.0	2.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5				
	Year 4	10%	$m				0.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5				
	Year 5	10%	$m					0.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.5	2.5	2.5	2.5	2.5	2.5				
	Total	100%	$m	0.0	0.5	2.0	5.5	8.5	9.5	10.0	10.0	10.0	10.0	10.0	11.5	14.5	22.0	23.5	25.0	25.0	25.0	25.0	25.0	25.0	26.0	50.0	221.5	297.5
Total		Start	ha	3,500	7,500	7,500	5,500	5,500	5,500	5,500	4,800	4,500	4,500	4,500	7,500	7,700	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	35,000	23,800	79,200	138,000
		Complete	ha	2,000	2,000	2,000	2,500	4,500	7,000	6,500	5,500	5,500	5,500	5,500	4,800	4,500	5,000	5,200	8,000	8,000	8,000	8,000	8,000	8,000	20,000	28,500	67,500	116,000
			$m	5.5	20.7	38.8	54.6	50.3	42.6	41.1	39.4	37.7	33.6	31.4	33.2	38.9	52.2	55.4	58.1	58.1	58.1	58.1	58.1	58.1	212	183	528	923
Cumulative Total		Start	ha	3,500	11,000	18,500	24,000	29,500	35,000	40,500	45,300	49,800	54,300	58,800	66,300	74,000	82,000	90,000	98,000	106,000	114,000	122,000	130,000	138,000				
		Complete	ha	2,000	4,000	6,000	8,500	13,000	20,000	26,500	32,000	37,500	43,000	48,500	53,300	57,800	62,800	68,000	76,000	84,000	92,000	100,000	108,000	116,000				
			$m	5.5	26.2	64.9	119.5	169.7	212.3	253.4	292.7	330.4	363.9	395.3	428.5	467.3	519.6	574.9	633.0	691.1	749.1	807.2	865.2	923.3				

Table 64: IMP Costs, Components 1 and 2

				IMP Phase I 2015-2020						IMP Phase II 2021-2025					IMP Phase III 2026-2035										Total			
Component 1: New Irrigation Development		Unit	Note	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Phase I	Phase II	Phase III	Total
Irrigation infrastructure (ha started)		ha'000		3.5	7.5	7.5	5.5	5.5	5.5	5.5	4.8	4.5	4.5	4.5	7.5	7.7	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0				
Irrigation infrastructure investments		$m		5.5	20.7	38.8	54.6	50.3	42.6	41.1	39.4	37.7	33.6	31.4	33.2	38.9	52.2	55.4	58.1	58.1	58.1	58.1	58.1	58.1	212.3	183.0	528.0	923.3
Feasibility, design and supervision	20%	$m		1.1	4.1	7.8	10.9	10.1	8.5	8.2	7.9	7.5	6.7	6.3	6.6	7.8	10.4	11.1	11.6	11.6	11.6	11.6	11.6	11.6	42.5	36.6	105.6	184.7
Subtotal Component 1				**6.6**	**24.8**	**46.5**	**65.5**	**60.3**	**51.1**	**49.3**	**47.2**	**45.2**	**40.3**	**37.6**	**39.8**	**46.7**	**62.7**	**66.5**	**69.7**	**69.7**	**69.7**	**69.7**	**69.7**	**69.7**	**254.8**	**219.6**	**633.6**	**1,108.0**
Component 2: Sustainable Irrigation Management																												
Rehabilitation/upgrading		ha'000	a/		1.0	2.0	3.0	4.7	4.7	4.7	4.7	4.7	4.7	4.7														
Cost of rehabilitation/upgrading		$m			5.0	10.0	15.0	23.5	23.5	23.5	23.5	23.5	23.5	23.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.0	117.5	0.0	194.5
Catchment management/GAPs		ha'000	b/	35	75	75	55	55	55	55	48	45	45	45	75	77	80	80	80	80	80	80	80	80				
Cost of catchment management/GAPs			c/																									
Year 1	53 US$/ha	$m		1.9	4.0	4.0	2.9	2.9	2.9	2.9	2.5	2.4	2.4	2.4	4.0	4.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2				
Year 2	53 US$/ha	$m			1.9	4.0	4.0	2.9	2.9	2.9	2.9	2.5	2.4	2.4	2.4	4.0	4.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2				
Year 3	53 US$/ha	$m				1.9	4.0	4.0	2.9	2.9	2.9	2.9	2.5	2.4	2.4	2.4	4.0	4.1	4.2	4.2	4.2	4.2	4.2	4.2				
Year 4	53 US$/ha	$m					1.9	4.0	4.0	2.9	2.9	2.9	2.9	2.5	2.4	2.4	2.4	4.0	4.1	4.2	4.2	4.2	4.2	4.2				
Year 5	53 US$/ha	$m						4.0	2.9	2.9	2.9	2.9	2.5	2.4	2.4	2.4	4.0	4.1	4.2	4.2	4.2	4.2	4.2	4.2				
Total Catchment Management		$m		1.9	5.8	9.8	12.7	17.8	15.6	14.6	14.2	13.7	12.8	12.1	13.5	15.2	18.7	20.6	21.0	21.2	21.2	21.2	21.2	21.2	63.6	67.3	195.0	326.0
O&M of completed systems		ha'000		2.0	4.0	6.0	8.5	13.0	20.0	26.5	32.0	37.5	43.0	48.5	53.3	57.8	62.8	68.0	76.0	84.0	92.0	100.0	108.0	116.0				
O&M of completed systems		$m	d/	0.5	1.0	1.5	2.1	3.3	5.0	6.6	8.0	9.4	10.8	12.1	13.3	14.5	15.7	17.0	19.0	21.0	23.0	25.0	27.0	29.0	13.4	46.9	204.5	264.7
Subtotal Component 2				**2.4**	**11.8**	**21.3**	**29.8**	**44.5**	**44.1**	**44.7**	**45.7**	**46.5**	**47.0**	**47.7**	**26.8**	**29.7**	**34.4**	**37.6**	**40.0**	**42.2**	**44.2**	**46.2**	**48.2**	**50.2**	**154.0**	**231.7**	**399.5**	**785.2**

a/ 5% of existing scheme area rehabilitated per annum @ US$ 5,000/ha

b/ 10 ha of catchment per irrigated hectare, beginning in year scheme started

c/ US$ 265/ha of catchment over five years

d/ US$ 250/ha/year (equal to 2.5% of investment cost)

Table 65: IMP Costs, Component 3

				IMP Phase I 2015-2020						IMP Phase II 2021-2025					IMP Phase III 2026-2035										Total			
Component 3: Capacity Building		Unit	Note	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Phase I	Phase II	Phase III	Total
Institutional rationalisation			e/																									
Institutional capacity:																												
No of DoI staff		Pers.	f/	400	500	600	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700				
New staff recruited		Pers.		30	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Incremental staff number		Pers.		30	130	230	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330				
Incremental staff costs		$m	g/	0.4	1.6	2.8	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0				
Staff training		$m	h/	0.6	0.8	0.9	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1				
Vehicles		$m	i/	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3				
Equipment		$m	j/	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3				
Other recurrent costs		$m	k/	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5				
Total Institutional Capacity		$m		2.2	3.6	4.9	6.3	6.3	6.3	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	29.5	30.1	60.1	119.6
Standards and Accreditation																												
Development of standards		$m	l/		0.30																							
Periodic review/modification of standards		$m	l/				0.1		0.1			0.1				0.1					0.1							
Annual registration cost		$m				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1				
Total Standards and Accreditation		$m		0.0	0.3	0.1	0.2	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.9	0.6	1.2	2.7
Irrigation Management			m/																									
Year 1	8%	$m		0.5	2.0	3.7	5.2	4.8	4.1	3.9	3.8	3.6	3.2	3.0	3.2	3.7	5.0	5.3	5.6	5.6	5.6	5.6	5.6	5.6				
Year 2	8%	$m			0.5	2.0	3.7	5.2	4.8	4.1	3.9	3.8	3.6	3.2	3.0	3.2	3.7	5.0	5.3	5.6	5.6	5.6	5.6	5.6				
Year 3	8%	$m				0.5	2.0	3.7	5.2	4.8	4.1	3.9	3.8	3.6	3.2	3.0	3.2	3.7	5.0	5.3	5.6	5.6	5.6	5.6				
Year 4	8%	$m					0.5	2.0	3.7	5.2	4.8	4.1	3.9	3.8	3.6	3.2	3.0	3.2	3.7	5.0	5.3	5.6	5.6	5.6				
Year 5	8%	$m						0.5	2.0	3.7	5.2	4.8	4.1	3.9	3.8	3.6	3.2	3.0	3.2	3.7	5.0	5.3	5.6	5.6				
Total Irrigation Management		$m		0.5	2.5	6.2	11.5	16.3	19.9	21.8	21.9	20.2	18.6	17.6	16.8	16.8	18.2	20.3	22.8	25.2	27.1	27.6	27.9	27.9	56.9	100.1	230.4	387.4
Subtotal Component 3				**2.7**	**6.4**	**11.2**	**17.9**	**22.7**	**26.3**	**27.9**	**28.0**	**26.5**	**24.8**	**23.7**	**22.9**	**23.0**	**24.3**	**26.4**	**28.9**	**31.3**	**33.3**	**33.7**	**34.0**	**34.0**	**87.2**	**130.8**	**291.7**	**509.8**

e/ No costs incurred
f/ Currently 370 staff with 330 vacancies, total establishment 700
g/ Average cost of salaries and on-costs US$ 1,000/staff month
h/ Training allowance of 1,500 per staff member per year
i/ 10 new vehicles per annum during Phase I, 5 per annum thereafter @$50,000 per vehicle
j/ Computers, office equipment, survey equipment etc.
k/ Lump sum annual allocation
l/ Initial cost $300,000; reviews $100,000
m/ Cost of soft investments in percent of infrastructure investment cost

Table 66: IMP Costs, Component 4

Component 4: Coordination and Management	Unit	Note	IMP Phase I 2015-2020						IMP Phase II 2021-2025					IMP Phase III 2026-2035										Total			
			2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Phase I	Phase II	Phase III	Total
IMP Steering Committee	$m	n/	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.12	0.10	0.20	0.42
IMP Management Unit: Staff Costs																											
IMPMU Director	$'000		90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90				
Professional Staff (7)	$'000		420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420				
Office Assistants (5)	$'000		60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60				
Drivers (3)	$'000		30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30				
International Technical Assistance	month		6	12	12	12	8	6																			
National Technical Assistance	month		12	24	24	24	24	12																			
International Technical Assistance	$'000		150	300	300	300	200	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
National Technical Assistance	$'000		120	240	240	240	240	120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Total IMPMU Staff Costs	$'000		870	1140	1140	1140	1040	870	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600				
Total IMPMU Staff Costs	$m		0.9	1.1	1.1	1.1	1.0	0.9	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	6.2	3.0	6.0	15.2
IMPMU Office Costs																											
Office furniture and equipment	$'000	o/	40				40				40				40				40				40				
Rent	$'000		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24				
Communications	$'000		12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12				
Other office operating costs	$'000		12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12				
Travel and DSAs	$'000	p/	50	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72				
Total IMPMU Office Costs	$'000		138	120	120	120	160	120	120	120	160	120	120	120	160	120	120	120	160	120	120	120	160				
Total IMPMU Office Costs	$m		0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.8	0.6	1.3	2.7
Vehicles																											
Purchase vehicles (3)	$'000		150								150								150								
Vehicle operating costs	$'000		36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36				
Total vehicle costs	$'000		186	36	36	36	36	36	36	36	186	36	36	36	36	36	36	36	186	36	36	36	36				
Total vehicle costs	$m		0.19	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.19	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.19	0.04	0.04	0.04	0.04	0.37	0.33	0.51	1.21
Workshops and Meetings																											
National IMP launch workshop (2 days)	$'000		20																								
Annual review workshops (1 day)	$'000			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10				
Miscellaneous meetings and workshops	$'000		20	30	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40				
Total Workshops and meetings	$'000		40	40	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50				
Total Workshops and meetings	$m		0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.28	0.25	0.50	1.03
Subtotal Component 4			**1.3**	**1.4**	**1.4**	**1.4**	**1.3**	**1.1**	**0.8**	**0.8**	**1.0**	**0.8**	**0.8**	**0.8**	**0.9**	**0.8**	**0.8**	**0.8**	**1.0**	**0.8**	**0.8**	**0.8**	**0.9**	**7.7**	**4.3**	**8.5**	**20.6**

n/ IMPSC meeting costs: 4 meetings per year @ $5,000/meeting o/ Replaced every five years p/ Five days travel per professional staff member @ $150/day

Table 67: Indicative Financing Framework

				IMP Phase I 2015-2020						IMP Phase II 2021-2025					IMP Phase III 2026-2035										Total			
				2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Phase I	Phase II	Phase III	Total
Total Irrigation Master Plan		$m		**12.9**	**44.3**	**80.4**	**114.6**	**128.8**	**122.6**	**122.7**	**121.7**	**119.2**	**112.9**	**109.8**	**90.4**	**100.2**	**122.1**	**131.3**	**139.5**	**144.2**	**148.0**	**150.4**	**152.7**	**154.7**	**503.7**	**586.4**	**1,333.4**	**2,423.5**
Investment Costs		$m		11.9	42.8	78.3	111.8	124.9	116.9	115.5	113.1	109.1	101.5	97.1	76.5	85.0	105.8	113.7	119.9	122.6	124.3	124.8	125.1	125.1	**486.8**	**536.4**	**1,122.7**	**2,145.9**
Recurrent Costs		$m		1.0	1.5	2.1	2.8	3.9	5.7	7.2	8.6	10.1	11.4	12.7	13.9	15.2	16.3	17.6	19.6	21.6	23.7	25.6	27.6	29.6	**17.0**	**50.0**	**210.7**	**277.6**
Total Costs		$m		12.9	44.3	80.4	114.6	128.8	122.6	122.7	121.7	119.2	112.9	109.8	90.4	100.2	122.1	131.3	139.5	144.2	148.0	150.4	152.7	154.7	**503.7**	**586.4**	**1,333.4**	**2,423.5**
Financing Plan	Percent																											
Component 1: New Irrigation Development	I	II	II																									
GoM	5	10	15	0.3	1.2	2.3	3.3	3.0	2.6	4.9	4.7	4.5	4.0	3.8	6.0	7.0	9.4	10.0	10.5	10.5	10.5	10.5	10.5	10.5	13	22	95	130
Development Partners	65	50	35	4.3	16.1	30.2	42.6	39.2	33.2	24.6	23.6	22.6	20.1	18.8	13.9	16.3	21.9	23.3	24.4	24.4	24.4	24.4	24.4	24.4	166	110	222	497
Private Sector	20	30	40	1.3	5.0	9.3	13.1	12.1	10.2	14.8	14.2	13.6	12.1	11.3	15.9	18.7	25.1	26.6	27.9	27.9	27.9	27.9	27.9	27.9	51	66	253	370
Beneficiaries (farmers)	10	10	10	0.7	2.5	4.7	6.5	6.0	5.1	4.9	4.7	4.5	4.0	3.8	4.0	4.7	6.3	6.6	7.0	7.0	7.0	7.0	7.0	7.0	25	22	63	111
Subtotal Component 1				**6.6**	**24.8**	**46.5**	**65.5**	**60.3**	**51.1**	**49.3**	**47.2**	**45.2**	**40.3**	**37.6**	**39.8**	**46.7**	**62.7**	**66.5**	**69.7**	**69.7**	**69.7**	**69.7**	**69.7**	**69.7**	**254.8**	**219.6**	**633.6**	**1,108.0**
Component 2: Sustainable Irrigation Management																												
GoM	5	10	15	0.1	0.5	1.0	1.4	2.1	2.0	3.8	3.8	3.7	3.6	3.6	2.0	2.3	2.8	3.1	3.2	3.2	3.2	3.2	3.2	3.2	7.0	18.5	29.3	54.8
Development Partners	75	60	45	1.4	8.1	14.9	20.8	30.9	29.4	22.8	22.6	22.3	21.8	21.4	6.1	6.8	8.4	9.3	9.5	9.5	9.5	9.5	9.5	9.5	105.5	110.9	87.8	304.1
Private Sector	20	30	40	0.4	2.2	4.0	5.5	8.3	7.8	11.4	11.3	11.2	10.9	10.7	5.4	6.1	7.5	8.2	8.4	8.5	8.5	8.5	8.5	8.5	28.1	55.4	78.0	161.6
Beneficiaries (farmers)	100%of O&M			0.5	1.0	1.5	2.1	3.3	5.0	6.6	8.0	9.4	10.8	12.1	13.3	14.5	15.7	17.0	19.0	21.0	23.0	25.0	27.0	29.0	13.4	46.9	204.5	264.7
Subtotal Component 2				**2.4**	**11.8**	**21.3**	**29.8**	**44.5**	**44.1**	**44.7**	**45.7**	**46.5**	**47.0**	**47.7**	**26.8**	**29.7**	**34.4**	**37.6**	**40.0**	**42.2**	**44.2**	**46.2**	**48.2**	**50.2**	**154.0**	**231.7**	**399.5**	**785.2**
Component 3: Capacity Building																												
GoM	5	10	15	0.1	0.3	0.6	0.9	1.1	1.3	2.8	2.8	2.6	2.5	2.4	3.4	3.4	3.6	4.0	4.3	4.7	5.0	5.1	5.1	5.1	4.4	13.1	43.8	61.2
Development Partners	95	90	85	2.6	6.1	10.7	17.0	21.5	25.0	25.1	25.2	23.8	22.3	21.3	19.5	19.5	20.6	22.4	24.6	26.6	28.3	28.7	28.9	28.9	82.9	117.7	248.0	448.6
Private Sector	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beneficiaries (farmers)	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal Component 3				**2.7**	**6.4**	**11.2**	**17.9**	**22.7**	**26.3**	**27.9**	**28.0**	**26.5**	**24.8**	**23.7**	**22.9**	**23.0**	**24.3**	**26.4**	**28.9**	**31.3**	**33.3**	**33.7**	**34.0**	**34.0**	**87.2**	**130.8**	**291.7**	**509.8**
Component 4: Coordination and Management																												
GoM	5	10	15	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.4	0.4	1.3	2.1
Development Partners	95	90	85	1.2	1.3	1.3	1.3	1.2	1.0	0.7	0.7	0.9	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.9	0.7	0.7	0.7	0.7	7.4	3.9	7.3	18.5
Private Sector	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beneficiaries (farmers)	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal Component 4				**1.3**	**1.4**	**1.4**	**1.4**	**1.3**	**1.1**	**0.8**	**0.8**	**1.0**	**0.8**	**0.8**	**0.8**	**0.9**	**0.8**	**0.8**	**0.8**	**1.0**	**0.8**	**0.8**	**0.8**	**0.9**	**7.7**	**4.3**	**8.5**	**20.6**
Total IMP																												
GoM	5	9	13	0.6	2.2	3.9	5.6	6.3	5.9	11.6	11.4	11.0	10.2	9.8	11.6	12.9	16.0	17.1	18.1	18.5	18.7	18.8	18.9	18.9	24.5	54.0	169.3	247.8
Development Partners	72	58	42	9.5	31.6	57.1	81.7	92.9	88.6	73.4	72.2	69.6	64.9	62.2	40.2	43.4	51.7	55.7	59.1	61.4	62.9	63.3	63.5	63.5	361.3	342.3	564.7	1,268.3
Private Sector	16	21	25	1.7	7.1	13.3	18.6	20.3	18.0	26.2	25.5	24.7	23.0	22.0	21.3	24.7	32.5	34.8	36.3	36.3	36.3	36.3	36.3	36.3	79.1	121.3	331.5	531.9
Beneficiaries (farmers)	8	12	20	1.2	3.5	6.2	8.7	9.3	10.1	11.6	12.7	13.9	14.8	15.9	17.3	19.1	22.0	23.6	26.0	28.0	30.0	32.0	34.0	36.0	38.9	68.8	267.8	375.5
Total	100	100	100	**12.9**	**44.3**	**80.4**	**114.6**	**128.8**	**122.6**	**122.7**	**121.7**	**119.2**	**112.9**	**109.8**	**90.4**	**100.2**	**122.1**	**131.3**	**139.5**	**144.2**	**148.0**	**150.4**	**152.7**	**154.7**	**503.7**	**586.4**	**1,333.4**	**2,423.5**

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APPENDIX 1: ATLAS OF MAPS

APPENDIX 2: AGRICULTURE

APPENDIX 3: SOILS

APPENDIX 4: HYDROLOGY

APPENDIX 5: INVENTORY OF EXISTING SCHEMES

APPENDIX 6: IRRIGATION DESIGN

APPENDIX 7: INSTITUTIONAL

APPENDIX 8: ENVIRONMENTAL

APPENDIX 9: WEB

APPENDIX 10: FINANCIAL AND ECONOMIC ANALYSIS