Appendix C

Irrigation Human Resources Development Plan

The Project on the Revision of National Irrigation Master Plan

in the United Republic of Tanzania

Final Report
Appendix C: Irrigation Human Resources Development Plan

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Abbreviations

AEO	Agricultural Extension Officer
ASDP	Agricultural Sector Development Programme
ASDS	Agricultural Sector Development Strategy
ATC	Arusha Technical College
BWO	Basin Water Office
CGL	Comprehensive Guidelines
CoAF	College of Agricultural Sciences and Fisheries Technology
CRB	Contractors Registration Board
CSA	Cooperative Societies Act
DADP	District Agricultural Development Plan
DAICO	District Agriculture, Irrigation and Cooperative Officer
DC	District Council
DCQA	Division of Compliance and Quality Assuarance
DEST	Department of Engineering Sciences and Technology
DID	District Irrigation Department
DIE	District Irrigation Engineer
DIDT	District Irrigation Development Team
DITS	Division of Irrigation and Technical Services
DOSS	Division of Operations and Support Services
DP	Development Partner
ERB	Engineers Registration Board
FY	Fiscal Year
GE	Graduate Engineer
GoT	The Government of Tanzania
HQ	Headquarters
HRM	Human Resource Management
HWRE	Hydrology and Water Resources Engineering
IA	Irrigation Association
IC	Irrigation Cooperative
IS	Irrigation Section
IHRDP	Irrigation Human Resources Development Plan
IO	Irrigators Organization
JICA	Japan International Coopertion Agency
KATC	Kilimanjaro Agricultural Training Centre
KATI	Kizimbani Agricultural Training Institute
LGA	Local Government Authority
MAFC	Ministry of Agriculture, Food Security and Cooperatives
MALF	Ministry of Agriculture, Livestock and Fisheries
MATI	Ministry of Agriculture Training Institute
MC	Municipal Council
MKUKUTA	National Strategy for Growth and Poverty Reduction
MoEVT	Ministry of Education and Vocational Training
MoWI	Ministry of Water and Irrigation
MUST	Mbeya University of Science and Technology
M&E	Monitoring and Evaluation
NM-AIST	Nelson Mandela African Institution of Science and Technology
NGO	Non-governmental Organization
NIA	National Irrigation Act
NIMP 2002	National Irrigation Master Plan 2002
NIMP 2018	National Irrigation Master Plan 2018
NIRC	National Irrigation Commission
OD	Ordinary Diploma
O&M	Operation and Management
PE	Personnel Emoument
PE	Professional Engineer

PHRD	Professional Human Resource Development
PO-RALG	President's Office Regional Administration and Local Government
RIO	Regional Irrigation Office
SUA	Sokoine University of Agriculture
S&I	Survey and Investment
TANCAID	Project for Capacity Development for the Promotion of Irrigation Scheme Development Under the District Agricultural Development Plan
TANRICE	Project for Supporting Rice Industry Development in Tanzania
TCDC	Tanzania Cooperative Development Commission
TCU	Tanzania Commision for Universities
UDSM	University of Dar es Salaam
URT	The United Repubuic of Tanzania
VAEO	Village Agricultural Extension Officer
VID	Village Irrigatin Development
WAEO	Ward Agricultural Extension Officer
WI	Water Institute
ZIO	Zonal Irrigation Office

Chapter 1 Introduction

1.1 Background

The Government of Tanzania (GoT) has placed a high priority on irrigation development under national policies and strategies: National Strategy for Growth and Reduction of Poverty or MKUKUTA I (2005) and MKUKUTA II (2010); the Agricultural Sector Development Programme (ASDP) Phase I (2006) and Phase II (2016); Kilimo Kwanza initiative launched in 2009; and the Five Years Development Plan I (2011) and II (2016). The area of focus is to accelerate small, medium and large-scale irrigation development in coordination with smallholders and the private sector investors.

The GoT has also formulated a series of sector-specific policies and plans. Among others, the National Irrigation Master Plan (NIMP 2002) has been the basic document for guiding the policy directions of irrigation development. Since more than a decade has passed since the formulation of NIMP 2002, the GoT has decided to revise the NIMP, considering the changes surrounding the irrigation sector, such as political, economic and social circumstances, a shift toward commercial agriculture, water resource availability and the impact of climate change. Accordingly, the GoT requested Japan International Cooperation Agency (JICA) to support the revision process of the plan. The implementation period of the National Irrigation Master Plan 2018 (hereinafter, NIMP 2018) is set from 2018 to 2035.

The initial NIMP in 2002 identified the shortage of technical human resource in the irrigation sector as one of the major constraints of irrigation development. The Ministry of Water and Irrigation (MoWI) and JICA thus discussed and reached a consensus on the importance of formulating a plan for technical human resource development in the irrigation sector. Subsequently, a formulation team comprised of the GoT officials and JICA experts prepared a draft plan in 2010. However, the plan was not finalized due to unexpected events, including an organizational change of shifting the then Division of Irrigation and Technical Services (DITS) from the MoWI to the then Ministry of Agriculture Food Security and Cooperatives (MAFC). Since then, the division had experienced a series of organizational restructuring, leading finally to the establishment of the National Irrigation Commission (NIRC) under the National Irrigation Act in 2013. With the new agency put in place for implementing and supervising overall irrigation development in the country, the GoT decided to restart the finalization process of the Irrigation Human Resources Development Plan (hereinafter, IHRDP or the Plan) in line with NIMP 2018.

1.2 Objectives

The overall goal of the Plan is to identify the measures to develop the technical human resources in the irrigation sector, put them into development components, and incorporate them into the framework of NIMP 2018. To achieve this goal, the Plan sets the following specific objectives:

i) To review the present status of human resources and update the situation analysis conducted in 2010; and
ii) To formulate a feasible strategy and approach for irrigation human resources development and

present a set of development components together with timeframe and cost implications.

Although irrigation development is multidisciplinary in nature involving different types of professionals, e.g. civil, irrigation, agricultural, water resource and environmental engineers, land surveyors, agronomists, and community development officers, the Plan places a special emphasis on irrigation-related engineers and technicians because a shortage of these professionals will directly affect the effective planning and implementation of irrigation development in the country. The Plan is set in the same timeframe of NIMP 2018: Phase I (-2025) and Phase II (-2035).

1.3 Method

The process of formulating the Plan consists of three parts. The first part (Chapter 2) will review the current situation of human resources based on the 2010 analysis as well as the NIMP 2002 implementation status. The second part (Chapter 3) will present a series of development components and human resource demand and supply projection. The third part (Chapter 4) will provide a cost estimate for the IHRDP implementation as part of NIMP 2018.

Chapter 2 Situation Analysis

2.1 Introduction

This chapter first reviews the current status of irrigation human resources and updates the situation analysis conducted in 2010. Subsequently, the development components proposed in the NIMP 2002 as well as their progress are reviewed.

The analysis looks at the human resources from demand and supply sides. The demand side consists of the public sector (central government agencies and local governments) and the private sector (irrigators organizations and private service providers). On the supply side, there are educational and training institutes and private service providers.

2.2 Demand Side of Irrigation Human Resources

2.2.1 National Irrigation Commission

Under the National Irrigation Act enacted in 2013, the National Irrigation Commission (NIRC) takes the overall roles and responsibilities for promoting irrigation development. The NIRC has a headquarters and 8 zonal irrigation offices (ZIOs).

The following table shows the number of NIRC technical staff by profession and by office.

Table 2.2.1 Allocation of NIRC Technical Staff (As of Feb. 2018)

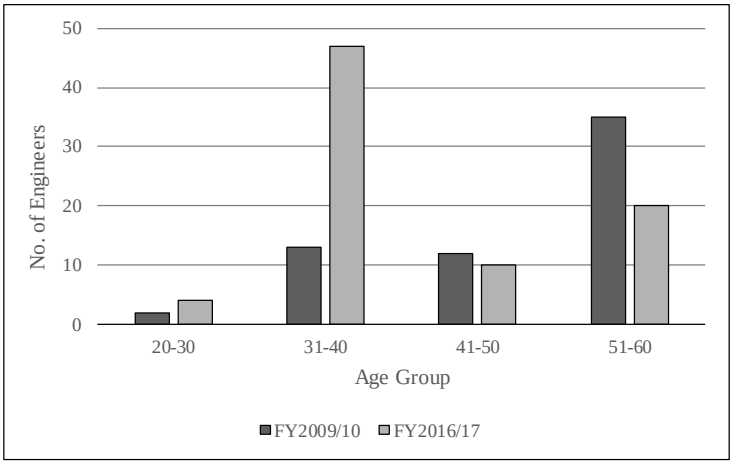
	Profession	HQ	Morogoro	Kilimanjaro	Mtwara	Mbeya	Dodoma	Tabora	Mwanza	katavi	Total
1	Civil/Irrigation/Agricultural Engineer	10	12	6	8	14	9	7	8	1	**75**
2	Mechanical Engineer	1	0	0	0	0	0	0	0	0	**1**
3	Environmental Engineer	4	0	0	0	0	1	0	0	0	**5**
4	Economist/ Agricultural Economist	6	1	0	0	0	0	0	0	0	**7**
5	Community Development Officer	5	1	0	0	1	0	0	1	0	**8**
6	Land Surveyor	1	1	2	1	1	1	1	2	1	**11**
7	Quantity Surveyor	0	0	1	0	0	0	0	0	0	**1**
8	Hydrologist/ Hydrogeologist	0	0	0	0	0	0	0	0	0	**0**
9	Agricultural Officer	4	5	6	1	5	6	3	2	1	**33**
10	Assistant Agricultural Officer	0	0	0	0	0	0	0	1	0	**1**
11	ICT Officer	1	0	0	0	0	0	0	0	0	**1**
12	Administrative Officer	4	0	0	0	0	0	0	0	0	**4**
13	Accountant	7	1	1	1	1	1	1	1	1	**15**
14	Auditor	2	0	0	0	0	0	0	0	0	**2**
15	Statistician	2	0	0	0	0	0	0	0	0	**2**
16	Suppliers Officer	4	1	1	0	2	0	1	0	0	**9**
17	Legal Officer	1	0	0	0	0	0	0	0	0	**1**
18	Mass Communication Officer	1	0	0	0	0		0	0	0	**1**
19	Technician (Irrigation/Civil)	0	4	5	1	0	5	4	3	0	**22**
20	Technician (Mechanical)	0	1	1	0	0	1	0	0	0	**3**
21	Livestock Officer	0	0	2	0	0	0	0	0	0	**2**

	Profession	HQ	Morogoro	Kilimanjaro	Mtwara	Mbeya	Dodoma	Tabora	Mwanza	katavi	Total
22	Plant Operator	0	0	1	0	0	1	0	0	0	**2**
23	Others	11	7	5	1	4	4	3	3	1	**39**
	Total	**64**	**34**	**31**	**13**	**28**	**29**	**20**	**21**	**5**	**245**

Source: The NIRC edited by JICA Project Team.

If compared with the data in 2011 of the then Division of Irrigation and Technical Services (DITS) at the MoWI, the number of engineers has decreased from 91 to 81. The number of land surveyors has also decreased from 16 to 11. While there were hydrologists in 2011, there is none in 2018.

Under the current condition, the ZIO's supports to the LGAs for small-scale irrigation development are rather extensive. The ZIO engineers attentively support the LGAs in conducting feasibility study, designing, preparing tender documents, and supervising the constructions. In other words, the ZIOs practically function as a consultant for the LGAs. Meanwhile, the number of LGAs to cover ranges from 17 to 31 for each ZIO even under the eight-zone system. Considering that further irrigation development is to take place at the LGA level, this extensive support system of zonal engineers might not be sustainable in the long run.



Note: One engineer with no age available was excluded from this data.
Source: The NIRC edited by JICA Project Team.

Figure 2.2.1 NIRC Engineers by Age Group (FY 2009/10 and 2016/17)

Another issue is the aging of experienced engineers. As shown in the figure above, the senior engineers (51-60 years old), who formed the largest age group in FY 2009/10, have already retired. Instead, the largest group consists of those at the age of 31-40 in FY 2016/17. Thus, little time is left for them to learn from the senior engineers, who have broad experiences of large-scale irrigation projects in the 80s and 90s.

2.2.2 Local Government Authorities

Local Government Authorities (LGAs) are the main implementing body of small-scale irrigation development. Yet they are understaffed with technical officers in the irrigation sector. As the table below shows, it is hardly the case that each LGA secures at least one engineer or one technician. 37% of all LGAs (66 out of 180 LGAs[1]) do not have either irrigation/agricultural engineer or irrigation technician. With regard to engineers, 116 of 180 LGAs (64%) have no irrigation/agriculture engineers.

[1] The number of LGAs excludes those which are not yet operational or of little relevance in irrigation development at the time of analysis (2017), i.e. Dar es Salaam City, Ubungo MC, Kigamboni MC, Kibiti DC and Songwe DC. Hence the total is 180.

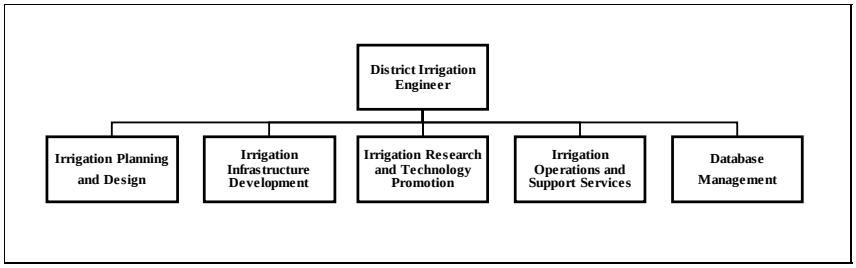
Table 2.2.2 Allocation of Irrigation Engineers and Technicians in LGAs (Feb. 2017)

Zone	Dodoma	Katavi	Kilimanjaro	Mbeya	Morogoro	Mtwara	Mwanza	Tabora
Number of LGAs	22	17	25	22	20	23	31	20
Irrigation/ Agricultural Engineer	**14**	**8**	**13**	**13**	**14**	**10**	**14**	**7**
Irrigation Technician	**12**	**14**	**48**	**35**	**21**	**15**	**22**	**8**

Source: JICA Project Team (with the support of the NIRC).

An ideal situation is that a LGA attaches one irrigation technician to each irrigation scheme for regular monitoring; however, such case has not been confirmed in the field[2]. As for construction supervision, one district officer (such as irrigation technician or VAEO) and one zonal engineer are normally assigned.

As the LGA's capacity in irrigation development is low, most of the technical tasks along the irrigation development process (such as feasibility study, detailed design, and preparation of tender document) are commissioned to the zonal office. Also, due to the limitation of budget, the LGAs rarely contract out the consultancy service to private firms. The NIA recommends the establishment of irrigation department (DID) where appropriate, and yet such reorganization has not been observed among the LGAs. The National Irrigation Development Strategy (draft, 2013) suggests the organizational arrangement of DID shown in the figure above.



Source: The National Irrigation Development Strategy (Draft), November 2013.

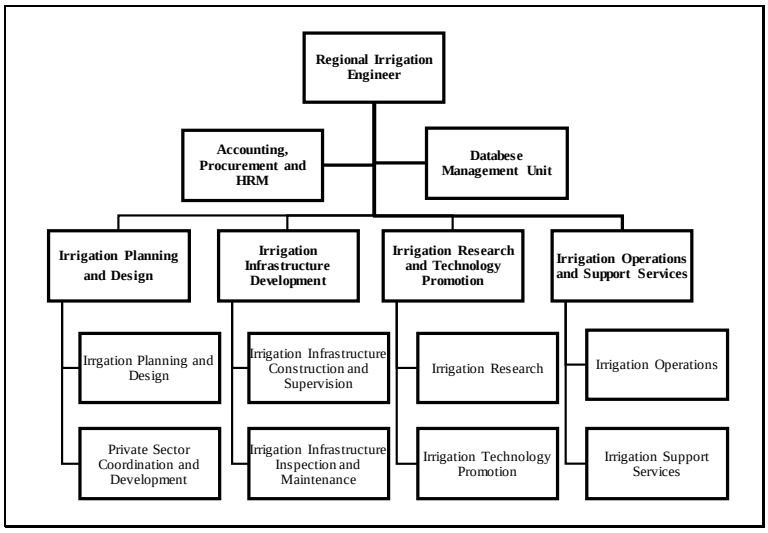
Figure 2.2.2 Proposed DID Organizational Structure

The NIA guides the LGAs to follow the comprehensive guidelines (CGL) for formulation, implementation and operation and maintenance (O&M) of small-scale irrigation schemes. With the support of a development partners' project (JICA TANCAID), the capacity of LGAs for following CGL process is gradually developing, and yet much effort is required for nationwide roll-out.

[2] There is a case of Mvomero DC and Moshi DC, where agricultural officers, including village agricultural extension officers (VAEO) and ward agricultural extension officers (WAEO) are attached to each irrigation scheme in the district.

2.2.3 Region

The NIA directs the establishment of regional irrigation offices (RIOs). Yet it is not certain if the reorganization takes place in the short term. At present, few experts are assigned at the Regional Secretariats (RS) to provide technical advice to the LGAs in the irrigation sector. As a consequence, the RS currently function as an administrative supervisor of LGAs whenever there is a miscommunication between zones and LGAs[3]. While the estabilishement of RIO is highly recommended considering the excessive workload of ZIOs and outreach to remote LGAs, the investment cost for RIO set-up all over the nation at a time is rather high. One option under such ciricumstances is to establish RIOs in phases with reduced functions and personnel.



Source: The National Irrigation Development Strategy (Draft), November 2013.

Figure 2.2.3 Proposed RIO Organizational Structure

2.2.4 Irrigators Organization

According to the NIRC data[4], there are 458 Irrigation Organizations (IOs) in mainland Tanzania, and yet only 8 IOs are registered under the NIA regulations. Conventionally, there are two types of irrigators organizations: Irrigators Associations (IA) and Irrigators Cooperatives (IC). Besides these registered irrigators, there are traditional irrigators groups engaged in smaller scale irrigation practice. Main characteristics of IA and IC are shown below.

Table 2.2.3 Types and Characteristics of Irrigators Organizations

Type	Registration	Membership	Main Function	Land Title	Water Use Permit	Main Source of LGA Support	Major Challenge
IA	NIRC*	Compulsory	Water management, O&M	Individual/ Group	Permit obtained at BWO	Technical: DAICO office/AEO Management: CDO	- Incentives for group activities. -Administrative/financial management
IC	TCDC/ NIRC	Voluntary	Water Management, O&M, Cooperative Activities	Individual/ Group	Permit obtained at BWO	Technical: DAICO office/AEO Management: Cooperative Officer	- Involvement of non-members in O&M activities.

*Note: * After the negotiation between the NIRC and MoHA, mandate of IA registration is transferred to the NIRC.*
Source: JICA Project Team.

IAs and ICs have several differences in their objectives and features. First, IAs maintain compulsory membership as a rule among all irrigators while ICs are voluntarily formed groups in nature. Second, IA activities are in principle limited to O&M and water management of irrigation schemes. Besides such

[3] For instance, if a LGA delays a payment to the contractor of a LGA-level irrigation scheme construction although the fund has been disbursed to the LGA, zonal office first sends a letter to the LGA for explanation or early payment. If any action is not taken by the LGA, the zone refers to the regional office for administrative intervention.
[4] DOSS and DCQA, NIRC (as of June 2016).

activities, ICs are also engaged in collective activities of production, input purchase, harvesting, processing, marketing or distribution (so-called business practices). In general, the IC members are regarded to be more committed to group activities, pursuing profit out of collective actions. Yet their major challenge is how to urge non-member irrigators to pay for the operational costs, such as O&M and water use permit.

The NIA Regulations (2015) allows ICs to be registered under the NIA by obtaining a certificate of compliance while remaining as a cooperative established under the Cooperative Societies Act (CSA, 2013) only if they abide by the NIA[5]. Yet there need further adjustments between the NIA and CSA, such as compulsory or voluntary membership, fees, and audit conditions.

LGA's support system for ICs and IAs also differ. For ICs, district cooperative officers are assigned to monitor their activities, providing training on financial management and annual auditing. That is partly why cooperatives are considered to be better in financial management than the associations. For IAs, community development officers often provide the support as part of their role for supporting group activities. Technical supports are provided by irrigation technicians or extension officers with a background of irrigation for both IAs and ICs. In reality, however, few LGAs can afford to attach technicians to each irrigation scheme, and the supports of zonal officers are provided mainly in the construction phase. As such, LGA's support system to IO is especially weak in O&M as well as technical inputs to crop production and marketing.

2.2.5 Private Sector

There are few local engineering firms specializing in irrigation development[6]. Hence, the demand for irrigation engineers or technicians are not high in the private sector. This is partly due to the fact that the ZIOs undertake most of consulting works for small-scale irrigation scheme construction, and thus there is little market demand or incentive for private sector involvement. This situation might be unavoidable with limited budget allocated to irrigation development[7] although there is an argument that the NIRC should keep from providing consultancy work to individual projects[8]. For large-scale irrigation development, consulting and engineering works are usually commissioned to a foreign private firm although there is some room for local firms to participate in the project as associates.[9]

As for the contractors, there are several civil contractors based in Dar es Salaam and regional capitals, which have been awarded with LGA-level irrigation constructions. However, there are few contractors specialized in irrigation development[10]. As a result, civil contractors do not selectively employ irrigation engineers or technicians but merely as "civil engineers/technicians".

[5] Refer to Article 8, National Irrigation Regulations 2015, URT.
[6] According to the ERB, there are only two local firms registered for irrigation engineering field. There are 211 registered local engineering firms and 86 foreign firms in Tanzania (as of December 2016).
[7] If consulting work is commissioned to the zonal office, the LGA will only provide daily allowance and transportation for the zonal engineers.
[8] The argument against the NIRC's consultancy work is twofold: 1) Professional liability and indemnity are not covered if the supervisor of a project is also the implementer; and, 2) Public involvement keep local consulting firms out of business.
[9] Interviews with local engineering firms based in Dar es Salaam.
[10] There is one contractor specializing in irrigation development in Mbeya. The manager is a retired zonal officer engineer.

2.3 Supply Side of Irrigation Human Resources

2.3.1 Engineers and Contractors

According to the Engineers Registration Board (ERB) data, the numbers of registered graduate engineers (GE)[11] have been increasing in agricultural/irrigation discipline. For instance, GE increased from 126 in 2009 to 289 in 2016 (129% increase). This increase is largely thanks to the start of irrigation engineering course at the Arusha Technical College (ATC) and Sokoine University of Agriculture (SUA), and the number is likely to increase further when engineering courses of the Water Institute (WI) and the University of Dar es Salaam (UDSM) start producing their graduates.

As for the registered professional engineers (PE)[12] in the same discipline, the number increased from 57 (2009) to 88 (2016), but the increase is not as sharp as GE (54% increase). Employment status of GE and PE are shown below.

Table 2.3.1 Employment Status of Registered Engineers

GE

	Employment Status	Nos.	%
1	LGA/ Region Offices	103	31%
2	MALF/ NIRC	59	18%
3	Other Government Agencies	28	8%
4	R&D Institutions /Training Institutes	8	2%
5	Private Companies	48	14%
6	NGOs	6	2%
7	Unemployed	82	25%
	Total	334	

PE

	Employment Status	Nos.	%
1	LGA/ Region Offices	4	4%
2	MALF/ NIRC	52	57%
3	Other Government Agencies	14	15%
4	R&D Institutions /Training Institutes	5	6%
5	Private Companies	9	10%
6	NGOs	3	3%
7	Unemployed	4	4%
	Total	91	

Note: The GE and PE included here are those registered in the categories of Civil/Irrigation, Agricultural, Irrigation/Water, Agricultural/Irrigation and Mechanical/Irrigation.
Source: ERB (January 2017) edited by JICA Project Team.

Although the data are limited to the status of registered engineers, the following can be inferred from them:

- GEs are primarily employed by (or returned to) regional and district offices while few PEs are employed by them. This implies that there are many inexperienced engineers assigned in LGAs without PE's guidance. Experienced engineers are mostly allocated in the MALF and NIRC.
- More graduate engineers are employed by private companies than are senior engineers. Employers include engineering firms, civil contractors, cash crop companies, such as tea, coffee and sugar.
- Unemployment rate is much higher for GEs (25 %) than PEs (4%). LGAs and regions employ the GEs to a certain extent, but not enough to absorb the unemployed.

As for civil contractors, the registered contractors are classified by the limit amount of single contract.

[11] GE is a registered engineer who holds a bachelor's degree or above in engineering without professional experience.
[12] PE is a registered engineer who holds a bachelor's degree or above in engineering with professional experience and approved reports of her/his work (designing, field work and management).

Table 2.3.2 Registered Civil Works Contractors by Class (2016)

Class	Limit for Single Contract (TZS million)	Number of Contractors
1	Unlimited	63
2	5,000	16
3	3,000	52
4	1,500	222
5	750	625
6	300	1,105
7	150	1,099
Total		3,182

Source: ERB (January 2017) edited by JICA Project Team.

In terms of contract amount, class 5 contractors and above are eligible for small-scale irrigation construction. In practice, however, full-scale irrigation construction is rarely undertaken due to budget limitations, and the awarded contractors range from class 4 to 7 with lower-class contractors engaged in partial rehabilitation or construction of irrigation schemes[13]. In many cases, LGAs find the contractors in their regional centres, such as Dar es Salaam, Mbeya, Moshi, Arusha, Iringa, and Mwanza.

2.3.2 Educational and Training Institutions

There are several educational and training institutes which provide irrigation engineers and technicians. The following table shows current degree and diploma courses directly contributing to irrigation human resources development. Notable change since 2009 is the start of 1) ATC's diploma and degree courses, 2) USDM's degree course, and 3) WI's diploma and degree courses. As shown in the table, intake capacity of diploma courses is less than half of degree courses; that is, more engineers are produced than are technicians at present. Since more technicians are required for the supervision of field operations, present status of irrigation human resources provision is rather unbalanced. On the other hand, most of education and training institutes are inclined to focus on degree courses. Hence, further expansion of diploma (technician) courses cannot be expected under the current circumstances.

Table 2.3.3 Degree and Diploma Courses for Irrigation Engineers and Technicians (2016/17)

Skill Level	Institution	Course	Admission Capacity
Engineer	ATC	B. Eng. in Civil and Irrigation Engineering	66
	WI	B. Sc. in Water Resources and Irrigation Engineering	300
	SUA	B. Sc. in Agricultural Engineering	65
		B. Sc. in Irrigation and Water Resources Engineering	65
	UDSM	B. Sc. in Agricultural Engineering and Mechanization	30
	Total		**526**
Technician	ATC	Ordinary Diploma in Civil and Irrigation Engineering	75
	WI	Ordinary Diploma in Irrigation Engineering	120
	MATI Igurusi	Ordinary Diploma in Irrigation	62
	Total		**257**

Note: The figures are on an annual admission capacity basis.
Source: Data from Tanzania Commission for Universities (TCU) and individual education and training institues.

(1) Water Institute

Water Institute (WI) is a research, constancy and educational institution under the Ministry of Water and Irrigation. The WI provides bachelor's, diploma and certificate courses on water resources and irrigation,

[13] Data obtained from the CRB and several LGAs (Kakonko DC, Kibondo DC, Moshi DC and Hai DC)

water supply and sanitation, water laboratory technology, hydrology and hydrogeology. The institute provides degree and diploma courses in water resources and irrigation engineering. WI started Ordinary Diploma in irrigation Engineering in 2011/12 and BSc. in Water Resources and Irrigation in 2013/14. Thus, the institute expects to produce first degree holders in 2016/17.

Table 2.3.4 WI's Admission Capacity, Actual Intake and Number of Graduates

Course		2012/13	2013/14	2014/15	2015/16	2016/17
BSc. in Water Resources and Irrigation Engineering	Admission Capacity	-	100	200	200	300
	Actual Intake	-	69	118	193	220
	No. of Graduates	-	-	-	-	-
OD in Irrigation Engineering	Admission Capacity	60	60	60	70	120
	Actual Intake	42	51	49	36	92
	No. of Graduates			9	33	-

Source: WI.

There is no concrete data for employment status of graduates, but diploma holders are mainly recruited by water companies, sugar companies and the NIRC[14]. The WI has the laboratories of soil mechanics, hydrology, water quality, pump mechanics and survey. The practical training of irrigation is conducted at the Agricultural Research Institute of Mlingano.

(2) Arusha Technical College

Arusha Technical College (ATC) is under the jurisdiction of Ministry of Education and Vocational Training (MoEVT) and provides degree and diploma courses of civil and irrigation engineering. BSc. in Civil and Irrigation Engineering started in 2010/11 and Ordinary Diploma in 2011/12.

Table 2.3.5 ATC's Admission Capacity, Actual Intake and Number of Graduates

Course		2012/13	2013/14	2014/15	2015/16	2016/17
BSc. in Civil and Irrigation Engineering	Admission Capacity	30	30	30	66	66
	Actual Intake	25	29	29	60	61
	No. of Graduates	-	21	24	25	30
OD in Civil and Irrigation Engineering	Admission Capacity	50	50	50	75	75
	Actual Intake	48	27	23	17	25
	No. of Graduates	-	-	26	44	23

Source: ATC.

As for the employment status, the ATC conducted a tracer study of degree course graduates.

Table 2.3.6 Employment Status of BSc. Graduates

Graduation Year	2014	2015	2016	Total	%
Number of Graduates	21	24	25	70	100
Government Agency	11	16	10	37	53
Private Company	6	4	5	15	21
Unemployed/ Unknown	3	4	10	17	24

Source: ATC.

According to the study, more than half of the graduates (53%) are employed by government agencies. Yet most of them are returners, who were on leave to obtain a bachelor's degree. New graduates who

[14] Interview with the rector of WI.

entered the private sector are mostly employed by the construction companies as a "civil engineer," presumably not engaging in irrigation development.

There is a small demo plot for showcasing various types of irrigation methods (drip, sprinkler, border, furrow, basin and pipe). Besides, there is a plan of development a training farm outside of the campus, which will feature rainwater harvesting, water reservoir and groundwater as sources of irrigation. The main concept of these farms is the introduction of water efficient irrigation methods in semi-arid areas in Tanzania. The department of civil engineering has hydraulic, soil and plant, water quality, geomatics, and computer laboratories to be provided with equipment[15].

(3) Sokoine University of Agriculture

Sokoine University of Agriculture (SUA), under the jurisdiction of MoEVT, offers various disciplines of academic courses in the agriculture sector. Especially, the Department of Engineering Sciences and Technology (DEST) at the College of Agriculture provides BSc. in Agricultural Engineering, and a course of BSc. in Irrigation and Water Resources Engineering (started in 2011/12). Also, the department offers MSc. in Agricultural Engineering and MSc. in Irrigation Engineering and Management.

Table 2.3.7 SUA Admission Capacity, Actual Intake and Number of Graduates

Course		2012/13	2013/14	2014/15	2015/16	2016/17
BSc. in Agricultural Engineering	Admission Capacity	N/A	N/A	60	60	65
	Actual Intake	N/A	82	105	168	110
	No. of Graduates	10	27	15	9	60
BSc. in Irrigation and Water Resources Engineering	Admission Capacity	N/A	N/A	60	60	65
	Actual Intake	N/A	98	62	60	49
	No. of Graduates	-	-	32	46	46

Source: TCU and SUA.

Graduates of the two courses are mostly employed by the MoWI, MALF, ZIOs of NIRC and LGAs[16]. There used to be three laboratories of soil mechanics, water resources and hydraulics; however, they are currently closed to be used for the class rooms. The SUA has a test field of about 100 ha in the main campus premise with an earth dam and drip irrigation demo plots. In addition, the university owns 1,500 ha land for test fields at Mazimbu campus. The university also has conducted the consultancy work on irrigation development.

(4) University of Dar es Salaam

University of Dar es Salaam (UDSM) is under the MoEVT and opened the College of Agricultural Sciences and Fisheries Technology (CoAF) and has offered BSc. in Agricultural Engineering and Mechanization since 2015/16.

Table 2.3.8 USDM Admission Capacity, Actual Intake and Number of Graduates

Course		2012/13	2013/14	2014/15	2015/16	2016/17
BSc. in Agricultural Engineering and Mechanization	Admission Capacity	-	-	-	40	40
	Actual Intake	-	-	-	43	37
	No. of Graduates	-	-	-	-	-

Source: UDSM.

[15] JICA provided an open channel apparatus for the hydraulic laboratory in 2016. Other equipment will be provided by AfDB project.
[16] Interview with the DEST.

The Department of Agricultural Engineering still lacks necessary laboratories, such as for flow measurement, equipment and training farms.

(5) Ministry of Agriculture Training Institutes

There are 14 Ministry of Agriculture Training Institute (MATIs). Among them, only MATI Igurusi provides specific diploma course for irrigation technicians. Kilimanjaro Agricultural Training Centre (KATC) provides training on irrigated rice production for farmers and extension officers.

Table 2.3.9 Summary of MATIs (as of 2016/17)

Name of Institute	Location	Program	Course	No. of Tutors	Capacity
MATI Igurusi	Mbeya	Irrigation Land Use Planning	Diploma, Short Course	19	124
MATI Illonga	Morogoro	General Agriculture Food Production and Nutrition	Diploma, Certificate, Short Course	23	300
MATI Mlingano	Tanga	Agricultural Mechanization	Diploma, Short Course	13	80
MATI Mtwara	Mtwara	General Agriculture	Diploma, Certificate, Short Course	19	520
MATI Tumbi	Tabora	General Agriculture	Diploma, Certificate, Short Course	13	650
MATI Ukiriguru	Mwanza	General Agriculture	Diploma, Certificate, Short Course	19	250
MATI Uyole	Mbeya	General Agriculture Crop Production	Diploma, Certificate, Short Course	28	495
National Sugar Institute Kidatu	Morogoro	General Agriculture	Diploma, Certificate, Short Course	13	175
KATC	Moshi	General Agriculture (Irrigated Rice Farming)	Diploma, Certificate, Short Course	25	64
Horticultural Research and Training Institute Tengeru	Arusha	Horticulture	Diploma, Short Course	17	70
Kilombero Agricultural Training and Research Institute	Morogoro	General Agriculture	Certificate, Short Course	8	88
MATI Maruku	Bukoba	General Agriculture	Certificate, Short Course	10	180
MATI Mubondo	Kigoma	General Agriculture	Certificate, Short Course	8	120
Farmers Training Centre (ATI) Inyala	Mbeya	General Agriculture	Certificate, Short Course	11	112

Source: MALF.

(a) MATI Igurusi

MATI Igurusi currently runs two diploma courses of irrigation and land use planning. Total enrolment is 85 in 2016/17, of which 58 students for irrigation course and 27 students for land use planning course. Graduates are mostly employed in the public sector while a few obtain employment at private firms, such as sugar companies. MATI Igurusi has a strong intension to be a specialized irrigation training institute[17].

For practical training, the institute rents several irrigated plots in nearby areas. In addition, a training farm of 38 acres is under construction to demonstrate surface, pipe and drip irrigation with a river and reservoir as water source. One soil testing laboratory was established with the PHRD (Professional Human Resource Development) grant. Yet the institute faces the challenges of rehabilitation and

[17] Interview with the principal and lecturers of MATI Igurusi.

procurement of necessary equipment.

(b) Kilimanjaro Agricultural Training Centre

Kilimanjaro Agricultural Training Centre (KATC) has a diploma course for general agriculture since 2007. It is mainly aimed at training prospective extension officers. Annual enrolment of the course is about 60. Besides the diploma course, KATC, in collaboration with TANRICE-2 project, conducts a set of short courses for farmers and extension officers on irrigated rice farming in collaboration with 6 MATIs and Kizimbani Agricultural Training Institute (KATI) in Zanzibar.

(6) Mbeya University of Science and Technology

Mbeya University of Science and Technology (MUST) has a degree course and a diploma course for civil engineering. In 2015/16, the MUST accepted 291 students for the degree course, and 99 for the diploma course. Although the university does not have a specific course for irrigation engineering, there is an intension to open a course like the one in the ATC, based on its course for civil engineering[18]. Besides, the MUST has been commissioned by the Mbeya ZIO and LGAs to conduct topographical survey as well as design and construction supervision of irrigation schemes[19]. There are soil testing lab and materials testing lab at the Department of Civil Engineering.

(7) The Nelson Mandela African Institution of Science and Technology

The Nelson Mandela African Institution of Science and Technology (NM-AIST) belongs to a network of Pan-African Institutions of Science and Technology, and is a graduate university. The NM-AIST currently accepts 108 Ph. D and masters' degree students. 25 students are at the School of Materials, Energy, Waters and Environmental Science, which includes Hydrology and Water Resources Engineering (HWRE) programme. Maximum admission capacity of the institution is about 300-500. 50% of the graduates of hydrology and water resources engineering courses get employed as academic staff either NM-AIST or other institutes. The other 50% are mostly employed by the basin water boards as hydrologists. A few obtained employments at the utility companies and other private companies, or LGAs as district engineers[20].

The HWRE conduct a series of studies on water accounting, water resources modelling and water productivity in irrigation. The institution also conducted a consultancy work on reuse of waste water for irrigation, and an environmental flow assessment of Wami/Ruvu rivers for Kilombero irrigation project. Also, the NM-AIST has various types of laboratories of water, soil, environmental, energy and life science.

2.4 Key Issues for Irrigation Human Resources Development

Based on the situation analysis above, the following table summarizes the key issues of irrigation human resources development.

[18] Interview at the MUST.
[19] For instance, topographical survey for Kilolo irrigation scheme, and Namingo'ngo irrigation scheme for design and construction supervision.
[20] Interview at the NM-AIST.

Table 2.4.1 Key Issues and Possible Measures for Irrigation Human Resources Development

	Key Issue	Possible Measure
Demand Side	**[NIRC/ZIO]**	
	- Decrease in technical officers and equipment.	- Formulation of recruitment and procurement plan and implementation.
	- Retirement of experienced technical staff.	- Recruitment of technical staff. - Provision of on-the-job training in irrigation projects.
	- Work overload of ZIO in outreaching numerous or remote LGAs.	- Gradual introduction of RIO. - Outsourcing to the private firms.
	- Extensive support for LGAs	- Outsourcing to the private firms. - Training for LGA technical/extension staff.
	[LGA]	
	- Quantity and quality of engineer/technicians.	- Formulation of recruitment plan and implementation. - Provision of on-the-job training in irrigation projects.
	- Sufficient support for irrigation schemes and IOs.	- Clarification on the demarcation of IO supports.
	- Appropriateness of setting up DID.	- Strengthening of DIDT. - Gradual introduction of DID.
	[Region]	
	- Ambiguous status in irrigation development, including the establishment of RIOs.	- Gradual introduction of RIO.
	- Shortage of technical staff	- Allocation of technical staff based on their roles.
	[IO]	
	- Support from NIRC/LGA (O&M, water management, organizational and business management, etc.).	- Allocation of trained staff to each irrigation scheme.
	[Private Sector]	
	- No attractive market in the irrigation sector.	- Outsourcing of part of NIRC works to private service providers.
	- Involvement of local engineering firms and contractors in medium/large-scale irrigation projects.	- Affirmative measures to involve local engineering firms in public irrigation projects.
Supply Side	- Lack of incentive to supply irrigation engineers/technicians without sufficient demands.	- Affirmative measures to involve local engineering firms in public irrigation projects. - Recruitment and training plan and implementation at the LGA level.
	- Allocation of inexperienced engineers without practical training.	- Provision of on-the-job training in irrigation projects.

Source: JICA Project Team.

Among others, following points are of imminent concern for promoting irrigation human resources development.

- The NIRC is understaffed, underequipped and undertrained considering the workload assigned to the agency.
- Considering the fact that ZIOs virtually provide consultancy work for the LGAs, current eight-zone system is not sufficient in outreaching all LGAs, especially for remote ones.
- LGAs heavily depend on the ZIOs for their irrigation development. They are generally understaffed for effective implementation of irrigation projects. Strengthening of District Irrigation Development Team (DIDT) should be considered especially for the LGAs with sizable number of existing/planned irrigation schemes to monitor.
- LGAs need to consider the on-the-job training for extension officers for irrigation project support, for a dramatic increase in the provision of irrigation technicians cannot be expected

from the existing educational and training institutes.

- Current system of registration and support for IOs should be improved. Especially, who is responsible for what aspects of IO support should be clearly defined.
- Involvement of the private sector is not promoted with extensive supports of ZIOs to LGAs, especially for small-scale irrigation projects. There is a need to introduce affirmative measures to promote the role of private service providers.

2.5 Review of NIMP 2002 Programs

NIMP 2002 set short and medium-term programs for further irrigation development in terms of institutional, technical and management aspects. The following table shows these programs and their implementation status. The programs related directly to the human resources development are highlighted.

Table 2.5.1 Summary on the Review of NIMP 2002 Programs

	Subject-wise Program	Objective	Implementation Status
Short-Term	A1: Irrigation Section (IS) Institutional Improvement Programme	- Institutional improvement plan of the IS is carried out.	- NIRC established.
	B1: IS Working Mandate Formulation Programme	- Proper working mandate of IS is regulated and started to be applied.	- NIA enacted, and its application to be promoted.
	B2: Contract Management System Improvement programme	- New contract management system (procedure/guideline) is started to be applied.	- Uncompleted.
	B5: Cooperation Channeling within Irrigation-Sector Establishment Programme	- Properly linked mandate and duties of each agency in irrigation sector are established.	- Coordination enhanced under ASDP I.
	B6: Sub-sectors Coordination System Establishment	- Proper coordination directive among every subsector related to irrigated agriculture are established.	- Coordination enhanced under ASDP I.
	C1: Survey and Investigation Guideline Establishment Programme	- Survey and Investigation(S&I) Guideline for new irrigation planning is completed and distributed.	- CGL formulated and distributed.
	C2.1: Planning Guideline Establishment Programme	- Guideline for planning new irrigation scheme is completed and distributed.	- CGL formulated and distributed.
	C2.2: Designing Guideline Establishment Programme	- Guideline for designing new irrigation scheme is completed and distributed.	- CGL formulated and distributed.
	C3.1: O&M Guideline Establishment Programme	- Guideline for O&M of irrigation scheme is completed and distributed.	- CGL formulated and distributed.
	C3.2: M&E Guideline Establishment Programme	- Guideline for M&E of irrigation scheme is completed and distributed.	- CGL formulated and distributed.
	C4: Farmers' Participation in Irrigation Development Programme	- Guideline for farmers' participation is prepared and tested in model schemes for replication nationwide.	- CGL formulated and distributed.
	C6: Farmers' O&M Manual Establishment Programme	- Guideline for farmers' O&M of irrigation scheme is completed and distributed.	- CGL formulated and distributed.
	C7: Establishment of DADP Formulation Guideline for Irrigated Agriculture Development	- Guideline for DADP formulation of irrigated agriculture development is prepared and distributed.	- DADP Guidelines and CGL formulated and distributed.
	D1: Web-site and Networking Establishment Programme	- Web-site for IS is established. And intra-network system is extended within IS and in between ZIOs.	- Uncompleted.
	D2: Technical Manuals Handling Guideline Establishment Programme	- Guideline for handling technical manuals is completed and distributed.	- Completed.
	D3: Information and Database Improvement Programme	- Database for irrigation development and management is developed.	- Developed but further improvement required.
	D4: Irrigation Development Contactors and Consultants' Listing Programme	- Inventories for contractors and consultants for irrigation contract works are completed and updated.	- Uncompleted.
	D7: Existing-scheme Monitoring System Establishment Programme	- Monitoring system of existing irrigation schemes is established and put into operation.	- Ongoing
	E1.1: Irrigation Technology Research Center Establishment Programme	- Irrigation technology center is established and operated.	- Uncompleted.
	E1.2: Perennial Irrigation Method Improvement Programme	- Improving measures for perennial irrigation practice in Tanzania are established.	- Uncompleted.
	E1.3: Flood Irrigation Development Programme	- Sustainable flood irrigation (water harvesting) know-how for marginal areas is established and applied.	- Uncompleted.
	E1.4: Small Dam Technology for Irrigation Development Establishment Programme	- Adequate small dam technology for irrigation development is established and applied.	- Uncompleted.
	E1.5: Environmental Assessment Study for Irrigation Practice in Tanzania	- Environmental issues affected presently in and by irrigation practice in Tanzania are elucidated.	- Uncompleted.
	E1.6: Study of River-Basin Approach in Irrigation Development	- Proper river-basin approach for irrigation sector is established as a form of guideline.	- Uncompleted.
	E.3: IS's Equipment Management Programme	- An equipment management system in IS is established and operated.	- Uncompleted.
	E4: Irrigation Development Consultants and Contractors' Training Programme	- Irrigation development contractors and consultants' training system is established and operated.	- Uncompleted.
	E5: Farmers' Participation Training Programme	- Farmers' participation training programme for irrigated agriculture is established and conducted.	- CGL formulated.
	E6.1: Irrigated Agriculture Training Programme for Rice Production Increase	- Productivities of rice increases in the model sites through the KATC's training.	- Training conducted.
	E6.2: Irrigated Agriculture Training Programme for Cash Crops Production Increase	- Productivities of irrigated cash crop increase in the model sites through training of the programme	- Uncompleted.
Medium-term	A2: LGA Institutional Strengthening Programme for Irrigation Development	- Institutional improvement plan of the irrigation sector's organization in LGA office is authorized and implemented.	- DADP developed under ASDP 1, CGL formulated, and NIA to be operationalized.
	B3: Regulatory Networking System Establishment between LGAs and IS	- Regulatory Networking System between LGAs and IS is established and started.	- Uncompleted.
	B4: NGOs' Intervention in Irrigation Development Encourage Programme	- Encouragement plan for NGOs' intervention in irrigation development is established and started.	- Uncompleted.
	C5: Village Irrigation Development (VID) Guideline Establishment Programme	- VID Guideline for planning, designing, construction and O&M is complete and distributed.	- CGL formulated and distributed.
	D5: LGAs' Data Organization Programme	- LGAs' data organization system related to irrigation development are established or improved.	- ASDS introduced.
	E2: Hydraulic Experimental Center Establishment Programme	- A Hydraulic Experimental Center is established and operated in a suitable manner.	- Uncompleted.
	E7: Integrated Irrigation Development Model Establishment Programme	- Pilot models of integrated irrigation development are implanted.	- Uncompleted.

Source: JICA Project Team.

From the table, the areas to be improved in human resources development can be summarised as follows:

- According to the NIMP 2002 programs, the NIRC has been established under the NIA. Yet there is a room for further operationalization of the NIA so as to improve the NIRC functionality, including the set-up of RIOs.
- As recommended in the NIMP 2002, a set of guidelines has been developed and compiled as "the Comprehensive Guidelines for Irrigation Scheme Development" (CGL). The NIA designates this CGL to be applied for LGA-level irrigation development, operation and maintenance. While the formulation of the guidelines was completed, there is still a need for wider application in the field.
- While the CGL also guides the procurement of consultants or contractors, the measures for involving the private sector have not been undertaken effectively, especially for small-scale irrigation projects.
- There is a plan of establishing a research and training center specifically for irrigation development.

Chapter 3 Irrigation Human Resources Development Plan

3.1 Goal

The overall goal of the Irrigation Human Resource Development Plan is to strengthen the technical and organizational capacities of the stakeholders involved in irrigation development in line with NIMP 2018 as well as the NIA and other related sector policies and programs.

3.2 Strategy

First, the Plan and its activities are formulated in accordance with NIMP 2018. In other words, the IHRDP is part of NIMP 2018, being set in the timeframe of the master plan. Consequently, the Plan follows the timeframe of Phase I (2018-2025) and Phase II (2026-2035) of NIMP 2018. Second, the Plan is intended to be practical and feasible. In this regard, the primary focus is placed on capacity development of the NIRC and immediate stakeholders in the irrigation sector. Also, the planned interventions are limited to those that are controllable by these immediate stakeholders, especially the NIRC. While the Plan fully respects the National Irrigation Act (2013) and will contribute to its operationalization, the IHRDP suggests realistic and practical measures for gradual achievement of the Act based on the current circumstances. Third, irrigation capacity development requires a focus on practical training at every level. As such, on-the-job training along the project cycles of NIMP 2018 is the basic mode of operation for capacity development in the Plan.

3.3 Roles of Major Stakeholders

The expected roles of major stakeholders in the Plan are summarized below.

Table 3.3.1 Roles of Major Stakeholders

Institution	Role
NIRC Headquarters	・ Overall management of irrigation development and capacity development. ・ Operationalization of National Irrigation Act and regulations, and related policies and plans. ・ Implementation of mid to large-scale irrigation projects. ・ Coordination of major stakeholders in irrigation development ・ Provision of technical guidelines and manuals for irrigation development. ・ Registration and supervision of IOs. ・ Research and technology promotion for irrigation development.
ZIO/RIO	・ Support for feasibility studies, detailed designs and tender documents for irrigation projects. ・ Supervision of irrigation projects. ・ Technical supports to LGAs. ・ Data collection of irrigation-related information in the area. ・ Coordination between NIRC headquarters, region, LGAs, IOs and the private sector.
LGA (DIDT/DID)	・ Implementation of small-scale irrigation projects. ・ Formation of DIDT/DID assigned for overall irrigation development within the LGA. ・ On-site supervision, monitoring, data collection and reporting of irrigation projects. ・ Supports for formation of IOs, provision of training and technical advice, and monitoring based on the comprehensive guidelines.
IO	・ Operation and maintenance and water management of the irrigation scheme. ・ Financial/administrative management of the organization.
Educational and Training Institutes	・ Supply of irrigation human resources, e.g. irrigation engineers and technicians. ・ Provision of training to the stakeholders. ・ Research activities in irrigation development.
Private Engineering Company/ Contractor	・ Provision of consulting services for irrigation projects. ・ Provision of construction work.

Source: JICA Project Team

3.4 Development Components

The following shows the development components (DC) of the Plan, i.e. areas of focus for the capacity development primarily led by the NIRC. These components are part of NIMP 2018 and compatible with its soft component. (See the NIMP 2018 main document.)

Table 3.4.1 Summary of Development Components

Development Component	Description
[DC 1] Improvement of NIRC function	・ Review of staff assignment, equipment and facilities. ・ Staff recruitment and procurement of equipment and facilities.
[DC 2] Strengthening of ZIO and DIDT functions	・ Set-up of RIOs. ・ Promotion of proper implementation arrangement and staff assignment at the LGA level.
[DC 3] Capacity development along irrigation scheme development	・ Preparation of training modules. ・ Training for NIRC/ZIO personnel. ・ Training for DIDTs/DIDs and IOs along small-scale irrigation project cycle. ・ Coordination and arrangement for on-farm/subject-matter training for IOs.
[DC 4] Strengthening of IO support system	・ Promotion of IO registration. ・ Promotion of IO's collective/cooperative activities (partly covered in DC 3).
[DC 5] Promotion of private sector involvement	・ Promotion of local firm involvement in irrigation projects. ・ Encouragement of technical transfers in irrigation projects. ・ Provision of technical manuals and guidelines.
[DC 6] Preparation of guidelines and manuals	・ Review of existing irrigation-related guidelines and manuals. ・ Preparation of guidelines and manuals.
[DC 7] Research and development	・ Identification of research topics and commission of research. ・ Addition of research function to NIRC.
[DC 8] Monitoring and evaluation	・ Improvement of monitoring system. ・ Performance monitoring and evaluation (within the NIMP 2018).

Source: JICA Project Team

3.4.1 DC 1: Improvement of NIRC Function

(1) Outline

To realize the implemntation system deliniated in the NIA and NIMP 2018, the status of staff assignment and availability of equipment and facilities at the NIRC need to be reviewed for update and improvement. This review should be undertaken in accordance with the following development components (DC 2 to DC 8). In addition, present staff vacancies need to be taken into consideration.

(2) Interventions

- To review staff assignments, equipment and facilities of the NIRC.
- To recruit additional technical staff and procure equipment and facilities.

3.4.2 DC2: Strengthening of ZIO and DIDT Functions

(1) Outline

The NIA stipulates the establishment of regional irrigation offices (RIOs). As described in Chapter 2, ZIO is already overloaded with extensive supports to the LGAs in the zone. It is sensible, therefore, to devolve part of ZIO's works to regionally-located stations. Meanwhile, limitation of staff and finance has kept the NIRC from quick transfer to the RIO system.

One possible solution is to introduce the RIOs in a phased and selective manner as follows:

- The 8 ZIOs continue to function as the center of zonal operation. They also serve as a regional center in the located region. In other words, the RIOs will be newly established in 18 regions

(26 regions minus 8 regions).

- 18 regions are prioritized for a phased introduction of RIOs based on scheme development priorities in NIMP 2018. In addition, physical accessibility from zonal office to particular region will be taken into consideration.

The NIA also recommends the set-up of District Irrigation Department (DID) in consultation with the PO-RALG. Considering the present staff allocation status, however, it is rather practical and realistic to improve the current operational structure of the LGA at least in the short-term perspective. As shown in Chapter 2, the priority is to fill the gap of technical staff shortage for small-scale scheme development. The addition of LGA engineers and technicians should also be phased in accordance with the priorities of scheme development projects proposed in NIMP 2018.

As the situation analysis suggests, there is a concern for low provision of technicians; the LGAs cannot afford to assign a technician to each irrigation scheme. Therefore, it is recommended that LGAs attach other field staffers, such as extension officers, to respective schemes for IO support in the phase of operation and management. The officers will also function as a liaison between the IOs and LGA. In the meantime, it is advisable that the LGA at least assigns one technician per engineer for the support of project management.

(2) Interventions

- To establish RIOs in a phased manner along NIMP 2018 implementation.
- To promote the sufficient level of staffing and organizational arrangement at the LGAs in consultation with relevant agencies.

3.4.3 DC3: Capacity Development along Irrigation Scheme Development

(1) Outline

(a) Capacity Development for LGA and IO

The NIA guides to follow the comprehensive guidelines (CGL) for small-scale irrigation development. Desirable mode of capacity development for CGL practice is on-the-job training in which LGA officers and IO members learn through atcual project implementaiton.

The CGL consists of three stages of irrigation development: i) formulation; ii) implementation; and iii) O&M. In addition, there is a following stage of IO training on production, organizational management and other subjects for collective activities, which are not specifically covered by the CGL. To create individual farmer's incentive and motivation for active engagement in IO activities, it is recommended to extend the support for visible outcomes; that is, increase in agricultural production, higher income generation, and better group management with accountability and transperancy.

i) Formulation

CGL's formulation stage covers 12 steps, from project prioritization to finalization of irrigation scheme formulation plan. In this period, the ZIO/RIO can support and provide advice to the DIDT/DID throughout the process.

ii) Implementation

Implementation stage has 9 steps, including formation of project committee and IO, acquisition of water use permit, feasibility study, detailed design, preparation of tender document and construction. Here, close involvement and guidance from ZIO/RIO is of significant importance, providing technical transfer to the DIDT/DID personnel as trainer of IOs. If the ZIO/RIO is short of capable engineers or technicians, the NIRC can consider outsourcing part of the tasks to private service providers.

iii) O&M

The CGL's O&M stage includes establishment of O&M system and training on facility operation and maintenance, water management and record keeping. The primary trainees are IO members, while field officers attached to the scheme and other DIDT/DID officers should also be trained and guided by the ZIO/RIO personnel.

iv) On-farm training

While irrigation scheme development and O&M are the main scope of CGL, training on good agricultural practice is also a significant part of IO's capacity development. This requires a support from the MALF and other stakeholders in the agriculture sector. For instance, the curriculum development and training implementation can be outsouced to the MATIs (see Section 2.3.2 (5)). The trainees are core members of IOs and LGA field officers attached to particular schemes.

v) Organizational and business training

If an IO or some members of the IO indend to start collective input purchase, processing, marketing and sales or capital investment for equipment and facilities, they are required to form a group/cooperative as business entity. In such a case, different types of supports for organizational and business activities should be provided by other stakeholders, such as TCDC and district cooperative officers, MATIs, financial institutions, NGOs engaged in agribusiness. The trainees are the core members of IOs and LGA field officer attached to the schemes.

(b) Capacity Development of NIRC Technical Staff

The process of small-scale irrigation development is well articulated in the CGL. Besides the CGL process, NIRC technical staff needs to be well versed in standard design, specifications, drawing and construction management. Thus, comprehensive training will be provided to NIRC engineers and technicians on the subjects mentioned above, so that they become the master trainers or technical advisors of small-scale projects and the managers of large-scale projects.

At the same time, the NIRC will develop the modules for all types of trainng referring to the existing guidelines and manuals.

(2) Interventions

- To conduct the training for DIDTs and IOs along small-scale irrigation project cycle.
- To coordinate and arrange on-farm/subject-matter training for IOs.
- To conduct the training for the NIRC (including ZIO and RIO) technical staff on technical manuals, checklists and procedures.

- To develop training modules for each stakeholder, utilizing the existing materials.

3.4.4 DC4: Strengthening of IO Support System

(1) Outline

The Irrigation Regulation of the NIA guides that a cooperative can be registered as IO by obtaining a certificate of compliance issued by the NIRC. In other words, the NIRC accepts a group registered to other authorities as an IO if the group abides by the NIA and its regulations.

Yet the registration process is slow at the moment; only 8 organizations registered to the NIRC as of January 2017. To provide proper support and monitoring to the IOs, the registration needs to be promoted, especially for the prioritized irrigation schemes in the NIMP 2018.

To attract individual irrigator's active involvement in IO activities, it is recommended that IOs also engage in collective production and marketing activities (registering as a cooperative is an option) in order to enhance the members' motivation and incentive for participation, i.e. increased production and income. If agricultural production and resulting income are increased for better livelihood, they will recognize the importance of sustain the irrigation scheme with proper maintenance work. To do so, the NIRC is required to consult with TCDC and other agencies for better coordination in promoting supports for cooperative activities while solving administrative issues mentioned in the situation analysis in a way that the irrigators' financial and managerial burdens will be minimized. A series of training programs on group management and agricultural practice in DC 3 is also effective in promoting IO collective activities.

LGA field officers attached to the scheme will provide day-to-day supports and refer IO's requests to other technical or administrative bodies, such as district council and irrigation office.

(2) Interventions

- To promote IO registration under the NIRC.
- To encourage IO's to engage in collective/cooperative activities in coordination with TCDC and other stakeholders.

3.4.5 DC5: Promotion of Private Sector Involvement

(1) Outline

At present, consulting work and construction for medium to large scale irrigation projects, financed by development partners or private investers, are mostly commissioned to foreign companies. To promote capacity development of local engineering firms and contractors, it is advisable for the government to promote their participation in those projects.

In the past, many tanzanian irrigation engineers and technicians had learned from foreign experts in large-scale irrigation projects in the course of project implementation. Unfortunately, most of those experienced local engineers and technicians have retired. Yet the effectiveness of such on-the-job training have been verified from the past experience.

One of possible measures is to set a condition in the tender process to encourage joint venture or any

other forms of partnership between foreign and local firms. If the procuring entity is the government, such preference can be included in the tender document in accordance with the Public Procurement Act and its regulations. Another measure is to include technical transfer component in an irrigation projects (most probably the ones supported by development partners) in which private sector engineers as well as NIRC officers are well involved and trained in the project process. It is expected that those local firms can learn from foreign companies and grdually accumulate the capacity of managing irrigation projects on their own. This arrangement will widen the market entry for local companies and lead to larger job opportunities in the private sector. As the agency which oversees all irrigation development plans and related programs and projects, the NIRC is in a good position to ensure the addition of such conditions in the project designs and contracts.

In addition, the NIRC needs to share the technical standards (such as design, specifications, and construction management) and procedures for public irrigation projects, so that the private stakeholders will actively engage in irrigation development projects.

(2) Interventions

- To promote joint venture or partnership with local firms in the project contracts.
- To encourage the inclusion of a component for technical transfer in DP-supported irrigation projects.
- To share the technical manuals and guidelines with private engineering firms and contractors.

3.4.6 DC6: Preparation of Guidelines and Manuals

(1) Outline

There is a need for the NIRC to prepare and organize technical manuals and guidelines (such as standard design manual, standard technical specifications, drawing standard, and standard construction management manuals) so that the NIRC technical staff can take uniform approach and methods for irrigation construction. Other materials of irrigation development, e.g. production, processing, marketing, and group management, can be collected from other agenicies for review and compilation for the purpose of capacity development.

(2) Interventions

- To review existing irrigation-related guidelines and manuals.
- To prepare and update guidelines and manuals: standard design manual, standard technical specifications, drawing standard, standard construction management manual, checklists for study, design and construction supervision.

3.4.7 DC 7: Research and Development

(1) Outline

There are several areas of irrigation development where further research and development are necessary, such as irrigation efficiency, water and land conflict management, gender mainstreaming, climate change, water budgeting and auditing and O&M costing. The NIRC as the overseer of ,irrigation development, is in the position to promote such research activities. Yet the areas of interest are diverse

and multidisciplinary, and the resource of NIRC cannot cover all subjects. One possible mode of opertion is to rely on outer resources if the commission is not well-equipped for a particular topic. For instance, if an academic and research institute has a comparative advantage in a paricular area of focus, then the NIRC can commission the research to that institute. In the country, there are sizable number of institutes which are specializing in various areas of irrigation development, such as SUA, ATC, NM-AIST, WI, MUST, agricultural research institutes and MATIs. (See Section 2.3.2). As such, the NIRC can focus on its area of advantage and function as a coordinator of various irrigation researches.

To achieve this goal, it is also advisable for the NIRC to have a center with minimum research facilities and equipment, which can also serve as a place for disseminating applicable irrigation techniques.

(2) Interventions

- To identify areas of focus for irrigation research.
- To conduct a series of research or commission it to external agencies.
- To develop a center for research and training.

3.4.8 DC 8: Monitoring and Evaluation

(1) Outline

To monitor individual irrigation projects, the roles and responsibilities of each stakeholder should be clarified. In the case of small-scale irrigation project, DIDT/DID is fully responsible for monitoring the whole process, from formulation to implementation to O&M, and requests technical supports from concerned irrigation office if need arises. Regular data collection of performance indicators are conducted by field officers attached to irrigation schemes. The data are compiled at the LGA level and reported to ZIO office.

At the central level, periodical performance reviews are implemented for checking the NIMP 2018 progress. As part of it, the status of capacity development is also reviewed.

(2) Interventions

- To promote LGA's monitoring, data collection and reporting of irrigation scheme development.
- To review the status of capacity development as part of periodical NIMP 2018 evaluation.

3.5 Timeframe

The following figure shows the timeframe of IHRDP implementaion by development component.

Phase	Phase I (2018-25)								Phase I (2026-35)									
Year	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	9	10
[DC 1] Improvement of NIRC function																		
(1) To review staff assignments, equipment and facilities of NIRC	■																	
(2) To recruit additional technical staff and procure equipment and facilities	■	■	■	■														
[DC 2] Strengthening of ZIO and DIDT functions																		
(1) To establish RIOs	■		■		■				■		■		■		■			
(2) To promote the sufficient level of staffing and organizational arrangement at the LGAs	■		■		■				■		■		■		■			
[DC 3] Capacity development along irrigation scheme development																		
(1) To conduct training for DIDTs and IOs	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
(2) To coordinate and arrange on-farm/subject-matter training for IOs	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
(3) To conduct training for NIRC technical staff	■			■	■	■			■		■		■	■		■		
(4) To coordinate and arrange on-farm and other training programs for IOs	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
[DC 4] Strengthening of IO support system																		
(1) To promote IO registration under NIRC	■			■		■	■		■		■		■	■		■		
(2) To encourage IO's to engage in collective/cooperative activites	■			■		■	■		■		■		■	■		■		
[DC 5] Promotion of private sector involvement																		
(1) To promote involvement of private contractors	■		■		■			■			■			■		■		
(2) To share technical manuals and guidelines	■		■		■			■			■			■		■		
[DC 6] Preparation of guidelines and manuals																		
(1) To review existing materials	■																	
(2) To prepare and update manuals and guidelines	■				■			■					■					■
[DC 7] Research and development																		
(1) To identify areas of focus for irrigation research	■																	
(2) To conduct irrigation researches		■	■	■			■	■	■		■		■		■		■	
(3) To develop a research cente						■	■	■										
[DC 8] Monitoring and evaluation																		
(1) To promote LGA's monitoring and data collection	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
(2) To review the status of capacity development (as part of RNIMP evaluation)	■				■				■				■					■

Source: JICA Project Team

Figure 3.5.1 IHRDP Implementation Schedule

3.6 Projection of Human Resource Needs

In this section, human resource demand and supply in the NIMP 2018 period are projected. On the supply side, human resource supply in the labour market is projected based on the findings in the situation analysis. On the demand side, required number of irrigation engineers and technicians are estimated to undertake the development components described in Section 3.4.

(1) Supply

As described in Section 2.3.2, annual acceptance capacities of irrigation engineering and technician courses are 526 and 257, respectively. However, these numbers are calculated on an intake capacity basis, and need to take the following into account for practical numbers for the employment in the public sector.

- Graduation rate against intake capacity.
- Graduates of foreign engineering courses.
- Employment trend (employment rate by sector or industry).

After considering these factors, the numbers available for public employment are currently estimated at around 184 for engineers and 80 for technicians per year.

(2) Demand

In the Plan, human resource demand refers to that of irrgiation engineers and technicians at the NIRC and LGAs for effective implementation of NIMP 2018. Accordingly, the required numbers are estimated in accordance with the requirement for implementing development components mentioned in Section 3.4. Basic conditions of estimating human resource demand for NIMP 2018 implementation are presented below.

Table 3.6.1 Basic Conditions for Demand Projection under NIMP 2018

Actor	Condition
NIRC	[NIRC Headquarters and ZIO] - To fill current vacancies of respective divisions and units. (Phase I) - To fill the vacancies of the retired. (Phase I and II). [RIO] - To assign 1 engineers and 2 technicians at each RIO. - RIO-setup is phased between the Phase I and II.
LGA	- To assign at least 1 engineer for every 2,500 ha[21] of irrigation area in the LGA. - To assign at least 2 technicians for every engineer. - To prioritize LGAs in accordance with scheme priorities of NIMP 2018.

Note: Establishment of DID is not considered in setting these conditions.
Source: JICA Project Team

Based on the conditions above, the demand for irrigation engineers and technicians in NIMP 2018 period is projected as follows.

Table 3.6.2 Demand Projection for Irrigation Engineers and Technicians under NIMP 2018

Position/Organization	Current*	Additional Recruitment (NIMP 2018 Phase I)	Additional Recruitment (NIMP 2018 Phase II)
NIRC HQ/ZIO/RIO			
Engineer	**75**	**114**	**27**
NIRC HQ/ZIO	75	108	15
RIO	0	6	12
Technician	**22**	**49**	**28**
ZIO	22	37	4
RIO	0	12	24
LGA			
Engineer	**93**	**298**	**156**
Technician	**175**	**606**	**318**

Note: 1) The baseline data used for this estimation are: i) NIRC/ZIO staff data obtained in Jan. 2017 and Feb. 2018 from NIRC, and ii) LGA staff data obtained by JICA Project Team with the support of the NIRC in Feb. 2017.
2) The projection for NIRC staff is based on the data on proposal for NIRC staff allocation obtained from NIRC in February 2018.
3) Retirement rate of the NIRC personnel (calculated with the data obtained in Jan. 2017) is also applied to that of LGA personnel.
Source: JICA Project Team

Considering annual supply level, it is safe to conclude that the demand for engineers would not exceed the supply in the course of NIMP 2018 implementation if domestic educational and training institutes maintain the current level of human resource supply. In terms of technicians, however, it should be noted that an effort must be made to promote the employment rate of diploma holders in the public sector to fulfill the increasing demand.

[21] Assumption here is that one engineer oversees about 10 schemes (250 ha x 10 schemes=2,500 ha).

Chapter 4 Cost Estimate

In this chapter, the cost estimate is presented for implementing the development components described in Chapter 3.

4.1 Development Cost

The IHRDP will be implemented as part of NIMP 2018, and its development cost (capital cost) is included in the cost of soft components in NIMP 2018. (See the NIMP 2018 main document.)

4.2 Recurrent Cost

Besides the capital cost for implementation, the Plan implies an increase in the recurrent cost on the part of the NIRC, with additional technical staff and expanded operational set-up. Thus, the recurrent cost should be properly noted for the effective implementation of the Plan as well as NIMP 2018.

The Plan proposes to increase NIRC engineers and technicians by 2.9 times over the course of NIMP 2018 implementation. Meanwhile, the estimated reccurent budget of the NIRC is about TZS 4.5 billion in FY 2016/17[22]. As most part of the budget is allocated for personal emoluments (PE)[23], it can be assumed that an increase in staff size would proportionally increase reccurent budget. Suppose the ratio between technical staff and supporting staff remains at the current level, the IHRDP implentation can triple the recurrent spendings in the finaly year of NIMP 2018.

As for the increase in LGA technical staff, the NIRC is not in the position of directly command or request an increase in the staffing of LGAs. As shown in Chapter 3, however, proper implementation of IHRDP requires the LGAs to increase irrgiation-related engineers and technicians by 5.8 times in NIMP 2018 period.

In consideration of these cost implications, the NIRC needs to make an effort to secure its own budget and consult with relevant agencies for LGA-level staff increase, especially the concerned LGAs and the PO-RALG.

[22] Ministry of Finance and Planning, GoT, "Budget Book Volume II for FY 2016-17."
[23] In the budget estimate of FY 2016/17, around 93% of recurrent budget was allocated for PE.

Attachment 1: Details of Supply Projection

(1) Engineer

Institution	A) Intake Capacity *	B) Graduation Rate **	C) Annual Graduation (A x B) ***	D) Rate for Public Employment ****	E) Available for Public Employment (C x D)
ATC	66	0.84	55	0.48	26
SUA (Ag. Eng.)	65	0.92	59	0.48	28
SUA (Irr. Eng.)	65	0.7	45	0.48	21
WI	300	0.62	186	0.48	89
UDSM	30	0.84	25	0.48	12
Foreign	N/A	N/A	17	0.48	8
				Total	184

Note:

** Based on the data obtained from each institution and TCU.*

*** Estimations are made with the following data:*

ATC: Calculated with the data of 2010/11 entry students of ATC.

SUA: Calculated with the data of 2015/16 graduates.

WI: Calculated with the data of 2012/13 entry students of OD Water Supply and Sanitation course.

UDSM: Calculated with the data of 2010/11 entry students of ATC.

**** Based on the ERB's GE data.*

***** Calculation is made based on the ERB data for GE employment status. "Public employment" refers to the employment by LGA, RS, NIRC and MAFC. The unemployed are not included in the rate*

Source: JICA Project Team

(2) Technician

Institution	A) Intake Capacity *	B) Graduation Rate **	C) Annual Graduation (A x B)	D) Rate for Public Employment ***	E) Available for Public Employment (C x D)
ATC	75	0.84	63	0.48	30
WI	120	0.62	74	0.48	35
MATI Igurusi	62	0.54	33	0.48	15
				Total	80

Note:

** Based on the data obtained from each institution and TCU.*

*** Estimations are made with the following data:*

WI: Calculated with the data of 2012/13 entry students of OD Water Supply and Sanitation course.

MATI Igurusi: Calculated from 2015/16 second-year enrollment.

**** Calculation is made based on the ERB data for GE employment status. "Public employment" refers to the employment by LGA, RS, NIRC and MAFC. The unemployed are not included in the rate*

Source: JICA Project Team

Attachment 2: Details of Demand Projection

(1) NIRC Headquarters and ZIO

(a) Engineer

	A) Proposed*	B) Current**	C) Retired (-2025, Phase I) ***	D) Retired (-2035, Phase II) ***	E) Phase I Demand (A-B+C) ****	F) Phase II Demand (D) ****
NIRC HQ/ZIO	171	75	12	15	108	15

Note:
** Based on the data obtained from the DAHRM, NIRC in February 2018.*
*** Data obtained from the DAHRM, NIRC in February 2018.*
**** Based on the data obtained from the DAHRM, NIRC in January 2017 and February 2018.*
***** An assumption here is that the NIRC employs younger generations (-40 year-old) for the newly recruited.*

(b) Technician

	A) Proposed*	B) Current**	C) Retired (-2025, Phase I) ***	D) Retired (-2035, Phase II) ***	E) Phase I Demand (A-B+C) ****	F) Phase II Demand (D) ****
ZIO	56	22	3	4	37	4

Note:
** Based on the data obtained from the DAHRM, NIRC in February 2018.*
*** Data obtained from the DAHRM, NIRC in February 2018.*
**** Based on the data obtained from the DAHRM, NIRC in January 2017 and February 2018.*
***** An assumption here is that the NIRC employs younger generations (-40 year-old) for the newly recruited.*

(2) RIO

(a) Engineer

	A) Proposed*	B) Current	E) Phase I Demand **	F) Phase II Demand**
RIOs	18	0	6	12

Note:
** An assumption here is to assign 1 officers per RIO.*
*** 6 RIOs are established in the Phase I and 12 in the Phase II.*

(b) Technician

	A) Proposed*	B) Current	E) Phase I Demand **	F) Phase II Demand**
RIOs	36	0	12	24

Note:
** An assumption here is to assign 2 officers per RIO.*
*** 6 RIOs are established in the Phase I and 12 in the Phase II.*

(3) LGA

(a) Engineer

	A) Current *	B) Additional Demand for Phase I **	C) Additional Demand for Phase II **	D) Retired (-2025, Phase I) ***	E) Retired (-2035, Phase II) ***	F) Phase I Demand (B+D) ****	G) Phase II Demand (C+E) ****
LGA	93	284	138	14	18	298	156

Note:
** Based on the information from the ZIOs with the help of the DAHRM, NIRC in February 2017.*
*** Basis of the additional demand is to assign one engineer for every 2,500 ha of irrigation area in the LGA.*
**** Since the data for LGA retirement rate is not available, that of NIRC technical staff is applied.*
***** An assumption here is that the LGAs employ younger generations (-40 year-old) for the newly recruited.*

(b) Technician

	A) Current *	B) Additional Demand for Phase I **	C) Additional Demand for Phase II **	D) Retired (-2025, Phase I) ****	E) Retired (-2035, Phase II) ****	F) Phase I Demand (B+D) *****	G) Phase II Demand (C+E) *****
LGA	175	578	283	28	35	606	318

Note:
** Based on the information from the ZIOs with the help of the DAHRM, NIRC in February 2017.*
*** Basis of the additional demand is to assign two technicians per engineer.*
**** Since the data for LGA retirement rate is not available, that of NIRC technical staff is applied.*
***** An assumption here is that the LGAs employ younger generations (-40 year-old) for the newly recruited.*

Appendix D

Atlas

The Project on the Revision of National Irrigation Master Plan

in the United Republic of Tanzania

Final Report
Appendix D: Atlas

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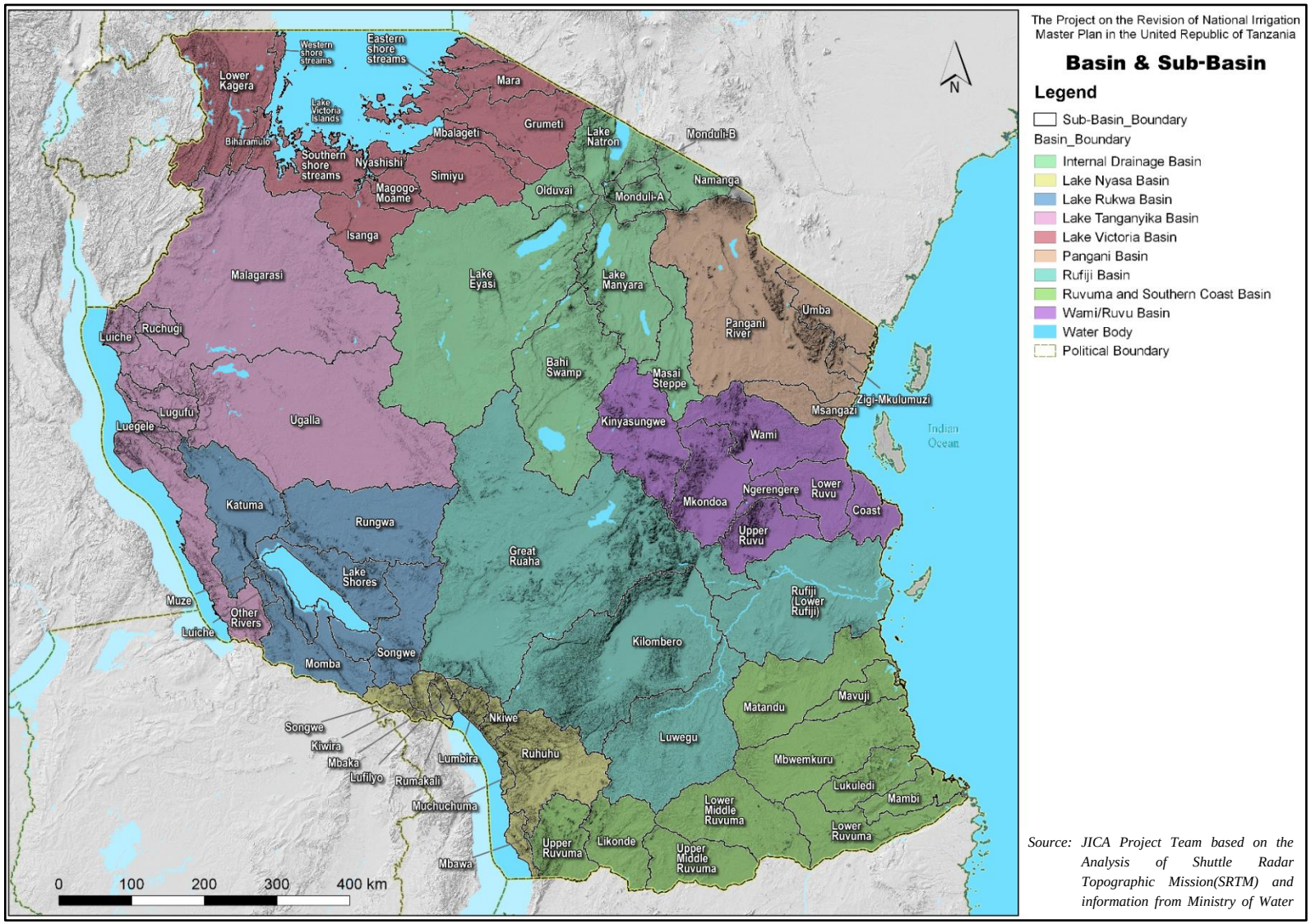
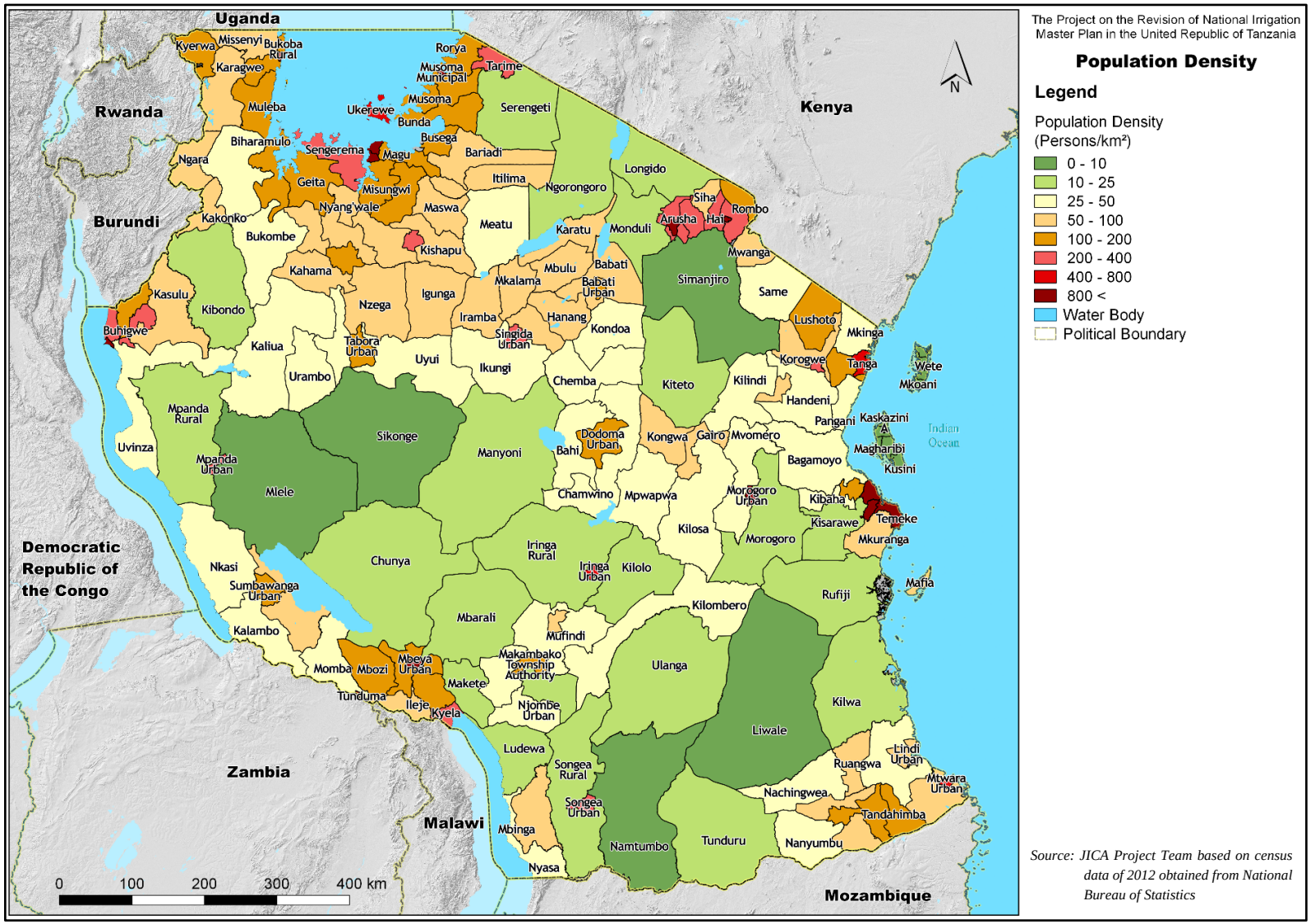
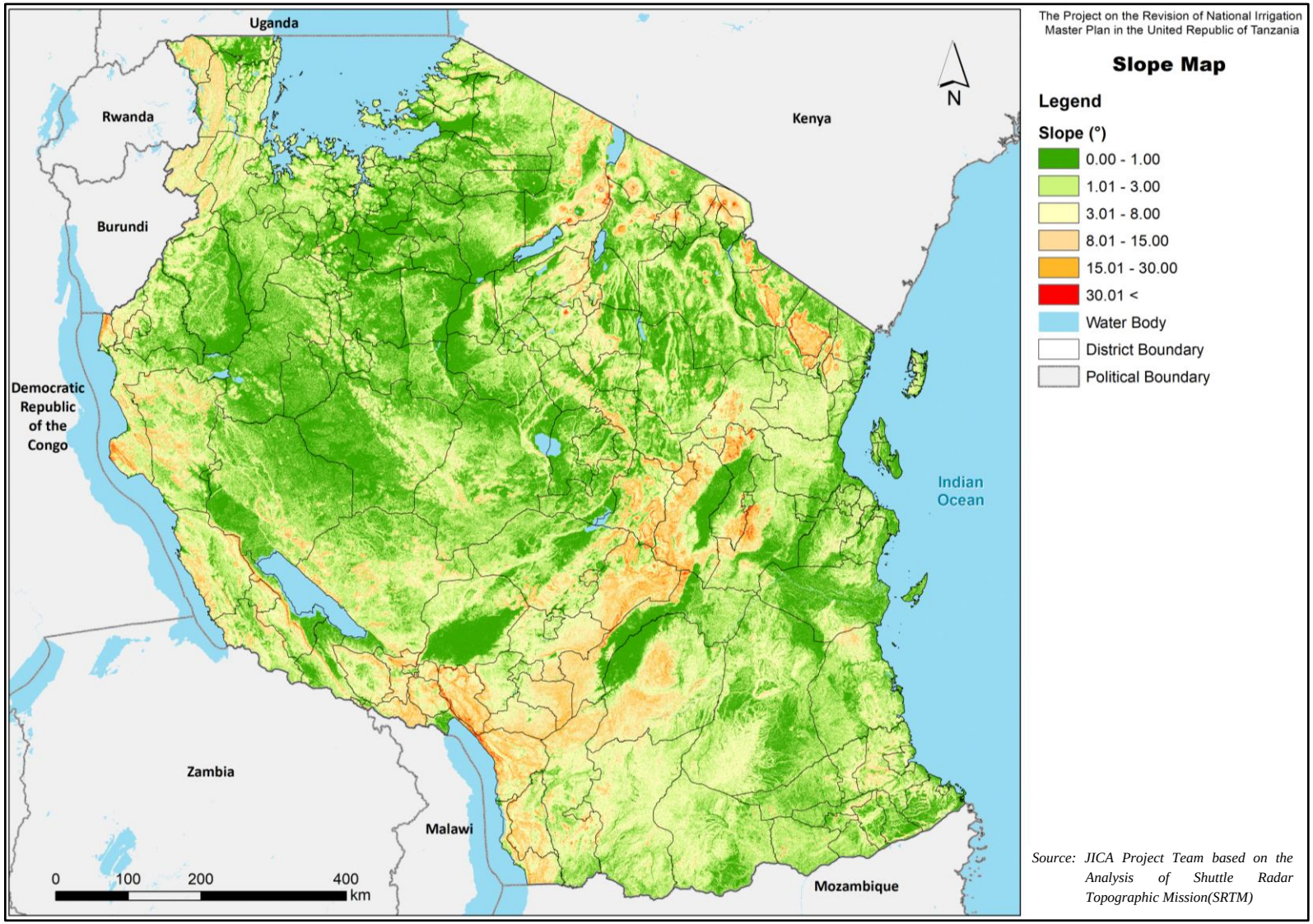


Source: JICA Project Team based on the Analysis of Shuttle Radar Topographic Mission(SRTM) and information from Ministry of Water

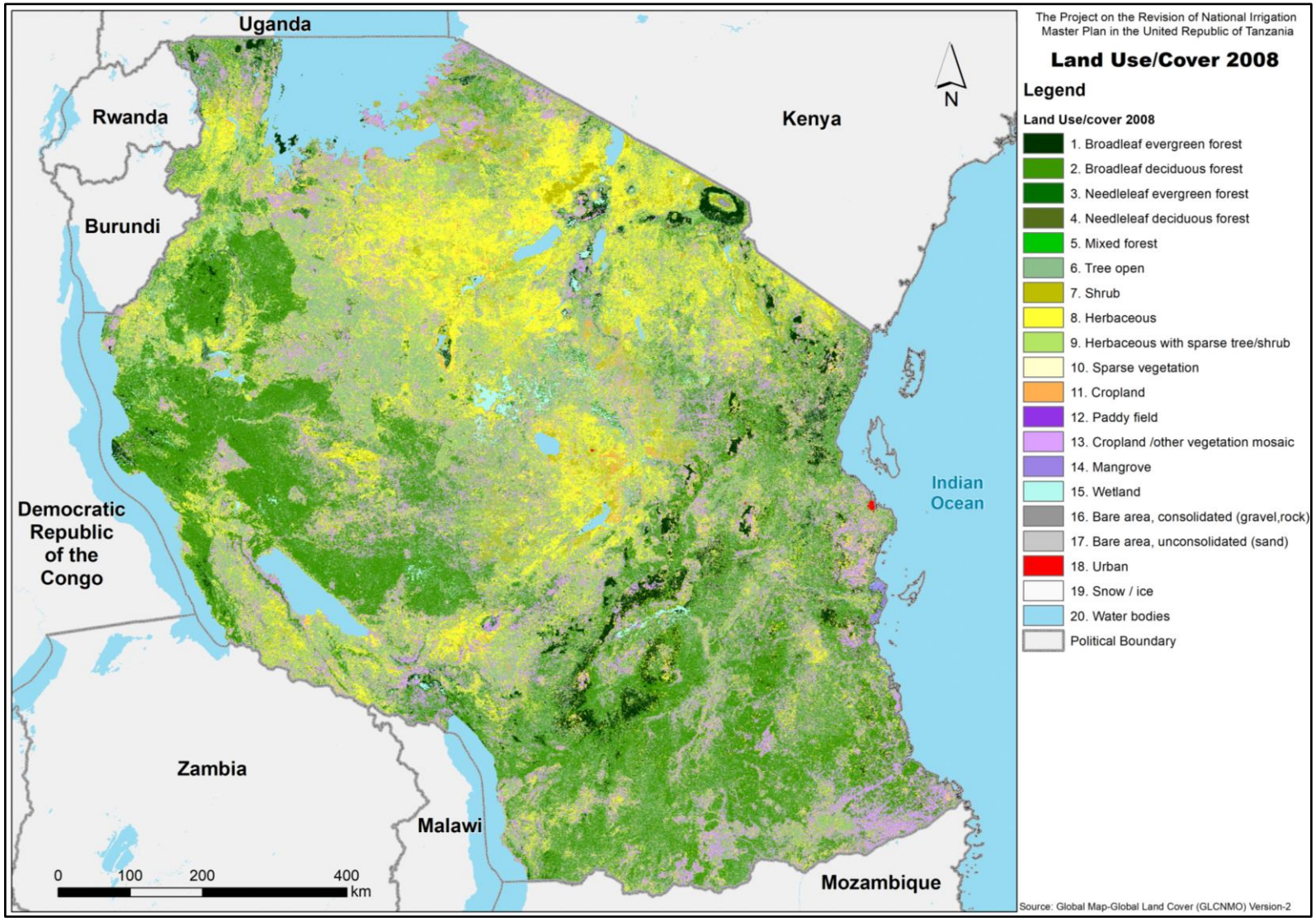
Map 1 Basin and Sub-Basin in Tanzania



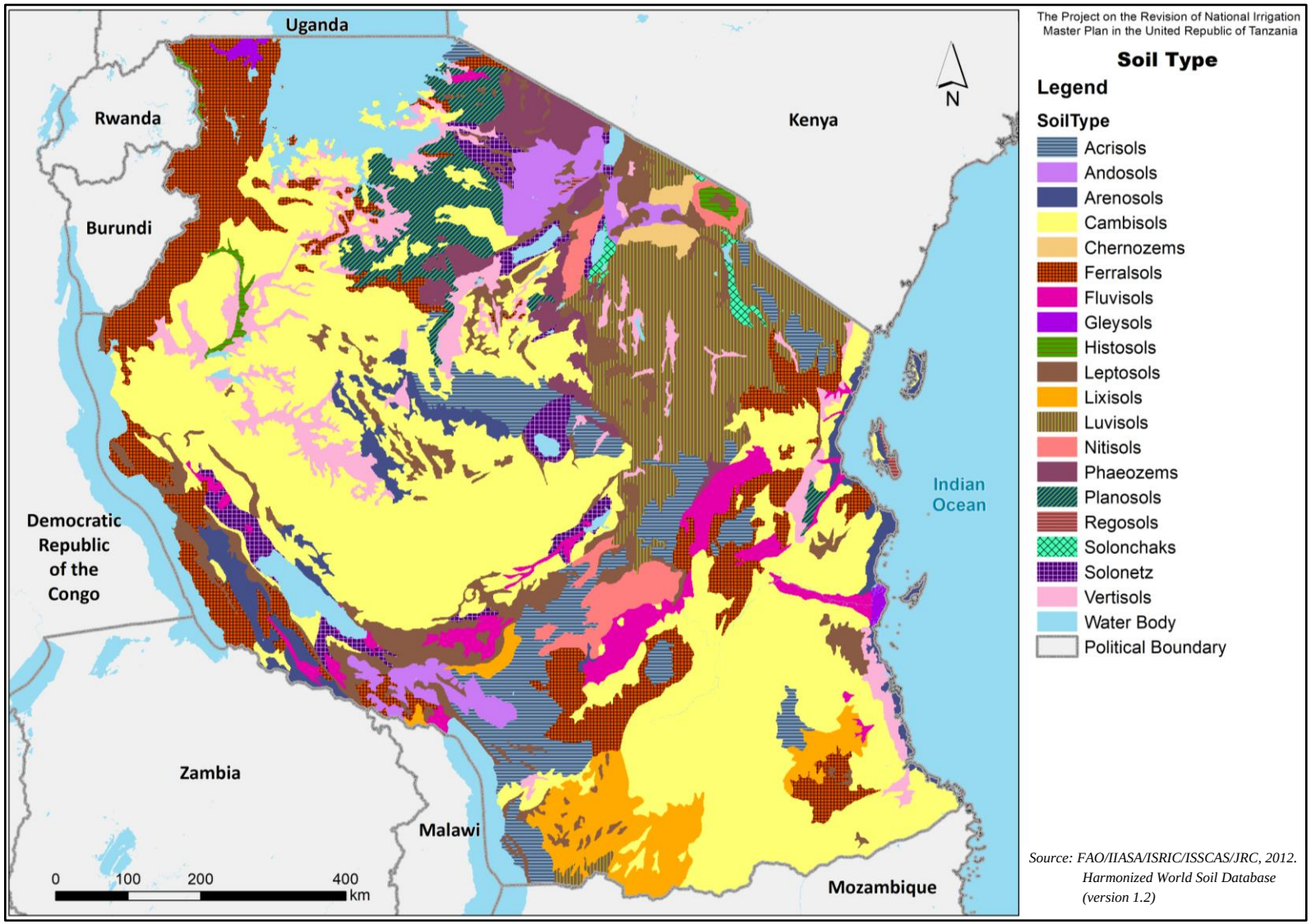
Map 2 Population Density of 2012



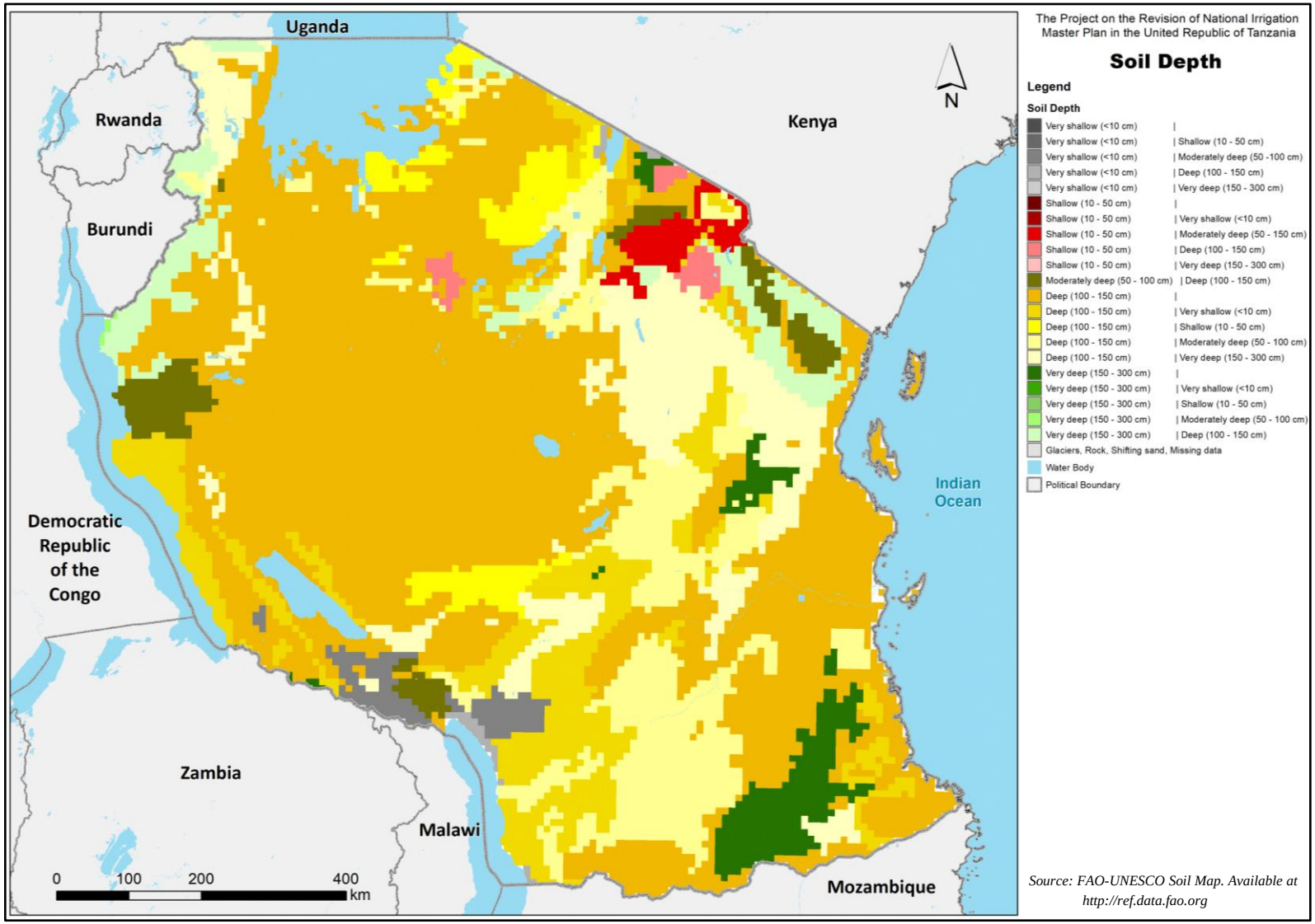
Map 3 Land Slope in Degree



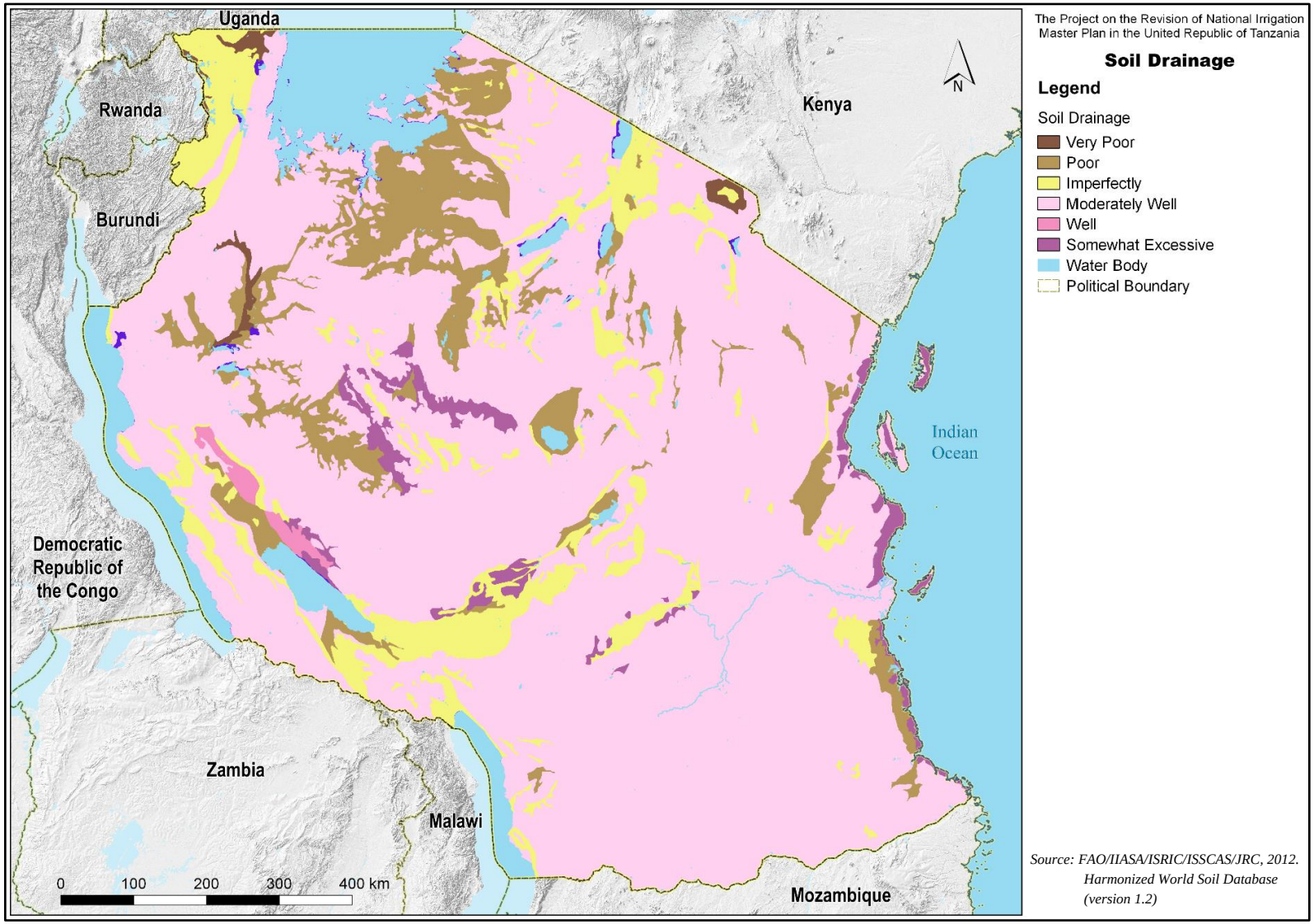
Map 4 Land Use of Tanzania



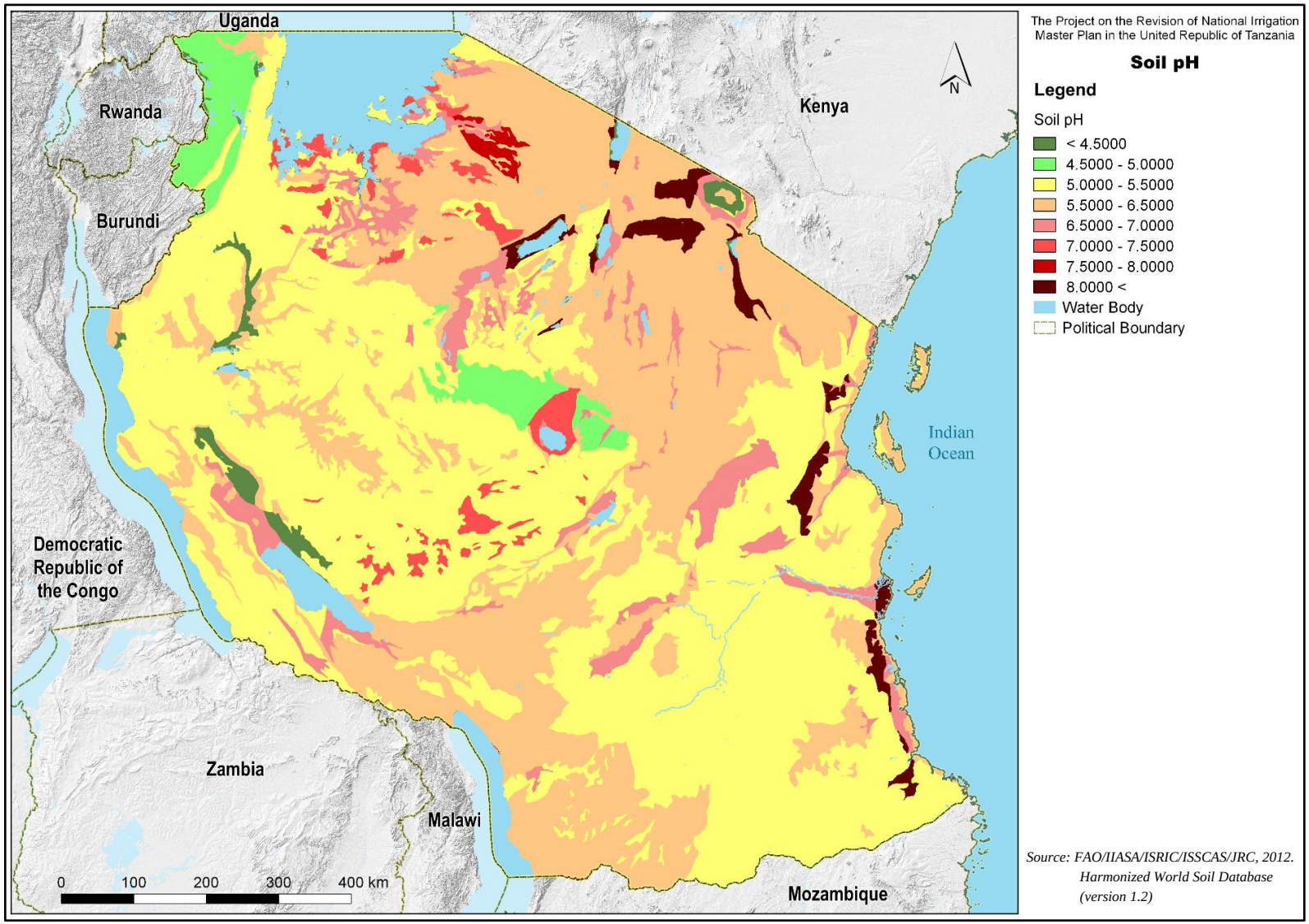
Map 5 Soil Type of Tanzania



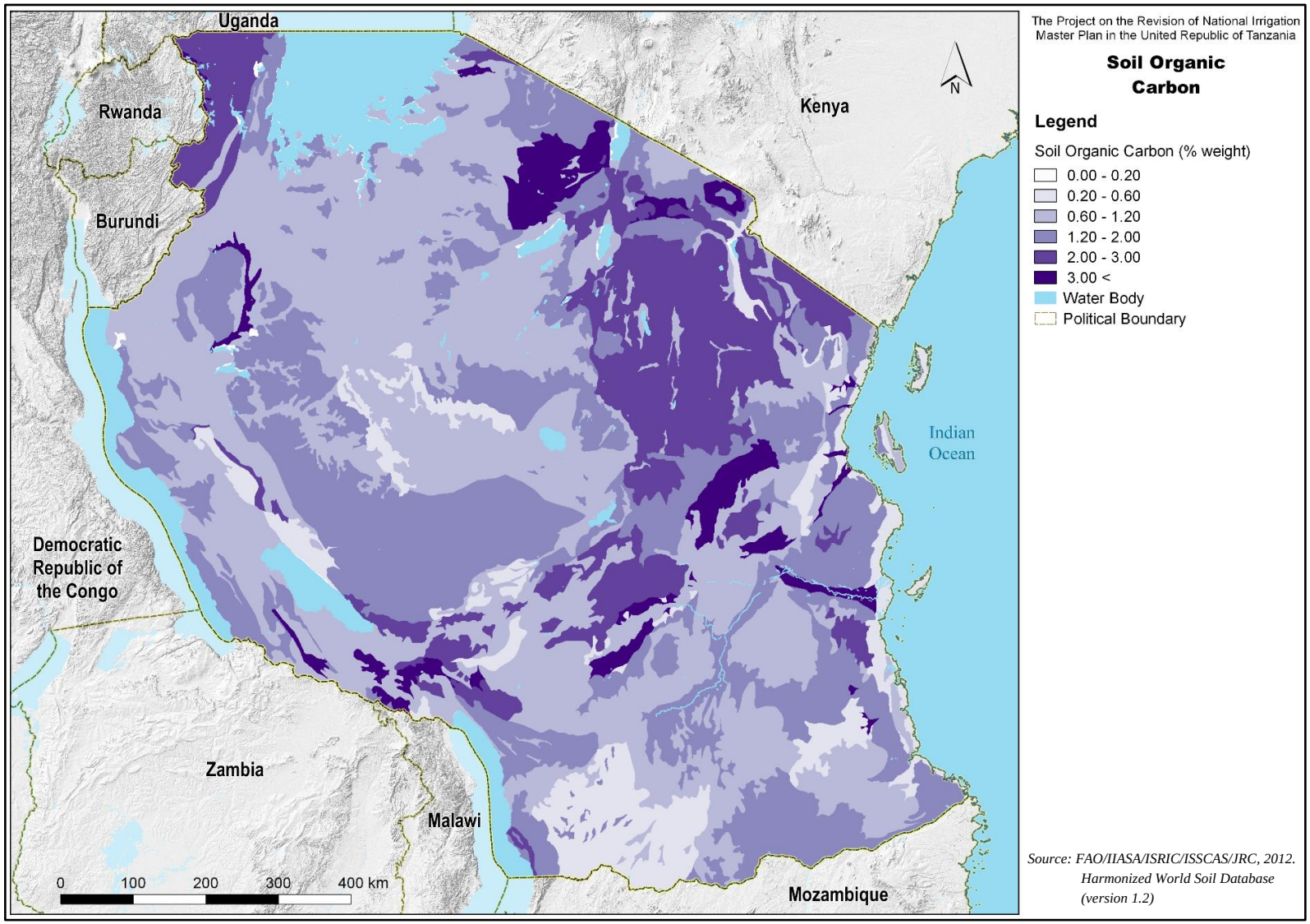
Map 6 Soil Depth of Tanzania



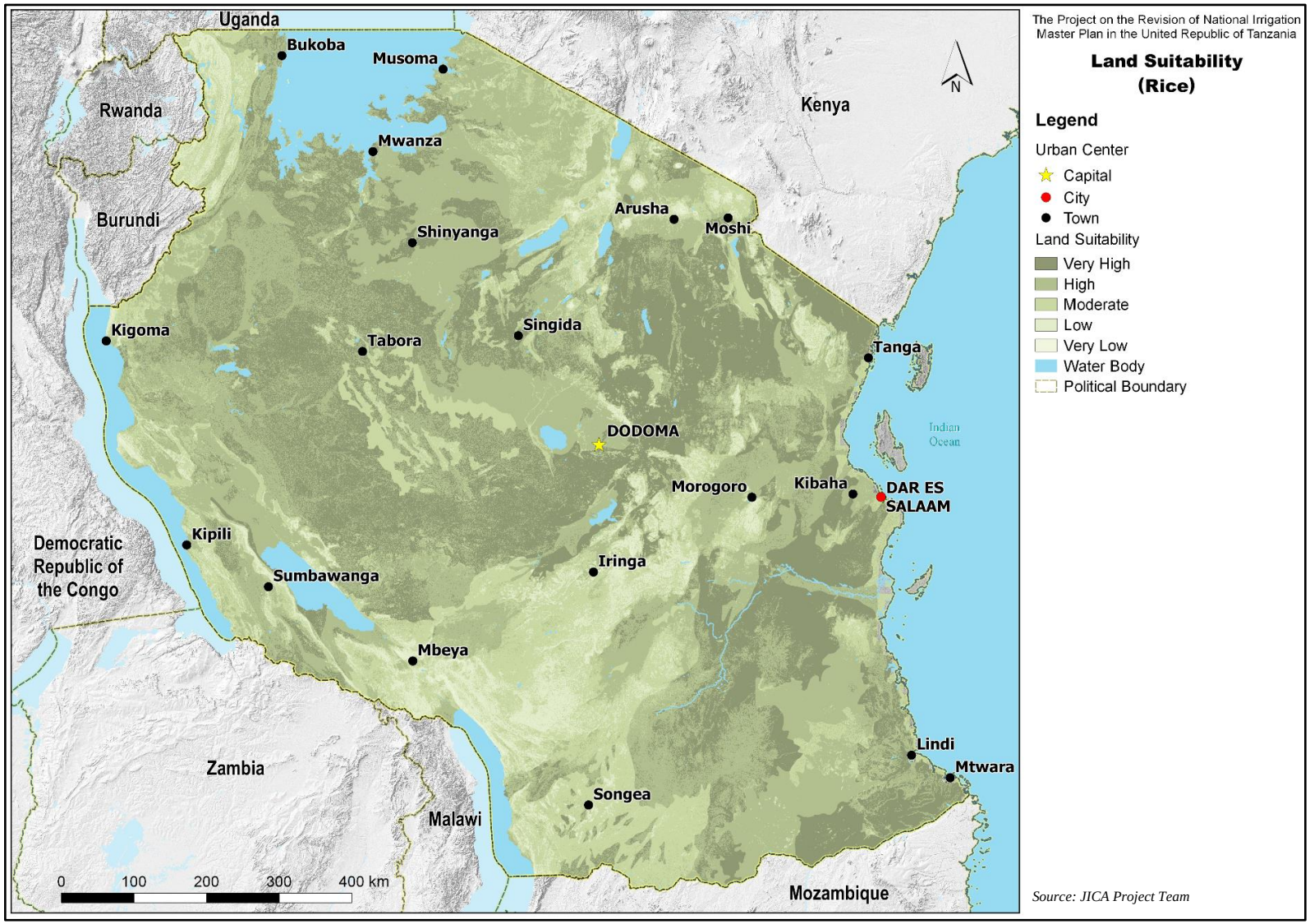
Map 7 Soil Drainage of Tanzania



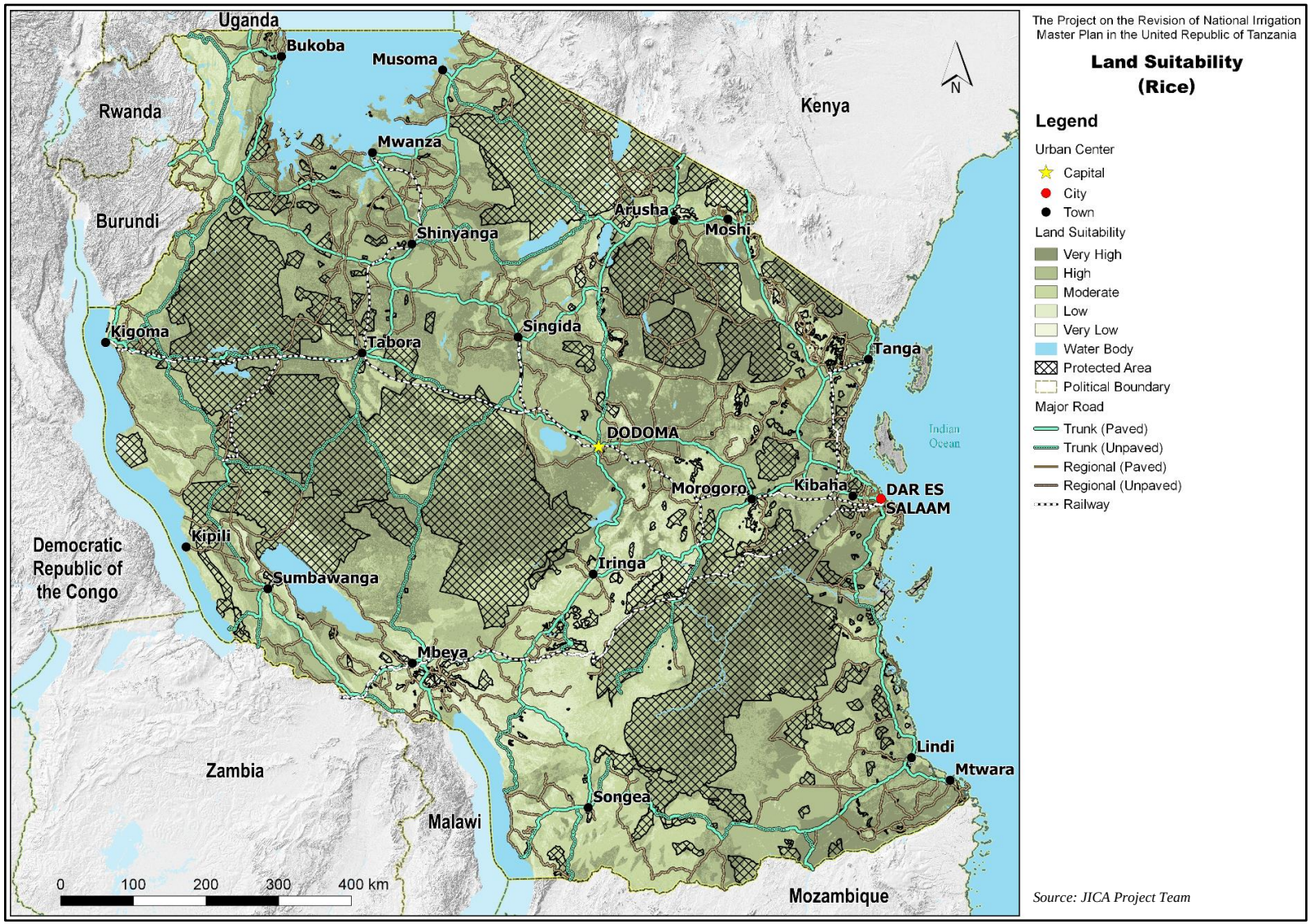
Map 8 Soil pH of Tanzania



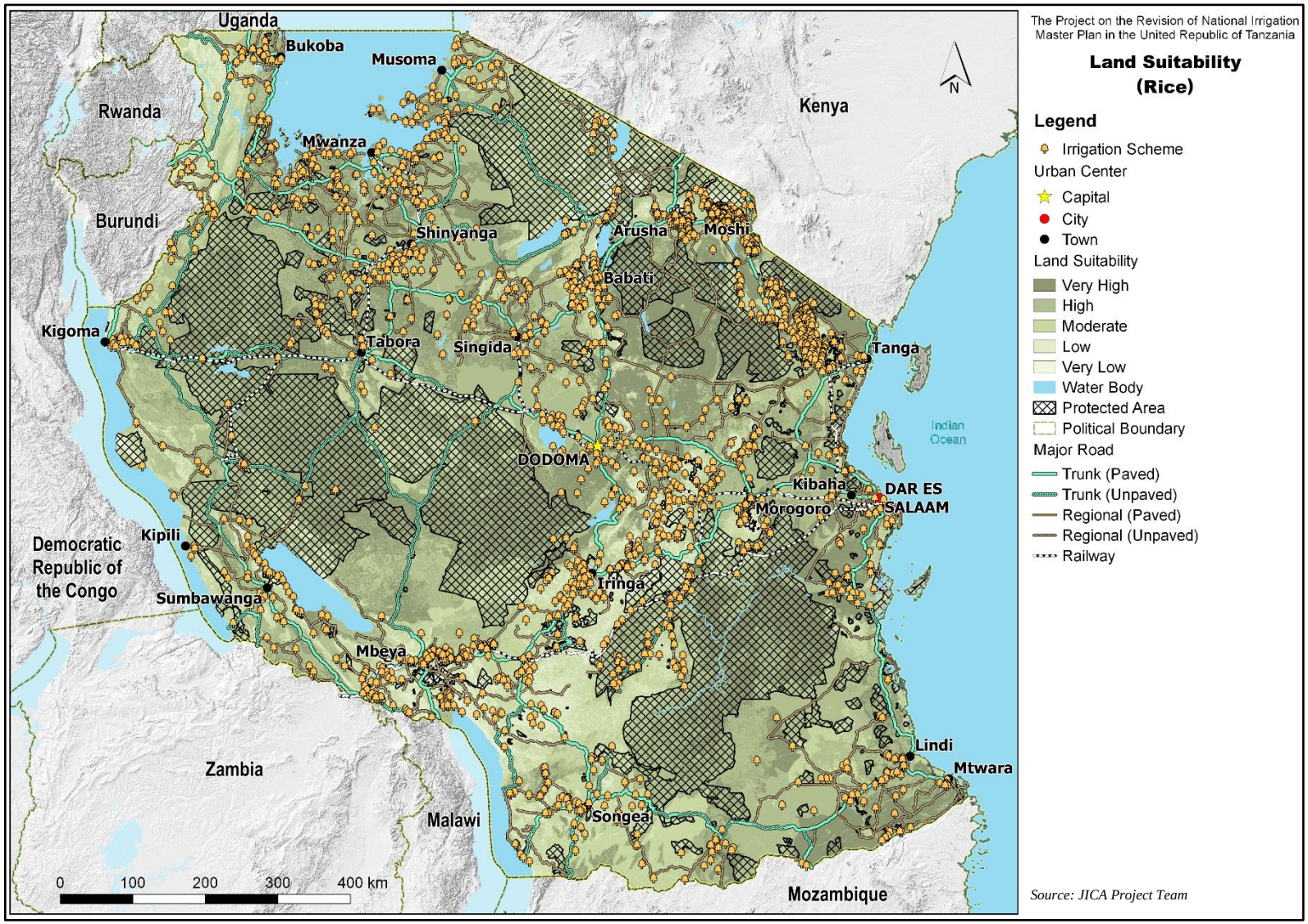
Map 9 Soil Organic Carbon of Tanzania



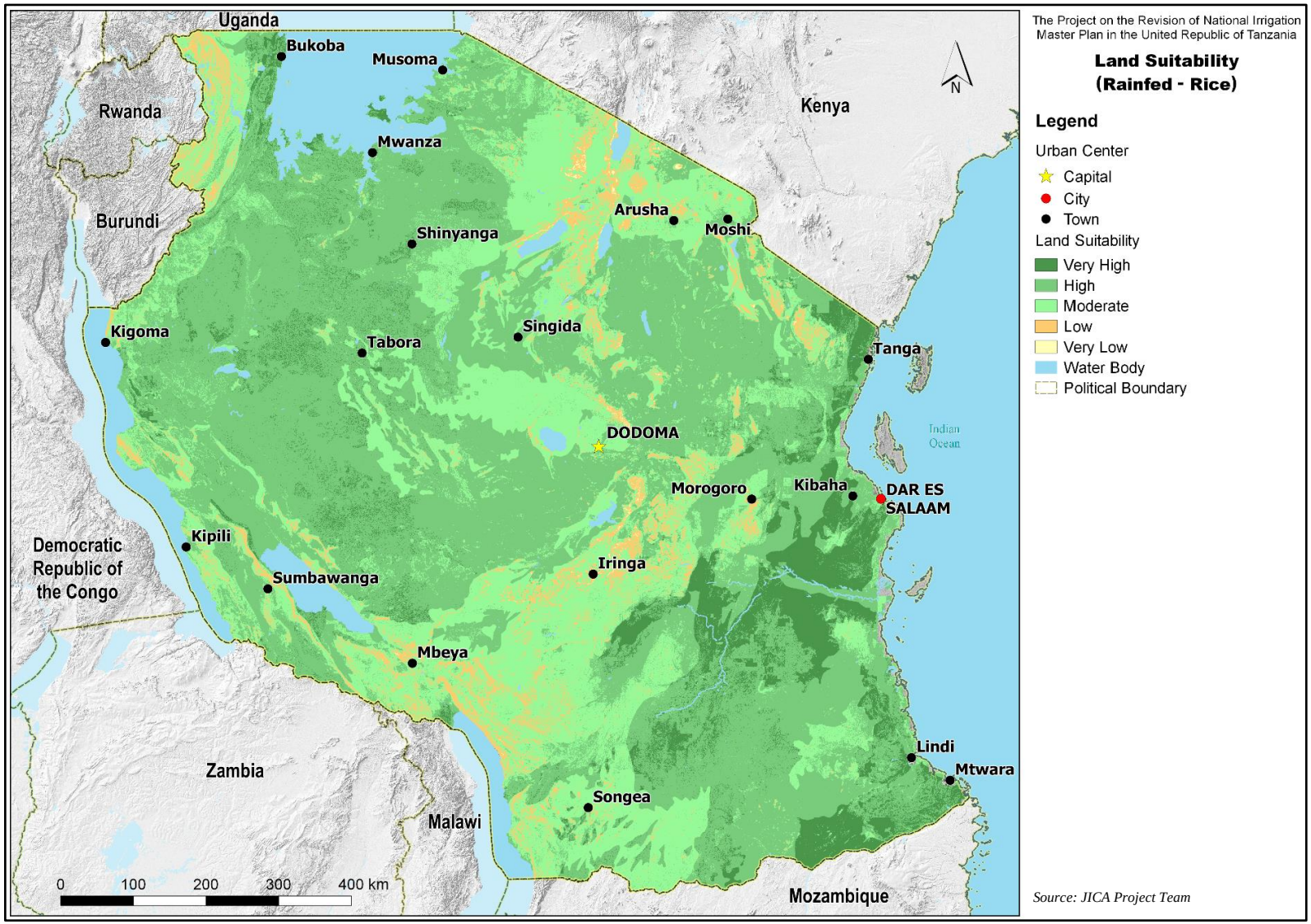
Map 10 Land Suitability for Paddy Field (Land Resource)



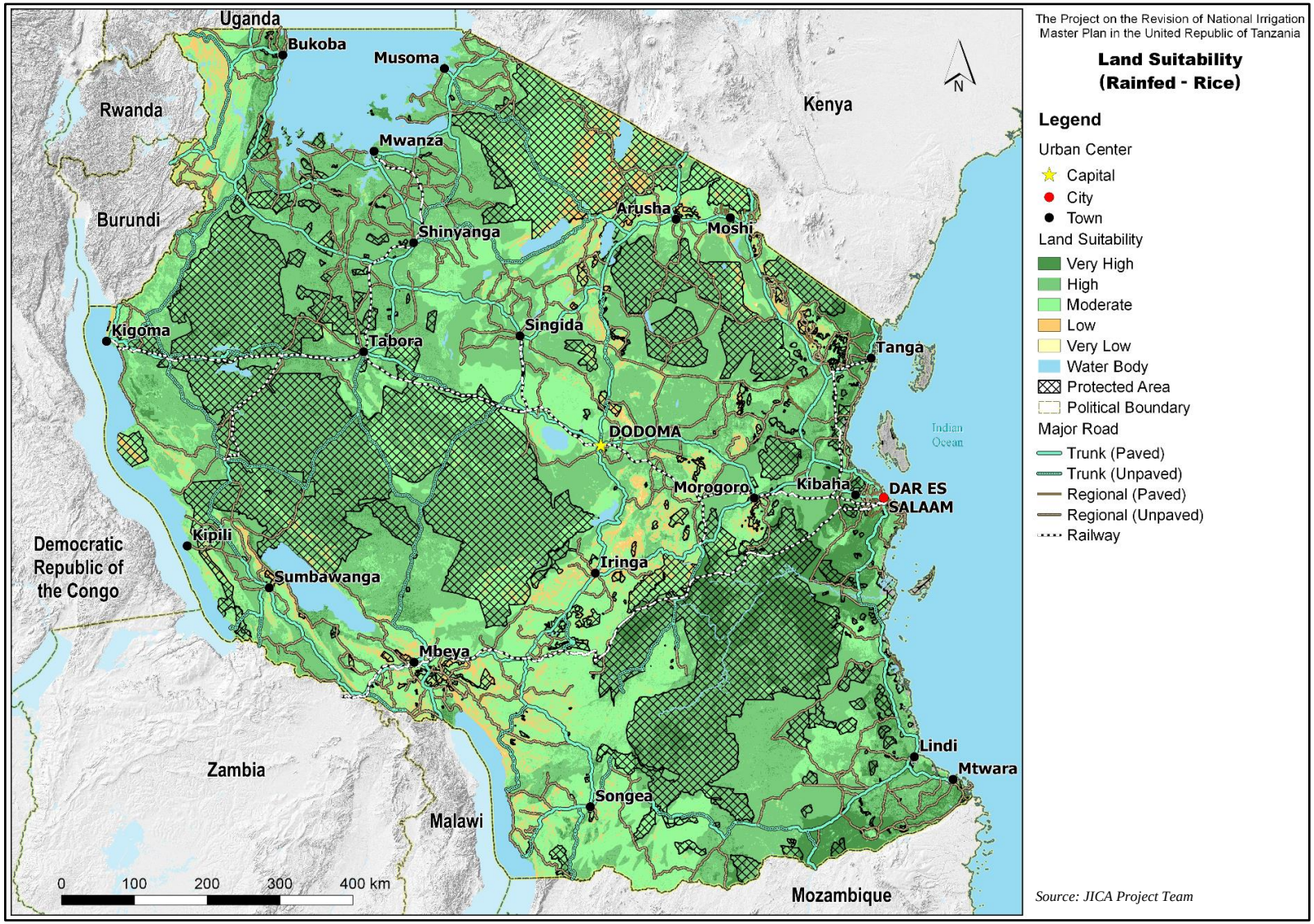
Map 11 Land Suitability for Paddy Field and Protected Area Coverage (Land Resource)



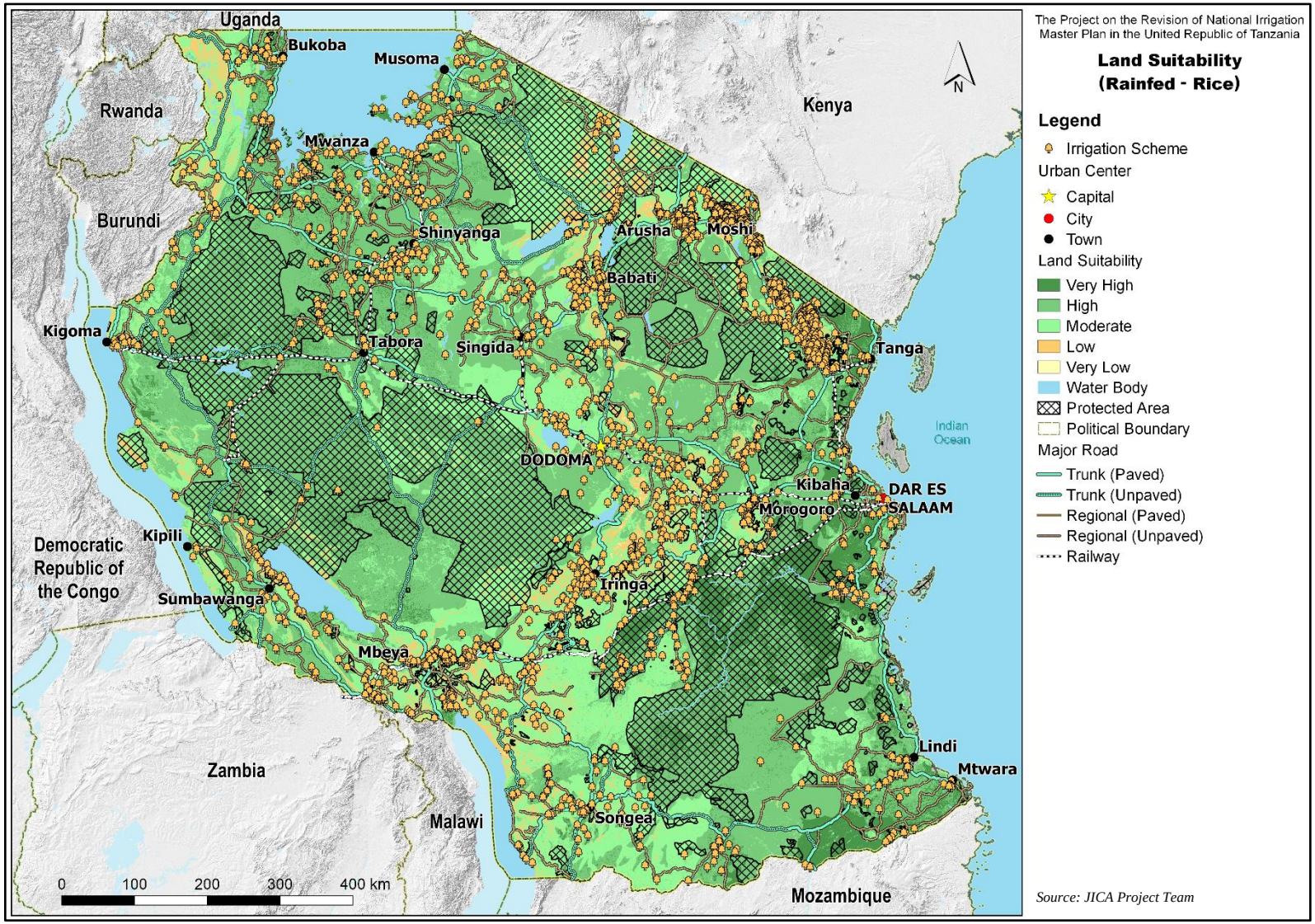
Map 12 Location of Irrigation Schemes within Land Suitability for Paddy Field and Protected Area Coverage (Land Resource)



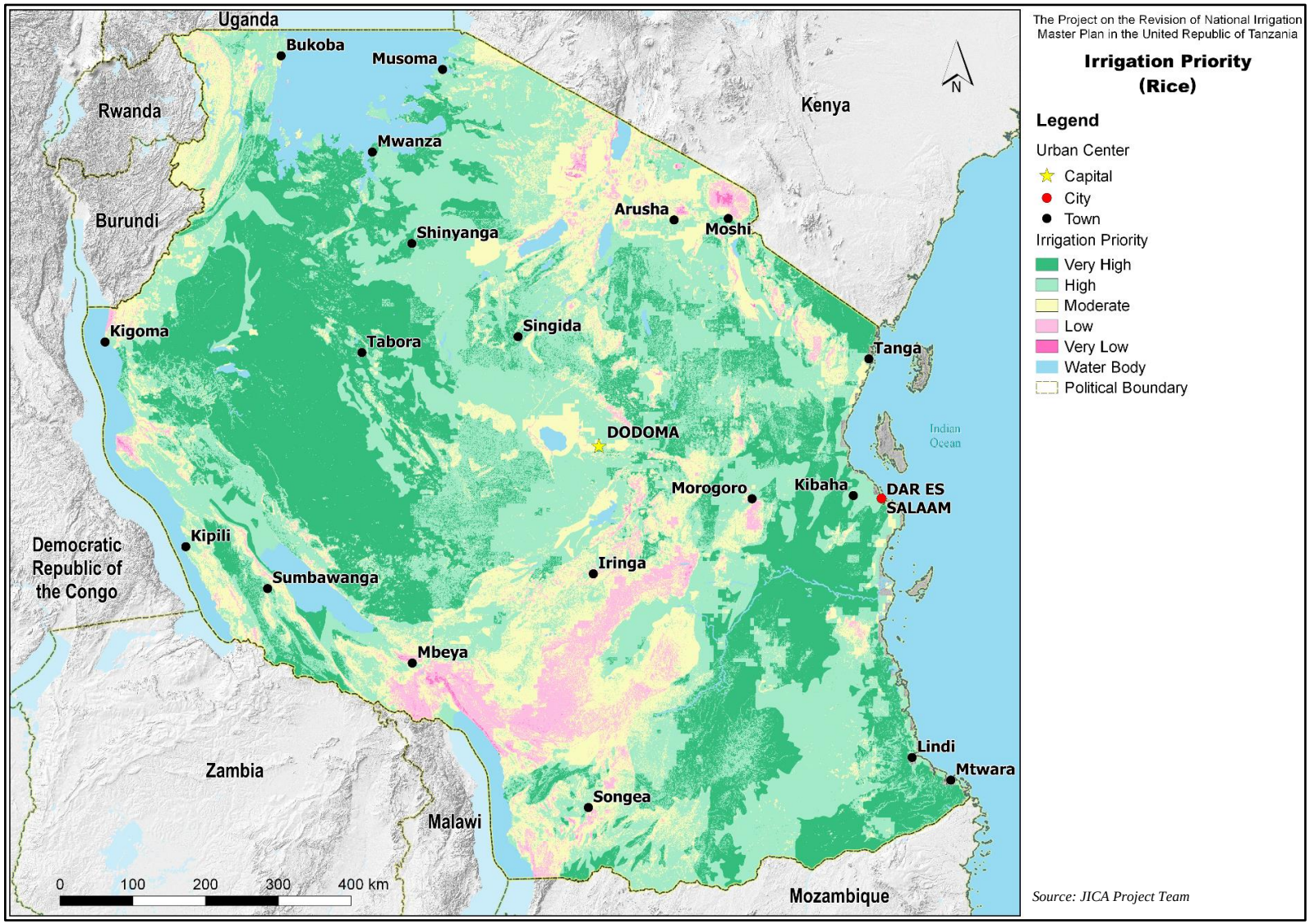
Map 13 Land Suitability for Paddy Field (Rainfed Condition)



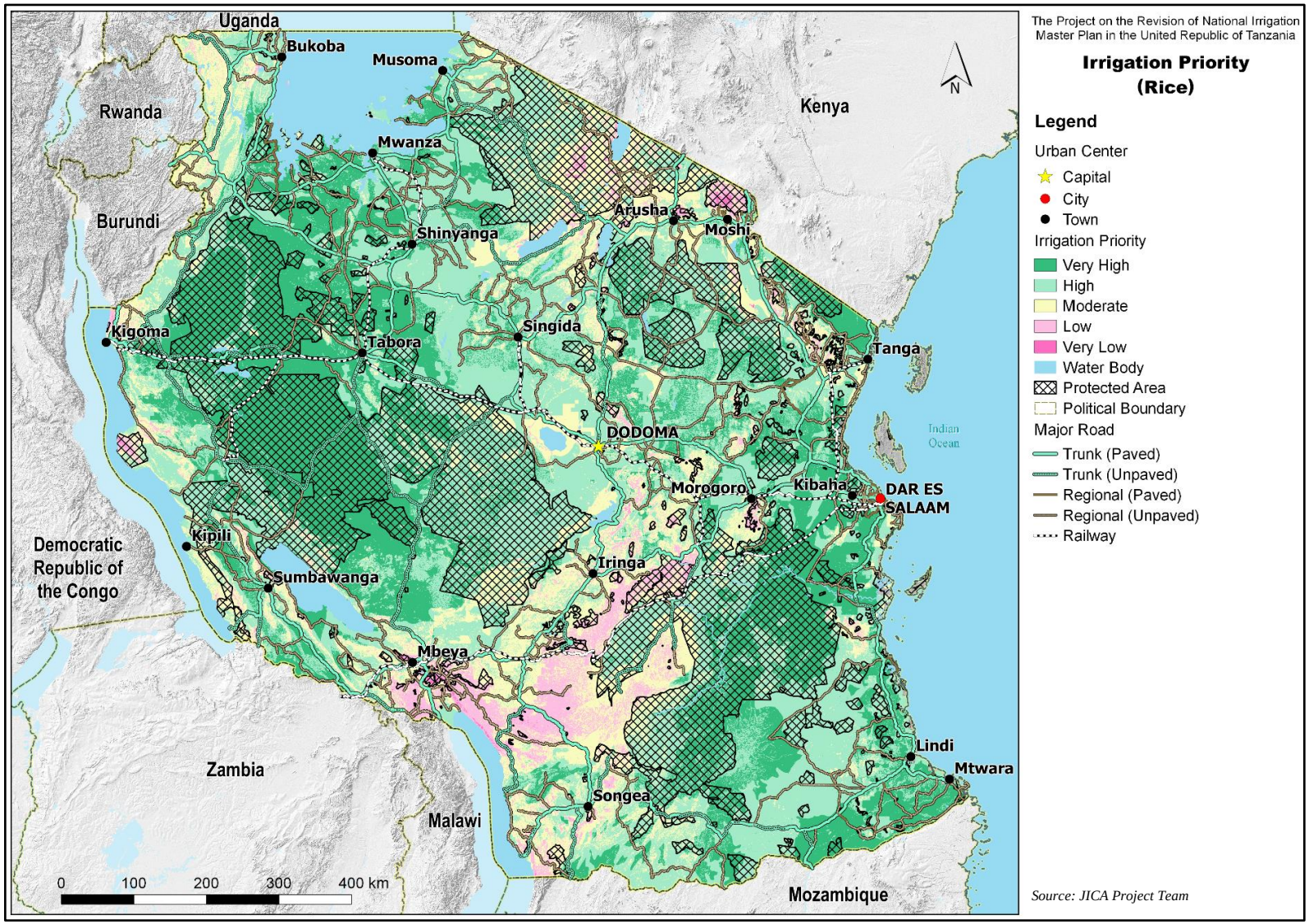
Map 14 Land Suitability for Paddy Field and Protected Area Coverage (Rainfed Condition)



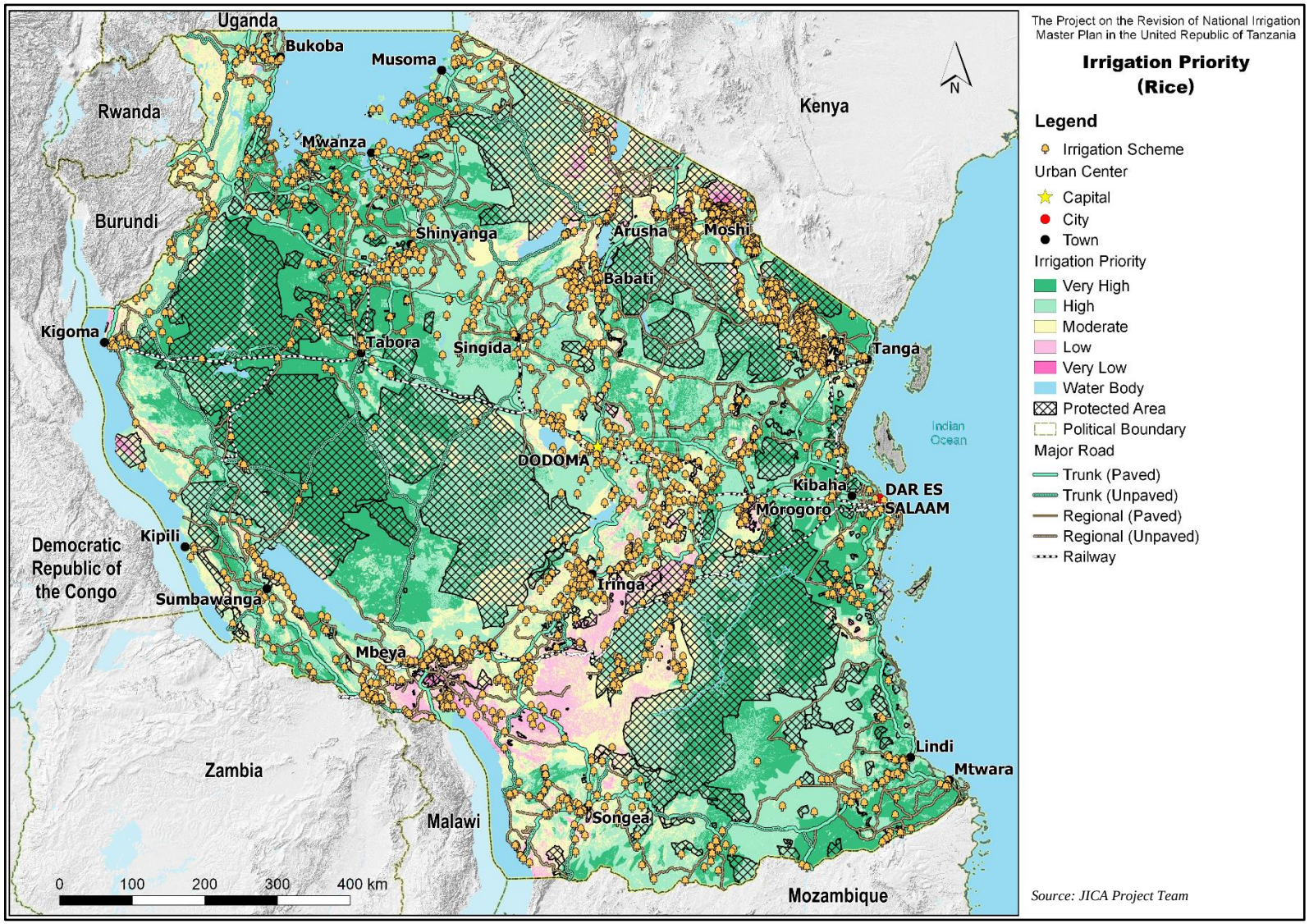
Map 15 Location of Irrigation Schemes within Land Suitability for Paddy Field and Protected Area Coverage (Rainfed Condition)



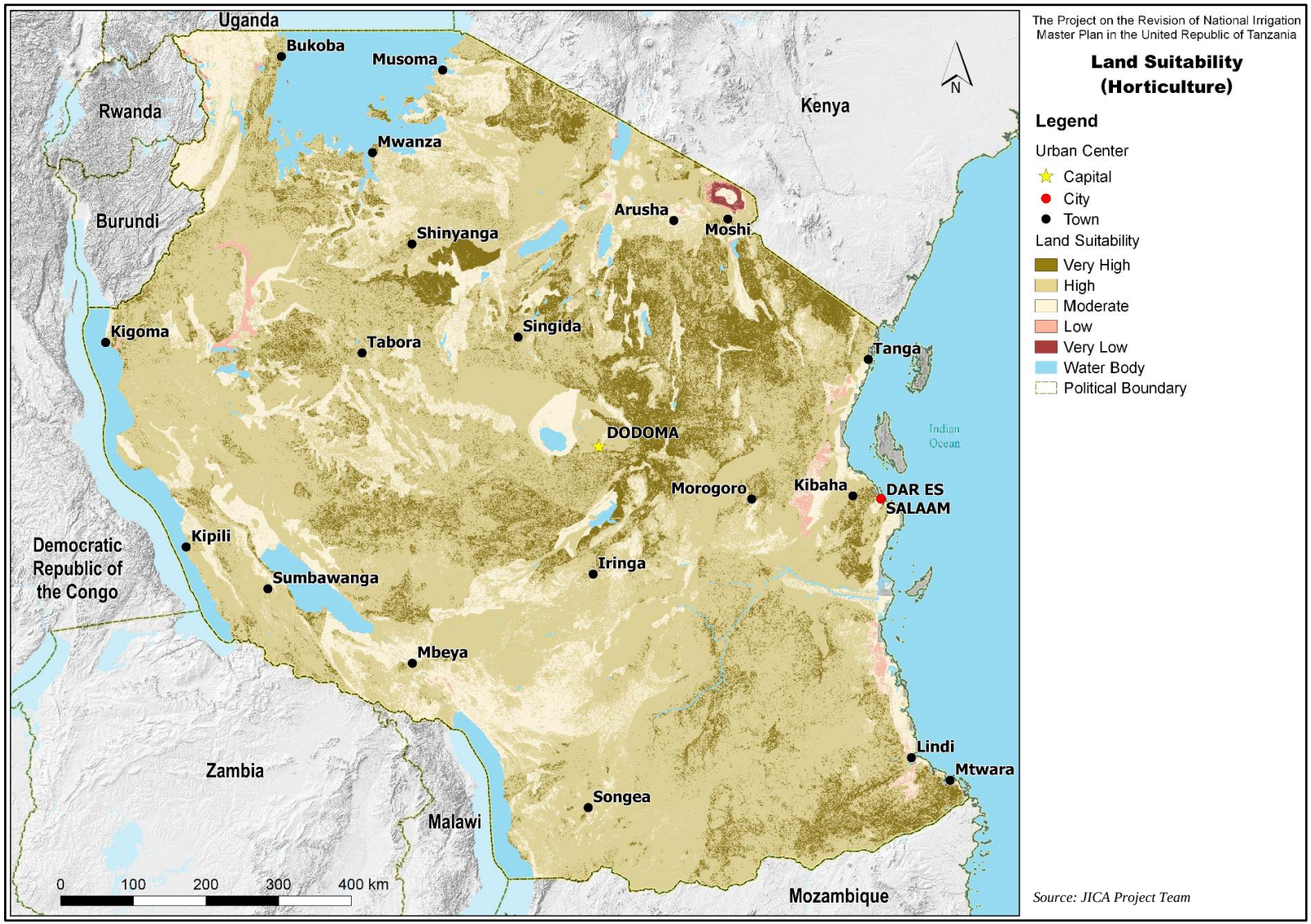
Map 16 Irrigation Priority for Paddy Field



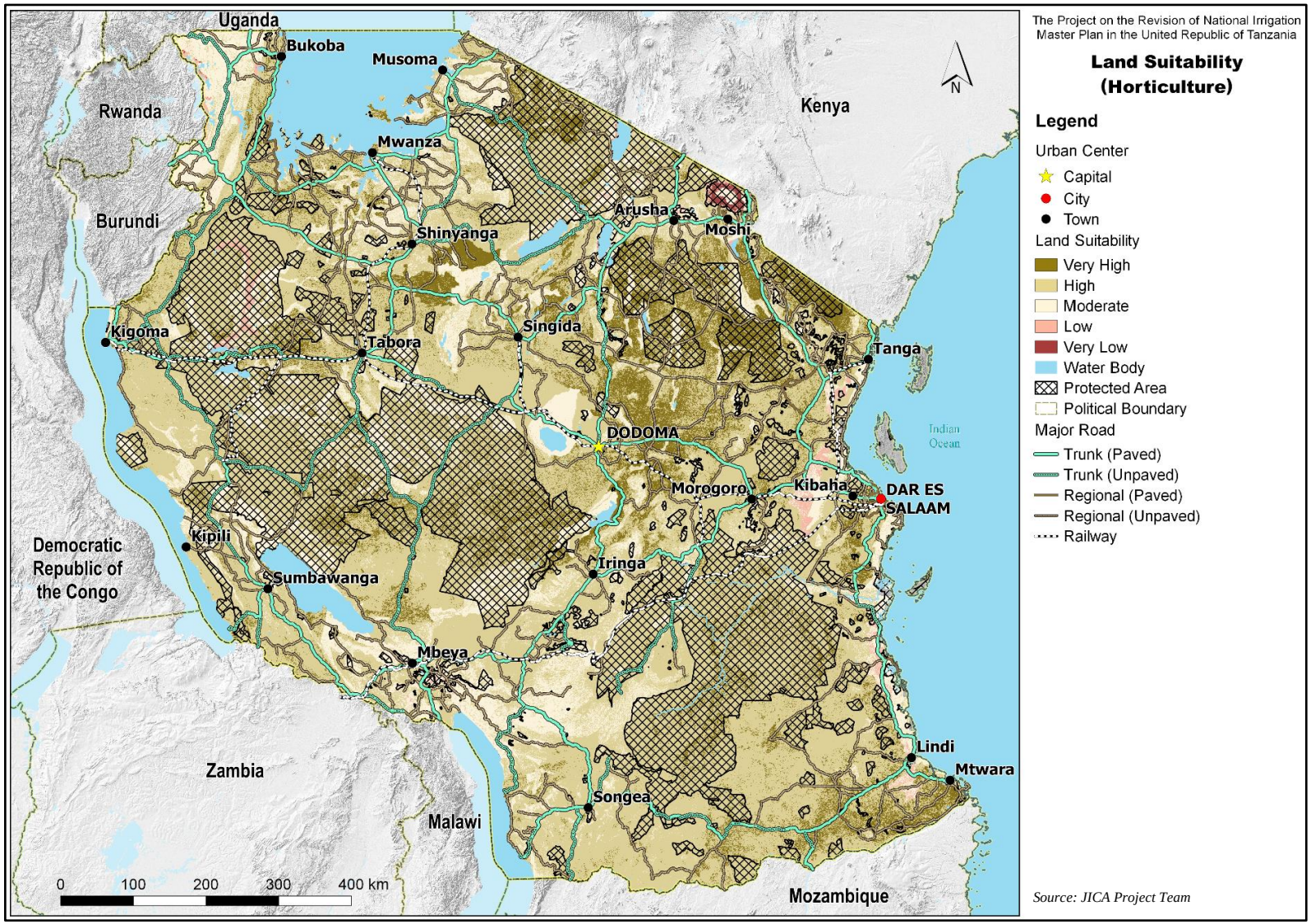
Map 17 Irrigation Priority for Paddy Field and Protected Area Coverage



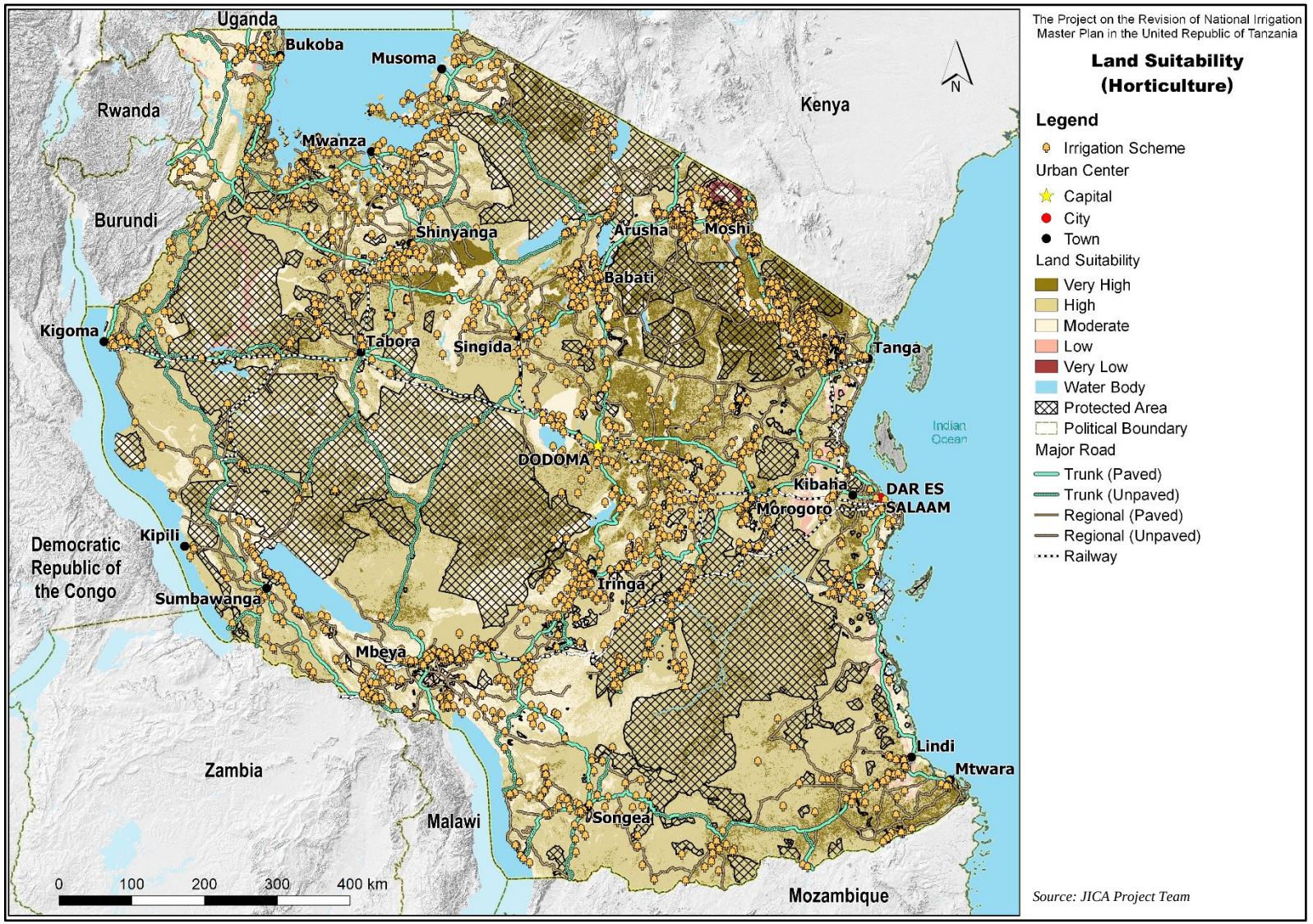
Map 18 Location of Irrigation Schemes within Irrigation Priority for Paddy Field and Protected Area Coverage



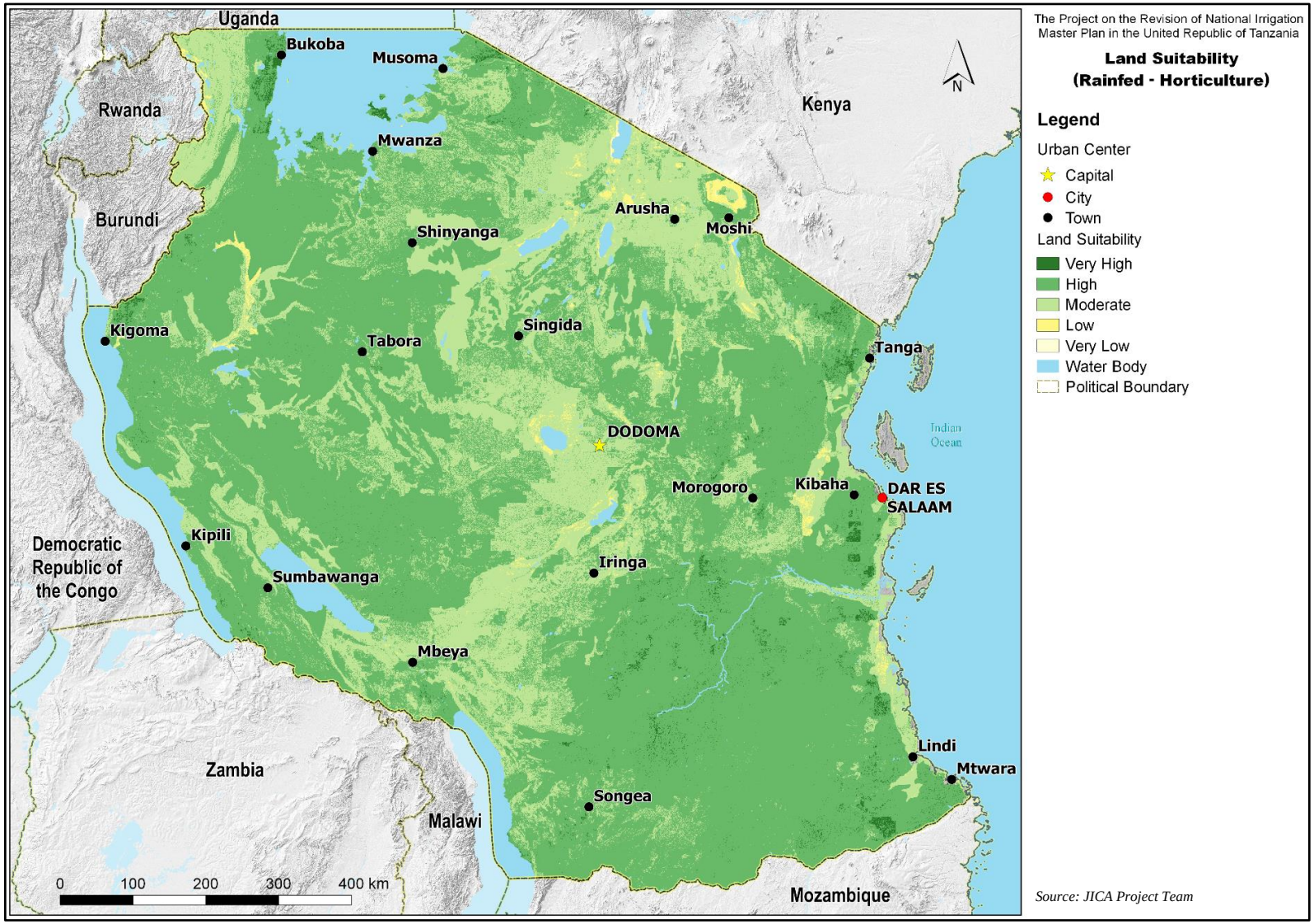
Map 19 Land Suitability for Horticulture Crops (Land Resource)



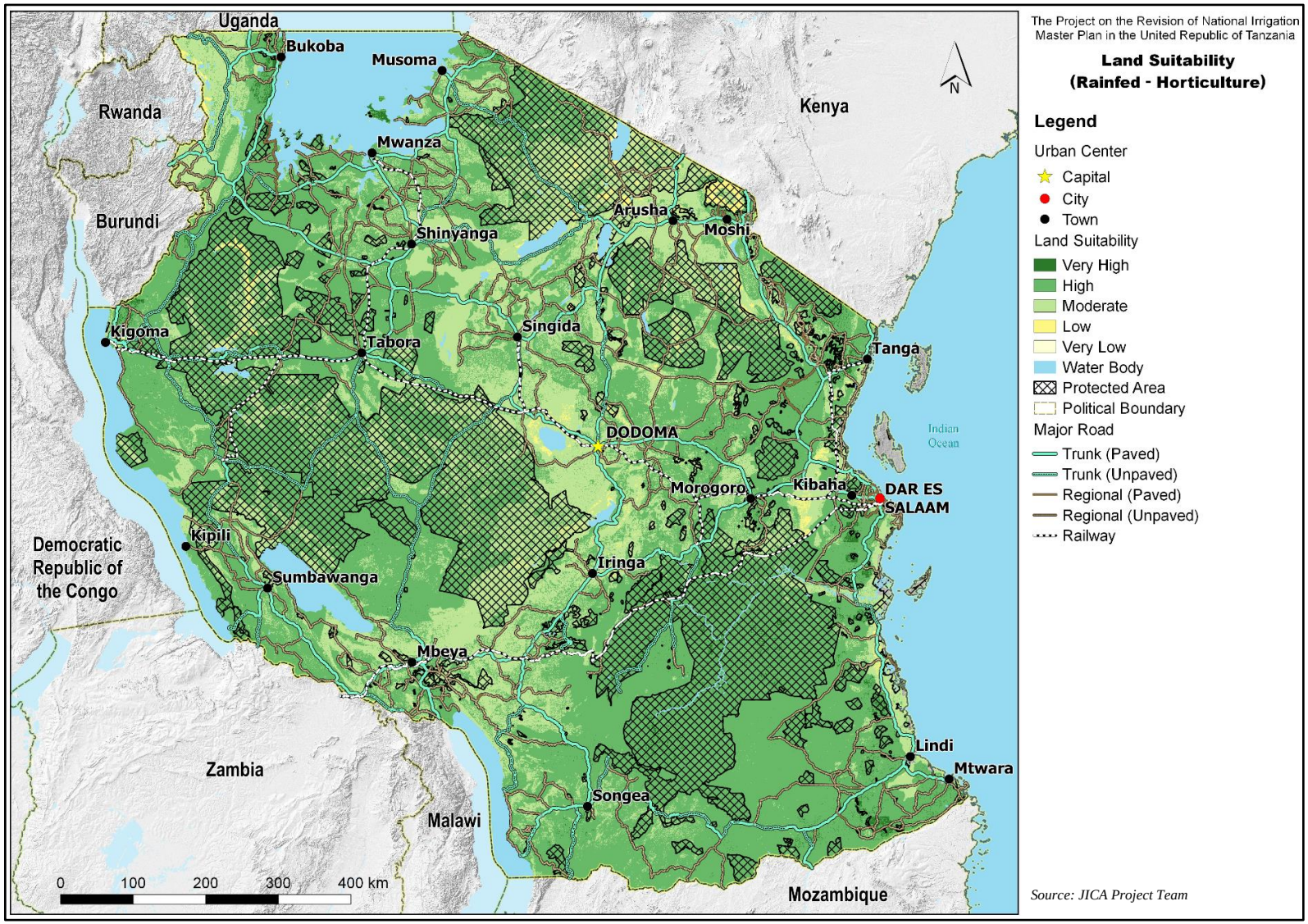
Map 20 Land Suitability for Horticulture Crops and Protected Area Coverage (Land Resource)



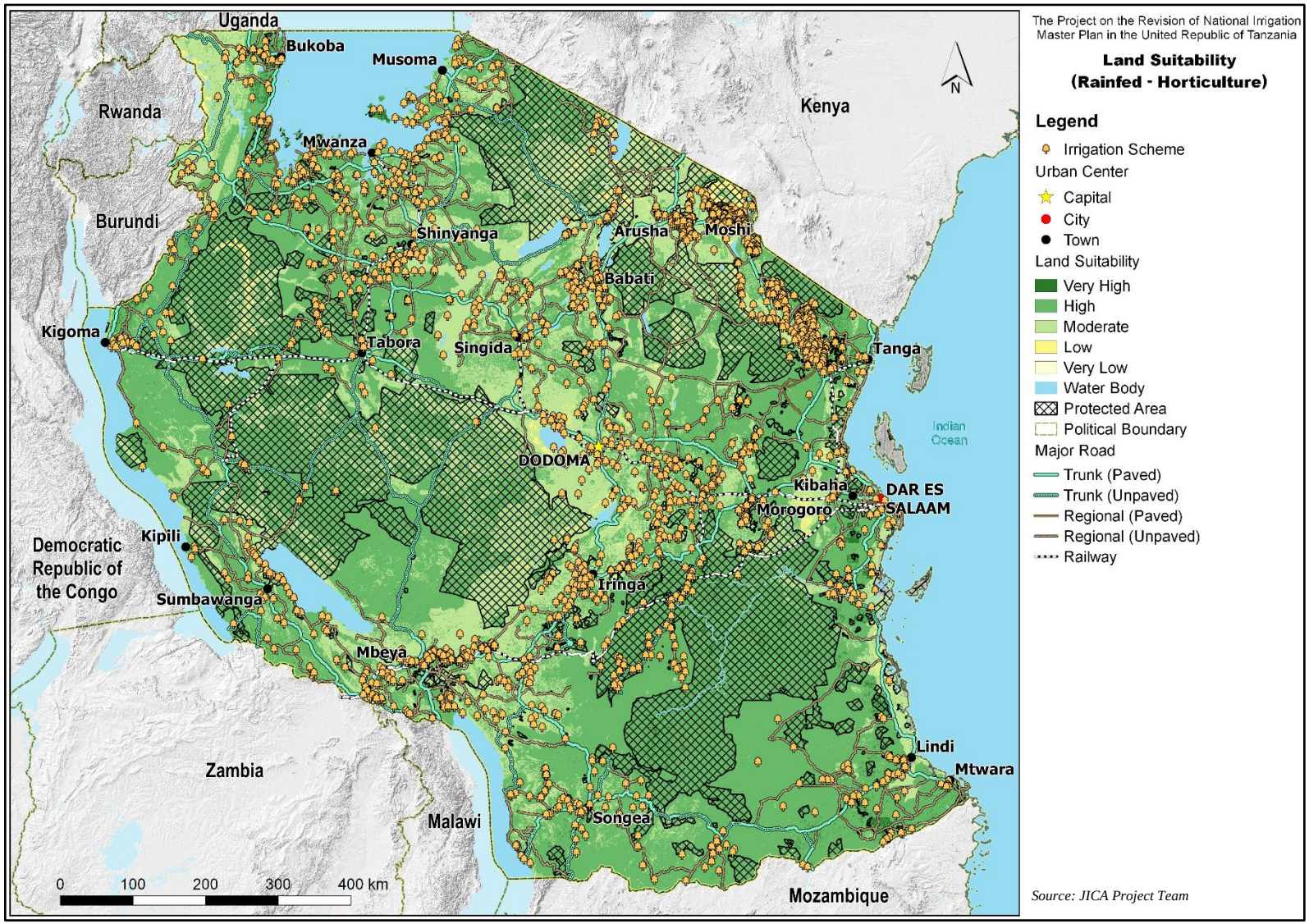
Map 21 Location of Irrigation Schemes within Land Suitability for Horticulture Crops and Protected Area Coverage (Land Resource)



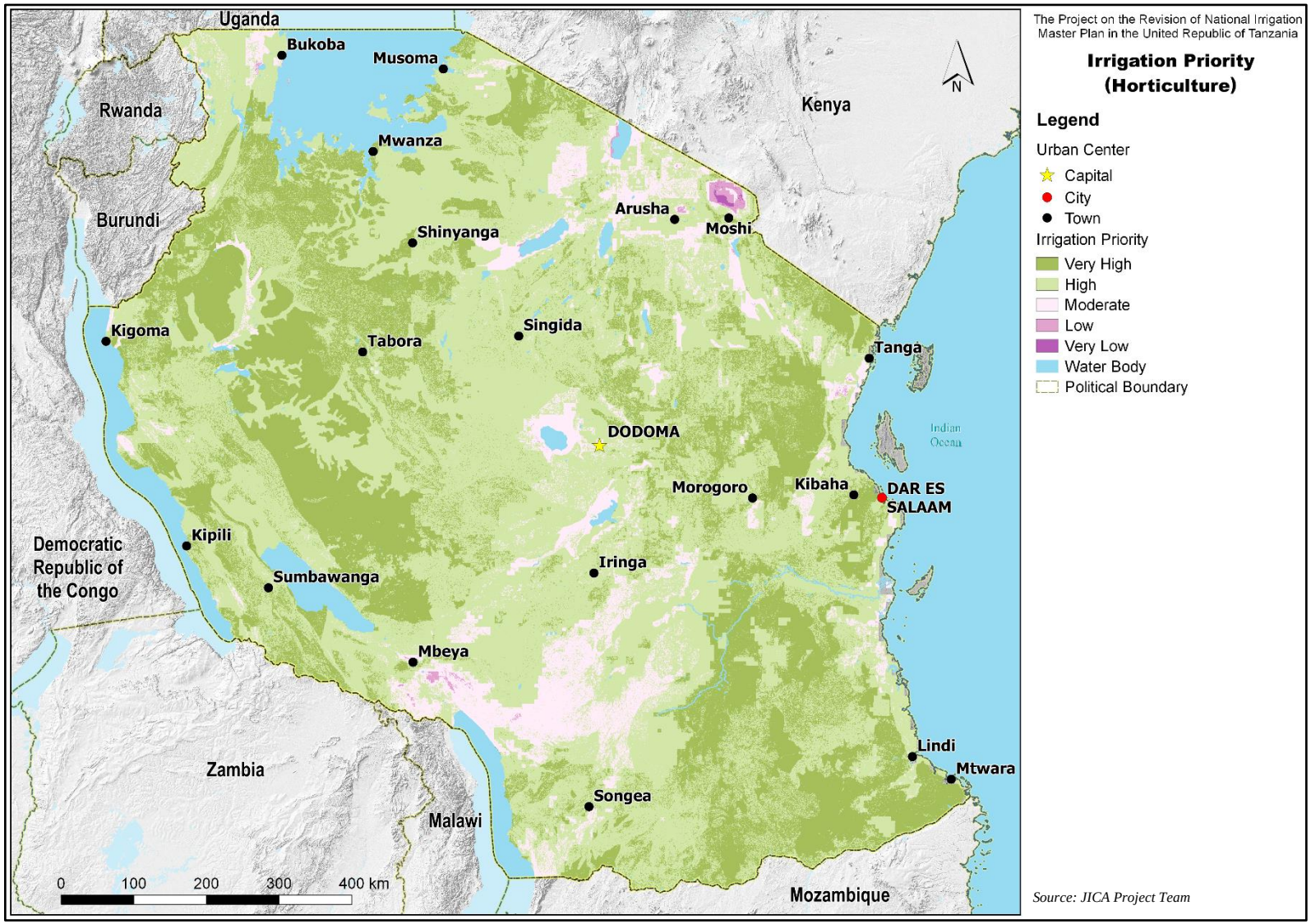
Map 22 Land Suitability for Horticulture Crops (Rainfed Condition)



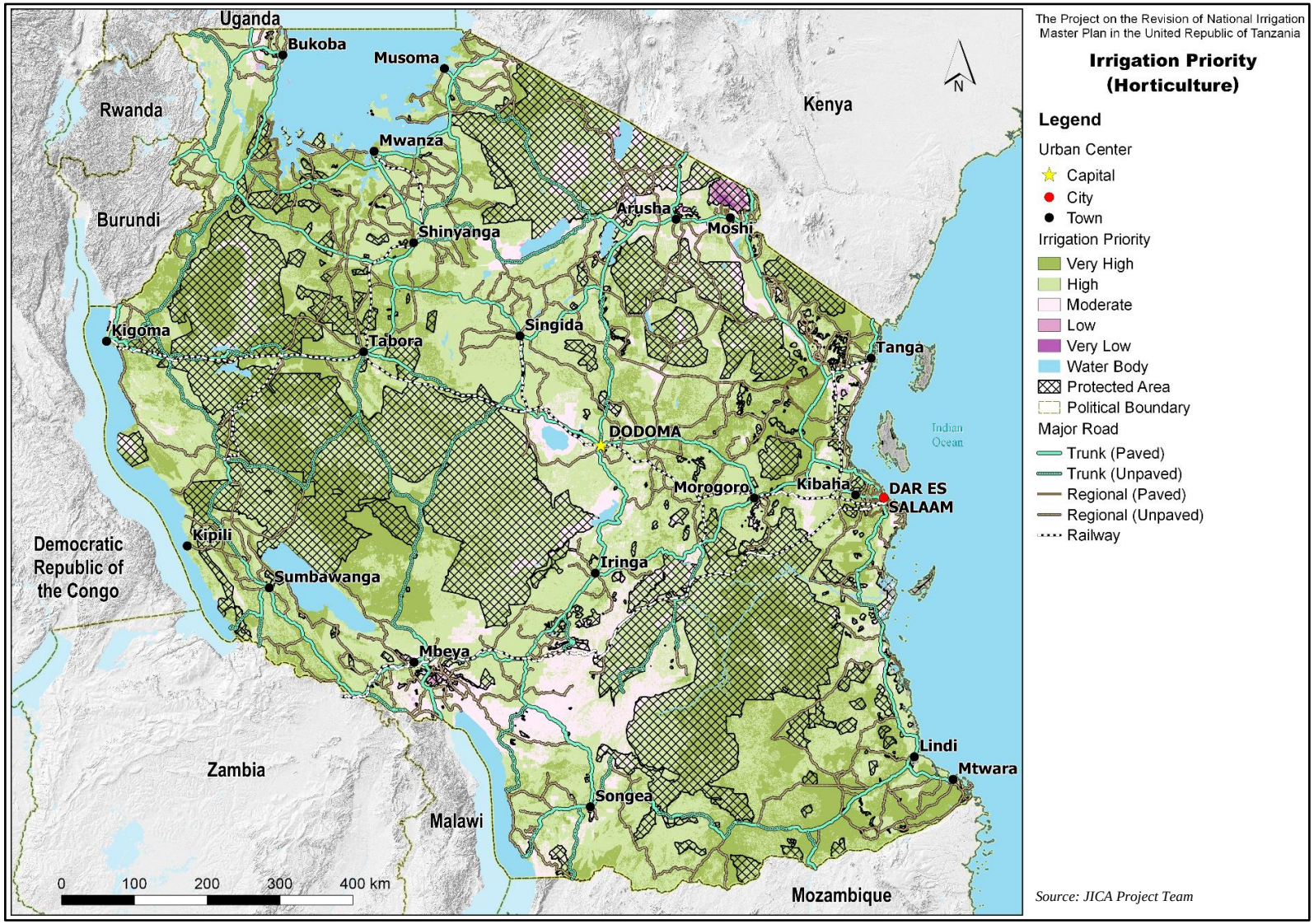
Map 23 Land Suitability for Horticulture Crops and Protected Area Coverage (Rainfed Condition)



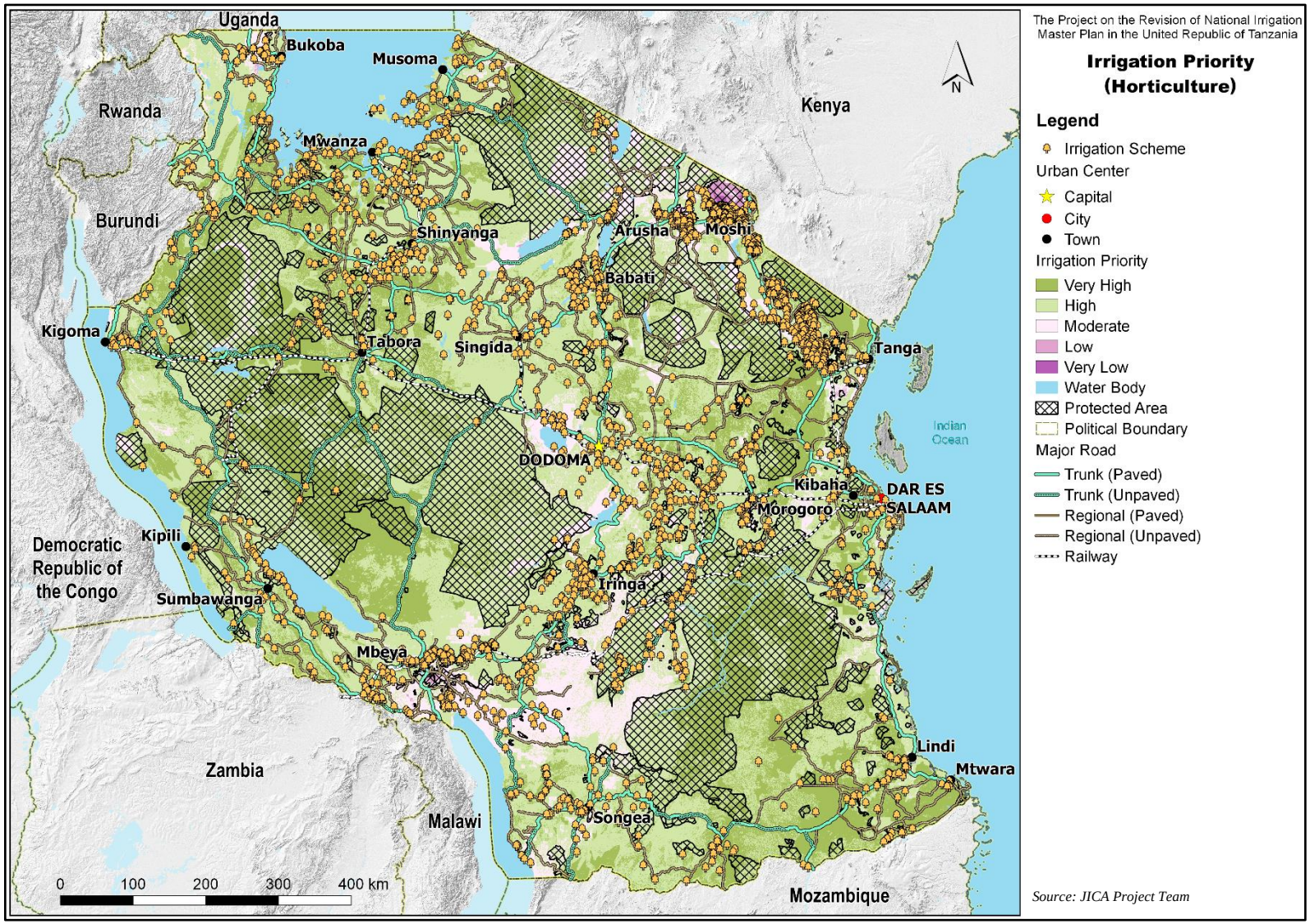
Map 24 Location of Irrigation Schemes within Land Suitability for Horticulture Crops and Protected Area Coverage (Rainfed Condition)



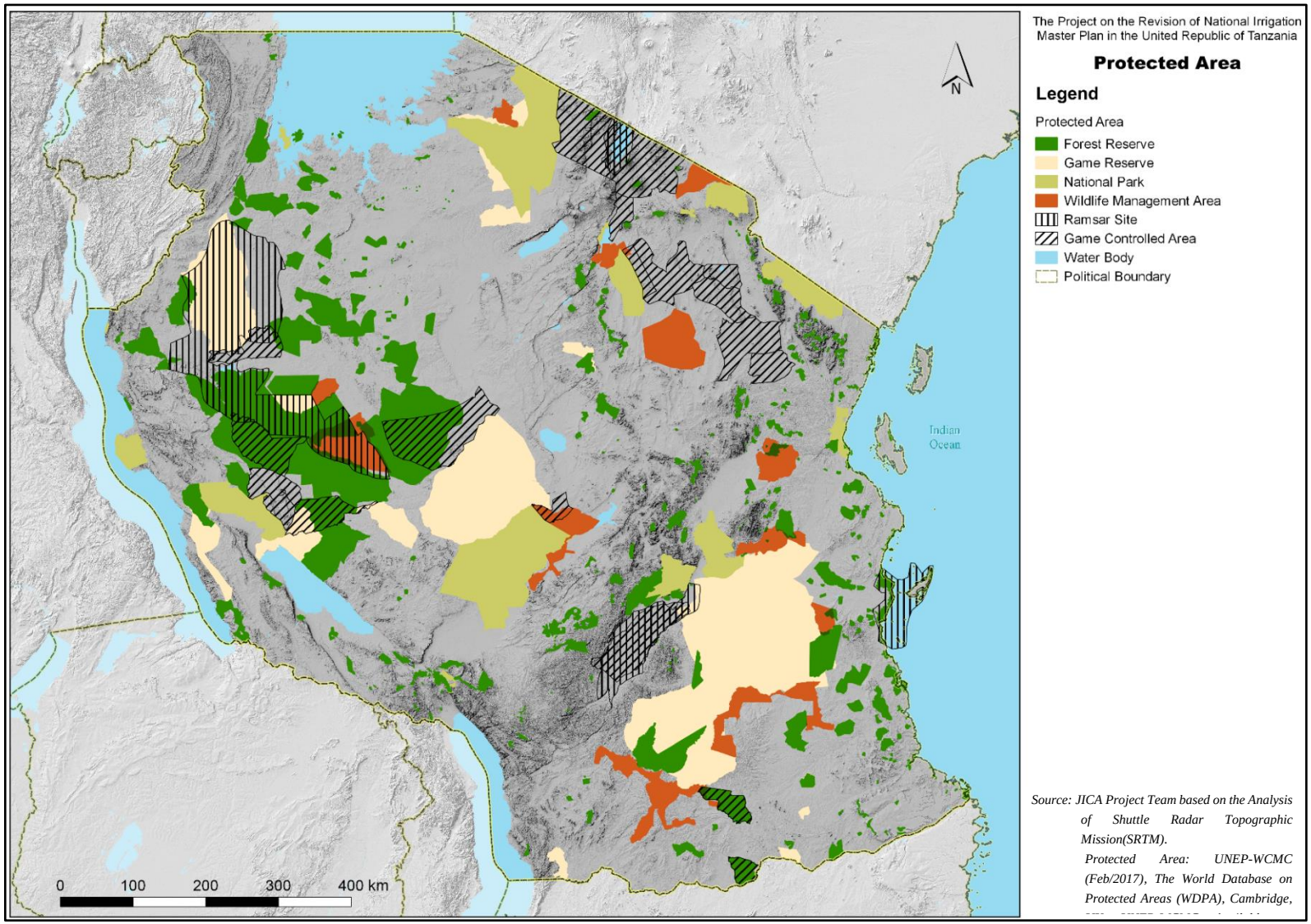
Map 25 Irrigation Priority for Horticulture Crops



Map 26 Irrigation Priority for Horticulture Crops and Protected Area Coverage



Map 27 Location of Irrigation Schemes within Irrigation Priority for Horticulture Crops and Protected Area



Map 28 Types of Protected Area