The United Republic of Tanzania
President's Office
Regional Administration and
Local Government

The City Council of Dodoma

TANZANIA STRATEGIC CITIES PROJECT (TSCP)
- SECOND ADDITIONAL FINANCING (AF2)
(IDA CREDIT NO. 5947-TZ)

Drainage and Sanitation Development Plan for Dodoma City

FOR

THE PROVISION OF CONSULTANCY SERVICES FOR STUDY AND DESIGN OF STORM WATER DRAINAGE SYSTEM AND PREPARATION OF DRAINAGE & SANITATION DEVELOPMENT PLAN (DSDP) FOR DODOMA CITY FOR A PERIOD OF 2020-2040

(CONTRACT NO. LGA/020/2018-2019/C/04)

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CHEIL ENGINEERING

AJOMA CONSULT LIMITED

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List of Abbreviation

ABR	Anaerobic Baffled Reactor
AF2	Second Additional Financing
AIDS	Acquired Immunity Deficiency Syndrome
AGNPS	Agricultural Non-Point Source Pollution
AHP	Analytic Hierarchy Process
ALAT	Association of Local Authorities of Tanzania
AMC	Antecedent Moisture Condition
ASDP	Agricultural Sector Development Programme
BOD	Biochemical Oxygen Demand
BOQ	Bill of Quantity
CAPEX	Capital Expenditure
CBOs	Community Based Organizations
CBP	Central Business Park
CCD	The City Council of Dodoma
CDA	Capital Development Authority
COD	Chemical Oxygen Demand
CRVA	Climate Risk and Vulnerability Assessment
CWs	Constructed Wetlands
DADPs	District Agricultural developent Plans
DEM	Digital Elevation Model
DQA	Data Quality Assessment
DRM	Disaster Risk Management
DSDP	Drainage & Sanitation Development Plan
DTM	Digital Terrain Model
DUWASA	Dodoma Urban Water Supply and Sanitation Authority
DXF	Drawing Exchange Format

LIST OF ABBREVIATION

EAC	East African Community
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
ESA	European Space Agency
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
EUROSEM	European Soil Erosion Model
EWURA	Energy and Water Utilities Regulatory Authority
FWS	Free Water Surface
GIS	geographic information system
GN	Government Notice
GOT	The Government of Tanzania
GPSs	General Planning Schemes
GST	Geological Survey of Tanzania
HEC-RAS	Hydrologic Engineering Conter's River Analysis System
HWSD	Harmonized World Soil Database
IDA	International Development Association
LGAs	Local Government Authorities
MAR	Mean Annual Rainfall
MDGs	Millennium Development Goals
MGR	Metre-gauge Railway
MKUKUTA	National Strategy for Growth and Poverty Reduction
NAWAPO	National Water Policy
NEMC	National Environment Management Council
NEP	National Environmental Policy
NGOs	Non-governmental Organizations
NLP	National Land Policy
O&M	Operation and Maintenance
O&OD	Opportunities and Obstacles to Development

LIST OF ABBREVIATION

OJT	On-the-Job Training
OPEX	Operational Expenditures
PDO	Project Development Objectives
PFD	Process Flow Diagram
PO-RALG	President's Office, Regional Administration and Local Government
RBWB	River Basin Water Board
SATEEC	Sediment Assessment Tool for Effective Erosion Control
SCS-CN	Soil Conservation Service-Curve Number
SDR	Sediment Delivery Ratio
SEA	Strategic Environmental Assessment
SFD	Shit Flow Diagram
SGR	Standard Gauge Railway
SSF	Subsurface Flow
SWAT	Soil and Water Assessment Tool
SWMM	Storm Water Management Model
TANESCO	Tanzania Electric Supply Company Limited
TANROAD	Tanzania National Roads Agency
TARURA	Tanzania Rural and Urban Roads Agency
TBS	Tanzanian Bureau of Standards
TMA	Tanzania Metheological Agency
TOR	Terms of Reference
TSCP	Tanzania Strategic Cities Project (TSCP)
TSS	Total Suspended Solids
UASB	Upflow Anaerobic Sludge Blanket Reactor
UDOM	University of Dodoma
USLE	Universal Soil Loss Equation
USPED	Unit Stream Power-based Erosion/Deposition
VEO	Village Executive Officer
VIP	Ventilated Improved Pit

LIST OF ABBREVIATION

WDC	Ward Development Committee
WEO	Ward Executive Officer
WEPP	Water Erosion Prediction Project
WHO	World Health Organization
WRMA	Water Resources Management Act
WSPs	Wastewater Stabilization Ponds
WWTP	Wastewater Treatment Plant

SECTION 1. INTRODUCTION

I. Purpose of the Project

1. Background of the Project

1.1. Tanzania Strategic Cities Project (TSCP)

The Government of Tanzania (GoT) through the President's Office-Regional Administration and Local Government (PO-RALG) has received funds from the World Bank (IDA Credit) to implement the Tanzania Strategic Cities Project (TSCP). PO-RALG has been implementing the TSCP since 2010 with 8 participating urban Local Government Authorities (LGAs): Tanga CC, Arusha CC, Mwanza CC, the City Council of Dodoma, Ilemela MC, Kigoma Ujiji MC, Mbeya CC and Mtwara Mikindani MC.

The TSCP was prepared in a response to a request from the GoT to assist with the financing of an investment operation that would provide finance for critical infrastructure in the key urban LGAs and support for improved fiscal and management capacity for urban development and management. TSCP recognize the strategic importance of Tanzania urban centers as the engines for the country's structural transformation, economic growth and nationwide improvements in welfare. The Participating eight urban LGAs have strategic importance to mainland Tanzania in terms of their physical locations, importance for regional trade, demographic weight and contribution to the national economy.

TSCP Objectives and Outcomes are as follows:

- The Development Objective: is to improve the quality of and access to basic urban services in seven elected Participating Local Government Authorities (LGAs).
- The Purpose: rehabilitation and expansion of urban infrastructure and institutional strengthening activities aimed at improving the fiscal and management capacities of the Participating LGAs.
- Project Outcomes: the TSCP will improve the welfare and capacities of the LGAs to identify their key problems, determine the appropriate solutions in the form of subprojects, plan their implementation and assume full responsibility for their maintenance and management.

1.2. TSCP Second Additional Financing (AF2)

During the design and preparation of TSCP, the participating LGAs prioritized infrastructure sub-projects that would substantially enable the project objectives to be achieved. At the project appraisal, it was determined that due to cost estimates being far above the available funds under the credit, only a limited number of the prioritized projects in the list were to be financed under the project and the remaining sub-projects would be considered in future in case additional financing(AF) becomes available.

The GoT through the PO-RALG is currently implementing TSCP-AF1, which is in the final stage of implementation, and at the same time has prepared a new credit for the TSCP Second Additional Financing (TSCP-AF2) under the World Bank (through the International Development Association (IDA)) to fund the sub-projects that were either not financed and thus not implemented during initial TSCP financing or are newly identified priority sub-projects which complement the objectives of TSCP.

Accordingly, the GoT has finally received a credit from the International Development Association (IDA) towards the cost of Tanzania Strategic Cities Project (TSCP) – Second Additional Financing (AF2). It is intended that part of the proceeds of the credit will be used to cover eligible payments under the contract for the ***'Provision of consultancy services for study and design of storm water drainage system and preparation of Drainage & Sanitation Development Plan (DSDP) for Dodoma City for a period of 2020-2040'*** under the TSCP – Second Additional Financing (AF2).

AF2 is the third phase of implementation of the TSCP; the first phase being implementation of the Parent or Original TSCP, which ended in 2015 and the second phase, namely, TSCP First Additional Financing (AF1) is currently in the final stage of implementation. Through AF2 funds, the City Council of Dodoma wishes to have an overall Drainage and Sanitation Development Plan prepared, which will look forward for the next 20 years (to 2040) while also undertaking the study and design of storm water drainage system.

The study and design of storm water drainage system and preparation of Drainage and Sanitation Development Plan for Dodoma City will prioritize further secondary and tertiary drainage and sewerage and sewage treatment investments, develop operations and maintenance schemes and budgets and carry out related work for city urban resilience and capital works planning.

2. Necessity of the DSDP Project

Dodoma city is growing and urbanizing considerably fast following the shift of the national capital from Dar es Salaam, which leads to an increase in water demand and wastewater flow as well. However, Dodoma city still remains without access to proper sanitation and wastewater treatment facilities and have been facing problems of wastewater disposal.

Most of the sewerage infrastructure in Dodoma city are lacking, are outdated, not designed to meet local conditions, poorly maintained and entirely unable to keep pace with rising urban populations (Fig. 1). And, a large volume of untreated wastewater has been discharged directly to the ground water and public water bodies, threatening human health, ecosystems, biodiversity, food security, and the sustainability of the water resources.

Fig. 1 Exhausted Sewerage System in Dodoma city

Dodoma city has areas which are vulnerable to seasonal flooding because of its natural flat topography and increased rainfall due to climate change may cause flood damage to transport, communications and buildings infrastructures, etc. A storm water drainage system in Dodoma city serves only central areas and, in outlying neighborhoods, storm water runs along natural ravines which are not able to collect and drain all surface runoff during heavy rain.

As for current institutional arrangement for drainage and sanitation system, the drainage is the responsibility of the City Council of Dodoma (CCD) but, wastewater collection and treatment is not the responsibility of the CCD but of the Dodoma Urban Water and Sanitation Authority (DUWASA) and private sector, which complicates the institutional responsibilities and arrangements for sanitation and drainage system in the city.

Accordingly, through this project we will establish the storm water drainage and sanitation development plan and measures to solve the problems mentioned above.

II. Scope of the Project

The below table shows the major conditions of this project. The consultant team is supposed to conduct this project for 12 months from 6th May 2019 to 5th May 2020 and mobilize 16 staffs and provide 80.75 man-months in total.

Table 1 Major Conditions of the Project

<table>
<tr><th>Item</th><th>Description</th></tr>
<tr><td>Project Title</td><td>Provision of Consultancy Services for Study and Design of Storm Water Drainage System and Preparation of Drainage & Sanitation Development Plan (DSDP) for DODOMA City for a Period of 2020-2040</td></tr>
<tr><td>Client</td><td>• The City Council of Dodoma</td></tr>
<tr><td>Objectives</td><td>• To develop an integrated Drainage and Sanitation Development Plan (DSDP)
• To propose priority projects in the initial 5 years with a conceptual engineering design level</td></tr>
<tr><td>Financial Resources</td><td>• A Part of Tanzania Strategic Cities Project(TSCP) – Second Additional Financing(AF2) financed by the International Development Association (IDA) of World Bank</td></tr>
<tr><td>Project Period</td><td>• 12 months (May 6, 2019 to May 5, 2020)</td></tr>
<tr><td>Consultants</td><td>• Cheil Engineering Co., Ltd. (in Korea)
• AJOMA Consult Limited (in Tanzania)</td></tr>
<tr><td>M/M to be provided</td><td>• Total: 80.75 M/M
<table>
<tr><th>Item</th><th>International Staffs</th><th>Local Staffs</th><th>Total</th></tr>
<tr><td>Key Staffs</td><td>32.0 M/M</td><td>8.0 M/M</td><td>40.0 M/M</td></tr>
<tr><td>Non-Key Staffs</td><td>2.0 M/M</td><td>38.75 M/M</td><td>40.75 M/M</td></tr>
<tr><td>Total</td><td>34.0 M/M</td><td>46.75 M/M</td><td>80.75 M/M</td></tr>
</table></td></tr>
</table>

The main objectives of this project can be classified into two categories as follows:

The primary objective is to **develop an integrated Drainage and Sanitation Development Plan (DSDP)** on the basis of previous Master Plan and General Planning Schemes for the Dodoma city. The DSDP will cover storm water drainage, wastewater collection and treatment and fecal sludge management during the period from 2020 and 2040. And it will define institutional, structural and non-structural measures needed to develop, operate and maintain drainage and sanitation system.

The second objective is to propose at least 5 priority projects during the initial 5 years period in a conceptual engineering level.

And, the tasks of consultancy services can be classified into 6 large categories: Baseline Assessment; Methodology and Outline of Draft DSDP; Validation Workshop and Consultation; Draft DSDP; Consultative Period; and Final DSDP.

The below table shows the tasks and related activities for the consultancy services. In this phase, we have performed the activities for the baseline assessment and this report also covers the results and activities about the baseline assessment.

Table 2. Tasks of Consultancy Services

Tasks	Activities
Baseline Assessment	• Data Collection and Review • City Scale Flood Model • Institutional mapping of storm-water drainage, urban sanitation and resilience, as well as flood management. • Survey and Mapping • Urban Development • Wastewater and Fecal Sludge • Storm Water Drainage and Flood Control Planning and Design • Green Growth, Climate Change, Urban Resilience and Sustainability • Monitoring Tool
Methodology and Outline of Draft DSDP	• Proposing a methodology to develop the DSDP • Proposing an outline of the resultant DSDP structure
Validation Workshop and Consultation	• Validation of the methodology and outline of the DSDP • Focus Group Discussion • Incorporation of the feedback into the draft DSDP
Draft Drainage and Sanitation Development Plan	• Description of targets and milestones • Full description of selected measures • Financial analysis of CAPEX & OPEX and sustainability consideration • Prioritization and phasing of the projects that require investment • Strengthen the Monitoring and Evaluation systems • Preparation of pre-F/S, conceptual designs and TOR for the priority projects
Consultative Period	• Making the draft DSDP available to the public via the internet • Workshop and focus group meetings to seek additional feedback
Final Drainage and Sanitation Development Plan	• Preparation of final DSDP based on comments from public & stakeholders • Posting the final DSDP on the internet

And, pursuant to ToR and Consultants' Proposal, the consultants are supposed to provide the Clients with the deliverables and reports as shown in the below table.

Table 3. Deliverables

Report		Description of Report	Submission Date
Consultancy Service	Inception Report	• Setting out the parameters of the consulting services, Consultant's site organization and schedule. • Project overview, approach and methodology for the Services. • Organization, work plan and project schedule.	Within 4 weeks after the commencement date
	Monthly Progress Report	• All activities and progress of each month. • Problems together with actions or recommendations on remedial measures for correction. • The work plan during the coming month.	-
Baseline Assessment and Methodology and Outline of the DSDP	Baseline Assessment and Outline Report	• Introduction and background for Baseline assessment methodology. • Assessment results about the state of affairs, key baseline indicators, stakeholders mapping and analysis. • Feedback regarding the Technical Assistance Fiche.	Within 3 months after the commencement date
Drainage and Sanitation Development Plan	Draft Report	• Review and consideration of the existing system. • Survey and interview result. • Baseline Assessment Report including methodology and outline of the Drainage and Sanitation Development Plan. • Pre-Feasibility Study with draft conceptual engineering and drawings for an initial priority project to be implemented over a 5 year period. • Institutional arrangement, regulations,health and environmental Situation. • Potential technical options.	Within 6 months after the commencement date
	Final Report	• All survey and analysis result for existing drainage and sanitation system. • Technical option considering project site situation. • Final selection of the technical option. • Final Pre-Feasibility Study for a priority Wastewater and Drainage Project over a 5 year period including final conceptual engineering designs, drawings and cost estimates. • Approval of selected option.	Within 12 months after the commencement date
	Technical Evaluation Report	• Results of technical evaluation with recommendations on technically responsive bidders.	According to the required schedule
Others	Technical Report	• Any special technical issues or problems during the assignment period.	As required or upon request

SECTION 2. CURRENT STATUS ASSESSMENT

I. Project Area

The Project area for this project is Dodoma city which is the national capital of the United Republic of Tanzania and the city's features are as follows:

1. Geography

The Dodoma city is located at 6°10′23″S 35°44′31″E Coordinates in the center of the country, the town is 453 kilometers west of the former capital at Dar es Salaam and 441 kilometers south of Arusha, the headquarters of the East African Community. It is also 259 kilometers north of Iringa through Mtera. It covers an area of 2,669 square kilometers of which 625 square kilometers are urbanized.

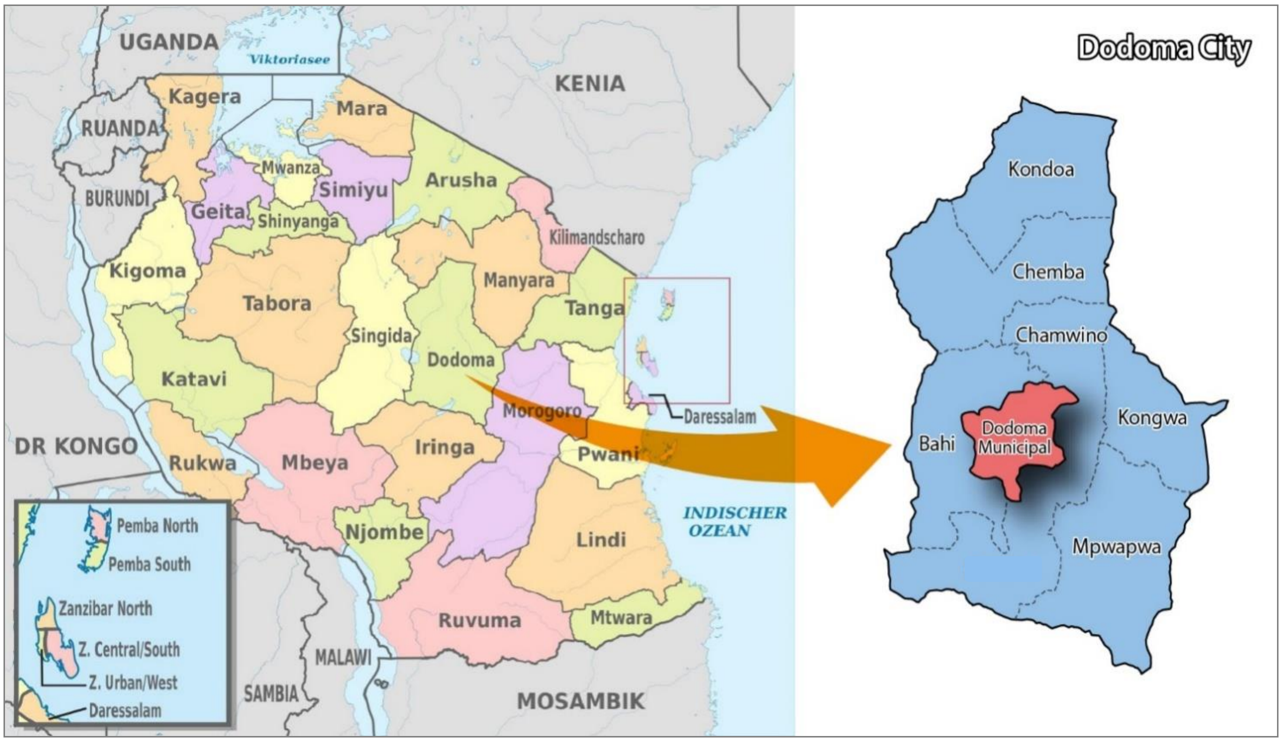

Fig. 2 Map of Tanzania and Dodoma City

2. Administrative Areas

The Dodoma region is one of Tanzania’s 31 administrative regions and, as shown in the Fig. 2, the Dodoma region has 7 districts: Bahi, Chamwino, Chemba, Dodoma, Kondoa, Kongwa and Mpwapwa districts.

Before 2012, the Dodoma city has only 37 wards administratively but, immediately after the 2012 National Census, it has been divided into 41 wards as follows:

• Chahwa • Chamwino • Chang'ombe Dodoma • Chigongwe • Chihanga • Dodoma Makulu • Hazina	• Hombolo • Hombolo Bwawani • Ihumwa • Ipagala • Ipala • Iyumbu • Kikombo • Kikuyu Kaskazini	• Kikuyu Kusini • Kilimani • Kiwanja cha ndege • Kizota • Madukani • Majengo • Makole • Makutupora	• Matumbulu • Mbabala • Mbalawala • Miyuji • Mkonze • Mnadani • Mpunguzi • Msalato • Mtumba	• Nala • Ngh'ongh'onha • Nkuhungu • Ntyuka • Nzuguni • Tambukareli • Uhuru • Viwandani • Zuzu

And, the below figure shows the boundary of the wards since 2012.

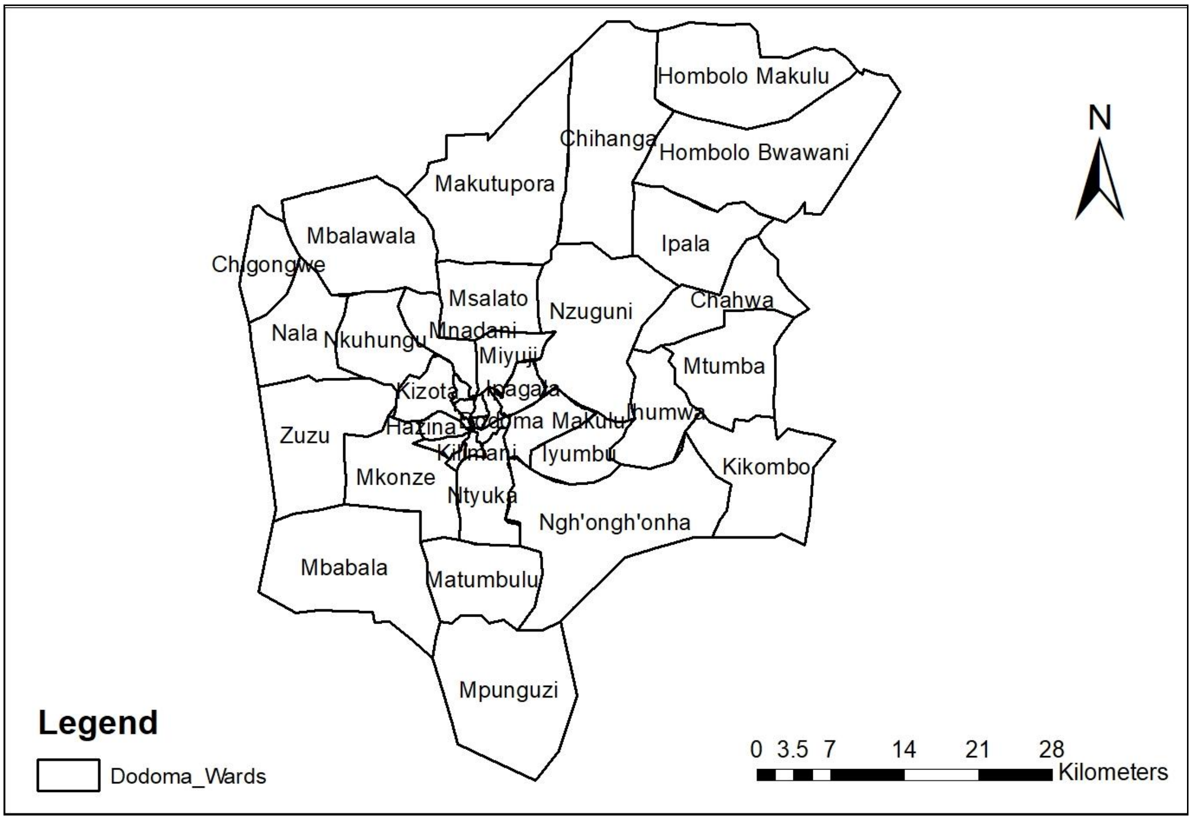

Fig. 3 Current boundary of the wards in Dodoma City

However, there are three wards to be added to Dodoma city according to the Dodoma city Master Plan of 2019. The wards include Msanga, Chamwino Ikulu and Buigiri which are now belonging to Chamwino District as shown in the below figure. However, the three wards are planned to be belonging to the Dodoma city in the future since the government city will be located in the three wards. Especially, the president house (Ikulu) will be shifting from Dar es Salaam to the Chamwino Ikulu.

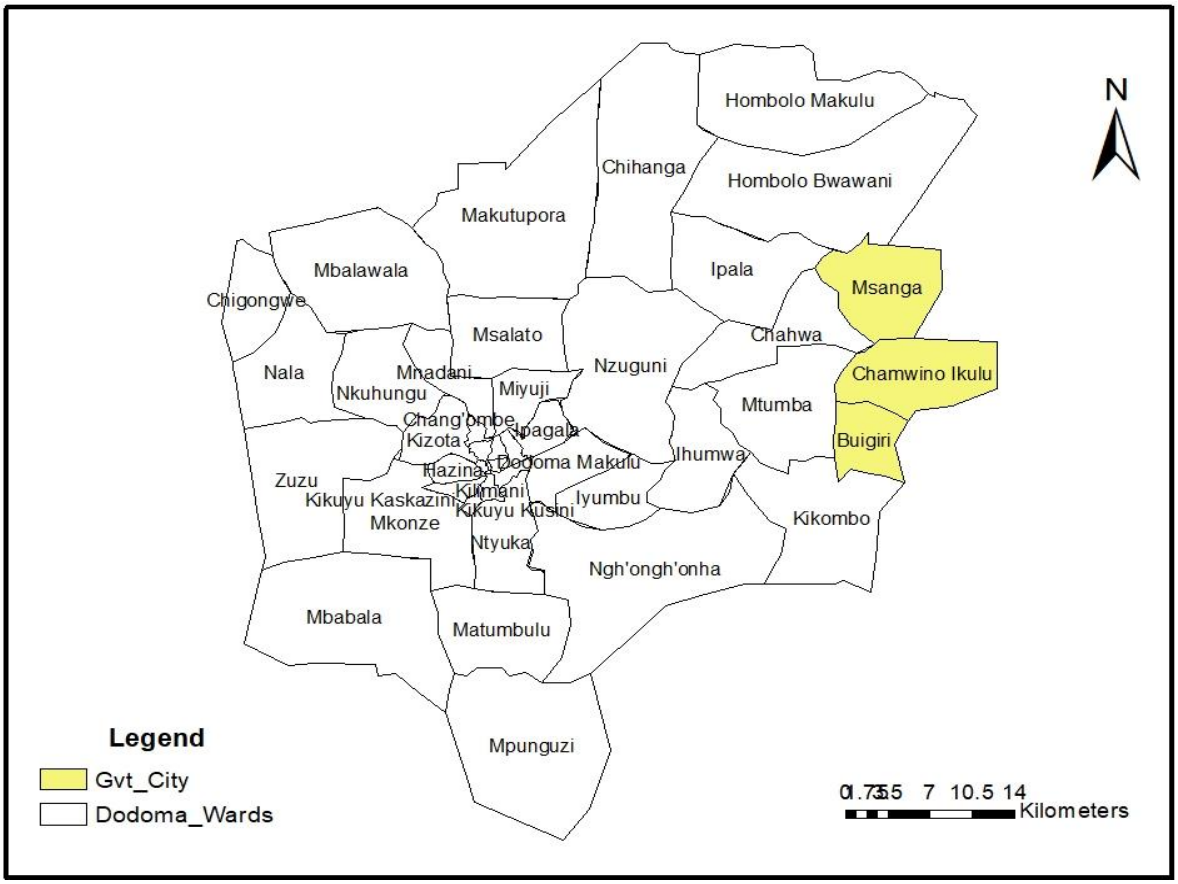

Fig. 4 Boundary of the Wards in Dodoma City according to the Master Plan

3. Population

Dodoma city is one of the fastest growing cities in Tanzania following the shift of the national capital from Dar es Salaam. Dodoma city is not only the national capital of the United Republic of Tanzania but also the capital of Dodoma Region, with a population of 579,591 as of 2019, which is from the City Master Plan dated on April 2019.

The below table shows the population of each ward, which is presented in the 2012 National Census and the City Master Plan.

Table 4. Population of Dodoma City's Each Ward

S/N	National Census in 2012		City Master Plan in 2019		Remark
	Ward	Population	Ward	Population	
1	Viwandani	4,883	Viwandani	6,880	
2	Uhuru	2,419	Uhuru	3,408	
3	Chamwino	19,175	Chamwino	27,015	
4	Kiwanja cha Ndege	10,129	Kiwanja cha Ndege	14,271	
5	Makole	10,504	Makole	14,799	

S/N	National Census in 2012		City Master Plan in 2019		Remark
	Ward	Population	Ward	Population	
6	Miyuji	14,965	Miyuji	21,084	
7	Msalato	6,718	Msalato	9,465	
8	Makutupora	14,430	Makutupora	20,330	
9	Chihanga	11,004	Chihanga	15,503	
10	Hombolo	22,457	Hombolo Bwawani	14,640	
11	Ipala	6,026	Hombolo Makulu	17,000	
12	Nzuguni	15,466	Ipala	8,490	
13	Dodoma Makulu	17,097	Nzuguni	21,790	
14	Mtumba	17,268	Dodoma Makulu	24,088	
15	Kikombo	8,343	Mtumba	12,465	
16	Ng'hong'honha	9,536	Ihumwa	12,464	
17	Mpunguzi	17,891	Kikombo	11,754	
18	Tambukareli	6,584	Ng'hong'honha	13,435	
19	Kilimani	6,471	Matumbulu	10,950	
20	Kikuyu Kusini	5,974	Mpunguzi	14,256	
21	Kikuyu Kaskazini	9,852	Tambukareli	9,276	
22	Mkonze	12,515	Kilimani	9,117	
23	Mbabala	11,901	Kikuyu Kusini	8,417	
24	Zuzu	6,485	Kikuyu Kaskazini	13,880	
25	Hazina	9,540	Mkonze	17,632	
26	Madukani	2,421	Mbabala	16,767	
27	Majengo	5,214	Zuzu	9,137	
28	Kizota	34,453	Hazina	13,441	
29	Nala	5,567	Madukani	3,411	
30	Mbalawala	8,830	Majengo	7,346	
31	Ntyuka	4,558	Nkuhungu	24,005	
32	Chigongwe	7,281	Kizota	24,535	
33	Chang'ombe	25,415	Nala	7,843	
34	Iyumbu	2,700	Mbalawala	12,440	
35	Chahwa	4,365	Ntyuka	6,422	
36	Mnadani	14,373	Chigongwe	10,258	
37	Ipagala	18,146	Chang'ombe	35,807	
38	-		Iyumbu	3,804	
39	-		Chahwa	6,150	
40	-		Mnadani	20,250	
41	-		Ipagala	25,566	
Total		410,956	Total	579,591	
42	Msanga			11,895	To be belonging

S/N	National Census in 2012		City Master Plan in 2019		Remark
	Ward	Population	Ward	Population	
43	Chamwino Ikulu			10,486	to Dodoma city from Chamwino District
44	Buigiri			10,221	
Total				32,602	
Grand Total				612,193	

4. Demographics

Out of the total population based on the 2012 National Census, 199,487 people (48.5 percent) are male while 211,469 people (51.5 percent) are female. The average household size is 4.4 people. Dodoma is populated by different ethnic groups because it is a government administrative center, although the indigenous ethnic groups are the Gogo, Rangi, and Sandawe. There are also small Indian minorities.

5. History

The Dodoma was founded in 1907 by German colonists during construction of the Tanzanian central railway. The layout followed the typical colonial planning of the time with a European quarter segregated from a native village.

In 1967, following independence, the government invited Canadian firm Project Planning Associates Ltd to draw up a master plan to help control and organize the then capital of the country Dar es Salaam that was undergoing rapid urbanization and population growth. The plan was cancelled in 1972 in part due to its failure to adequately address the historical and social problems associated with the city.

In 1974, after a nationwide party referendum, the Tanzanian government announced that the capital would be moved from Dar es Salaam to a more central location to create significant social and economic improvements for the central region and to centralize the capital within the country. The cost was estimated at £186 million and envisaged to take 10 years. The site, the Dodoma region, had been looked at as a potential new capital as early as 1915 by the then colonial power Germany, in 1932 by the British as a League of Nations mandate and again in the post-independence National Assembly in 1961 and 1966.

With an already established town at a major crossroads, the Dodoma region had an agreeable climate, room for development and was located in the geographic centre of the nation.

A new capital was seen as a more economically viable alternative than attempting to reorganize and restructure Dar es Salaam and was idealized as a way of diverting development away from continued concentration in a single coastal city that was seen as anathema to the government's goal of socialist unity and development. Objectives for the new capital included: that the city becoming a symbol of Tanzania's social and cultural values and aspirations; that the capital city function being supplemented by industrial-commercial development; and that the mistakes and features of colonial planning and modern big cities such as excessive population densities, pollution and traffic congestion were to be avoided.

The Capital Development Authority (CDA) invited some international firms to submit proposals for the best location and preparation of a master plan. And the winner, decided by the CDA together with independent American consultants, was Project Planning Associates Ltd., of Canada whose plan for Dar es Salaam was seen as inadequate and not responsive enough to the local conditions and needs for Tanzania’s largest city. Their plan envisaged a city of 400,000 persons by 2000 and 1.3 million by 2020.

In 1974, Dodoma had a population of 40,000 and was chosen as the actual site of the new capital. The existing population size was not seen as an impediment while existing infrastructure would reduce construction costs.

The city, designed over 1,000 hectares, was meant to be "the chief village in a nation of villages," built at a human scale meant to be experienced on foot.

As part of the move of the government, a capitol complex was envisaged and multiple designs by different international teams offered competing visions and versions of the siting and layout of a capitol complex. These competing proposals, some paid for by foreign governments as a form of aid and others by the firms involved were presented as early as 1978. However, it was not until 2006 that the Chinese government delivered a finished parliament building in Dodoma. The final location of the parliament was not in its original intended location in the master plan, with the location now being developed as a site for a university.

As much of the initial design never came to fruition over the past 40 years, government offices and embassies had resisted moving offices to Dodoma from Dar es Salaam which remains the commercial and the de facto capital of Tanzania.

However, recently, all government offices and staffs have moved to Dodoma even though some of them are working in temporary rented offices around the city center and in University of Dodoma. However, their permanent offices are now under construction in Mtumba area called 'Government city' which is located 17 km away from the City center.

6. Infrastructure

A major highway connects Dodoma with Dar es Salaam via the Morogoro region in the east. To the west, there are roads to Mwanza and Kigoma going through Tabora. The Great North Road links the city with Arusha to the north, via Kondoa.

The city is also served by the Central Railway Line which connects it over a distance of 465 kilometres (289 mi) with Dar es Salaam in the east. But, Standard Gauge Railway (SGR) project is now under construction to replace the old and inefficient metre-gauge railway (MGR) system. The proposed SGR Project will be undertaken in the following two phases: Phase I (Dar es Salaam to Morogoro, 205 km) and Phase II (Morogoro to Makutupora via Dodoma, 336 km).

And, the Dodoma Airport is managed by the Tanzania Civil Aviation Authority. But the size of planes for the airport is limited to small aircraft only. So, there are plans to build a new airport outside the city with increased runway length and weight-bearing capacity.

7. Climate and Weather

Dodoma features a semi-arid climate with relatively warm temperatures throughout the year. While average highs are somewhat consistent throughout the year, average lows dip to 13 °C in July. Dodoma averages 570 mm of precipitation per year, the bulk of which occurs during its wet season between November and April. The remainder of the year comprises the city's dry season.

Table 5. Climate data for Dodoma

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high (°C)	35.3	36.0	33.5	32.7	32.9	31.7	31.1	34.1	33.8	36.1	36.0	36.4	36.4
Average high (°C)	29.4	29.4	29.0	28.7	28.0	27.1	26.5	27.3	29.0	30.5	30.1	30.4	28.8
Average low (°C)	18.6	18.6	18.3	17.9	16.5	14.4	13.6	14.2	15.3	16.9	18.3	18.8	16.5
Record low (°C)	15.7	16.2	14.9	14.9	10.3	8.9	7.6	9.3	11.1	13.0	14.4	14.4	7.6
Average rainfall (mm)	133.7	144.5	113.9	57.8	5.3	0.1	0.03	0.01	0.01	2.08	26.25	123.28	606.96
Average rainy days (≥ 1.0 mm)	10	9	7	5	1	0	0	0	0	0	2	7	41
Average relative humidity (%)	66	68	70	68	63	60	59	58	55	53	55	63	62

II. Institutional Mapping

1. Policy framework

1.1. National Environmental Policy (NEP), 1997

The National Environmental Policy outlines the framework of fundamental changes that are needed to bring environmental considerations into the mainstream of decision making in Tanzania. It provides policy guidelines, plans, guidance on priorities, and recommendations for monitoring and review of policies, plans and programmes that directly relate to the environment.

The National Environmental Policy particularly stresses on the need to formulate environmental legislation and sectorial legislations as an essential component for an effective and comprehensive environmental management and improvement of life.

1.2. National Water Policy (NAWAPO), 2002

The National Water Policy recognises water as an important requirement for all humans to maintain health, and to restore and maintain the functions of natural ecosystems. The main objective of this policy is to develop a comprehensive framework for sustainable development and management of water resources. The policy aims to ensure that beneficiaries fully participate in all stages of water resource development and recognizes the fundamental but intricate linkages between water and socio-economic development, including environmental requirements.

1.3. National Land Policy (NLP), 1995 (Revised in 1997)

The NLP is a comprehensive policy pronouncement regarding land tenure, management and administration. The overall objectives of this policy among other things are; to promote and ensure the existence of a secure land tenure system in Tanzania and; to sustainably foster optimal use of land.

This policy emphasizes on integrated planning and improved management of urban centres and the designation of urban and land uses, based on environmental impact considerations.

NLP recognises the importance of social services such as water supply, road networks, waste management and energy development that take place on land for human benefits, to be done in a right manner so as to protect land for other uses and avoid land degradation. In addition, the policy identifies the need for conservation and preservation of prehistoric/historic sites and buildings.

As this policy recognizes the importance of protecting public service utilities for environmental protection, the design and construction of the Project will consider restoration of public service utilities and road infrastructure. The Project’s design, construction and operation will also ensure that solid waste does not accumulate and create blockage of drainage systems through periodic cleaning of open drains.

1.4. National Health Policy, 2007

The first objective of this policy includes reducing the burden of disease and infant mortality, and increasing life expectancy through, among other things, facilitating environmental health and sanitation. The policy also aims to promote awareness among government employees and the community at large that health problems can only be adequately solved through multi-sectoral cooperation. The Ministry of Health will continue to collaborate with other stakeholders with the aim of achieving better environmental health and sanitation, and will enforce the safe management of solid and liquid waste at each facility.

1.5. Community Development Policy, 1996

The first aim of the policy is to enable Tanzanian communities to build a better life though self-reliance and the use of locally available resources. Tanzanians shall be enabled to join together and increase their commitment to self-development. One of the policy’s objectives is to help to respond to and meet the basic needs of communities, such as:

- Food and nutrition
- Health and sanitation
- Water and environmental sanitation
- Appropriate technology for domestic energy use

The policy also aims to help guide efforts to improve rural and urban environments.

1.6. National Human Settlements Development Policy, 2000

Among other important objectives of this policy is to recognize environmental protection within human settlements and protection of natural ecosystems against pollution, degradation and destruction with two main objectives:

- To promote development of human settlements which are sustainable;
- To facilitate the provisions of adequate and affordable shelter to all income groups in Tanzania.

Additionally, the policy recognizes the role of the National Environment Policy and other sectoral policies for attainment of urban development and need for coordination and cooperation with other sectors / stakeholders, including Community-Based Organisations (CBO), and Non-Governmental Organisations (NGO) in urban development planning.

From a very preliminary stage of project development, the importance of stakeholder's involvement and interested parties was recognized. The project itself has an ultimate objective of ensuring the safety and welfare of the people while considering the protection and sustainable development of human settlements.

1.7. Agricultural and Livestock Policy, 1997

Agricultural and Livestock Policy addresses the changes that affect the agricultural sector in Tanzania and specifically addresses restrictions to agricultural practices stemming from the National Land Policy and the need for agricultural practices to ensure protection of the environment. The objective of this policy is to improve food security and alleviate poverty, while promoting integrated and sustainable use and management of natural resources such as land, soil, water and vegetation.

Although this project is being mostly developed in urban areas, the area reserved for the implementation of the detention ponds contain various vegetation forms which need to be cleared for the construction of the facilities. Moreover, agricultural activities such as urban faming may be practiced in this area for domestic consumption.

1.8. National Forrest Policy, 1998

The overall goal of the National Forest Policy of 1998 is to enhance the contribution of the forest sector to sustainable development of Tanzania and conservation and management of natural resources for the benefit of present and future generations. In practice this means that forests have to be managed in terms of socio-economic, ecological and cultural sustainability, in accordance to the principles of multi-functionality and equitable benefits and responsibility sharing.

The policy sets four priority areas for legislation and implementation, namely: forest land management; forest-based industries and products; ecosystem conservation and management; and institutional and human resources.

2. Legal framework

2.1. Environmental Management Act (EMA) No. 20, 2004

The National Environmental Management Act (EMA) No. 19 of 1983 started the process of regulating environmental management in Tanzania. Although draft EIA guidelines and procedures were produced in 1997 and amended in 2003, the country lacked a coherent code of supporting legislation to enable effective environmental management. Therefore, a study was initiated with funding from the World Bank, known as the Institutional and Legal Framework for Environmental Management Project. This culminated in the promulgation of the Environmental Management Act (EMA) No. 20 in 2004.

EMA provides a policy framework for environment and natural resources management and:

- Provides the legal and institutional framework for the sustainable management of the environment;
- Stipulates impact and risk assessments, the prevention and control of pollution, waste management, environmental quality standards, public participation, compliance and enforcement;
- Provides for the implementation of the National Environment Policy;
- Repeals the National Environment Management Act of 1983;
- Provides for the continuance of the National Environment Management Council, as well as the National Environment Trust Fund.

Sub-section 129 (1) and (2) of the Act states that every local government authority shall construct storm water drains within its area of jurisdiction and make sure they remain clean.

2.2. Local Government (District Authorities) Act, 1982

The Tanzania Local Government Act of 1982 has the objective of making better provisions for, and to consolidate laws relating to, local government, to repeal the Local Government Ordinance, to repeal certain other written laws and to provide for other matters connected with or incidental to the organization of local government in Mainland Tanzania. This Act aims at improving procedures and functions of local government authorities especially in urban areas.

2.3. Land Acquisition Act No. 47, 1967

The Land Acquisition Act of 1967 stipulates the power and the procedures for acquiring land and the required degree of compensation. The Act repeal and replace the Land Acquisition Ordinance, to provide for compulsory acquisition of lands for public purposes and in connection with housing schemes.

The relevance of this Act relates to the compensation of land taken and loss of properties of the people affected by the project.

2.4. Public Health Act No. 1, 2009

This Act provides for the promotion, preservation and maintenance of public health with a view to ensuring the provisions of comprehensive, functional and sustainable public health services to the general public. Public Health Act also addresses the protection of the environmental health and sanitation including healthcare waste management.

The central theme of this act is to provide for the promotion, preservation and maintenance of public health with a view to ensuring the provisions of comprehensive, functional and sustainable public health services to the general public and to provide for other related matters. Major issues addressed in this act include operation of housing & hygiene, human settlements, solid & liquid waste, food & nutrition, control of diseases and workers' health. Relevant sections of this Act related to the implementation of this project include the following:

- Section (81) Transportation and Disposal of Liquid Waste:

a) The authority shall ensure that sewage from cesspool and sludge from septic tanks are collected and transported by specified vehicles for liquid waste disposal;

b) Ensure that sewage is appropriately treated prior to its discharge into water bodies or open land, the sewage will not increase the risk of infections or ecological disturbance and environmental degradation;

c) Designate and ensure compliance with designated disposal ponds, sewage treatment facilities and sewer points.

- Section 73(1)(c): To collect, transport and dispose of solid and liquid waste from buildings, premises and land.

2.5. Water Resources Management Act No. 11, 2009

The Water Resources Management Act (WRMA) repeals the Water Utilisation (Control and Regulation) Act No. 42 of 1974.

This law covers issues of institutional and legal framework, principles for water resources management and prevention and control of water pollution. It established the National Water Board, BWB, catchments and sub-catchments and offences and penalties.

The objective of the WRMA is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled to meet the basic human needs of present and future generations.

2.6. Water Supply and Sanitation Act No.5, 2019

The Water Supply and Management Act established the legal framework for sustainable management and transparent regulation for water supply and sanitation services with a view to give effect to the National Water Policy, 2002.

The Act outlines the responsibilities of government authorities involved in the water sector, establishes Water Supply and Sanitation Authorities as commercial entities and allows for their clustering where this leads to improved commercial viability. It also provides for the registration and operation of Community Owned Water Supply Organisations and regulates the appointment of board members.

And, this act has regulated the offences and penalties as following table:

Table 6. Offences and Penalties

S/No.	Offences	Penalties
1	Any person, who damages, hinders, disrupts, diverts or interferes with water works or sanitation works or other assets owned or vested in a water authority or community organization	500,000 Tshs ≤ Fine ≤ 50 million Tshs or 2 yrs ≤ Imprisonment ≤ 5 yrs
2	Any person who abstract or draws off from water works water using a pipe, drain, pond, pump or other means whereby water may be conveyed or retained	500,000 Tshs ≤ Fine ≤ 50 million Tshs or 12 months ≤ Imprisonment ≤ 5 yrs or to both In addition to fine or imprisonment the court may issue an order requiring the person to remedy any damage or loss caused.

S/No.	Offences	Penalties
3	Any person who misuses or wastes, or causes or allows to be misused or wasted any water passing into, through or upon or near any premises from the waterworks	500,000 Tshs ≤ Fine ≤ 10 million Tshs or 6 months ≤ Imprisonment ≤ 2 yrs or to both
4	Any person who alters or causes or permits to be altered any appurtenances with intent to avoid the accurate measurement or register of water by means of any meter or to obtain a greater supply of water than he is entitled to or to avoid payment for the supply of water or who interferes with or damages any meter.	500,000 Tshs ≤ Fine ≤ 10 million Tshs or 6 months ≤ Imprisonment ≤ 2 yrs or to both
5	In the case of subsequent	10 million Tshs ≤ Fine ≤ 20 million Tshs or 2 yrs ≤ Imprisonment ≤ 5 yrs or to both In addition to fine or imprisonment under this section, the court shall order the payment of cost incurred to repair or replace an appurtance altered or meter damaged or interfered with, and the cost incurred shall be recovered from that person as a civil debt by way of summary suit.
6	Any person who uses any water supplied to him by a water authority or community organisation for purposes other than those for which water is supplied	5 million Tshs ≥ Fine or 6 months ≤ Imprisonment
7	Any person who; a) washes his person or bathes in any part of the waterworks or waterworks area or in any vessel used by a water authority or community organisation for supplying water from any public tap b) washes, throws or causes or permits to enter into waterworks or waterworks area or into any vessel used by a water authority or community organisation for supplying water from any public tap, any animal, clothing, material or thing c) wrongfully opens or closes any lock, cock, valve or manhole of the waterworks	50,000 Tshs ≤ Fine ≤ 1 million Tshs or 1 month ≤ Imprisonment ≤ 3 months or to both
8	1) Any person who deposits or allows or causes to be deposited any earth material or liquid in such manner or place that it may be washed, fall or be carried into the waterworks	1 million Tshs ≤ Fine ≤ 5 million Tshs or 12 months ≤ Imprisonment ≤ 3 yrs or to both
	2) Where the earth material or liquid under subsection (1) has been washed into waterworks or sanitation works	10 million Tshs ≤ Fine or 2 yrs ≤ Imprisonment or to both
9	Any person who on any part of the waterworks erects or inhabits or allow or causes to be erected or inhabited any structure whether of permanent or temporary nature or who inhabits any cave, cavity, depression or hole in any part of the waterworks	1 million Tshs ≤ Fine ≤ 10 million Tshs or 6 months ≤ Imprisonment ≤ 2 yrs or to both
10	A person who dumps, discharges or cause to be dumped or discharged any unauthorized waste into the sanitation works	1 million Tshs ≤ Fine ≤ 3 million Tshs or 6 months ≤ Imprisonment ≤ 2 yrs or to both

2.7. Energy and Water Utilities Regulatory Authority (EWURA) Act, 2001

The general function of EWURA is to regulate the provision of water supply and sanitation services by a water authority or other persons. This includes the establishment of standards related to equipment and tariffs chargeable for the provision of water supply and sanitation services.

2.8. Urban Planning Act No. 8, 2007

The aims of this act are to provide for the orderly and sustainable development of land in urban areas, to preserve and improve amenities, to provide for the grant of consent to develop land and powers of control over the use of land, and to provide for other related matters. This includes improving the provision of infrastructure and social services for the development of sustainable human settlements.

3. Institutional Regulatory Framework

3.1. National Environmental Standards

In terms of section 140 of the EMA, the National Environmental Standards Committee of the Tanzanian Bureau of Standards (TBS) is required to develop, review and submit proposals for environmental standards relating to: water quality, discharge of effluent, air quality, noise and vibration, subsonic vibration, ionising and other radiation, soil quality, noxious smells, light pollution, electromagnetic waves and microwaves.

Especially, among them, the national environmental standards compendium presents the permissible limits or municipal and industrial wastewater discharged to water bodies and the below table shows the major permissible limits.

Table 7. Major Permissible Limits of Municipal and Industrial Wastewater Discharged to Water Bodies

S/No.	Parameter	Limit
1	BOD_5 at 20°C	30 mg/L
2	COD_{cr}	60 mg/L
3	Color	300 TCU
4	pH range	6.5~8.5
5	Temperature range	20~35°C
6	TSS	100mg/L

S/No.	Parameter	Limit
7	Turbidity	300 NTU
8	Chlorides	200
9	Nitrate	20
10	Phosphorus Total (as P)	6
11	Sulphate (SO_4^{2-})	500
12	Sulphides(S^-)	1
13	Total Kjeldahl Nitrogen	15
14	Oil and Grease	10
15	Total Coliform	10,000 counts/100ml

Remark:

1. Monitoring should be done by sampling in accordance to EMDC 1 (1179) ± Sampling Methods.

2. Effluent shall be treated onsite prior to discharge, dilution is not treatment.

3. Effluents are not discharged in close proximity to water supply sources and recreational areas

The following distances from sources of pollution should always be taken into account and be an integral part of every water supply system.

Table 8. Distance from Water Supply System to Source of Contamination

Source of Contamination	Minimum Distance from Source
Pit preview, septic tanks and sewers.	50 metres
Borehole latrines, seeping pits, trenches and sub surface sewage disposal fields.	100 metres
Cesspools, sanitary landfill areas and graves.	150 metres

In addition to the above minimum distances, the following precautions must also be observed:

a) Domestic livestock and other animals should be kept away from the intake by fencing the area of a minimum radius of 50 meters from the installation.

b) Defecation and urination around the intake should be completely prohibited, by law.

c) Drainage and run off waters should be led away from intakes.

d) The water source should be guarded against inundation by the flooding of nearby rivers.

e) Soil erosion should be prevented by reforestation and other methods.

f) Algal growth should be prevented by draining swamps and pools around the intake or reservoir.

3.2. Soil Quality Standards Regulations, 2007

The Soil Quality Standards Regulation provides a framework for environmental protection considerations by different sectors into the mainstream of decision making to ensure minimum environmental negative impacts due to agricultural practices and use of external inputs. It requires the agriculture sector to ensure food security and eradication of rural poverty through the promotion of production systems, technologies and practices that are environmentally sound, with emphasis on strengthening of environmentally sound use, monitoring, registration and management of agro-chemicals use.

There is a risk for soil pollution at the construction sites generally limited to accidental spillages of hydraulic oil, fuel oil and petroleum at individual work sites and along the drainage routes.

3.3. Solid Waste Management Regulations, 2009

These documents regulate the implementation of the EMA (2004). The regulations are guided by three principles: the precaution principle, the polluter pays principle and the producer extended responsibility principle, meaning that manufactures or any person exercising jurisdiction under this Act shall, in relation to any decision, order, exercise of any power or performance of any function, be guided by these principles of environment and sustainable development relevant to waste disposal and management.

Local governments implement the regulations and Schedule 1 of the regulations highlight the types of waste and recommended modes of treatment for the same.

3.4. Water Quality Standards Regulations, 2007

The object of these Regulations is to protect human health and to promote the conservation of the environment, enforcing minimum water quality standards prescribed by the National Environmental Standards Committee. At the same time the water quality standards enable the National Environmental Standards Committee to determine water usages for purposes of establishing environmental quality standards and values for each usage and ensure that all discharges of pollutants take into account the ability of the receiving waters to accommodate contaminants without detriment to the uses specified for the waters concerned.

Since the interventions under the Sub-project will be held in Sinza River, the risk of water contamination during construction phase is high, particularly in regard to accidental spillages of oil and fuel from the vehicles and machinery allocated to works.

3.5. The Land (Assessment of the Value of Land for Compensation) Regulations, 2001

These regulations provide the possibility of claiming for compensation for land or "unexhausted improvement" to be paid by the Government. The assessment basis shall be the market value of the land and certain allowances may be granted: Compensation for loss in any interest in land shall include the value of unexhausted improvement, disturbance allowance, transport allowance, accommodation allowance, and loss of profits.

4. Institutional Administrative Framework

4.1. Water Supply and Sanitation Sector

According to the Water Supply and Sanitation Act No.12 of 2009 the institutional set-up for water supply and sanitation services and related authorities from national level to village level includes:

- Minister Responsible for Water;
- Minister responsible for Local Government;
- Energy and Water Utilities Regulatory Authority (EWURA);
- Regional Secretariats; and
- Local Government Authorities (City, Municipal, District, Ward and Village).

The functions of each institution are outlined in the Water Supply and Sanitation Act and here presented in brief in the Table 9. The following table presents the main institutions involved and their responsibilities.

Table 9. Responsibilities of Institutions related to Water Supply and Sanitation Service

Administrative level	Institution	Responsibility
National	The Minister responsible for Water – Ministry of Water and Irrigation	• Determine legislative aspects of the provision of water supply and sanitation services; • Determine policy and strategy aspects of the provision of water supply and sanitation services; • Coordinate technical and financial support for

Administrative level	Institution	Responsibility
		water supply and sanitation services; • Coordinate planning and resource mobilization for water supply and sanitation services through external support, Non-Governmental Organizations and the public; • Ensure the provision of the technical guidance to Water Supply and Sanitation Authorities and RUWASA; • Coordinate and monitor water and sanitation authority strategies and plans; • Monitor performance of and regulate community based water supply organizations; • Supervise implementation of the provisions of water supply and sanitation service; • Cause to be prepared the National Water Sector Master Plan developed under the Water Resources Management Act; and • Facilitate provisions of low cost technologies of water supply and sanitation services to communities.
	The Minister responsible for Local Government – PO-RALG	• Establish Water and Sanitation Authority; • Cluster water authorities in order to achieve commercial viability; • Creating a conducive environment for community and private sector participation in development, operation and management of water supply and sanitation services; and • Creating a conducive environment for Water and Sanitation Authorities, RUWASA and community organizations in the execution of functions connected with provisions of water supply and sanitation services.
	Energy and Water Utilities Regulatory Authority (EWURA)	• Exercise licensing and regulatory functions in respect of water supply and sanitation services; • Establish standards relating to equipment attached to the water and sanitation system; • Establish guidelines on tariffs chargeable for the provisions of water supply and sanitation services; • Approve tariffs chargeable for the provision of water supply and sanitation services; • Monitor water quality and standards of performance for the provision of water supply and sanitation services; • Initiate and conduct investigations in relation to the quality of water and standards of service given to consumers;

Administrative level	Institution	Responsibility
		• Conduct studies necessary for administrative or management purposes; • Collect and compile data on licensees as it considers necessary for the performance of its functions; • Issue orders or give directions to any person granted a license in respect of a regulated activity; • Establish or approve standards and codes of conduct in respect of (i) licensees; (ii) consumers; and (iii) public safety; • Promote the development of water supply and sanitation services in accordance with recognized international standard practices and public demand.
Regional	Regional Secretariat	• Coordinate and follow up status of planning and implementation of water supply and sanitation services in the Region; and • Create a conducive environment for water authorities, RUWASA and Community Organizations in the execution of functions connected with provisions of water supply and sanitation services in the Region.
Districts	Urban Authorities – City Council of Dodoma	• Make by-laws in relation to water supply and sanitation to give effect to the efficient and sustainable provision of these services in their areas of jurisdiction by water authorities or community organizations; • Coordinate physical planning with the water authorities and community organizations; • Set aside funds from own sources for water supply and sanitation project; • Facilitate the acquisition by communities desirous of owning and managing their water schemes of certificates of title prior to the communities taking over responsibility; • Mobilize communities to take over water supply schemes; • Approve by-laws for protection of water sources, operations of community organizations and other service providers; and • Promote provision of sanitation facilities in the areas of community based water supply schemes.
	Urban Water Supply and Sanitation Authorities – DUWASA	• Responsible for efficient and economical provision of water supply and sanitation services; • Secure the continued supply of water for all

Administrative level	Institution	Responsibility
		lawful purposes by continuously treating the water and monitoring the quality of water supplied at such times; • Develop and maintain waterworks and sanitation works; • In consultation with relevant authorities protect and maintain water sources; • Advise the Government in the formulation of policies and guidelines relating to potable water standards; • Plan and execute new projects for the supply of water and the provision of sanitation; • Educate and provide information to persons on public health aspects of water supply, water conservation, sanitation, and similar issues; • Liaise with relevant government authorities on matters relating to water supply and sanitation and the preparation and execution of plans relating to the expansion thereof; • Collect fees and levies including any regulatory levy for water supply and sanitation services supplied to consumers by the water authority; • Provide bulk procurement and distribution of water chemicals and materials to ensure availability of water chemicals and materials which meet required standards; • Propose water supply and sanitation tariffs; • Provide amenities or facilities which the water authority considers necessary or desirable for persons making use of the services or the facilities provided by the water authority; and • Do anything or enter into any transaction which, in the opinion of the Board of the Water Authority, is calculated to facilitate the proper exercise of the functions of the Water Authority.
Community	Ward and Village Councils	• Promote the establishment of community organizations; • Co-ordinate community organization budgets with village council budgets; and • Resolve conflicts within community organizations.

4.2. Sanitation and Hygiene Sector

In Tanzania, responsibilities for sanitation and hygiene are spread over different sectors, such as water, health and education. The Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC) is developing a National Sanitation and Hygiene Policy. MoHCDGEC provides guidelines and technical assistance to councils, and prepares acts, regulations and standards for monitoring, regulating and supporting councils and other stakeholders. And, the Ministry of Education, Science, Technology and Vocational Training (MoESTVT) is responsible for coordinating sanitation and hygiene in schools, while the Prime Minister's Office leads the implementation of school sanitation and hygiene activities. And, PO-LARG is responsible for local government authorities (LGAs), which are in turn responsible for providing onsite sanitation in consultation with MoHCDGEC. LGAs report to the PO-LARG. And, urban water supply and sewerage authority (DUWASA) is responsible for sewerage services but not on-site sanitation, which is found predominantly in rural areas.

The below table shows the roles and responsibilities of key institutions in sanitation and hygiene sector.

Table 10. Roles and Responsibilities of Key Authorities in Sanitaiton and Hygiene Sector

Institutional Roles and Responsibilities	Key Institutions in sanitation and hygiene sector
Planning / Policy Formulation	• Ministry of Water and Irrigation • Ministry of Health, Community Development, Gender, Seniors and Children • Ministry of Education, Science, Technology and Vocational Training • National Sanitation and Hygiene Steering Committee
Financing	• Ministry of Health, Community Development, Gender, Seniors and Children • Ministry of Water and Irrigation • Ministry of Education, Science, Technology and Vocational Training • PO-LARG
Regulation	• Ministry of Water and Irrigation • Ministry of Education, Science, Technology and Vocational Training
Implementation	• Local government authorities • Prime Minister's Office
Operation and Maintenance	• Local government authorities • Private operators • Households/ landlords
Monitoring and Evaluation	• Tanzania Water and Sanitation Network (TAWASANET) • Annual Joint Water Sector Review (JWSRs)

4.3. Storm water Drainage Sector

According to the Water Resources Management Act No.11 of 2009, the Minister responsible for water establishes basin water boards who have power and functions regarding water resources management including land drainage which means providing for disposal of excess water on land and protection of water against flooding by structural or non-structural measures.

And, according to section 129(1) of the Environmental Management Act, 2004 it stipulates that the local government authority shall, within its area of jurisdiction, build or prepare storm water drains. And, the minister responsible for Environment may make some rules to maintain normal functions of the storm water drainage system. The section 129 of the Environmental Management Act, 2004 is as follows:

Environmental Management Act, 2004

- Section 129

(1) Every local government authority shall, within its area of jurisdiction, build or prepare storm water drains

(2) The storm water drains shall remain clean for the purposes for which they have been made.

(3) The Minister may make rules providing for:

(a) standard gradient for storm water drains to prevent water stagnation;

(b) the periodic cleaning of storm water drains to remove deposits; and

(c) covered storm water drains, inspection covers and appropriate trap chambers for inspection and removal of deposits.

The functions of each institution are outlined in the Water Resources Management Act and Environmental Management Act here presented in brief in the Table 11. The following table presents the main institutions involved and their responsibilities.

Table 11. Responsibilities of Institutions related to Stormwater Drainage

Administrative level	Institution	Responsibility
National	The Minister responsible for Water – Ministry of Water and Irrigation	• Oversee policy and legislative aspects of integrated water resources management; • Appoint members of the National Water Board; • Establish basin water boards; • Provide for supervision and coordination of basin water boards; • Facilitate sectoral coordination and coordinated planning on aspects that may impact on water resources; • Ensure and safeguard national interest on trans-boundary water resources; • Formulate regulations, technical standards and guidelines;

Administrative level	Institution	Responsibility
		• Ensure sustainable development of water resources of national interest; and • Provide for the safe construction of and management of dams.
	The Minister responsible for Environment – Vice President's Office Union Affairs and Environment	• Responsible for matters relating to environment and articulation of policy guidelines necessary for the promotion, protection and sustainable management of environment in Tanzania. • Making rules providing for: (a) standard gradient for storm water drains to prevent water stagnation; (b) the periodic cleaning of storm water drains to remove deposits; and (c) covered storm water drains, inspection covers and appropriate trap chambers for inspection and removal of deposits.
	The Director of Water Resources	• Coordinate activities of Basin Water Boards; • Conduct national water resources management planning and an implementation strategy; • Oversee water basin planning and management; • Integrate inter-sectoral coordination and planning on aspects that may have impact on water resources; • Evaluate existing and proposed policies and activities of the Government ministries and agencies relating to the allocation, management and protection of water resources and, on the basis of that, formulate policies and programmes aiming at management and development of water resources and control of water pollution; • Ensure that water resource management operates according to the principles of environment sustainability; • Supervise and coordinate the activities of Basin Water Boards and serve as a link channel of communication between these bodies and the Government; • Resolve inter-sectoral and inter-basin conflicts; • Supervise and coordinate data collection and national water resources assessments; • Determine national investment priorities and financing patterns on water resources; • Coordinate and harmonize externally funded projects and programmes affecting water resources; • Facilitate the conduct of water audits and

Administrative level	Institution	Responsibility
		provide technical support in terms of information tools, basin models and decision support systems; • Recommend to the Minister legislative measures for the management of water resources and the effective control of water pollution; • Prepare annual reports on the state of water resources in the country; and • Ensure protection of water sources of national interest.
	National Water Board	• Examine any matter which may be referred to it by the Minister or any sector Ministry relating to sustainable management of water resources; • Advise on investment priorities and financing patterns and co-ordinate and harmonize externally funded projects and programmes affecting water resources; • Advise on integration of inter-sectoral water resources assessment and planning; • Advise on coordination of basin planning and management; • Advise on inter-sectoral or inter-basin conflicts; • Advise on investment priorities and financing patterns; • Advise on inter-basin water transfer; • Advise on trans-boundary water resources management; • Recommend to the Minister legislative measures for the management of water resources and the effective control of water pollution; • Liaise with the Director on technical matters; • Prepare the bi-annual report on the state of the water resources; and • Perform such other water resources advisory functions as the Minister may deem necessary.
Basin	Basin Water Board – Wami/Ruvu Basin Water Board	• Prepare basin water resources management plans, projects budgets and an implementation strategy; • Integrate district plans into basin water resources management plans; • Provide guidelines and standards for construction and maintenance of water source structures; • Monitor, evaluate and approve construction and maintenance of water source structures;

Administrative level	Institution	Responsibility
		• Collect, process and analyze data for water resources management; • Maintain and update assessments of the availability and potential demand for water resources; • Approve, issue and revoke water use and discharge permits; • Monitor and enforce water use and discharge permits and pollution prevention measures; • Resolve intra-basin conflicts; • Implement water resources management projects and programmes; • Coordinate the inter-sectoral water resources management at the basin level and serve as a channel of communication between these sectors and water users in general; • Advise the Director on technical aspects of trans-boundary water issues in the basin; • Appointment of Chairman and members of the Catchment and Sub-catchment Committees; • Prepare reports on the state of water resources in a basin.
Catchment and Sub-Catchment	Catchment and Sub-catchment Water Committees	• To coordinate and harmonize catchment or sub-catchment integrated water resources management plan; • To resolve water resources conflicts in the catchment or sub-catchment; and • To perform other delegated functions by the Basin Water Board.
Local Government	Local Government Authority – The City Council of Dodoma	• Build or prepare storm water drains; • Make the storm water drains clean for the purposes for which they have been made.

4.4. Local Government System in Tanzania

4.4.1. Legal Basis for Local Government

Constitutional Provisions

The constitution of the United Republic of Tanzania gives recognition to the establishment of local government institutions throughout the country. Article 145 of the constitution stipulates that parliament will enact a law elaborating the procedure for establishing LGAs as well as spelling out their functions, responsibilities and powers.

Main Legislative Texts

The Local Government (District Authorities) Act 1982 and the Local Government (Urban Authorities) Act 1982 provide for the establishment of rural and urban LGAs as district township authorities and village authorities. The Acts were amended in 1999 by the Local Government Laws (Miscellaneous Amendments) Act (No. 9) 1999. Other important legislation includes the Local Government Finances Act 1982; the Urban Authorities (Rating) Act 1983; the Local Authorities Elections Act 1979 and the Regional Administration Act 1997. The Local Government Services Act (No. 10 of 1982) as amended by Act No. 6 of 1999, to provide for decentralized human resource management, was repealed by the Public Services Act (No. 8) 2002.

4.4.2. Structure of Local Government

Local Government within the State

The 30 regions and 148 districts are administrative entities which are charged with maintaining law and order.

Ministerial Oversight

The President's Office – Regional Administration and Local Government (PO-RALG) is responsible for local government in mainland Tanzania and works. The main role of the minister and their department is to formulate broad national policies and to monitor local authorities to ensure that these policies are integrated into locally developed programmes. The department works in collaboration with sector ministries, which also formulate policies relating to areas such as education, health, roads, water and agriculture.

Council Structures

Below the level of local authorities there exist a number of democratic bodies to debate local development needs. In the rural system, the hamlets (*vitongoji*) comprise an elected chairperson who appoints a secretary and three further members, all of whom serve on an advisory committee. In urban areas the street (*mtaa)* is the smallest unit within an urban authority. The recently established street committees, unlike those of the hamlets, have a fully elected membership comprising a chairperson, six members and an executive officer. These committees provide a grassroots link to the ward structure, and mobilize participation of local people in local development. Priorities for local service delivery and development projects are discussed by the committees, before being forwarded to the ward development committee

(WDC). In the rural system proposals reach the WDC via the village council. WDC membership includes the elected ward councilor as chairperson, the ward executive officer (WEO), a salaried official with no voting rights, women councilors, all village chairpersons within the ward and all village executive officers (VEOs). The WDC coordinates development plans and social service plans, supervises project implementation and service delivery activities, and is an intermediary for discussing initiatives arising from the sub-ward levels and development plans from the higher tier local authorities.

4.4.3. Organized Local Government

The Association of Local Authorities of Tanzania (ALAT) represents local government on the mainland of Tanzania. It is a voluntary organization with a membership of 133 urban and district councils. Its functions are: to provide a forum for exchanging views and experiences among member LGAs; to provide advocacy on policy and legislative matters likely to affect LGAs; to disseminate information and provide expert advice; to make representations and proposals to government; and to represent LGAs and their views in international forums.

4.4.4. Intergovernmental Relations

Intergovernmental relations are formally structured under the amended local government legislation and the Regional Administration Act 1997. The regional secretariats have a pivotal role, facilitating links with the centre and carrying out their enabling function at regional, district and divisional levels. The Regional Administration Act 1997 also established regional and district consultative committees for each region and district. These committees must provide advice to LGAs regarding their development plans and monitor and ensure coordination of the overall economic development of the region. Each committee consists of the regional commissioners and district commissioners of all districts within the region, all chairpersons/mayors of district and urban authorities, all directors of urban and district authorities, and members of Parliament (MPs) of constituencies within the region. ALAT has a formal role for collective bargaining and dispute resolution in the local government service. National government ministries issue guidelines which should be used by LGAs in the implementation of national policies.

Decisions made by LGAs should not be at variance with national policies. At the regional level there are national government offices which serve as extended arms of national government. These 24 regional offices coordinate and provide advice and technical support to help LGAs discharge their duties to the required standard. The regional offices have a duty to create an enabling environment for LGAs to provide services and bring about development at the local level. There is a regional consultative committee in every region chaired by the regional commissioner and drawing members from the districts, including council chairpersons, district commissioners, MPs and the chief executives of the councils in the region. The functions of regional consultative committees, which are established by law, include considering and providing advice to LGAs regarding development plans. ALAT, whose membership includes an MP from each region, will be involved whenever there is a policy issue that relates to local government, before a decision is made at cabinet level. This is normally done through workshops and working sessions organized by PO-RALG, and representatives of ALAT are invited. Policy recommendations are sometimes discussed at meetings of the executive committee of ALAT and later at the annual conference where all LGAs are represented. There are also three parliamentary committees which handle issues of direct consequence to LGAs; the Legal and Administrative Committee, the Local Authorities Accounts Committee and the Parliamentary By-laws Committee.

4.4.5. Systems for Community Involvement

- **Legal Requirement**

Amendments to the Local Government (District Authorities) Act 1982 provide for councils to organize public hearings for people to question political leaders and staff. Councils are also empowered to establish service boards, open to all citizens in the area, providing an opportunity to influence service provision. Participatory budget-making is encouraged and enabled by bottom-up budgeting through the WDCs and the democratic structures above them. Local authorities are now required to promote and ensure democratic participation.

- **Implementation**

Through the participatory planning methodology known as ‘opportunities and obstacles to development’ (O&OD), communities kick-start the process of planning. During the O&OD process the needs of various social groups are taken into consideration. Whenever a council plans to implement a specific project it must organize a public hearing where the benefits of the project and how it will be implemented are explained and the public are encouraged to provide their views.

4.4.6. Overview of Local Government Service Delivery Responsibility

Each LGA is responsible in its area of jurisdiction for the maintenance and facilitation of peace, order and good government; for the promotion of the social welfare and economic wellbeing of the people; and for the furtherance of social and economic development. LGAs are allowed to cooperate with other organizations and agencies in providing the following services: suppression of crime, maintenance of peace and good order and protection of lawfully acquired public and private property; control and improvement of agriculture, trade, commerce and industry; the furtherance and enhancement of health, education and social, cultural and recreational life; the relief of poverty and distress as well as assistance and amelioration of life for the young, the aged and the disabled or infirm; and the development, mobilization and application of productive forces to the war against poverty, disease and ignorance. The basic functions of district and urban authorities, within their jurisdictions, are to maintain law, order and good governance, to promote the economic and social welfare of the people and to ensure effective and equitable delivery of services to all. Additionally they must formulate, coordinate and supervise the implementation of plans for economic, social and industrial development in their areas, monitor and control the performance of the council and its staff, collect and ensure the proper use of council revenues, make by-laws, and (in district LGAs) approve by-laws made by village councils. District councils also regulate and coordinate the development plans, projects and programmes of villages and township authorities within their areas.

4.5. Local Government Authorities in Dodoma City

4.5.1. The City Council of Dodoma

Dodoma has historically had two governance structures – the Capital Development Authority (CDA) and Dodoma Municipal Council – however, the CDA was subsequently dissolved by presidential executive decree on May 15, 2017. The Capital Development Authority (CDA) was formed in 1973 when the Local Government System was abolished. It was required to plan and develop the capital, assist in the transfer of various government offices to Dodoma, and acquire and hold land any other immovable property. By the time the Local Government (District Authorities) Act of 1982 and the Local Government (Urban Authorities) Act of 1982 were enacted, powers of the Dodoma Municipal Council were reinstated and the Council became responsible for undertaking participatory urban planning and supporting activities for capital city development. Dissolution of the CDA came as a response to do away with the confusion of having two government entities responsible for infrastructure and service provision. Thus, the current President has ordered the complete transfer of activities and properties to the Dodoma Municipal Council. Nevertheless, the CDA was a critical institution during the first 44 years of Dodoma's existence as Tanzania’s capital city.

And, after the administrative arrangement, the Dodoma Municipal Council was elevated from a municipality to city status as the City Council of Dodoma in 2018.

Other institutions involved in developing the capital city represent various sectoral interests. These are the Tanzania National Roads Agency, Tanzania Rural and Urban Roads Agency, Tanzania Electric Supply Corporation, Dodoma Water Supply Authority and Tanzania Telecommunication Company Limited, etc.

4.5.2. Dodoma Urban Water Supply and Sewerage Authority (DUWASA)

DUWASA was established under section 3(I) of Cap.272 of 1997 as repealed by section 60 of Water Supply and Sanitation Act No. 12 of 2009. And, the Water Act No. 12 of 2009 has repealed in 2019 and replaced by the Water and Sanitation Act No.5 of 2019.

Before DUWASA water supply and sanitation issues were managed by the district council under the District water Engineer. All the responsibility of water supply in central parts and peripherals of Dodoma City are expected to be taken by this authority. DUWASA is a fully autonomous entity that is legally responsible for urban water supply and sewerage services in Dodoma City. It has the following roles and responsibility:

- Plans, develops and maintains the water and sewerage network;
- Sets water and sewage disposal tariffs;
- Promotes public education on public health aspects of water supply and waste water disposal;
- Plans and implements medium and long term financial and investment plan related to water supply and sewerage services; and
- Provides quality service to the customers.

Its operation is governed by the following regulations Water Supply and Sanitation Act (2019), finance Act (2001) public Procurement Act (2004), EWURA Act (CAP 414) and Memorandum of Understanding between Ministry of Water and Irrigation and DUWASA.

And, DUWASA has a plan on water and sewage disposal tariffs as following table:

Table 12. Current and Approved Water Prices (Shilling / Cubic meters)

Customer group	Uses	Current water price (Tshs)	Approved water price	
		2017/18	2018/19	2019/20
Domestic	0-5 6-10 11-30 >30	1,045 1,110 1,190 1,230	1,160 1,225 1,245 1,295	1,170 1,250 1,260 1,300
Institutional		1,465	1,610	1,620
Commercial		1,465	1,630	1,660
Public Point		1,035	1,195	1,200
Whole Customers		3,519	1,800	1,800
Industrial			1,630	1,600
Average Price		1,288	1,383	1,397

Table 13. Current and Approved Fee for Clean Water / Wastewater Connection (Tsh/Connection)

Customer group	Current Fee	Approved Fee	
	2017/18	2018/19	2019/20
Domestic	20% of the Connection costs	20 percent of the connection costs as set out in Section 24 of the 2013 Water Regulations	
Institutional			
Commercial			

Table 14. Current and Approved Fee for Restoration of Water Services After Disconnection (Tsh / Restoration Services)

Customer group	Current Fee	Approved Fee	
	2017/18	2018/19	2019/20
Domestic	20,000	15,000	15,000
Institutional	50,000	15,000	15,000
Commercial	50,000	15,000	15,000
Public Point	20,000	15,000	15,000

Table 15. Current Prices and Approved Prices for Wastewater (Tsh/Month)

Customer group	Current Fee	Approved Fee	
	2017/18	2018/19	2019/20
Domestic	40 percent of clean water costs	40 percent of clean water costs	
Institutional			
Commercial			

Table 16. Current and Approved Fee for Wastewater from Customers who do not have Dodoma Water Services (Tsh/month)

Customer group	Current Fee	Approved Fee	
	2017/18	2018/19	2019/20
Domestic	NA	40 percent of clean water costs (derived from the client's vision)	
Non- Domestic	NA		

Table 17. Current and Approved Fee for Wastewater Trucks (Tsh/Cubic metre)

Wastewater Sources	Current Fee	Approved Fee	
	2017/18	2018/19	2019/20
Domestic	40,000	60,000	60,000
Non- Domestic	50,000	75,000	75,000

Table 18. Current and Accredited Prices for Wastewater in Ponds (Tsh/Meter Cubic)

Customer group	Current Fee (Tshs/truck)	Approved Fee	
	2017/18	2018/19	2019/20
Truck	3,000	1,000	1,000

Table 19. Curent and Approved Prices for Consumers of Water for More than a month (Tsh/month)

Customer group	Current Fee	Approved Prices	
	2017/18	2018/19	2019/20
Domestic	NA	40% of the average water price for the past three months before the water was cut	
Institutional	NA		
Commercial	NA		

Table 20. Current and Accredited Prices for Service (Shilling per month)

Customer group	Current Fee	Approved Fee	
	2017/18	2018/19	2019/20
Domestic	3,000	Fee not Allowed	
Institutional	5,000		
Commercial	5,000		
Worship houses	3,000		

Table 21. Performance Indicators (2018/19-2019/20)(is made under paragraph 4(a))

Description	Units	Performance Objective	
		2018/19	2019/20
Number of people in the network of sanitation	%	80	82
Water loss Amount	%	27	26
Scope of Wastewater Network	%	13	14
Effectiveness of revenue collection (without debt)	%	81	90

5. Institutional Issues and Constraints

The existing institutions responsible for drainage and sanitation development in Tanzania are characterized by inadequate establishments and weak data base; low skills and awareness of the roles and responsibilities of the stakeholders; inadequate financing; weak enforcement of by-laws; inadequate equipment, facilities and number of qualified staff and absence of legal framework. Linkages between relevant institutions are weak and their respective roles and responsibilities are not clearly defined to develop the drainage and sanitation plan effectively. Hence the government authorities under the ministry in charge of drainage and sanitation development are advised to define clearly related legal framework, create awareness on policies and legislative issues as well as facilitation of linkages between relevant institutions for the drainage and sanitation sector.

III. Urban Development

1. Previous City Master Plans

1.1. Dodoma Master Plan – 1976

Project Planning Associates of Toronto teamed up with local experts in preparing the Dodoma Master Plan. The scene was set for the beginning of intensive work that included technical studies, examination of existing facilities, surveys and mapping. The master plan was approved by President Nyerere in July 1976, two and half years later.

The planners initially surveyed three possible sites for the capital before selecting Dodoma town. It already had some infrastructure like housing, office buildings, commercial, health and educational facilities. The town was also a centre of communication with main national roads. The central railway line and the telecommunication network further contributed to the selection of this site and offered a useful starting point for the construction of the new capital. Selection of an empty site would have been much more expensive. In addition, Dodoma and the surrounding areas give plenty of scope for planned expansion and topography suitable for attractive development.

The 1976 plan defined a linear urban growth system arranged in tiers of communities, with decentralised employment and organised around bus way/bikeway system (see Fig. 5). The new capital was presented as a series of residential communities dispersed about an urban core containing the existing town, the future National Capital Centre and various other functions. A new system of arterial roads and a right-of-way for buses linked the various areas using a pattern of ‘elongated loops’. The network of public utilities proposed for the city was integrated with this system.

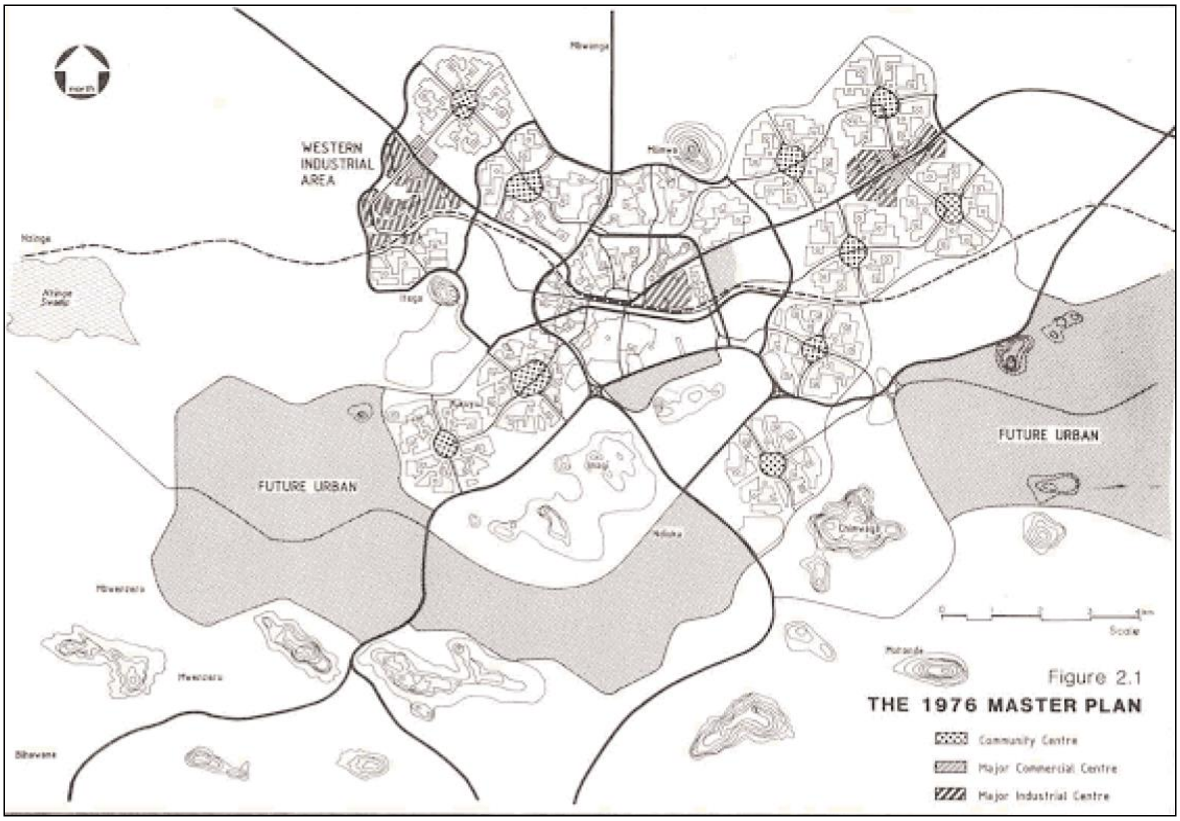

Fig. 5 Dodoma Master Plan – 1976

The main concepts of the 1976 plan included:

- A hierarchy of service centres with shopping, places of worship and recreation.
- Public transport based on buses, cycleways and pedestrian paths.
- Mixed income residential communities, conforming to Tanzania’s policy of socialism and self-reliance.
- Low rise buildings.
- A garden city – each community of 25,000 was to be circled by a green belt to serve as boundaries between communities also to be used for small scale farming by residents of the area. The capital city was to be surrounded by an afforestation belt of 22,000 hectares.
- Regional Development - the principal towns of the adjacent districts were to be expanded and developed as growth centres.
- Urban renewal of the old town.

The strengths of the 1976 master plan included a logical framework (see Fig. 6), clear objectives, attention to detail, concern for regional and intra-regional aspects and design and siting recommendations. The plan drew heavily on overseas models and experiences but there were attempts to integrate Tanzanian political and cultural aspirations into the detailed design of urban areas. Its modest government buildings and focus on the needs of the residents reflected the political philosophy of the governing party.

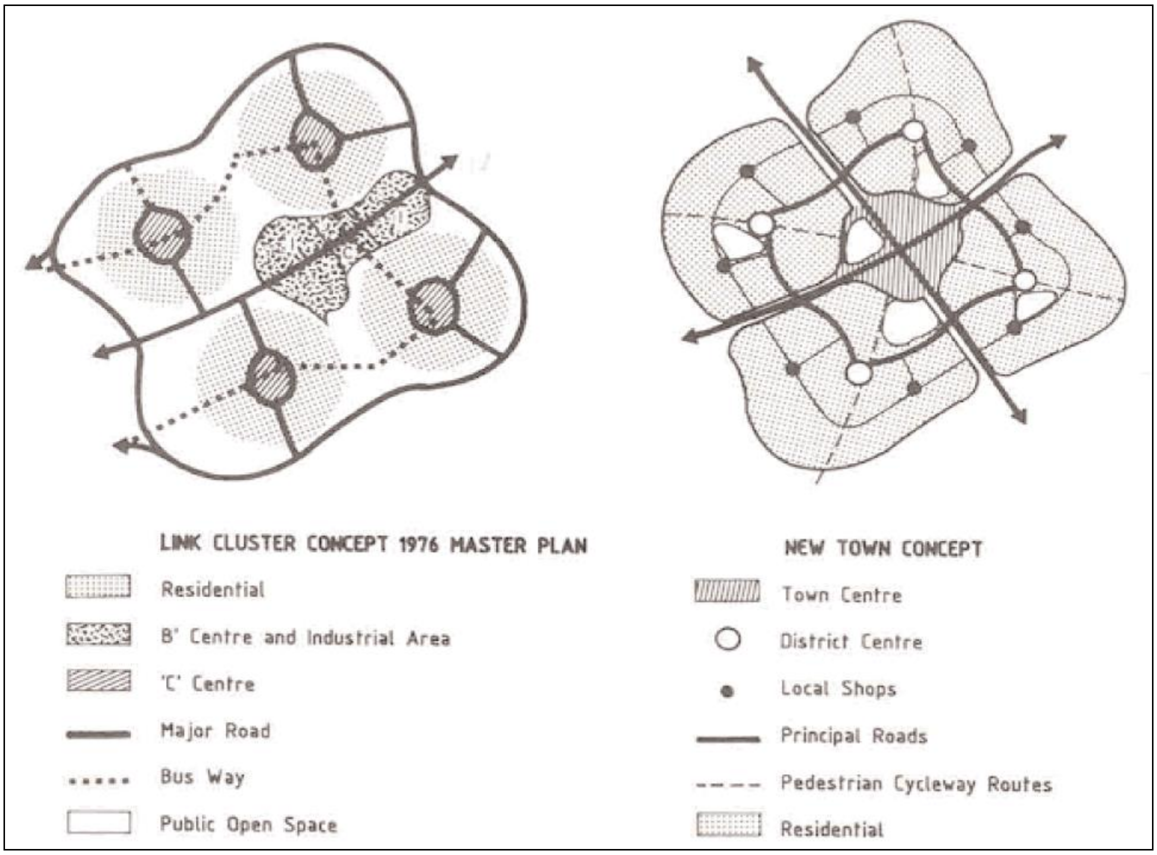

Fig. 6 Urban Concept of Dodoma Master Plan – 1976

However, the 1976 plan had many weaknesses. It spelled out what was required; but did not describe how to achieve or finance it. Similarly, on the resource side, the plan indicated that the estimated cost for the first year's building programme was T.Shs 370 million. This was reduced by decision of government to approximately T.Shs 100 million. There was no mechanism within the plan to make adjustments for substantial cuts in funds and resources. The plan's other weaknesses included:

- Consumption of land and resources.
- Failure to adequately address water supply.
- High-tech solutions to low-tech problems, especially for utilities.
- Impact of city growth on regional ecology.
- Ignoring traditional urban forms.

- Unrealistic staging proposals.
- Weak implementation agencies, which are addressed below.
- Inflexible physical design in the neighborhood units and hierarchy of activity centres.
- Insufficient attention to informal housing and urban fringe lands.

The plan had an unrealistic transfer program for government departments. The government proposed to transfer seven ministries between 1975 and 1980. The programme paid little cognisance to the lead-time for the construction of facilities and infrastructure. Other national capitals found that it takes 15-20 years to transfer all departments –sometimes longer- and enormous infrastructure investment is required to precede the move of the first ministries. That investment was not forthcoming in Dodoma and the transfer programme should have been adjusted. The 1976 master plan report was most successful in its presentation of a vision for the capital as it might be in the future. The plan presented a confident picture of staged growth for Dodoma from the 1975 population of 45,000 up to 350,000 at the year 2000. Beyond that time, the plan made provision for further growth towards a population of 1 million. In fact, the population grew to 45,800 in 1978; 83,200 in 1988 and an estimated population of 320,540 people in 2003. So, Dodoma's population increased without adequate infrastructure or the planned transfer of the government.

1.2. Strategic Planning - 1988

Poor progress in implementing the 1976 Master plan led to a review and revised plan, which took into account the new economic realities in Tanzania. The 1988 plan prepared by Cameron McNamara of Brisbane, Australia, used the strengths of the 1976 plan and learnt from its weaknesses to produce a better plan.

The 1988 review proposed an alternative urban concept, which could fit better with culture, the economics of development and the physical terrain surrounding Dodoma. This was the creation of new towns of between 90,000 to 120,000 people instead of the organic growth concept of the 1976 plan. The new town concept has the advantages of:

- Reducing infrastructure and development costs.
- A much larger population that can support a more diversified and larger employment,
- commercial and services base.
- A major centre which forms a central place.

- Creating a choice of settlement areas in Dodoma.
- Avoiding a monotonous linear expansion of communities.
- Recognised a high proportion of people that can only afford to walk or cycle to work.

Each new town would be finished before the next one was developed. The 1988 plan proposed that each new town constructed in the outlying valleys, would help to establish a physical identity for each new town, similar to the strategy for expanding Canberra. The plan provides for a future population of 500,000 to 600,000 people, but there would be further land available for the development of additional new towns should the need arise in the future.

The plan also adjusted the service centres and road network, and deleted the busways. It added low cost housing programmes with sites and services projects. The plan suggested that CDA prepare a five-year programme of national capital urban design projects to improve the capital image.

The government scaled back the number of ministries to be transferred until the mid 1990s, leaving most in Dar es Salaam. This transfer programme was to be coordinated with the construction of offices, houses, energy supply, water, and telecommunications.

1.3. Dodoma Master Plan - 2010

The master plan covering the period from 2010-2030 was prepared by SAMAN Corporation of the Republic of Korea and Tanzania Human Settlement Solutions (Tanzania). They conducted the review of the Dodoma Capital City Master Plan 1976 and generated what came to be known as “The National Capital City Master Plan 2010” together with 5 technical supplements detailing various aspects of city development targeting a horizon of year 2030 with a projected population of 2.5 million inhabitants.

This plan contains the basis for detail planning on the future land use plan of the Capital City District, policies and guidelines for the development control, implementation and action plan on the capital transfer programme. The Dodoma Capital City Master Plan 2010 consists of five chapters as follows:

- **Chapter 1: Introduction**

The first chapter of the Main Report describes the project background, TOR, goals and objectives, work scope, methodology and work program for carrying out the assignment including the structure of the final report.

- **Chapter 2: Existing Site Condition and Assessment**

This chapter describes current site physical developments in relation to the 1976 Master Plan and the 1988 Master Plan review. It also gives information on data collected, reviewed and analyzed including projections for land requirements for the National Capital City based on both studies and targeted population. The studies analyzed give policy directions that will be used for planning purposes.

- **Chapter 3: The Foundation for the Master plan 2010**

Chapter three outlines the basic Master Plan concept by describing and defining the goal(s) and vision for the reviewed Master Plan. It also looks into the basic land use plans, urban structure and community framework for the capital city.

- **Chapter 4: The DODOMA National Capital City Master Plan 2010**

- The Land Use Plan and Development Guidelines.

The chapter also describes the general and specific land use development policies and guidelines including the implementation staging of the new Master Plan. It also describes all land use zones as categorized in the revised Master Plan.

The chapter also briefly provides the recommended government administrative city location and plan at Mtumba, its main functions and procedures for a detailed design of the city which will enable its development.

- Transport and Traffic Plan

This chapter describes the Transportation Plan Systems that will ensure all areas are served by well-functioning movement systems, i.e. roads, trams, railways, air transport including all transportation corridors and terminals.

- Open Space Systems Plan.

The chapter provides an over view of the open space systems in the New National Capital City Master Plan. It elaborates on their hierarchy and connections to the main transportation corridors, land use categories; their functions including recreation, green belt, conservation and general landscaping.

- Infrastructure Development Plan.

Chapter six outlines and gives the general policies and development guidelines for servicing the city in terms of infrastructure services i.e. water supply, storm water management system, sewerage management system, solid waste management plans, energy supply.

Chapter 5: Implementation of the Master Plan 2010

This chapter describes the completion of the development of the National Capital City, costs and phasing plan. It also includes development process, methods and cost estimates for Phase One development.

Especially, the Technical Supplement (TS) 3 addresses an Infrastructure Plan which included public water (drinking water), sanitary sewer (wastewater), and storm water drainage (rain water) but also had other types of facilities, such as roads, electric power supply and Information Communication Technology (ICT) system. It adopted the proposal of constructing the wastewater treatment plant at Nzuguni one and proposed the second wastewater treatment plant on the eastern side of the proposed Msalato airport. And, the treated wastewaters were recommended to be reused. The Master Plan proposed the sewage management and storm water drainage management plans for the Dodoma city as shown in the below figures.

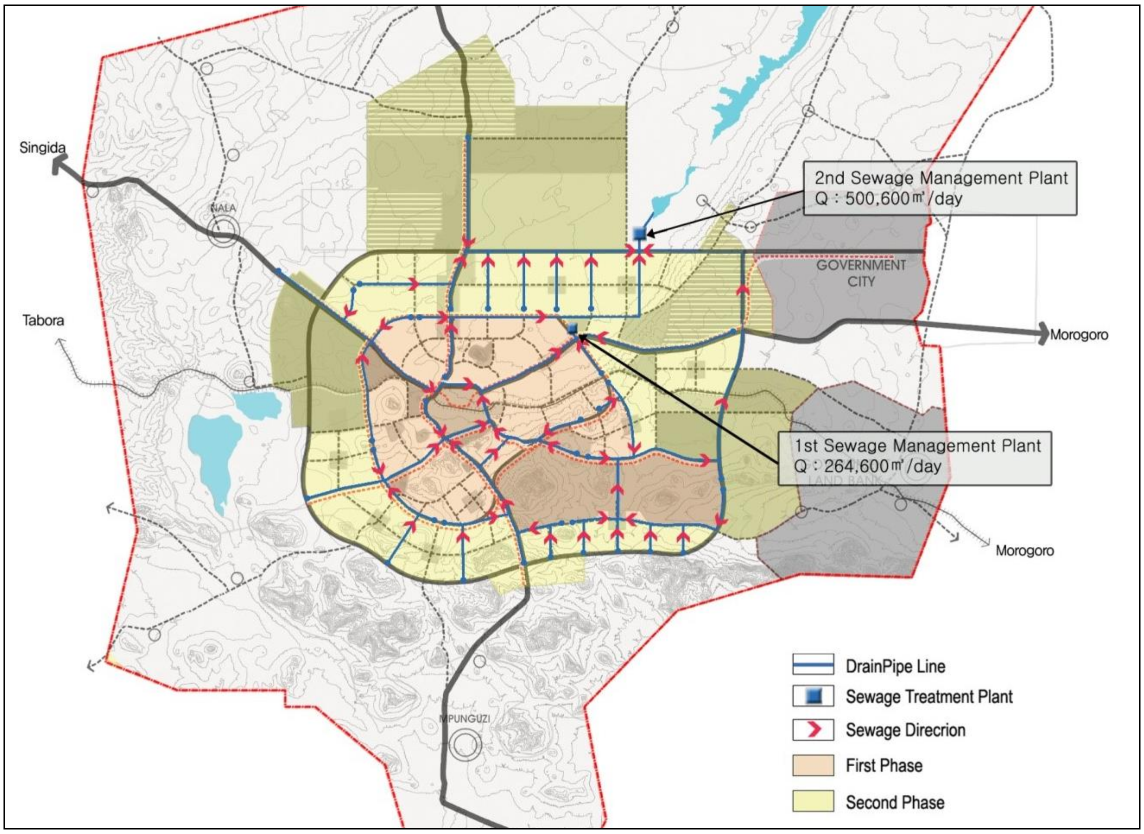

Fig. 7 Sewerage Management Plan Proposed by Dodoma Master Plan – 2010

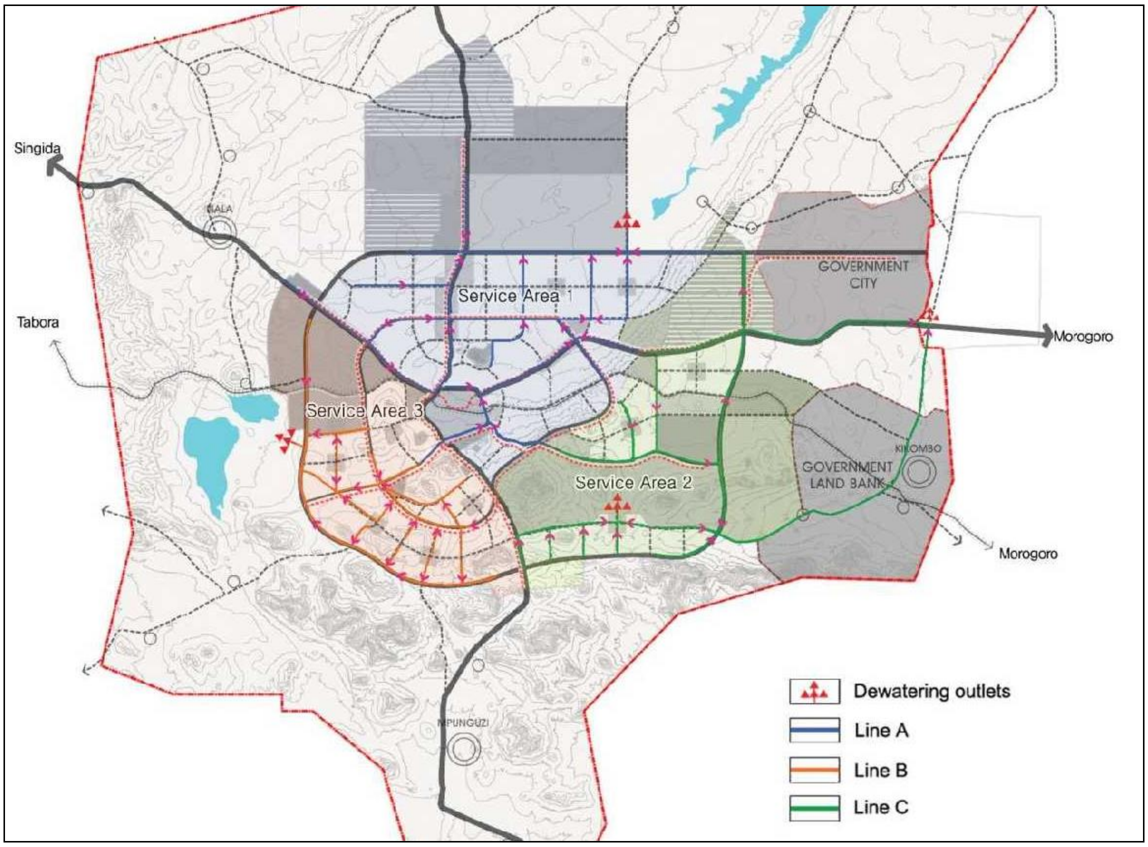

Fig. 8 Storm Water Drainage Management Plan Proposed by Dodoma Master Plan – 2010

2. Land Use Plan

According to the City Master Plan of 2019, it recommended land use development to take place largely within the confines of the outer ring road. Further development should take place along the Hombolo corridor, Singida road, Iringa road and along Bihawana road.

The total area is 261,529.96 hectares. Areas of each land use categories are as shown in the Table 22 and the Fig. 9 shows the proposed land use plan of Dodoma city.

Table 22. Capital City District Land Use Plan

S/No	Land use category	Area (Ha)	% of Total Area
1	Residential	34,072.97	13.03
2	Commercial and CBD	887.15	0.34
3	Institutional	34,460.14	13.18
4	Industrial	333.34	0.13
5	Nature reserve and recreation	47,775.68	18.27
6	Scattered settlements and farming	20,4240.9	35.95
7	Mzakwe water source field	34,505.74	13.19
8	Catchment area for well fields	6,411.26	2.45
9	Dry Port	536.37	0.21

S/No	Land use category	Area (Ha)	% of Total Area
10	Marshalling Yard	499.68	0.19
11	Airport	4,429.68	1.69
12	Government City	742.17	0.28
13	Water bodies	2,868.29	1.10
Total		**261,529.96**	**100.00**

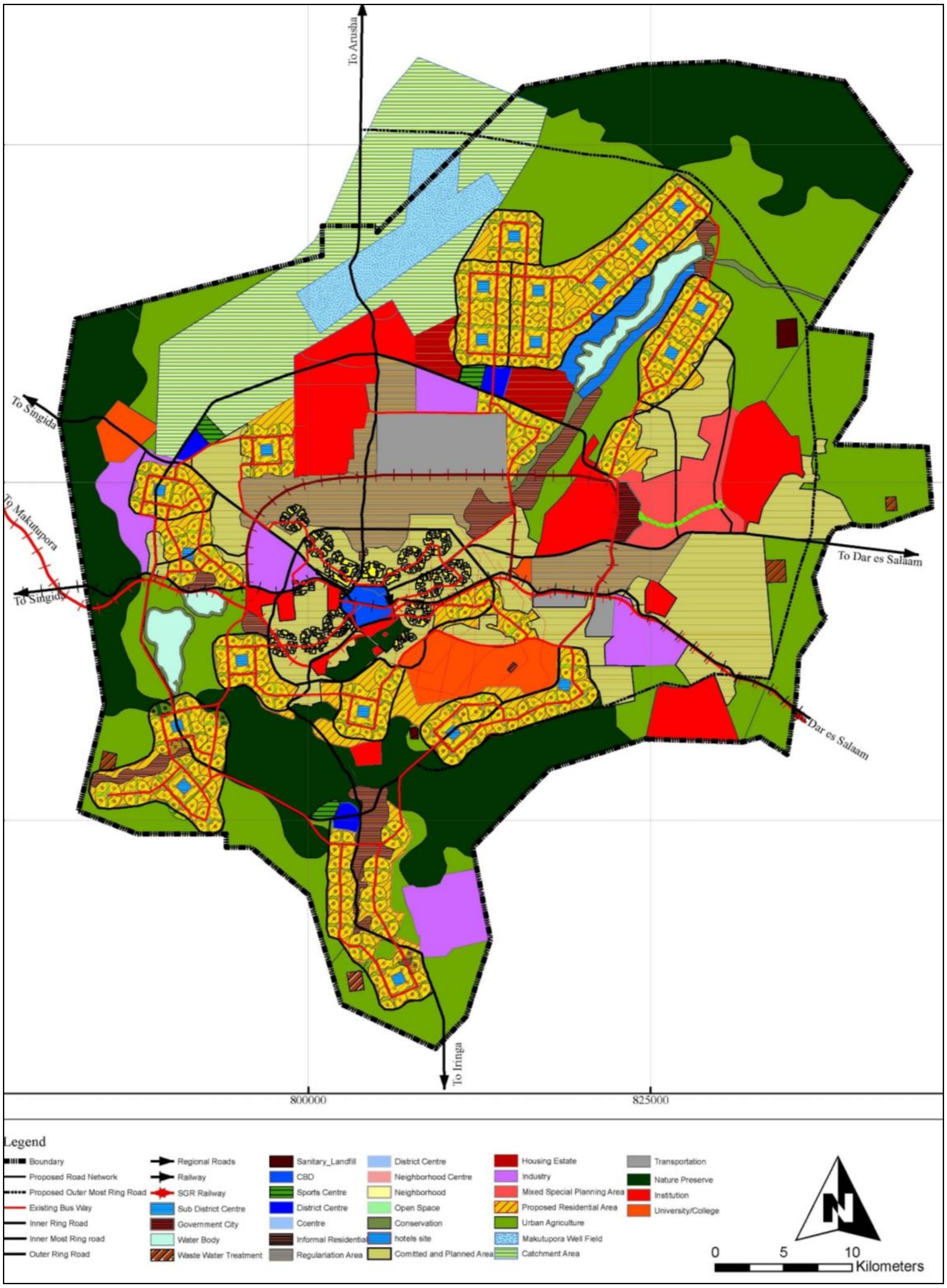

Fig. 9 Proposed Land Use Plan of Dodoma city

3. Population Projection

Dodoma city is the national capital of the United Republic of Tanzania and the capital of Dodoma Region, with a population of 410,956 which is from the 2012 National Census. Dodoma city is one of the fast-growing cities in Tanzania following the shift of the national capital from Dar es Salaam.

According to the Master Plan for a period of 2019 to 2039, the population of Dodoma city as of 2019 is presented at 579,591 and the future population was projected by the below equation.

$$P_t = P_o(1+r)^t \quad \text{(2.1)}$$

Where,

P_t: Projected population after t years

P_o: Present population

r : Rate of growth

t : Number of years over which growth is to be measured

The annual growth rate (r) of 5.5 percent has been adopted in the Master Plan, which was reported in the 2012 Population census. With this annual population growth rate, the population of Dodoma, including the 3 wards to be belonging to Dodoma city, is predicted to be 1,884,473 in the 2040. The distribution of the projected population by in wards is as detailed in the Table 23.

Table 23. Projected Population of Dodoma City by 2040

S/N	Ward	Po	r (%)	t	$Pt=Po(1+r)^t$
1	Viwandani	6,880	5.5	21	21,178
2	Uhuru	3,408	5.5	21	10,491
3	Chamwino	27,015	5.5	21	83,158
4	Kiwanja cha Ndege	14,271	5.5	21	43,929
5	Makole	14,799	5.5	21	45,555
6	Miyuji	21,084	5.5	21	64,901
7	Msalato	9,465	5.5	21	29,135
8	Makutupora	20,330	5.5	21	62,581
9	Chihanga	15,503	5.5	21	47,722
10	Hombolo Bwawani	14,640	5.5	21	45,065
11	Hombolo Makulu	17,000	5.5	21	52,330

S/N	Ward	Po	r (%)	t	$Pt=Po(1+r)^t$
12	Ipala	8,490	5.5	21	26,134
13	Nzuguni	21,790	5.5	21	67,075
14	Dodoma Makulu	24,088	5.5	21	74,149
15	Mtumba	12,465	5.5	21	38,370
16	Ihumwa	12,464	5.5	21	38,367
17	Kikombo	11,754	5.5	21	36,182
18	Ng'hong'honha	13,435	5.5	21	41,356
19	Matumbulu	10,950	5.5	21	33,707
20	Mpunguzi	14,256	5.5	21	43,883
21	Tambukareli	9,276	5.5	21	28,554
22	Kilimani	9,117	5.5	21	28,064
23	Kikuyu Kusini	8,417	5.5	21	25,909
24	Kikuyu Kaskazini	13,880	5.5	21	42,726
25	Mkonze	17,632	5.5	21	54,275
26	Mbabala	16,767	5.5	21	51,613
27	Zuzu	9,137	5.5	21	28,126
28	Hazina	13,441	5.5	21	41,375
29	Madukani	3,411	5.5	21	10,500
30	Majengo	7,346	5.5	21	22,613
31	Nkuhungu	24,005	5.5	21	73,893
32	Kizota	24,535	5.5	21	75,524
33	Nala	7,843	5.5	21	24,143
34	Mbalawala	12,440	5.5	21	38,293
35	Ntyuka	6,422	5.5	21	19,768
36	Chigongwe	10,258	5.5	21	31,577
37	Chang'ombe	35,807	5.5	21	110,222
38	Iyumbu	3,804	5.5	21	11,710
39	Chahwa	6,150	5.5	21	18,931
40	Mnadani	20,250	5.5	21	62,334
41	Ipagala	25,566	5.5	21	78,698
42	Msanga	11,895	5.5	21	36,616
43	Chamwino Ikulu	10,486	5.5	21	32,278
44	Buigiri	10,221	5.5	21	31,463
Total		**612,193**			**1,884,473**

4. Areas Served by Water Supply and Sewerage System

4.1. Areas Served by Water Supply

The main source of water supply in Dodoma city is the Makutupora (Mzakwe) well field located about 27 kilometres north of Dodoma City along the Arusha road. There are 24 Boreholes in this well field. Out of the 24 boreholes, 15 are designated for water production in which 10 boreholes are operational and 3 boreholes are on standby basis. Two boreholes are not installed with pumps. At present the operational boreholes have production capacity of 61,560 m^3/day.

Water is pumped from the boreholes in Makutupora well fields to the two reservoirs with 680m^3 and 800m^3 storage capacities. In these two tanks water is disinfected using Calcium hypochlorite the only treatment done for water from Mzakwe well fields. From these tanks water is pumped to either booster stations or to the distribution tank from where it is supplied to the customers. Dodoma water supply to a large extent is distributed by gravity; however, some areas are supplied by pumping directly from the booster stations. The pipe networks comprise of pipes ranging from 600mm to 50mm diameters covering a total length of about 306.6 kilometres.

Based on the existing water sources and the distribution system, among the 41 wards, only 21 wards are supplied with water from Mzakwe well field as shown in Fig. 10. The distribution in these wards is at different levels of demand. The actual water demand for Dodoma city by 2018 is 104,023.9 m^3/day. Hence there is a deficit of 34,000 m^3/day. The 20 wards remaining are not supplied with water from DUWASA but rather, the use water from wells.

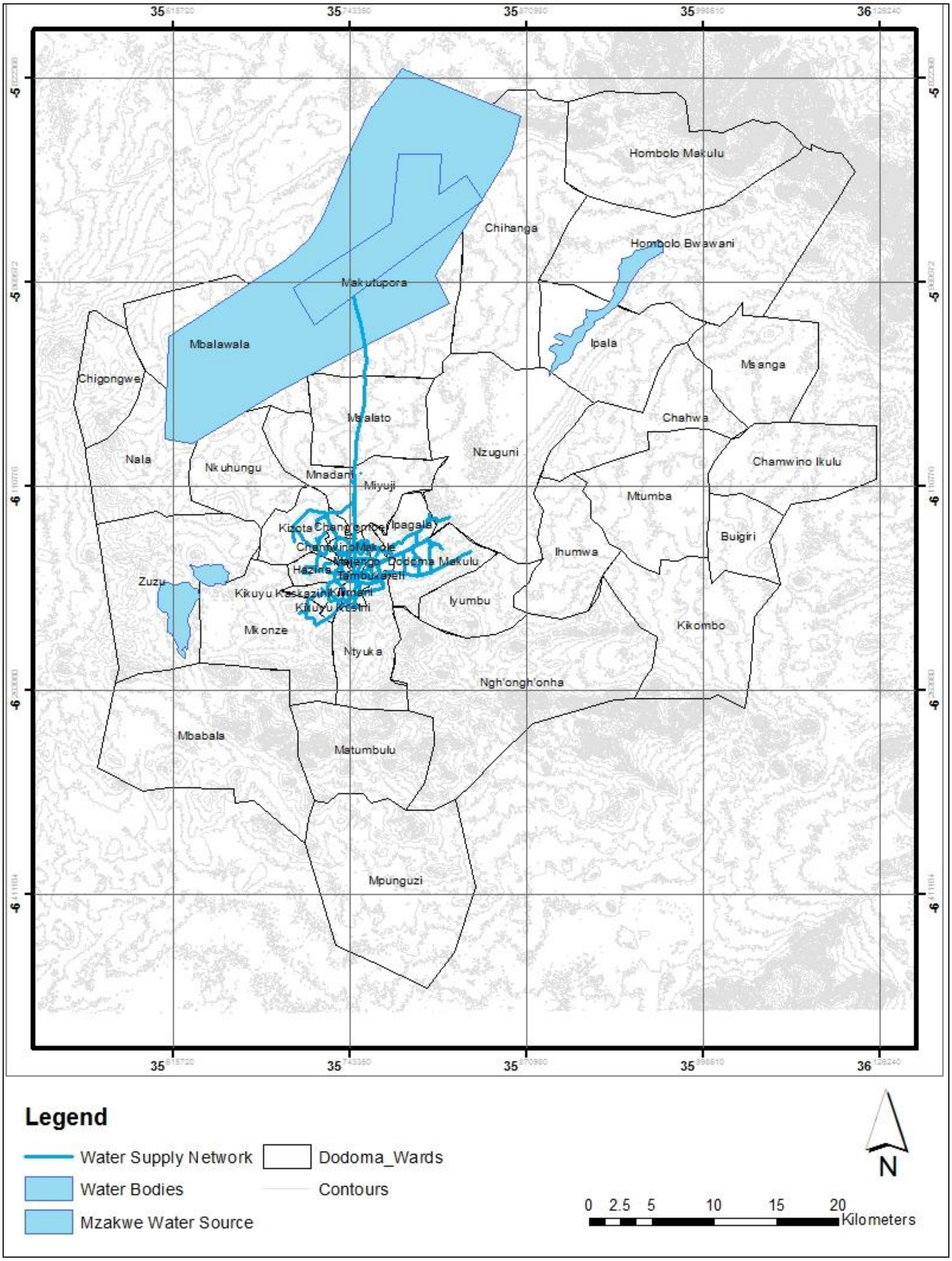

Fig. 10 Areas Served by Water Supply

4.2. Areas Served by Sewerage System

Based on information from DUWASA, site visit and household interviews conducted, the present situation on sewerage and sewage disposal can be summarized as follows. The onsite sanitation system serves 94 percent of the total population of Dodoma City. These systems comprise of septic tanks with their associated soak away pit and pit latrines. Only the town centre wards are the once connected to the sewer system. The sewer line has a total of 24.3 kilometres of the trunk main, with the maximum diameter of 1,000mm, and this trunk sewer was designed to serve 423,000 people.

The wards where the trunk mains were installed include Kizota, Kikuyu North, Kikuyu South, Hazina, Chamwino, Tambukareli, Kiwanja cha Ndege, Madukani, Uhuru, Kilimani, Majengo, Viwandani. Among them, however, currently only four (4) areas are served with a comprehensive reticulation sewers network namely: Mlimwa West (Area C), Mlimwa East (Area D), Central Business Park (CBP) and Hazina, representing about 6% of the population of Dodoma City. And these areas are highlighted in yellow color as shown in Fig. 11.

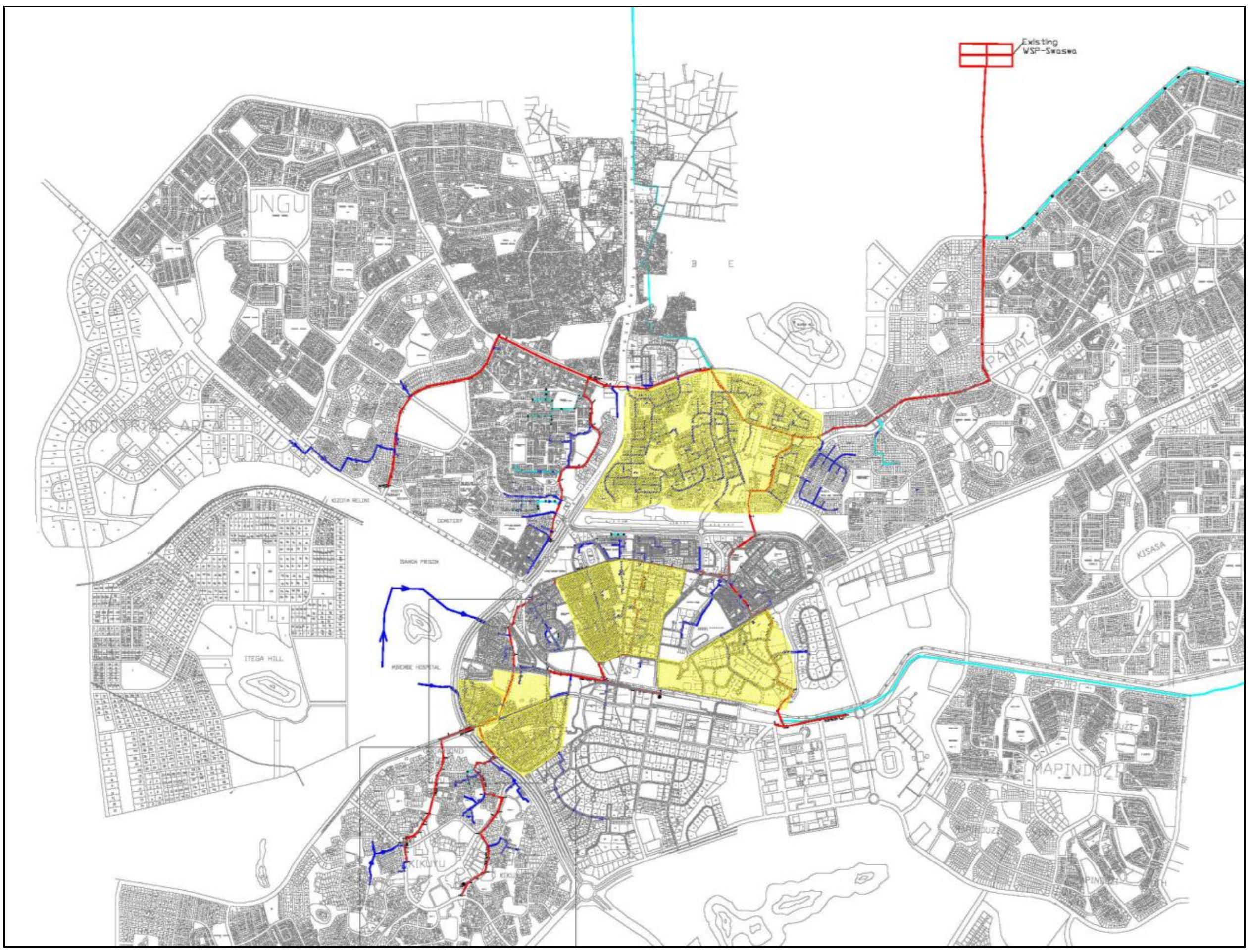

Fig. 11 Areas Served by Sewerage System

5. Socio-Economic Characteristics

5.1. Economic Activities

The main source of livelihood for Dodoma is Agriculture and Livestock keeping accounting for about 75% of the people's income. Major food crops include: maize, sorghum, cassava and millet which are drought tolerant crops while cash crops grown include groundnuts, grapes, simsim, sunflower, tomatoes, water lemon and rosella. Forestry and beekeeping products provide for some family earnings in areas where such activities are practiced.

About 25% of the population in the City is employed in petty business, small and medium scale industries, consultancy, construction works, transportation, and in social and administrative services. Main industrial products include mattresses, furniture and mineral water. Others include honey, wax and herbs from the forests. Per capital income is estimated to be TZS 470,000/= in general.

5.1.1. Agriculture

Dodoma City Council, as most of the areas in Tanzania depend highly on rain fed agriculture, impacted with climate change, low soil fertility due to wind and water erosion, non-adherence to proper crop husbandry practices, lack of access to credits by many farmers, use of low yielding local seed varieties and low use of farmyard manure and industrial fertilizers which hinder good food crop production.

About 71% (196,000 hectares) of the total area (276,900 hectares) is suitable for agricultural production. The estimated area for food crop production is 107,249 hectares and about 49,304 hectares are for cash crops production. The rest of the land is subdivided into grazing land (39,447 hectares), forest reserves (30,046 hectares), open land (11,362 hectares) and urban area covers 39,492 Hectares.

The city receives rainfall from November to April during which the cropping season takes place. With good rains, surplus millet and sorghum is produced and sold to other regions, providing a good economic ground for Dodoma City Farmers. There has been a fluctuation in estimated production in tons of major food cash and crops from 2012 to 2016 as indicated in the tables below.

Table 24. Estimated Production in Tons of Major Food Crops

Crops	2012	2013	2,014	2,015	2,016
Maize	4,912	9,617	4,388	5,509	4,406

Crops	2012	2013	2,014	2,015	2,016
B/Millet	19,537	26,333	32,287	38,335	21,753
Sorghum	7,792	9,576	8,700	9,257	6,274
Cassava	6,440	12,911	10,220	17,210	17,498
Bambaranuts	3,363	2,314	3,526	4,010	3,785
Others		13	16	14	18
Total	**42,044**	**60,764**	**59,137**	**74,335**	**53,734**

Table 25. Estimated Production in Tons of Major Cash Crops

Crops	2012	2013	2014	2015	2016
Sunflower	13,583	9,882	9,850	10,310	10,744
Groundnuts	6,256	10,224	10,582	12,646	16,582
Grapes	4,477	4,934	5,116	5,331	5,669
Simsim	4,042	3,944	5,154	4,332	3,371
Total	**28,358**	**28,984**	**30,702**	**32,619**	**36,366**

5.1.2. Livestock

Livestock form an important part of family wealth and savings, providing an essential source of income for most families in the project area, particularly those in the urban rural mixed wards such as Zuzu, Nzuguni, Kikombo, Msalato, Makutupora, Mtumba, Mnadani, Nala and Mkonze.

There has been a market decline of indigenous cattle in 2016/17 compared with 2015/16. The decline was also observed in dairy cattle and pigs leading for decreased income for the livestock-keeping households. Markets for goats and poultry had increased, hence an increased income from 2014-2017 as indicated in the table below.

Table 26. Marketing of Major Livestock in Dodoma City council; 2014, 2015 and 2016

Categories	Total number of Livestock Marketed			Total value of livestock		
	2014/15	2015/16	2016/17	2014/15	2015/16	2016/17
Indigenous Cattle	24,990	41,421	26,817	13,744,500,000	27,027,202,500	19,442,325,000
Dairy Cattle	375	296	189	206,250,000	193,140,000	13,025,000
Beef Cattle	9	0	0	4,950,000	-	-
Goats	67,023	85,369	118,236	3,351,150,000	4,994,086,500	8,867,700,000
Poultry	168,265	169,725	170,455	1,766,782,500	1,951,837,500	2,130,687,500
Pig	8,008	1,023	937	1,321,320,000	179,025,000	168,660,000
Sheep	5,735	2,221	12,788	286,750,000	122,155,000	863,190,000
Total	**274,405**	**300,055**	**329,422**	**20,681,702,500**	**34,467,446,500**	**31,485,587,500**

Source: Livestock Office, 2017

5.1.3. Forestry

Dodoma City has about 68,392 ha of forests comprised of forest reserves and greenbelt forest. These include *Adousonia digidata*, *Acacia species*, *Dalbergia nulano xylon*, *Terminalia species*, *Euphorbia triculi*, *Mangifera Indica*, *Ficus species* and many others. Most of these are used for different purposes such as firewood, medicine, construction and fruits.

The Greenbelt forest includes natural forests and exotic species. This forest surrounds Dodoma City Council through Ihumwa, Zuzu, Bahi - road and Arusha-road. Most of the enriched species in this forest are; *Leucaena lucocephala*, *Azadrachita indica*, *Adansoniadigitata and Syzigium cuminii*.

Table 27. Forest Reserves and Greenbelt Forest

Name of forest	No .of ha	Location	Gazzeted year
Chigongwe forest reserve	4,864	Nala ward	1950
Greenbelt forest	20,000	Around Dodoma Municipal	1970
Chinyami forest reserve	43,330	Hombolo/ Chihanga	1989
Vikonje forest reserve	198	Mtumba	1989

Source: City Profile, 2017

5.1.4. Beekeeping

Zuzu and Ng'hong'hona were among the potential areas for bee keeping in the City. The City had about 11,938 beehives supporting self-employed residents in the area to earn considerable amount of income through selling wax and honey. The farmers lacked capacity to practice modern beekeeping. Instead, they practiced traditional processing, which does not attract international markets.

The table below shows wax and honey production in Dodoma City from 2013-2016. The production of wax kept declining annually while that of honey-maintained similarities.

Table 28. Wax and Honey Production in Dodoma City Council

Year	Product (Kgs)		Value (Tshs)	
	Honey	Wax	Honey	Wax
2013/14	24,700	3,900	24,700,000	46,800,000
2014/15	27,350	1,120	27,350,000	13,440,000
2015/16	26,893	1,890	26,893,000	18,900,000

Source: Dodoma City Profile (2017)

5.1.5. Trade, Commerce and Industrial Activities

Dodoma City is highly involved in commerce, trade and industry, which is the driving force for economic activities. Activities under this sector are classified into trading, service, manufacturing and agro-based. Kizota, which is the most highly populated Ward, is the prominent industrial area followed by Viwandani. The below table shows the small-scale industries in the City. The industrial sector is the top employer for youth and supports hundreds of households to earn a living.

Table 29. Type of Small Scale Industries by Ward

Ward	Type of Industry	Number of industries	Total No. of staff
VIWANDANI	Sunflower oil processing mill	01	04
	Service industry – garage	06	12
	Carpentry	10	43
	Food processing	01	06
	Maize milling	01	03
	Welding	02	05
UHURU	Timber processing	09	30
	Maize milling	01	02
	Welding	03	07
CHAMWINO	Sunflower oil processing mill	03	08
	Service industry garage	02	07
	Carpentry/timber processing	03	08
	Maize milling	03	08
	Welding	03	06
K/NDEGE	Welding	01	05
MAKOLE	Sunflower oil processing mill	11	24
	Service industry garage	04	10
MIYUJI	Sunflower oil processing	01	03
	Service industry garage	01	05
	Carpentry/timber processing	07	12
	Food processing	01	04
	Maize milling	08	15
	Welding	09	14
MSALATO	Sunflower oil processing	01	03
	Maize milling	03	05
MAKUTUPORA	Sunflower processing mill	01	02
	Service industry garage	02	07
	Carpentry/timber processing	04	25
	Maize milling	03	05
	Welding	03	06
DODOMA/MAKULU	Sunflower oil processing	06	13
MTUMBA	Maize milling	01	02
KIKOMBO	Sunflower oil processing mill	01	02
TAMBUKARELI	Sunflower oil processing	01	-
	Service industry garage	01	03

Ward	Type of Industry	Number of industries	Total No. of staff
	Maize milling	01	02
	Welding	01	02
KILIMANI	Sunflower oil processing mill	01	03
	Maize milling	02	03
	Welding	01	04
KIKUYU KUSINI	Sunflower oil processing mill	03	06
	Service industry garage	01	03
	Carpentry/timber processing	01	04
	Welding	01	03
KIKUYU KASKAZINI	Sunflower oil processing mill	-	-
	Service industry garage	01	02
	Carpentry/timber processing	05	20
	Food processing	01	03
ZUZU	Sunflower oil processing mill	04	10
HAZINA	Service industry garage	03	15
	Carpentry/timber processing	02	06
	Maize milling	03	06
	Welding	06	18
MADUKANI	Carpentry/timber processing	04	30
	Maize milling	01	04
	Welding	06	21
MAJENGO	Sunflower oil processing mill	04	13
	Carpentry /timber processing	10	20
	Maize milling	01	03
	Welding	12	30
KIZOTA	Sunflower oil processing mill	06	40
	Service industry garage	13	98
	Carpentry/timber processing	01	18
	Food processing	03	108
	Maize milling	03	25
	Welding	07	35
NTYUKA	Maize milling	01	02
CHANG’OMBE	Sunflower oil processing mill	02	04
	Service industry garage	01	03
	Carpentry/timber processing	08	14
	Food processing	-	-
	Maize milling	09	13
	Welding	07	12
MNADANI	Sunflower oil processing mill	06	17
	Service industry garage	05	09
	Carpentry/timber processing	03	04
	Maize milling	11	08
IPAGALA	Sunflower oil processing mill	06	-
	Service industry garage	01	03
NKUHUNGU	Sunflower oil processing mill	02	09
	Service industry garage	01	01
	Carpentry/timber processing	04	22

Ward	Type of Industry	Number of industries	Total No. of staff
	Food processing	02	05
	Maize milling	04	07
	Welding	03	16

Source: Dodoma City Profile, 2017

Dodoma City is also enriched with grapes processing industries as indicated in the table below:

Table 30. Grapes Processing Industries

Processing Plants	Installed capacity (liters)	Utilized capacity liters (2015/2016)	% of Utilization
Cetawico	3,000,000	1,950,000	65
Bihawana	20,000	20,000	100
Alko Vintage	2,000,000	1,400,000	70
Veyula	60,000	21,000	35
Hombolo Mleche Company	300,000	135,000	45
Harry Wine	200,000	80,000	40
Uwazamam	100,000	60,000	60
Dane Holding	6,000	3,300	55
Total	**5,686,000**	**3,669,300**	**65**

5.1.6. Trading Activities

The trading activities in the City include hawking, vegetable selling, second hand clothes selling, fish selling, wholesalers, retailers, hardware, bars and bottle stores, butchery, sugar selling, food vending, chips selling, fuel wood and charcoal, brick selling. Such activities are carried out throughout the City, but much is concentrated within the Town centre and the major trading centers of Hombolo, Mpunguzi, Zuzu, Kikombo and Ihumwa.

5.1.7. Service Activities

The service activities available in the district include tailoring, accommodation, hair dressing, welding battery charging, shoe repairing, laundry, milling, radio repairing, building, hairdressing, minibus operating, motor vehicle repairing and telephones.

With support from the Community Development Department, some youth in Dodoma City had organized themselves in socio economic groups. These groups are eligible for credit and loans and contribute to the growth of youth welfare and contribution to the City's economy.

5.1.8. Manufacturing Activities

Manufacturing activities in the City are undertaken on a small scale, which include bakery, carpentry and joinery, pottery, honey processing, tinsmith, basket making, weaving, knitting, shoe making, timbers sawing and brick making.

5.1.9. Financial facilities

Financial facilities are essential for trading activities in any City. These provide for access to credit and facilitate management of business plans for institutions and individual businessmen and women. There are 14 banks operating in the City as indicated in the table below.

Table 31. Names of Banks Available in Dodoma City Council

S/No.	Names of the available Banks
1	NMB Bank
2	CRDB
3	NBC
4	BARCLAYS
5	POSTAL BANK
6	EQUITY
7	DCB
8	DIAMOND TRUST BANK
9	BOA
10	ABC
11	UTT
12	FINCA ACB
13	TWIGA BANCORP
14	WOMEN BANK

5.2. Housing Conditions

Majority of the residents in Dodoma City own their residential premises, which most of them had been inherited from their ancestors. Others had bought land from residents to settle or rented houses especially in urban areas. Dodoma is a growing City that attracts migrants in search of economic and employment opportunities.

There are three types of housing structures in City Council: (1) cement bricks with iron sheet /or tiles roofing (2) stone walls with iron sheet/tiles roofing; and (3) mud or timber walls with iron sheet roofing or grass thatched. Most of the houses at the town centres are constructed by brick and corrugated iron-sheets, also government offices and few individual houses are constructed by bricks and the roofing is by tiles. New big expensive hotels and new expensive houses are also being constructed in the City indicating an attraction to medium and high - income people. Whereas the low-income people own/rent mud, wood and iron /grass thatched houses. These are mostly located in the squatter areas or in the outskirts of the City.

Housing density distribution varies from one ward to the other by being determined by kind of activities taking place in that particular ward/area. The central part of city has high-density houses because it is the commercial/business area, offices, as well as residential.

5.3. Social Services

5.3.1. Education

Pre-Primary Education

Dodoma City has 102 pre-primary classrooms, among which 83 are owned by the government, and 19 owned by religious institutions and private organizations. Pre-Primary classrooms have 6,693 Pupils. The table below shows sex distribution for public and private owned Primary Schools.

Table 32. Sex Distribution for Public and Private Owned Pre Primary Schools

S/No.	Institutions	Number of Pupils		Total
		Boys	Girls	
1	Public/Government Owned	3,308	3,385	6,693
2	Religious/Private Owned	860	824	1,684
Total		**4,168**	**4,209**	**8,377**

Primary Education

Dodoma Municipal Council has 111 Primary Schools. Among them 92 are public owned Schools and 19 private owned Schools. The tables below shows number of Pupils and Teachers by sex for Public and Private owned Schools as well as buildings and furniture.

Table 33. Number of Pupils by Sex for Primary Education

S/No.	Institutions	Number of Pupils		Total
		Boys	Girls	
1	Public/Government Owned	33,089	34,747	67,836
2	Religious/Private Owned	3,333	3,260	6,593
Total		**36,422**	**38,007**	**76,429**

Table 34. Number of Teachers by Sex for Primary Education

S/No.	Institutions	Number of Teachers		Total
		Male	Female	
1	Public/Government Owned	374	1,235	1,609

S/No.	Institutions	Number of Teachers		Total
		Male	Female	
2	Religious/Private Owned	151	152	303
Total		**525**	**1,387**	**1,912**

Table 35. Number of buildingsand furniture for Primary Education

S/No.	Areas of Improvement	Quantity Required	Quantity Available	Percentage
1	Classrooms	1,696	902	53
2	Teachers Houses	1,609	176	16
3	Desks	22,612	11,787	52
4	Latrine Holes	3,061	1,044	34

Special Education

The Council has 8 centers for pupils with disabilities. These centers include Mpunguzi, Nala, Mlezi, Kaloleni, Hombolo, Chinangali, Dodoma Viziwi and Miyuji Cheshire with total of 947 pupils. The table below shows Pupils with disabilities by sex.

Table 36. Number of Pupils with Disabilities by Sex

S/No.	Type of Disability	Number of Pupils		Total
		Boys	Girls	
1	Blind	3	4	7
2	Deaf	24	29	53
3	Mental Disability	64	63	127
4	Physical Disability	51	45	96
5	Albino	4	6	10
6	Autism	11	8	19
Total		**157**	**155**	**312**

Secondary Education

Dodoma Municipal Council has 51 Secondary Schools of which 36 are Public/community owned and 15 Private Schools. 3 Secondary Schools among 36 Public Secondary Schools are boarding and the rest are day schools (Boarding Secondary Schools include Bihawana, Dodoma and Msalato Girls Secondary school).

Table 37. Number of Students by Sex for Secondary Education

S/No.	Institutions	Number of Pupils		Total
		Boys	Girls	
1	Public/Government Owned	8,982	7,798	16,780
2	Religious/Private Owned	3,017	3,434	6,451
Total		**11,999**	**11,232**	**23,231**

Table 38. Number of Teachers by Sex for Secondary Education

S/No.	Institutions	Number of Teachers		Total
		Male	Female	
1	Public/Government Owned	326	502	828
2	Religious/Private Owned	272	114	386
Total		**598**	**616**	**1,214**

Higher Learning Institutions

Dodoma City had 7 registered colleges and universities namely: Capital Teachers College, Mineral Resources Institute, UDOM, CBE, St. John's, IRDP and Hombolo. These comprised about 36,990 students (23,569M, 13,665F) in 2016/17 offering about 284 programs. Male students outnumber female students by 26%. This could be due to the types of courses offered, particularly in Mineral Resources Institute and UDOM where the number of female students was very low.

The City also hosts 14 vocational training centres offering 51 courses with about 2,165 students (1,468M, 697F). The number of women was still low, standing at 32%.

5.3.2. Health Facilities

Dodoma City Council ensures provision of health services through 76 health facilities among which 51 were owned by government as shown in the table below:

Table 39. Ownership of Health Facilities

S/No	Type	Government	Parastatal	Faith-Based Organizations	Private	Total
1	Hospital	2	1	2	0	5
2	Health Centers	4	4	2	2	12
3	Dispensaries	31	7	9	9	56
4	Special Clinics	1	1	0	1	3
Total		**38**	**13**	**13**	**13**	**76**

Source: Dodoma City Profile, 2017

Shortage of Medical personnel had been reported as the major challenge in provision of health services. Currently, there were 400 medical personnel of whom 77 were doctors, 194 nurses and other cadres leaving a gap of about 459 medical personnel.

ARI, malaria and diarrhoea were the top-ranking diseases among the top ten diseases in Dodoma City covering about 58% of treatment as indicated in the table below.

Table 40. Ten Most Common Causes of Morbidity in DMC in 2016

Name of Disease	Number of cases	Percentage (%)	Rank
ARI	62,503	30.8	1
Malaria	30,770	15.2	2
Diarrhoea Disease	24,397	12	3
Other Diagnosis	21,942	10.8	4
Skin Diseases	20,868	10.3	5
Pneumonia	13,693	6.7	6
Eye conditions	8,008	3.9	7
Intestinal worms	7,967	3.9	8
Emergency surgical conditions	7,910	3.9	9
Fractures	5,135	2.5	10
Total	**203,193**	**100.0**	-

Source: Dodoma City Profile, 2017

5.3.3. Energy

Firewood and charcoal are the most common sources of energy for cooking in the City. Electricity is mostly used for lighting and operating electricity appliances. The energy sector in Dodoma Municipal Council consists of electricity, firewood, charcoal, gas, petroleum products (kerosene, petrol, and diesel) cow dung, solar energy and biogas.

The electricity infrastructure in Dodoma City Council is currently under the Tanzania Electricity Supply Corporation (TANESCO). TANESCO supplies the power through its National grid system.

Table 41. Number of Coustomers Using/Connected to Electricity;

Year	No. of Customers		
	Institution	Domestic	Commercial
2012/13	1,102	23,888	7,304
2013/14	1,200	31,862	8,200
2014/15	1,304	41,242	9,004
2015/16	1,350	49,711	10,016
2016/17	1,364	58,668	11,204

Source: TANESCO

5.3.4. Transport

Roads

Dodoma City has a road network length of 917.34 km. This includes Tarmac road 105.91 km, Gravel 227.79 km and Earth 583.64 km. Of these, 902.56 km is passable throughout the year while 14.87 km is not passable most of the year, particularly during rainy seasons.

Access to transport

The main mode of intermediate transport is by motorcycle (bodaboda) followed by minibuses and then the main conventional ones such as buses. In their absence, using of bicycle, walking and head loading are the commonest mode of travel and transport in the City.

There has been an increase in the number of transport modes such as buses, minibuses, cars, etc. The majority of these transport modes ply in the city and major trading centers leaving the bulk of the rural areas underserved. Service provided to most of the rural areas is not sufficient due to poor road network that resulted into frequent breakdowns thereby incurring heavy operational costs. Some private minibuses operate in the rural areas, but their operations are inadequate and sporadic leaving the rural people with no option but to resort to use of unlicensed and unauthorized vehicles as the only means of transport. Currently, traffic jams had begun, particularly along the Road to Dar es Salaam attributed with residential expansion in areas such as Swaswa, Ilazo, Kisasa and Nzuguni.

Airport and Airstrip

There is one operating airport in the City at Kiwanja cha ndege Ward. A Mission Aviation Fellowship Company (MAF) and other undetermined air service providers mostly provide the air services. The air services are not used commercially effectively since the business has not captured well the market. However, in most cases the airport serves well for Government business when top Government officials visit the capital of Dodoma. Plans are underway for designing and construction of Dodoma International Airport at Msalato. Compensation has been affected and designs are in progress. There is also an airstrip at Hombolo that is privately used by the Catholic Missionaries.

Railway

Dodoma City is well connected with most areas through the central line which is a major railway line in Tanzania. It runs west from Dar es Salaam to Mwanza and Kigoma. In the City, there are three railway stations at Zuzu, Kikombo and Dodoma town (Tambukareli). However, services provided by the Railway Corporation have not been impressive due to number of factors including having old facilities and detonating infrastructure and managerial problems.

5.3.5. Communication

Dodoma City has good communication services. There are several service providers offering postal services, telephone lines, Internet, radios, TVs and newspapers. Key service providers include: Airtel, Vodacom, TTCL mobile, Tigo and Halotel. Radio stations include: RTD, RFA, KISS FM, Nyemo FM, Dodoma FM, RADIO MWANGAZA FM, RADIO ONE, East Africa Radio, Capital Radio FM, Kifimbo Radio FM, RASS FM, Clouds FM and RADIO UHURU. The provided services have been important in terms of social and economic prosperity of the City, particularly the use of online payment systems.

The City has access to TV stations namely Television ya Taifa, Independent Television, Star Television, Agape Television Net Work and Channel Ten. Common newspapers in the City include Mwananchi, Gurdian, Uhuru, Mtanzania, Mzalendo, Tanzania Daima, Dailynews, The Citizens and East African newspape

5.3.6. Police Services

There are police posts in most of the Wards such as Viwandani, Majengo, Dodoma Makulu, Iyumbu, Uhuru, Madukani, Tambukareli, Hazina, Mnadani, Kilimani, Nzuguni and Makutupora. Most of cases reported in such posts are referred to police stations. The police facilities found in the City are shown in the tables below.

Table 42. Total number of Crimes Reported in Police Station and Number of People Jailed in 2016

Total no. of Police in the Council	Total number of			Total Number of People Jailed due to		
	Violent Crimes Reported	Property Crimes Reported	Drug Crimes Reported	Violent Crimes	Property Crimes	Drug Crimes
517	4,892	6,826	168	91	102	58

Table 43. Total Number of Accidents Reported in the Police Station and Number of People Injured/died in 2016

Total number of Accidents involving				Total Number of People Died/Injured from Accidents involving							
Motor vehicles only	Motor vehicle Versus Motor Cycles	Motor cycles only	Motor vehicles and Motor cycles versus Pedestrian	Motor vehicles only		Motor vehicle Versus Motor Cycles		Motor cycles only		Motor vehicles and Motor cycles Versus Pedestrian	
				D	I	D	I	D	I	D	I
40	26	30	18	8	5	12	15	20	31	7	16

Note: D: Died, I: Injured

Table 44. Total Number of Theft Cases Reported in the Police Station and Number of People Jailed in 2016

Total no. of Police Posts in the Council	Total number of				Total Number of People Jailed due to stealing of			
	Motor vehicles stolen	Motor cycles stolen	Bicycles stolen	Livestock stolen	Motor vehicles	Motor cycles	Bicycles	Livestock
12	0	240	53	67	0	61	24	39

5.3.7. Judiciary Services

Judiciary services available in Dodoma City include primary courts; district courts; resident magistrate's courts and high court.

6. Initiative to 'Make Dodoma Green'

6.1. Background and Strategies of National Level

In December, 2017 Tanzania launched a nationwide tree planting campaign aimed at rescuing the nation from the risk of becoming a desert. Especially, Tanzania's vice president Samia Suluhu Hassan launched the planting tree campaign dubbed 'Dodoma Kijani' means 'Green Dodoma' as the move to ensure the capital city becomes green from a semi-arid.

The Vice-President said 61 percent of country risk becoming a desert and, according to the UN Food and Agriculture Organization's 2010 Global Forests Resources Assessment, Tanzania has 33 million hectares of forests and woodland, but the country has been losing more than 400,000 hectares of forest a year for two decades.

Thus, the Vice-President's Office for Union Affairs and Environment has been working closely with ministries responsible for land, water, natural resources and local government. And they have strategies to make Dodoma green as follows:

- Establishing green belts (e.g. planting trees along the roads)
- Forcing owners of huge chunks of land to plant trees
- Incorporating tree planting programme in Dodoma Master Plan
- Establishing small forests in general lands surrounding the town
- Establishing water infrastructures and improving water sources

6.2. Activities of the City Council of Dodoma for 'Make Dodoma Green'

We have interviewed an environmental expert of the City Council of Dodoma about the initiative to 'Make Dodoma Green'. And the expert explained the role of CC on activities for the initiative as follows:

- Planting trees along the roads and open spaces.
- Create awareness to the community to grow at least five trees per house/plot.

- Prevention for the natural trees.
- Insisting for the Institutions to plant trees.
- CCD has a plant nursery at Maili Mbili, they offer free plants to individuals and sale to Contractors.
- CCD conduct group training for production of seedlings.

6.3. Expected Benefits from the Tree Planting

We can expect the benefits from the tree planting as follows:

- Prevention of desertification,
- Decrease in the flood risk,
  - + Increase in the infiltration of rain water
  - + Increase in an ability to hold the rain water
  - + Increase in a macro pore space in ground
- Absorption of harmful gases,
- Increase in humidity and moisture
- Roots stabilize soil aggregates and stream banks,
- Creation of a habitat and Enhancement of ecosystem functions,
- Improvement of landscape beauty of the city, etc

6.4. Various Practical Options to Support the Initiative

The basic direction of storm water management for Dodoma City should be planned to secure water resources for the 'Green Dodoma'. Our suggestions for this purpose are as follows:

6.4.1. Rainwater harvesting at plot level

Dodoma City is located in area with long dry season; the rainfall season is between December and April. However, the intensity of these rains is high. The Master plan is proposing that at each plot level there should be rainwater harvesting infrastructure to conserve these resources, at the same time protecting the environment through reduction of erosions. The storage facilities of the rainwater should correspond to the roof surface areas.

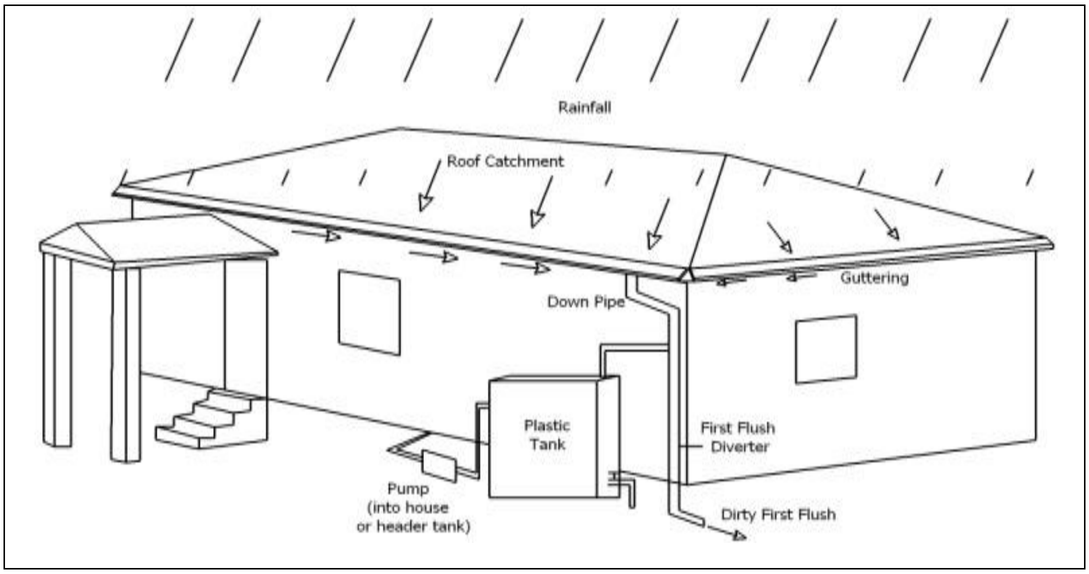

Fig. 12 Diagram of the Rainwater harvesting at plot level

6.4.2. Establishing of infiltration basins

Hardening of surfaces through paving of road and parking areas increases the surface runoff and reduces the recharge of the groundwater sources. The Master Plan is proposing establishment of the infiltration basins in carparks, along roadway corridors within footpaths and at the middle of the two-way roads with green infrastructures at the middle. Landscape design of swales and buffer strips along the road edge will assist in addressing storm water quality whilst also being sensitive to other important landscape functions such as beauty and soil erosion controls. As such, it is important that swale and buffers are carefully designed and integrated within the surrounding landscape character.

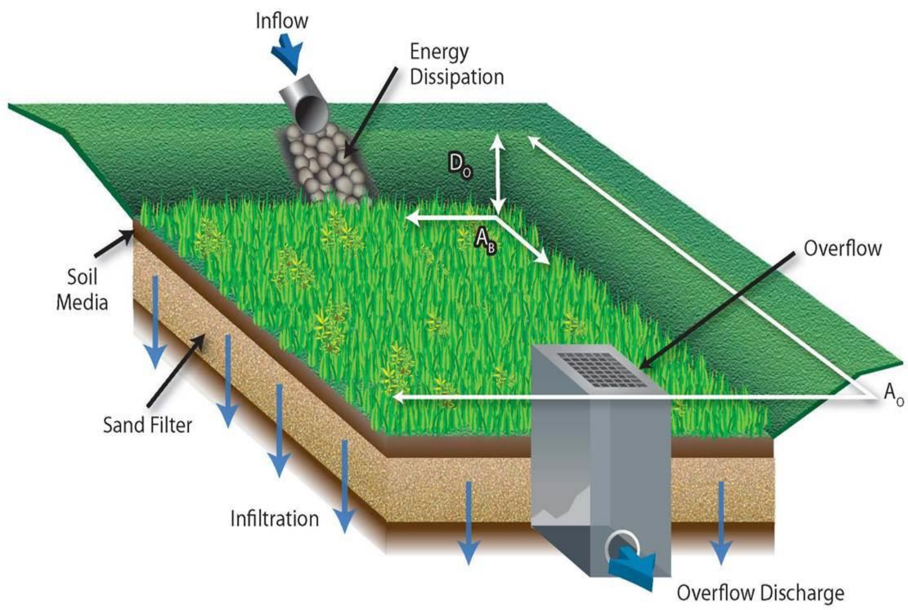

Fig. 13 Proposed infiltration basins for flood

6.4.3. Establishing new ponds

The Master Plan proposes establishment of retention ponds whenever possible and utilization of green infrastructure. Water retention ponds are proposed in various areas located in low laying areas along the natural storm drains such as streams and ravines. These ponds will be surrounded by green areas to mimic and restores natural hydrology. This will improve soil water holding capacity and minimize the erosion of the soil in most of the affected and potentially erosion prone areas. The green infrastructure will improve water quality through its filtering of pollutants, but also by reducing the volumetric flow of storm water to be handled, and therefore, minimizing damage to the biological, physical, and chemical integrity of receiving waters. Some of the areas in which ponds can be established include the area northwest of the proposed Msalato airport.

6.4.4. Green Infrastructure Approach

Rolling hills surrounding the Dodoma City, grapes farms, forest reserves and streams give Dodoma city a unique sense of identity and provide valuable water catchment areas. However, low capacity to manage these catchments is turning to flooding risk. Conventional low-density development is evident in the city not only diminishes the scenic beauty but also contributes to degradation of the city's forest. Growth provides employment (through agricultural sector), housing, recreational and cultural opportunities, but it can be designed and planned to use land efficiently, reinforce a community's "sense of place," and improve the city's beauty and environmental conditions. Two strategies at the city scale will help Dodoma achieve bluing and greening while allowing the City to grow and prosper:

- Protect all the existing forests including the surrounding mountains
- Establish green belts and protect them

Green belts will be established as buffer between one community and the other. This will help in improving the condition in these communities. The other part includes areas along the road sides, the areas surrounding the water bodies, around the landfill and wastewater treatment plants. All these areas together with the natural forest will augment the size of green areas in the City. The benefits of green belts are as follows:

- Reduces flood risk
- Reduces pollution of streams and water supply
- Creates habitat and enhances ecosystem function
- Improves landscape beauty of the City
- Protects the existing forests

Dodoma remains with small areas that are still covered with forest. Most of the forests have been cleared in the process of either securing energy construction materials or expansion of farm lands. The remaining forests need to be protected, being both lowlands or in mountains. Dodoma City has a total of 68,392 hectares designated as forest reserve areas. The surrounding mountain are covered with forests; however, the current trend shows that a lot of activities related to the cutting of these trees for charcoal, building materials and clearance for farming are taking place at unprecedented rates. These actions need to be brought to an end, thereby allowing these forests to regenerate and improve the infiltration of the rainwater into the soil. This will ultimately lead to a reduction of surface water runoff. Planting vegetation has the following impacts:

- Depth and surface roughness greatly increase infiltration of precipitation
- Highly variable ability to hold water
- Roots stabilize soil aggregates and stream banks
- Increase macro pore space and preferential flow/infiltration
- In riparian zones, traps sediments, and sequesters nutrients

- Trees increase infiltration and long term water supply to streams
- Trees increase humidity and thus precipitation
- Trees increase evaporation and thus cloud formation

6.4.5. Reclamation of Wastewater for Non-Potable Use

The 2019 Master Plan proposes reclamation of wastewater for non-potable uses. Various uses which currently use potable water can be substituted by reclaimed water (Table 45). The master plan recommends the establishment of the quality standards for reuse of treated wastewater. The reclaimed water will be used for non-potable uses such as: washing cars, flushing toilets, cooling water for power plants, concrete mixing, artificial lakes, irrigation for golf courses and public parks, and for hydraulic fracturing.

Table 45. Non Potable Use of Reclaimed Wastewater

Categories of use	Uses
Urban uses	Irrigation of public parks, landscape, sporting facilities, private gardens, roadsides, street cleaning, fire protection systems, vehicle washing, toilet flushing for big facilities such as schools and high-rise buildings, dust control, street cleaning, building washing
Agriculture	Food crops commercially processed, pasture for milking animals, seed crops, ornamental flowers, orchards
Industrial	Dust control, washing aggregates, making concrete, soil compaction
Recreational use	Golf course irrigation, sports field, Recreational impoundments with or without public access (fishing, boating), aesthetic impoundments
Environmental use	Aquifer recharge, wetlands, stream augmentation, wildlife habitat

Using drinking water for outdoor landscape needs is a waste of money for the water supplier and to the end user, especially in areas prone to drought. A pressurized secondary water supply may help to reduce the cost of providing treated water by reducing the need to develop drinking water treatment facilities to provide for both indoor and outdoor water needs. In many instances, water for outdoor use may comprise more than 50 percent of annual water demand. Substituting a pressurized secondary water supply to meet this outdoor demand would greatly reduce the demand on existing water treatment systems. To meet such quality, it is recommended that wastewater treatment plants to be designed with all four major components of wastewater treatment plant such as preliminary, primary, secondary and tertiary treatment units. The reclaimed water can help in greening of Dodoma City. Dodoma is a semi-arid land;

thus, greening of the areas is only possible by employing concepts of integrated water resource management and efficiently uses water resources.

IV. Storm Water Drainage System

1. Current Status of the Existing Drainage System

1.1. General

The current storm water management system in Dodoma City consists mainly of the main storms and local storm water channels. The main storm water drainage are parabolic grass swale traversing through the city centre, collecting storm water from the local storm water channels constructed along the road sides. It transports the storm towards the north east part of the City then, towards Hombolo Dam. In areas where these main storms do not exist water has created natural valley or ravines in which the storm water flows towards the same direction. However, these natural features meander through built up areas eroding the banks of these canyons, thus endangering the houses constructed close to them. The 1976 Master Plan and 1988 Strategic Plan proposed some storm water channels; some of these storm water channels have been constructed while others are yet to be constructed. The proposals focused only on the build-up areas. The existing storm water channel has a total of 29.46 kilometres. Therefore, as the new areas are being developed the need for storm water to these areas becomes a necessity.

1.2. Rivers and Storm Water Drains

Stormwater drainage system is the responsibility of the City Council of Dodoma. The drainage system comprises of about 10 main Storm water drains with some smaller ones, Council in which the drains are situated. The main drains in the Dodoma City area are as follows: Pombe River, Mkalama River, Kikuyu River, Imagi River, Mwangaza-Nzuguni Storm Water Drain, Nkuhungu Storm Water Drain, Sabasaba Storm water Drain, Ilazo-Ipagala-Hombolo Storm Water Drain, Kisasa Storm Water Drain and Kizota Storm Water Drain (Fig. 14).

Consideration needs to be given to the impact on the receiving environment, its integration into the built environment, and to recognize water supply is a limited resource and the urban drainage system provides opportunities to reduce the consumption of potable water. The overall goal is to manage the quantity and quality of water effectively in regard to the amenity of development and the environment.

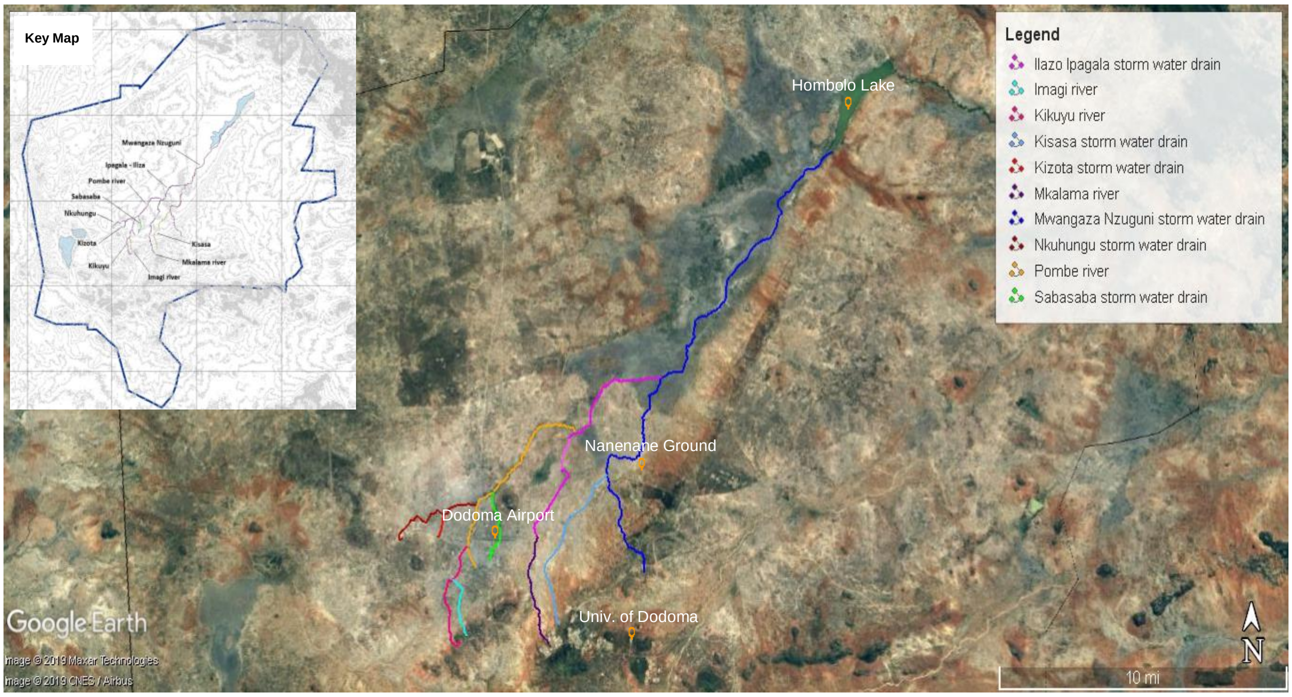

Fig. 14 Rivers and Storm Water Drains

1.2.1. Kizota Storm Water Drain

Kizota storm-water drain receives water from Itega mountains down the railway. Water is drained from the mountains through the drain that is under the railway across the drain that is under Singida road. The drain continues from the road towards the place where it joins with the Nkuhungu stormwater drain at Bwawani street. The drain is small and cannot accommodate all the water from upstream that pass through it, thus causing floods during rainy season around areas of Kisabuje Street which affect people's properties including houses and other possessions. The photos below show the damage caused by stormwater

Fig. 15 Kizota Storm Water Drain

1.2.2. Nkuhungu Storm Water Drain

It is a constructed drain. Nkuhungu storm-water drain receives water from the mountains. It is an open-drain from the industries to areas along Singida road. It is then a closed drain in areas near Bwawani where it is also left open. In areas of Bwawani where Nkuhungu and Kizota drains join, water normally overflows and cause floods to nearby residential areas. In the year 2017, five houses were destructed completely. Moreover, water tends to clog due to solid waste accumulation, sedimentation and growth of weeds thus, creating a breeding site for insects which in turn causes diseases to the residents of that area.

Fig. 16 Nkuhungu Storm Water Drain

1.2.3. Ilazo-Ipagala Storm Water Drain

It is a constructed storm-water drain. It starts from Morogoro road. It is still a new well-Constructed and protected drain thus the drainage structures are still sufficient. It runs down through to Ilazo pond where water normally floods to residential houses and causes destruction of houses.

Fig. 17 Ilazo-Ipagala Storm Water Drain

1.2.4. Pombe River

It runs along police station, then Majengo market where it joins with Kikuyu river. Along Majengo market, the river is polluted since there are many economic activities conducted along the river. This forms a basis of pollution to the downstream and receiving water body as the pollutants will be transported from one point to another. The drainage structures (culverts and bridges) are blocked with too much vegetation growth, debris materials together with solid wastes and accumulation of sand thus affecting the flow of water during rainfall season. Which in turn could lead to overflow of water to the nearby areas and cause damage to properties and possessions.

Fig. 18 Pombe river

1.2.5. Imagi River

Runs from Imagi mountain down the hill to area near Singida roundabout where it joins with Kikuyu river. The river receives water from side ditches along the roads. It has no effects on the surroundings except that currently the structures are filled with sand, solid wastes and debris materials. It definitely needs to be cleaned.

Fig. 19 Imagi river

1.2.6. Kisasa Storm Water Drain

Kisasa stormwater drain runs from the mountains near the University of Dodoma down the hill along Dodoma Makulu, through Kisasa along Morogoro road behind Martin Luther school where it directly goes to join with Mwangaza Stormwater drain. The rate of erosion of this drain along Dodoma Makulu area is high as the width of the drain increases as days go by. This leads to sedimentation downstream which in turn also affects the drainage structures by filling the culverts with sand and other debris materials. Consequently, water fails to pass thus, leading to the overflowing of water downstream. Also, along Makulu (Njedengwa), during rainfall; means of accessibility becomes a challenge since there is no Bridge for people to use hence it is hard to pass through the drain to get access to town.

Fig. 20 Kisasa Storm Water Drain

1.2.7. Mwangaza Storm Water Drain

Mwangaza stormwater drain; drains water from Njedengwa, Kisasa storm-water drain, Nzuguni where it goes to pour its water at Hombolo dam. Generally, the condition of this drain is fair; only that there are drainage structures, for instance, the Nzuguni culvert which is accumulated with debris materials and solid wastes and also other drainage structures at TBA quarters where the outlet wing wall is broken.

Fig. 21 Mwangaza Storm Water Drain

1.2.8. Sabasaba Storm Water Drain

Sabasaba stormwater drain drains water from the side drains around the city center passing through Sabasaba Market then airport to Mlimwa C where it meets with the Pombe river. Part of Sabasaba drain is constructed, for instance near Kimbinyiko roundabout to Sabasaba market and thereafter it is not constructed. It then flows through the culverts under the airport to Mlimwa C. Generally, the drain has no issues along the areas where it passes, but rather it is affected with an accumulation of debris materials and solid wastes in its drainage structures which may consequently hinder the flow of water. Also, there is pollution as a result of garage activity along the river and wastewater being released from the residential and commercial buildings near the drain. This poses a threat to the residents near the drain as well as the downstream.

Fig. 22 Sabasaba Sorm Water Drain

1.2.9. Kikuyu River

Kikuyu river drains water from mountains near the Kikuyu area to Iringa roundabout where it joins with Imagi river and finally to the Majengo market where it joins with the Pombe river. The river does not cause any effects to the residents living along. Although it was observed that the width of the river is increasing due to erosion and in the end causing sedimentation in downstream. Moreover, the houses nearby are in danger of being affeced as a result of eriosion. Some of the drainage structures such as the bridge at Mlezi are full of sand and there is an accumulation of solid wastes. Consequently, this may hinder the flow of water during rainy season. Also, there is a small drain at Camp David area, which normally overflows during rainfall season since the drains are accumulated with sand thus water can not pass freely and in the end, water overflows to the nearby shops and residential areas.

Fig. 23 Kikuyu Storm Water Drain

1.2.10. Mkalama River

Mkalama river receives water from mountains near the University of Dodoma and also once the Mkalama Makulu pond is full, it overflows to the Mkalama river. It drains water from the mountains and ends at Morogoro road where it joins Ilazo -Ipagala stormwater drain. The river does not cause any effects to the residents living along the river. Moreover, as time goes on, the width of the river increases due to erosion and as a result leading to sedimentation downstream.

Fig. 24 Mkalama Storm Water Drain

1.2.11. Mkalama-Tambukareli Storm Water Drain

It runs from Mkalama mountains downhill through Tambukareli towards Ilazo Ipagala stormwater drain. The drain normally causes floods during rainfall season as water scatter in areas of Rock hotel.

Fig. 25 Mkalama-Tambukareli Storm Water Drain

1.2.12. Side Drains

Generally, the condition of side drains is bad. The drains are full of solid wastes and sand. As the rain season is approaching, the drains will be having bad impacts to the residents, offices as well as commercial buildings in which these side drains pass. Water will fail to pass and consequently leading to overflowing of water to the buildings. This may lead to destruction of properties and possessions.

Fig. 26 Side Drains

1.3. Existing Water Retention Ponds

Dodoma has many ponds; some are naturally formed and others constructed ones. In general, they are full of sediments and solid waste and as a result the depth is reduced. Therefore, they need to be cleaned, as well as sediments removed, in order to minimize or control overflowing during rainfall.

Retention ponds are stormwater control structures that provide retention and treatment of contaminated stormwater runoff. These ponds capture and retain stormwater runoff, wet retention ponds control stormwater quantity and quality. From a health standpoint, there is always a concern with standing water such as a drowning hazard, particularly with children. Ponds can also draw mosquitoes, which may contribute to the transmission of some diseases.

A total of twenty-one (21) ponds in Dodoma City were surveyed to observe the existing situation (Fig. 27). They are all storage ponds and water in these ponds is used for different domestic activities such as cleaning and washing but also water is used for agricultural activities hence providing food to the community as well as a source of income.

Currently, these ponds are affected with siltation. This is due to the fact that, these ponds have no sieving chamber before the water coming from the storm water drains enters the ponds. Thus, all the materials from runoff enter the ponds and settle down. Moreover, it is due to the fact that there are different activities taking place around the ponds including cultivation, as well as livestock drink water from the ponds. Thus, the rate of erosion and sedimentation is accelerated in the ponds.

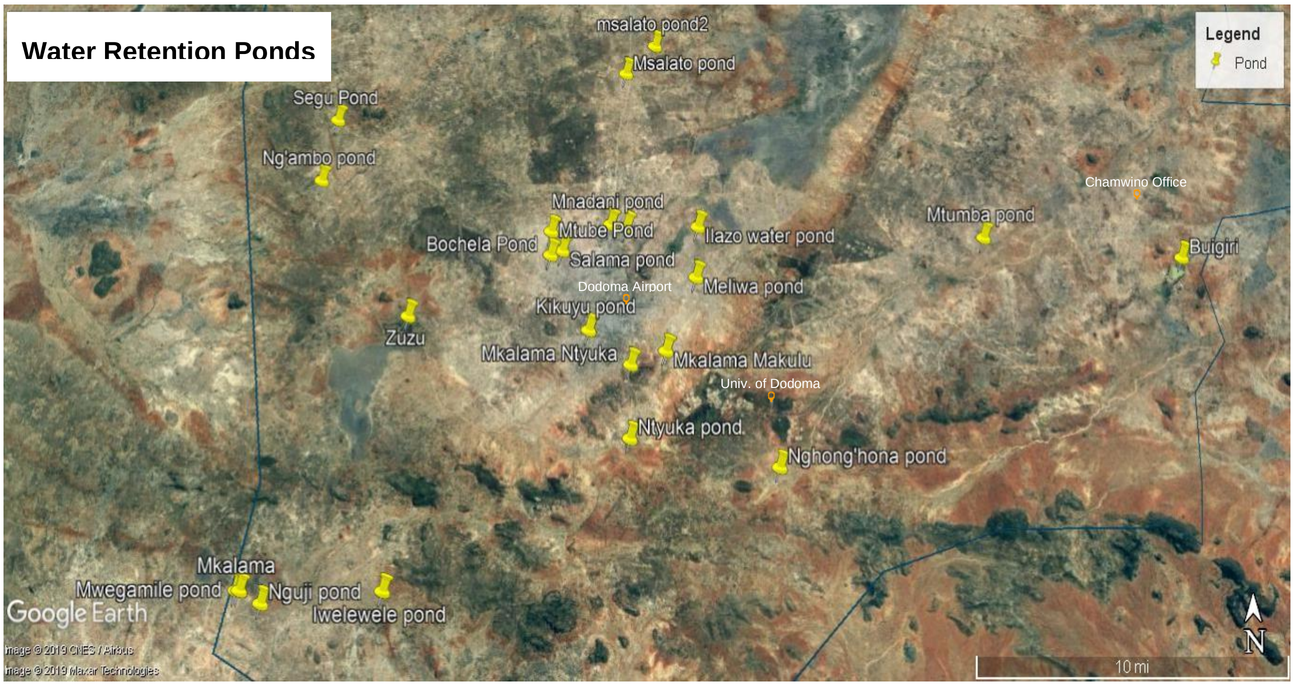

Fig. 27 Existing Water Retention Ponds

1.3.1. Bochela Pond

This pond is located at Nkuhungu ward. It receives large volume of water from Itega hill that run from the industrial area along Singida road to the next side of Singida road. Also, there are two culverts along Singida Highway (near Nduvini Autoworks) which collect water from elevated points and direct it to Bochela pond. In the rainy season, this pond tends to overflow and affects a number of surveyed plots within the neighbourhood. Bochela pond is too shallow and so eroded and as a result tends to affect the residence area around it by overflowing hence floods to the nearby area. Also, there is no proper direction of storm water to this pond and this causes water to scatter around people's residences.

Fig. 28 ***Bochela pond***

1.3.2. Mtube Pond

This pond is located at Kizota, just like Bochela. IT is bowl like in nature and accumulates water from Bochela Pond(when it overflows) and it has no outlet channels. It also collects water from Ndachi neighbourhood. Therefore, the higher the rainfall intensity the more the water accumulation and overflow. Mtube pond is shallow and eroded in some parts and as a result tends to affect the residence area around it by overflowing hence floods the nearby area. Also, there is no proper direction of storm water to this pond and this causes water to scatter around people's residences. There are activities taking place round this pond like fishing and small agricultural activities like irrigation of vegetables.

Fig. 29 ***Mtube pond***

1.3.3. Ilazo Pond

This pond is located in the Ilazo area; it receives water from overflowing of Ilazo- Ipagala storm water drain and areas around it. Ilazo pond is shallow due to siltation and accumulation of sand and as a result there is low water storage capacity. In rainy season the pond tends to overflow, causing floods to the residential area as a result it affects areas surrounding it as well as people's properties.

Fig. 30 Ilazo pond

1.3.4. Salama Pond

Salama pond is found in Nkuhungu ward; it receives water from different areas around it. Water flowing to this pond are not well directed that is, they flow randomly. This water also accumulates debrises and silts into the pond, this reduces pond's depth as a result low water storage capacity. In rainfall season, floods occur in areas around pond and people's properties are destructed.

Fig. 31 Salama Pond

1.4. Flood Prone Areas

Flood prone areas were observed to be the areas near the water retention ponds. The areas are Ilazo, Bochela and Mtube and Salama. Also, due to existing storm water facilities that are insufficient, areas of Kisabuje and Bwawani are normally affected during rainfall season. Moreover, the areas near Swaswa waste stabilization ponds are observed to be affected with wastewater from the ponds when water overflow during rainfall season thus making people at higher risk of being affected with epidemic diseases.

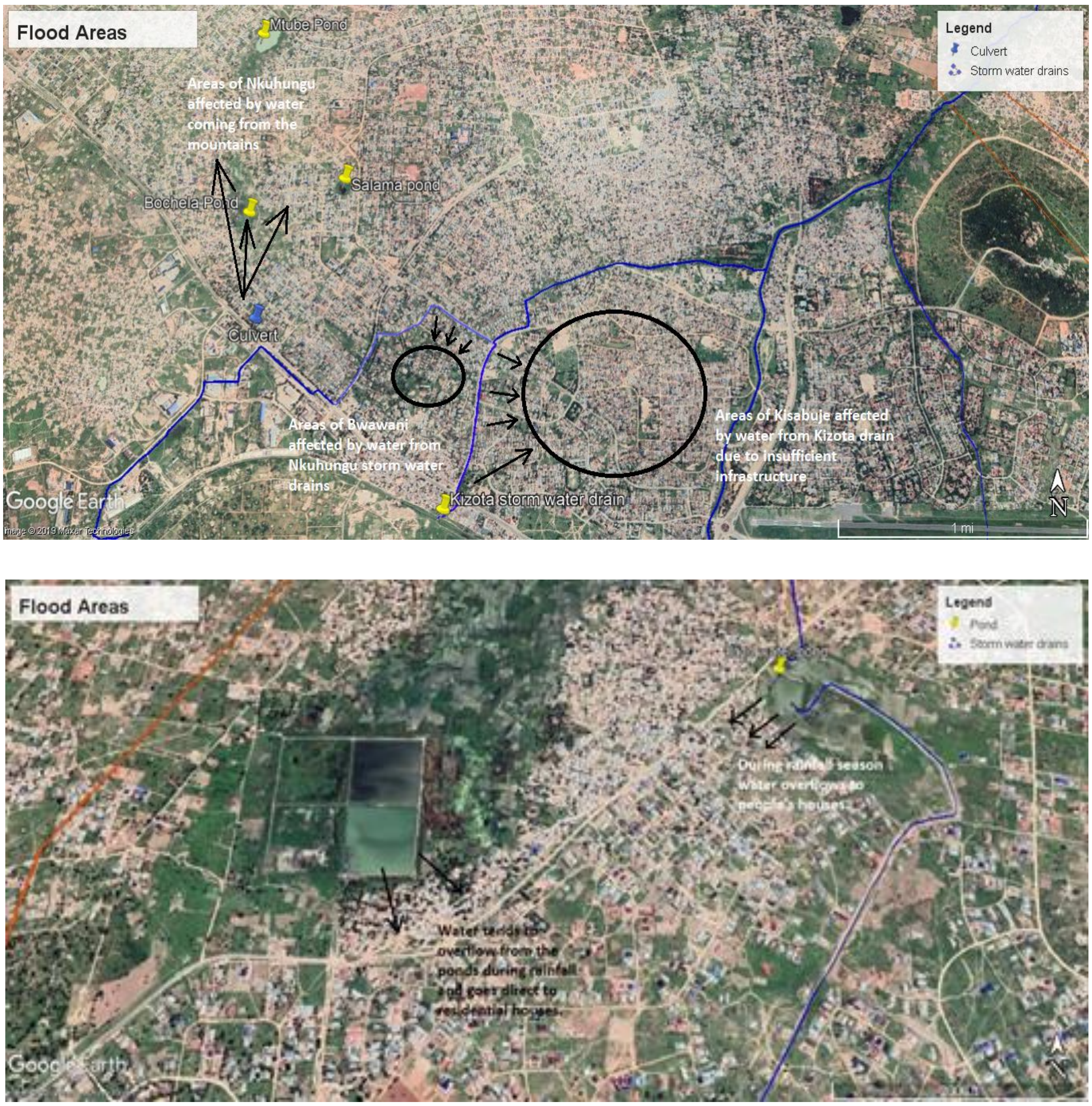

Fig. 32 Flood Prone Areas

Fig. 33 Sites Affected by Flooding

1.5. Inventory Analysis for Road Structures (Culverts)

In addition to lack of these infrastructures in areas to be developed, some of the developed storm water channels are still facing some challenges.

The main storm water channel from Kikuyu and Area D combine in Mlimwa C area, however the channels provided, together with the culverts for crossing the road from Miyuji to Mlimwa C, are not sufficient to accommodate the combined storm water flows. As a result, the Mlimwa C areas are frequently flooded during the rainy season. The reason for flooding is that the size of the stormwater channels leaving are twice that of those that bring in the water (Fig. 34).

Fig. 34 Culverts A from Area D, B from Kikuyu and F in Mlimwa C

Culverts conveying stormwater that crosses roads, railroads and highways consisting of concrete and metallic pipes were surveyed as well. It was observed that, some of the culverts are blocked with debris materials thus water cannot flow through the culverts which during rainfall season can cause floods to the areas near the culverts.

Fig. 35 Curverts blocked with Debris Materials

2. Previous and Existing Plans on Storm Water Drainage System

2.1. Establishing new storm water drains and improving the existing ones

The City Master Plan of 2019 is proposing establishing of new storm water drainage. The plan is to reuse the land that has already been degraded, such as ravines and streams. This will entail reshaping the stream to form parabolic shape, planting the grasses and protection of the banks prone to erosions. This aims at having all the main storm drains being parabolic vegetated swale. The size of these swales will be based on the expected storms bearing in mind the impacts of the expected development. Thus, it is proposed that the main storm channels should have a minimum reserve of 5 meters, and a maximum of 15 meters to allow for vegetating the sides of the storm drain.

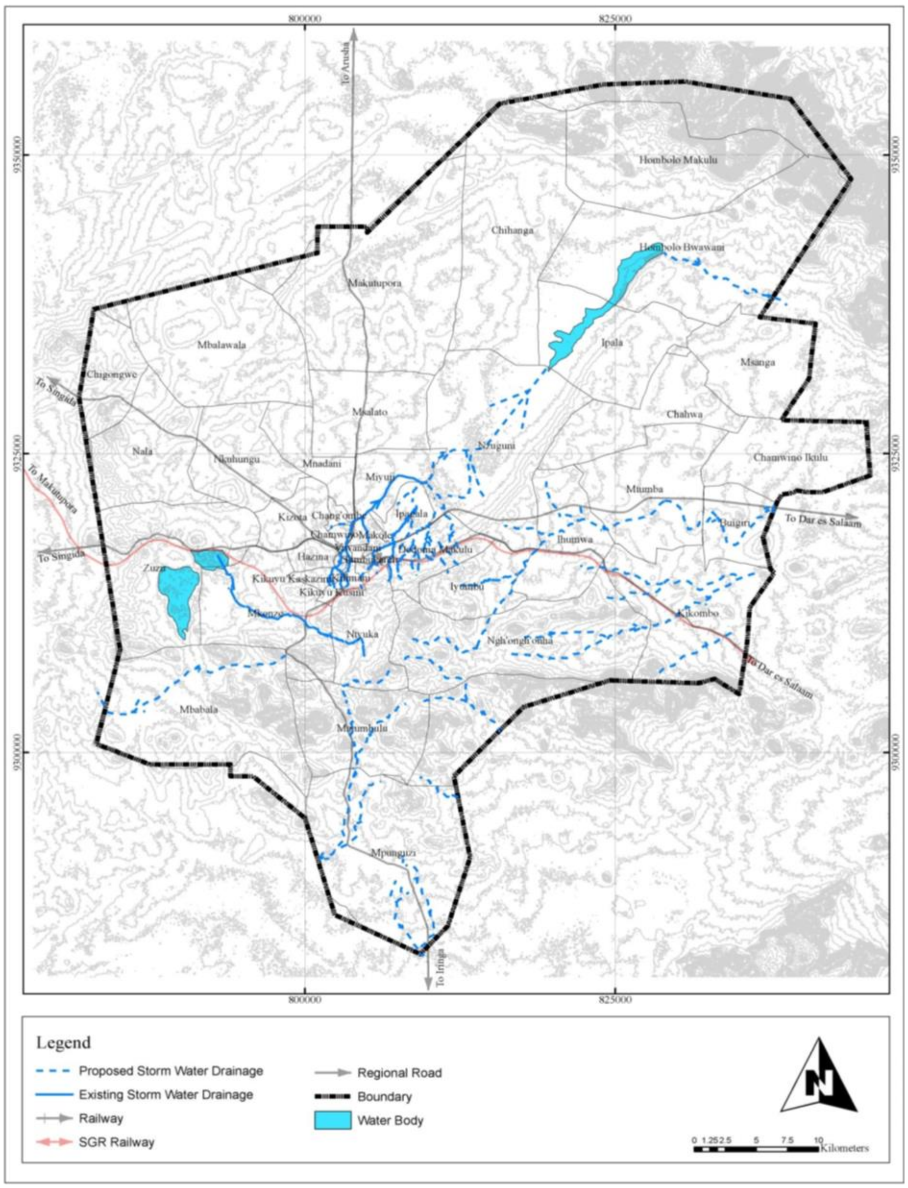

Fig. 36 Proposed Storm Water Management Plan

Furthermore, the Master Plan proposes expansion of the grass swale from the junction where the main storm from area D and Kikuyu meet to provide sufficient area for accommodating the expected flows. In addition to this the Culvert C in Mlimwa C area shall be expanded to at least the size of the preceding culverts along the Arusha road (B) or Wajenzi road (A) to easy flow of storm through and minimize the possibility of flooding in these areas.

To address the problem of storm water in Nzuguni area the Master Plan proposes the channel be expanded to accommodate all the storm discharged from the city storms and provide a large bridged corresponding to the anticipated flows of the storm water in these areas.

2.2. Establishing and Reinstating Water Retention Ponds

2.2.1. Establishing new ponds

The Master Plan proposes establishment of retention ponds whenever possible and utilization of green infrastructure. Water retention ponds are proposed in various areas located in low laying areas along the natural storm drains such as streams and ravines. These ponds will be surrounded by green areas to mimic and restores natural hydrology (Figure 37). This will improve soil water holding capacity and minimize the erosion of the soil in most of the affected and potentially erosion prone areas. The green infrastructure will improve water quality through its filtering of pollutants, but also by reducing the volumetric flow of storm water to be handled, and therefore, minimizing damage to the biological, physical, and chemical integrity of receiving waters. Some of the areas in which ponds can be established include the area northwest of the proposed Msalato airport.

Fig. 37 A Water Retention Pond Surrounded by Green Areas

2.2.2. Reinstating existing retention ponds

In areas where there are natural ponds, the master plan proposes reinstating these retention ponds which are located in various parts of the city. The re-establishment will include paving the way for ponds by removing any structure that has encroached the pond, dredging to remove mud so as to deepen the pond resulting into high volumes of storm water being retained within the city. Example of such an area is the Ilazo pond. The Master plan proposes that the Ilazo pond be dredged to remove sediments and weeds and expand the outfall including the bridge along the Martin Luther King School road to accommodate the anticipated flows.

Preserving these areas is critical for maintaining water volume and quality and reducing runoff. The investment in storm water retention ponds “pays back” by reducing runoff and flooding risks, protecting scenic character and creating recreational opportunities for the area’s residents and visitors. Some of these areas that require reinstating of the ponds include the Buigiri dam (Fig. 38) and the Zuzu ponds.

Fig. 38 Buigiri Dam

2.3. Erosion Control

The topography of Dodoma has several areas with steep slopes slanting from the hills surrounding Dodoma. These slopes are affected by erosions forming ravings and streams. The ravines and streams are prone to erosive forces of storm water.

Erosion control measures for these areas include; introduction and reinstating of the existing water storage ponds, protection banks of these water channels using gabions and riprap constructions (Fig. 39 and Fig. 40) in areas showing rapid expansion of banks. Vegetation can also be used as banks protection measures on the slopes of ravines and storm water channels, for the root systems tend to hold the soil together.

Fig. 39 Gabion for Control of Bank Erosion in Storm Water Drainage

Gabions are recommended to be used in the storm water stretching from Meriwa towards Ilazo, since this area is very narrow with a lot of meandering which are liable to the erosive forces. The applications of check dams are possible is shallow storm drains like the Medeli storm water channel from Shabiby round about to Emmaus I areas.

Fig. 40 Riprap Construction for Erosion Prevention in Storm Water Drainage

The challenge to ravine management is to cope with increased storm water runoff anticipated as the results of increasing the hardpans in order to reduce mass wasting on the slopes and stream incision within the ravines. As most of the areas in the watershed are not fully urbanized, it is anticipated that runoff will increase greatly in the future.

Implementation of these protection measures will maintain existing fluvial geomorphology, protect watercourses from further deterioration and ensure protection of public safety and property. The introduction of check dams along the swale will reduce the flow velocity and thereby reducing the erosive effects of the moving water (Fig. 41)

Fig. 41 Check Dams along the Main Storms

3. Survey and Mapping

3.1. Spatial Data Acquisition

3.1.1. Digital Terrain Model

Two high resolution DTM data have been used:

- SRTM 30m resolution
- CCD 2m resolution

The DTM data have been used for:

- Catchment delineation
- Drainage network analysis
- Extracting the river geometry/cross sections
- Extracting the Elevation – storage characteristics of the ponds

Digital Elevation Model of CCD (2m gap)

- Source of Data:

Contour data was acquired from the City Council of Dodoma. Contour data were in Drawing Exchange Format (DXF) file with more than 700 files containing sheets that needed to be combined to make a complete contour map of Dodoma City. These contour data were produced by Photomap (Kenya) Ltd in November 2007 under Capital Development Authority (CDA).

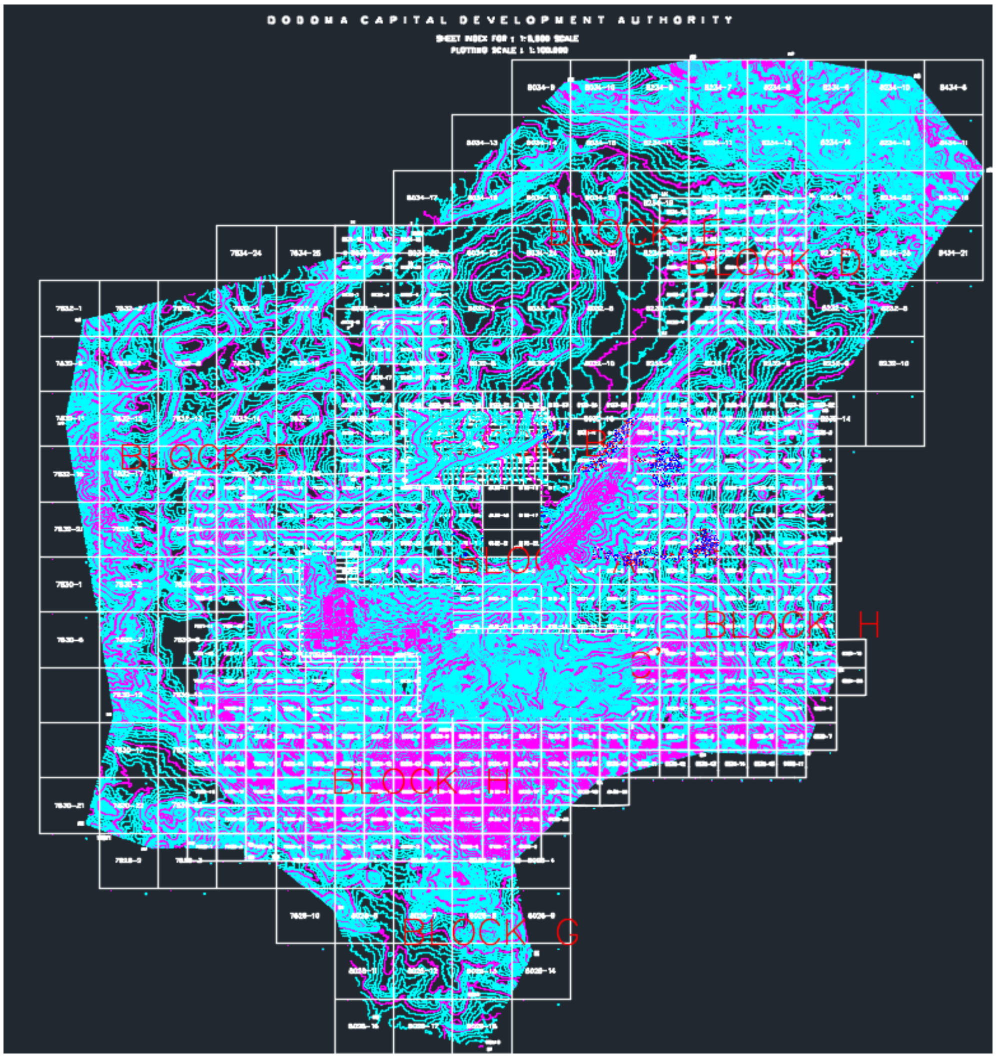

Fig. 42 Combined contour map with Map Index for CCD Dodoma

In the combined contour map, there were gaps with missing sheets. A total of nine sheets were missing numbered 8132-11, 8132-12, 8132-16, 8132-17, 8132-21, 8132-22, 800318-11, 800318-16, 800318-21 as shown in the Fig. 43.

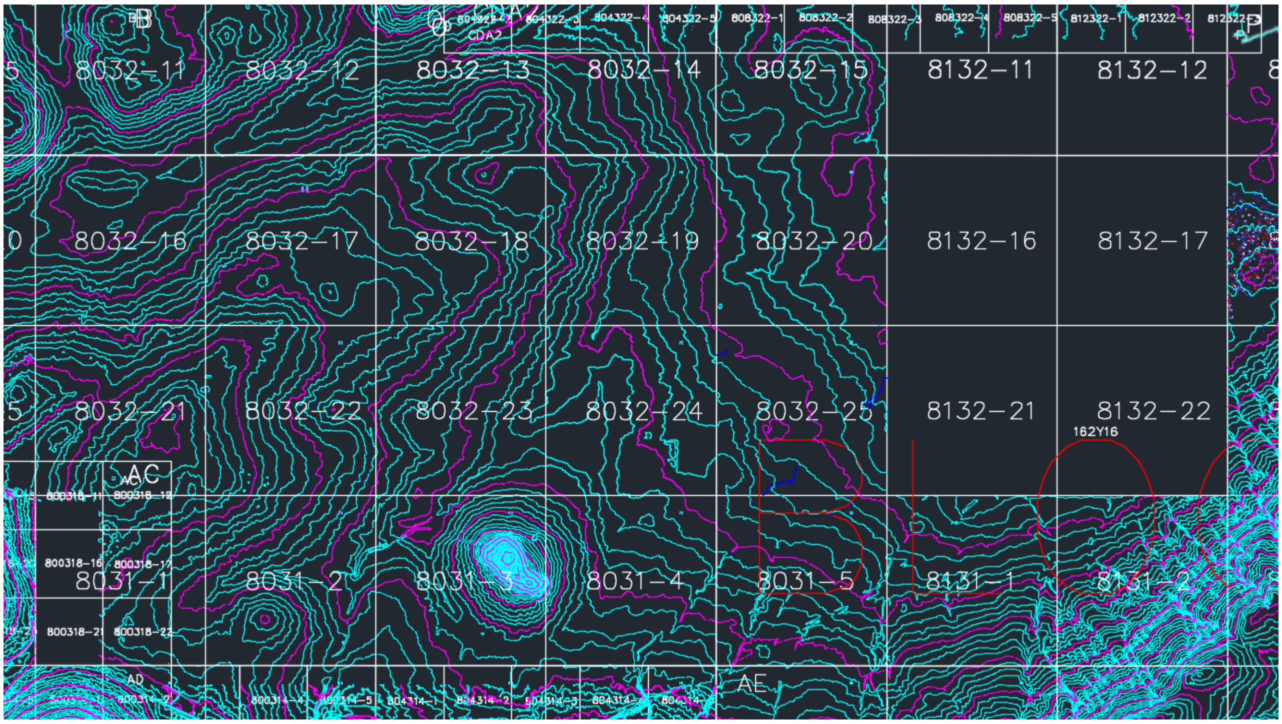

Fig. 43 The missing contour data

These gaps were filled by using 30m-SRTM DEM which was first calibrated to match the properties of contour map. Contour data was created from the calibrated DEM within the gaped area and ready to be patched to contour map.

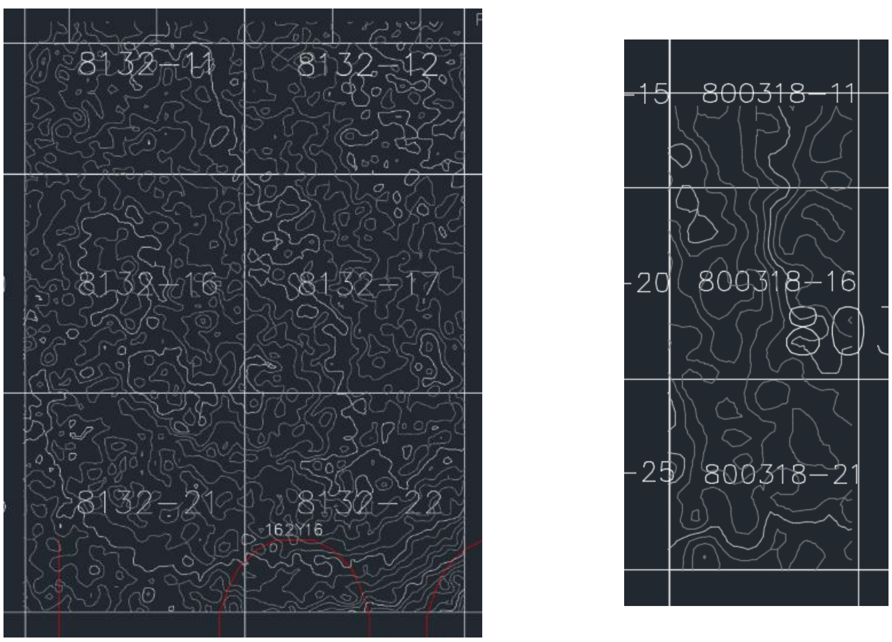

Fig. 44 Contour data to be patched

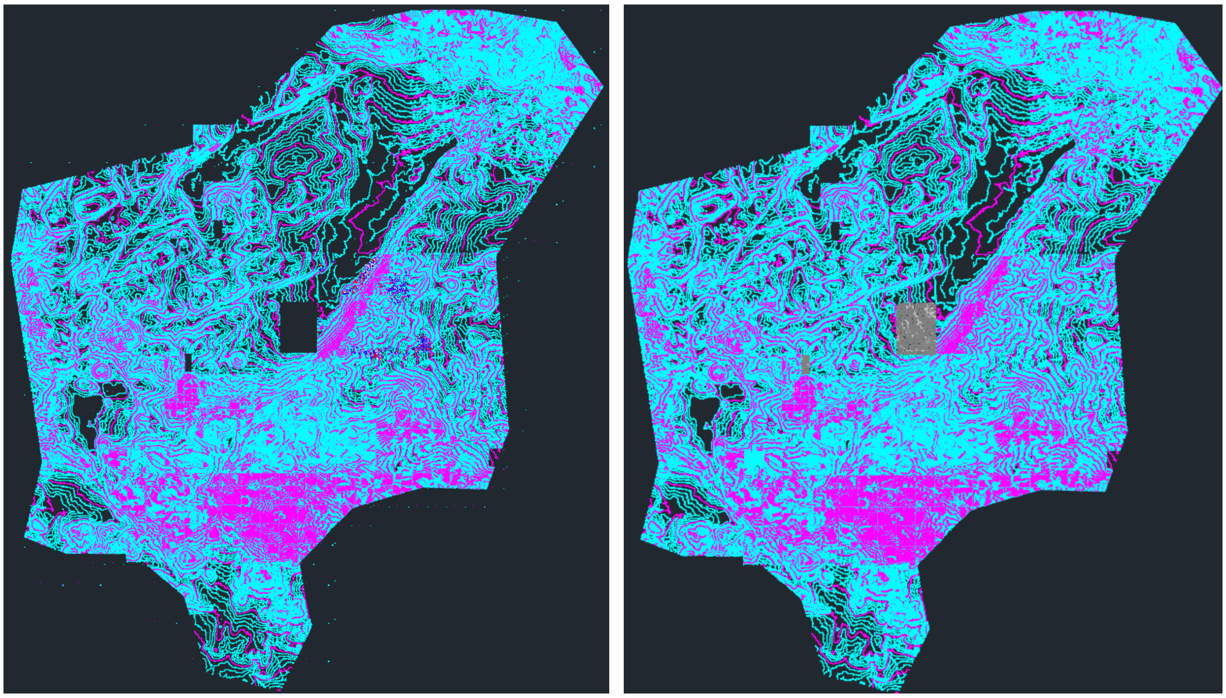

Fig. 45 Contour map with gaps (Left) side by side with the patched contour map (Right)

After patching DEM, it was generated as shown in the figure below.

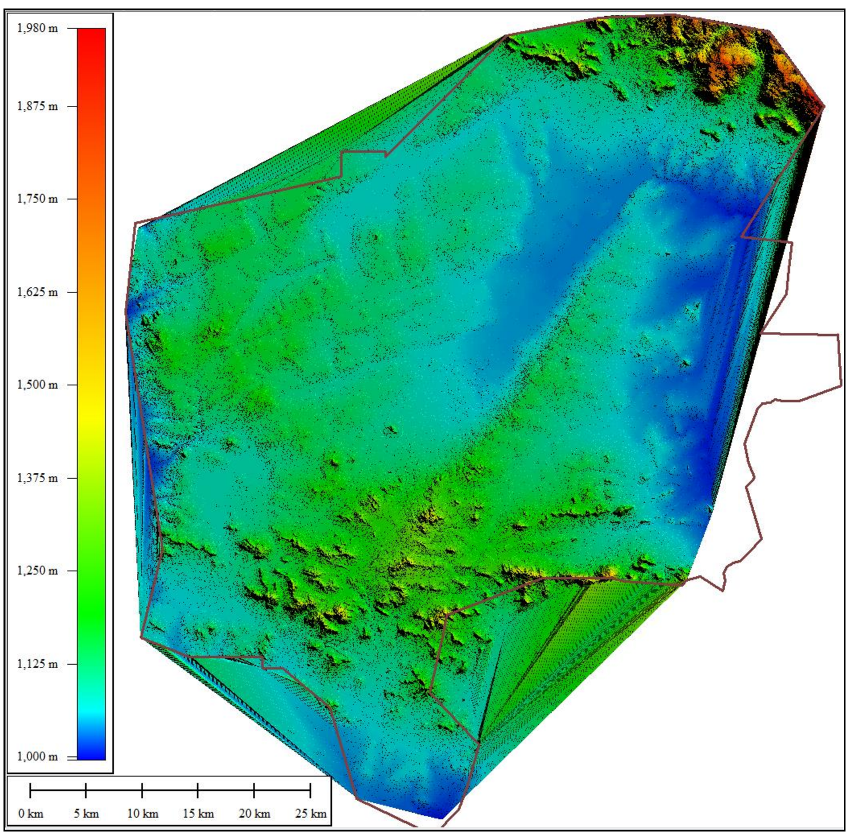

Fig. 46 2m DEM generated from patched contour map with boundary of CCD Dodoma

Even though the contour data provided us with higher accuracy of terrain data within Dodoma City but there are other areas which were not covered by the contours especially in the eastern part on which the Government City is situated at.

3.1.2. Current Land Use/Cover

The land use/cover data have been obtained from European Space Agency (ESA) Climate Change Initiative. The dataset has been developed at 20m, based on 1 year of Sentinel-2 A satellite observations from December 2015 to December 2016. Two classification algorithms, the Random Forest (RF) and Machine Learning (ML), were used to transform the cloud-free reflectance composites generated by the pre-processing module into a land cover map. The two maps resulting from both approaches are then combined either to select the best representation of a land cover class which will be part of the final S2 prototype LC 20m map of Africa 2016 or, in case of unreliable LC class delineation, the reference layer is used to consolidate the land cover classification.

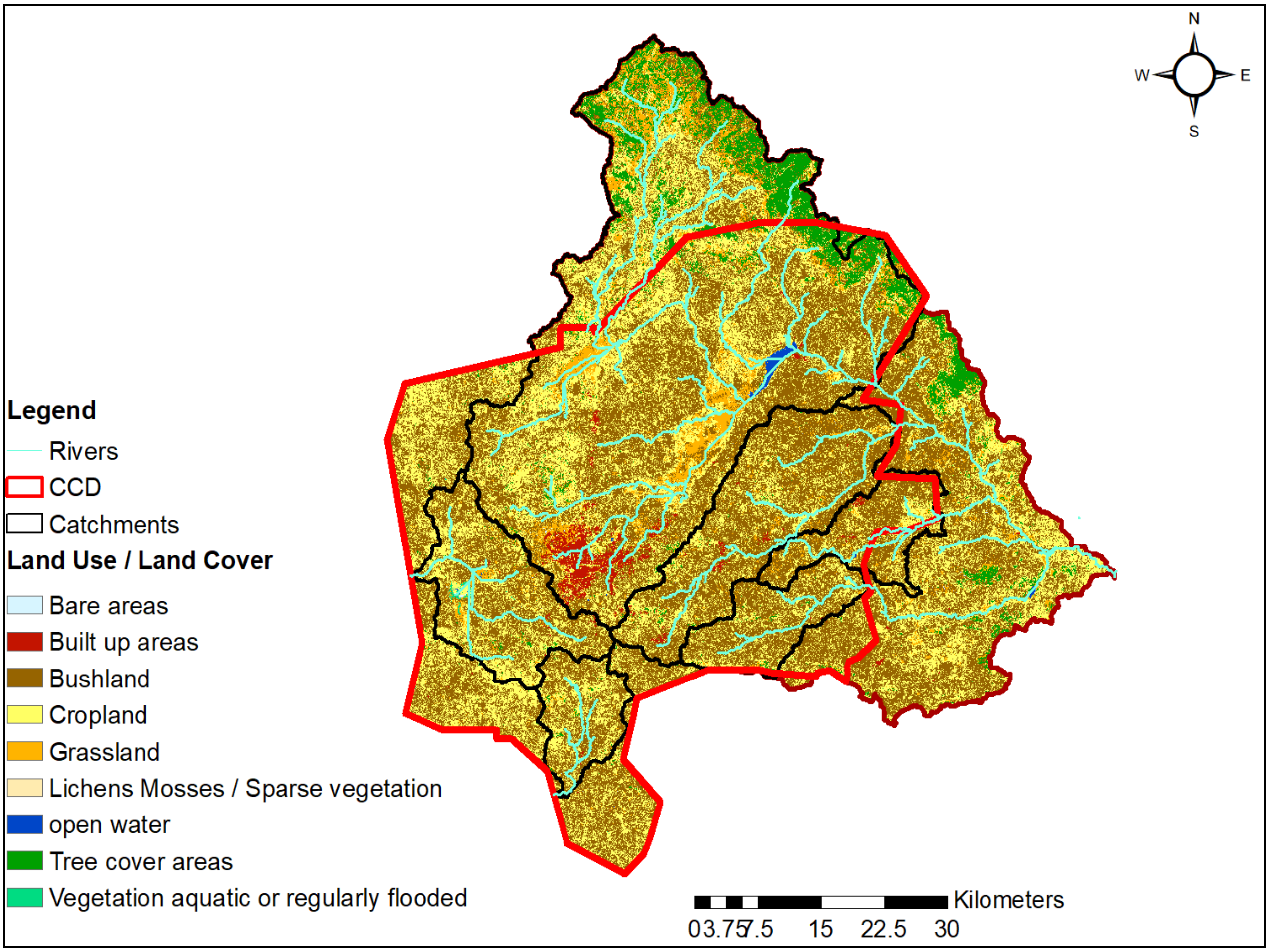

Fig. 47 Current Land Use / Cover for Dodoma City

Table 46. Current Land Use Coverage for Dodoma City

S/No.	Land Uses	Area(km^2)	Coverage (%)
1	Tree cover areas	243.04	6.13
2	Bushland	1,940.52	48.95
3	Grassland	268.54	6.77
4	Cropland	1,450.54	36.59
5	Vegetation aquatic or regularly flooded	2.05	0.05
6	Lichens Mosses / Sparse vegetation	0.07	0.00
7	Bare areas	2.90	0.07
8	Built up areas	48.26	1.22
9	Snow and/or Ice	8.68	0.22
10	open water	243.04	6.13

3.1.3. Geological Formation

The geology map produced by the Geological Survey of Tanzania (GST) has been used to understand the lithology in CCD.

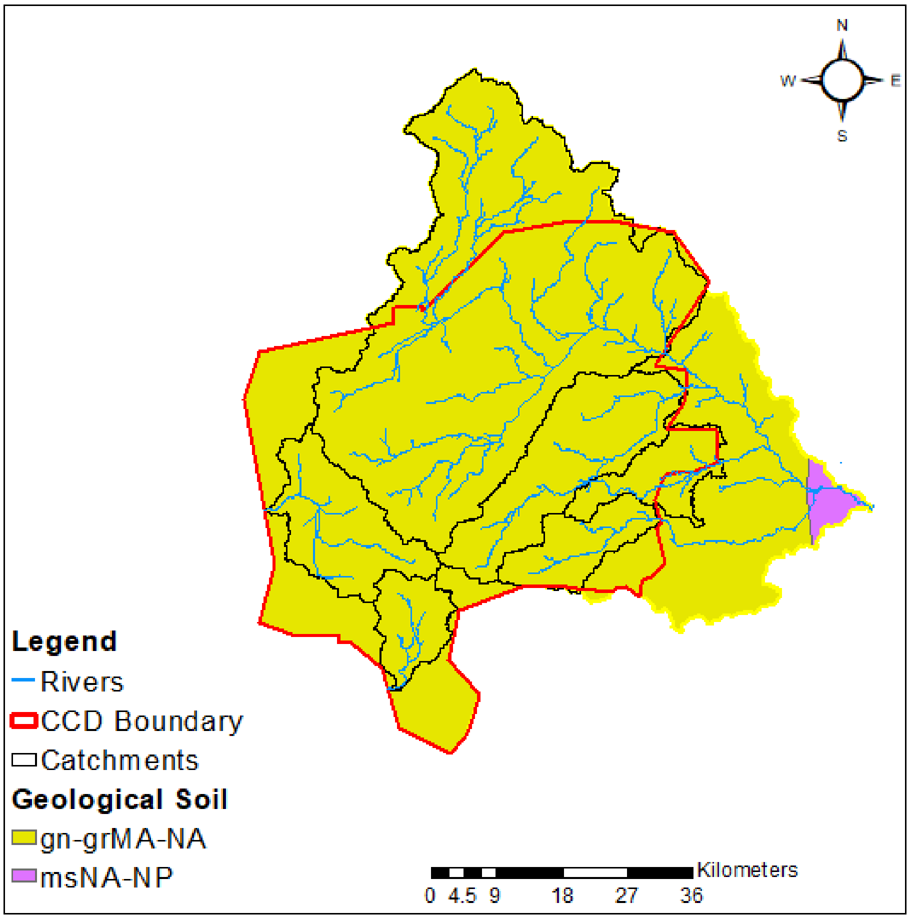

Fig. 48 Geology Map for Dodoma City

Table 47. Geological Characteristics of Dodoma City

CODE	GEOLOGY	LITHOLOGY	ADDITIONAL INFORMATION
msNA-NP	Meta-sediment - meta-igneous complex	Meta-igneous, meta-sedimentary rocks	Palaeo-Neoproterozoic East African Orogen (Mozambique Belt)
gn-grMA-NA	Gneiss-granite-migmatite complex (Dodoma and Isangan Group)	Granitoids, migmatite, mafic dykes, lamprophyre, cataclasite	Meso-Neoarchaen Dodoma crystalline complex

3.1.4. Soil Formation

The Harmonized World Soil Database (HWSD) has been used to classify soils in the CCD catchments.

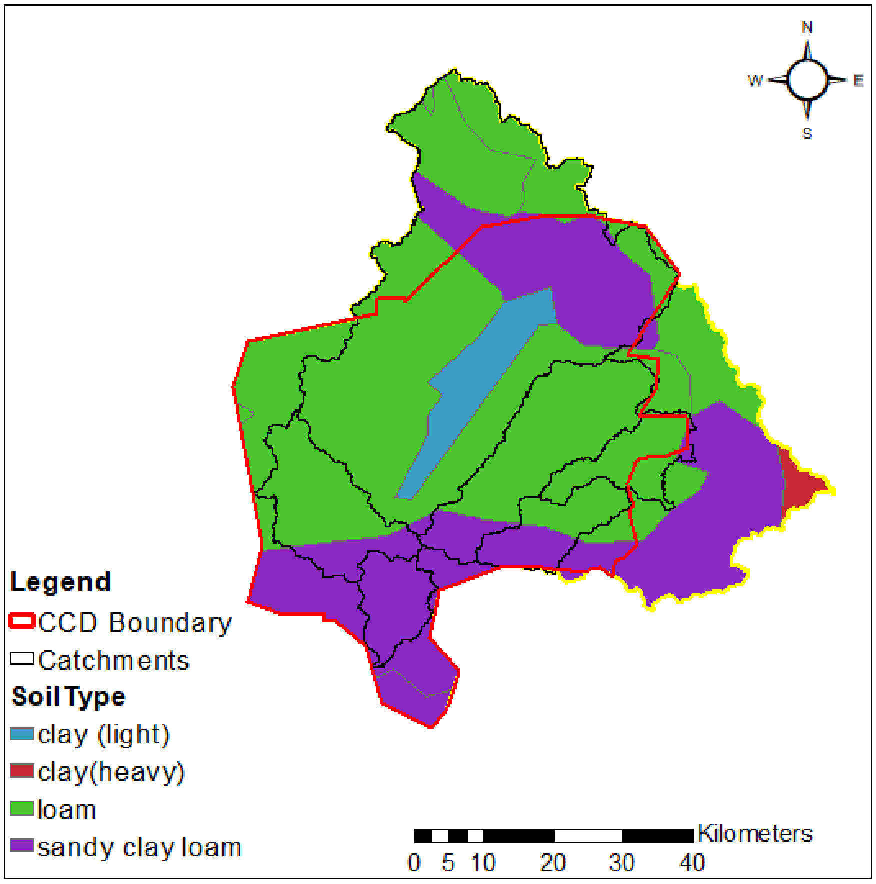

Fig. 49 Soil Map for Dodoma City

Table 48. Soil Characteristics and the Coverage in Dodoma City

S/No.	Soil Name	Soil Type	Area(km^2)	Coverage (%)	HydroGroup
1	Phaeozems	sandy clay loam	395.74	9.98	C
2	Leptosols	loam	350.49	8.84	B
3	Vertisols	clay (light)	185.41	4.68	D
4	Acrisols	loam	2006.29	50.61	B
5	Cambisols	sandy clay loam	989.46	24.96	C
6	Luvisols	clay(heavy)	37.22	0.94	D

3.2. Hydro-meteorological Data Acquisition

3.2.1. Temperature, Related Humidity and Evaporation

Temperature, related humidity and evaporation data were collected in order to characterize the climate of a region. Relevant data was found in the River Basin Water Board (RBWB) database for Dodoma airport and for the period 1970-2010. The analysis results are presented in Table 49 and in Fig. 50. The main observations are as follows:

- Pan evaporation is maximum between October and March with a peak in October corresponding more or less to the rainy season. Pan evaporation is minimum in April and July.
- Annual pan evaporation is big. This can be explained by the lower relative humidity which is a semi-arid region characteristic.

Table 49. Temperature, Relative humidity, pan and potential evaporation at Dodoma Airport

Period of 1970-2010		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Annual
Temperature	(℃)	24.8	24.6	24.1	24.1	23.8	23.3	22.4	20.8	20.1	20.8	22.2	23.8	22.9
Relative humidity	(%)	55	60	62	62	64	66	64	61	59	58	55	52	60
Pan Evaporation	(mm)	288	255	231	213	242	185	187	185	195	264	300	327	2872
Potential evaporation	(mm)	210	164	143	132	146	141	148	146	156	190	201	232	2007

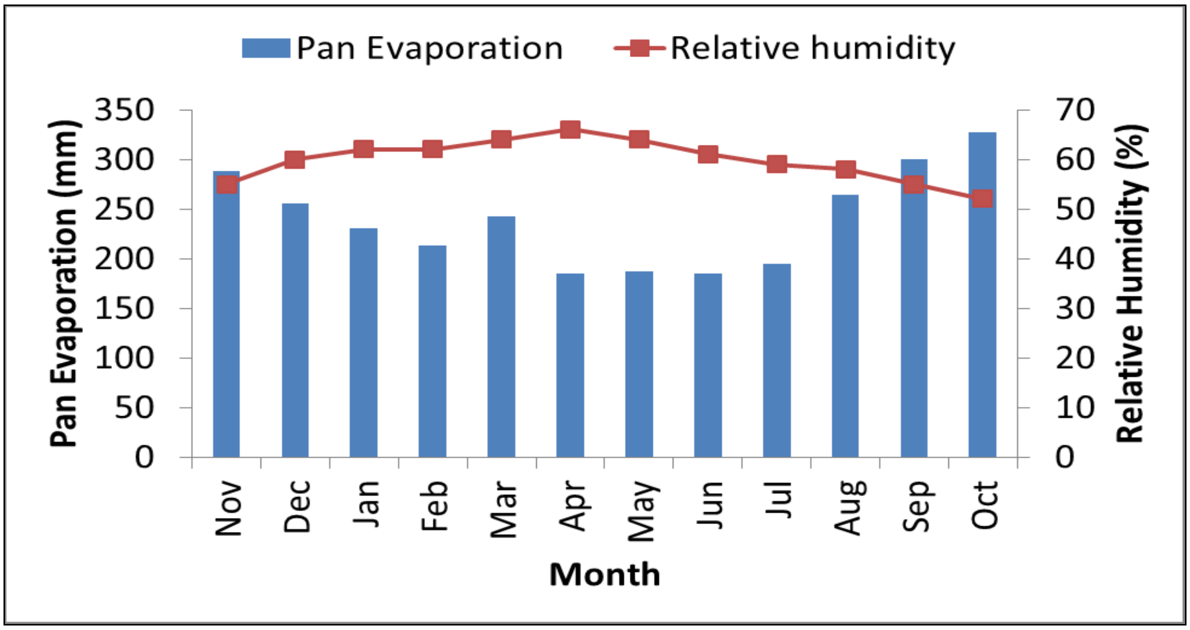

Fig. 50 Pan Evaporation and Relative Humidity at Dodoma Airport station

3.2.2. Rainfall

The collection of rainfall data involved extensive consultations with basin water board, Tanzania Meteorological Agency (TMA) and other sources like researchers from academic and research institutions. Fig. 51 shows the distribution of rainfall stations within and around CCD while Table 50 presents their inventory.

For the daily rainfall data, statistic measures such as min, max, standard deviation (SD), Coefficient of variation (CV), Skewness, Kurtosis and the total rainfall for very wet days (Rvwd) were calculated. The procedure for calculation Rvwd were:

- Identifying the wet days (daily precipitation >= 1 mm)
- Computing the 95th percentile of precipitation on wet days (PRwn95)
- Identifying the very wet days (daily precipitation >= PRwn95)
- Computing the total precipitation on the very wet days:

Generally, the main observations are as follows:

- The rainfall regime is unimodal with one rainy season from November to April.
- Dry and wet years are relatively evenly distributed over the long observation period.
- The long-term rainfall evolution may be partly described by cycles of dry and wet periods.
- The rainfall variability is high especially at the daily time step.
- Heavy storms tend to occur as a consequence of tropical disturbances prevailing over large areas
- The maximum daily rainfall (269.2mm) was observed at Bihawana farmers station in year 1999 (Table 51).
- Mean annual rainfall (MAR) ranges between 483-710mm (Table 52)

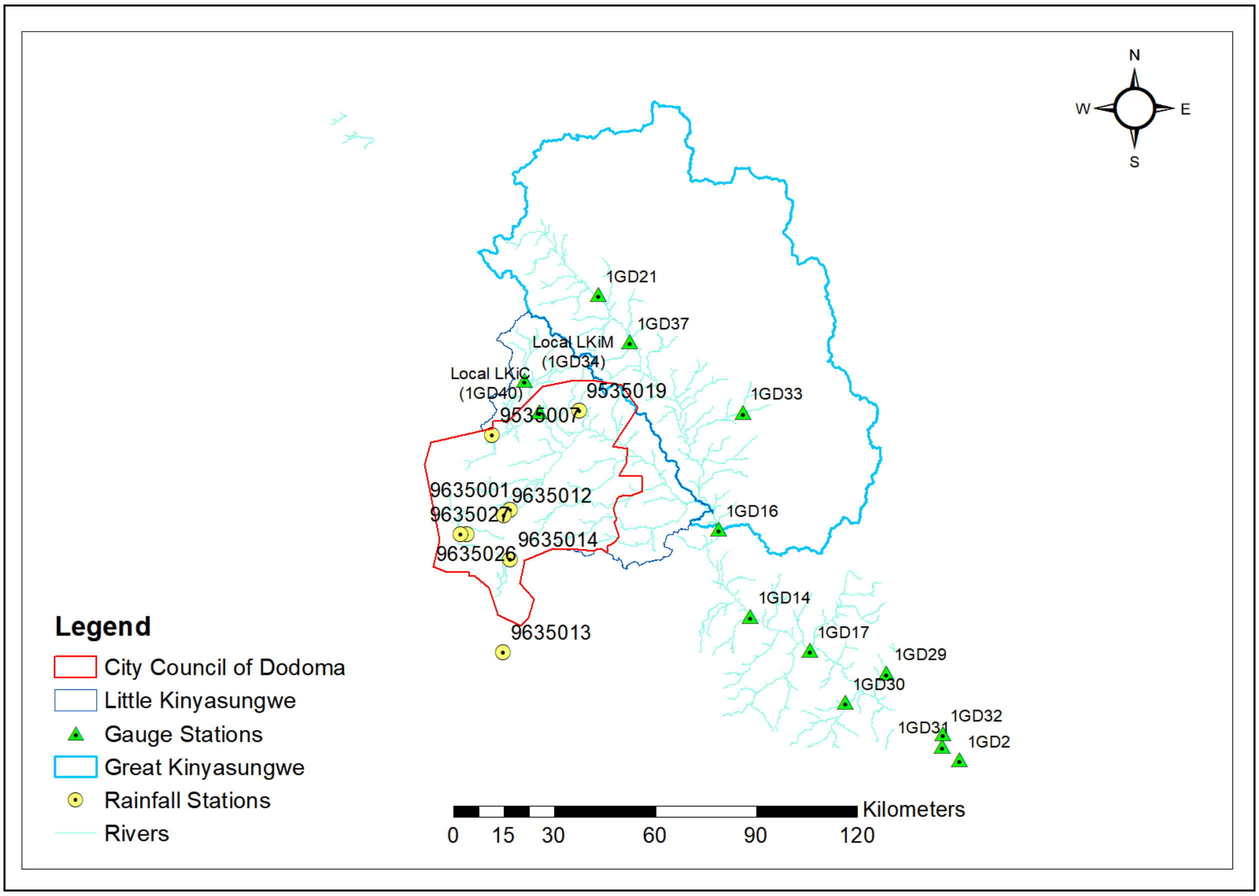

Fig. 51 Distribution of rainfall stations within and around Dodoma City

Table 50. Inventory of the Rainfall Stations within and around Dodoma City

Station code	Station Name	Lat. [ºS]	Long. [ºE]	Elevation [m.a.s.l]	Available Records
9635001	Dodoma Airport	-6.167	35.767	1,120	1932, 1935 - 2013
9635026	Bihawana Seminary	-6.233	35.650	999	1983 - 1996, 2001 - 2013
9635027	Bihawana Farmers	-6.233	35.633	999	1987 - 2013
9635012	Dodoma Maji	-6.183	35.750	1,133	1961 - 1990, 1992 - 2013
9635014	Matumbulu Dam	-6.300	35.767	1,067	1962 - 1995
9635013	Mlowa Dam	-6.550	35.750	914	1962 - 1985, 1990 - 1995
9535007	Makutopora Maji	-5.966	35.7166		1967 - 1999
9535019	Hombolo Agromet	-5.9	35.95		1974 to 1997

Table 51. Statistic Summary of the Analyzed Daily Rainfall Data

Station Name	Min.	Mean	Max.	SD	CV	Skewness	Kurtosis	Rvwd	NA's	n
Dodoma Airport	0.000	1.57	119.8	6.9437	4.4215	6.9892	61.9416	10,965.3	122	29221
Bihawana	0.000	1.661	118	7.2352	4.3563	6.6188	54.9843	3,224.1	1098	9862
Bihawana Farmers	0.000	2.104	269.2	10.0583	4.7801	9.5619	143.9943	3,961.6	2615	9862
Matumbulu	0.000	1.499	142.6	6.8022	4.5377	7.0835	67.8022	3,614.8	1185	12418
Mlowa Dam	0.000	1.351	114.4	5.9408	4.3977	6.945	64.5017	3,055.1	739	10957
Dodoma Maji	0.000	1.591	106	7.0158	4.4105	6.6627	55.0023	5,818.1	2810	18993
Makutopora Maji	0.000									
Hombolo Agromet	0.000									

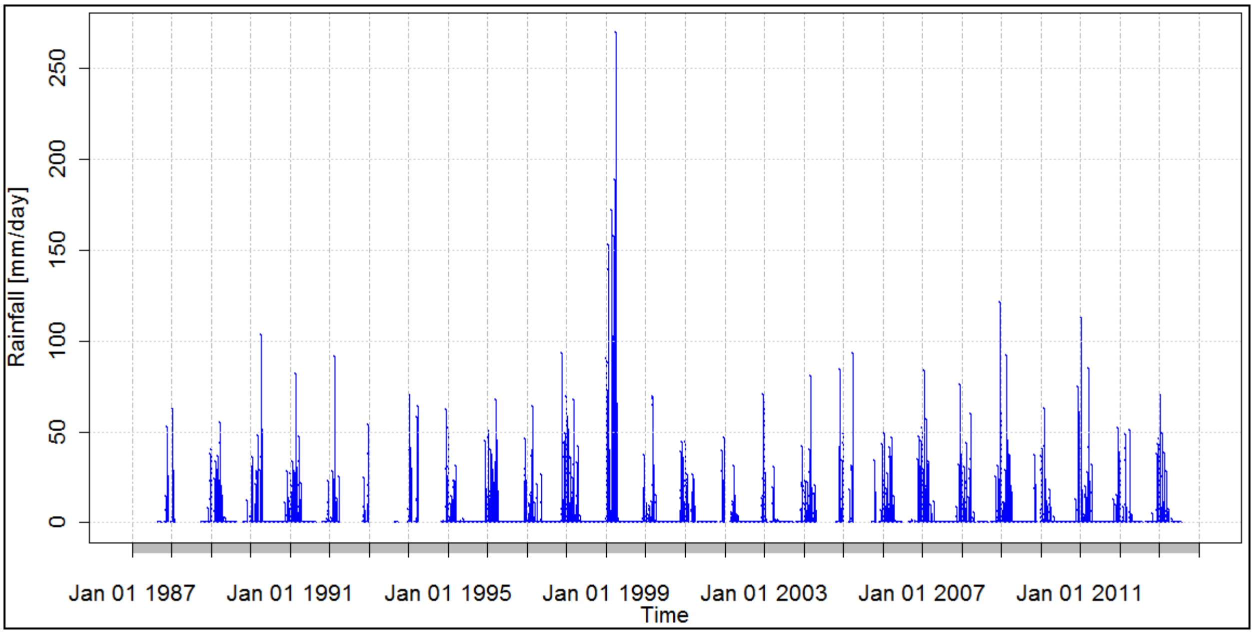

Fig. 52 Daily rainfall time series data for the Bihawana farmers station

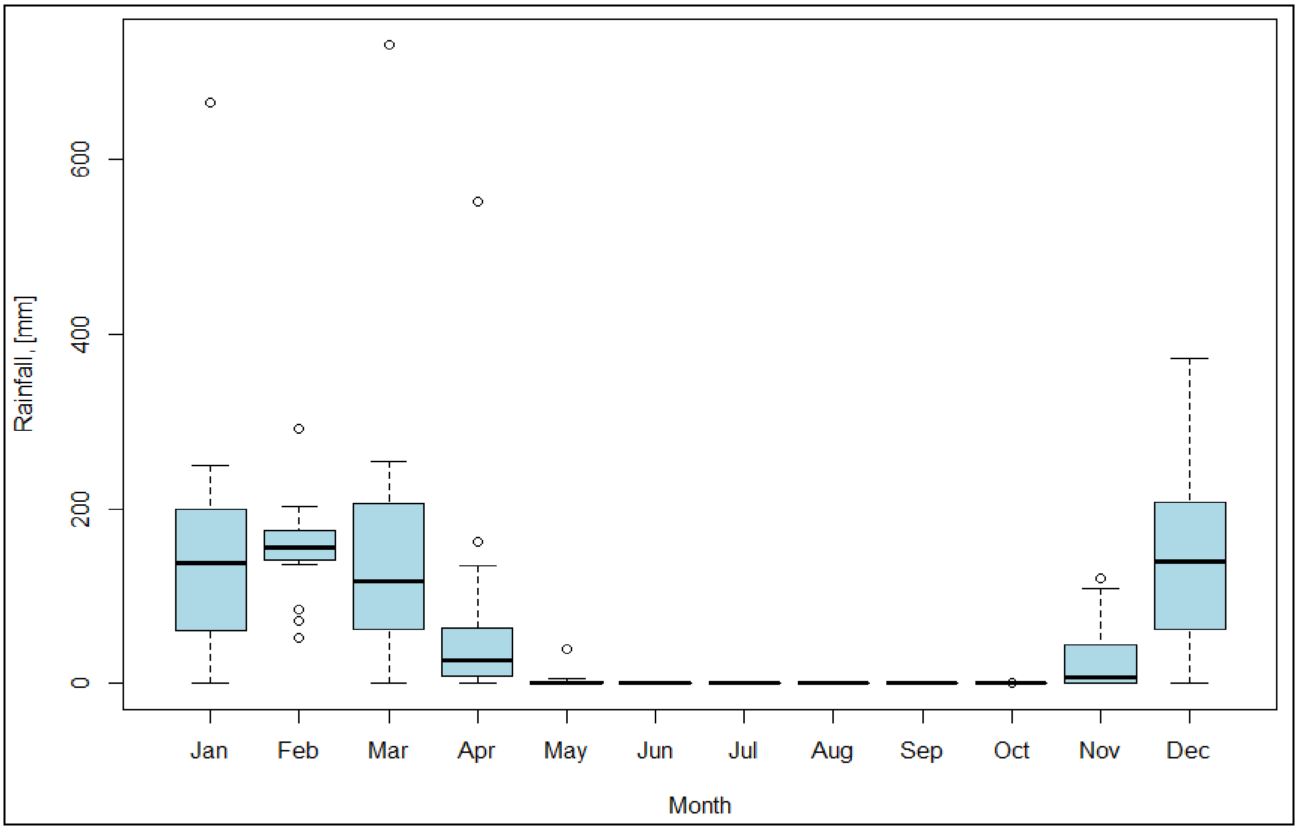

Fig. 53 Seasonal rainfall boxplot for the Bihawana farmers station

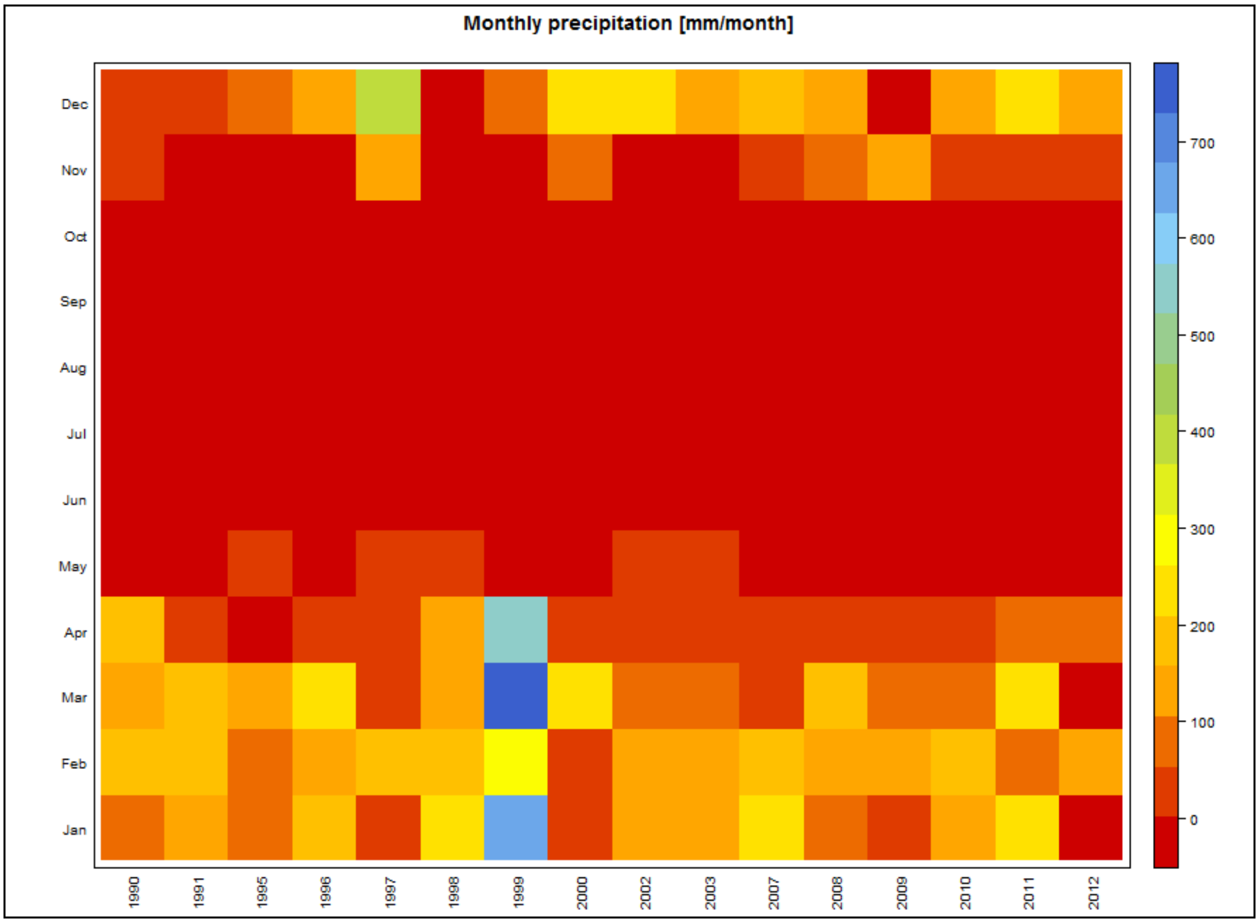

Fig. 54 Monthly rainfall time series data for the Bihawana farmers station

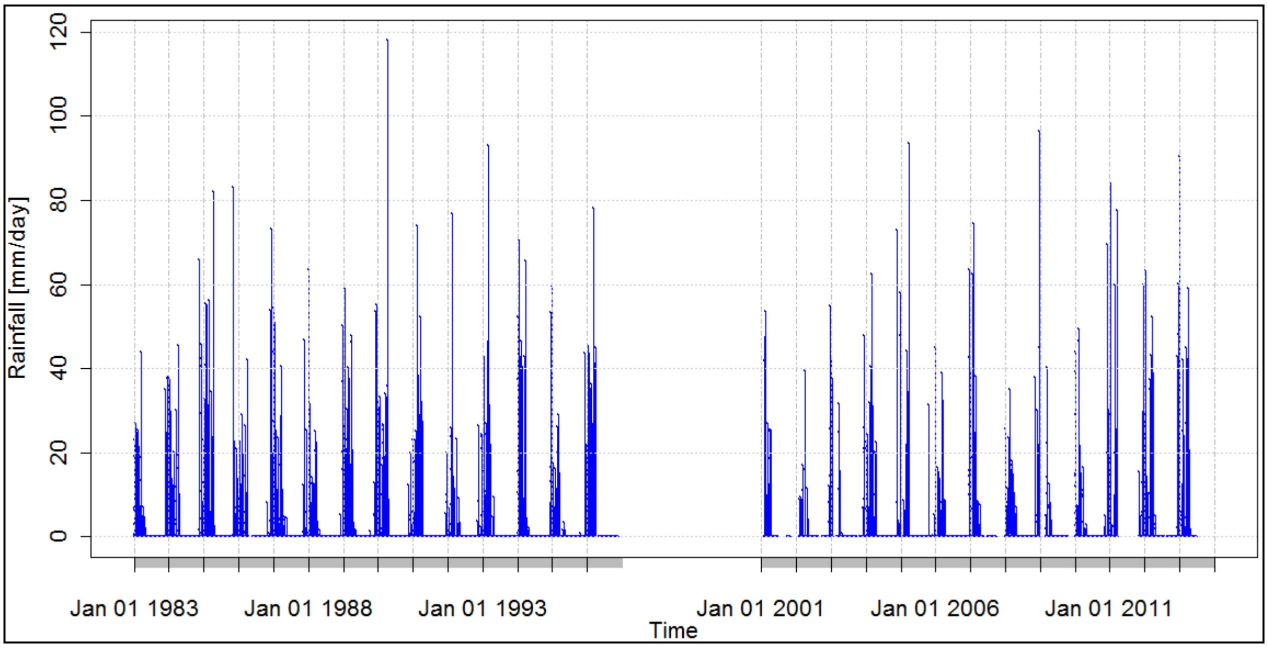

Fig. 55 Daily Rainfall Time Series Data for the Bihawana Seminary Station

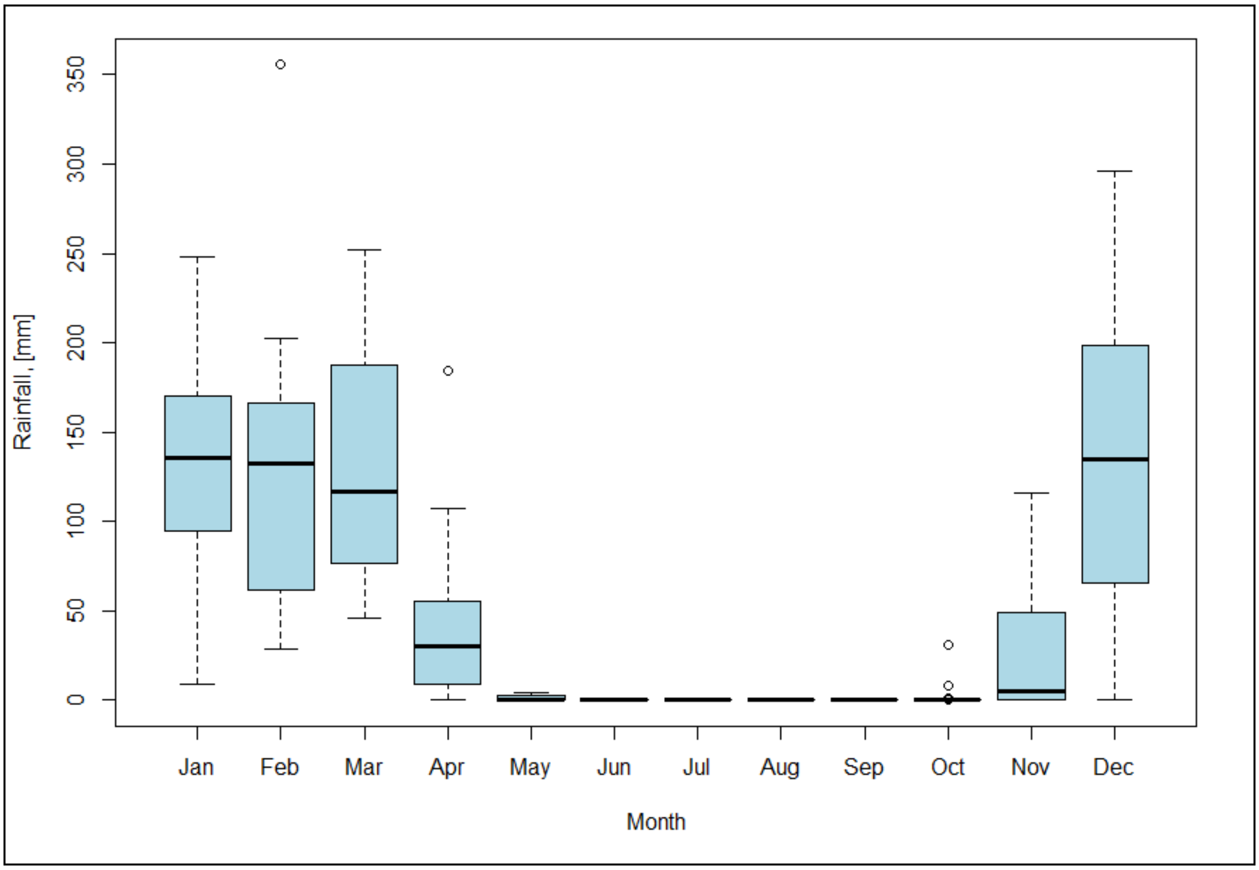

Fig. 56 Seasonal rainfall boxplot for the Bihawana Seminary station

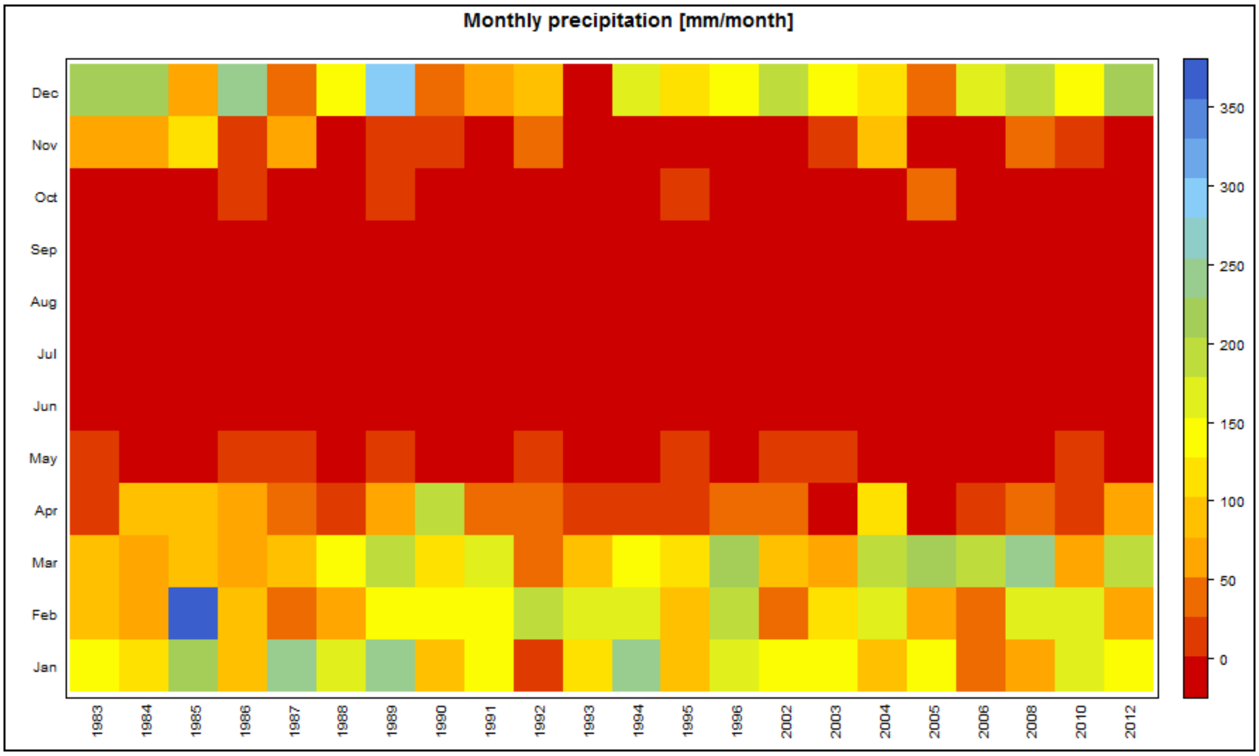

Fig. 57 Monthly rainfall time series data for the Bihawana Seminary station

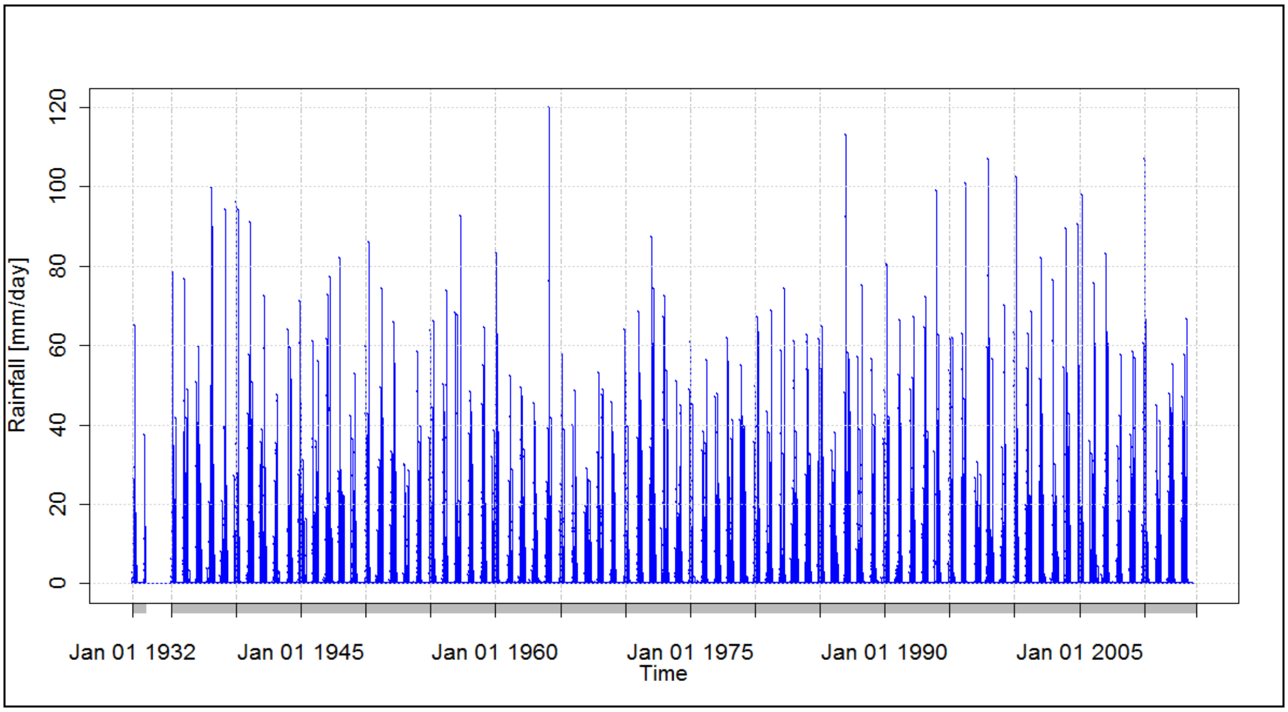

Fig. 58 Daily rainfall time series data for the Dodoma Airport station

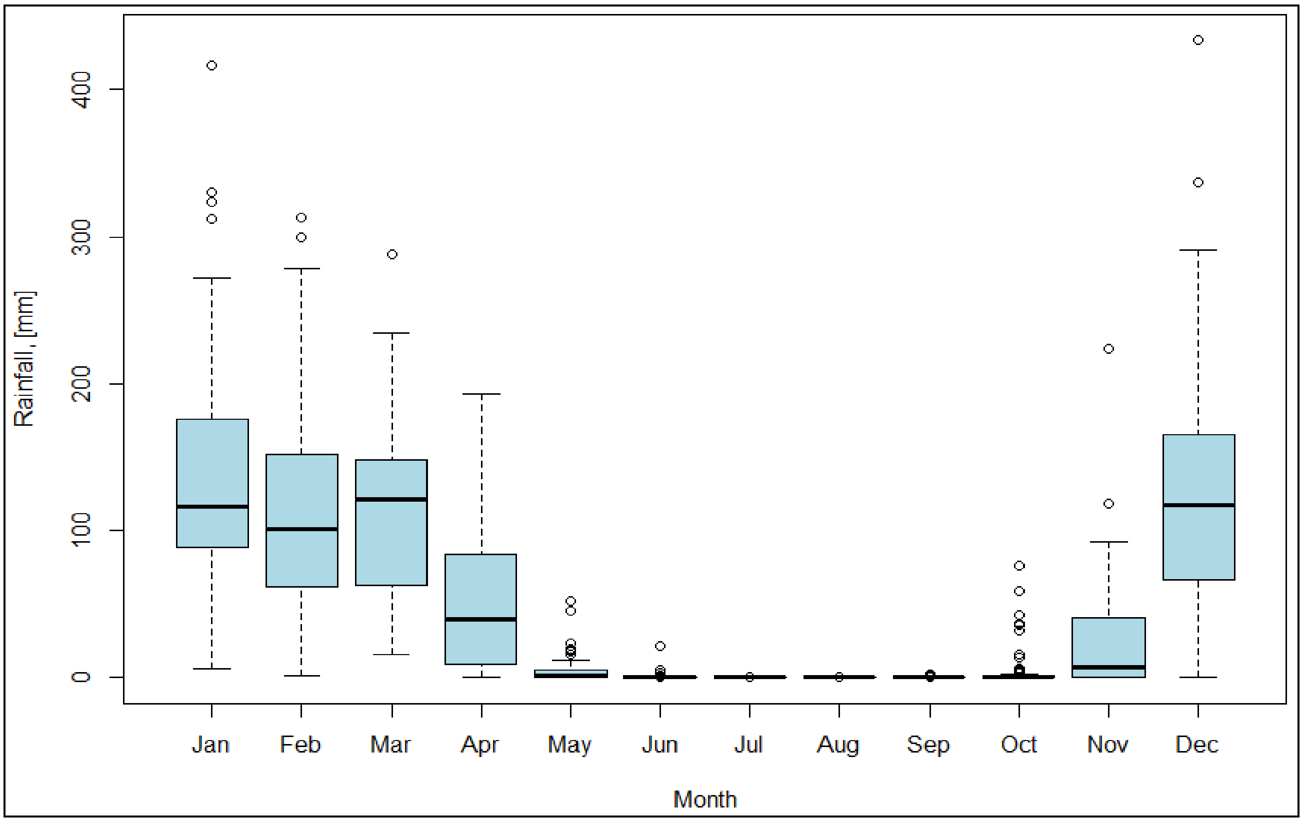

Fig. 59 Seasonal rainfall boxplot for the Dodoma Airport station

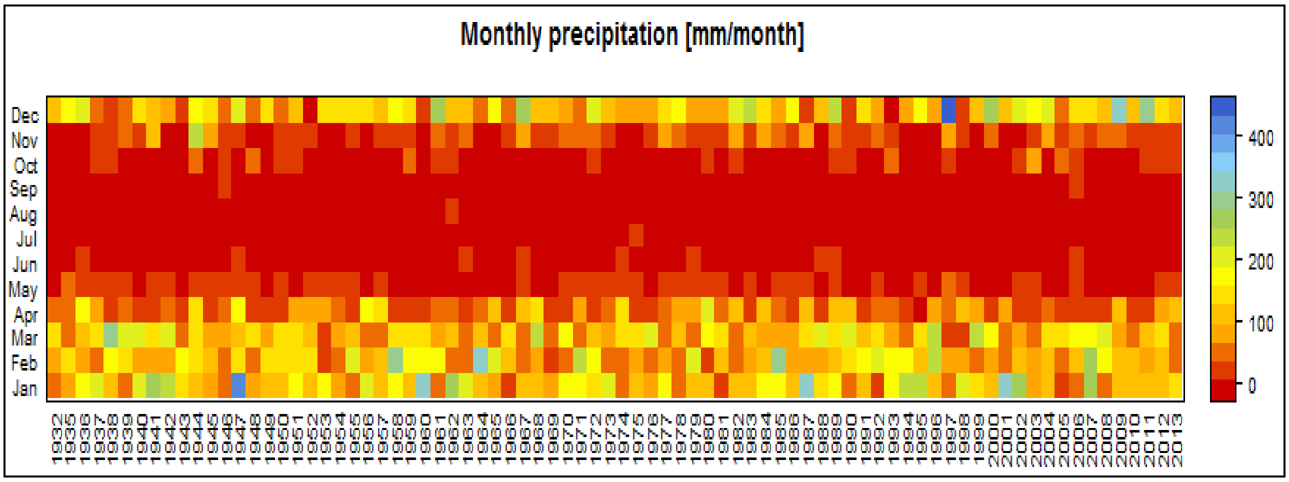

Fig. 60 Monthly rainfall time series data for the Dodoma Airport station

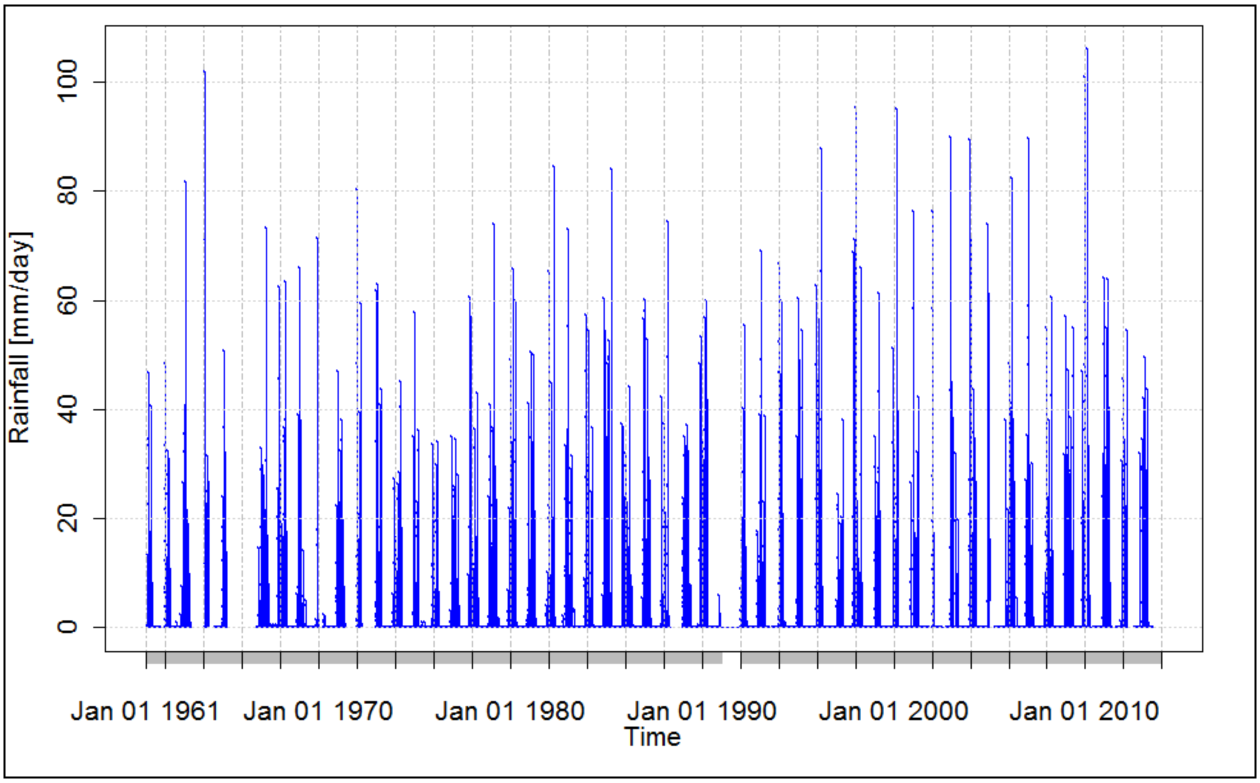

Fig. 61 Daily rainfall time series data for the Dodoma maji station

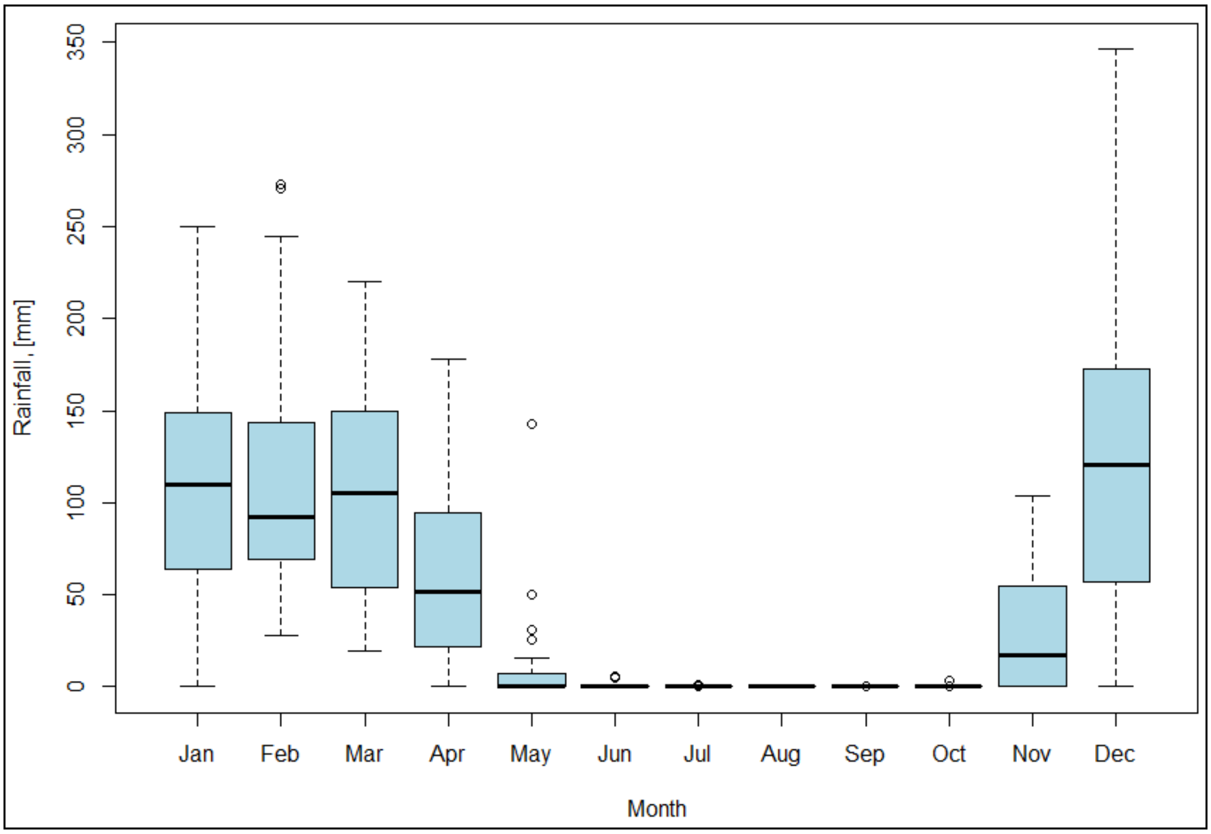

Fig. 62 Seasonal rainfall boxplot for the Dodoma maji station

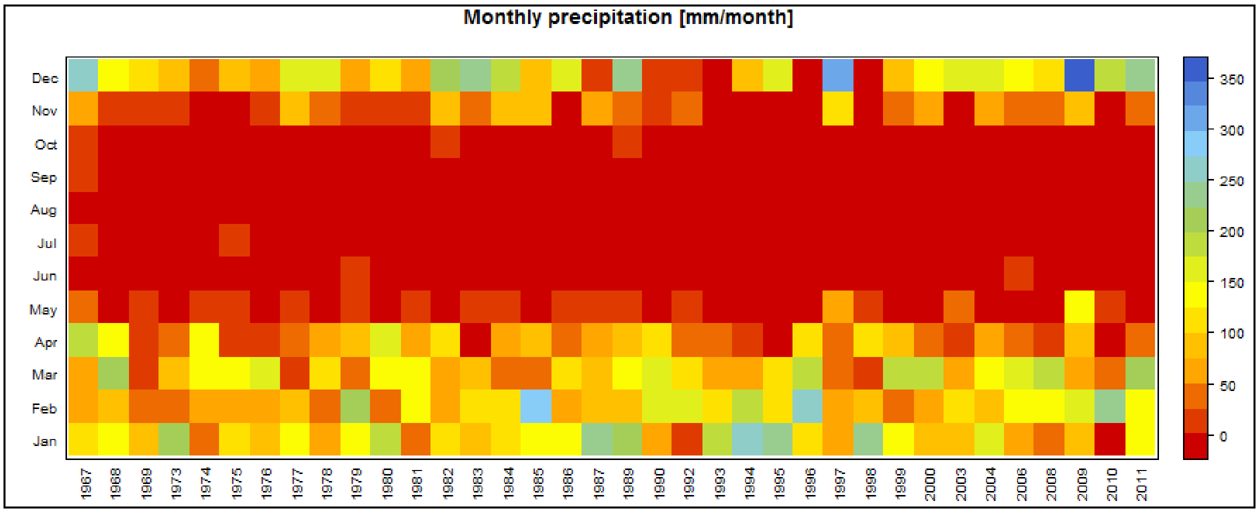

Fig. 63 Monthly rainfall time series data for the Dodoma maji station

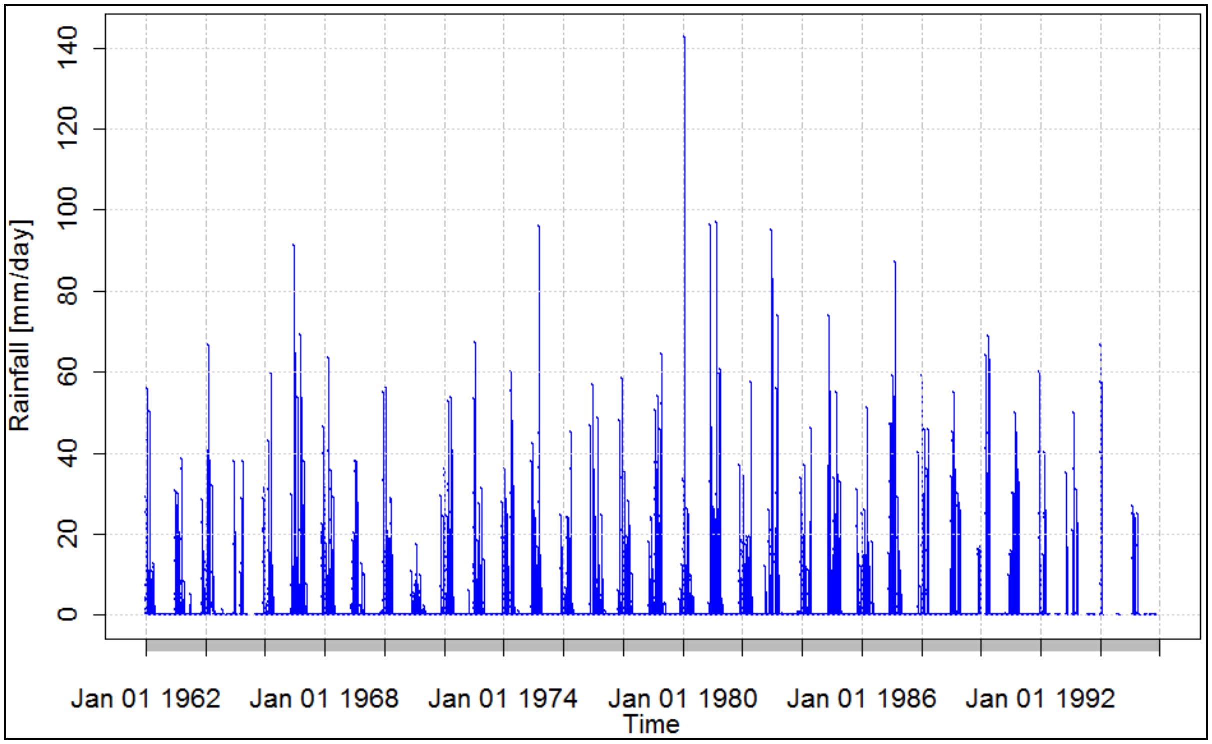

Fig. 64 Daily rainfall time series data for the Matambulu dam station

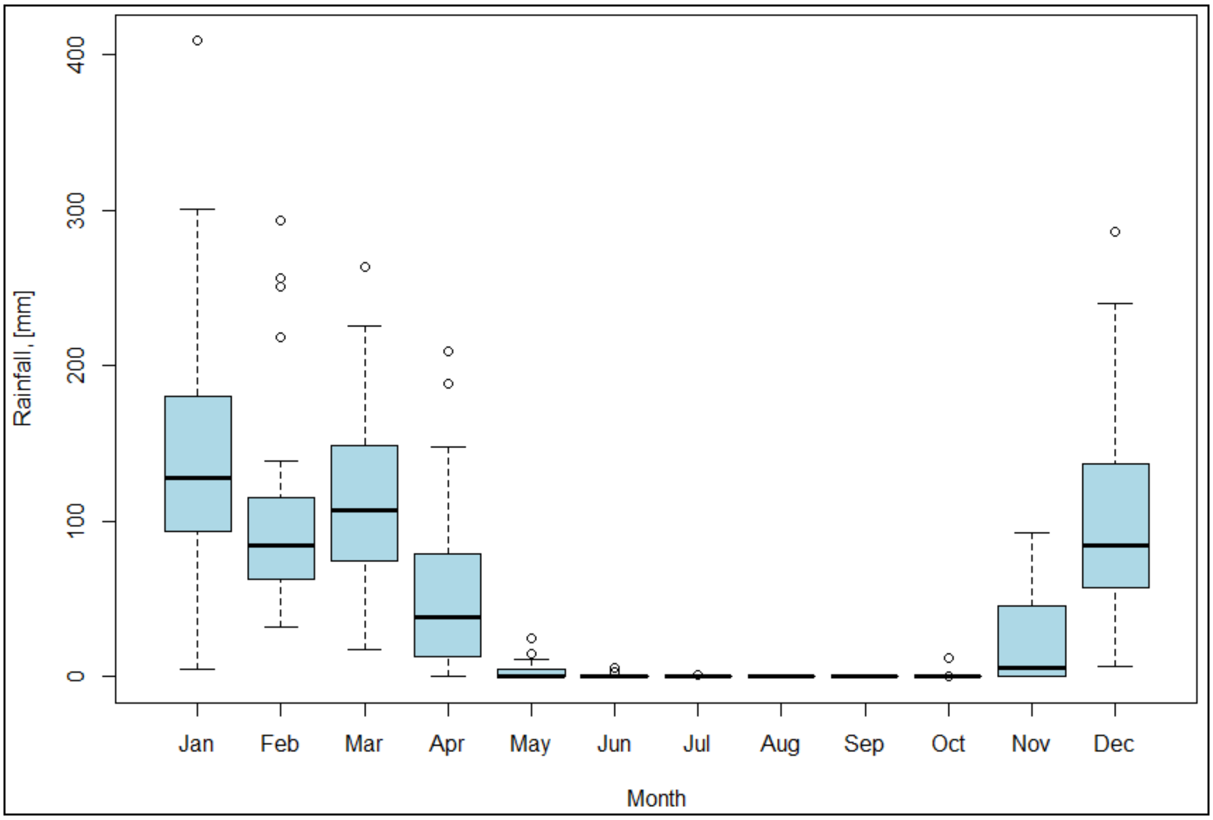

Fig. 65 Seasonal rainfall boxplot for the Matambulu dam station

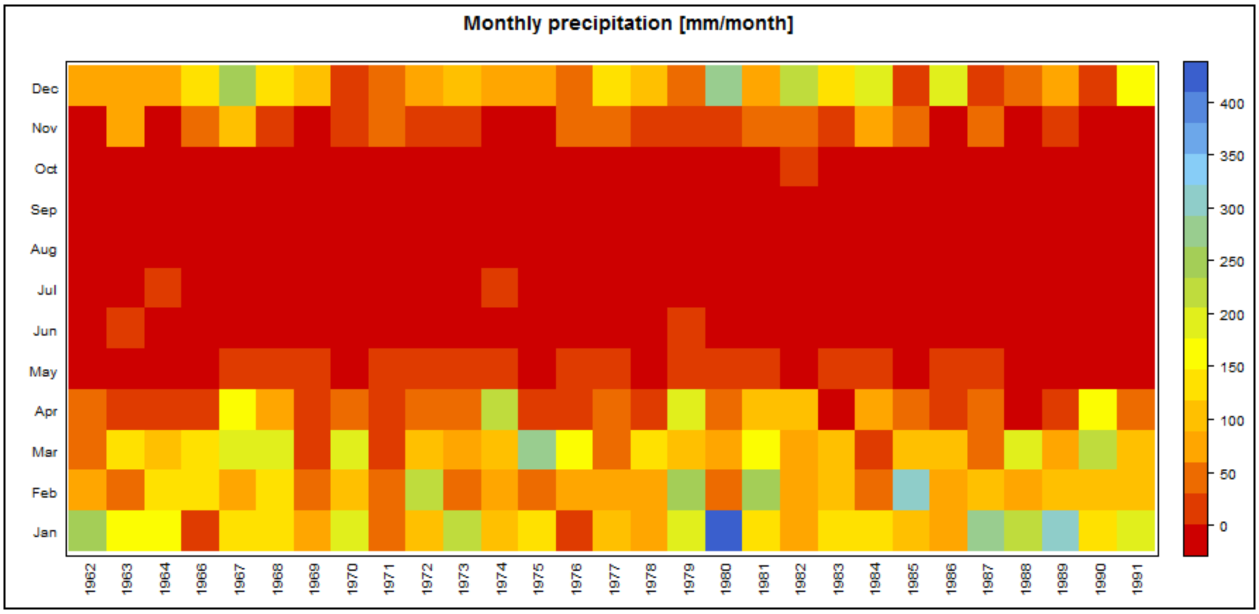

Fig. 66 Monthly rainfall time series data for the Matambulu dam station

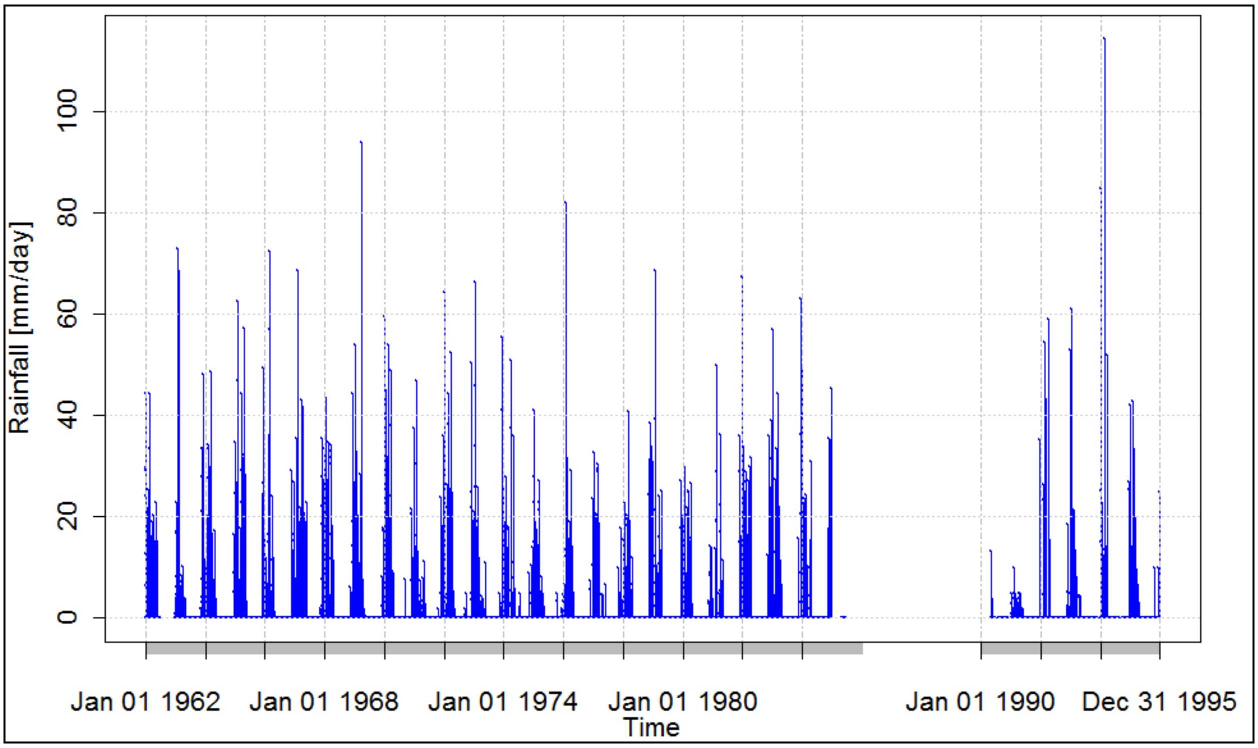

Fig. 67 Daily rainfall time series data for the Mlowa dam station

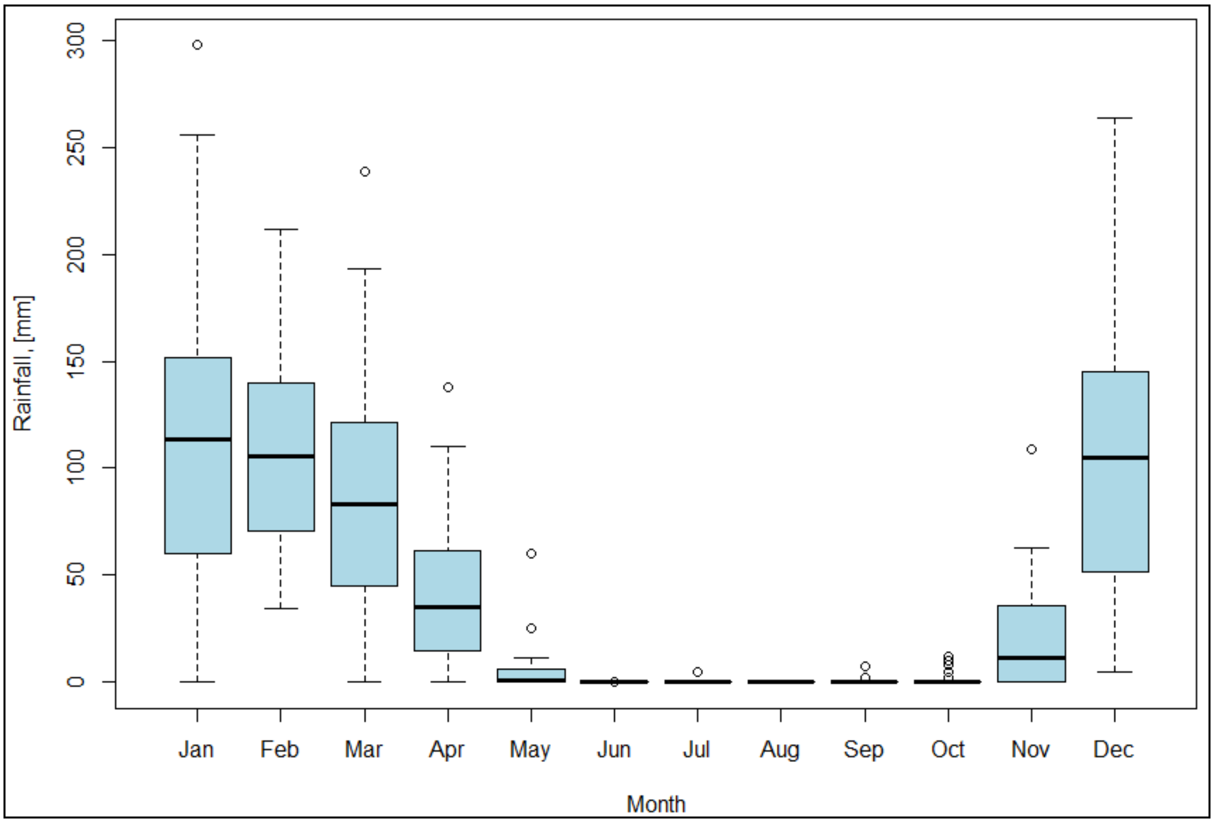

Fig. 68 Seasonal rainfall boxplot for the Mlowa dam station

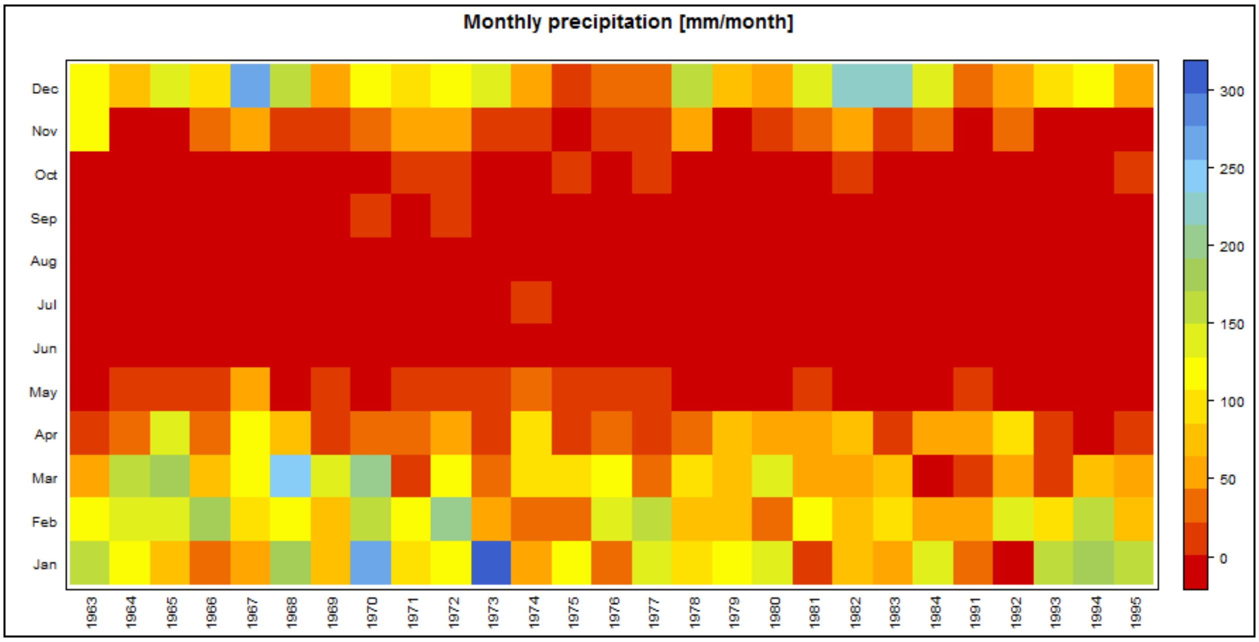

Fig. 69 Monthly rainfall time series data for the Mlowa dam station

Table 52 Mean annual rainfall (MAR) for the stations within and around CCD

Station name	Years selected	MAR
Bihawama Farmers	16	710.64
Bihawama Seminary	22	596.23
Dodoma Airport	80	573.44
Dodoma Maji	36	562.80
Matambulu Dam	29	551.36
Mlowa Dam	27	483.05
Makutopora Maji	29	533
Hombolo Agromet	23	635.80

3.2.3. Streamflows

Table 53. Streamflows

Station	River Name	Location	Lat.	Long.	Establish	Observation Period		Area (km2)
						Historical	Recent	
1GD16	Kinyasungwe	Kongwa/Dodoma (Old Dodoma Rd.Br.)	-6.218	36.327	28-Feb-58	1958-1987	2000-Up to now	6,656.0
1GD21	Kinyasungwe	Itiso	-5.590	36.000	17-Nov-71	-	2004-Up to now	900.0
1GD33	Masena	Ibumila	-5.903	36.390	24-Dec-72	-	-	240.0
Local LKiC	Little Kinyasungwe	Chihanga	-5.905	35.844	13-Sep-06	-	2006-Up to now	-
Local LKiM	Little Kinyasungwe	Mayamaya	-5.819	35.804	28-Feb-74	-	2006-Up to now	172.3
1GD37	Great Kinyasungwe	Ikombo	-5.716	36.085	30-Oct-71	1974-1991	2006-Up to now	951.0

3.3. Flood Risk and Vulnerability Hazard Mapping

3.3.1. Flood hazard zones delineation

The flood generating factors, such as slope, elevation, rainfall, drainage density, land use, and soil type in the CCD were rated and combined to delineate flood hazard zones using multi-criteria AHP techniques in a GIS environment.

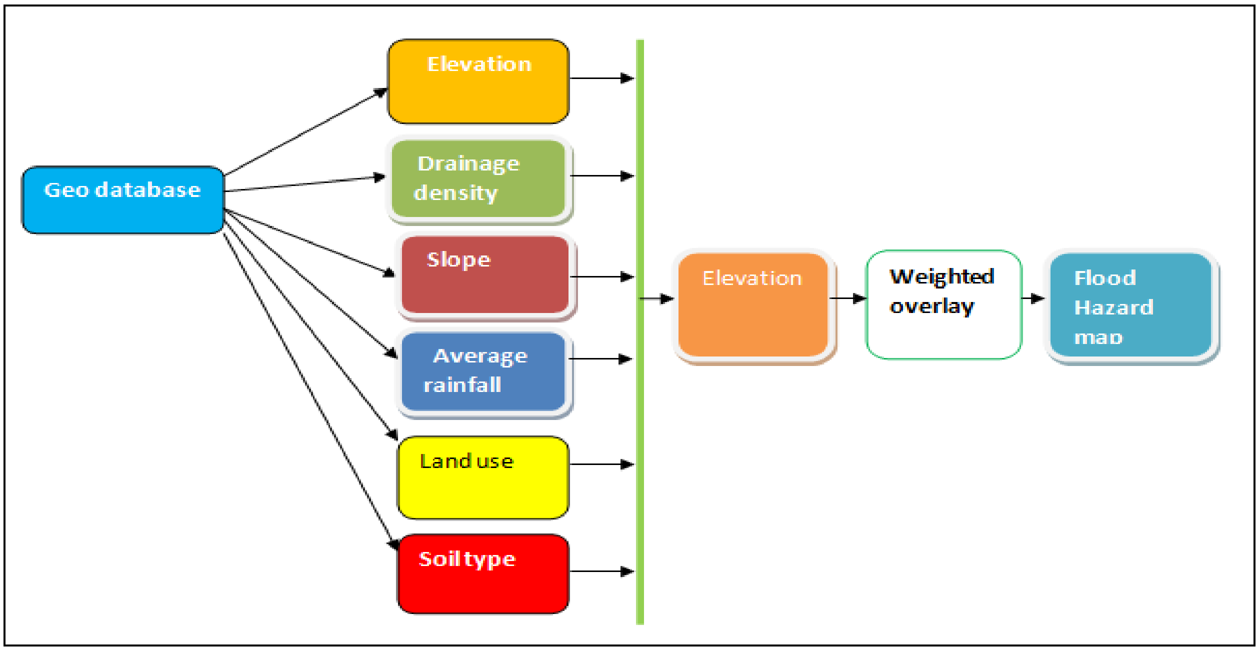

Fig. 70 Methodology for flood hazard mapping

3.3.2. Flood hazard factor analysis

The rasterized and classified flood generating factors have to be weighted. In this study Saaty`s approach was used based Analytic Hierarchy Process (AHP), where a pair-wise comparison was prepared for each map using a nine-point importance scale (Table 55). According to Saaty, (1980) AHP is a multi-criteria decision-making technique, which provides a systematic approach for assessing and integrating the impacts of various factors, involving several levels of dependent or independent, qualitative as well as quantitative information. It is a methodology to systematically determine the relative importance of a set of activities or criteria by pair wise comparison.

The computed Eigen Vector values (Table 56) were used as coefficient for the respective flood factors that is elevation, land use, rainfall, drainage density, slope and soil type layers to be combined in weighted overlay in ArcGIS to generate the final flood hazard map of Dodoma City, using the following equation: Flood hazard=0.439 × [Elevation]+0.239 × [Drainage density]+0.134 × [Slope]+0.092 × [Rainfall]+0.059 × [Land use]+0.038 × [Soil type]

Table 54. Satty's Scale (weight) for Pair-wise Comparison of Flood Factors

Less important				Equally important
extremely	Very strong	Strongly	moderately	
1/9	1/7	1/5	1/3	1

Table 55. The weights for the pair-wise comparison matrix of flood generating factors in the Dodoma City

	Elevation	Drainage	Slope	Rainfall	Land use	Soil type
Elevation	1					
Drainage density	1/5	1				
Slope	1/3	1/3	1			
Rainfall	1/5	1/5	1/3	1		
Land use	1/5	1/7	1/5	1/3	1	
Soil type	1/7	1/7	1/5	1/3	1/3	1

Table 56. The Eigen Vector weights of each flood factor obtained after the pair-wise comparison

Elevation	0.439
Drainage density	0.239
Slope	0.134
Rainfall	0.092
Land use	0.059
Soil type	0.038

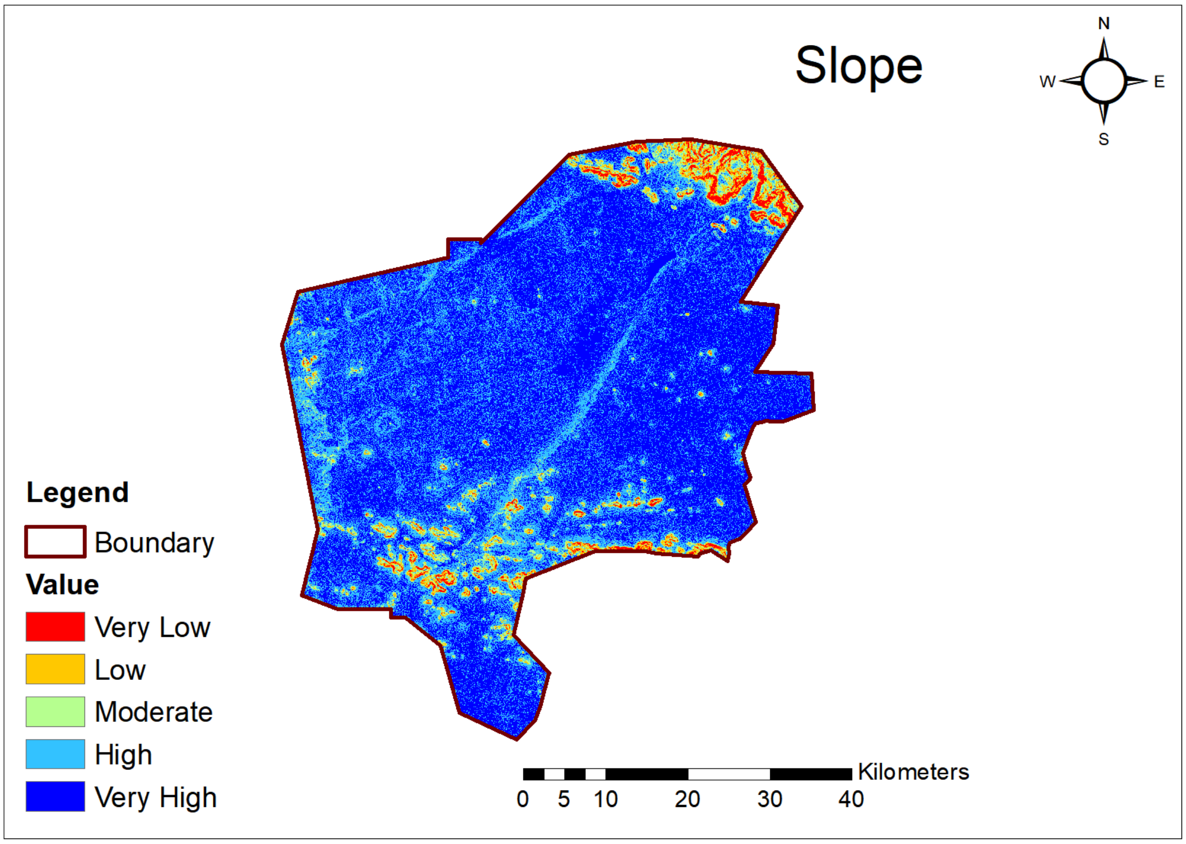

Fig. 71 Susceptibility to flooding: rating of slope

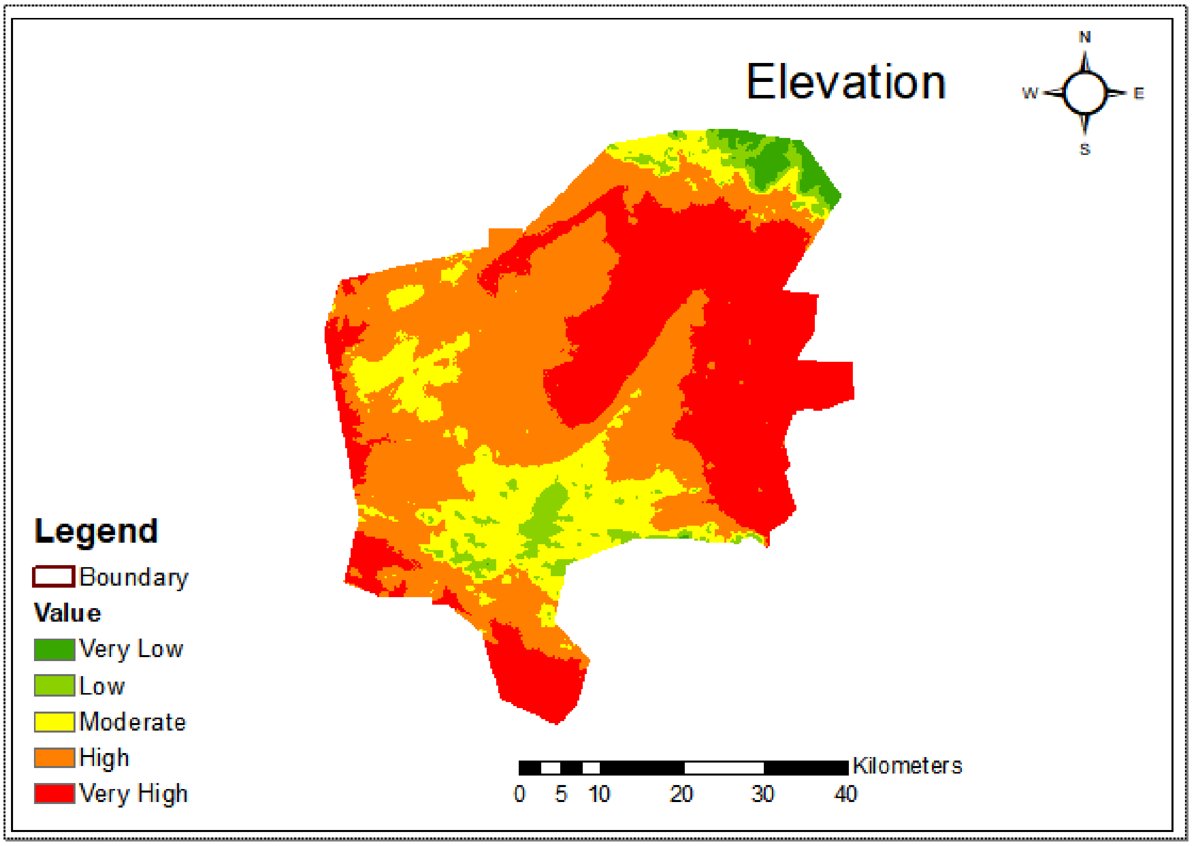

Fig. 72 Susceptibility to Flooding: Rating of Elevation

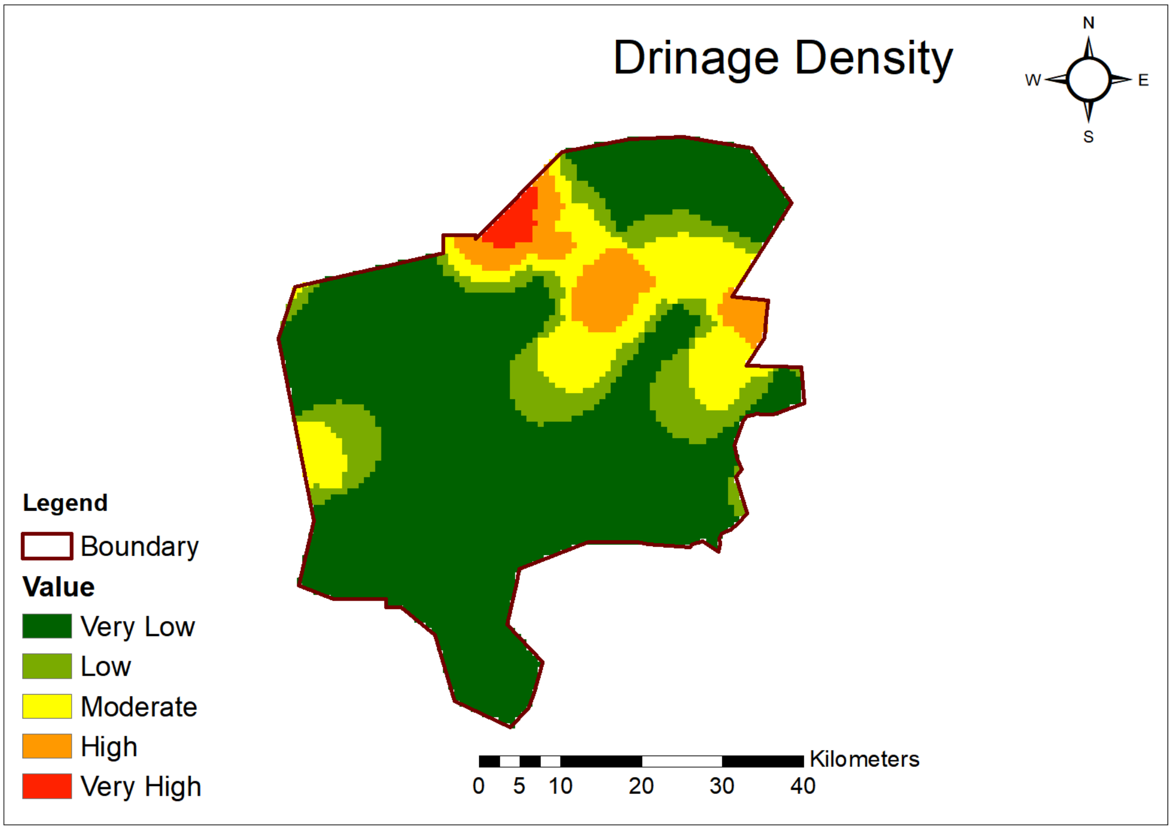

Fig. 73 Susceptibility to Flooding: Rating of Drainage Density

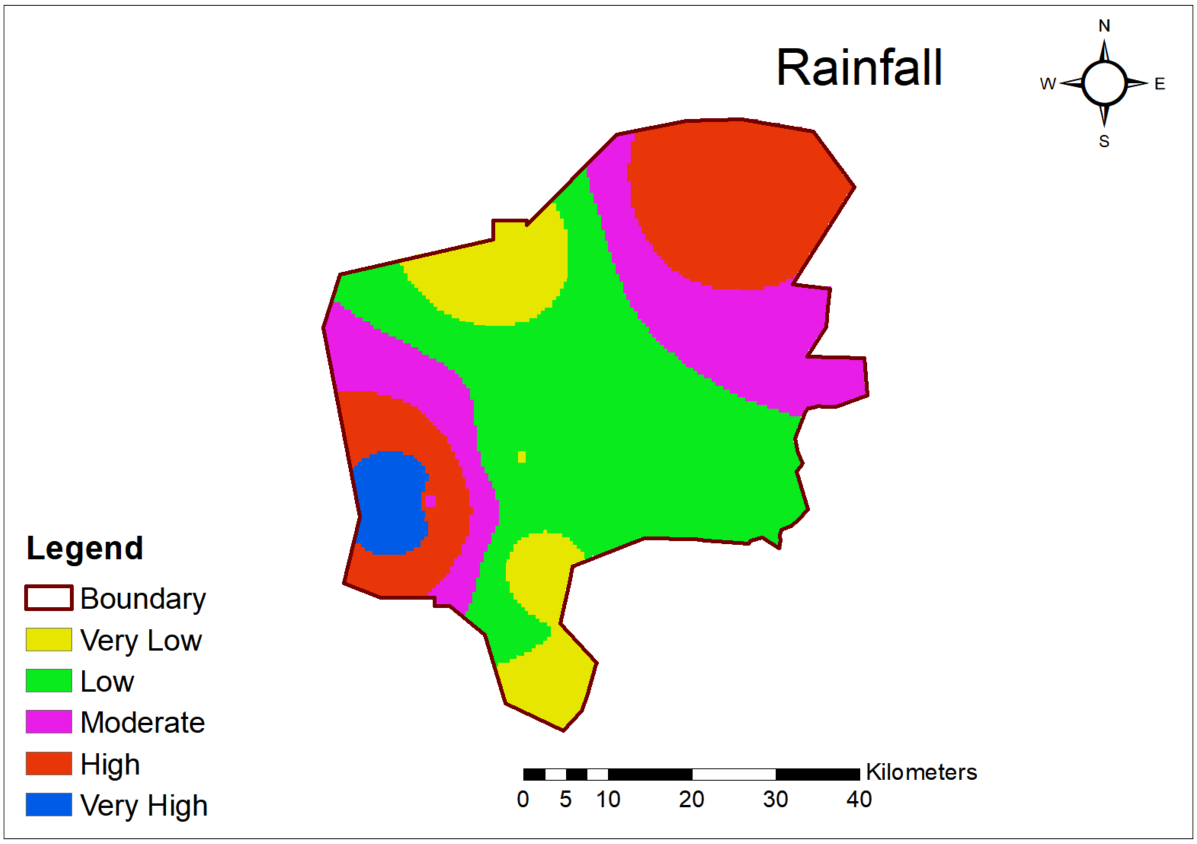

Fig. 74 Susceptibility to flooding: rating of drainage rainfall

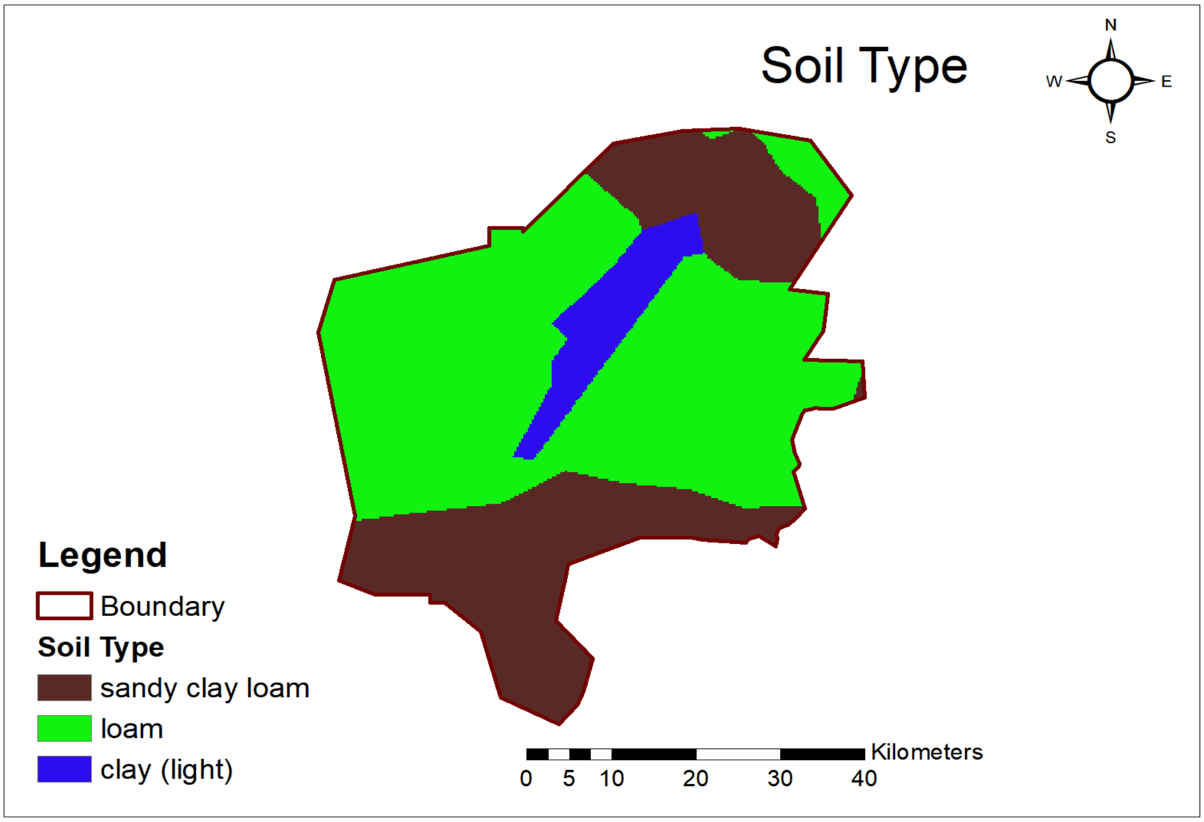

Fig. 75 Susceptibility to Flooding: Rating of Soil Type

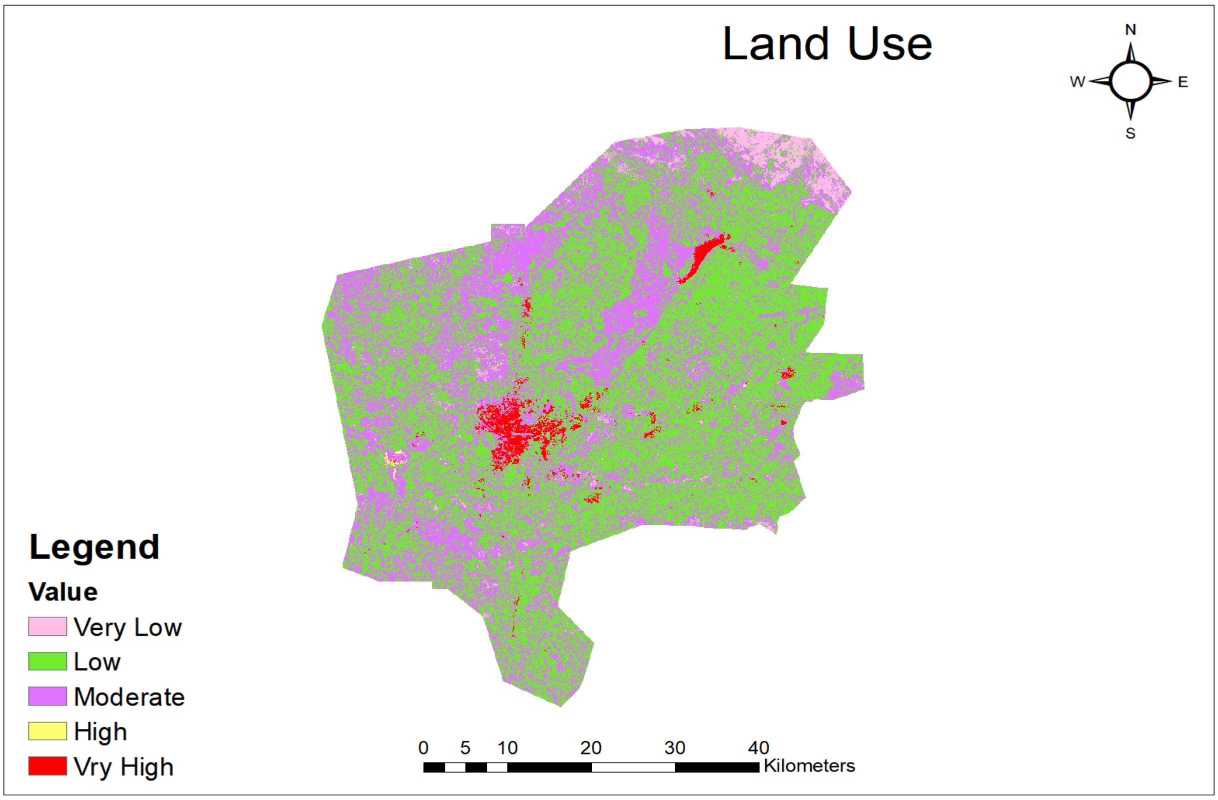

Fig. 76 Susceptibility to flooding: rating of land use

3.3.3. Flood hazard map

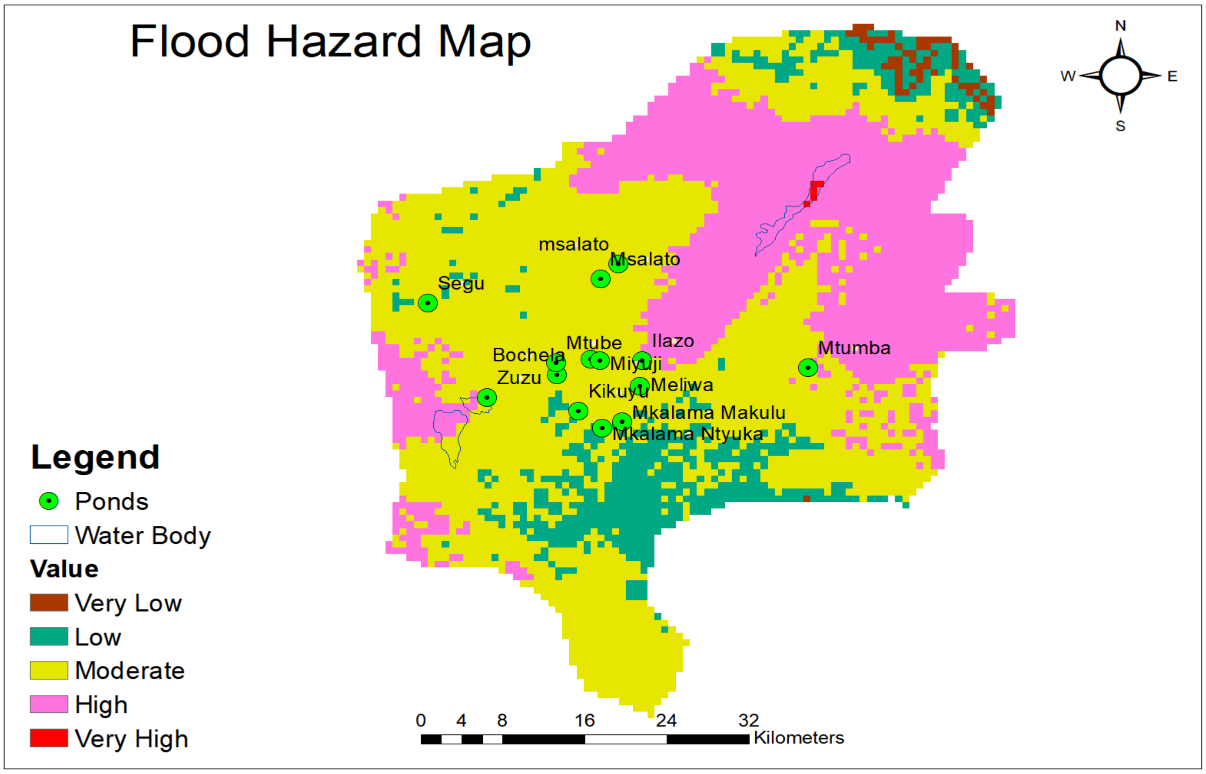

Fig. 77 Flood Hazard Map of Dodoma City

4. City Scale Flood Model

4.1. Delineation of the Drainage Catchments

A total of six (6) catchments draining the CCD have been delineated. Catchments C1 up to C4 drains to the little Kinyasungwe river which joins the Greater Kinyasungwe river about 20km from the CCD boundary.

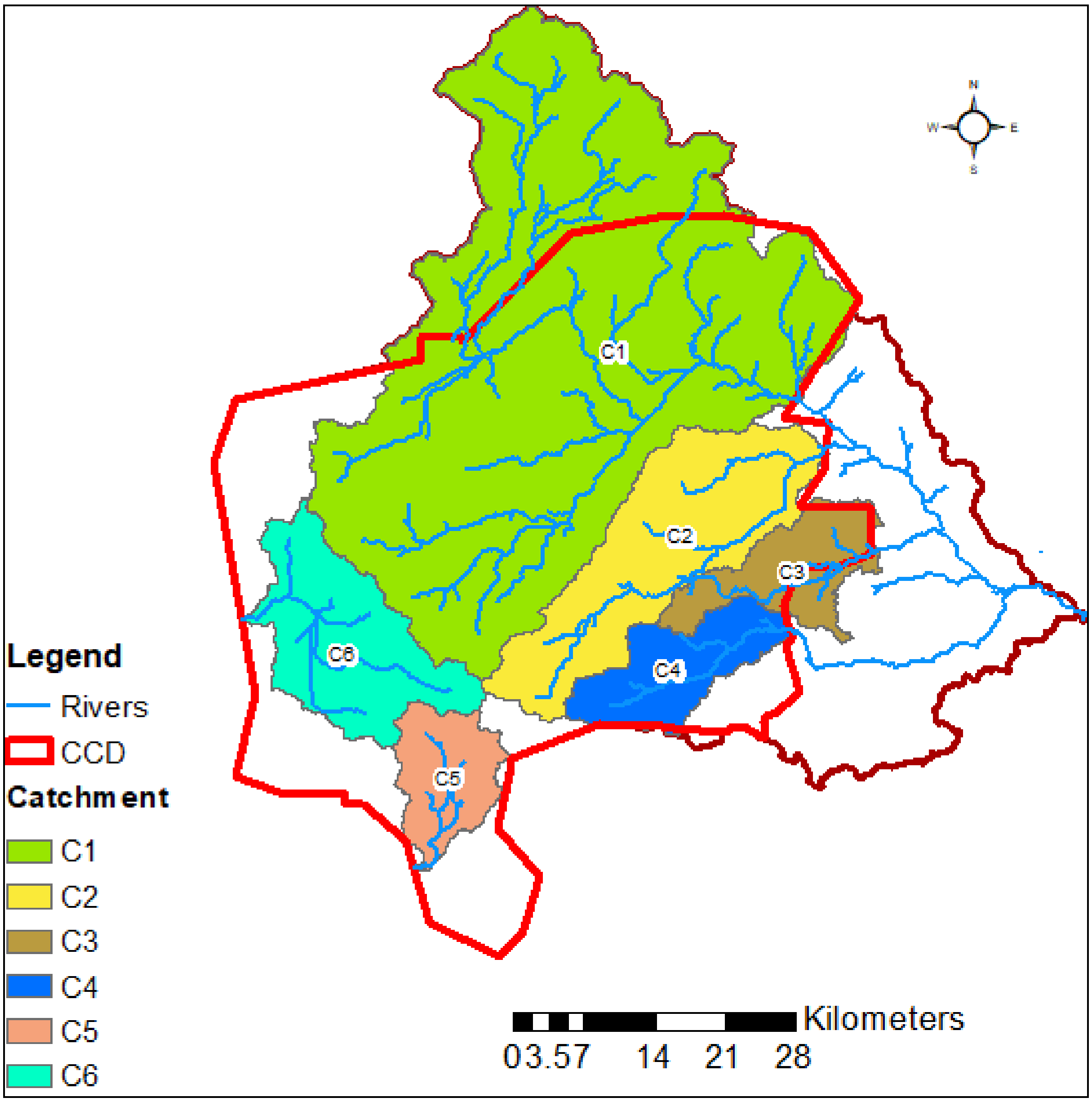

Fig. 78 Catchments Draining the Dodoma City

4.2. Physical Characteristics of the Catchments

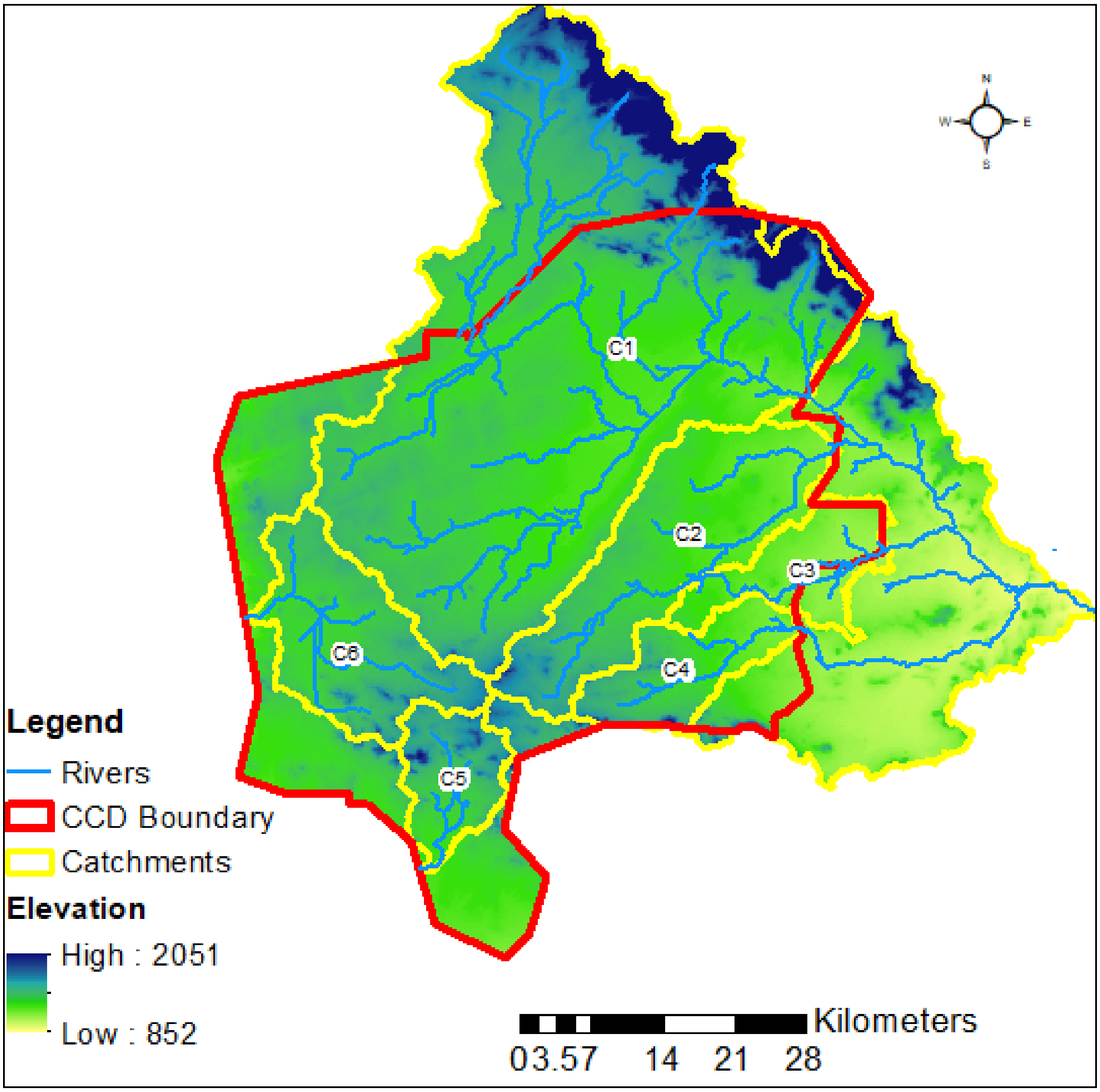

Fig. 79 Digital terrain model (30m) in the Dodoma City catchments

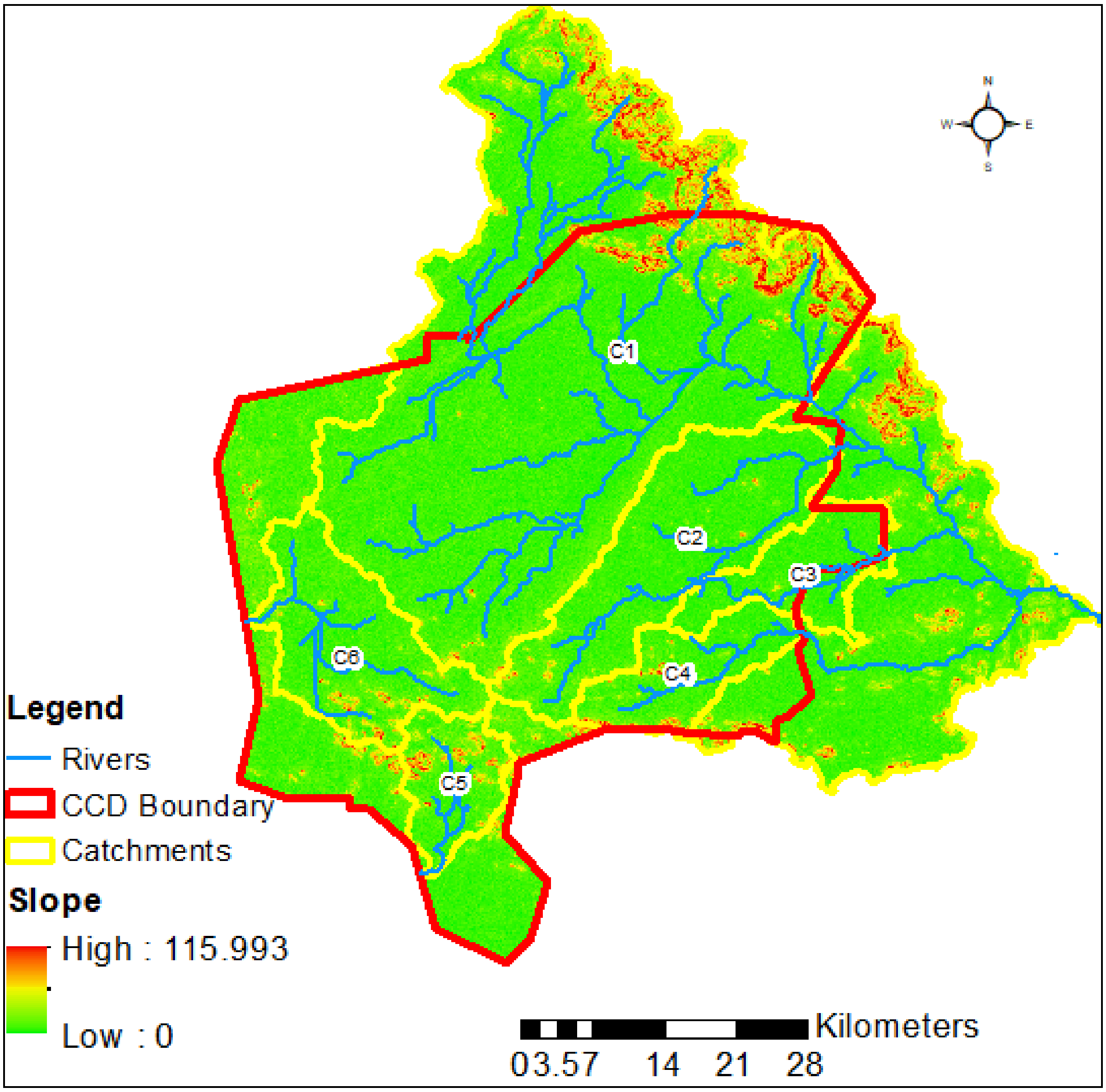

Fig. 80 Slope Distribution in Dodoma City Catchments

Table 57. Summary of the physical catchment characteristics

Catchment Code	Catchment Name	Area (km^2)	River Length (m)	River Slope (%)	Catchment Slope (%)
C1a	W240	105.30	1,116.60	0.00	13.03
C1b	W250	55.23	9,101.85	0.01	6.54
C1c	W260	105.35	11,742.74	0.00	3.84
C1d	W270	112.88	8,110.56	0.00	14.23
C1e	W280	64.12	16,986.52	0.00	13.46
C1f	W290	37.97	561.28	0.00	3.32
C1g	W300	124.49	5,358.93	0.00	13.95
C1h	W310	148.48	27,061.81	0.00	4.32

Catchment Code	Catchment Name	Area (km^2)	River Length (m)	River Slope (%)	Catchment Slope (%)
C1i	W320	87.67	1,926.02	0.00	13.76
C1j	W330	85.27	25,936.60	0.00	20.75
C1k	W340	0.52	21.88	-1.69	2.99
C1l	W350	156.85	11,756.01	0.00	4.08
C1m	W360	7.34	5,929.53	0.01	2.74
C1n	W370	29.26	27,257.52	0.00	3.22
C1o	W380	105.08	6,765.34	0.00	4.98
C1p	W390	0.00	1,793.85	0.00	6.04
C1q	W400	5.45	16,472.75	0.00	3.81
C1r	W410	110.36	9,544.50	0.00	3.39
C1s	W420	94.42	13,142.36	0.00	3.67
C1t	W430	131.28	211.26	0.00	3.68
C1u	W440	104.63	16,591.00	0.00	4.89
C1v	W450	0.06	2,427.89	0.00	2.78
C1w	W460	55.47	14,122.02	0.00	5.06
C2a	W40	20.24	7,735.10	0.00	2.88
C2b	W50	85.82	3,767.00	0.00	3.17
C2c	W60	269.01	33,472.99	0.00	4.28
C3	W20	143.19	4,596.56	0.00	3.33
C4	W20	145.69	16,226.43	0.01	7.46
C5	W20	119.21	9,228.45	0.00	9.71
C6a	W120	31.67	6,610.16	0.01	4.28
C6b	W130	9.88	3,029.16	0.01	7.21
C6c	W140	23.05	430.02	-0.01	4.37
C6d	W150	12.74	2,670.99	0.00	4.73
C6e	W160	0.30	1,176.92	0.00	7.62
C6f	W170	9.73	6,091.91	0.01	3.32
C6g	W180	33.65	6,914.61	0.00	3.99
C6h	W190	10.87	810.98	-0.01	5.37
C6i	W200	24.35	2,165.75	0.00	4.08
C6j	W210	69.60	21,292.62	0.01	6.62
C6k	W220	35.96	14,180.56	0.00	11.93

4.3. Rainfall Runoff Modelling

4.3.1. Design Storms Rainfall Intensity

Daily maximum rainfall data for the seven (6) were used to estimate maximum rainfall intensity for different return periods based on Gumbel distribution which is one of the most widely used probability-distribution functions of extreme values in hydrological and meteorologic studies for prediction of flood peaks, maximum rainfalls, maximum wind speed, etc. The probability density function [f(R)] and Cumulative Distribution Function [F(R)] of Gumbel distribution is given by:

$$f(R) = \frac{e^{-(R_i-\alpha)/\beta} e^{-e^{-(R_i-\alpha)/\beta}}}{\beta}, R_i, \beta > 0 \qquad \text{.........................} (2.2)$$

$$F(R) = e^{-e^{-(R_i-\alpha)/\beta}}$$

where α and ß are location and scale parameters. The parameters were computed by method of moments (MOM) and used to estimate extreme rainfall (R_T) for different return periods using the relation:

$$R_T = \alpha + Y_T \beta \qquad \text{..} (2.3)$$

Where,

$$\alpha = \overline{R} - 0.5772157\beta$$

$$\beta = \left(\sqrt{6}/\pi\right) S_R$$

$$Y_T = -Ln(-Ln(1-(1/T)))$$

where $\overline{R}$ and SR are the mean and standard deviation of the recorded rainfall data.

Table 58. Gumbel based extreme rainfall estimates for different return periods in the stations within and around Dodoma City

Return Period, T (Years)	Gumbel Variate	Estimated Extreme Rainfall, R_T (mm)					
		Dodoma Airport	Bihawama Farmers	Bihawama Seminary	Mlowa Dam	Matambulu Dam	Dodoma Maji
2	0.37	67.03	71.17	67.45	51.69	59.99	63.12
10	2.25	93.84	138.00	94.44	84.52	93.63	91.01
20	2.97	104.09	163.54	104.76	97.07	106.48	101.66
50	3.90	117.35	196.60	118.11	113.30	123.12	115.46
100	4.60	127.29	221.37	128.11	125.47	135.59	125.79

Table 59. Rainfall Intensity Frequency Curve for Dodoma MET Station (2006 - 2016)

	Rainfall depth in mm						
	15min	30min	1hrs	2hrs	6hrs	12hrs	24hrs
2yrs	15.83	22.73	25.75	30.20	33.69	36.49	53.45
5yrs	20.62	30.61	31.05	40.48	50.86	56.71	69.95
10yrs	23.79	35.83	34.56	47.28	62.23	70.09	80.87
25yrs	27.79	42.43	39.00	55.88	76.59	87.00	94.67
50yrs	30.76	47.32	42.29	62.26	87.25	99.55	104.90
100yrs	33.71	52.18	45.56	68.59	97.82	112.00	115.06
	Rainfall intensity in mm/hr						
	15min	30min	1hrs	2hrs	6hrs	12hrs	24hrs
2yrs	63.33	45.46	25.75	15.10	5.61	3.04	2.23
5yrs	82.47	61.23	31.05	20.24	8.48	4.73	2.91
10yrs	95.14	71.66	34.56	23.64	10.37	5.84	3.37
25yrs	111.15	84.85	39.00	27.94	12.77	7.25	3.94
50yrs	123.03	94.64	42.29	31.13	14.54	8.30	4.37
100yrs	134.82	104.35	45.56	34.30	16.30	9.33	4.79

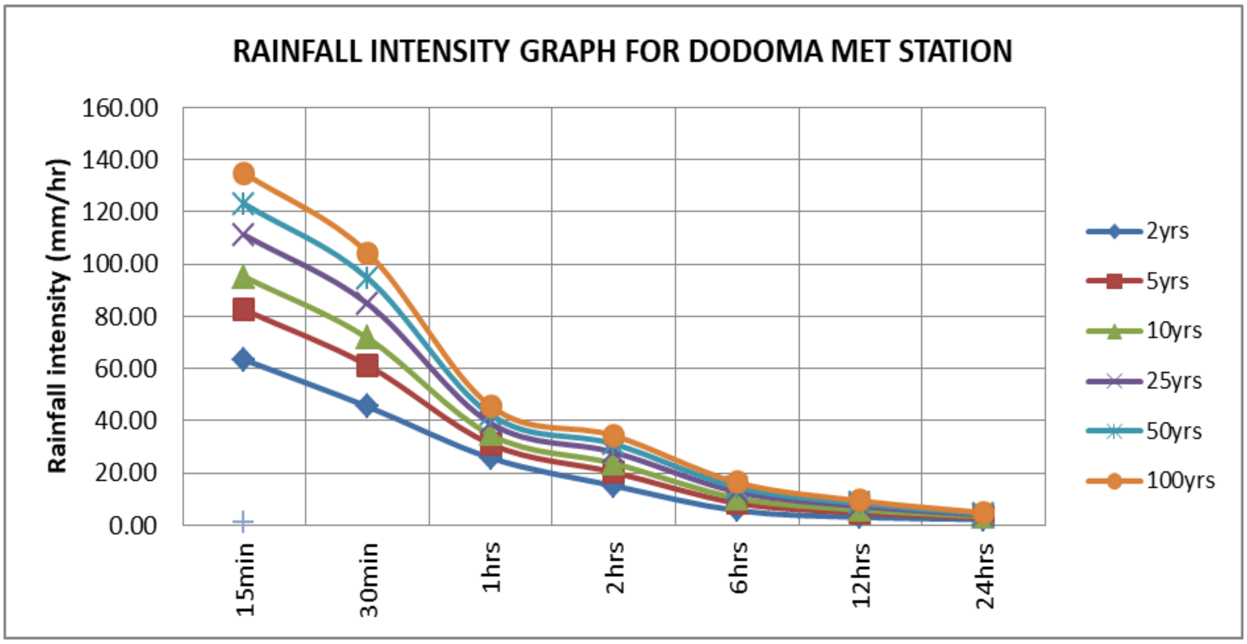

Fig. 81 Rainfall Intensity Graph for Dodoma Met Station (2006 – 2016)

4.3.2. Model Selection

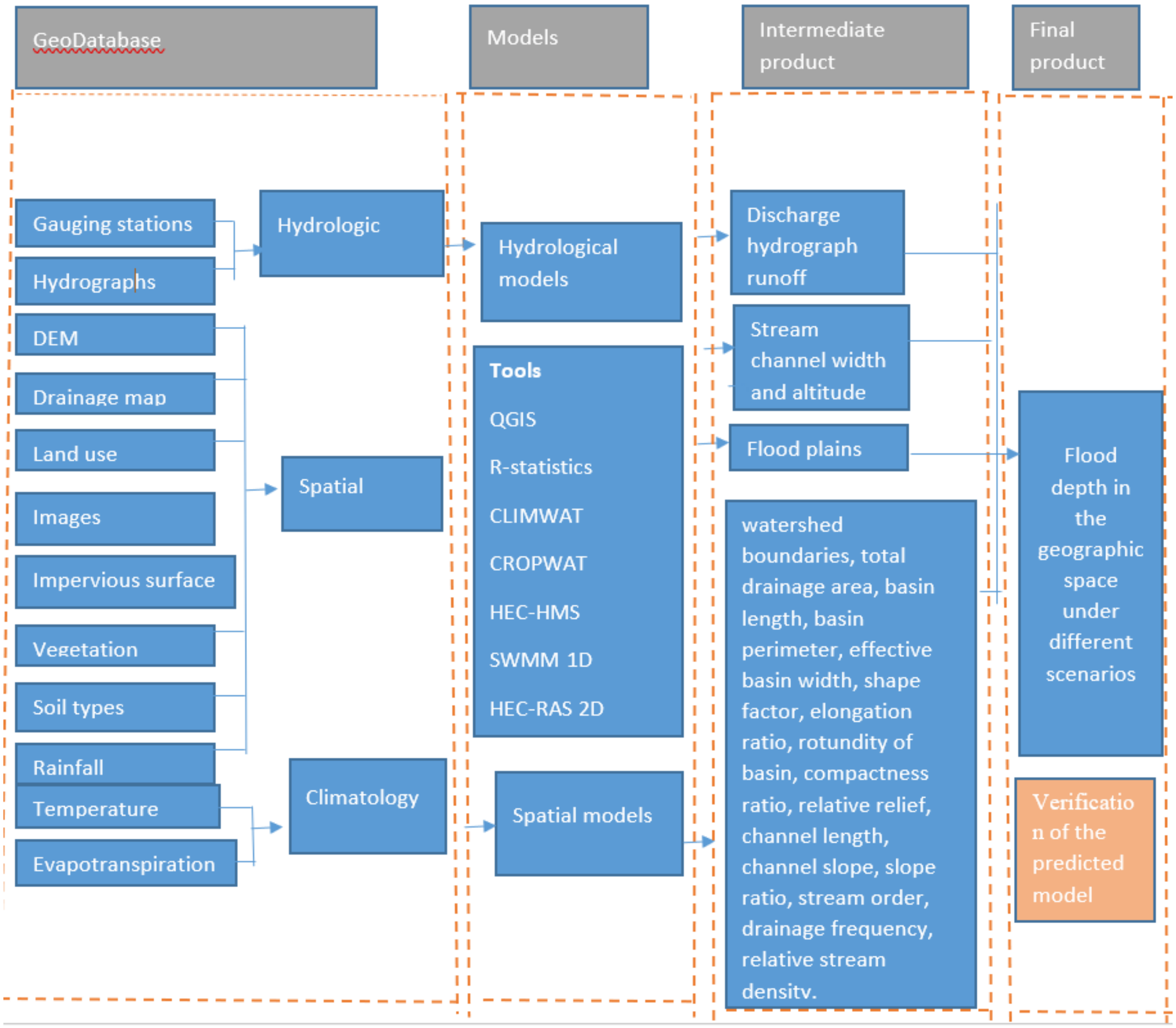

Fig. 82 Model Selection

4.3.3. Model Development

The HEC HMS model has four components to simulate the basic hydrologic processes of runoff generation from rainfall, its transformation and combination with baseflow, and its routing towards the outlet. These four components are (i) infiltration loss, (ii) direct runoff, (iii) baseflow, and (iv) channel routing.

- **Transform method**

SCS UH unit hydrograph procedure is adopted to simulate simulate a natural hydrograph. This procedure assumes that discharge at any time is proportional to the volume of runoff and that time factors affecting hydrograph shape are constant.

The standard lag is defined as the length of time between the centroid of precipitation mass and the peak flow of the resulting hydrograph:

$$t_L = 0.342 \frac{L^{0.8}}{s^{0.5}} \left(\frac{1000}{CN} - 9\right)^{0.7} \quad \text{.................................} \ (2.4)$$

Where,

t_L = *lag (h);*

L = *Longest flow path (km);*

s = *average watershed land slope (%);*

CN = *Curve Number.*

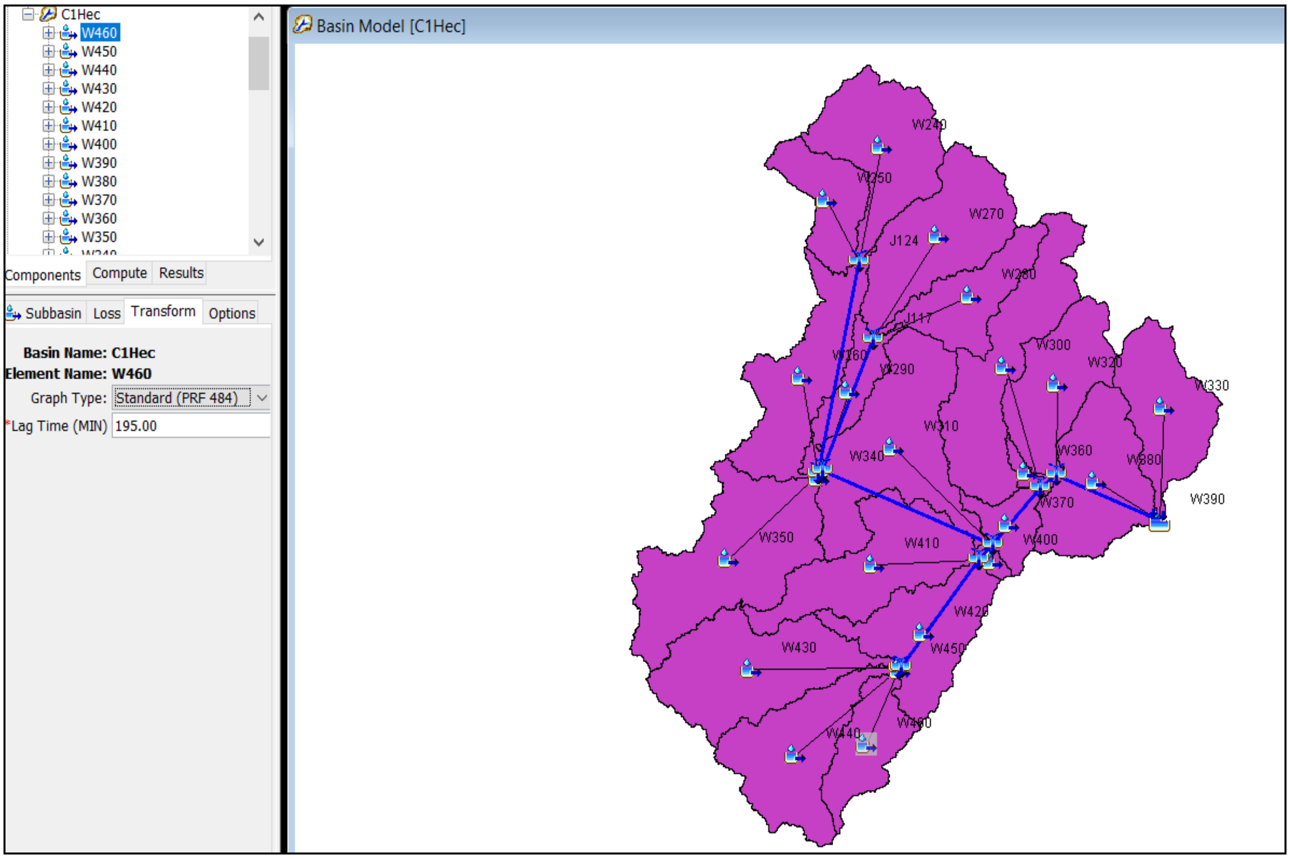

Fig. 83 HEC-HMS SCS Unit Hydrograph Transform Method in Dodoma City Catchment

Loss Method

The Soil Conservation Service (SCS) curve number (CN) method is selected for computing the runoff volume. The soil and land-cover maps are used to compute for the Curve Number (CN) parameter of the SCS-CN infiltration loss component. The CN parameter is dependent on landcover, hydrologic soil group based on the soil texture, and antecedent moisture condition. The higher the CN, the higher the runoff potential.

In assigning a curve number to a hydrologic soil-cover complex, it is necessary to consider first the antecedent moisture condition (AMC) of the watershed (Table 60). AMC is the total rainfall in the five-day period preceding a storm or rainfall event under consideration.

AMCI is basically a “dry” condition, while AMCII connotes a “normal” moisture condition of the watershed. AMCIII refers to a “wet” condition of the watershed. In this assignment, CN(II) values were initially used and later transformed to CN(III) using the equation:

$$CNIII=23*(10+0.13CNII) \cdots\cdots (2.5)$$

Table 60. Classification of Antecedent Moisture Conditions (AMC) for the Runoff Curve Number Method

AMC	Total 5-day antecedent rainfall
I	< 35.56 mm.
II	35.56 - 53.34 mm
III	> 53.34 mm

Table 61. Adjusted Curve Number for AMC Conditions in the CCD Catchments

Cover description		Curve Numbers for hydrologic soil group, AMCIII conditions			
Value	Land Uses	A	B	C	D
1	Tree cover areas	77	84	90	93
2	Bush land	66	80	87	90
3	Grassland	65	82	89	92
4	Cropland	74	86	90	93
5	Vegetation aquatic or regularly flooded	61	80	88	92
6	Lichens Mosses / Sparse vegetation	57	79	87	91
7	Bare areas	86	92	94	96
8	Built up areas	87	92	94	96
9	Snow and/or Ice	94	96	97	98
10	open water	100	100	100	100

- Dodoma City`s catchment antecedent moisture condition (AMC)

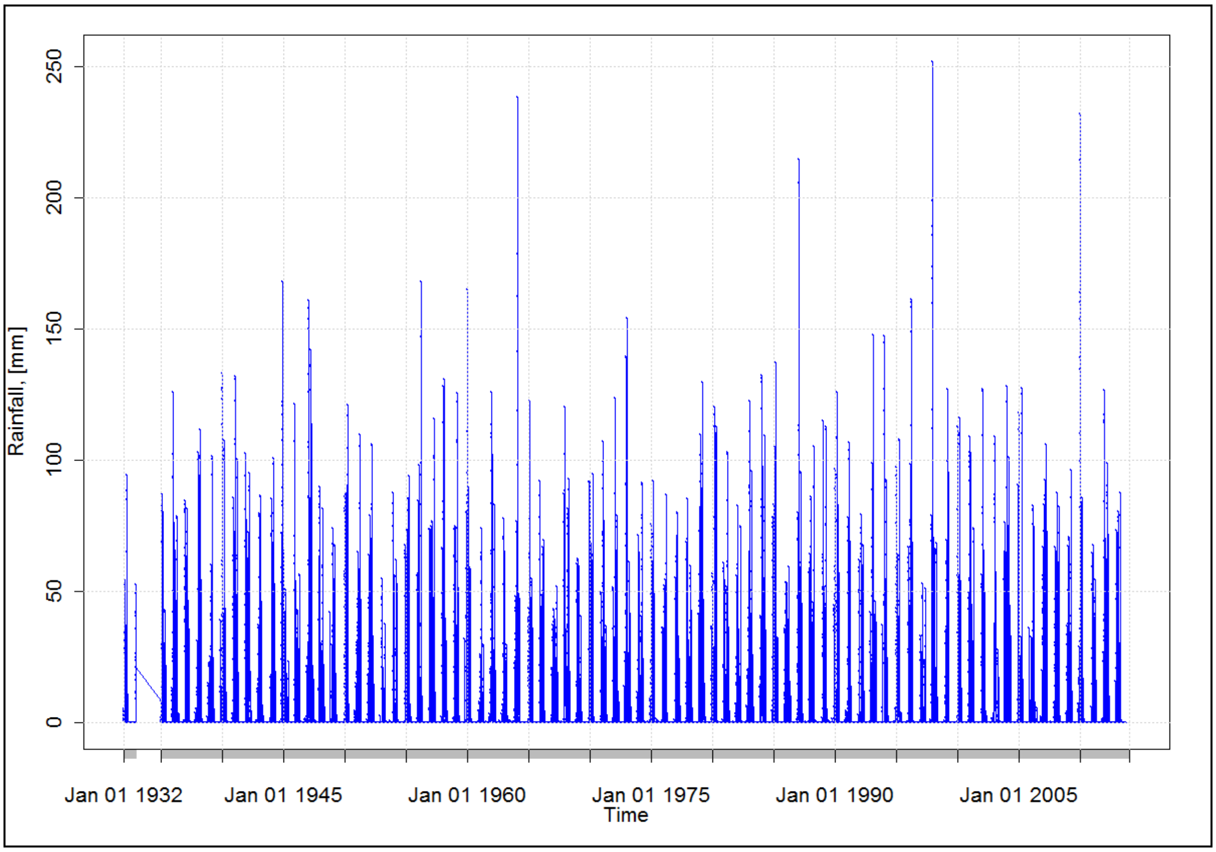

Fig. 84 Dodoma Airport 5-days accumulated rainfall

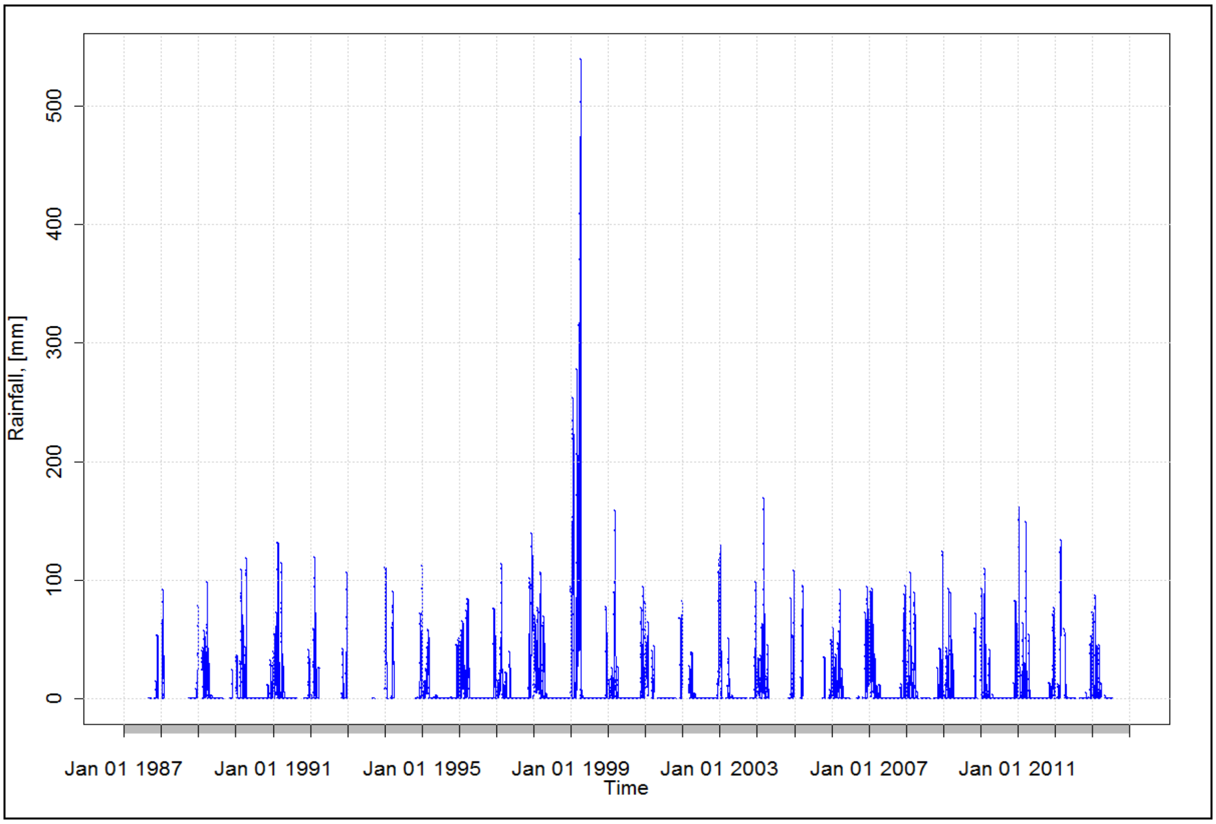

Fig. 85 Bihawana_Farmers 5-days accumulated rainfall

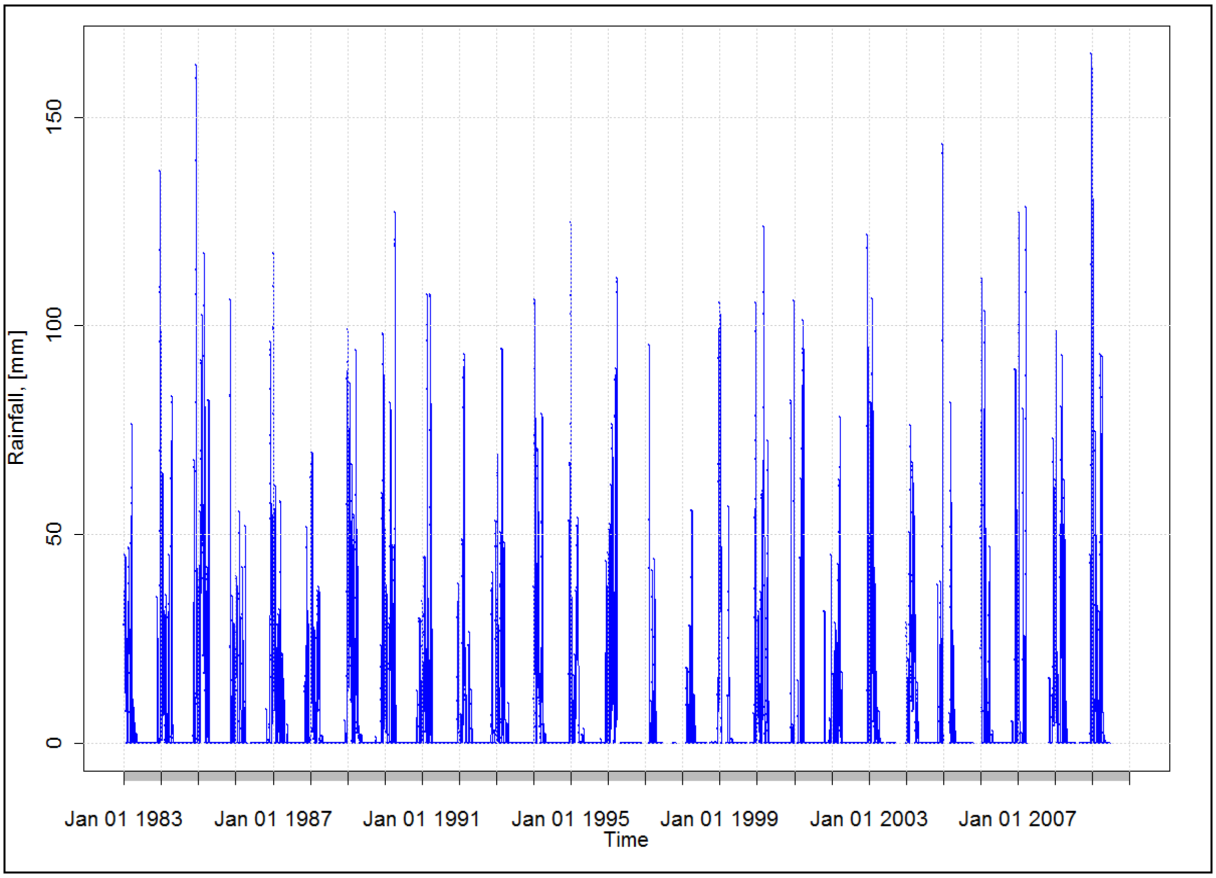

Fig. 86 Bihawana 5-day accumulated rainfall

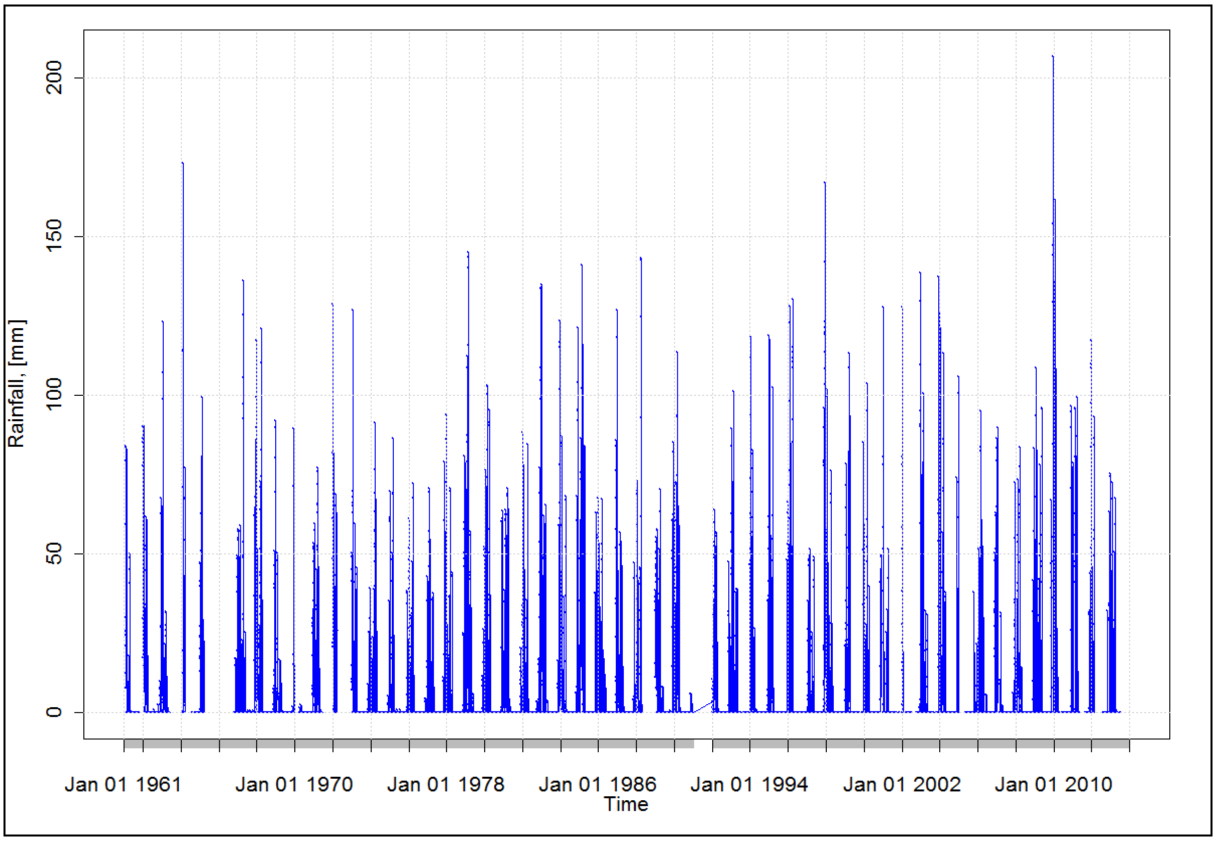

Fig. 87 Dodoma Maji 5-day Accumulated Rainfall

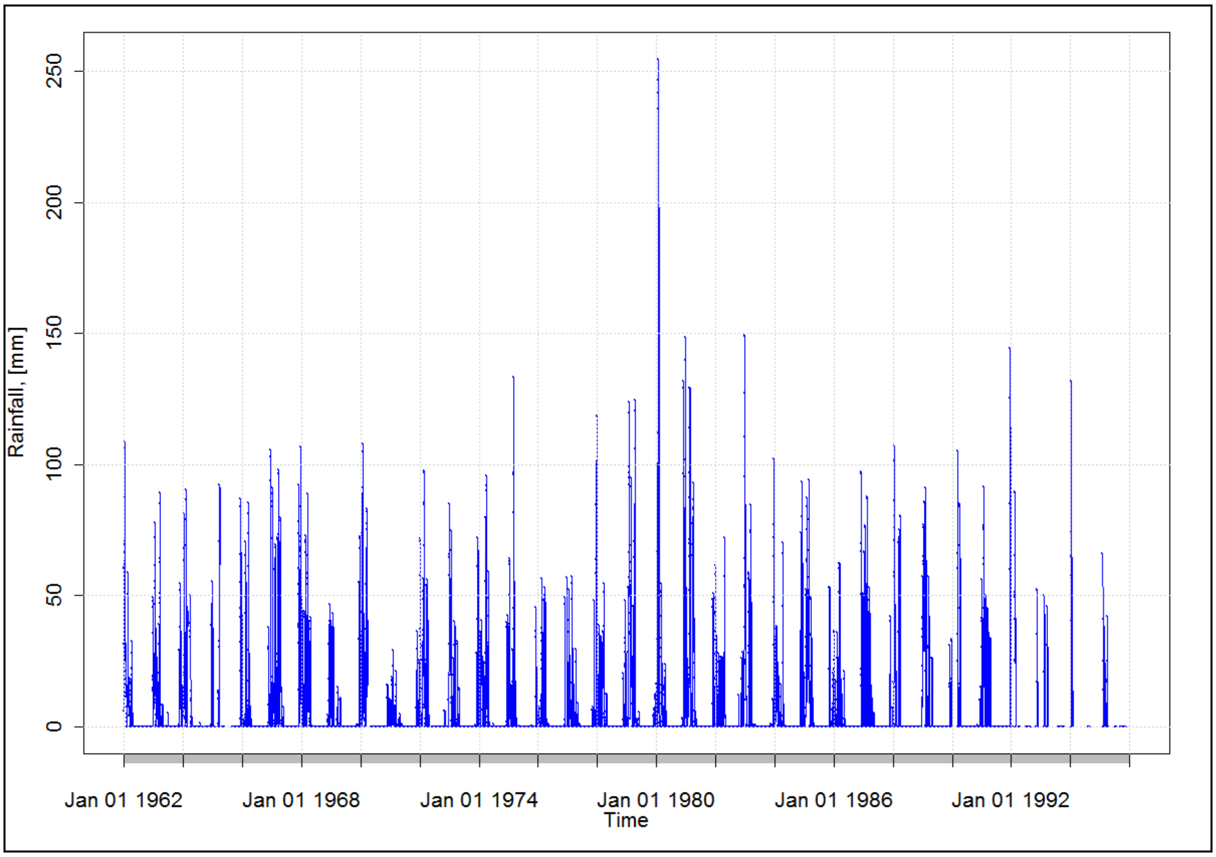

Fig. 88 Matumbulu 5-day Accumulated Rainfall

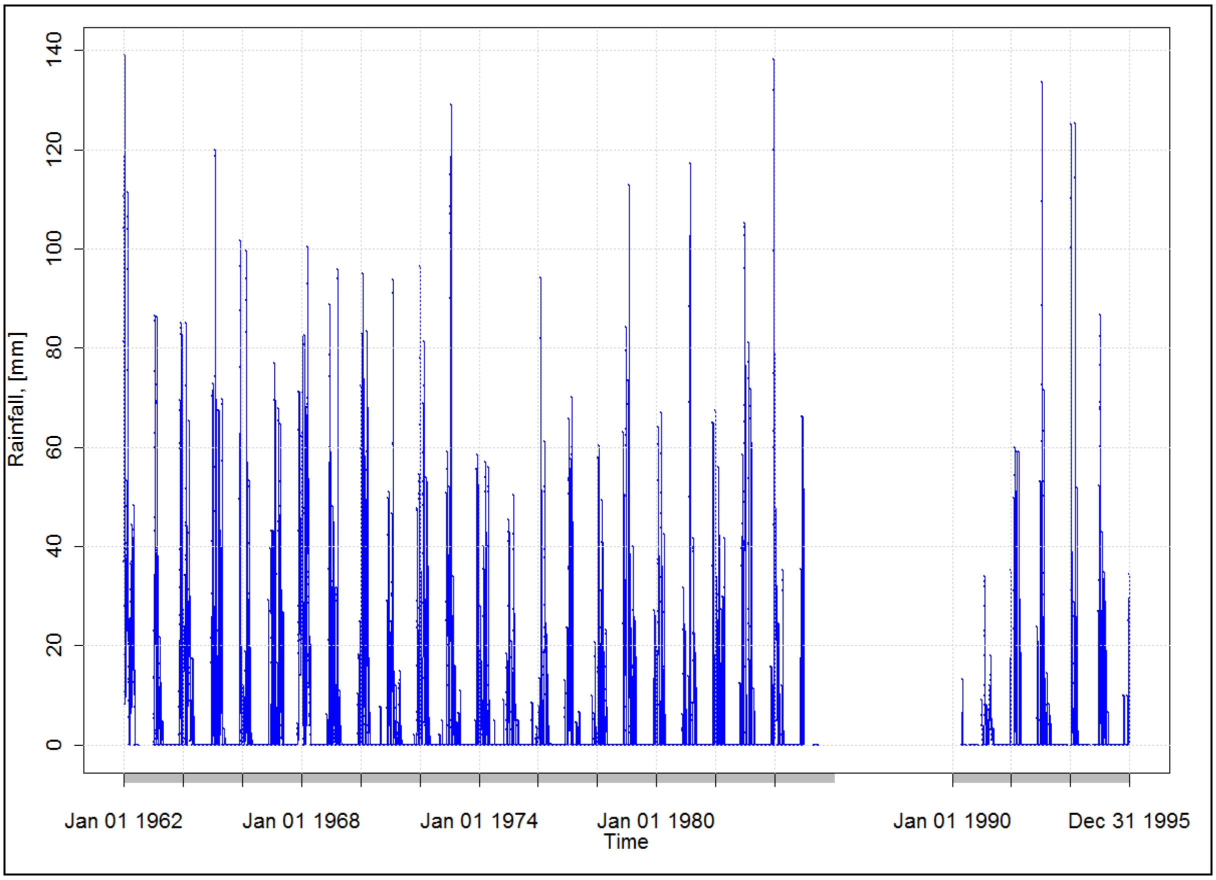

Fig. 89 Mlowa Dam 5-day Accumulated Rainfall

4.3.4. Peak Flow Analysis Results for Catchments in Dodoma City

Table 62. Peak Flow Analysis Results for Catchment 1

Catchment Code	Catchment Name	CN	TC (hrs)	Lag Time (hrs)	Q5-yr	Q10-yr	Q25-yr	Q50-yr	Q100-yr
					Current Conditions				
C1a	W240	83.03	4.69	2.82	253.11	301.71	334.11	370.56	435.35
C1b	W250	83.89	4.91	2.95	151.33	180.39	199.76	221.55	260.29
C1c	W260	84.71	9.09	5.46	126.91	151.28	167.52	185.80	218.29
C1d	W270	83.81	4.78	2.87	256.12	305.30	338.08	374.96	440.53
C1e	W280	85.69	4.05	2.43	175.64	209.36	231.84	257.14	302.10
C1f	W290	85.28	7.00	4.20	61.47	73.27	81.14	89.99	105.73
C1g	W300	87.8	5.73	3.44	212.82	253.68	280.92	311.57	366.05
C1h	W310	86.61	9.70	5.82	155.61	185.49	205.41	227.82	267.66
C1i	W320	89.37	3.34	2.00	281.50	335.54	371.57	412.11	484.17
C1j	W330	85.42	3.06	1.84	297.15	354.20	392.23	435.02	511.09
C1k	W340	84.10	0.97	0.58	4.63	5.52	6.11	6.78	7.96
C1l	W350	83.27	8.79	5.27	202.68	241.59	267.54	296.72	348.61
C1m	W360	94.95	2.50	1.50	30.84	36.76	40.71	45.15	53.05
C1n	W370	88.94	4.07	2.44	52.46	62.53	69.24	76.80	90.23
C1o	W380	89.28	5.51	3.31	212.17	252.91	280.06	310.62	364.93
C1p	W390	90.00	0.02	0.01	0.04	0.05	0.05	0.06	0.07
C1q	W400	83.40	2.30	1.38	25.44	30.32	33.58	37.24	43.75
C1r	W410	89.40	7.66	4.60	174.78	208.34	230.71	255.88	300.62
C1s	W420	86.57	7.24	4.34	138.90	165.57	183.35	203.36	238.91
C1t	W430	84.08	9.59	5.75	168.96	201.40	223.03	247.36	290.61
C1u	W440	88.62	5.99	3.60	197.83	235.81	261.14	289.62	340.27
C1v	W450	84.73	0.33	0.20	0.84	1.00	1.10	1.22	1.44
C1w	W460	86.35	5.42	3.25	135.45	161.46	178.80	198.30	232.98
C1a	W240	83.03	4.69	2.82	253.11	301.71	334.11	370.56	435.35
C1b	W250	83.89	4.91	2.95	151.33	180.39	199.76	221.55	260.29
C1c	W260	84.71	9.09	5.46	126.91	151.28	167.52	185.80	218.29
C1d	W270	83.81	4.78	2.87	256.12	305.30	338.08	374.96	440.53
C1e	W280	85.69	4.05	2.43	175.64	209.36	231.84	257.14	302.10
C1f	W290	85.28	7.00	4.20	61.47	73.27	81.14	89.99	105.73
C1g	W300	87.80	5.73	3.44	212.82	253.68	280.92	311.57	366.05
C1h	W310	86.61	9.70	5.82	155.61	185.49	205.41	227.82	267.66
C1i	W320	89.37	3.34	2.00	281.50	335.54	371.57	412.11	484.17
C1j	W330	85.42	3.06	1.84	297.15	354.20	392.23	435.02	511.09
C1k	W340	84.10	0.97	0.58	4.63	5.52	6.11	6.78	7.96
C1l	W350	83.27	8.79	5.27	202.68	241.59	267.54	296.72	348.61
C1m	W360	94.95	2.50	1.50	30.84	36.76	40.71	45.15	53.05
C1n	W370	88.94	4.07	2.44	52.46	62.53	69.24	76.80	90.23
C1o	W380	89.28	5.51	3.31	212.17	252.91	280.06	310.62	364.93
C1p	W390	90.00	0.02	0.01	0.04	0.05	0.05	0.06	0.07
C1q	W400	83.4	2.30	1.38	25.44	30.32	33.58	37.24	43.75

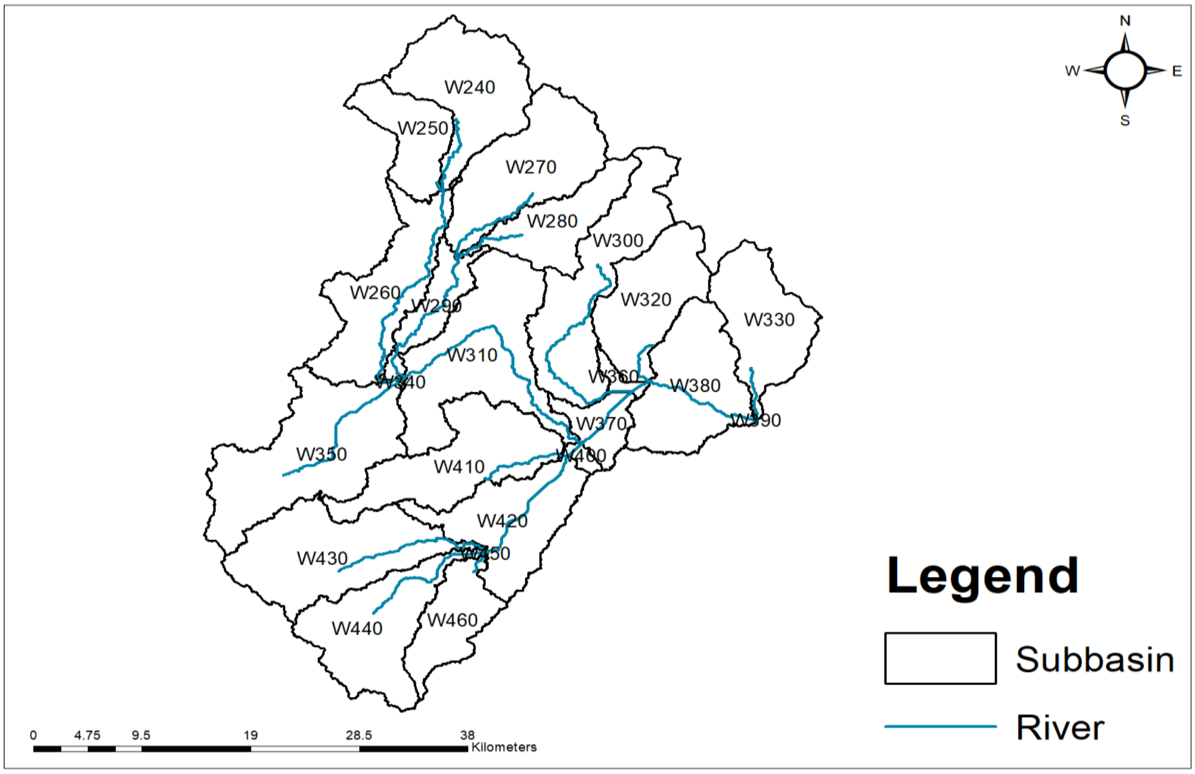

Fig. 90 Peak flow results for catchment 1 (C1)

Table 63. Peak flow analysis results for Catchment 2 (C2)

Catchment Code	Catchment Name	CN	TC (hrs)	Lag Time (hrs)	Q5-yr	Q10-yr	Q25-yr	Q50-yr	Q100-yr
					Current Conditions				
C2a	W40	84.78	4.57	2.74	58.98	70.30	77.85	86.34	101.44
C2b	W50	85.16	8.12	4.87	141.11	168.20	186.26	206.58	242.71
C2c	W60	86.49	12.7	7.6	241.94	288.39	319.35	354.19	416.13

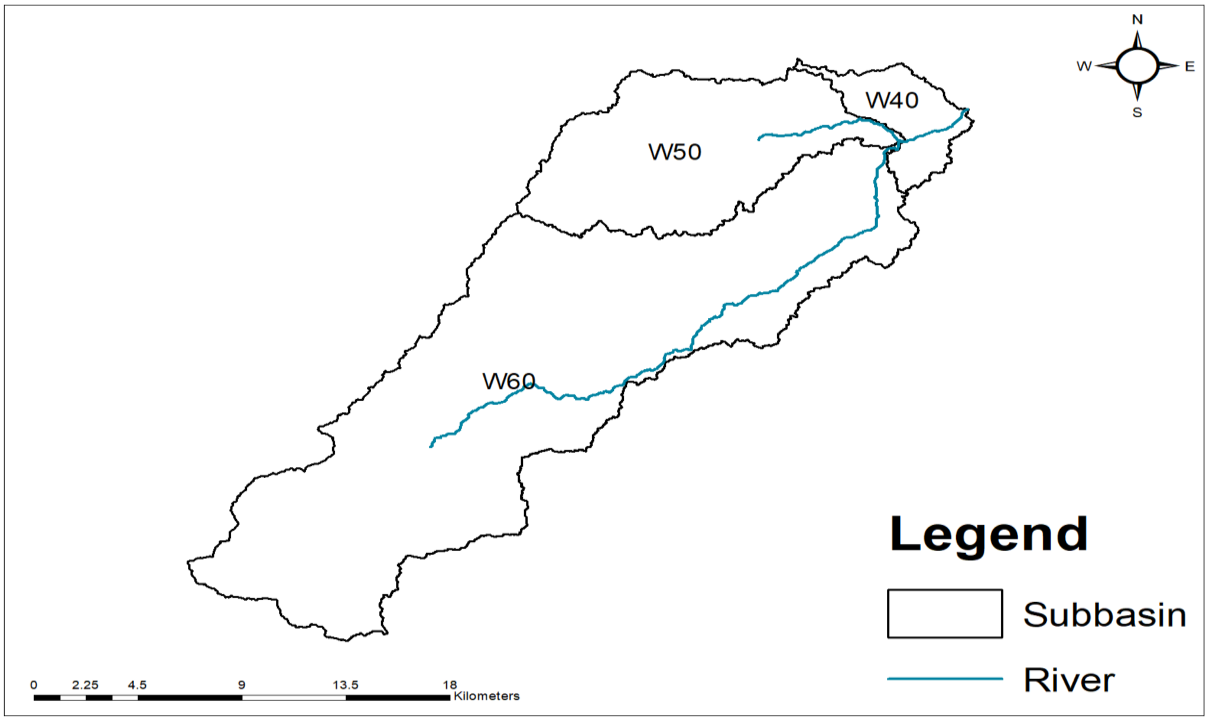

Fig. 91 Peak flow map for Catchment 2 (C2)

Table 64. Peak flow analysis results for Catchment 3 (C3)

Catchment Code	Catchment Name	CN	TC (hrs)	Lag Time (hrs)	Q5-yr	Q10-yr	Q25-yr	Q50-yr	Q100-yr
					Current Conditions				
C3	W20	85.4	10.6	6.38	188.55	224.76	248.89	276.04	324.31

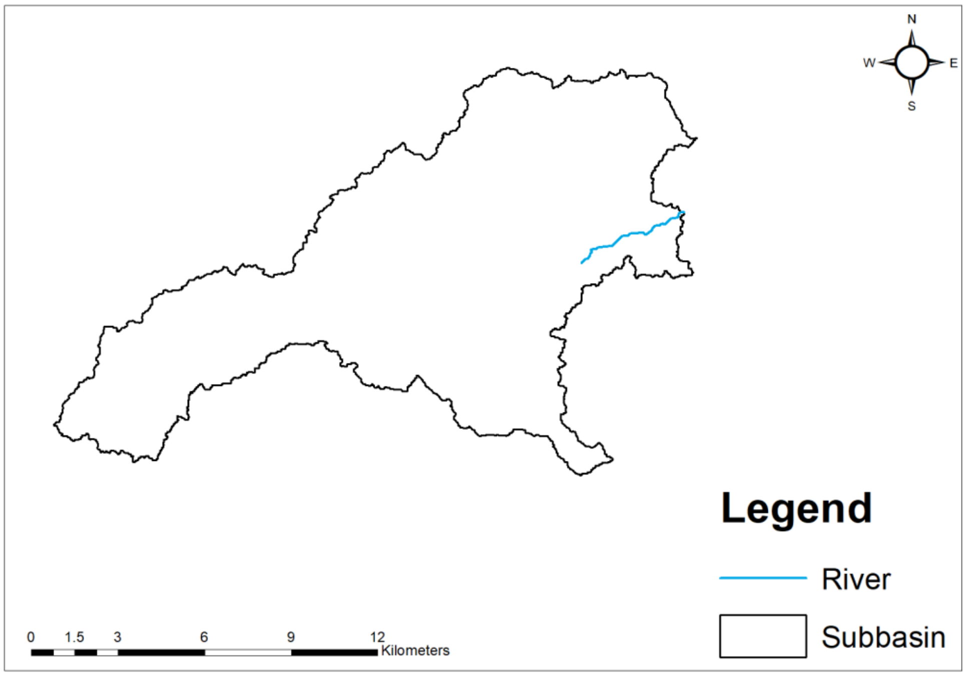

Fig. 92 Peak flow results map for Catchment 3 (C3)

Table 65. Peak flow analysis results for Catchment 4 (C4)

Catchment Code	Catchment Name	CN	TC (hrs)	Lag Time (hrs)	Q5-yr	Q10-yr	Q25-yr	Q50-yr	Q100-yr
					Current Conditions				
C4	W20	87.3	6.04	3.63	269.52	321.26	355.76	394.57	463.57

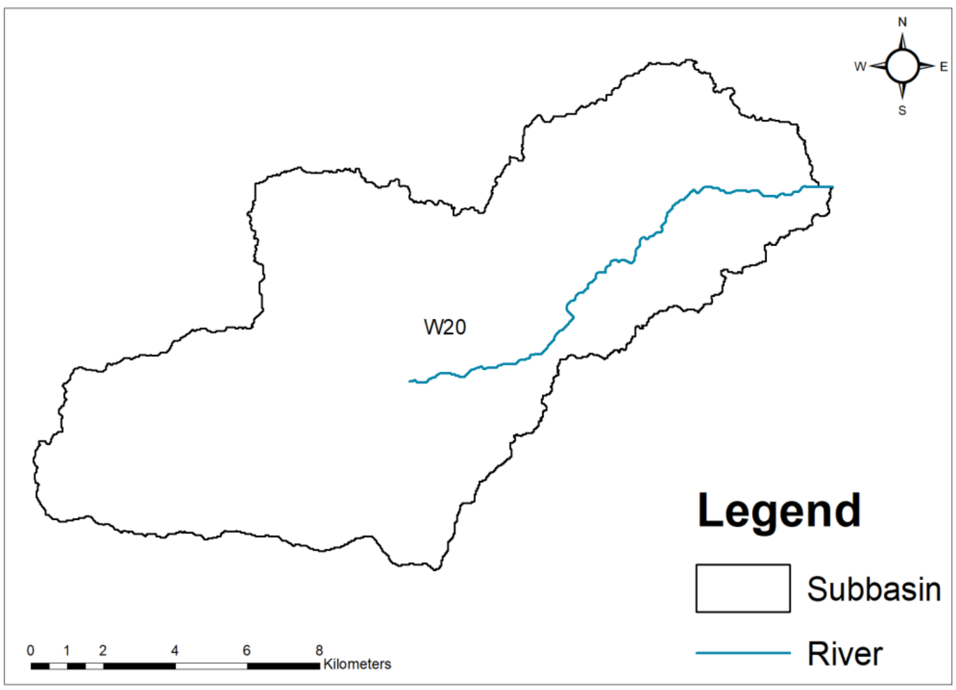

Fig. 93 Peak flow analysis map for Catchment 4 (C4)

Table 66. Peak flow analysis results for Catchment 5 (C5)

Catchment Code	Catchment Name	CN	TC (hrs)	Lag Time (hrs)	Q5-yr	Q10-yr	Q25-yr	Q50-yr	Q100-yr
					Current Conditions				
C5	W20	89.65	4.14	2.48	306.93	365.86	405.15	449.35	527.92

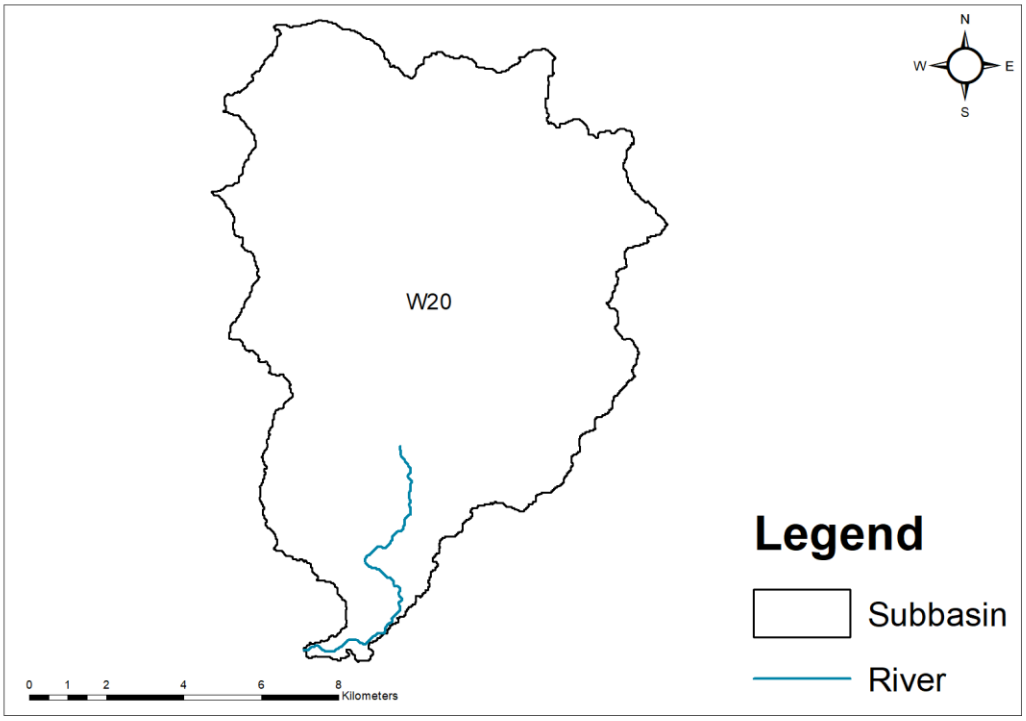

Fig. 94 Peak flow analysis map for Catchment 5 (C5)

Table 67. Peak flow analysis results for Catchment 6 (C6)

Catchment Code	Catchment Name	CN	TC (hrs)	Lag Time (hrs)	Q5-yr	Q10-yr	Q25-yr	Q50-yr	Q100-yr
					Current Conditions				
C6a	W120	82.59	4.49	2.69	91.52	109.09	120.81	133.99	157.42
C6b	W130	83.83	2.22	1.33	47.56	56.70	62.78	69.63	81.81
C6c	W140	84.38	3.62	2.17	79.46	94.71	104.88	116.32	136.67
C6d	W150	84.6	2.9	1.74	54.32	64.74	71.70	79.52	93.42
C6e	W160	85.75	0.57	0.34	3.58	4.27	4.73	5.25	6.17
C6f	W170	85.11	3.77	2.26	35.97	42.87	47.48	52.65	61.86
C6g	W180	84.68	4.61	2.77	89.72	106.94	118.42	131.34	154.31
C6h	W190	84.61	3.08	1.85	46.46	55.39	61.33	68.02	79.92
C6i	W200	83.19	3.53	2.12	85.93	102.43	113.43	125.80	147.80
C6j	W210	87.31	5.62	3.37	135.19	161.14	178.45	197.91	232.52
C6k	W220	89.13	3.13	1.88	108.94	129.85	143.79	159.48	187.37

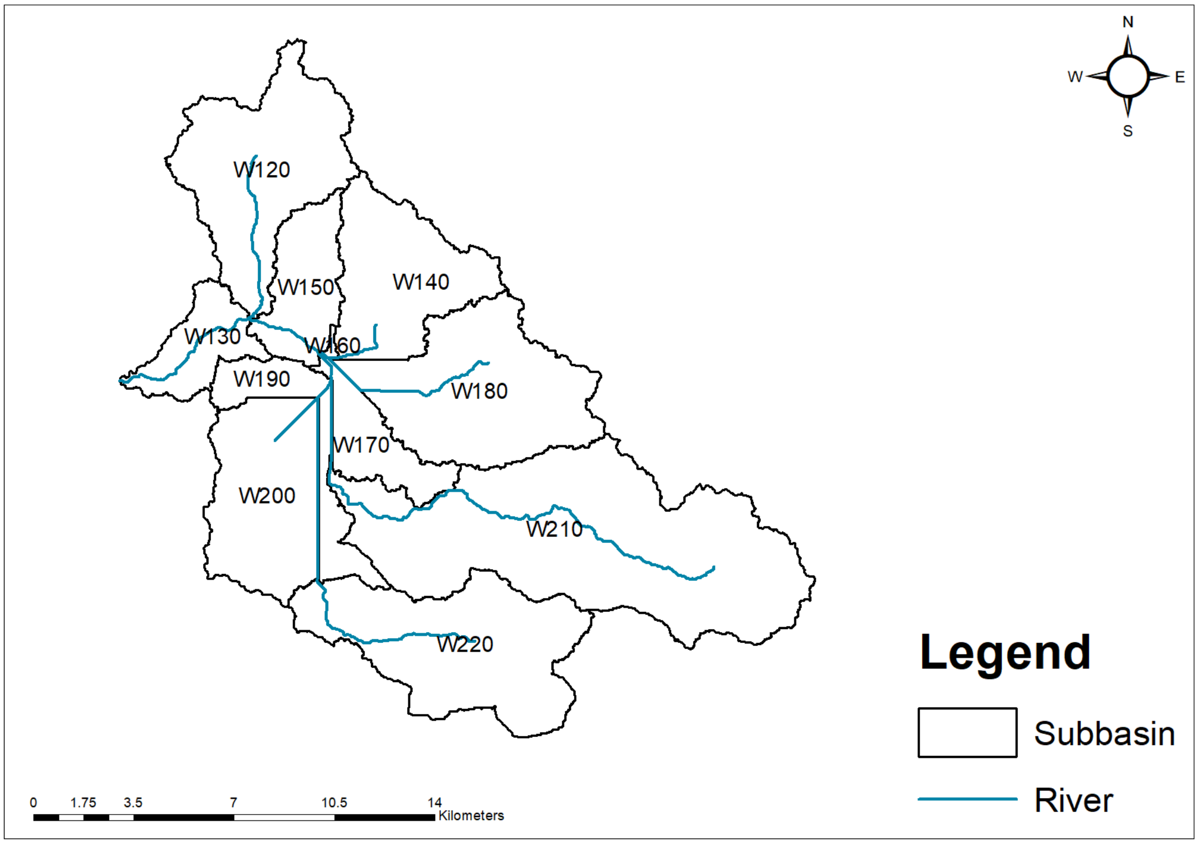

Fig. 95 Peak flow analysis map for Catchment 6 (C6)

4.4. Hydraulic Modelling (HEC-RAS Model)

Hydrologic Engineering Center-River Analysis System (HEC-RAS), a renowned hydrodynamic model for natural channel networks has been used as a modelling framework. HEC-RAS is designed to perform 1D/2D hydraulic calculations for a full network of natural and constructed channels. The HEC-RAS system contains four components for:

- Steady flow water surface profile computations;
- Unsteady flow simulation;
- Movable boundary sediment transport computations; and
- Water quality analysis.

A key element is that all four components use a common geometric data representation and common geometric and hydraulic computation routines. In steady flow water surface profiles component, water surface profiles are calculated for steady gradually varied flow. The system can handle a single river reach, a dendritic system, or a full network of channels. The steady flow component is capable of modeling subcritical, supercritical, and mixed flow regime water surface profiles. In model set up, it is necessary to divide the cross sections into parts that have homogeneous hydraulic properties, in the direction of the flow (Fig. 96). These are usually the left/right overbanks and the main channel. It is assumed that there is no exchange of energy across the boundaries. Both the water Surface elevation and the total energy head are assumed to be constant at the whole cross section. Such an assumption partly helps to reduce data requirements on observed water surface for calibration. Besides, in the field practice, it is difficult to capture the small changes in water surface elevation between the inner and out banks at the meander as theoretically idealized.

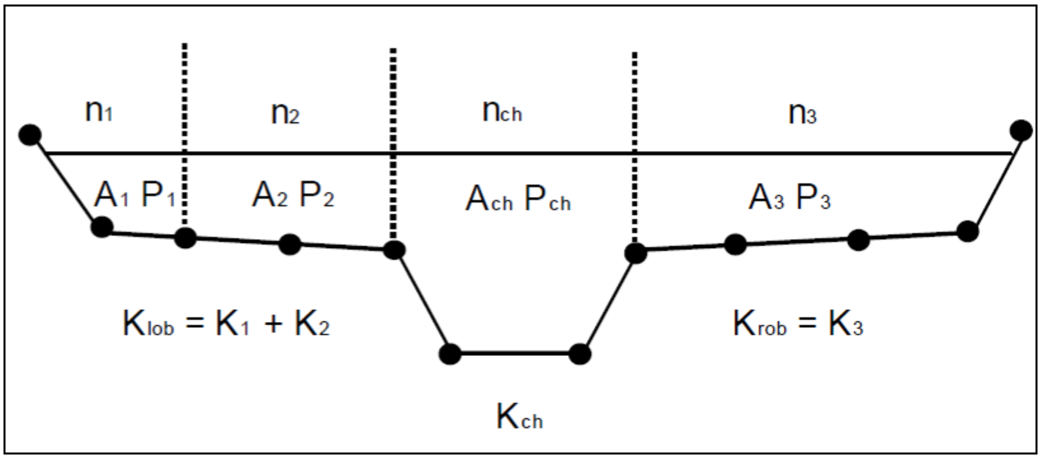

Fig. 96 HEC-RAS Model Cross Section Subdivided into Parts that have Homogeneous Hydraulic Properties.

Note: K_i is conveyance factor; n_i is Manning's roughness number; P_i is wetted perimeter; A_i is flow area; lob, ch, and rob signify left overbank, main channel, and right overbank, respectively.

The basic computational procedure is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction (Manning Equation) and contraction/expansion (coefficient multiplied by the change in velocity head). The momentum equation is utilized in situations where the water surface profile is rapidly varied. These situations include mixed flow regime calculations (i.e., hydraulic jumps), hydraulics of bridges, and evaluating profiles at river confluences (stream junctions). The effects of various obstructions such as bridges, levees, culverts, weirs, spillways and other structures in the flood plain may be considered in the computations.

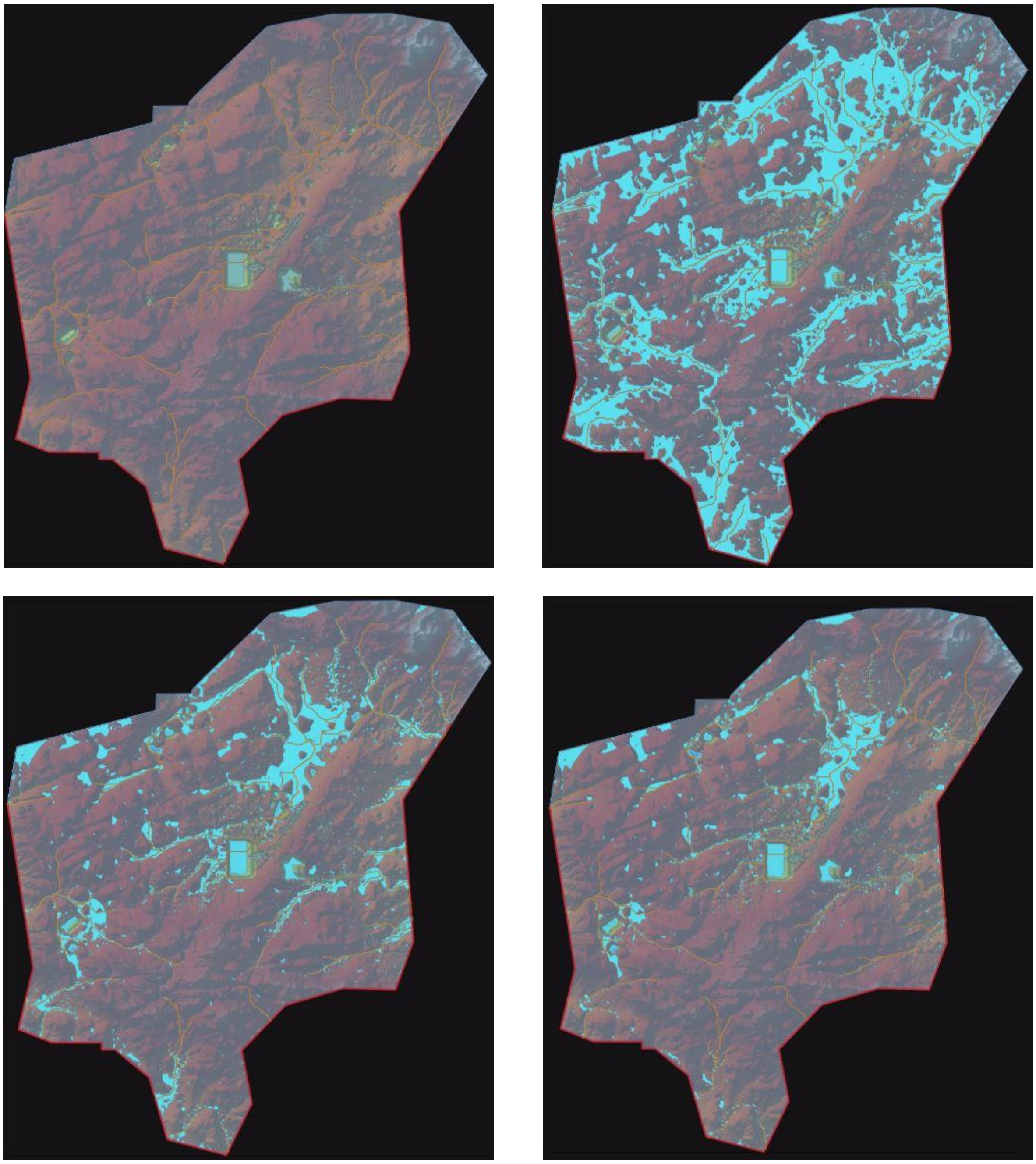

Fig. 97 Results of flood modelling

5. Soil erosion and Sedimentation Analysis

5.1. The conceptual framework

Various efforts have been made worldwide to evaluate soil erosion and sediment yield spatially and temporarily to develop effective soil erosion best management practices. Among those, modeling approaches have been often utilized. The Universal Soil Loss Equation (USLE), Water Erosion Prediction Project (WEPP), Soil and Water Assessment Tool (SWAT), European Soil Erosion Model (EUROSEM), Agricultural Non-Point Source Pollution (AGNPS) are widely used for various soil erosion studies. The input requirements for these models vary to some extents. The USLE model has been widely used because its input data are available in most countries and the model is relatively easy to implement. This USLE model has been integrated with GIS for spatiotemporal analysis of soil erosion by many researchers worldwide. The Sediment Assessment Tool for Effective Erosion Control (SATEEC) is one of them with several enhanced modules for sediment yield estimation at a watershed scale with higher accuracies in sediment evaluation (Lim et al., 2005). It should be noted that other complex model such as SWAT estimates soil erosion only from sheet and rill erosion, excluding gully erosion which is also one of the soil erosion types occurring in a watershed. To estimate soil erosion containing all of the erosion stated above, nLS model (McCuen & Spiess, 1995) for gully head detection and Unit Stream Power-based Erosion/Deposition (USPED, Mitas, L. & Mitasova, 1998; Mitasova et al., 1996) model for gully erosion is integrated with the SATEEC system.

- **Sediment Assessment Tool for Effective Erosion Control (SATEEC)**

The RUSLE model in the GIS-based Sediment Assessment Tool for Effective Erosion Control (SATEEC) has been applied to estimate soil loss and sediment yield for any location within the CCD Catchments. The RUSLE equation (metric) is defined as:

$$A = R \times K \times L \times S \times C \times P \quad \cdots\cdots (2.6)$$

Where,

A=annual soil loss (ton ha-1year-1); R=rainfall erosivity factor (MJmmha-1year-1);

K=soil erodibility factor (ton h MJ-1mm-1); L=slope length factor (-);

S=slope steepness factor (-);

C=cover-management factor (-);

P=supporting practices (-) (Renard et al.,1997)

The derivations of the input parameters required as in the SATEEC GIS System to predict the average annual rate of soil loss are discussed below. All datasets were projected to UTM ARC1960 projection system and resampled to a grid resolution of 30m.

5.2. Rainfall-Runoff Erosivity Factor (R)

Rainfall is a driver of soil erosion processes and its effect is accounted for by the R-factor. The R-factor accounts for the effect of raindrop impact and also shows the amount and rate of runoff associated with precipitation events. It is computed as total storm energy (E) time the maximum 30-minute intensity (I30), or EI, and is expressed as the rainfall erosion index (Renard et al., 1997). Lack of continuous pluviograph data relating to rainfall intensity motivated the application of the equation established by Wischmeier and Smith (1978) to derive the R factor.

$$R = \sum_{i=1}^{12} 1.735 \times 10^{\left(1.5\log\frac{p_i^2}{p} - 0.8188\right)} \quad \cdots\cdots (2.7)$$

Where,

pi=the monthly amounts of precipitation;

p=annual precipitation.

The annual summation of pi^2/p is called the Fournier equation. For this assignment, long term records of annual and monthly rainfall were used to calculate the R-factor. The rainfall erosivity values for the different stations within and around Dodoma City's boundary were used to interpolate a rainfall erosivity surface using the IDW technique available in ArcGIS 9.3. The IDW interpolation method was selected because rainfall erosivity sample points are weighted during interpolation such that the influence of rainfall erosivity is most significant at the measured point and decreases as distance increases away from the point. The R factors were found to range from 241 to 418 MJ·mm/ha.h.yr, showing climatologically high erosion potential especially in the highlands (Fig. 98).

Table 68. Rainfall-Runoff erosivity (R-factor) values in the station within and around Dodoma City

Code	Station Name	Latitude	Longitude	R-factor
9635001	Dodoma Airport	-6.167	35.767	285.8983
9635026	Bihawana Seminary	-6.233	35.65	283.8045
9635027	Bihawana Farmers	-6.233	35.633	418.9929
9635012	Dodoma Maji	-6.183	35.75	264.1265
9635014	Matumbulu Dam	-6.3	35.767	288.8744
9635013	Mlowa Dam	-6.55	35.75	205.0616

Code	Station Name	Latitude	Longitude	R-factor
9535007	Makutopora Maji	-5.966	35.7166	277.8415
9535019	Hombolo Agromet	-5.9	35.95	298.6548

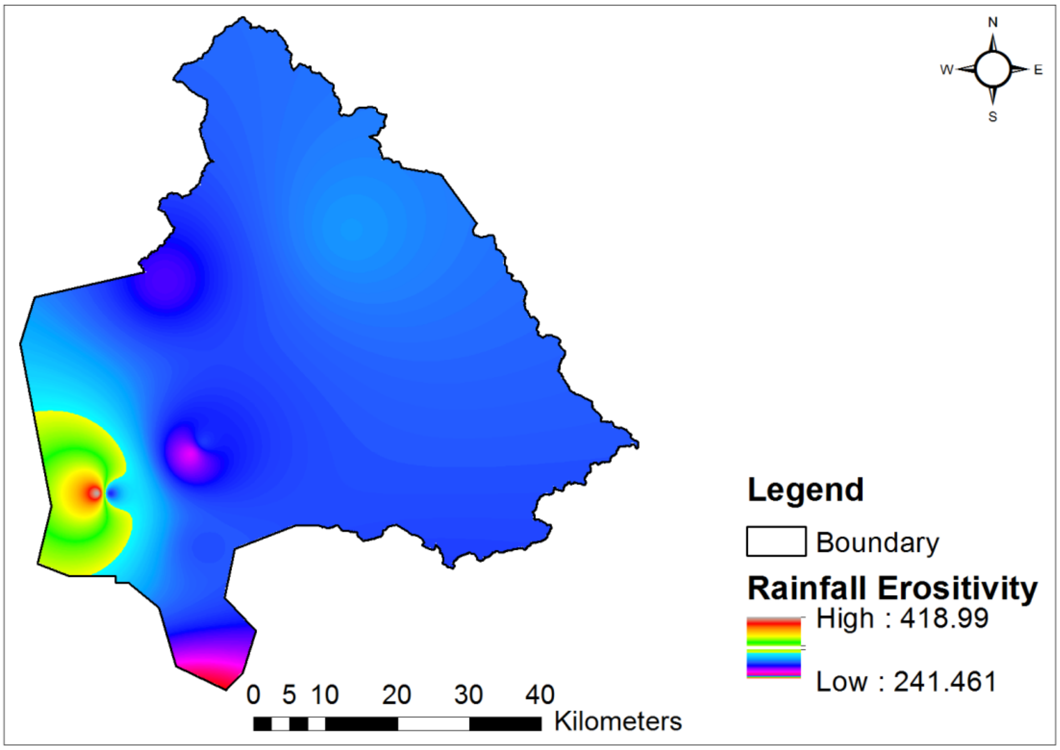

Fig. 98 Spatial distribution of R factor in the CCD catchments

5.3. Soil Erodibility Factor (K)

Fig. 99 Shows the distribution of the major soil types within CCD Catchments. The soil data is from FAO/UNESCO 1:5 million scale soil maps (FAO/UNESCO, 2003). The dominant soil types are sandy clay loam (24.96%) and loam (50.61%). These are group C and B soils respectively, characterized by moderately to low infiltration capacities, according to the soil hydrological group ratings (USDA–SCS,1972).

The K factor measures soil susceptibility to rill and interrill erosion. It depends on the physical and chemical properties of soils, such as texture, aggregate stability, shear strength, infiltration capacity, organic matter content, etc. K factor must be estimated from field measurement or experiments, or through calibration or with Monte Carlo Simulation (Burrough & McDonnell, 1998). However, limited with (time, fund etc.) soil information and parameters for estimating K factor in CCD Dodoma were extracted from FAO database and previous studies. Soil erodibility values for each soil type was added to the soil classification shapefile database in ArcGIS 9.3 software and converted to a 30m grid map. It should be noted that most of the previous researchers have used the soil erodibility nomograph which was developed in the USA. But their final values were obtained after calibration in the local conditions. Since, for this assignment, the values cannot be calibrated, it was necessary to compare more than one method of soil erodibility estimation. Equations suggested by Williams (1975) and Mulengera (1996); Mulengera and Payton (1999) have been used for this purpose. Both equations yielded lower values but the latter was as lower as 10 times. This equation was developed for the tropical conditions but have not been widely used. Therefore, considering the methods and data uncertainties, the previous values were adopted. Fig. 100 shows the spatial soil erodibility map of CCD catchments.

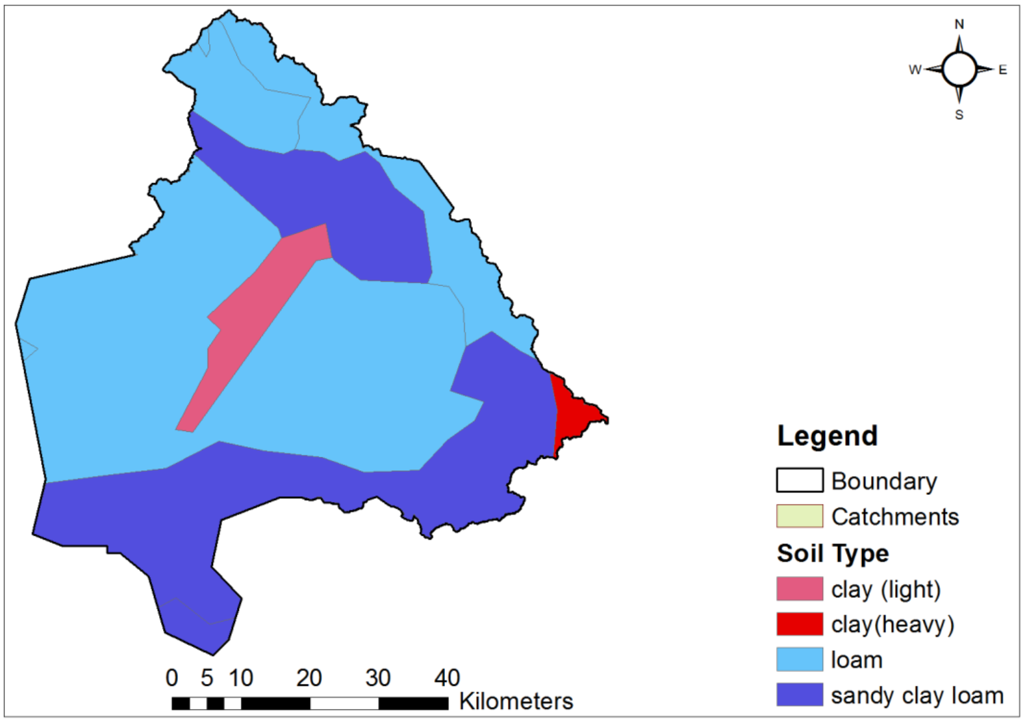

Fig. 99 Soil type distribution within CCD Catchments

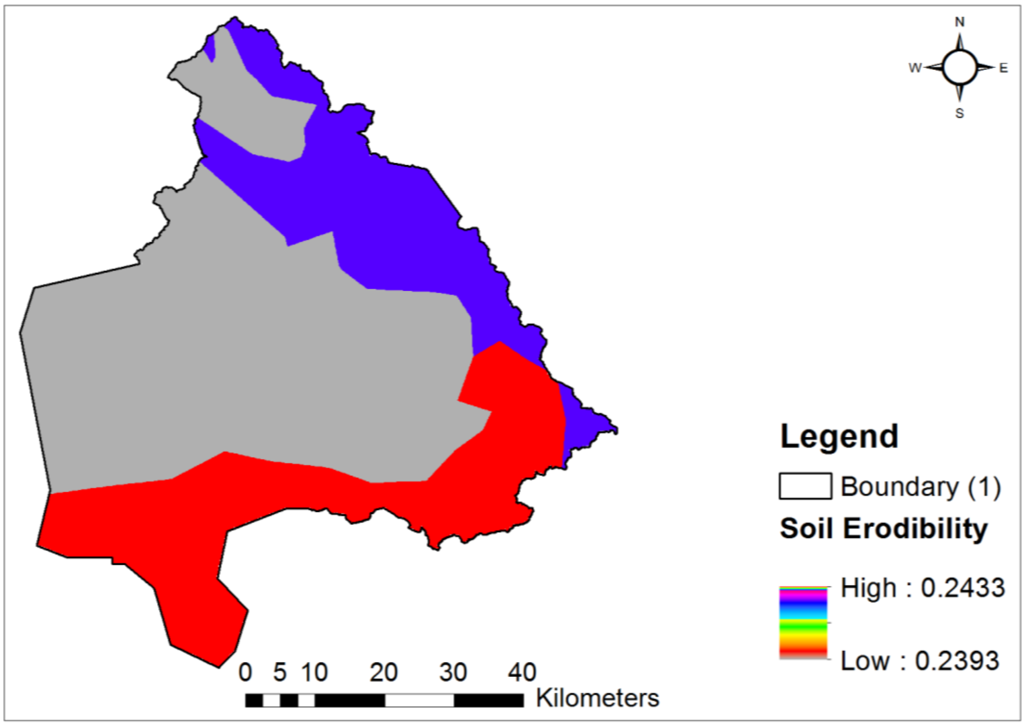

Fig. 100 Shows the soil erodibility map of the CCD Catchments

5.4. Cover management factor (C)

Land use is one of the most important factors that affect surface erosion, runoff, and evapotranspiration in a watershed.

The 1km resolution landuse data from the Global Land Cover Facility (Hansen et al., 2000) was used to determine the land use and cover types in the CCD Catchments. The main land cover types are Dryland cropland and pasture (29.76%), Savanna (20.22%), Cropland/woodland mosaic (5.69%), Shrubland (1.92%), Grassland (37.94%) and Baren or sparsely vegetated (0.35%) (See Fig. 101).

In the RUSLE model, the effect of vegetation cover is incorporated in cover management, the C factor. The effect of vegetation cover as a control on soil erosion is well established. The higher C factor values indicate higher soil erosion potential as the C factor is a ratio of soil loss in a cover management sequence to soil loss from the bare soil unit plot (Nyakatawa et al., 2001). The map of C factor (Fig. 101) was generated by reclassification of each land cover type using C values extracted from previous studies. It is also worth noting that, most of previous researcher have used the table values developed in the U.S.A., which may not represent farming practices and conditions found in the tropics.

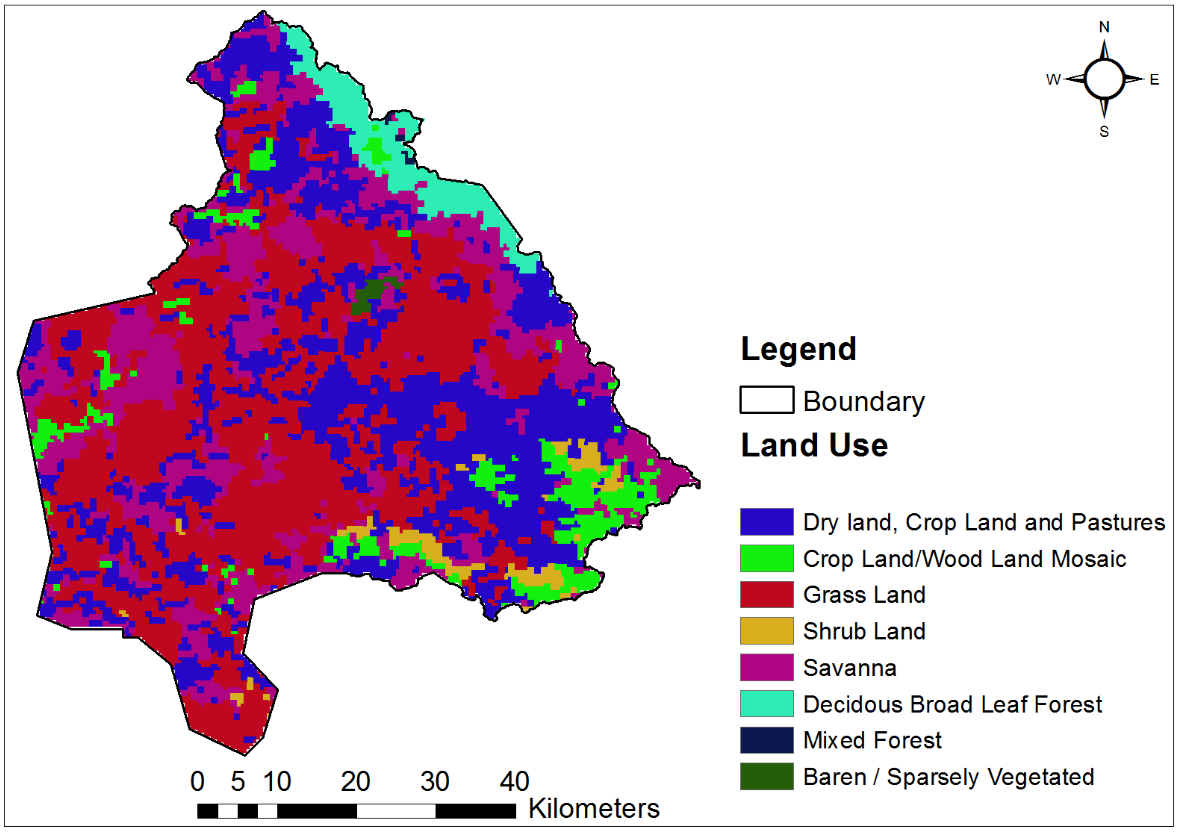

Fig. 101 Land cover type distribution within CCD Catchments

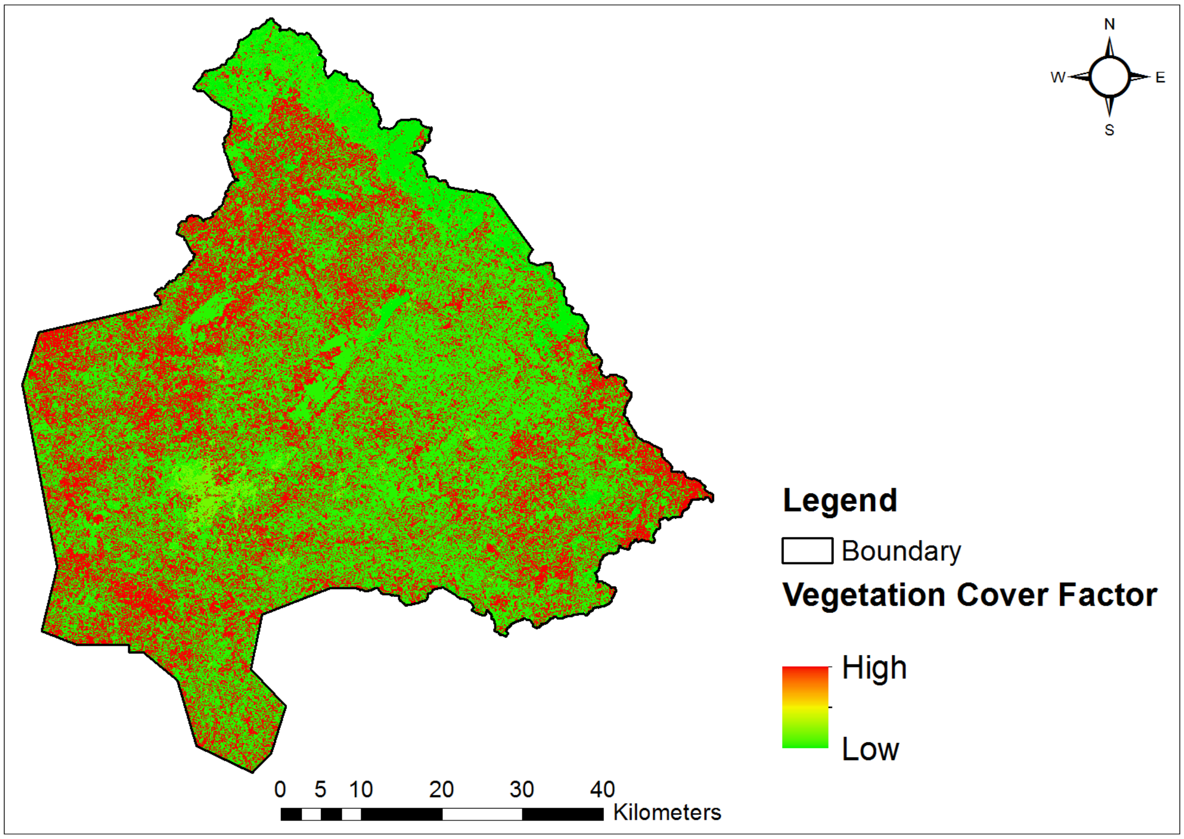

Fig. 102 Vegetation cover factor map of CCD Catchments

5.5. Slope-length (L) and slope steepness (S)

The effect of topography on erosion is expressed by the L and S factors in the RUSLE model. They are best determined by field measurement. However, fieldwork is both time consuming and labor extensive for the studied watershed. Therefore, a 30m Digital Elevation Model (DEM) was used to derive the L and S parameters using a Slope Length function available in ArcView SATEEC GIS-software. The equations developed by Desmet and Govers (1996) were used and are shown below.

L factor:

$$L = \left(\frac{\lambda}{22.13}\right)^m \qquad m = \frac{F}{(1+F)} \qquad F = \frac{\sin\beta / 0.0896}{3(\sin\beta)^{0.8} + 0.56} \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{(2.8)}$$

$$m = ((\sin([slop]*0.01745)/0.0896)/(3*pow(\sin([slop]*0.01745),0.8)+0.56)) \quad \cdots\cdots \text{(2.9)}$$

Where,

λ = the slope length along the horizontal projection rather along the sloping surface;

m = the slope length exponent;

β = slope angle (%).

The L factor with upslope drainage contributing area was computed as:

$$L(i,j) = \frac{(A(i,j)+D^2)^{m+1} - A(i,j)^{m+1}}{x^m . D^{m+2} . (22.13)^m} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{(2.10)}$$

$$L = \frac{(pow([Flowacc]+1000,([m]+1)) - pow(([Flowacc],[m]+1))}{(pow(100,[m]+2)*pow(22.13,[m]))} \quad \cdots\cdots\cdots \text{(2.11)}$$

Where,

A (i, j) [m] = unit contributing area at the inlet of grid cell;

D = grid spacing;

x = shape correction factor.

The S factor was computed thus:

$$S(i,j) = \begin{cases} 10.8\sin\beta(i,j) + 0.03, \tan\beta(i,j) < 0.09 \\ 16.8\sin\beta(i,j) - 0.50, \tan\beta(i,j) \geq 0.09 \end{cases} \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{(2.12)}$$

Where,

β (i, j) = the mean slope angle of all sub-grids in the steepest direction.

Hillslope length λ is calculated as the grid area divided by the total length of streams in the same grid. Fig. 103 Shows the spatial distribution of LS factor in the CCD Catchments.

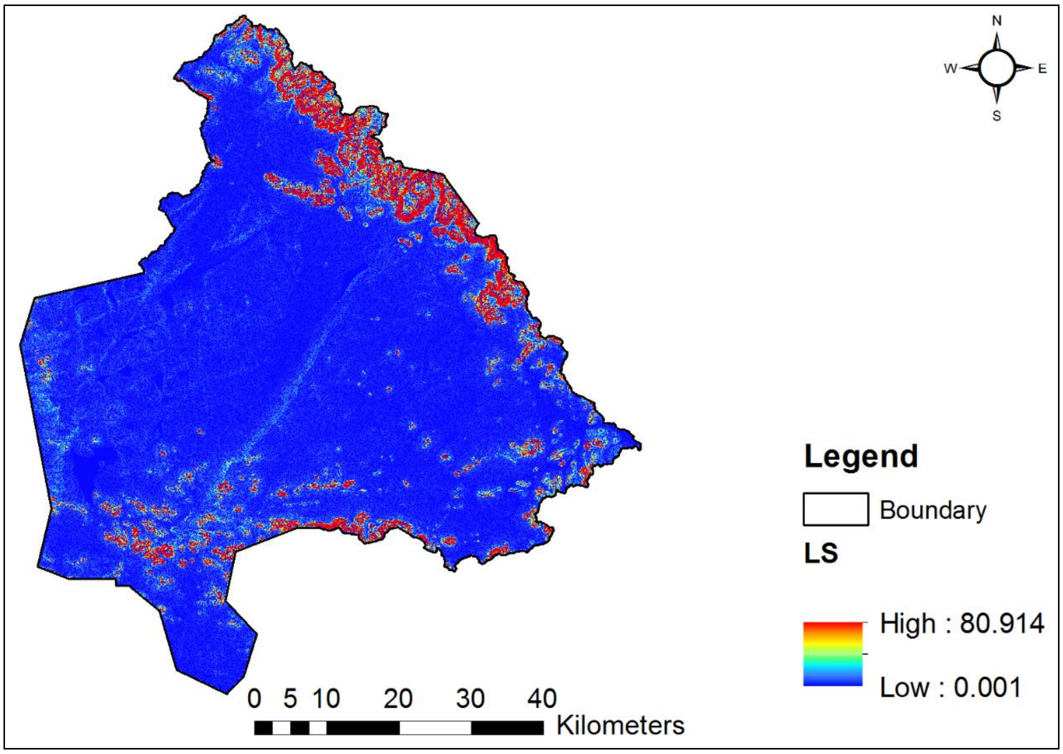

Fig. 103 Spatial distribution of LS factor within CCD Catchments

5.6. Conservation practice factor (P)

The support practice factor is defined as the ratio between soil loss with a specific support practice and the corresponding loss with upslope and downslope tillage. Renard and Forster (1983) explain that support practice essentially affects soil erosion through altering the flow pattern, gradients, or direction of surface runoff and by reducing the amount and rate of runoff. The conservation rating ranges from 0.001 to 1, with a lower P-value indicating that a more effective conservation practice is in place to curtail soil erosion.

5.7. Sediment delivery ratio (SDR)

The USLE cannot be directly used to estimate the amount of sediment reaching downstream areas because some portion of the eroded soil may be deposited while travelling to the downstream point of interest (Lim et al., 2005). To account for these processes, the SDR is used to estimate the total sediment transported to the watershed outlet. The values of SDR for an area are affected by catchment physiography, sediment sources, transport system, texture of eroded material, land cover, etc. Williams and Berndt (1974) found that the average channel slope is more significant than other parameters in estimating SDR, which is expressed as:

$$SDR = 0.627 \times S^{0.403} \quad (2.13)$$

Where,

S (%) = slope of watershed.

This equation was considered to give a reasonable estimation of the SDR in cases where data are inadequate (Onyando et al., 2005) and was adopted in the CCD catchments.

5.8. Estimated soil erosion and sediment yield

Fig. 104 presents the soil erosion results in the CCD Catchments. Estimated soil loss in the whole Catchments is 7,304,430 ton/year. The average rate exceeds the 5 ton/ha/yr soil loss tolerance limit mostly in the upper areas. These results reflect observations made in the field during a reconnaissance survey. Most of the areas with extremely severe erosion, were observed in higher elevations indicating the significance of percent slope in determining soil erosion. It is noticeable that areas associated with high rates of soil loss are closely linked to communal settlements where overgrazing and wood harvesting greatly reduce vegetation, leaving the highly erodible soils vulnerable to the effects of soil erosion.

Sediment mobilized by sheet and rill erosion may be deposited by a variety of mechanisms prior to reaching stream channels. Major factors which influence the long-term sediment yields/delivery from a catchment as reported in Morris and Fan (1998) and Ndomba (2007) are:

- Erosion process - the sediment delivered to the catchment outlet will generally be higher for sediment derived from channel-type erosion which immediately places sediment into the main channels of the transport system, as compared to sheet erosion
- Proximity to catchment outlet - sediment delivery will be influenced by the geographic distribution of sediment sources within the catchment and their relationship to depositional areas. Sediment is more likely to be exported from a source area near the catchment outlet as compared to a distant sediment source, since sediment from the distant sources will typically encounter more opportunities for re-deposition before reaching the catchment outlet
- Drainage efficiency - hydraulically efficient channels networks with a high drainage density will be more efficient in exporting sediment as compared to catchments having low channel density

- Soil and land cover characteristics - finer particles tend to be transported with greater facility than coarse particles. Because of the formation of particle aggregates by clays, silts tend to be more erosive and produce higher delivery ratios than clay soils
- Depositional features - the presence of depositional areas, including vegetation, ponds, wetlands, reservoirs and floodplains, will decrease the sediment yields at the catchment outlet. Most eroded sediments from large catchments may be re-deposited at the base of slopes, as outwash fans below gullies, in channels or on floodplains
- Catchment size and slope - a large, gently sloping catchment will characteristically have a lower delivery ratio than a smaller and steeper catchment.

Fig. 105 presents the slope-based SDR values in the CCD Catchments, estimated sediment delivery ratio in Catchments C1, C2, C3 and C4 combined is 0.107 and of Catchments C5 and C6 is 0.107 and 0.086 respectively and sediment yield in Catchments C1, C2, C3 and C4 combined is 509361 ton/year and soil loss in Catchments C5 and C6 is 62706.4 ton/year and 53980.1 ton/year respectively. Fig. 106 shows the sediment yields delivered at any location within the catchments. It should be noted that there may be uncertainties due to model errors and accuracy of input datasets. It is well known that the USLE was not developed for this kind of environment. Many studies showed that USLE substantially overestimates soil erosion and sediment yield in such settings due to sediment deposition in irregular and long slopes. The data problems are very typical for large watersheds especially in developing countries where data are not readily available.

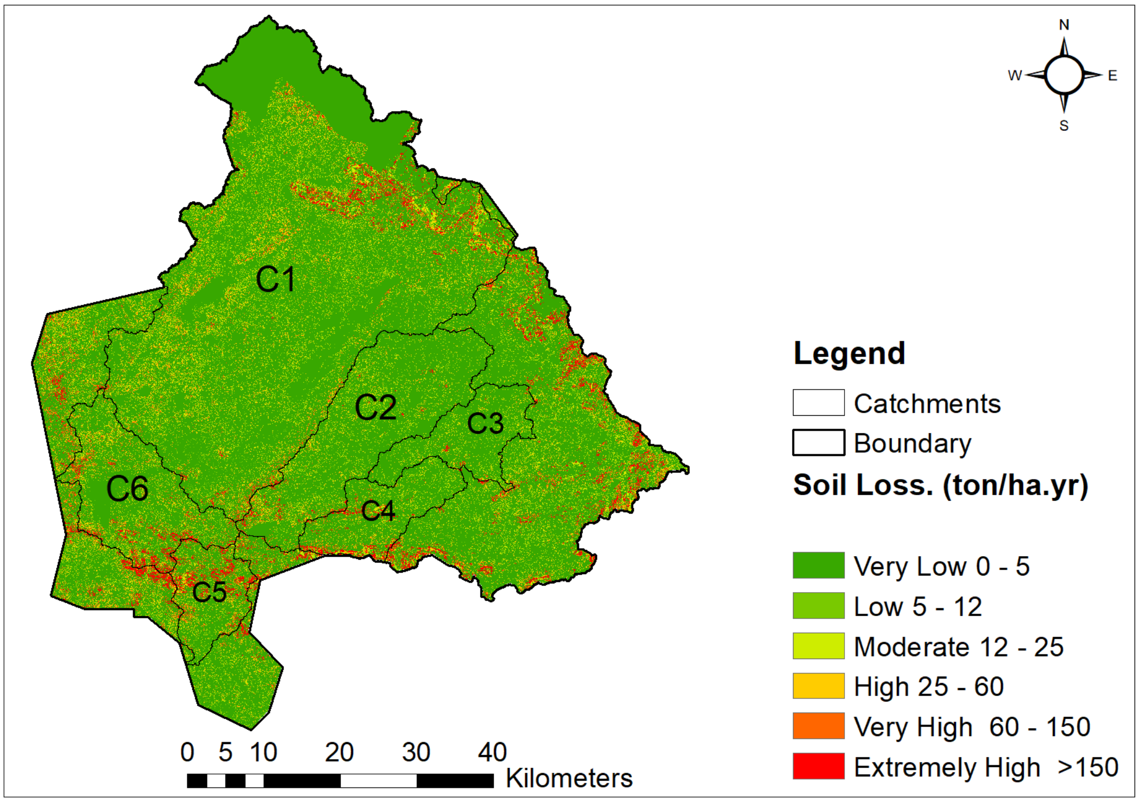

Fig. 104 Soil loss distribution in the CCD Catchments

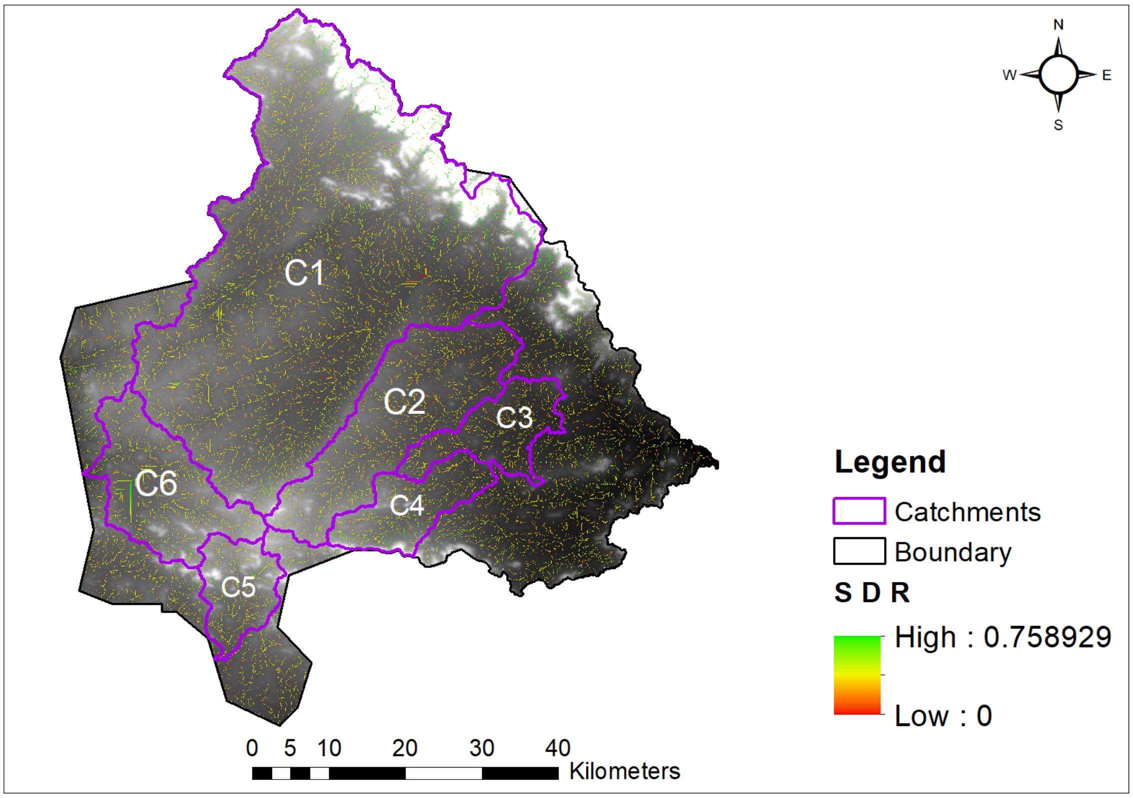

Fig. 105 Slope-based SDR map in the CCD Catchments

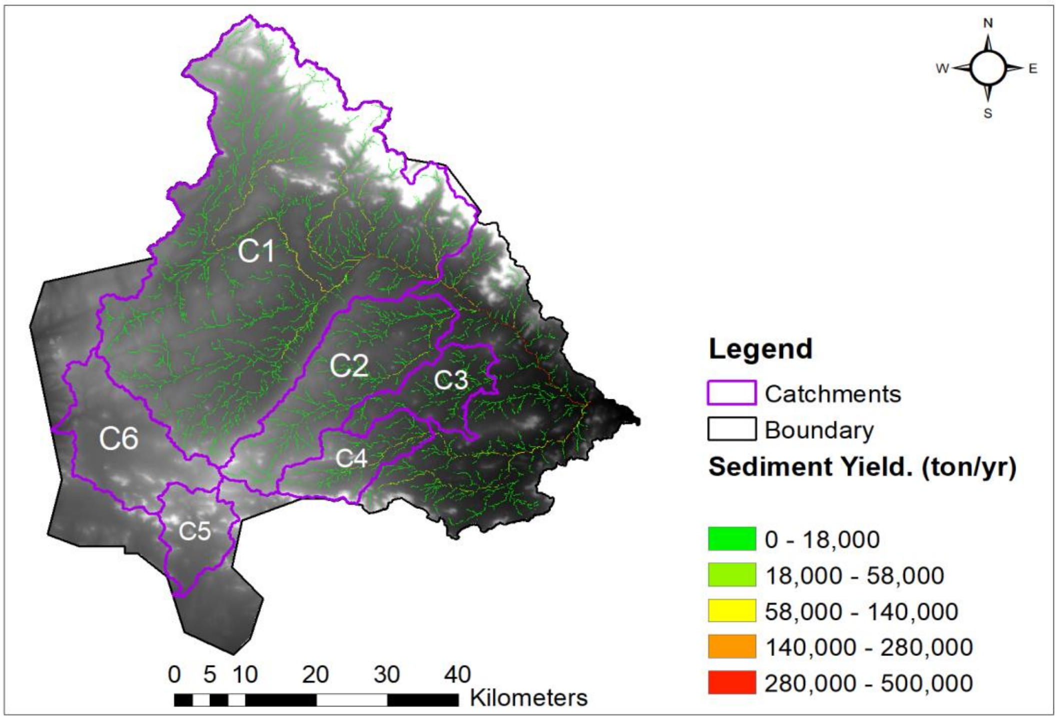

Fig. 106 Spatially distributed sediment yield in the CCD Catchments

6. Climate Change

6.1. Comparison between recent and past data

6.1.1. Rainfall days

The Fig. 107 shows a graphical plot showing rainfall trends for Dodoma in the last 30 years. This graph shows a decrease in the average rainfall in Dodoma.

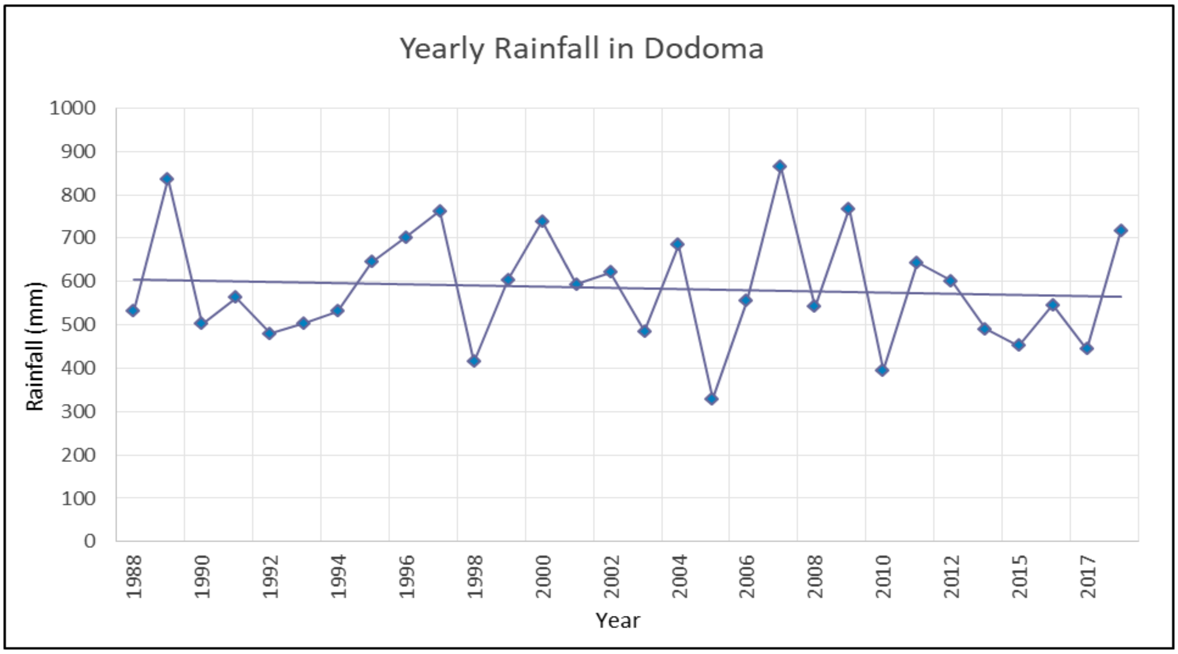

Fig. 107 NA Rainfall for Dodoma (1988 ~ 2018)

Data provided by the Tanzania Meteorological Agency (2006) shows the total rainfall in Dodoma is expected to increase in 2020, however the dry period will become drier and the rainy period has become more wet. This is shown by the table below:

Table 69. Historical and Expected Future Rainfall in Dodoma Region

	Rainfall in millimetres, historical trend (1974 ~ 2004)	Rainfall in millimetres, expected future trend (2020)
Total Average Rainfall, Rain Season	488	586
Total Average Rainfall, Dry Season	86	77
Total Rainfall	574	663

Source: Based on Tanzania Meteorological Agency (2006)

6.1.2. Rainfall days, onset, cessation

The number of rain days in Dodoma shows a decreasing trend, suggesting the duration of the growing season is reducing. The rainfall onset and cessation dates have shifted backwards only slightly that for all practical purposes is more or less constant. This means the growing season starts and ends earlier than it used to indicating a shift in the growing season.

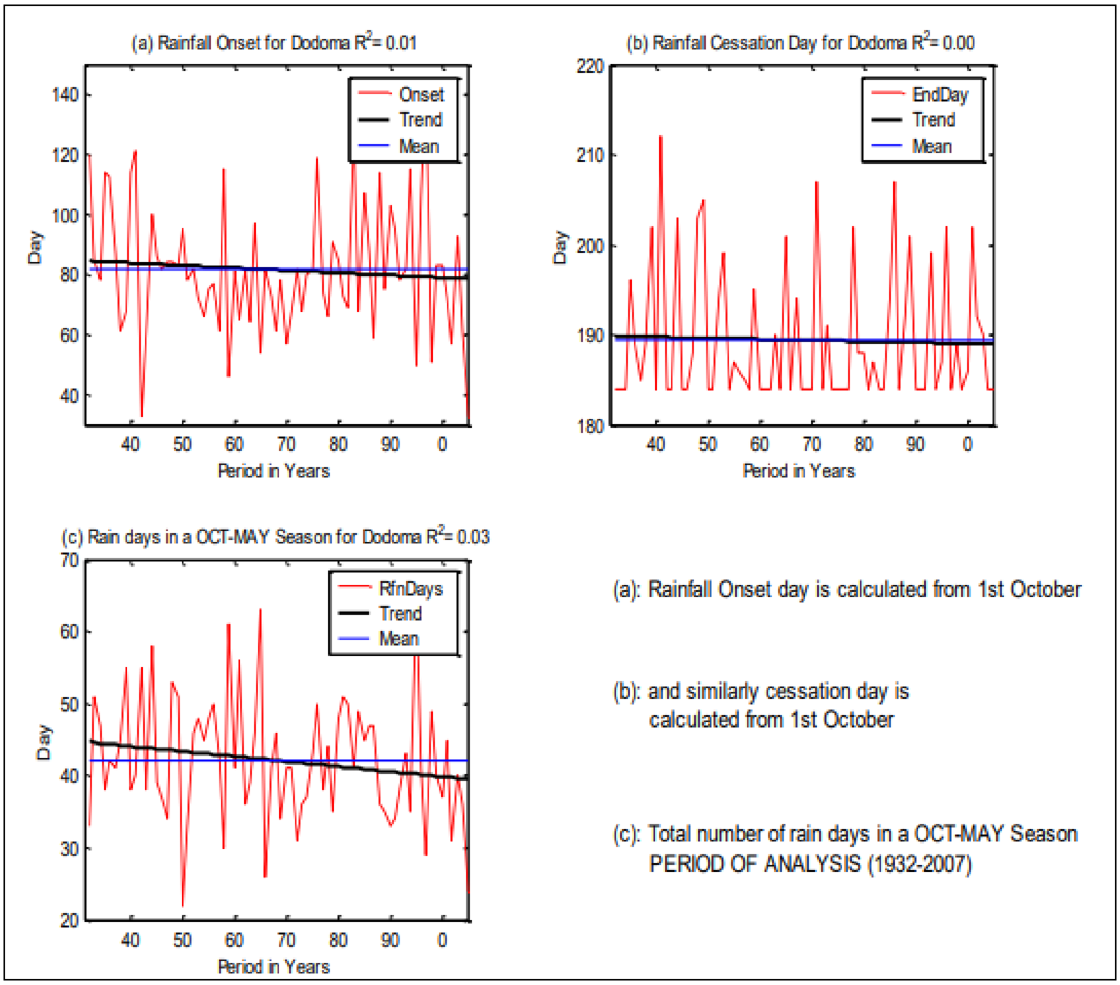

Fig. 108 Number of Rain Days, Rainfall Onset and Cessation Dates in Dodoma

6.2. Effects of Climate change in Dodoma

6.2.1. Damage to Infrastructure

Increased rainfall due to climate change can result in increased flooding, which can cause damage to transport, communications and buildings. In December 2009 and January 2001, unusual heavy rainfall associated with El Niño event saw widespread flooding in Morogoro (Kilosa) and Dodoma (Mpwapwa and Kongwa) regions, which led to severe damage on road, bridges, water dams, railway, electricity poles, drainage networks, water supply, and human settlements.

6.2.2. Wet and Dry Periods

Precipitation is predicted to increase with 5–30% during the rainy season and decrease with 5–10% during dry months for year 2020 in Tanzania and especially the interior parts of the country, such as Dodoma, will experience temperature increases and longer dry periods (Hulme and others 2001 and Clark and others 2003).

6.2.3. Availability of Water

The changes in precipitation will influence the availability of water, resulting in increased demand for larger water storage in Dodoma, where precipitation is concentrated over a short period. This will in-turn influence crop yield, which will again influence income, agricultural employment and household nutritional status.

6.2.4. Surface Run-off

De Wit and Stankiewicz (2006) performed a study which considered variable changes in precipitation in order to assess changes in drainage across Africa by the end of this century on the City of Dodoma. The study found the area is projected to experience a 10% rise in rainfall by the end of this century based on a composite of 21 GCM models, this suggests a rise in perennial drainage to a total of 136% in Dodoma.

6.2.5. Agriculture

The average rainfall for the Dodoma Region is 574 mm and about 85% of this rainfall falls in the months between December and April (Tanzania Meteorological Agency 2006). Rainfall is rather unpredictable in frequency and amount and climate change is expected to increase this uncertainty. The unreliable rainfall imposes a pattern of risk aversion in agriculture and is a serious constraint on present efforts to improve crop yields. The figure below shows a large variability in rainfall from 2001 and 2002:

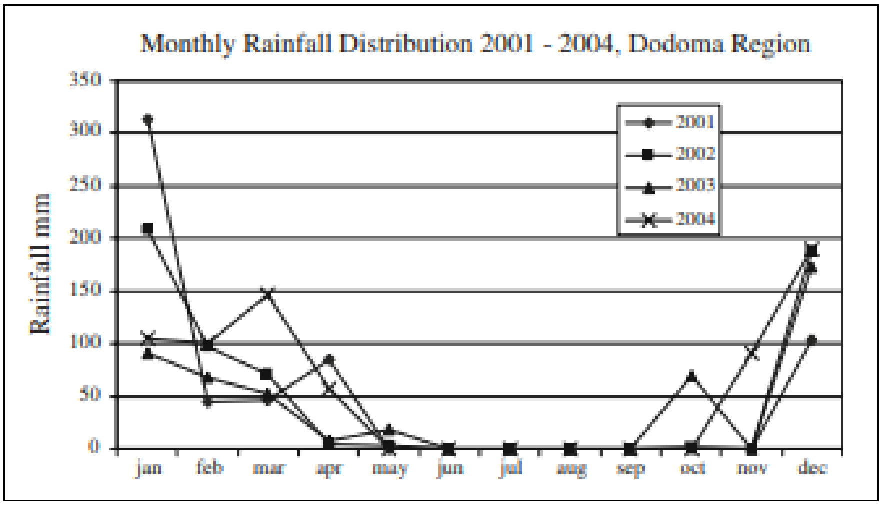

Fig. 109 Monthly Rainfall from 2001 to 2004 in Dodoma (TMA, 2006)

6.3. Existing Climate Change strategies

6.3.1. Agriculture

The Dodoma Municipal Council through its Agriculture department is keen in reducing vulnerability to climate change through following up of activities that are aimed at boosting agricultural production both at household and Municipal level. The vision of the Agricultural department is keen in reducing vulnerability to climate change through activities aimed at boosting agricultural production at household and Municipal level. This will in-turn facilitate sustainable food security and increased agri-based incomes. They aim to promote and facilitate agricultural productivity, sustainable management and the utilisation of natural recourses to ensure food security and increased incomes at household level.

There are nine Technical departments that are responsible for executing various activities aiming at achieving the vision for agriculture. These include:

- Agriculture, Irrigation and Cooperatives
- Livestock and Fisheries
- Water
- Sanitation and Environment
- Natural Resources and
- Community Development and Social Welfare.

Irrigation Development

Dodoma Municipality has several irrigation sites that have been developed over the years. These sites mainly use canals, water cans and drips. The water sources include dams, man-made lake, streams and boreholes. The following table shows the traditional irrigation by ward covering an area about 3,200 hectares. From the existing data, 389 hectares were used for irrigation in 2011/12 representing 12.2% of the total irrigable area. Furthermore, 325 hectares were cultivated under traditional irrigation, representing 10.2% of irrigable area. The major crops cultivated in the irrigable land are vegetables and grapes (Dodoma Socio-Economic Profile, 2017).

Table 70. Irrigation Prospects by Ward (Dodoma Municipal Council, 2016)

Ward	Estimated Potential Area (Ha) for irrigation	Major crops
Viwandani	0	-
Uhuru	0	-
Chamwino	0	-
K/Ndege	0	-
Makole	0	-
Miyuji	0	-
Msalato	0	-
Makutupora	70	Grapes, maize, sorghum, groundnuts
Chihanga	350	Grapes, Maize, row crops
Hombolo Makulu	500	Sorghum, maize
Hombolo Bwawani	150	Grapes, vegetable, maize
Ipala	150	Vegetable, sorghum, maize
Nzuguni	120	Paddy, sorghum, maize
D/Makulu	0	-
Mtrumba	50	Vegetable, sorghum
Kikombo	150	Vegetable, sorghum, groundnuts
Ngh’ong’onha	0	-
Mpunguzi	500	Grapes, vegetable, sorghum, maize
Tambukareli	0	-
Kilimani	0	-
Kikuyu Kusini	0	-
Kikuyu Kaskazini	0	-

Ward	Estimated Potential Area (Ha) for irrigation	Major crops
Mkonze	120	Vegetable, sorghum, maize
Mbabala	420	Grapes, vegetable, sorghum, maize
Zuzu	500	Paddy, vegetable, fruits
Hazina	0	-
Madukani	0	-
Majengo	0	-
Kizota	0	-
Nala	0	-
Mbalawala	70	Paddy, vegetable, sorghum
Ntyuka	0	-
Chigongwe	20	Groundnuts, maize
Chang'ombe	0	-
Iyumbu	0	-
Chahwa	30	Sorghum, groundnuts
Mnadani	0	-
Ipagala	0	-
Total	**3,200**	

This table shows there is a high potential for irrigation which has not been exploited, this means there is a need to intensify irrigation farming that will increase production of various crops in the area.

Fig. 110 Results of Irrigation at Small Scale in Zuzu Village

Livestock

The City Council of Dodoma, through its department of Livestock and Fisheries, is embarking on various activities aiming at increasing the population of livestock and improving the quality of livestock products. These are done through: vaccination campaigns of different diseases, artificial insemination program, dipping services and empowering programs to stakeholders (Dodoma Socio-Economic Profile, 2017).

Fig. 111 Some of Livestock Kept in the City Council of Dodoma

Dodoma will be highly vulnerable to climate change impacts, as more than 75% in the municipality depends on agriculture and livestock keeping for their livelihood (Ephrahim and Fadhili, 2015). Adaptation systems are therefore need to be implemented so that crop yields do not severely deteriorate.

Potential adaptation measures to changes in rainfall patterns for crops include rainwater storage for irrigation, adjustment of planting dates, changes in fertilisation, introduction of new crop varieties and location, application of conservation tillage and reduced utilisation of marginal lands. Other systems are discussed below in more detail below:

6.3.2. Water Supply

Catchment management is instrumental in ensuring groundwater resources are used sustainably and not subject to pollution. Groundwater supplies are important to domestic water supply in Africa because they often tend to hold water of good quality as well as typically store larger quantities of water than their annual recharge, enabling the maintenance of steady supplies even during low rainfall seasons (Calow and MacDonald, 2009). Shifting away from shallow dugwells – which are vulnerable to contamination, especially in urban areas – and handpumps – which tend to have poor reliability – would also be a sound strategy for both urban and rural areas (Foster et al., 2006). For the dry areas such as Dodoma, groundwater is the most viable supplemental source of domestic water (URT, 2010a; Foster et al., 2006)

6.4. Enhancing Climate Change Strategy

In order to maximise the impact of climate change strategies, especially in the rural developments, the implementation of the following are critical

- Support innovative approaches by farmers to build their resilience to climate change
- Help farmers take advantage of available funding and mitigation incentives
- To have a coherent dialogue on climate change, agricultural development and food security
- Training of existing in-house staff on the issue of climate change and rural development
- Creating a new organisational structure in Dodoma with dedicated expertise on climate change and the environment, which will share operational staff with regional divisions in pursuing a common agenda on climate change.

Key partnership is needed between the government and other key groups, such as local farmers NGO's, national and local public institutions including the Ministry of Agriculture. This will help empower the local communities and institutions in Dodoma to participate in climate-change related decision-making processes as well as aid in building their capacity to respond using their own experiences.

V. Sanitation System

1. General

Wastewater management is an integral part of the city management that ensures the sanitation of the area is well taken care of. The management aspects include collection, transportation, treatment and disposal of the wastewater for the lifetime of this Master Plan (2019 – 2040). Wastewater in Dodoma is currently handled by both on-site sanitation system and off-site sanitation system. The off-site system is managed through a sewerage system which comprises of collection, transportation, treatment and disposal of wastewater. The treatment facility currently manages two main wastewater categories namely central sewerage system developed under the Dodoma Trunk Service Project I and II between 1977 and 1979 and hauled wastewater from the septic tanks (septage).

The most predominant method of sewage and wastewater disposal and management in Dodoma city is on-site sanitation, comprising both pit latrines and septic tanks with associated soak pits and infiltration trenches. This method was found to be in use by about 94% of the population of Dodoma City.

2. Existing Sanitation System

Based on information from DUWASA and the Health department of CCD, the present situation on sewerage and sewage disposal can be summarized as follows.

The on-site and off-site sanitation system serves 94 percent and 6 percent of the total population of Dodoma City respectively.

The on-site sanitation system comprises of septic tanks with their associated soak away pit and pit latrines. Septic tanks system is used by 21.3 percent of the total population. Most of these are people with in-house water connections. About 71.3 percent of households without in-house water connection use pit latrines as means of liquid waste disposal.

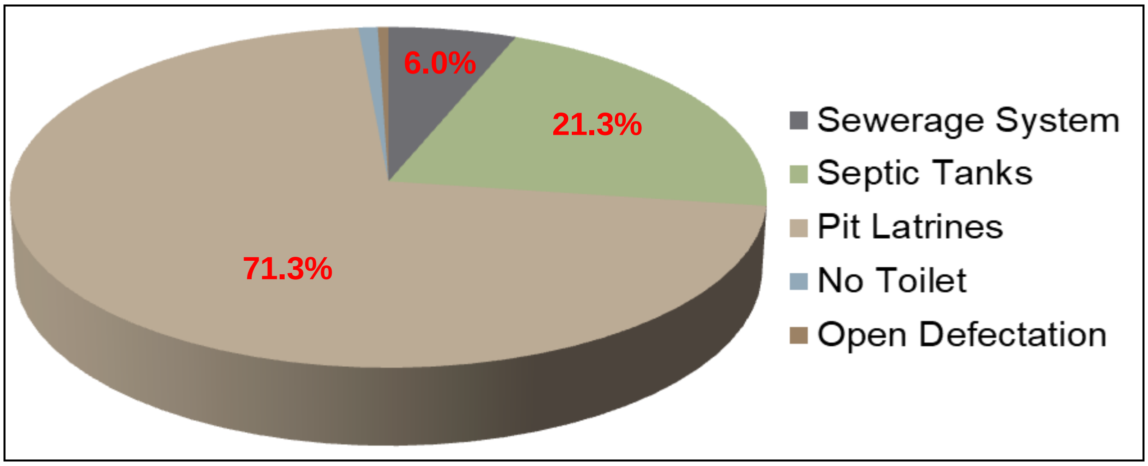

Fig. 112 Composition of Existing Sewerage and Sanitation System

The existing wastewater collection system can be grouped into two; namely by use of wastewater emptier or tankers and sewerage system for off-site connections.

Tankers carry wastewater from the septic tank/pit latrine and dispose it off into the waste stabilization ponds located at Swaswa. The cost for one trip truck to dispose the effluent from the septic tanks is normally negotiable for the private operator and fixed for DUWASA, namely for DUWASA is about 60,000/= Tsh per trip, while the accredited cost at the ponds for the private operator is fixed to 1,000/= Tsh per cubic meter of sewage. On the other hand, the fee for in-house sewage connected is 40% of water supply fee for each of cubic meter.

Currently, there are 9 tankers with varied capacity from $6m^3$ to $12m^3$ owned by the private company and individuals and 1 tanker owned by DUWASA. The tanker owned by DUWASA has $6m^3$ volumes with gauge reading which can show how much volume is carried at any time.

2.1. Existing Offsite Sanitation System

2.1.1. Coverage of the Piped Sewerage System

According to the current Master Plan, the sewer line has a total of 30.2 kilometres of the trunk main, with the maximum diameter of 1,000mm, and this trunk sewer was designed to serve 423,000 people.

To date, lateral sewers have been laid only in Mlimwa East, West and Central Business Park (CBP) as shown in the Fig. 113. Some of the sewer pipes are made of concrete with rigid concrete joint, with diameters ranging from 150mm to 1,000mm. The 600mm outfall trunk sewer has a maximum hydraulic design capacity of $13,000m^3$ per day which is equivalent to the capacity serving about 423,000 people. However, the sewerage system is serving only 6% of the Dodoma urban population due to lack of adequate lateral sewer pipes.

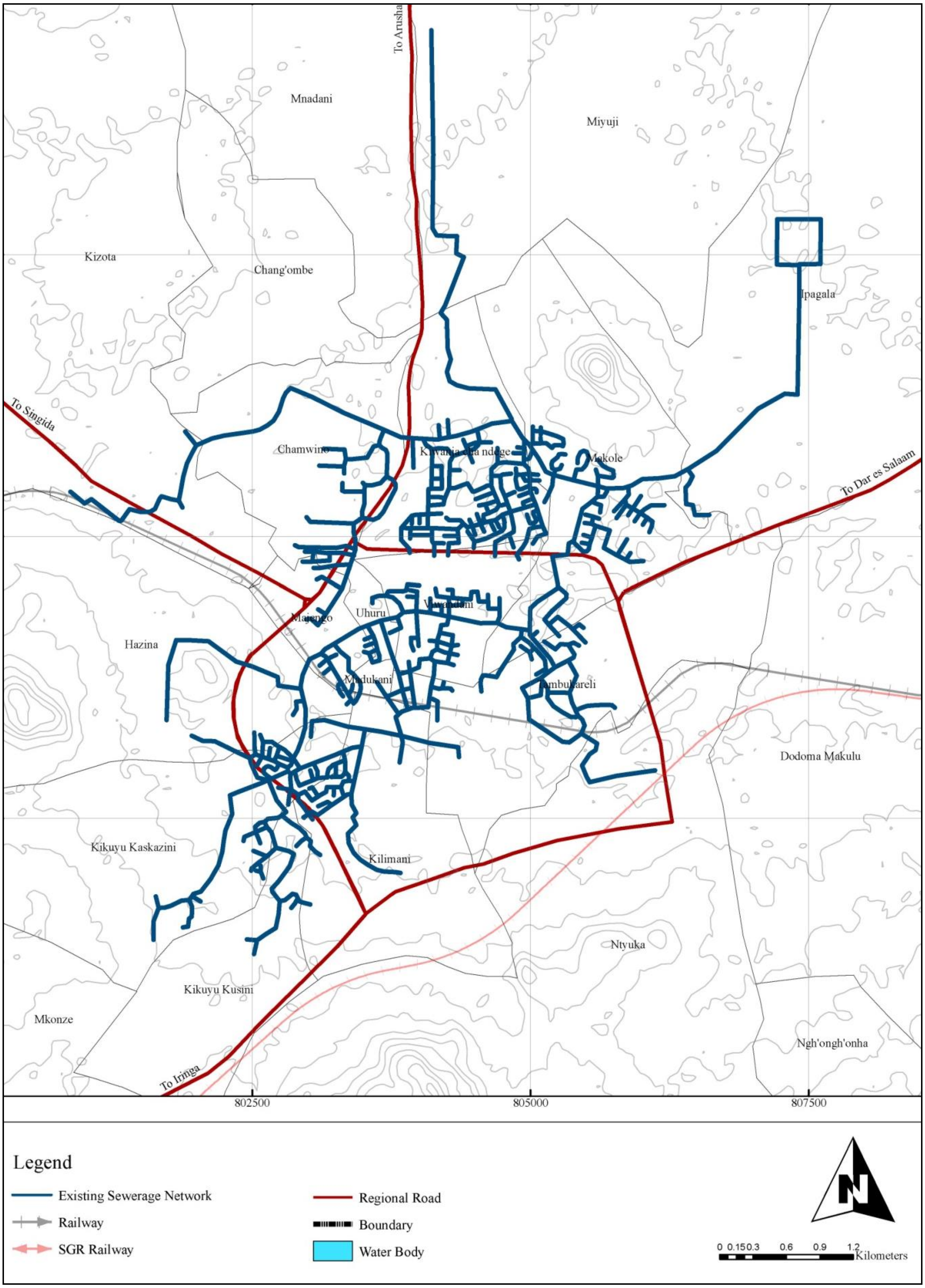

Fig. 113 Existing Sewerage System

2.1.2. Existing Trunk Sewer System

The existing trunk sewer system was developed under the Dodoma Trunk Service Project Ⅰ and Ⅱ. The system consists of 30.2km of pre-cast concrete spigot and socket rigid jointed concrete pipes ranging in diameter between 250-1,000mm. The trunk sewers cover some of the developed areas of Dodoma City and extensions is required to cover the whole city.

The existing trunk sewer include Trunk Sewer ‘I’, Sub-trunk Sewer ‘SI’, Trunk Sewer ‘K’, Sub-trunk Sewer ‘SK’, Trunk Sewer ‘H’, Trunk Sewer ‘B’ and Trunk Sewer ‘M’ leading to the existing Sewage Treatment Works at Swaswa. Detail of these trunk sewers are as summarized in the Table 71 below.

Table 71. Summary of Trunk Sewer

S/No.	Name of Trunk Sewer	Diameter (mm)	Sewers (km)
1	Trunk Sewer ‘I;	600 – 750	5.0
2	Sub-trunk Sewer ‘SI’ (Sewer J)	300 – 375	1.8
3	Trunk Sewer ‘K’	450 – 750	6.6
4	Sub-trunk Sewer ‘SK’	250 – 375	2.1
5	Trunk Sewer ‘H’	300 – 400	2.0
	Sub-trunk Sewer ‘SH’	300	0.6
6	Trunk Sewer ‘B’	250 – 450	1.9
	Sub-trunk Sewer ‘SB’	250	5.3
7	Trunk Sewer ‘M’	600 – 1,000	4.9
Total			**30.2**

- **Trunk Sewer ‘I’**

This trunk sewer measures approximately 4.7km in length. It consists of pre-cast concrete rigid jointed spigot and socket pipes ranging in diameter between 600-750mm. Currently, the sewer starts from a point within Chinangali East, just off the main Tabora Road, and passes between Chinangali West and East, north of Mlimwa West (Area C), through Mlimwa East (Area D) and to the north of Chadulu before joining Trunk Sewer 'M' near lpagala West.

- **Trunk Sewer ‘SI’**

This is a Sub-trunk to Trunk Sewer 'I'. It mainly serves Chinangali East area to the west of the Great North Road. The Sub-trunk sewer measures approximately 1.8km in length and consists of precast concrete rigid jointed spigot and socket pipes ranging in diameter between

300-375mm. The sewer starts from within Chinangali East and joins the Trunk Sewer 'I' at a point to the north of the area.

- **Trunk Sewer 'K'**

This is currently the longest trunk sewer, measuring approximately 6.6km in length. It consists of precast concrete rigid jointed spigot and socket pipes ranging in diameter between 525-750mm. It starts from Kikuyu area to the south and passes through Hazina, under the Tabora Railway Line near Majengo, through Urban Renewal West, Urban Renewal East and Makole before joining the Trunk Sewer 'I' within Mlimwa East (Area D).

- **Trunk Sewer 'SK'**

This is a Sub-trunk to Trunk Sewer 'K'. It mainly serves the eastern part of Kikuyu area to the west of the Chimwaga Road. The Sub-trunk sewer measures approximately 2.1km in length and consists of pre-cast concrete rigid jointed spigot and socket pipes ranging in diameter between 225-375mm. The sewer starts from within Kikuyu and joins the Trunk Sewer 'K' at a point within Hazina area.

- **Trunk Sewer 'H' and 'SH'**

This sewer is essentially a Sub-trunk to Trunk Sewer 'K'. It mainly serves the Urban Renewal East area. It measures approximately 2.6km in length and consists of pre-cast concrete rigid jointed spigot and socket pipes ranging in diameter between 375-450mm. The sewer starts from a point to the south of Tabora Railway Line where it is extended to serve parts of Hazina East and Mlimani areas. The sewer finally joins Trunk Sewer 'K' at a point to the north of the area.

- **Trunk Sewer 'B' and 'SB'**

This sewer is essentially a Sub-trunk to Trunk Sewer 'K'. It mainly serves the Business Park and Makole areas to the east of the developed areas. The sewer measures approximately 2.6km in length and consists of pre-cast concrete rigid jointed spigot and socket pipes ranging in diameter between 250 - 450mm.

As is the case with Trunk Sewer 'H', the sewer starts at a point to the south of the railway line where it has been extended to serve parts of Mlimani and the National Capital Centre. It joins Trunk Sewer 'K' at a point within Makole.

Trunk Sewer 'M'

Trunk Sewer 'M' collects the wastewater from all the existing trunk sewers and delivers the same to the existing sewage treatment works at Swaswa. The sewer measures approximately 2.6km in length and consists of pre-cast concrete rigid jointed spigot and socket pipes ranging in diameter between 900-1000mm. The sewer starts at a point to the north of Chadulu and passes through lpagala West area before finally joining the Swaswa Sewage Treatment Works. The last 1.0km of the sewer is made up of 600mm diameter concrete pipe.

The existing trunk sewer in Dodoma City above is as follow according to each ward.

Table 72. Status of Existing Trunk Sewers for Each Ward

Item No.	Ward	Diameter (mm)	Length (Km)
1	Viwandani	400-675	3.1
2	Uhuru	300-400	0.8
3	Chamwino	300-675	4.2
4	Kiwanja Cha Ndege	750	1.6
5	Makole	250-1000	2.9
6	Tambukareli	300-450	1.6
7	Kilimani	300	0.4
8	Kikuyu Kasikazani	250-525	3.2
9	Hazina	525	1.5
10	Madukani	300	0.2
11	Majengo	525-600	0.6
12	Kizota	600	0.8
13	Ntyuka	250-450	4.4
14	Ngh'ongh'onha	250	0.9
15	Ipagala	600-1000	4.1
Total			**30.2**

2.1.3. Sewer Reticulation System

In spite of the wide coverage of the developed areas of Dodoma with trunk sewers, very few areas have been served with reticulation sewers or have indeed been connected to the existing sewerage system.

Currently only four (4) areas are served with a comprehensive reticulation sewers network namely: Mlimwa West (Area C), Mlimwa East (Area D), Central Business Park (CBP) and Hazina, representing about 6% of the population of Dodoma City.

Elsewhere, a few isolated institutions and other developments located in the vicinity of the trunk sewers have been connected to the· sewerage system. However, these cases are few and far apart.

The existing reticulation sewers in the four (4) areas above were developed as part of the Dodoma Trunk Services I and II Project (1977-1979) and Extension of Sewerage Systems in Hazina Area (2008). They comprise pre-cast spigot and socket rigid jointed pipes, with the Secondary Sewers ranging in diameter between 200-300mm and the Lateral Sewers (Tertiary Sewers) between 150-200mm. In total the Secondary Sewers and Tertiary Sewers network measure about 58km in length. Details of these sewers are as summarized in the table below.

Table 73. Existing Reticulation Sewers

S/No.	Area Served	Sewer Diameter (mm)	Sewer Length (km)
1	Area C	250 to 300	11
2	Area D	250 to 300	6
3	Hazina	150 to 250	8
4	Uhuru Madukani	150 to 355	6
5	Mlimwa	150	3
6	Area E	150	2
7	Chinangali	150 to 250	4
8	Makole	150 to 250	5
9	Kilimani	150	1
10	Majengo	150 to 250	4
11	Kikuyu	150	3
12	Airport	150	3
13	Uhindini	150 to 250	2
Total			**58**

Table 74. Status of Existing Reticulation Sewers for Each Ward

S/No.	Wards Served	Sewer Length (km)
1	Viwandani	8.3
2	Uhuru	0.1
3	Chamwino	5.6
4	Kiwanja Cha Ndege	15.0
5	Makole	8.0
6	Tambukareli	2.0

S/No.	Wards Served	Sewer Length (km)
7	Kilimani	1.6
8	Kikuyu Kasikazani	6.0
9	Hazina	7.4
10	Madukani	0.9
11	Majengo	1.8
12	Kizota	1.3
Total		**58**

2.1.4. Property Connections

The construction of the Lateral Sewers (Tertiary Sewers) had made provisions for property connections but in several cases the markings indicating the locations of these connections are difficult to trace. This situation has had a negative effect on the development of the areas as it has discouraged prospective and potential developers.

The property connection sewer pipes and/or chambers for the respective plots should, as a rule, be well marked for ease of identification during sewer connections to houses as they are developed. This will encourage potential developers and help to avoid cutting of the roads later when the need arises.

At the end of July, 2018, the Authority (DUWASA) had a total of 5,608 sewerage customers (against 40,906 water customers) including Domestic, Institutions, Commercial and Domestic Point Users. This translates to about 14% of the water customers, which is very low.

2.1.5. Operation and Maintenance Problems for Sewers

It was established that some sections of the trunk sewers were blocked at various areas with deleterious matter such as worn out clothes and plastic bags, which had been thrown into the system deliberately or ignorantly. Another major problem identified in the trunk sewers was the burying of the sewer manholes with construction materials in areas where buildings and civil works are going on or have recently been completed. The same problem was found to occur during construction of footpaths, drainage systems and installation of underground utility services such as telephone and electricity. The occurrence of this problem has made it difficult for the maintenance authority and the developers to locate the sewer lines' manholes and has in some instances resulted in the topsoil, cement, aggregates and other such sediments finding their way into the sewer system through the manholes. This situation has been aggravated by vandalism of the cast iron manhole covers and frames for re-use in manufacture of various “Ujasiriamali” items.

Missing Manhole Cover

Damaged Manhole Cover

Overflow from Manhole

Blockage of Sewer

Fig. 114 Problems on Sewer and Manholes

In order to alleviate some of these problems there is obvious need to promote health education to the public through the radio, television and newspapers. With regard to the operation and maintenance of the sewerage system, there is further need to maintain a well-coordinated, organized and supervised cleansing and flushing program. For the trunk sewers it would be necessary to carry out power rodding and jetting as and when necessary. Use of telescopic cameras and physical checks where feasible would help to enhance proper management and monitoring of the sewerage system. With regard to vandalism, it would be advisable to replace the stolen manhole covers and frames with concrete filled ones, which would discourage the tendency.

2.2. Existing Onsite Sanitation System

2.2.1. General

An on-site system is a wastewater collection and treatment system that is installed on a specified piece of land owned by a private person or entity. Hence, the landowner is fully responsible for this treatment system. It is usually applicable for low-cost, non-sewered sanitation (faecal sludge) systems as intermediate storage, but can also serve as pre-treatment modules for small-scale wastewater treatment systems. The main technology applicable for onsite sanitation system is the pit latrine or septic tank. In the vast majority of situations, these systems are already installed on-site but are often improperly designed, constructed and maintained, which poses severe environmental hazards. Apart from septic tanks providing some degree of pre-treatment, the effluent usually contains high concentrations of pollutants, which can carry severe public health and environmental burdens, especially in densely populated urban areas and in the vicinity of drinking water sources. Hence, proper sealing of containment options is crucial for environmental sanitation.

2.2.2. Pit Latrine

A pit latrine is a type of toilet that collects human feces in a hole in the ground. Urine and feces enter the pit through a drop hole in the floor, which might be connected to a toilet seat or squatting pan for user comfort. Pit latrines can be built to function without water (dry toilet) or they can have a water seal (pour-flush pit latrine). When properly built and maintained, pit latrines can decrease the spread of disease by reducing the amount of human feces in the environment from open defecation. This decreases the transfer of pathogens between feces and food by flies. These pathogens are major causes of infectious diarrhea and intestinal worm infections. Pit latrines are a low-cost method of separating feces from people.

Pit Lining

- Partial Lining

A "partially lined" pit latrine is one where the upper part of the hole in the ground is lined. Pit lining materials can include brick, rot-resistant timber, concrete, stones, or mortar plastered onto the soil. This partial lining is recommended for those pit latrine used by a great number of people — such as a public restroom in rural areas, or in a woodland park or busy lay-by, rest stop or other similarly busy location — or where the soils are unstable in order to increase permanence and allow emptying of the pit without it collapsing easily. The bottom of the pit should remain unlined to allow for the infiltration of liquids out of the pit.

- Fully Lining

A fully lined pit latrine has concrete lining also at the base so that no liquids infiltrate into the ground. One could argue that this is no longer a "pit" latrine in the stricter sense. The advantage is that no groundwater contamination can occur. The major disadvantage is that a fully lined pit latrine fills up very fast (as the urine cannot escape the pit) which results in high costs to empty and maintain the latrine. Increased odour can also be an issue as the pit content is much wetter and emits more odour. This type of pit latrine is used only in special circumstances, e.g. in denser settlements where groundwater protection is paramount.

Improvement of a Basic Pit Latrine

- Ventilated Improved Pit (VIP)

The ventilated improved pit latrine is a pit latrine with a black pipe (vent pipe) fitted to the pit and a screen (flyscreen) at the top outlet of the pipe. VIP latrines are an improvement to overcome the disadvantages of simple pit latrines, e.g. fly and mosquito nuisance and unpleasant odors. The smell is carried upwards by the chimney effect and flies are prevented from leaving the pit and spreading disease.

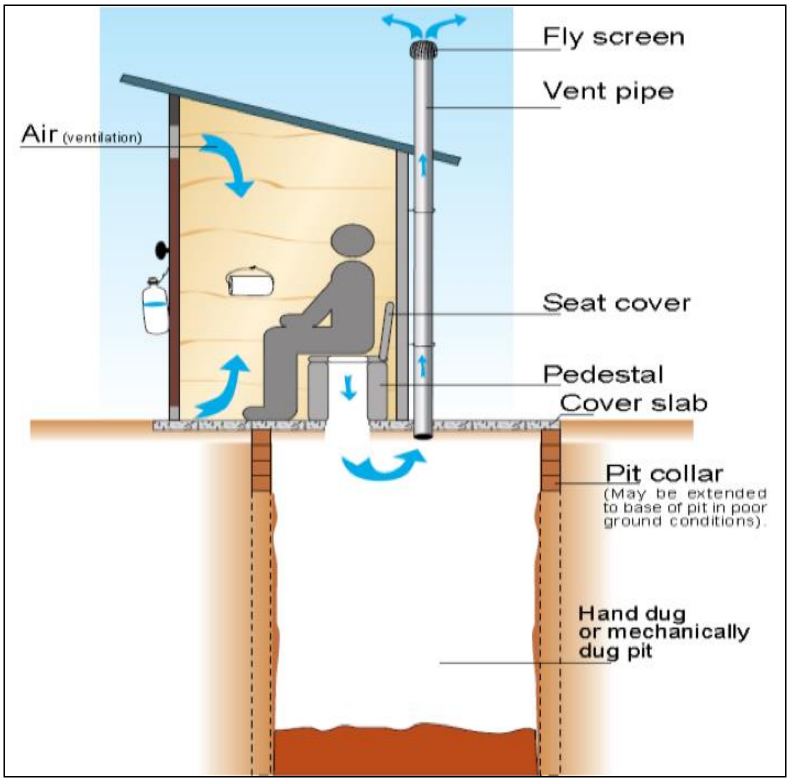

Fig. 115 Schematic View of Ventilated Improved Pit (VIP)

- Pour-Flush Pit Latrine

In a pour-flush pit latrine, a squatting or pedestal toilet with a water seal (U-trap or siphon) is used over one or two offset pits. Therefore, these types of toilets do require water for flushing but otherwise have many of the same characteristics as simple pit latrines. About one to three liters of water is used per flush in that case, and they often have two pits that are used one after the other (twin pit pour flush pit latrine). For this reason, they are subsumed under the term "pit latrine". The fecal sludge that is removed from the full pits of twin-pit pour-flush pit latrines is somewhat safer to handle and reuse than the fecal sludge from single pit pour-flush latrines. However, significant health risks for the workers who are emptying the pits remain in either case.

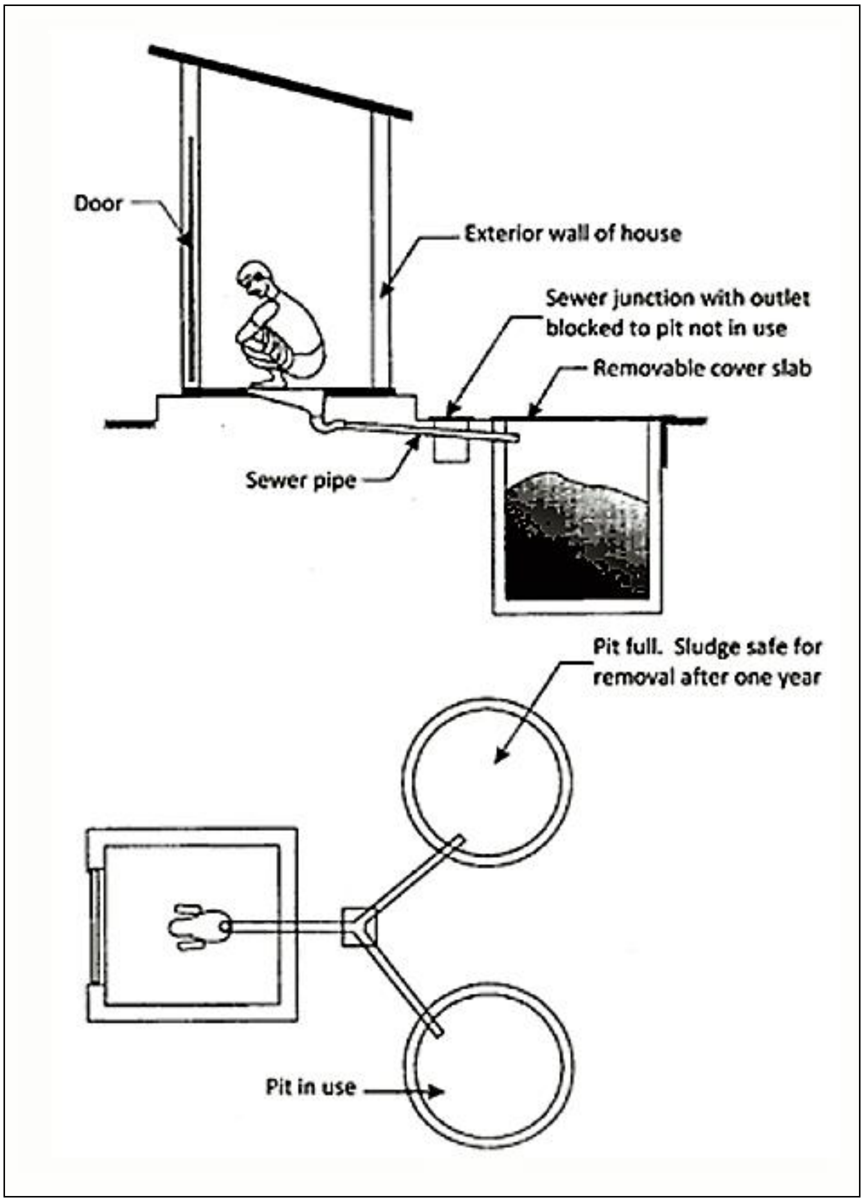

Fig. 116 Schematic View of Pour-Flush Toilet Linked to Twin Pits

Locating the Pit Latrine

Liquids leach from the pit and pass the unsaturated soil zone. Subsequently, these liquids from the pit enter the groundwater where they may lead to groundwater pollution. This is a problem if a nearby water well is used to supply groundwater for drinking water purposes. During the passage in the soil, pathogens can die off or be absorbed significantly, mostly depending on the travel time between the pit and the well. Most, but not all pathogens die within 50 days of travel through the subsurface.

The degree of pathogen removal strongly varies with soil type, aquifer type, distance and other environmental factors. For this reason, it is difficult to estimate the safe distance between a pit and a water source – a problem that also applies to septic tanks. Detailed guidelines have been developed to estimate safe distances to protect groundwater sources from pollution from on-site sanitation. However, these are mostly ignored by those building pit latrines. In addition to that, household plots are of a limited size and therefore pit latrines are often built much closer to groundwater wells than what can be regarded as safe. This results in groundwater pollution and household members falling sick when using this groundwater as a source of drinking water.

As a very general guideline it is recommended that the bottom of the pit should be at least 2 m above groundwater level, and a minimum horizontal distance of 30 m between a pit and a water source is normally recommended to limit exposure to microbial contamination. However, no general statement should be made regarding the minimum lateral separation distances required to prevent contamination of a well from a pit latrine. For example, even 50 m lateral separation distance might not be sufficient in a strongly karstified system with a downgradient supply well or spring, while 10 m lateral separation distance is completely sufficient if there is a well-developed clay cover layer and the annular space of the groundwater well is well sealed.

If the local hydrogeological conditions (which can vary within a space of a few square kilometres) are ignored, pit latrines can cause significant public health risks via contaminated groundwater. In addition to the issue of pathogens, there is also the issue of nitrate pollution in groundwater from pit latrines. Elevated nitrate levels in drinking water from private wells could result in the blue baby syndrome in children.

Maintenance

The requirements for safe pit emptying and fecal sludge management are often forgotten by those building pit latrines, as the pit will only fill up in a few years' time. However, safe fecal sludge management practices are lacking and causing public health risks as well as environmental pollution. Fecal sludge that has been removed from pits manually or with vacuum tankers is often dumped into the environment indiscriminately.

When the pit is full, the toilet is no longer usable. The time it takes to fill the pit depends on its volume, the number of users, the soil permeability and groundwater level. It can typically take between one and ten years or even longer in some exceptional cases. At that point, the pit can be covered and abandoned, and a new pit latrine built if space on the property permits this. The new pit latrine may reuse the shelter (superstructure) if the shelter can be moved without collapsing. In peri-urban or urban areas, full pits are not abandoned but rather emptied so that the toilets can continue to be used at the same location after the emptying has taken place.

The emptying can be done manually with shovels and buckets, with manually powered pumps or with motorized pumps mounted on a vacuum truck. For the fecal sludge to be pumpable, water usually needs to be added to the pit and the content stirred up, which is messy and smelly.

2.2.3. Septic Tank

A septic tank is an underground chamber made of concrete, fiberglass, or plastic through which domestic wastewater flows for basic treatment. Settling and anaerobic processes reduce solids and organics, but the treatment efficiency is only moderate (referred to as "primary treatment"). Septic tank systems are a type of simple onsite sewage facility.

The term "septic" refers to the anaerobic bacterial environment that develops in the tank that decomposes or mineralizes the waste discharged into the tank. But, the rate of accumulation of sludge is faster than the rate of decomposition. Therefore, the accumulated fecal sludge must be periodically removed, which is commonly done with a vacuum truck.

➲ **Structural Mechanism of Septic Tank**

A septic tank consists of a minimum of two, sometimes three concrete or plastic compartments of between 4,000 and 7,500 liters. The compartment walls extend 15-30cm above the liquid level. Avoiding surface or stormwater intrusion during rainy season shall be considered during the design. To prevent the wastewater from flowing backwards into the system, the outlet is constructed 10-15cm below the inlet. The first compartment occupies about two-thirds of the total septic-tank volume. All chambers are normally the same depth. The total volume of a septic tank can be estimated by assuming 80 to 100 litre per domestic user. The exact volume depends on the wastewater characteristics. Usual hydraulic retention time (HRT) is approximately 2 days.

Wastewater enters the first chamber of the tank, allowing solids to settle and scum to float. The settled solids are anaerobically digested, reducing the volume of solids. The liquid component flows through the dividing wall into the second chamber, where further settlement takes place. The excess liquid, now in a relatively clear condition, then drains from the outlet into the leach field. A percolation test is required prior to installation to ensure the porosity of the soil is adequate to serve as the leach field.

The remaining impurities are trapped and eliminated in the soil, with the excess water eliminated through percolation into the soil, through evaporation, and by uptake through the root system of plants and eventual transpiration or entering groundwater or surface water.

Either a piping network or a soak pit, often laid in a stone-filled trench or area, distributes the wastewater throughout the field with multiple drainage holes in the network or pit. The size of the leach field is proportional to the volume of wastewater and inversely proportional to the porosity of the leach field. The entire septic system can operate by gravity alone or, where topographic considerations require, with inclusion of a lift pump.

Maintenance

The treatment efficiency of septic tanks ranges from 25% to 50% COD removal. The removal rates drop drastically when accumulated sludge fills more than two-thirds of the tank. To avoid this, frequent desludging is necessary. Otherwise the septic tank fills up and wastewater containing undecomposed material discharges directly to the leach field. Not only is this detrimental for the environment but, if the sludge overflows the septic tank into the leach field, it may clog the leach field piping or decrease the soil porosity itself, requiring expensive repairs.

When a septic tank is emptied, the accumulated sludge (also known as fecal sludge) is pumped out of the tank by a vacuum truck. How often the septic tank must be emptied depends on the volume of the tank relative to the input of solids, the amount of indigestible solids, the ambient temperature, system characteristics, etc.

Services for de-sludging tend to empty a septic tank completely although the actual removal of settled solids is left purposefully incomplete, so as to leave at least some of the microbial populations in place to continue the anaerobic degradation processes that take place in a septic tank. And, an empty tank may be damaged by hydrostatic pressure causing the tank to partially "float" out of the ground, especially in flood situations or very wet ground conditions.

➲ **Environmental Concerns**

Septic tank is appropriate where there is a way of dispersing or conveying the effluent. If septic tanks are used in densely populated areas, on-site infiltration should not be used. Infiltration of the effluent can lead to contamination of groundwater aquifers. Additionally, oversaturation of the ground can cause wastewater to rise to the surface, posing a serious health risk.

2.2.4. Onsite Systems in Dodoma City

The most predominant method of sewage and wastewater disposal and management in Dodoma is the "on-site" sanitation, comprising both pit latrines and septic tanks systems with associated soakage pits or infiltration trenches, which is used by about 94% of the total population. Among them, septic tanks system is used by 21.3 percent of the total population and about 71.3 percent of households use pit latrines as means of liquid waste disposal.

Wastewater entering the onsite systems is decomposed anaerobically by bacteria. After a period of time empty tankers come to suck fecal sludge from some onsite systems and dump it into the Waste Stabilization Ponds in Swaswa area. And, there are many cases whereby the sludge from the empty tankers is discharged to the open land.

And, storm water drains were also used to dispose sewage in the project area. Residents living very close to the storm drains construct small outlets at the ground level that discharges wastewater into storm water drains constructed by the City Council, which can contaminate not only the storm water drains, but also public water bodies connected to the drains.

Moreover, due to the low permeability of the soils in most of the project area, the septic tanks and pit latrines do not function satisfactorily. This situation is made worse by incidences of flooding from storm water runoff, resulting in frequent filling up and over spilling of soak pits and pit latrines, which lead to unhealthy conditions in the inhabited areas. And, the facilities available for exhausting the septic tanks are also inadequate, which results in a situation that enhances prevalence of water borne diseases such as diarrhea, dysentery, typhoid fever and cholera.

With the increase in population and improved water supply in these areas, the situation may be aggravated further and could be a potential source of ground water contamination and may even contaminate the potable water in the existing ground water supply network.

2.3. Wastewater Treatment Facilities

2.3.1. Swaswa Wastewater Treatment Facility

The existing wastewater treatment facility is located at a site North-East of Mlimwa at Swaswa in Ipagala Ward. It comprises two (2) series of ponds in parallel, each with 2 no. of 200m × 200m square ponds and an average depth of 1.5m, covering an area of 16ha. The size of the ponds was fixed on the assumption that critical flow would not exceed 90l/c·d for an estimated population of 68,000 people, that is, an average wastewater flow of 6,120m^3/d. It receives wastewater through the pipe network and septage brought by tankers. On average 24 tankers empties sludge on daily basis.

However, the system is currently serving only small population of 48,000 people. Currently, only one of the series of ponds (the Eastern Series) is operational, the other series is being prepared for desludging.

The most efficient oxidation ponds are those that most closely simulate plug flow as opposed to mixed flow. The present construction comprising of square ponds allows for short-circuiting of the effluent, which leads to uncompleted biological treatment and hence poor quality of effluent. Ponds should be rectangular in plan with a width to length ratio ranging between 1:2 to 1:3 and with inlet and outlets at the diametrically opposite corners. In order to produce high quality effluent at least three (3) to four (4) ponds are required in series. To attain the required degree of wastewater treatment, the flow should be passed through different stages as follows:

- Anaerobic ponds – Removal of settleable matter
- Facultative ponds - Reduction of the Biological Oxygen Demand (BOD) of the organic matter by photosynthetic algae and finally
- Maturation ponds - pathogen removal and polishing of the wastewater.

However, it has the anaerobic and facultative ponds only without maturation ponds which has a role of pathogen removal. And, the design of treatment system was not properly done lacking the preliminary units such as screen and grit chamber. In addition to this the system has no a sludge drying bed and two of these ponds are not working.

Thus, it discharges effluent that does not comply with the permissible Tanzania and other standards. The DUWASA has conducted a water quality analysis on the influent and effluent of WSPs at Swaswa area and we confirmed that the test results are as follows:

Table 75. Summary of the Influent Test Results (2018)

Month	BOD (mg/l)	COD (mg/l)	Color (TCU)	Fecal Coliform (per 100ml)	Nitrate (mg/l)	pH	Phosphorus (mg/l)	Total Coliform (per 100ml)	Total Suspended Solids(mg/l)
January	456	821	120	N/A	148	7.7	55	N/A	317
February	347	625	114	N/A	139	7.7	48	N/A	278
March	321	578	121	N/A	124	7.8	36	N/A	243
June	340	578	75	N/A	105	8.1	12	N/A	227
July	266	478	65	N/A	270	7.7	21	N/A	342
Average	**346**	**616**	**99**	**N/A**	**157**	**7.8**	**34**	**N/A**	**281**

Table 76. Summary of the Effluent Test Results (2018)

Month	BOD (mg/l)	COD (mg/l)	Color (TCU)	Fecal Coliform (per 100ml)	Nitrate (mg/l)	pH	Phosphorus (mg/l)	Total Coliform (per 100ml)	Total Suspended Solids(mg/l)
January	190	304	88	42,000	110	7.7	36	54,000	83
February	188	301	91	38,000	104	7.8	31	51,000	90
March	86	138	76	33,000	87	7.9	21	45,000	81
June	120	204	33	12,000	63	8.4	8	20,000	74
July	98	176	58	13,000	72	8.3	9	21,000	89
Average	**136**	**225**	**69**	**27,600**	**87**	**8.0**	**21**	**38,200**	**83**
Tanzania and other Standards	**30**	**60**	**300**	**<5,000**	**20**	**6.5 ~ 8.5**	**6**	**10,000**	**100**

In order to solve the failure of wastewater treatment, a new wastewater treatment facility (Nzuguni WWTP) was proposed by previous master plans but it has not been constructed to date. The selected location for the new sewage treatment plant is 5km downstream of the present ponds. The land was reserved for the treatment facilities on the basis of the 1976 Master Plan.

standards for wastewater reuse have not been established yet. Lack of standards may hinder the operationalization of the wastewater reuse as the quality may easily compromise people by exposure to the communicable diseases.

2.3.2. Institutional Wastewater Treatment Facilities

Prior to the development of the Trunk Services I & II, a few institutions in Dodoma had their own sewage treatment facilities designed to meet their wastewater management and disposal needs. However, due to lack of water and thus inadequate wastewater for treatment, these institutional sewage treatment works are no longer operational and have since been abandoned. St Johns University, which is located in Kikuyu Complex area, lsanga Prison and Mirembe Mental Hospital situated within Hazina area are currently connected to the existing sewerage system.

Currently the only institution with its own sewage treatment facility designed to meet their wastewater management and disposal needs is Dodoma University (UDOM), which is described here below.

UDOM Sewerage System

The trunk sewers were designed to collect sewage from the following colleges and staff areas: 1) College of Humanities and Social Sciences 2) College of Education 3) College of Informatics and Virtual Sciences 4) College of Health Sciences 5) College of Earth Sciences 6) College of Life Science and 7) Other Supporting Facilities.

The sewers comprise secondary and lateral/tertiary lines made up of flexible jointed pre-cast concrete spigot and socket pipes, except in few areas where the conditions dictated use of uPVC or steel pipes.

A breakdown of the proposed sewers system technical data; including names of the areas, total sewer lengths, total number of manholes and the estimated total wastewater generated from the respective areas being served are summarized in the table below.

Table 77. Existing Sewerage System in UDOM

S/No.	Name of Sewer	Length of Sewers (km)	No. of Manholes
1	A1 - A65 (College of Informatics and Virtual Sciences to College of Education)	6.205	65

S/No.	Name of Sewer	Length of Sewers (km)	No. of Manholes
2	B1 - A11 (UDOM complex, Social Sciences, etc)	3.098	35
3	B81 - B8	0.3	4
4	B101- B10	0.4	5
5	B131 - B13	0.2	3
6	A141 - A14	0.6	7
7	A171- A17	0.3	4
Total		**11.103**	**123**

The trunk sewer "A" discharges wastewater from UDOM main campus to the wastewater stabilization ponds system, which consists of Anaerobic, Secondary Facultative and Maturation ponds. It has 2 No. series as given in the table below. And, its capacity was designed to serve a population of 100,000 people in UDOM campus, which can be estimated at about 9,000m^3/d (100,000 capita × 90l/c·d) as a design capacity.

Table 78. Pond Details per Series (With 2No Series)

Pond	Depth (m)	Top Length (m)	Top Width (m)	Top Area (m^2)
Anaerobic	3.5	85	50	4,250
Secondary Facultative	2.0	192	100	19,200
Maturation Pond 1	1.5	184	95	17,480
Maturation Pond 2	1.5	112	59	6,608
Total				**47,538**

The total area used by the two (2) series is therefore 95,076 m^2 (47,538m^2 × 2), which is equal to about 10 ha.

2.4. Household Survey for Sanitation Conditions

We have conducted household survey to confirm if the sanitation data from DUWASA is correct from 18th Aug. 2019 to 22nd Aug. 2019.

2.4.1. Sample Size

The total population and number of households in Dodoma city was estimated at 410,956 and 92,982 in 2012 respectively. Thus, the current number of households in Dodoma city could be estimated at about 131,135 according to the current total population of Dodoma city.

A sample size can be calculated has been calculated by using the following formula.

$$Sample\ Size = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + (\frac{z^2 \times p(1-p)}{e^2 N})} \quad \text{.................................} \ (2.14)$$

Where,

N = Total Households Size in Dodoma City;

e = Margin of Error (percentage in decimal form)

z = z-score.

The z-score is the number of standard deviations a given proportion is away from the mean. To find the right z-score to use, refer to the table below:

Table 79. Correlation between Desired Confidence Level and z-score

Desired Confidence Level	z-score
80%	1.28
85%	1.44
90%	1.65
95%	1.96
99%	2.58

We have chosen 95% and 5% for the desired level of confidence and margin of error respectively. Then, according to the above formula, we can get the 384 households as the sample size.

2.4.2. Methodology of Sampling and Target Wards

The selected samples should be representative of the total households' characteristics. Thus, we have classified the Dodoma city into five regions in every direction: Central; Northwest; Northeast; Southwest and Southeast regions. Based on this condition, we randomly chose five wards in the five regions respectively as follows:

Table 80. Target Wards for Sampling

S/No.	Region	Wards	Total Households	Sample size planned	Actual sample size done
1	Southeast	Mtumba Ward	3,301	60	78
2	Southwest	Mbabala Ward	3,875	70	82
3	Central	Kizota Ward	8,312	151	132
4	Northwest	Mbalawala Ward	2,769	50	39
5	Northeast	Hombolo bwawani Ward	2,850	52	42
Total			**21,107**	**384**	**373**

2.4.3. Results of Households Survey for Sanitation Conditions

The following table show the results of Households Survey, which has 95% and 5% for the desired level of confidence and margin of error respectively. And, we can see that these results are almost similar to the data from DUWASA if we consider the error range, ±5%.

Table 81. Results of Households Survey for Sanitation Conditions

S/No.	Wards		Piped Sewer System	Septic Tank	Pit Latrine			Open Defect
					Dry Toilet	Pour Flush	VIP	
1	Mtumba	No. of HH	0	13	19	33	13	0
		%	0%	16.7%	24.4%	42.2%	16.7%	0.0%
2	Mbabala	No. of HH	0	8	10	42	21	1
		%	0%	9.8%	12.2%	51.2%	25.6%	1.2%
3	Kizota	No. of HH	4	52	35	36	3	2
		%	3.0%	39.4%	26.5%	27.3%	2.3%	1.5%
4	Mbalawala	No. of HH	0	10	11	15	3	0
		%	0%	25.6%	28.2%	38.5%	7.7%	0%
5	Hombolo bwawani	No. of HH	0	11	12	15	4	0
		%	0%	26.2%	28.6%	35.7%	9.5%	0%
Total		No. of HH	4	94	87	141	44	3
		%	1.1	25.2	23.3	37.8	11.8	0.8

2.5. Survey on Fecal Sludge Flow Collected by Empty Tankers

Fecal sludge is a mixture of human excreta, water and solid wastes (e.g. toilet papers or other anal cleansing materials, menstrual hygiene materials) that are disposed of in pits, tanks or vaults of onsite sanitation systems. The onsite sanitation facilities in Dodoma generates sludge and when the containments are full, they are emptied by the vacuum tankers before being transported to the existing wastewater stabilization ponds for disposal.

Fig. 117 Vacuum tankers discharging Fecal sludge at the disposal point

The following is the table showing the vacuum tankers number of trips recorded by DUWASA for a period of a year from July 2018 to July 2019. The results show there is maximum number of trips during rainy season. The maximum number of trips was found to be 785 in March 2018 while the minimum number of trips was found to be 469 in August 2019.

Table 82. Monthly No. of Trips for Fecal Sludge Disposal at the Existing Swaswa WSPs (DUWASA)

S/No.	Month	No. of trips monthly	Days	Approx. average trips per day	Max. No. of trips per day	Min. No. of trips per day
1	Jul-18	469	31	15	25	15
2	Aug-18	494	31	16		
3	Sep-18	533	30	18		
4	Oct-18	530	31	17		
5	Nov-18	541	30	18		
6	Dec-18	634	31	20		
7	Jan-19	632	31	20		
8	Feb-19	578	28	21		
9	Mar-19	785	31	25		
10	Apr-19	668	30	22		
11	May-19	712	31	23		
12	Jun-19	548	30	18		
Total		**7,124** trips/year	365			
Average				20		

We have conducted a survey at the Swaswa disposal point to record the number of trips of vacuum tankers and their carried volume of fecal sludge per day in order to find an estimate of average volume of fecal sludge collected per each trip of each vacuum tanker. The data was recorded for a period of 7 days from 14th Oct. to 20th Oct. 2019. The following table shows the survey results about the average daily fecal sludge disposal rate by vacuum tanker per trip.

Table 83. Survey Results about the Average Daily Fecal Sludge Collected by Vacuum Tanker per Trip.

Date		Pit Latrine		Septic Tank		Total fecal sludge collected (m^3/trip)
		No. of trips/day	Fecal sludge collected per day(m^3)	No. of trips/day	Fecal sludge collected (m^3/day)	
1	14th Oct.	0	0	28	292	10.43
2	15th Oct.	0	0	20	185	9.3
3	16th Oct.	0	0	25	241	9.64
4	17th Oct.	0	0	23	196	8.52
5	18th Oct.	1	5	26	263	9.93
6	19th Oct.	1	5	16	168	10.12
7	20th Oct.	1	4	14	171	11.67
Total		**3**	**14**	**152**	**1,516**	**69.61**

Date	Pit Latrine		Septic Tank		Total fecal sludge collected (m^3/trip)
	No. of trips/day	Fecal sludge collected per day(m^3)	No. of trips/day	Fecal sludge collected (m^3/day)	
Average	**0.43**	**2**	**21.7**	**216.57**	**9.94**
Percentage		**2.3%**	**-**	**97.7%**	**-**

From the results of the survey, the total amount of Faecal sludge collected by empty tankers trucks per year was obtained based on the total number of trips in a year and the average total discharge volume of faecal sludge carried by each septic truck per trip for a period of 7 days as shown in the following table.

Table 84. Fecal sludge collected per year

Total number of trips per year	Average fecal sludge collected per trip(m^3/trip)	Total fecal sludge collected per year (m^3/year)	FS collected from septic tank (97.7%)	FS collected from pit latrine (2.3%)
7,124	9.94	70,813	69,184 m^3/yr	1,629 m^3/yr

About 97.7% of the total fecal sludge disposed at Swaswa WSP's are from septic tanks which means that very few are collecting the wastewater from pit latrines. The per capita fecal sludge accumulation rate can be identified based on information gathered from septic tank users only as follows:

Table 85. Sludge Acuumulation Rate in Dodoma City

Current population	Septic tank users (21.3%)	Total sludge collected from septic tank	Sludge production rate(m^3/person·yr)	Average sludge production rate(l/person·day)
579,590	123,453	69,184m^3/yr	0.56	1.53

The consultant has also conducted a survey on 41 households to identify an interval to empty the septic tanks and pit latrines. As a result, about 60 percent of the number of households do empty their full facilities after every 1 to 3 years. The following table shows the results of the households survey on the emptying intervals, which has 80% and 10% for the desired level of confidence and margin of error respectively.

Table 86. Emptying Time Intervals

Intervals	No. of HH	Percentage (%)
Less than 1 year	6	14.63
Between 1 & 3 years	25	60.98
Between 4 & 5 years	4	9.76
Above 5 years	6	14.63
Total	**41**	**100.00**

2.6. Shit Flow Diagram

2.6.1. SFD outcome

Based on the results of households' survey and data from related local government authorities and institutions etc., we have conducted making the SFD of Dodoma city as shown in the below diagram.

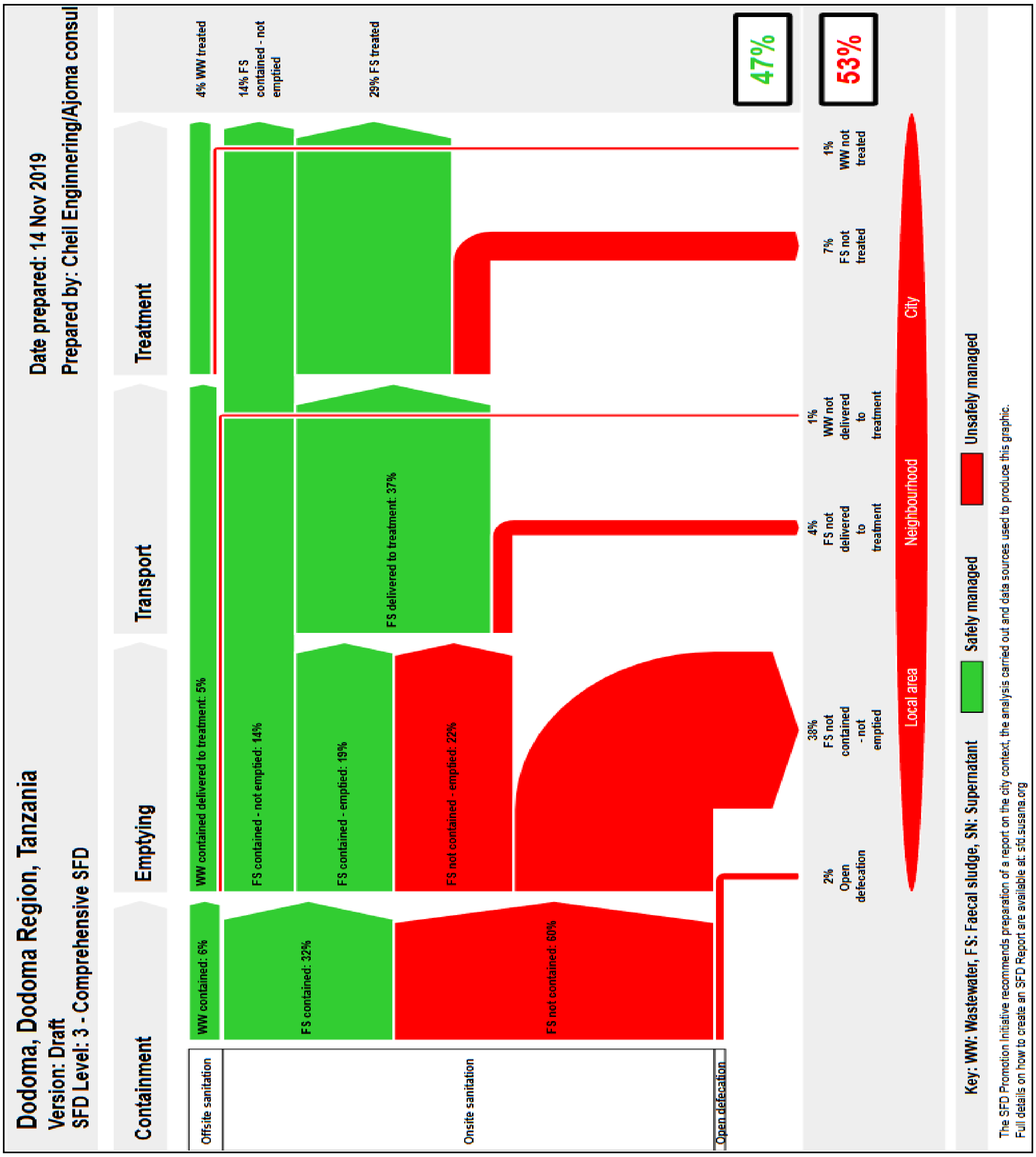

Fig. 118 Shit Flow Diagram of Dodoma City

2.6.2. Credibility of data

Estimations were based on a literature review of journal articles, research reports and national policy documents. If adequate information was not available in these sources, then unpublished reports and presentations were used. For triangulation to verify the validity of data, 14 key informant interviews and two focus group discussions were conducted. Observations on settlement structures, emptying service providers and treatment facilities were also used to verify credibility of data. Where assumptions were made, they were backed up by interview statements or results from focus group discussions. In addition, internal records from DUWASA supplied useful information that assisted the analysis of offsite sanitation. For low-income regions, a number of surveys was available for review and comparison. However, they tend to focus on issues such as user interface. In the future it would be more useful to include design and construction of containment technologies. Assumptions had to be made mainly for the middle/high income households due to the lack of data. Additionally, the following assumptions were made: 50% of residents reside in areas with high groundwater pollution risk. It was also assumed that 1% of wastewater is lost in an offsite sanitation system because existing mapping of soil and groundwater characteristics is limited.

2.6.3. Process of SFD development

Local government authorities and institutions were actively engaged in the process of data collection, for example, a focus group discussion with CCD health offices, urban planners, safety officers and environmental officers was conducted.

Table 87. General Containment Estimations

Item	Percentage (%)
Centralized sewer	6%
Flush toilet to open drain/Water body	1%
Septic tank	21%
Pit latrine	71%
Open defecation	1%

Table 88. Final Estimations for the SFD Matrix Calculations on Containment

No.	Explanation	SFD reference variable	Percentage
1	Toilet discharges directly to a centralized foul/separate sewer	T1A1C2	6%
2	Unlined pit, no overflow, in low risk areas	T1A6C10	15%
3	Fully lined tank (sealed, no outlet or overflow)	T1A3C10	12%
4	Lined tank with impermeable wall and open bottom, no outlet overflow	T1A3C10	5%
5	Pit (all types), never emptied but abandoned when full and	T2A4C10	25%

No.	Explanation	SFD reference variable	Percentage
	covered with soil, not outlet or overflow, where there is a 'significant risk' of ground water pollution		
6	Open defecation	T1B11C7 TO C9	2%
7	Septic tank connected to soak pit where there is significant risks of groundwater pollution	T2A2C5	21%
8	Lined tank with impermeable walls and open bottom, no outlet or overflow, where there is significant risk of groundwater pollution	T2A4C10	14%

The average water table in Dodoma is between 1 to 1.5m during dry season and it is much lower up to 0.5m in north west parts of Dodoma where the underground rock layer is near to the earth surfaces like Kikuyu and Nala areas (DUWASA, 2019). During survey and interviews, it was observed that a total of 46% of Dodoma inhabitants use pit latrines in areas with significant groundwater contamination risks like Kikuyu, Kizota, Swaswa streets. However, unlined pits were reported to be built only in low water table areas because otherwise they would collapse. Therefore, it is estimated that a total of 54% of the unlined pits/tanks were reported to be built in areas with low groundwater contamination risk. Fully lined pits/tanks were reported to be built in areas with high water table like eastern side areas of Dodoma city. Fully lined pits/tanks were reported to be built in high-water table areas because people prefer to build semi-lined pit latrines where possible in order to save on construction and emptying costs.

Table 89. Estimation on Containment of Offsite and Onsite Sanitation

Variable	Percentage	Description
W5a	5%	WW contained centralized (offsite)
W4	1%	WW not contained(offsite)
F4	82%	FS contained (onsite)
F5	10%	FS not contained(onsite)
OD9	2%	Open defecation

Table 90. Emptying and Transport Technologies & Methodologies

Variable	Explanation	Dodoma context
W4a	WW contained delivered to centralized treatment plants	Going to swaswa wsp's (fraction of W4)
W5a	WW contained delivered to centralized treatment plants which is treated	The fraction of W4a
F3	FS contained, emptied	Septic tanks and lined pits
F4	FS contained, emptied delivered to treatment plant	Through vacuum trucks to wsp's at swaswa
F5	FS contained, emptied delivered to treatment plant and treated	Fraction of F4 is treated
OD9	Open defecation	ie.OD9

2.6.4. Discussion on SFD Outcomes

In Dodoma, it was estimated that 47% of excreta is managed safely of which 14% results from faecal sludge being contained and not emptied. And, it was also estimated that 53% of excreta ends up directly in the environment without adequate treatment.

Containment

The sanitation facilities used in Dodoma are pit latrines (71.3%), septic tank (21.3%) and a small number of urban dwellers connected to DUWASA sewer network (6%). The remaining 1.4% of excreta flows are 0.4% open defecation and 1% pour flush toilets going directly to open drains or water body. The sewer network covers only central areas of the city.

Fig. 119 Onsite practices in Swaswa Street

Emptying and Transport Services

Legal emptying in the city consists of vacuum trucks. There are around 12 motorized emptying tankers and transport service 11 providers have the vacuum tankers working in the city with capacities of around 6,000 to 20,000 litres capacity. Among them, 10 providers just possess one truck except YAPI MERKEZ COMPANY which is owning two vacuum trucks for discharging wastewater from their construction sites. It is observed that currently around 11 vacuum tankers with an average of 9.4m^3 can empty FS from onsite sanitation system. To discharge at DUWASA's faecal sludge treatment site (WSPs), the service providers have to register in DUWASA. The driver has to sign the vacuum truck rules. There are two operators at the WSPs who are daily recording the number of trips taken by each company and their respective vacuum trucks.

Table 91. 11 Owners of Vacuum Trucks Discharging FS to the Existing WSPs at Swaswa

S/N	Service Provider	Number of Registered Vacuum Truck	Ownership
1	DUWASA	1	Government
2	Marumbu	1	Private
3	Mkonyi	1	
4	Howo	1	
5	Amani	1	
6	Ikonde	1	
7	Kilya	1	
8	Clement	1	
9	Yapi Merkez	2	
10	Lomburi store	1	
11	Kitundu	1	
Total		11 trucks	

Meanwhile, the most predominantly emptying methods practiced by low income households dwellers include diversion digging another hole next to the old pit where FS can be flooded out to the side of containment system – often on heavy rain.

Fig. 120 A Pit Dug next to a Full Pit Latrine for Diversion

Treatment Technologies and Disposal

One WSP exist in Dodoma to treat wastewater. An existing wastewater stabilization pond at swaswa receive faecal sludge from emptying and transport service providers. Influent and and effluent parameters analyzed by DUWASA were obtained during field research. The analysis shows that TSS, BOD and COD is reduced up to more than 80%. Therefore, the amount of wastewater and fecal sludge treated is estimated at maximum of 80%, although it can be assumed that the actual Faecal sludge treatment efficiency is lower because existing swaswa ponds were not designed for FS treatment.

Service delivery context

Tanzania's National Water Sector Development Strategy 2006-2015 describes access to safe and hygienic methods of excreta disposal as a basic need and right for all human beings (MoWI, 2006). National policies and guidelines generally exist, but adaptation into local, concrete strategies is lacking, as is enforcement. Guidelines and manuals are not readily available online, but are distributed by the city council to local government authorities, which disseminate the documents through workshops and meetings. Policy documents acknowledge the importance of pro-poor support; however, low-income areas remain the most unserved areas, practicing unhygienic manual emptying methods and direct disposal of faecal sludge into the environment. Access to sewers and improved sanitation are clear goals, and sanitation and hygiene awareness raising campaigns are common, however, targets specifically referring to collection, transport and treatment of faecal sludge are lacking.

Emptying and transport service providers exist, however, they are not able to provide services to all wards and types of settlements. The road to the Waste stabilization ponds at Swaswa is not favorable for the vacuum trucks to use especially during rainy periods.

Improved access will require coordination and support from government authorities. There are plans to build new centralized treatment facilities for wastewater in the future use. Routine monitoring of access to sanitation services is carried out by environmental health officers at the sub-ward level, while the water supply and sanitation authority monitors the performance of wastewater treatment plants and sewerage system. Further information on access to sanitation services is collected through census and surveys conducted every few years under the National Bureau of Statistics.

A common definition of improved sanitation exists but is not executed in practice, also wastewater volumes through the sewer network are not measured (DUWASA, 2019). To increase safe disposal, treatment and end use of excreta will require clear policy guidelines, clear institutional accountability with targets and indicators along the whole sanitation service chain. This could create ownership by local government authorities and increase implementation at all levels.

3. Water Demand Projection

3.1. Domestic Water Demands

The City Master Plan shows planned boundaries of wastewater treatment zones as the below figure.

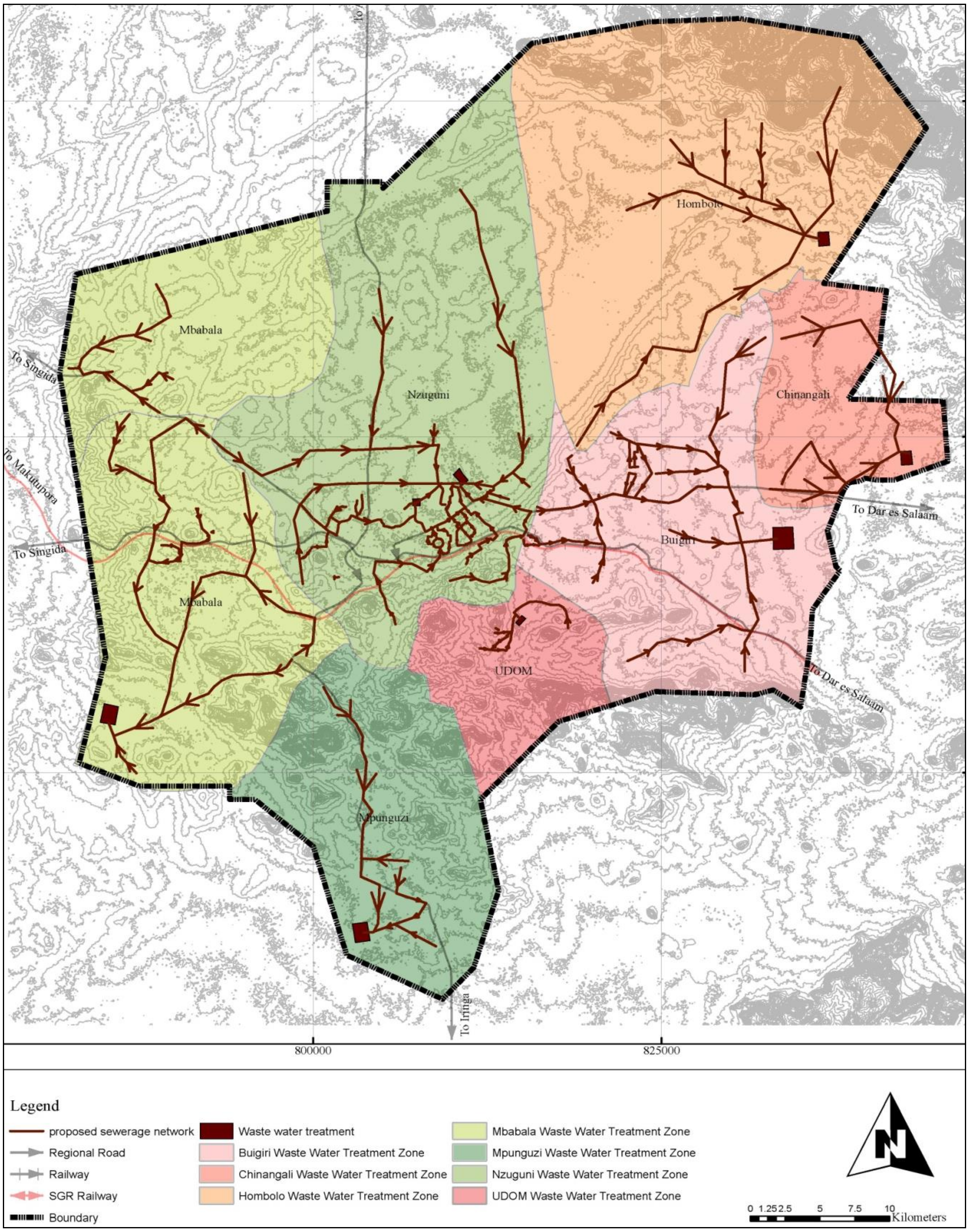

Fig. 121 Existing Wastewater Management Plan

However, the consultant has found out that a part of that is not feasible due to the topographical conditions and modified that as the below figure.

Based on the modified boundaries of wastewater treatment zones, the consultant has projected domestic water demand by each wastewater treatment zone based on the results of population projection mentioned earlier. The population of each wastewater treatment zone has been figured out by using the population density of each ward and their areas which are belonging to the zone (Fig. 122 and Annex 03).

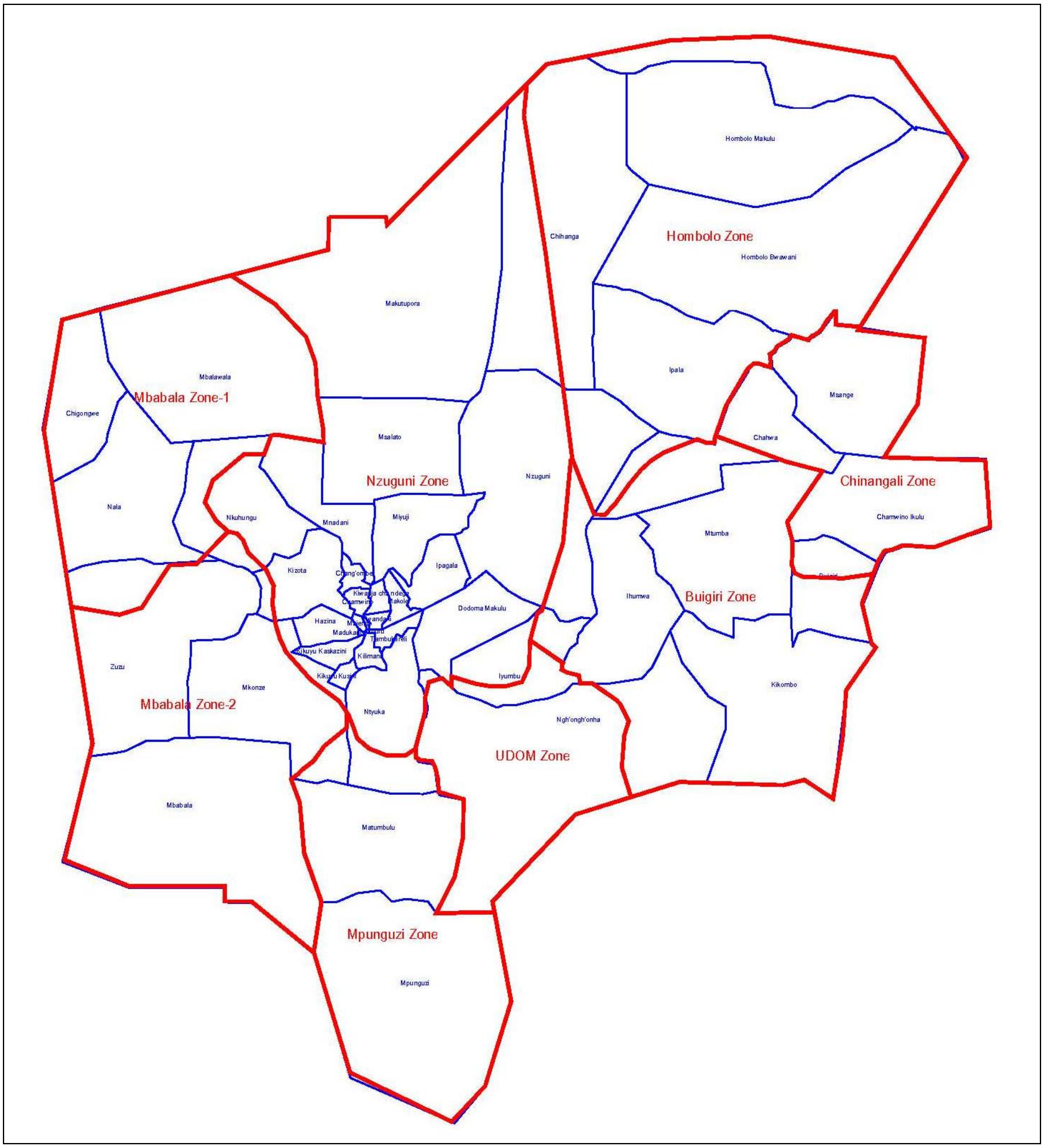

Fig. 122 Boundary of Wastewater Treatment Zones and Wards

Table 92. Population Project by Each Wastewater Treatment Zone

S/No	Wastewater Treatment Zones	No. of Wards Included	Wards in Wastewater Treatment Zone	Population Projection in 2025	Population Projection in 2040
1	Zone 1- Buigiri	8	Kikombo; Ngh'ongh'onha; Buigiri; Mtumba; Chahwa; Ihumwa; Iyumbu; Nzuguni	73,219	163,459
2	Zone 2 - Nzuguni	27	Chihanga; Makutupora; Msalato; Nzuguni; Miyuji; Mnadani; Nkuhungu; Ipagala; Dodoma Makulu; Iyumbu; Ngh'ongh'onha; Ntyuka; Mkonze; Kizota; Chang'ombe; Hazina; Kikuyu Kaskazini; Kikuyu Kusini; Kilimani; Tambukareli; Madukani; Uhuru; Majengo; Viwandani; Chamwino; Kiwanja cha ndege; Makole	481,925	1,075,886
3	Zone 3 – Mbabala(N)	5	Mbalawala; Chigongwe; Nala; Nkuhungu; Zuzu	56,643	126,455
4	Zone 4 – Mbabala(S)	6	Nala; Nkuhungu; Kizota; Zuzu; Mkonze; Mbabala	60,324	134,673
5	Zone 5 - Chinangali	4	Msanga ; Chamwino Ikulu ; Chahwa ; Buigiri	40,077	89,471
6	Zone 6 - Hombolo	6	Hombolo Makulu; Hombolo Bwawani; Chihanga; Ipala; Nzuguni; Chahwa	76,534	170,861
7	Zone 7 - Mpunguzi	4	Mpunguzi; Matumbulu; Ntyuka; Mkonze	40,038	89,384
8	Zone 8 - Udom	2	Ngh'ongh'onha; Iyumbu	15,357	34,283
Total				**844,118**	**1,884,473**

And, the consultant has referred to the Tanzania Water Supply and Wastewater Design Manual of 2009 to project a domestic water demands which will be required by Dodoma City in 2025 (Short-term period) and 2040 (mid- and long-term period). The below table shows the daily water consumption per capita (l/capita·day) recommended by the Tanzania Water Supply and Wastewater Design Manual and population composition rate by income level, which is mentioned in City Master Plan (Annex 4).

Table 93. Daily Water Consumption per Capita by Population Category

Population Category	Population Composition Rate (%)	Daily Water Consumption per Capita (l/capita·day)
High Income Group	8	200
Medium Income Group	40	110
Low Income Group	52	60

According to the Design Manual of MoWI, the peak factors are recommended based on the total population of the area as follows:

Table 94. Peak Factors for Domestic Water Demand in Tanzania

Population	Range of Peak Day Factors	Applied Peak Day Factor
10,000	1.80 – 1.50	1.50
10,000 – 30,000	1.50 – 1.40	1.40
30,000 – 100,000	1.50 – 1.30	1.30
100,000	1.30	1.30

Based on the results above, we could project the water demands by each zone in 2025 and 2040 as shown in the table below.

Table 95. Domestic Water Demands (Peak Day) Projection of Each Wastewater Treatment Zone

S/no.	Wastewater Treatment Zone	Domestic Water Demand in 2025 (m^3/d)	Domestic Water Demand in 2040 (m^3/d)
1	Zone 1- Buigiri	9,394	19,730
2	Zone 2 - Nzuguni	61,585	130,662
3	Zone 3 - Mbabala(N)	7,268	15,540
4	Zone 4 - Mbabala(S)	7,716	16,384
5	Zone 5 - Chinangali	5,204	10,940
6	Zone 6 - Hombolo	9,819	20,630
7	Zone 7 - Mpunguzi	5,147	10,751
8	Zone 8 - Udom	1,974	4,408
Total		**108,107**	**229,046**

3.2. Non-Domestic Water Demands

Non-domestic water demand comprises institutional, commercial and industrial water demands. The institutional water demand consists of schools, colleges, churches, mosques, health facilities, offices etc. In DUWASA customer classifications government institutions are separately identified from private institutions.

3.2.1. Institutional Demand

The institutional water demand consists of educational institutions (schools, colleges, University), religious buildings (churches, mosques), health facilities (hospitals, health centers, dispensaries), government offices, security establishments (JWTZ camps, prisons) etc. In DUWASA customer classifications, government institutions are separately identified from private institutions. However, this differentiation into government and private institutions was not considered necessary for water demand assessment, as the consumption is the same.

- **Educational Institutions**

The number and levels of public and private education institutions within the City was obtained from the relevant authorities.

- **Health Institutions**

The health facilities found in Dodoma are 5 Hospitals, 12 health centers and 56 dispensaries/clinics. There are also some private clinics. The Regional Hospital located in Madukani ward serves the entire Region. Mirembe Hospital is a mission hospital located in Hazina Ward. The City Health Officer provided data on existing health facilities including their outpatient attendance, in-patient beds and the ward in which they are located.

The water demand for the health facilities has been established based on the levels of attendants, outpatients and inpatient beds and the consumption rates. Future levels of the facilities have been estimated in tandem with the expected population growth rates in the areas they serve.

- **Religious Institutions**

The religious institutions consist of churches and mosques. Most of these provide water to their followers who attend these institutions. The present water consumption for these institutions was established from the billing records as almost all of them are metered. The future demand for water was estimated to increase in respect to population increase.

- **Government and Security Institutions**

Currently there are a considerable amount of government and security institutions present in Dodoma constructed at Tambukareli area and other wards such Mtumba, Msalato and Kikuyu North.

The water consumption of the existing government and security institutions was established based on the past consumption records. These have been estimated to increase at a rate of 4.0%.

The Master Plan has allocated about 30 ha in Tambukareli ward for the future establishment of the National Capital Center and about 700 ha in Mtumbe ward for new government city where most of the government offices are expected to be located. Although the pace of establishment of the offices largely depends on the transfer of the capital to Dodoma, the pace of establishment cannot be accurately predicted. Accordingly, for the new government city, the consultant has referred to the study which was conducted by DUWASA in 2018. The study estimated the water demand for the proposed government city as its fully functional capacity as being about 19,800 m^3/day in 2040.

3.2.2. Commercial Demand

Commercial facilities in Dodoma include markets, shops, banks, hotels/lodges and restaurants etc. At present most of the commercial activities are located around the Old Town and the National Capital Centre area. However, the Master Plan neighborhood concept envisaged commercial centers within each community area. At present, the commercial consumers water consumption accounts for 32% of the total domestic water consumption.

As the commercial areas are not fully designated within the land use maps, the commercial facilities have been estimated to grow at 4% per year which is similar to the population increase rate of the City.

3.2.3. Industrial Demand

There is limited industrial activity in Dodoma City. The existing industries are small scale industries located in Viwandani and along the railway line. The type of existing industries includes small textile, bakery, small workshops etc. The Pepsi Cola Bottling plant in Viwandani area is presently not operational. A new abattoir has been constructed in Kizota capable for slaughter of 350 cattle per day.

The Master Plan has allocated 466 ha of land in Kizota for industries. However, no major industries have been built to date. DUWASA customer records indicate no consumers that are designated as industries.

It is expected that no significantly large high-water consumption industries would be established in Dodoma in the near future. However, some light industries to process the hinterland produce are expected to grow within the designated industrial site. The water demand for the industrial activity has been established assuming reasonable use of this site for medium water use industries. The water consumption values have been adopted based on similar industries consumption experience in other towns.

3.2.4. Total Non-Domestic Water Demand

The individual assessments of the non-domestic water demands have been aggregated to obtain the total non-domestic water demand for each ward as shown in Annex 4. We have recalculated the non-domestic water demands of each wastewater treatment zone based on the ratio of ward's land area which is belonging to the zones. The below table shows the non-domestic water demands projection of each wastewater treatment zone in 2025 and 2040.

Table 96. Non-Domestic Water Demands Projection of Each Wastewater Treatment Zone

S/no.	Wastewater Treatment Zone	Non-Domestic Water Demand in 2025 (m^3/d)	Non-Domestic Water Demand in 2040 (m^3/d)
1	Zone 1- Buigiri	15,687	26,654
2	Zone 2 - Nzuguni	20,125	36,368
3	Zone 3 – Mbabala(N)	1,530	2,759
4	Zone 4 – Mbabala(S)	925	1,669
5	Zone 5 - Chinangali	933	2,075
6	Zone 6 - Hombolo	861	1,554
7	Zone 7 - Mpunguzi	457	828
8	Zone 8 - Udom	1,895	3,415
Total		**42,412**	**75,321**

3.3. Total Water Demand

Based on the above-mentioned domestic and non-domestic Water Demand, the total water demands in 2025 and 2040 are estimated as shown in the table below;

Table 97. Total Water Demand Projection of Each Wastewater Treatment Zone

S/no.	Wastewater Treatment Zones	Water demand in 2025 (m^3/d)	Water demand in 2040 (m^3/d)
1	Zone 1- Buigiri	25,082	46,384
2	Zone 2 - Nzuguni	81,709	167,029
3	Zone 3 – Mbabala(N)	8,798	18,300
4	Zone 4 – Mbabala(S)	8,641	18,053
5	Zone 5 - Chinangali	6,137	13,015
6	Zone 6 - Hombolo	10,680	22,184
7	Zone 7 - Mpunguzi	5,604	11,579
8	Zone 8 - Udom	3,869	7,822
Total		**150,519**	**304,367**

4. Wastewater Flow

4.1. Domestic and Non-domestic Wastewater Flow

The consultant has projected wastewater flow by each zone based on the projected water demand. And, according to the design manual, it specifies that 60 to 85% of the water consumption per capita becomes wastewater. Considering the Design Manual of MoWI, 75% conversion rate was adopted in the projection of wastewater flow.

The total domestic and non-domestic wastewater flow projected are presented as below;

Table 98. Domestic and Non-domestic Wastewater Flow

S/No.	Description	Projected Wastewater in 2025 (m^3/d)	Projected Wastewater in 2040 (m^3/d)
1	Zone 1- Buigiri	18,811	34,788
2	Zone 2 – Nzuguni	61,282	125,272
3	Zone 3 – Mbabala(N)	6,598	13,725
4	Zone 4 – Mbabala(S)	6,481	13,540
5	Zone 4 – Chinangali	4,602	9,761
6	Zone 5 – Hombolo	8,010	16,638
7	Zone 6 – Mpunguzi	4,203	8,685
8	Zone 7 – Udom	2,902	5,867
Total		**112,889**	**228,275**

From the table above it can be seen that the projected wastewater for Nzuguni zone is about 57% of the total wastewater projected on the same year for all the seven zones.

4.2. Infiltration

The extraneous water that enters the sewer system from the ground through sewer service connection, pipe joints, manholes etc., is termed infiltration. The rate and quantity of infiltration depends on the length of the sewers, the area to be sewered, the soil, topographic condition, characteristics and conditions of the sewer material. Normally, infiltration is estimated to vary from 35 to 115 m^3/km of sewer per day. Higher values can be assumed where the sewers are passing below the water table or water table is higher.

However, in this project, an allowance of 20% will be made for estimating the amount of groundwater infiltration as per the WHO Report No. 9.

4.3. Total Wastewater Flow

The below table shows the total wastewater flow which includes the amount of storm water to be infiltrated into sewer pipes. And, the estimated total wastewater flow will be used to determine the capacities of wastewater treatment plants to be proposed.

Table 99. Total Wastewater Flow including Infiltration

S/No.	Description	Projected Wastewater in 2025 (m^3/d)	Projected Wastewater in 2040 (m^3/d)
1	Zone 1- Buigiri	22,573	41,746
2	Zone 2 – Nzuguni	73,538	150,326
3	Zone 3 – Mbabala(N)	7,918	16,470
4	Zone 4 – Mbabala(S)	7,777	16,248
5	Zone 5 – Chinangali	5,523	11,713
6	Zone 6 – Hombolo	9,612	19,966
7	Zone 7 – Mpunguzi	5,043	10,421
8	Zone 8 – Udom	3,482	7,040
Total		**135,467**	**273,930**

SECTION 3. STORMWATER DRAINAGE AND SANITATION SYSTEM DEVELOPMENT PLAN

I. Stormwater Drainage System Development Plan

1. General

Stormwater management is an important provision that is required to drain a part of rainfall which appears on the surface and dispose it to an acceptable disposal site, e.g. Stream, Lake or Ocean through an outfall. It also offers protection of the soil erosion against erosive forces of moving water and protection of other natural features and man-made developments against floods and their associated impacts.

With increasing urbanization it becomes increasingly important but is far too often neglected or relegated to an afterthought in the development of urban infrastructure. Stormwater management is important because unattended high flood levels can cause property damage, loss of life and other problems to the health of a society e.g. contaminating the ground with sewage from flooded septic tanks and pit latrines. In the past, attention to this problem has been severely limited, especially in unplanned peri-urban areas with the consequence that in the rainy seasons, poorer residents having access to it, use ponded, polluted surface water even when potable water is available at kiosks and the overflow from pit latrines in particular, draining into such depressions, is a principle cause of disease outbreaks such as cholera. Whilst an adequate network of properly constructed and maintained drains can help alleviate this problem, there remain the problems of flood flow peaks and pollution. Alleviating flood flow peaks is most easily done by use of natural flood plains and wetlands and many towns and Cities in Tanzania originally contained such natural features. Regrettably over the years many of these have been reclaimed and built upon with the result that urban run-off increasingly causes flooding and destruction of property as well as occasional loss of life. Another increasing problem is the pollution load being conveyed by stormwater drainage systems out into rivers, lakes and the ocean and again this is a problem rarely addressed until now.

A storm water drainage system development plan for the Dodoma city has therefore been proposed in the chapters below, which include institutional, structural and non-structural measures to alleviate flooding, sedimentation and pollution.

2. Basic Direction and Strategies

No single type of technology or management control will resolve all storm water management problems which are facing Dodoma City. An effective management system will include a suite of technologies and controls tailored to the specific needs of the area.

The basic direction of storm water management for Dodoma City is to use landscape-based storm water management combined with green infrastructure. This will include special designed system which can slow runoff, increasing infiltration into the ground, retention ponds, wetlands and rainwater harvesting systems. A part of the storm water will be retained in ponds for irrigation and as landscape features within the City and extra storm water will be directed toward the Hombolo Dam via drainage water channel rehabilitated properly. Incorporating green infrastructure in Dodoma City landscape will reverse the current trends of gullies formations through increasing storm water infiltration into the ground rather than flowing quickly into receiving waters.

For efficient utilization of spaces for storm water management three strategies are utilized.

- Preserve: Protect and enhance natural features, such as undisturbed forests, wetlands, natural retention ponds and other natural areas.
- Recycle: Recycle land by directing development to already degraded land, e.g., using the ravine, streams and eroded areas for the main City storm water channels.
- Reuse: Capture and reuse storm water by directing it back into the ground through infiltration, reusing it for other purposes such as irrigation or allowing it to accumulate in refurbished ponds as landscape features to beautify the city.

3. Phased Objectives

The stormwater management planning process should define short-term objectives and medium and long-term objectives. The consultant defined the objectives of each term as follows:

Table 100. Phased Objectives of Stormwater Management Plan

Phase	Objectives
Short-Term Period (2020 – 2025)	• Rehabilitate the existing stormwater management facilities (Water Channels and Retention Ponds, etc.) to meet their capacity required for preventing floods which can occur in the most flood prone and important areas socially, economically and politically such as central area, government city and Chamwino Ikulu, etc.

Phase	Objectives
	• Construct a new stormwater management facilities to prevent floods which can occur in the most flood prone and important areas socially, economically and politically. • Expand and rehabilitate the main rivers and drains between central area and hombolo dam so that they can collect and drain storm water to hombolo dam quickly and effectively. • Rearrange the institutional frameworks of related local governments to improve stormwater management. • Promoting the initiative, 'Make Dodoma Green' by encouraging people to Plant trees.
Medium-Term Period (2026 – 2035)	• Construct a new stormwater management facilities to prevent floods which can occur in all flood prone areas in the city. • Install the infiltration basins near the boreholes as groundwater sources in Dodoma city, which are mainly located along the main roads and main rivers between central area and hombolo dam. • Prevent erosion and siltation by reinforcing banks of water channels and vegetation. • Improve recreational functions of stormwater management facilities such as forest, retention ponds and wet lands, etc. • Identify appropriate local government policies, schemes and process documents for the inclusion of stormwater management objectives and measures.
Long-Term Period (2036 – 2040)	• Improve stormwater management facilities to protect major infrastructures from flooding in the 100 Average Recurrence Interval (ARI) event. • Reduce the amount of impervious surfaces within the Dodoma city. • Reduce the amount of direct stormwater discharge into Hombolo dam by expanding infiltration basins, retention ponds and rainwater harvesting systems, etc. • Reduce the pollution load to the lake Hombolo. • Increase the amount of stormwater reuse systems within the Dodoma city. • Implement stormwater management objectives and measures to identified local government policies, schemes and process documents. • Establish a local Climate Change Fund to cope with the negative effects of climate change.

4. Institutional Measures

4.1. Establishment of a Separate Department for Stormwater Drainage Management

The City Council of Dodoma is currently in charge of managing the stormwater drainage system in the City. However, the city council has no a separate department to exclusively manage the system.

Thus, it is suggested that, the City Council of Dodoma should form an organ to specifically deal with stormwater, or to have specific personnel's like hydrologist and Drainage

Engineer who will deal with storm water systems in the city. This will help in addressing the issues of maintenance and handling of all matters related to stormwater including floods which is the major problem, soil erosion and sedimentation.

4.2. Establishment of a Local Climate Change Fund

Climate change is arguably the most important emerging issue for the world. It is predicted that climate change has potential for devastating impacts in Tanzania, undoing achievements in development for rural and urban populations, and effecting climate and related impacts on the environment and society. Without proper and people-centered attention, the impact on the country will be profound and increasingly negative over time; already people are migrating and society is changing in pockets across the country. Yet in Tanzania today, there is limited awareness of what climate change is and what should be done, and who is responsible for doing it.

People have always struggled with unpredictable weather patterns in their livelihood strategies and economic activities and the realities of climate change are difficult to grasp without appropriate efforts at raising awareness. Likewise, the authorities that should be tackling climate change are poorly informed and have few strategies or resources for action. Relevant authorities have made little investments in building knowledge about climate change or integrating climate change into policies, laws etc. Many existing policies may exacerbate climate change impacts, but this is not being analyzed. And tellingly, the government has not yet prioritized making effective preparations to access the funds available to support adaptation and mitigation measures for the citizens.

Due to extremely bad effects of climate change, it is now time for Government of Tanzania to establish a local Climatic Change Fund to tackle this matter which is going to help in:

- Investment in climate change mitigation or adaptation measures and;
- Development of knowledge products and services related to climate change;
- Facilitating knowledge management activities, including regional conferences and workshops.

5. Non-Structural Measures

5.1. Promotion of the Initiative 'Make Dodoma Green'

In December, 2017 Tanzania launched a nationwide tree planting campaign aimed at rescuing the nation from the risk of becoming a desert. Especially, Tanzania's vice president Samia Suluhu Hassan launched the planting tree campaign dubbed ''Dodoma Kijani'' meaning ''Green Dodoma'' as the move to ensure the capital city becomes green from a semi-arid. Thus, in order to promote the initiative of ''Make Dodoma Green'', the following should be done:

- **Institutions**

The act of planting trees and grasses should be compulsory in all institutions including universities, schools, hospitals, dispensaries, health centers, churches and mosques. Through this, most of the areas in the city will become green hence implementing the initiative of making Dodoma green.

- **Planting trees along the Roads**

Most of the pavements along and between the roads in Dodoma city are paved thus increasing the surface area for runoff. Instead of them being paved, trees and grasses can be planted. This will create aesthetic environment along the roads hence making Dodoma green.

- **Houses**

Each household should plant at least five trees depending on the coverage area. The building permit should clearly indicate that it is compulsory for a household to plant trees. And there should be a follow up made by the ward office to make sure that the law is adhered.

- **Planting trees in open spaces**

The government according to the master plan should indicate areas which are open spaces which can be used to plant trees hence making Dodoma green. These can also be used for recreational purposes.

- **Campaigns for making Dodoma green**

In achieving the initiative of making Dodoma green, awareness to the community on the importance as well as the ways to make Dodoma green, are very crucial tools towards achieving it. Thus, this awareness should start from grassroot level of primary schools to community level. This can be done by both governments and private sectors.

Maintaining Vegetations

In order to protect drainage facilities such as water retention ponds, drainage structures such as bridges and culverts there should be constantly maintenance of vegetation around them. This will help to prevent soil erosion and thus avoiding sedimentation in drainage structures and facilities.

5.2. Designation of Green Belt and Permeable Zones

A greenbelt is a policy and land use zone designation used in land use planning to retain areas of largely undeveloped, wild, or agricultural land surrounding or neighboring urban areas. Similar concepts are greenways or green wedges which have a linear character and may run through an urban area instead of around it. In essence, a green belt is an invisible line designating a border around a certain area, preventing development of the area and allowing wildlife to return and be established. This is one of ways of maintaining the aesthetic condition making Dodoma green, thus the city master plan should indicate and provide an area which can be used to have a green area. This will not only improve the aesthetic condition of the city, but also increase the permeable capacity to slow runoff and to be able to recharge groundwater.

Fig. 123 showing Greenbelt surrounding the urban core

5.3. Establishment of a Flood Warning System and Evacuation Plan

Having a flood warning system and evacuation plan in place before a flood occurs can help avoid confusion and prevent injuries and property damage. A thorough evacuation plan should include:

- **Conditions that will activate the plan;**

For people located in an area that is susceptible to flooding, they can recognize a flood risk by warning SMS sent from a related government and should monitor Weather Radio or commercial radio or television stations for information about flood chances by making a follow up on News. If they receive information about the possibility of flooding, they should be prepared to move to higher ground immediately. In all cases, they should be prepared to evacuate before water levels rise and potentially cut off evacuation routes. This should be aided by the department responsible for floods emergency.

- **Emergency functions and who will perform them**
  - Equipping

Flood hazard Team (workers) should get emergency supply kits and keep them in shelter locations.

  - Training and Exercises

· Ensure that all workers know what to do in case of an emergency.
· Practice evacuation plans on a regular basis.
· Update plans and procedures based on lessons learned from exercises.

- **Specific evacuation procedures, including routes and exits**
  - Make sure you secure or protect any hazards in your home before the flood strikes.
  - Be prepared to turn off electrical power when there is standing water, fallen power lines, or before you evacuate. Turn off gas and water supplies before you evacuate. Secure structurally unstable building materials.
  - Buy a fire extinguisher if you don’t already have one. Make sure your family knows where it is and how to use it

- **Equipment for personnel**

There should be enough equipment for people responsible for evacuation during floods.

- **Review the plan with workers**

The team responsible for hazardous events like floods should review their plans if are meeting the goal if not more strategies should be.

5.4. Maintenance Practices for Storm Water Drainage Channels

Maintenance of the stormwater drainage network includes inspection, cleaning and repair of open and piped drains, pits, treatment devices, detention basins and outfall structures. This network needs to be regularly cleaned in order to maintain its performance, especially immediately before the rainy season comes. Street sweeping is widely used in urban areas to reduce the accumulation of litter, leaves and coarse sediment from roads and footpaths. It is undertaken to improve aesthetics, public safety, and stormwater quality. However, it was observed that during street sweeping activities, the wastes are left to accumulate in the side drains which is the major cause for the blockages. So, the cleaners, should strictly throw wastes in the dustbins and not leaving them to accumulate in the drains.

Poor solid waste management is the major cause of blockage of stormwater drains in Dodoma city. In order to solve the problem of stormwater blockage for good, the source of blockages should be monitored. The City Council of Dodoma is responsible for the management of solid waste, it should make sure that all solid wastes are properly separated, collected and taken to the dumpsite for non-recyclable and non-reusable wastes. Also, in order to solve the problem of solid wastes, there should be an alternative way to reuse them, for instance, plastics and steel cans can be recycled in industries

5.5. Practice of Resettlement Assistance Programs

The National Human Settlement states that the government should ensure all the hazardous areas are protected from intrusion and are used for the specific/intended purposes and all hazardous or derelict lands area reclaimed to taken back and used for the appropriate land-uses. Thus, to control and reduce the risk of flood in most parts of Dodoma city, the local authorities should allocate people in well-planned areas and should enforce the regulations on what lands, which is prone to floods, should people not be allocated. Areas that are poorly drained and liable to flooding should not be occupied by any human activities such as residential, commercial buildings and industries, in order to allow water to flow freely as it goes to the receiving water body. Occupying these areas causes the failure of water to flow through the channel and consequently causing floods.

Namely, the local authorities play a major role on the non-structural measures for storm water drainage and flood control since they are responsible for:

- Creating and allocating land for human settlement development.
- Providing and maintaining infrastructure service intended to open up land for human settlement development.
- Enforcing settlement development conditions, standards and regulations

When approaching the rainy season, the Tanzania Meteorological Agency should provide the interpretation of their reports and prediction so that the government and sectors responsible can provide the solution before any challenges could face the community.

5.6. Campaign and Education

A key element for the successful implementation of non-structural stormwater management programs is an inclusive approach, which promotes the participation of stakeholders in the development and implementation of urban drainage plans.

The successful construction of a drainage system in a neighbourhood does not guarantee a successful drainage project. Users need to be aware of operation and maintenance requirements at the neighbourhood level. Often, one of the best solutions for maintenance is for community members to be responsible for the management of the drainage system, as the regular inspection and cleaning of drains is an important task that can be performed without specialized skills.

The main tool for creating such awareness at a macro level is by far, the media. The media can be used for the promotion of environmental awareness are newspaper, radio and television programs, as these are widely and frequently used modern media.

In this modern knowledge society, media plays a role of being a facilitator of development, disseminator of information, and being an agent of change. Educating the society about environmental concerns and ways to address the issues of Making Dodoma Green, proper solid waste management and proper stormwater facilities management is important. News, features, talk shows and discussions on radios and televisions will be of great value towards solving environmental problems in the City. The print, broadcast and Internet media can be a powerful tool in educating the public on environmental matters. In order to perform this role effectively, it is often necessary for the Government to work with the media. This is often done informally, through regular briefings and information centers. For instance, the Community Development Officers, Health officers together with the Environmental officers of the City should work hand in hand towards making sure that the society is aware of environmental issues through media. For instance, Radio Dodoma can be used as a media for the provision of education.

Children, as early as possible, should be aware of the environmental issues the world is facing. Environmental education helps students understand how their decisions and actions affect the environment. It also builds knowledge and skills necessary to address complex environmental issues, as well as ways that action can be taken to keep the environment healthy and sustainable for the future. Schools must lead conversation. Environmental awareness should be part of the curriculum in all schools from primary schools to advanced secondary schools. This will encourage young people to engage in their environment to protect it and help communities become more environmentally aware. This can be done through the introduction of the 3 R’s i.e. Reduce waste, reuse resources and Recycle materials. A good example is students using bottles for decorative purposes instead of them being left to the surroundings which later can block storm water ways. Also, there should be clubs for Environment in schools which will organize activities like planting trees and grasses. This will help children growing knowing why environment protection is important and how to protect it.

6. Structural Measures

6.1. A Plan on Rehabilitation of the Existing Drainage System

6.1.1. Purposes

Rehabilitation plans on the existing drainage system is aimed to:

- Protect waterways from pollution, including, nutrients, toxicants, sediment, litter and changes to water chemistry.
- Ensure new habitable buildings are protected from flooding in major storms and new subdivisions provide overland flow paths for all surface flows.
- Ensure that floodwaters don't present an unacceptable risk to the community.
- Ensure piped drains have sufficient capacity to convey minor storm events and guarantee flooding isn't a regular nuisance.
- Encourage measures to reuse stormwater as part of urban development.

- Ensure all new drainage assets being delivered through the land development process are constructed in a safe manner and don't present the community and our stakeholders with on-going safety issues.

6.1.2. Banks of the Rivers and Storm Water Drains

The banks of the storm water drains in Dodoma city are affected by erosion during rainfall season as most of the sections of the drains are left bare. There is neither vegetation nor any other means of protecting banks of the drains. Thus, as days pass by the width of the rivers and storm drains increases which puts the life and properties of the residents in danger. It also leads to sedimentation downstream causing the culverts to block. In order to solve this problem, the banks of the rivers and storm water drains should be protected with gabions. For instance, Kisasa storm water drain in areas of Dodoma Makulu, kikuyu storm water drain in areas of Camp David, Pombe river along areas of general hospital to Majengo sokoni, Mkalama river along Dodoma Makulu, the storm water drain that extends from Mkalama towards Ilazo ipagala storm water drain, Sabasaba storm water drain along Sabasaba stand, Mwangaza storm water drain along Nzuguni area. Implementation of these protection measures will maintain existing fluvial geomorphology, protect watercourses from further deterioration and ensure protection of public safety and property. The introduction of check dams along the swale will reduce the flow velocity and thereby reducing the erosive effects of the moving water.

Fig. 124 Gabions for Drains and Rivers Protection

6.1.3. Culverts and Bridges

The culverts and the bridges in Dodoma are filled with earth materials such as sand and mud, trash, debris and others are affected by sedimentation. Thus, the first solution to this problem is to perform desiltation to remove the blocking materials silts, debris and sediments from the culverts to allow water to flow freely through the drain.

6.1.4. Rehabilitation Plan for the Ponds

The following are the ways in which ponds can be rehabilitated.

- Desiltation should be done to remove the accumulated sand and other debris within the pond.
- Desiltation should be done prior to increasing the depth of the ponds. Otherwise, you may end up with a soggy workspace that is difficult to seal and prepare properly before the job is done. Heavy clay soil should be spread throughout the pond bed so that you have at least 15mm thickness throughout. The heavy machinery should be used to tamp down this clay layer so that it is for all practical purposes seamless. This will ensure that the pond is capable of retaining water indefinitely.
- Each pond should include an overflow, so that if the amount of rainfall exceeds the pond capacity, excess rainfall can be channeled through an outlet. This outlet can direct water to a creek, stream or river.

6.1.5. Pond Banks Protection

One of the main reasons as to why the ponds are affected with siltation is due to the fact that the banks have no protection from erosion. Thus, during rainfall, the soil from the pond banks is washed to the ponds leading to siltation. By protecting the banks of the ponds with gabions, it is possible to make the area a recreational area by planting grasses and trees around the ponds where people can go for leisure purposes.

Fig. 125 Gabions for Ponds Protection

6.2. A Plan on a New Drainage System

The new drainage system will involve the construction of new stormwater drains and new water retention ponds, footbridges, bridges and storm water treatment plant. The construction will be located on the existing degraded lands, ravines, and natural depression. The construction is divided into two phases: Short-term period, Medium & Long-term period.

Stormwater drainage systems to be located at the central part of the city are planned to be constructed in the short-term period (2020-2025) while for the medium -term period (2026-2035) the construction of the stormwater drains and ponds will be carried out. In the long-term phase (2035-2040), crossing structures (footbridges and a bridge) will be constructed for the drains that were constructed during the medium term..

The new length of proposed stormwater drains for Dodoma City has a total length of 442.4 km.

- **Short-term Period (2020-2025)**

In the short-term period, 54.3 km of stormwater drains will be constructed. This includes 8 new footbridges to provide access around the new and existing stormwater drains. will serve the central area of the city as shown in the figure below.

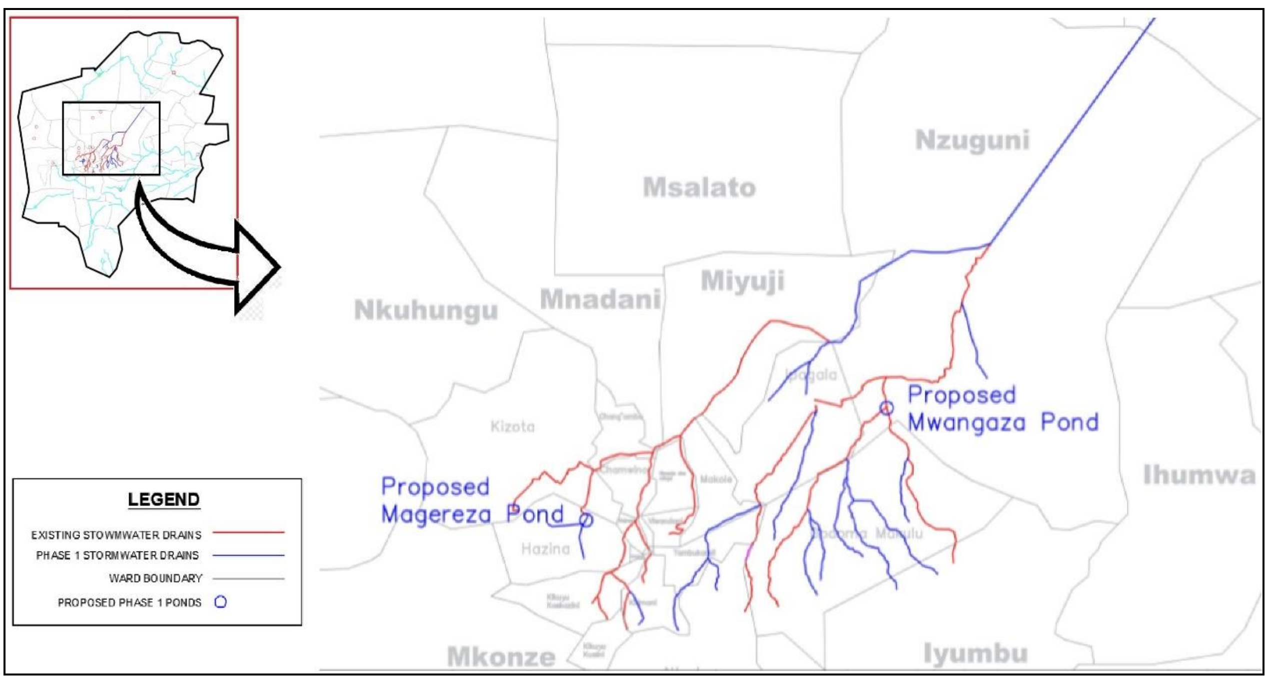

Fig. 126 Proposed Storm Water Drains and Water Retention Pond in Phase 1

The new storm water system will be based on the Master Plan, which has proposed the establishment of new storm water drainage based on the plan to reuse the land that has already been degraded, such as ravines and streams. This will entail reshaping the stream to form parabolic shape, planting the grasses and protection of the banks prone to erosions.. The size of these swales will be based on the expected storms bearing in mind the impacts of the expected development. For the protection of the banks of the drains, gabions will be used. Thus, the main storm channels should have a minimum reserve of 5 metres, and a maximum of 15 m to allow for vegetating the sides of the storm drain as well as gabions.

Table 101. Summary of Proposed New Storm Water Drains (Short-term Period)

Drain Name	Ward	Trapezoidal Length (km)	Vegetation Planting (km)	Gabion (km)
P1-01	Dodoma Makulu	0.0	2.2	0.0
P1-02	Iyumbu	0.0	0.7	0.0
P1-02	Dodoma Makulu	0.0	3.1	0.0
P1-03	Iyumbu	0.0	0.4	0.0
	Dodoma Makulu	0.0	1.8	0.0
P1-03	Dodoma Makulu	2.2	0.0	0.0
P1-04	Dodoma Makulu	0.0	0.3	0.0
	Dodoma Makulu	3.3	0.0	0.0
P1-05	Dodoma Makulu	0.0	0.7	0.0
	Dodoma Makulu	1.5	0.0	0.0
P1-06	Dodoma Makulu	0.0	1.2	0.0
	Dodoma Makulu	1.7	0.0	0.0
P1-07	Dodoma Makulu	0.0	0.0	1.7
	Ipagala	0.0	0.0	2.6
P1-08	Ntyuka	0.0	1.1	0.0
P1-09	Kilimani	0.0	0.8	0.0
	Kilimani	0.0	0.0	0.3
	Tambukareli	0.0	0.0	2.3
	Makole	0.0	0.0	2.0
P1-10	Ipagala	0.0	0.0	1.8
P1-11	Ipagala	0.7	0.0	0.0
	Ipagala	0.0	1.3	0.0
P1-12	Miyuji	0.0	2.2	0.0
	Nzuguni	0.0	3.8	0.0
P1-13	Nzuguni	0.0	8.1	0.0
	Ipala	0.0	0.6	0.0
P1-14	Viwandani	0.7	0.0	0.0
P1-15	Hazina	0.0	1.4	0.0
P1-16	Hazina	0.0	1.2	0.0
P1-17	Nzuguni	0.0	2.5	0.0
Total length		**10.1**	**33.4**	**10.8**
Total Cumulative Length			**54.3**	

Medium & Long-term Period (2026 – 2040)

The proposed storm water drains system during the medium period (2026 – 2035) will cover the peripheral areas of Dodoma City. The storm water drains involve the ones running from Ngh'ongh'ona towards Kikombo, Ngh'ongh'ona towards Iyumbu, Ihumwa, mtumba then to Buiguri, Mbabala, Zuzu, Msange and from Matumbulu towards Mpunguzi. The stormwater drains From Mbalawala towards Makutupora, Chihanga and then to Hombolo dam and the ones at Hombolo wards have been suggested by the Consultant to receive water from Chemba. Currently, it is suggested that the stormwater drains to be left natural except that there should be planting of trees along the banks to protect them from erosion and also to create green belts in the city. The total length for the new stormwater drains for the medium & long-term period is 388.1 km as shown in the figure and table below.

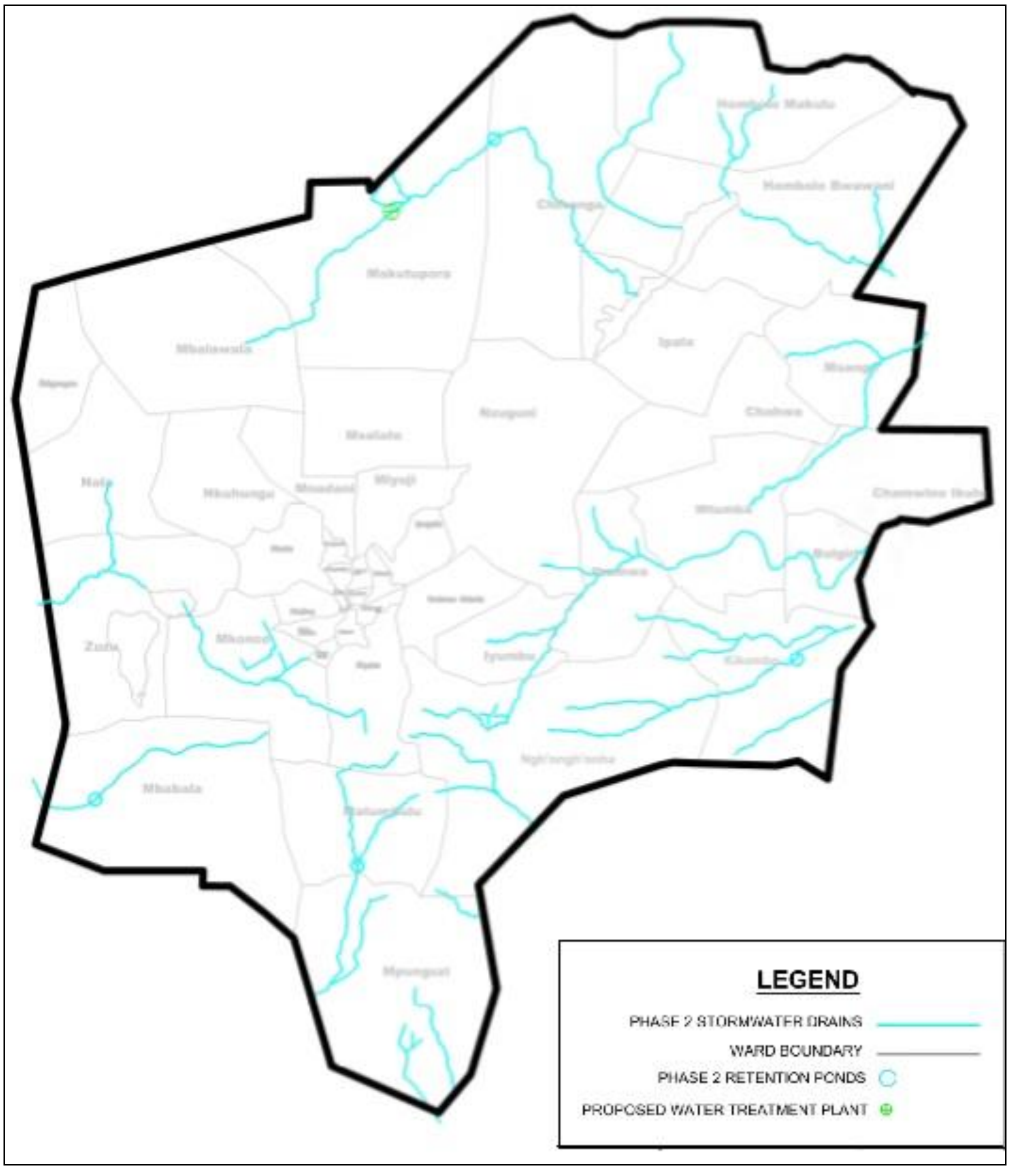

Fig. 127 Proposed Storm Water Drains and Water Retention Pond in Medium & Long-term Period

Table 102. Lengths of the Storm Water Drains in Each Ward (Medium & Long-term Period)

Drain Name	Ward	Natural Drain Length (km)
P2-01	Ngh'ongh'onha	10.4
	Iyumbu	2.5
	Ihumwa	11.3
	Mtumba	2.3
	Buigiri	9.7
	Mtumba	1.0
	Buigiri	9.7
P2-02	Iyumbu	5.2
P2-03	Nzuguni	2.6
	Ihumwa	1.3
P2-04	Ihumwa	4.9
P2-05	Ihumwa	1.1
P2-06	Ngh'ongh'onha	12.1
	Kikombo	10.8
P2-07	Kikombo	7.0
P2-08	Ngh'ongh'onha	1.5
	Kikombo	11.4
P2-09	Ihumwa	1.4
	Ngh'ongh'onha	0.6
	Kikombo	5.8
P2-10	Kikombo	7.4
P2-11	Ngh'ongh'onha	12.4
P2-12	Matumbulu	0.8
	Ngh'ongh'onha	3.6
P2-13	Ntyuka	3.9
	Matumbulu	7.8
P2-14	Matumbulu	7.5
	Mpunguzi	9.4
P2-15	Mpunguzi	8.1
P2-16	Ngh'ongh'onha	1.0
	Mpunguzi	3.2
P2-17	Mpunguzi	10.3
P2-18	Mpunguzi	1.3
P2-19	Mpunguzi	7.4
P2-20	Mbabala	18.1
P2-21	Ntyuka	4.2
	Mkonze	9.0
	Mkonze	1.4
	Mkonze	2.2
	Zuzu	1.0
P2-22	Hombolo Bwawani	12.7
P2-23	Nala	3.7
	Zuzu	2.8

Drain Name	Ward	Natural Drain Length (km)
P2-24	Zuzu	9.6
P2-25	Mtumba	4.1
	Chamwino Ikulu	6.5
	Msange	9.4
P2-26	Mkonze	3.0
P2-27	Mkonze	1.2
P2-28	Mkonze	5.7
P2-29	Mbalawala	3.8
	Makutupora	12.7
P2-30	Makutupora	3.9
P2-31	Makutupora	3.4
P2-32	Makutupora	7.3
	Chihanga	13.7
	Ipala	5.6
P2-33	Hombolo Bwawani	5.9
P2-34	Hombolo Makulu	9.2
	Chihanga	5.0
	Hombolo Bwawani	5.0
P2-35	Hombolo Makulu	3.9
P2-36	Hombolo Makulu	7.3
	Hombolo Bwawani	2.3
P2-37	Msanga	7.7
TOTAL		**388.1**

The long-term phase will not include the construction of any new storm-water drains. This phase will be dedicated to the construction of 3 footbridges and one vehicle bridge to provide access over the drains constructed in the medium term.

6.3. A Plan on New Retention Ponds

Short-term Period (2020-2025)

As the Master Plan proposes the establishment of water retention ponds whenever possible and utilization of green infrastructure, the new water retention ponds have been proposed in various areas located in low laying areas along the storm drains such as streams and ravines. These ponds will be surrounded by green areas to mimic and restore natural hydrology. This will also improve soil water holding capacity and minimize the erosion of the soil in most of the affected and potentially erosion prone areas. The green infrastructure will improve water quality through its filtering of pollutants, but also by reducing the volumetric flow of storm water to be handled, and therefore, minimizing damage to the biological, physical, and chemical integrity of receiving waters. The areas in which ponds can will be established include the area Kizota and Mwangaza. The water retention ponds will support the agriculture activities through irrigation. The investment in storm water retention ponds “pays back” by reducing runoff and flooding risks, protecting scenic character and creating recreational opportunities for the area’s residents and visitors.

- **Medium & Long-term Period (2026 – 2040)**

The construction of new stormwater drains system will also involve the construction of new water retention ponds at the areas of Kikombo, Mbabala, Matumbulu and Chihanga for water storage to reduce the amount of storm water that flows towards Hombolo dam and the little Kinyasungwe. This will also help to provide water for activities like irrigation and planting trees for the Initiative ‘Make Dodoma green’. The sizes of the ponds will depend on the amount of stormwater flowing through the storm water channels.

6.4. A Plan on Infiltration Facilities

A stormwater infiltration basin holds runoff and lets it soak into the ground. They can either drain rapidly or act as permanent ponds where water levels rise and fall with stormwater flows. Infiltration facilities can be designed to handle all runoff from a typical storm but could overflow in a larger one.

A stormwater infiltration basin holds runoff and lets it soak into the ground. The basins are open facilities with grass or sand bases. They can either drain rapidly or act as permanent ponds where water levels rise and fall with stormwater flows. Infiltration facilities can be designed to handle all runoff from a typical storm but could overflow in a larger one. Since the facility is designed to soak water into the ground, anything that can clog the base will reduce performance and be a concern. Generally, infiltration basins are managed like detention ponds but with greater emphasis on maintaining the ability to infiltrate stormwater.

The water source in Dodoma mainly is from the Boreholes. These are mainly found in Makutupora which is the main water source as well as the boreholes at Ihumwa. These sources need to be recharged in order to maintain enough water for different uses in Dodoma City. In order to recharge the underground water, it is suggested that there should be a creation of infiltration facilities near these water sources for the recharge of the boreholes. This can be done by introducing ponds near these areas so as to trap water flowing in these areas and then there should be an underground structure that helps water to soak into the ground.

II. Sanitation System Development Plan

1. General

The World Health Organization defines the term “sanitation” as “Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and feces. The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal”, but on the other hand, the Water Supply and Sanitation collaborative Council defines sanitation as “The collection, transport, treatment and disposal or reuse of human excreta, domestic wastewater and solid waste, and associated hygiene promotion”.

The overall purposes of sanitation are to provide a healthy living environment for everyone, to protect the natural resources, and to provide safety, security and dignity for people when they defecate or urinate. Effective sanitation systems provide barriers between excreta and humans in such a way as to break the disease transmission cycle. However, one of the main challenges is to provide sustainable sanitation. Maintaining and sustaining sanitation has aspects that are technological, institutional and social in nature.

Sanitation infrastructure has to be adapted to several specific contexts including consumers' expectations and local resources available. Sanitation technologies may involve centralized infrastructures like sewerage systems and centralized wastewater treatment plants while it may also take the form of relatively simple onsite sanitation systems. This can in some cases consist of a simple pit latrine or other type of non-flush toilet for the excreta management part.

Providing sanitation to people requires attention to the entire system, not just focusing on technical aspects such as the toilet, fecal sludge management or the wastewater treatment plant. The "sanitation value chain" involves the experience of the user, excreta and wastewater collection methods, transporting and treatment of waste, and reuse or disposal. All need to be thoroughly considered. Thus, in this project, the consultant is supposed to adopt a “City Wide Inclusive Sanitation (CWIS) Approach” in proposing sanitation solutions since sewerage system cannot be a practical solution for the whole Dodoma city.

2. Basic Direction and Strategies

The City Wide Inclusive Sanitation means that: everybody benefits from adequate sanitation service delivery outcomes; human waste is safely managed along the whole sanitation service chain; effective resource recovery and reuse are considered; a diversity of technical solutions is embraced for adaptive, mixed and incremental approaches; and onsite and sewerage solutions are combined, in either centralized or decentralized systems, to better respond to the realities found in the city. The city needs to develop comprehensive approaches to sanitation improvement that encompass long-term planning; technical innovation; institutional reforms; financial mobilization; and hygiene promotion, etc.

Sustainable sanitation approaches which focus on the entire the "sanitation value chain" should be taken into consideration in this project. In order to be sustainable, a sanitation system has to be economically viable, socially acceptable, technically and institutionally appropriate, and it should also protect the environment and the natural resources.

For improvement of the sewerage system, rehabilitation of the existing facilities, construction of a new main trunks and reticulation system to serve areas that are developed or are in the process of being developed and construction of new wastewater treatment facilities to cater for the needs of the City has to be implemented.

3. Phased Objectives

The sanitation development planning process should define short-term objectives and medium and long-term objectives. The consultant defined the objectives of each term as follows:

Table 103. Phased Objectives of Sanitation Development Plan

Phase	Targeted Coverage Rate by Sewerage System (%)	Objectives
Short-Term Period (2020 – 2025)	25.6%	• Rehabilitate the existing sewerage system in the central area. • Construct a new sewerage system for government city and Chamwino Ikulu and a part of central area. • Construct a new Nzuguni WWTP and a pipeline to connect with the WWTP. • Construct a new WWTP in the Buigiri zone which will treat wastewater discharged from the government city. • Construct a new WWTP in the Chinangali zone which will treat wastewater discharged from the Chamwino Ikulu. • Campaign and education for hygiene development • Improve the sanitation and hygiene environment for public

Phase	Targeted Coverage Rate by Sewerage System (%)	Objectives
		buildings such as hotel, shopping center, school, hospital, public office and recreational facility, etc. • Improve the tariff system for sustainable management.
Medium-Term Period (2026 – 2035)	81.1%	• Construct a new sewerage system for the remaining central area. • Construct a new WWTP for covering the whole Nzuguni zone. • Construct a new sewerage system for areas which are located on a zone having impermeable soil, high groundwater level, high flood risk and contaminated groundwater. • Construct a new trunk mains to cover the whole city. • Rearrange the institutional frameworks of related local governments to be responsible for managing onsite sanitation system. • Establish a tax incentive to encourage people who uses onsite systems to connect to a sewerage system.
Long-Term Period (2036 – 2040)	98.9%	• Strengthen the regulations about wastewater discharged from industrial factory and hospital, etc. • Apply a advanced wastewater treatment technology on the WWTP. • Construct new WWTPs for all treatment zones which do not have a WWTP. • Establish a local fund and legal aid provisions to support poor residents who are in a poor sanitation environment in the City.

Remark) The targeted coverage rates by sewerage system mean that the rates of households would be serviced by reticulation sewers which exclude property connection.

4. Institutional Measures

4.1. Improvement of the Tariff System

DUWASA is expecting to increase the revenue base as well as collection efficiency from the current 96% to 98% by June, 2020. Increment on revenue collection goes parallel with Reduction of NRW as this is the among the DUWASA’s critical challenges. According to the number of interventions set, DUWASA plans to reduce NRW from an average of 28.6% to 25.5%. The reduction of NRW will lead to low energy consumption hence cost reduction, increase in billing efficiency, fulfillment of customers water demand and increase in revenue. The action to revamp the situation will be through improving metering, leakage control through a specific roadmap, usage of emergency unit, regular illegal inspections, customers’ reconnection, customer surveys for upgrading the Billing Database and old pipe replacement.

In order to achieve 98% collection efficiency and earn more revenue DUWASA is carrying out the following:

A billing software is being improved to meet customer requirements; conducting intensive customers follow ups; dealing and serving customers accordingly in a more professional way; customer sensitization on full utilization of electronic payment modes i.e through customers' bank account, M-Pesa, and Tigo-Pesa.

In addition to the measures the authority is carrying out mentioned above, medium and long-term plan on a gradual raise of the tariff system should be established for a sustainable and successful management of the sewerage system in the city. But, the socioeconomical conditions of communities have to be parallelly taken into account because they do not willing to pay more money than they could afford to pay for the services.

For the details about the plan on a gradual raise of tariff system, See Section 4.1 of Financial Analysis.

4.2. Rearrangement of the Administrative Frameworks

Roles and responsibilities for sanitation and hygiene are spread over different sectors thus they can sometimes be unclear in the complex institutional set-up that characterizes the sanitation sector. The most important gap is the unclear separation between service delivery and regulation/monitoring/evaluation. The 2007 Water Sector Development Plan (NWSP) also addresses the overlapping roles and responsibilities of different authorities, which is considered to be one of the major reasons for the inefficient use of resources (human and financial), duplication of efforts and gaps in service provision.

The level of involvement of the governments varies, but there is a trend towards decentralization and localization. At the ministerial level, sanitation is managed by the Ministry of Water and Irrigation (MoWI) and by the Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC). However, how responsibilities are shared between the two ministries remains vague.

At the local government level, networked sanitation service provision is the responsibility of DUWASA, which is accountable to central government and are required to operate on a commercial basis, aiming for full cost recovery. This acts as a disincentive to investing in sanitation facilities of some areas where cost recovery is likely to be more difficult. And, Rural Water Supply and Sanitation Agency (RUWASA) which shall be responsible for development and sustainable management of rural water supply and sanitation projects comes into effect after the National Assembly enacted the Water Supply and Sanitation Act, 2019 and launched officially since the 1st July, 2019. However, RUWASA has focused on the rural areas' water supply system only, and there is no clear boundary between urban and rural areas which are managed by DUWASA and RUWASA respectively. Consequently, rural areas' sanitation and hygiene are still being disregarded.

Therefore, to solve the problems, we should take into account an establishment of separate authority and department in ministerial level and local government level which are responsible for only the sanitation and hygiene sector of both urban and rural areas. The reason why we should take into account such a measure is because they are more likely to prioritize water supply services than sanitation services because sanitation service has less profitable than the former. We should make an environment to invest in the sanitation services and projects actively for enhancing the public benefits regardless of direct economical profits.

The public benefits of improved sanitation can include lower health system costs, fewer days lost at work or at school through illness or through caring for an ill relative, and convenience time savings (time not spent queuing at shared sanitation facilities or walking for open defecation).

4.3. Establishment of Sewer Connection Incentive Program

This is one among one of the biggest challenges to the sewerage system in Dodoma since most of the people are not connected to the sewer. They want to connect to sewers and improve their onsite sanitation but are usually unwilling to connect to the sewer line due to the expenses encountered during the connection phase or cannot do it because of lack of information. This would be one of main factors to reduce the efficiency of investment to a sewerage system which normally requires a large amount of capital. Thus, we should consider the Sewer Connection Incentive Program (SCIP) to encourage and induce people to connect to the sewer so that it can enhance the investment efficiency and improve sanitation service. The incentives program can consist of a tax credit and a special loan system, etc.

4.4. Establishment of a Local Sanitation Fund and Legal Aid Provisions

Financing for sewerage and wastewater treatment plants is mainly covered by central government grants to the DUWASA but funds are small and tend to be hidden within budgets for water provision. For example, in 2012 the proportion of Tanzania's GDP that was invested in sanitation was less than 0.1%. Sanitation funding from national government supports the expansion of networked sanitation infrastructure, and does not invest in the first stage of the chain (containment). This means that, if the LGAs want to intervene to improve the poorest households' access to sanitation, they would need to generate their own funds to do so. However, they have very low financial capacity since it no longer has control of property tax collection and there are many restrictions on local government borrowing. Therefore, we should take into account a local sanitation fund to enhance investment capacity of local government authorities, especially for rural areas which normally have poor sanitation environment.

Section 21 of the Sanitation Act stipulates that: “in the exercise of powers and the discharge of duties, a water and sanitation authority shall take into account the existence and needs of economically disadvantaged persons when setting tariffs and other charges for water supply and sanitation services; and taking any action in any matter likely to have a negative effect on the economic well-being of such groups. The economically disadvantaged persons shall be identified by the water authority in collaboration with the local government authority”. Additionally, the National Water Policy sets goals for “improving services in low income and peri-urban areas and identifying vulnerable groups” and the Sanitation and Hygiene Policy proposes that “programmes supporting sanitation infrastructure and hygiene provision should consider the knowledge, beliefs, practices and needs of people of differing backgrounds, ages, cultures and ethnic groups”. It emphasizes that gender issues and the rights and concerns of women as well as the disabled should be integrated into all levels of implementation and decision making on sanitation and hygiene services.

However, there is no current institutional framework yet which does not consider the disadvantaged groups in detail. Thus, detailed legal aid provisions to allocate resources for sanitation of the disadvantaged groups should be taken into consideration.

5. Non-Structural Measures

5.1. Campaign and Education Program

➲ Education in Schools

School teachers, especially at primary level, should be trained and provided with suitable educational materials to educate the children to use sanitation facilities correctly at school and to understand the need for hygiene and latrines at home. Special lessons should be given to help children understand that a clean water supply with effective sanitation can lead to improved health. This will not only be of benefit to the children but will also serve to reinforce the health message to the community as the children report back to their parents.

➲ Promotion by Mass Media

There are many forms of the mass media that can be used for promoting specific sanitation options as well as for health education. The use and the balance between them will depend on the size of the target group, the relative wealth of the people and the availability of funding. Posters, billboards, newspapers, radio, loudspeaker trucks, slides, flip-charts, film, video, and broadcast television can all be used successfully in differing mixes. Careful planning is necessary, as too much information and health education coming too soon may lead to a build-up of resistance against the ideas.

5.2. Capacity Building of Local Government Agencies

The local government authorities (DUWASA and RUWASA) managing the sewerage system in Dodoma city needs to strengthen individual, organization and system abilities for sustainable development. Basing on performance assessment conducted by them on monthly, quarterly, semi-annually and annually basis through various set performance indicators, DUWASA can manage to identify areas that need improvement for the attainment of its strategic objectives, and then come up with organization’s capacity and development plans for improvement.

Additionally, most operations of the authorities are not yet computerized for billing system, database management system and internal communications, etc. Thus, utilization of available technologies should be taken into account to improve their capacity for efficient operation and management of sewerage system.

6. Structural Measures

Based on the Baseline Assessment findings and the proposed sewerage development strategy discussed above, the following structural measures to rehabilitate and improve the sewerage system detailed here below will be proposed.

6.1. A Plan on Enhancing the Existing Onsite Sanitation Environment

For the onsite sanitation system, the MoHCDGEC defines improved sanitation as "a latrine that is connected to a sewer, septic tank, VIP latrine, ecological sanitation systems, pour flush latrine or pit latrine with a washable floor and a complete super-structure". These are options we can consider to improve a poor onsite sanitation system in the City.

In this project, however, the consultants were advised not to include a structural measure of installing toilets or improved pit latrines at individual level. However, we considered a structural measure to improve the sanitation environment of public buildings such as hotel, market, school, hospital and public offices, etc. The provision of improved sanitation facilities for public buildings can be expected to provide unspecified individuals with positive experiences about using the improved sanitation systems in person which can induce people to improve their own sanitation environment. And, especially for schools, we can expect that the improved sanitation facilities can prevent students from being infected by diseases which can be caused by poor hygiene conditions, and teachers can educate students on hygiene education programs by utilizing the improved sanitation facilities in school, which can bring high educational effects. For girls, they are less likely to miss school by staying at home during menstruation.

6.2. A Plan on Rehabilitation of the Existing Sewer Pipelines

Some rehabilitation works for the exiting sewer pipelines that have already been proposed by DUWASA for the Year 2017/2018 to 2019/2020 and therefore excluded from the priority projects and investment plan. These include, but are not limited to, the following:

- Desludging of the series of WSPs on western side, which is on-going
- Replacement of lateral sewers for Area C, Area D and Central Business Park (CBP), which is on-going
- Construction of few lateral sewers for other areas by DUWASA (in-house)

6.2.1. Trunk Sewers

The existing trunk sewer network traverses through several built-up areas that can easily discharge into the system by gravity. In some of these areas, the positions of the connection points were marked conspicuously and are now difficult to locate. Where new connections need to be provided, they should be clearly shown on the drawings and adequately referenced for easy identification on site.

Field investigations revealed that the trunk sewer network requires remedial works covering the following components:

- ***Repair of the plumbing and water supply systems to the existing six (6) automatic flushing tanks.*** The repair of the six (6) flushing tanks will greatly assist the operation and maintenance of the sewerage system by reducing potential future blockages. Apart from minor repairs, the flushing tanks do not require any major changes in design or construction and should easily be put into operation.
- ***Replacement of all broken or missing manhole covers/frames and step irons identified on site.*** The design and quality standard of the manhole covers and step irons should be as per the Standard Details provided by DUWASA. However, DUWASA should consider using well-fitting concrete filled manhole covers and frames, which would discourage vandalism. A total of 200 manhole covers/frames and 4,000 step irons require replacement.
- ***Raising of manhole cover slabs in open areas to be about 150-500mm above the surrounding ground level to deter direct entry of storm water runoff into the sewers.*** The construction material and diameter of the raised section of the manhole should be to DUWASA's Standard Details and should match the existing manhole details in which the walls are made up of cement/sand blocks or equivalent reinforced concrete. A total of 200 manholes located within the Central Town area require raising as recommended.
- ***Flushing, unblocking and power rodding of the whole trunk sewer network to remove sediments and other deleterious matter that may have entered the sewerage system via broken manhole covers and sewers.*** This needs to be done on a regular basis and DUWASA should therefore make the necessary arrangements to fully equip the maintenance section with the required equipment. The maintenance equipment should include power rodding machine with rodding sticks, protective gloves, manhole cover keys, fume masks and other tools required for the operation.

6.2.2. Reticulation Sewers

The existing reticulation system only covers Mlimwa East (Area C) and West (Area D), Central Business Park (CBP) and Hazina (new). Some sections of the system are not quite in order structurally and are currently being replaced/rehabilitated by DUWASA and therefore excluded from the priority projects and investment plan. There is also need in some areas in Mlimwa and Central Business Park that require flushing and rodding to remove sediments and unblock sewer lines.

For the sewered areas, there is also the need to update the design/construction drawings of the sewerage reticulation system to give "as-built" particulars for the sewer lines and manholes for their easy identification on site and re-establishment in case of removal or replacement. The property connection sewer pipes and chambers should also be well marked and located for ease of identification during house connections to plots as they are developed.

6.2.3. Existing Wastewater Stabilization Ponds

The whole of the WSPs site needs to be cleared of the existing overgrown vegetation and floating matter, particularly at the pond's inlets. This would necessitate desludging of the ponds and reshaping of the embankments and pond bases to attain the original dimensions.

6.3. A Plan on New Sewer Pipelines

6.3.1. General

The plan for the new sewerage system is based on the total of eight (8) Wastewater Treatment Zones mentioned earlier in the chapter V.5 in Section 2. And, it was planned to be phased into Dodoma city for the period from 2020 to 2040 as follows:

- Short-term period: 2020 – 2025
- Medium- term period: 2026 – 2035
- Long-term period: 2035 – 2040

In the short-term phase, we planned to install the Nzuguni wastewater treatment facility covering 19 wards through the extension of some trunk sewers and the installation of new reticulation sewers, focusing on the area covered by the existing trunk sewer in the Nzuguni wastewater treatment zone. The existing Swaswa wastewater treatment ponds will be abandoned after completion of the Nzuguni wastewater treatment facility's construction.

In this phase, we have also taken into account the Government City in the Buigiri zone and Chamwino Ikulu in the Chinangali zone which are important areas in socioeconomical and political terms.

As for the medium and long-term phases, during this period, sewer systems within the remaining areas of Nzuguni Wastewater Treatment Zone will be installed and a new WWTP in the chihanga ward will be constructed to cover the increase in wastewater flow in this zone. We have also taken into account the installation of trunk mains for all remaining Wastewater treatment zones in this phase.

The eight (8) wastewater treatment zones and wards belonging to each zone are as follows:

Table 104. Status of the Wastewater Treatment Zones

Zone No.	Zone Name	Ward
Zone 1	Buigiri	Government City / Mtumba (except the Government City) / Kikombo / Ngh’ongh’onha (27.2%) / Buigiri (62.3%) / Chahwa (41.1%) / Ihumwa / Iyumbu (20.7%) / Nzuguni(14.1%)
Zone 2	Nzuguni	Chihanga(33.1%) / Makutupora / Msalato/ Nzuguni(66.5%) / Miyuji / Mnadani / Nkuhungu(53.4%) / Ipagala / Dodoma Makulu / Iyumbu(41.2%) / Ngh’ongh’onha(0.7%) / Ntyuka(65.9%) / Mkonze(8.7%) / Kizota(88.8%) / Chang’ombe/ Hazina / Kikuyu Kaskasini / Kikuyu Kusini / Kilimani / Tambukareli / Madukani / Uhuru / Majengo/ Viwandani / Chamwino / Kiwanja cha Ndege / Makole
Zone 3	Mbabala(N)	Mbalawala / Chigongwe / Nala (99.5%) / Nkuhungu (37.6%) / Zuzu(17.0%)
Zone 4	Mbabala(S)	Nala(0.5%) / Nkuhungu(9.0%) / Kizota(11.2%) / Zuzu(83.0%) / Mkonze(82.0%) / Mbabala
Zone 5	Chinangali	Msanga / Chamwino Ikulu / Chahwa(46.0%) / Buigiri(37.7%)
Zone 6	Hombolo	Hombolo Makulu / Hombolo Bwawani / Chihanga(66.9%) / Ipala / Nzuguni(19.3%) / Chahwa(12.9%)
Zone 7	Mpunguzi	Mpunguzi / Matumbulu / Ntyuka(34.1%) / Mkonze(9.3%)
Zone 8	Udom	Ngh’ongh’onha(72.1%) / Iyumbu(38.1%)

( ): Ratio of ward’s area belonging to a zone to total area of the zone

6.3.2. Proposed Material of Sewer Pipes

Common materials for sewer pipes include: unplasticized polyvinylchloride (uPVC) pipes, high density polyethylene (HDPE) pipes, precast concrete products, ductile iron (DI) pipes, glass reinforced plastic (GRP) pipes and steel pipes.

Among them, the related authority (DUWASA) prefer uPVC and HDPE. Thus, the consultant, in the new installation of sewer pipeline, suggest using the uPVC because it is cheaper and easier to fabricate as well as it is more suitable for direct burial and trenchless installations.

6.3.3. Trunk Sewer

Extensions of the Existing Trunk Sewers

The proposed extensions fall on existing trunk sewers ‘I’, ‘K’, ‘SK’ and ‘M’. Their reviewed design and technical details are summarized in the Table 105 below and highlighted in the following section.

Table 105. Extensions of Existing Trunk Sewers

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 2-Nzuguni	Trunk ’I’	Hazina	D450	3.1	37
			D500	0.6	
	Trunk ’K’	Kikuyu Kaskasini	D450	1.9	19
	Trunk ‘SK’	Kikuyu Kusini	D250	1.9	19
	Trunk ’M’	Ipagala, Nzuguni	D1400	1.0	50
			D1500	3.6	
			D1800	0.4	
Total			D250	1.9	75
			D450	5.0	
			D500	0.6	
			D1400	1.0	50
			D1500	3.6	
			D1800	0.4	
			Total	**12.5**	**125**

- Trunk Sewer ‘I’

It is proposed to extend this trunk sewer to serve part of Kizota and Hazina. The proposed extension measures approximately 3.7km and comprises 450 - 500mm diameter sewers.

- Trunk Sewer ‘K’

The proposed extension of this trunk sewer is located within the Kikuyu Complex and is intended to serve the northern parts of the area. The proposed extension measures approximately 1.9km and comprises 450mm diameter sewers. The sewer starts from within Kikuyu Complex and is designed to connect to the existing Trunk Sewer ‘K’.

- Trunk Sewer 'SK'

The proposed extension of this sub-trunk sewer is also located within the Kikuyu Complex and is intended to serve a section of the southern parts of the area. The extension measures approximately 1.9km and is proposed to comprise 250mm diameter sewers. The sewer starts from within Kikuyu Complex and is designed to connect to the existing Sub-Trunk Sewer 'SK'.

- Trunk Sewer 'M'

The proposed extension of this trunk sewer is located within the Ipagala and is installed from the inlet (D600mm) of the existing Swaswa wastewater treatment ponds to the planed Nzuguni treatment plant for transfer of existing wastewater and increased wastewater due to extension of the trunk sewer. The extension measures approximately 5.0km and is proposed to comprise 1,400 – 1,800mm diameter sewers.

New Trunk Sewers

In addition to the extension of the existing trunk sewers, other new trunk sewers will be constructed to serve other areas that are developed or are being developed outside the existing trunk sewers. The developments of these areas are at different stages and it would therefore be prudent to stage the sewerage systems to follow suit.

- Zone 1 - Buigiri

Details of the new trunk sewers for the Buigiri Treatment Zone are given in the Table 106.

Table 106. Details of Proposed New Trunk Sewer for Zone 1 - Buigiri

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 1 - Buigiri	Z1-P1-01	Government City	D400	0.5	38
			D500	2.6	
			D600	0.7	
			D700	5.9	126
			D900	0.4	
			D1,200	6.3	
	Z1-P1-02	Government City	D250	4.0	77
			D600	3.7	
			D700	0.8	27
			D800	1.9	
	Z1-P2-01	Ihumwa	D250	3.3	85
			D300	5.1	
	Z1-P2-02	Iyumbu	D250	1.7	17
	Z1-P2-03	Iyumbu	D250	4.9	50
		Ihumwa	D250	2.4	25
	Z1-P2-04	Nzuguni	D250	0.3	42

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
		Ihumwa	D250	3.8	
	Z1-P2-05	Kikombo	D250	4.9	131
			D300	5.5	
			D400	0.4	
		Buigiri	D400	2.2	
	Z1-P2-06	Ngh'ongh'onha	D250	3.7	85
		Kikombo	D250	4.8	
	Z1-P2-07	Mtumba	D250	5.5	56
	Z1-P2-08	Chahwa	D250	3.6	81
		Mtumba	D250	4.4	
	Z1-P2-09	Mtumba	D300	4.5	46
Total			D250	47.2	733
			D300	15.2	
			D400	3.1	
			D500	2.6	
			D600	4.4	
			D700	6.7	153
			D800	1.9	
			D900	0.4	
			D1,200	6.3	
			Total	87.8	886

- Zone 2 - Nzuguni

Details of the new trunk sewers for the Nzuguni Treatment Zone are given in Table 107.

Table 107. Details of Proposed New Sewers for Zone 2 - Nzuguni

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 2 - Nzuguni	Z2-P2-01	Iyumbu	D250	0.5	72
		Dodoma Makulu	D250	5.2	
			D300	1.1	
			D450	0.3	
	Z2-P2-02	Nzuguni	D250	2.4	24
	Z2-P2-03	Ipagala	D350	3.1	43
		Nzuguni	D400	1.1	
	Z2-P2-04	Nkuhungu	D350	5.3	122
			D400	1.8	
		Mnadani	D500	4.3	
		Msalato	D500	0.7	
		Miyuji	D700	8.3	97
		Ipagala	D800	0.4	
		Nzuguni	D800	0.7	
	Z2-P2-05	Makutupora	D450	2.0	119
		Msalato	D450	1.5	
			D500	5.1	

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
			D600	3.1	
	Z2-P2-06	Chihanga	D400	12.9	130
	Z2-P2-07	Nzuguni	D1,000	18.6	186
	Z2-P2-08	Kizota	D400	1.3	75
		Chang'ombe	D500	2.3	
		Miyuji	D600	3.8	
	Z2-P2-09	Ipagala	D700	0.9	9
Total			D250	8.1	585
			D300	1.1	
			D350	8.4	
			D400	17.1	
			D450	3.8	
			D500	12.4	
			D600	6.9	
			D700	9.2	292
			D800	1.1	
			D1000	18.6	
			Total	86.6	877

- Zone 3 & 4 - Mbabala (N) and Mbabala (S)

Details of the new trunk sewers for the Mbabala Treatment Zone are given in Table 108.

Table 108. Details of Proposed New Sewers for Zone 3 & 4 – Mbabala(N) & Mababala(S)

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 3 Mbabala (N) & Mbabala (S)	Z3-P2-01	Zuzu	D500	6.1	140
		Mbabala	D500	7.8	
	Z3-P2-02	Mbabala	D500	1.0	10
	Z3-P2-03	Mkonze	D300	6.5	117
		Zuzu	D300	2.9	
		Mbabala	D300	2.2	
	Z3-P2-04	Mkonze	D250	5.9	60
	Z3-P2-05	Nkuhungu	D250	2.4	124
		Zuzu	D250	4.7	
		Kizota	D250	0.9	
		Mkonze	D250	4.0	
	Z3-P2-06	Zuzu	D250	3.3	60
		Mkonze	D250	2.6	
	Z3-P2-07	Nala	D250	4.2	42
	Z3-P2-08	Nkuhungu	D250	1.2	110
		Nala	D250	9.6	
	Z3-P2-09	Mbalawala	D250	0.7	35
		Nala	D250	0.7	
			D350	1.9	
	Z3-P2-10	Mbabala	D250	2.2	76

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
			D350	1.4	
		Chigongwe	D350	3.7	
	Z3-P2-11	Mbalawala	D300	3.6	116
			D350	2.3	
		Chigongwe	D350	5.4	
			D400	0.1	
	Z3-P2-12	Zuzu	D300	2.9	176
		Nala	D300	9.9	
		Chigongwe	D300	4.7	
	Z3-P2-13	Mkonze	D250	0.3	150
		Mbabala	D250	10.0	
			D500	46.0	
Total			D250	52.8	1,216
			D300	32.7	
			D350	14.7	
			D400	0.1	
			D500	19.5	
			Total	119.7	

- Zone 5 - Chinangali

Details of the new trunk sewers for the Chinangali Treatment Zone are given in Table 109.

Table 109. Details of Proposed New Sewers for Zone 5 - Chinangali

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 4 - Chinangali	Z4-P1-01	Buigiri	D300	1.4	98
		Chamwino Ikulu	D300	4.7	
			D450	1.9	
			D550	0.9	
			D600	0.5	
			D700	5.3	54
	Z4-P1-02	Chamwino Ikulu	D250	6.9	70
	Z4-P2-01	Chahwa	D250	6.1	203
		Msanga	D250	10.5	
		Chamwino Ikulu	D250	2.9	
Total			D250	26.4	371
			D300	6.1	
			D450	1.9	
			D550	0.9	
			D630	0.5	
			D700	5.3	54
			Total	41.2	425

- Zone 6 - Hombolo

Details of the new trunk sewers for the Hombolo Treatment Zone are given in Table 110.

Table 110. Details of Proposed New Sewer for Zone 6 - Hombolo

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 5 - Hombolo	Z5-P2-01	Nzuguni	D250	1.4	270
		Chahwa	D250	5.8	
		Ipala	D250	11.8	
		Hombolo Bwawani	D250	7.8	
	Z5-P2-02	Hombolo Makulu	D250	4.0	142
		Hombolo Bwawani	D250	10.2	
	Z5-P2-03	Chihanga	D250	1.1	223
		Hombolo Makulu	D250	10.1	
		Hombolo Bwawani	D250	10.9	
Total			D250	63.1	635
			Total	63.1	

- Zone 7 - Mpunguzi

Details of the new trunk sewers for the Mpunguzi Treatment Zone are given in Table 111.

Table 111. Details of Proposed New Sewers for Zone 7 - Mpunguzi

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 6 - Mpunguzi	Z6-P2-01	Mkonze	D250	0.4	204
		Matumbulu	D250	9.5	
		Mpunguzi	D250	0.8	
			D300	2.7	
			D350	2.1	
			D400	3.0	
			D450	1.4	
	Z6-P2-02	Mpunguzi	D250	4.3	78
			D300	3.3	
	Z6-P2-03	Ntyuka	D250	0.2	77
		Matumbulu	D250	7.5	
Total			D250	22.7	359
			D300	6.1	
			D350	2.1	
			D400	3.0	
			D450	1.4	
			Total	35.3	

- Zone 8 - Udom

Details of the new trunk sewers for the Udom Treatment Zone are given in Table 112.

Table 112. Details of Proposed New Sewers for Zone 8 - Udom

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 7 - Udom	Z7-P2-01	Ngh'ongh'onha	D250	5.3	185
	Z7-P2-02		D250	11.3	
	Z7-P2-03		D250	1.8	
Total			D250	18.3	185
			Total	18.3	

Phased Plan on Trunk Sewers

We classified the construction works for proposed trunk sewers into two (2) phases in accordance with their preferred priorities as follows:

- Short-term phase (2020 - 2025)

Short-term phase consists of the extension of the existing trunk sewers in Zone 2 – Nzuguni; the new trunk sewers for Government City in Zone 1 – Buigiri; and the new trunk sewers for Chamwino Ikulu Ward in Zone 4 - Chinangali. The details are summarized in the following Table 113.

Table 113. Summary of the Trunk Sewers for Short-term phase (2020 – 2025)

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 2 - Nzuguni	Trunk 'I'	Hazina	450	3.1	75
			500	0.6	
	Trunk 'K'	Kikuyu Kaskasini	450	1.9	
	Trunk SK'	Kikuyu Kusini	250	1.9	
	Trunk 'M'	Ipagala, Nzuguni	1400	1.0	50
			1500	3.6	
			1800	0.4	
	Sub-total			12.5	125
Zone 1 - Buigiri	Z1-P1-01	Government City	D400	0.5	38
			D500	2.6	
			D630	0.7	
			D700	5.9	126
			D900	0.4	
			D1200	6.3	
	Z1-P1-02	Government City	D250	4.0	77
			D600	3.7	
			D700	0.8	27
			D800	1.9	

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
	Sub-total			26.8	268
Zone 4 - Chinangali	Z4-P1-01	Buigiri	D300	1.4	98
		Chamwino Ikulu	D300	4.7	
			D450	1.9	
			D550	0.9	
			D600	0.5	
			D700	5.3	54
	Z4-P1-02	Chamwino Ikulu	D250	6.9	70
	Sub-total			21.6	222
Total			D250	12.8	358
			D300	6.1	
			D450	7.4	
			D500	4.1	
			D600	4.9	
			D700	12.0	257
			D800	1.9	
			D900	0.4	
			D1200	6.3	
			D1400	1.0	
			D1500	3.6	
			D1800	0.4	

- Medium-term phase (2026 - 2035)

The below table shows the new trunk sewers to be implemented for the medium-term phase by each zone. The construction works of trunk sewers for all zones are planned to be completed in the medium-term phase.

Table 114. Summary of the Trunk Sewers for Medium-term Phase (2026 – 2035)

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 1 - Buigiri	Z1-P2-01~09	Ihumwa, Iyumbu, Nzuguni, Kikombo, Buigiri, Chahwa, Ngh'ongh'onha, Mtumba	D250	43.2	618
			D300	15.2	
			D400	2.6	
		Sub-total		61.0	
Zone 2 - Nzuguni	Z2-P2-01~09	Iyumbu, Dodoma Makulu, Nzuguni, Ipagala, Nkuhungu, Mnadani, Msalato, Miyuji, Makutupora, Chihanga, Kizota, Chang'ombe	D250	8.1	585
			D300	1.1	
			D350	8.4	
			D400	17.1	
			D450	3.8	

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
			D500	12.4	
			D600	6.9	
			D700	9.2	292
			D800	1.1	
			D1000	18.6	
		Sub-total		86.6	877
Zone 3 Mbabala (N) & Mbabala (S)	Z3-P2-01~13	Zuzu, Mbabala, Mkonze, Nkuhungu, Kizota, Nala, Mbalawala, Chigongwe	D250	52.8	1,216
			D300	32.7	
			D350	14.7	
			D400	0.1	
			D500	19.5	
		Sub-total		119.7	
Zone 4 Chinangali	Z4-P2-01	Chamwino Ikulu, Chahwa Msanga	D250	19.5	203
		Sub-total		19.5	
Zone 5 Hombolo	Z5-P2-01~03	Nzuguni, Chahwa, Ipala, Hombolo, Chihanga	D250	63.1	635
		Sub-total		63.1	
Zone 6 - Mpunguzi	Z6-P2-01~03	Mkonze, Matumbulu, Mpunguzi, Ntyuka	D250	22.7	359
			D300	6.1	
			D350	2.1	
			D400	3.0	
			D450	1.4	
		Sub-total		35.3	
Zone 7 - Udom	Z7-P2-01~03	Ngh'ongh'onha	D250	18.3	185
		Sub-total		18.3	
Total			D250	227.2	3,801
			D300	55.1	
			D350	25.2	
			D400	22.8	
			D450	5.2	
			D500	31.9	
			D600	6.9	
			D700	9.2	292
			D800	1.1	
			D1000	18.6	

Wards to be Served by Phased Trunk Sewer Installation

The below table shows the wards to be served by phased trunk sewer installation.

Table 115. List of Wards to be Served by Phased Truck Sewer Installation

S/No.	Name of Ward	Present	Short-term phase (2020 – 2025)	Medium-term phase (2026 – 2035)
1	Viwandani	◎		
2	Uhuru	◎		
3	Chamwino	◎		
4	Kiwanja cha ndege	◎		
5	Makole	◎		
6	Miyuji			◎
7	Msalato			◎
8	Makutopora			◎
9	Chihanga			◎
10	Hombolo Makulu			◎
11	Hombolo Bwawani			◎
12	Ipala			◎
13	Chahwa		◎	◎
14	Nzuguni		◎	◎
15	Dodoma Makulu			◎
16	Mtumba			◎
17	Ihumwa			◎
18	Kikombo			◎
19	Ngh’ongh’ohna	◎		◎
20	Mpunguzi			◎
21	Matumbulu			◎
22	Tambukareli	◎	◎	
23	Kilimani	◎	◎	
24	Kikuyu Kasikazini	◎	◎	
25	Kikuyu Kusini		◎	
26	Mkonze			◎
27	Mbabala			◎
28	Zuzu			◎
29	Hazina	◎	◎	
30	Madukani	◎	◎	
31	Majengo	◎	◎	
32	Kizota	◎		◎
33	Nkuhungu			◎
34	Nala			◎
35	Mbalawala			◎
36	Ntyuka	◎		◎
37	Chigongwe			◎

S/No.	Name of Ward	Present	Short-term phase (2020 – 2025)	Medium-term phase (2026 – 2035)
38	Chang'ombe			◎
39	Iyumbu			◎
40	Mnadani			◎
41	Ipagala	◎	◎	◎
42	Chamwino Ikulu		◎	◎
43	Msanga		◎	◎
44	Buigiri		◎	◎

6.3.4. Reticulation Sewer

Reticulation Sewers to be connected with the Existing Trunk Sewers

Considering that the existing sewage system is provided only to about 6% of the population of Dodoma City, the installation of a proper reticulation sewers may promote an increase in the number of people using sewerage system.

Therefore, to increase the number of people using sewerage system, reticulation sewers were planned primarily in the central areas of Zone 2-Nzuguni where it shows a high population density. and they are divided into those connected to the extended trunk sewers and to the new trunk sewers respectively.

The proposed reticulation sewers are summarised in Table 116 below.

Table 116. Reticulation Sewers to be Connected to Existing and Extented Trunk Sewers

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 2 - Nzuguni	Viwandani	D250	4.0	5,643
	Uhuru	D300	0.7	
	Chamwino	D250	24.6	
	Kiwanja Cha Ndege	D250	8.8	
	Makole	D250	15.5	
	Tambukareli	D250	10.2	
	Kilimani	D250	12.8	
	Kikuyu Kasikazani	D250	18.7	
	Mkonze	D250	41.3	
	Kikuyu Kusini	D250	25.5	
	Hazina	D250	22.5	
	Madukani	D250	1.0	
	Majengo	D250	1.1	
	N'gh'ongh'onha	D250	7.3	
	Ntiyuka	D300	40.8	

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
	Ipagala	D250	29.1	
Total		D250	222.4	5,643
		D300	41.5	
		Total	263.9	

Reticulation Sewers to the New Trunk Sewer

In addition to the reticulation sewers mentioned above, additional reticulation sewers are also planned to collect and treat wastewater from the Chamwino Ikulu Ward and the Government City which is currently under construction.

The proposed reticulation sewers are summarised in Table 117 below.

Table 117. Reticulation Sewers to be Connected to the New Trunk Sewers

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 1 - Buigiri	Government City	D400	29.5	3,580
	Mtumba	D400	103.5	
	Kikombo	D350	21.1	
	N’gh’ongh’onha	-	-	
	Buigiri	-	-	
	Chahwa	D250	80.3	
	Ihumwa	D300	12.2	
	Iyumbu	D250	79.7	
	Nzuguni	D250	6.7	
	Sub-total		333.0	
Zone 2 - Nzuguni	Kizota	D350	8.5	7,540
	Makutupora	D400	25.4	
	Msalato	D400	28.7	
	Miyuji	D250	44.8	
	Mnadani	D300	14.7	
	Chang’ombe	D300	5.3	
	Makole	D250	2.7	
	Ipagala	D300	88.8	
	Dodoma Makulu	D350	56.3	
	Nzuguni	D400	157.7	
	Nkuhungu	D350	111.4	
	Tambukareli	D250	15.9	
	Iyumbu	D300	55.2	
	Sub-total		615.4	
Zone 3 & 4 - Mbabala (N) & Mbabala (S)	Nala	D300	398.0	5,990
	Nkuhungu	D250	64.4	
	Kizota	-	-	
	Zuzu	D300	32.5	
	Mkonze	D300	156.9	

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
	Sub-total		651.8	
Zone 5 - Chinangali	Chamwino Ikulu(for State House Zone)	D300	59.2	2,618
	Chamwino Ikulu(except State House Zone)	D300	9.6	
	Buigiri	D250	139.9	
	Msanga	D300	4.6	
	Chahwa	D250	57.4	
	Sub-total		270,7	
Zone 6 - Hombolo	Nzuguni	D250	-	775
	Chahwa	D250	18.8	
	Sub-total		18.8	
Zone 7 - Mpunguzi	Mkonze	D250	6.0	343
	Matumbulu	D250	15.1	
	Ntyuka	D250	0.9	
	Sub-total		22.0	
Zone 8 - Udom	Iyumbu	-	-	266
	N'gh'ongh'onha	D350	18.8	
	Sub-total		18.8	
Total		D250	532.6	21,112
		D300	837.0	
		D350	216.1	
		D400	344.8	
		Total	1,930.5	

Phased Plan on Reticulation Sewer

- Short-term phase (2020 - 2025)

Reticulation sewers to be implemented in the short-term phase consist of those sewers which will be connected to the existing trunk sewers and new trunk sewers to be installed in Government city and in the Chamwino Ikulu and Buigiri Wards for the State House.

The below table shows a summarized plan on the reticulation sewers to be implemented in the short-term phase.

Table 118. Reticulation Sewers to be Implemented in the Short-term Phase (2020 – 2025)

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 1 - Buigiri	Government City	D400	29.5	548
Zone 2 - Nzuguni	Viwandani	D250	4.0	5,643
	Uhuru	D300	0.7	
	Chamwino	D250	24.6	
	Kiwanja Cha Ndege	D250	8.8	
	Makole	D250	15.5	
	Tambukareli	D250	10.2	

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
	Kilimani	D250	12.8	
	Kikuyu Kasikazani	D250	18.7	
	Mkonze	D250	41.3	
	Kikuyu Kusini	D250	25.5	
	Hazina	D250	22.5	
	Madukani	D250	1.0	
	Majengo	D250	1.1	
	N'gh'ongh'onha	D250	7.3	
	Ntyuka	D300	40.8	
	Ipagala	D250	29.1	
Zone 4 - Chinangali	Chamwino Ikulu (for State House)	D300	59.2	1,781
	Buigiri	D250	139.9	
Total		D250	362.3	7,972
		D300	100.7	
		D400	29.5	
		Total	492.5	

- Medium-term phase (2025 - 2035)

In this phase (2026-2035), we have established a plan on the reticulation sewers which will cover almost all of areas in the City except for eight (8) wards that do not have any DUWASA's water supply plan.

The below table shows a summarized plan on the reticulation sewers to be implemented in the medium-term phase (2026-2035).

Table 119. Reticulation Sewers to be Implemented in the Medium-term Phase (2026 – 2035)

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 1 - Buigiri	Mtumba	D400	103.5	3,032
	Kikombo	D350	21.1	
	N'gh'ongh'onha	-	-	
	Buigiri	-	-	
	Chahwa	D250	80.3	
	Ihumwa	D300	12.2	
	Iyumbu	D250	79.7	
	Nzuguni	D250	6.7	
	Sub-total		303.5	
Zone 2 - Nzuguni	Kizota	D350	8.5	7,540
	Makutupora	D400	25.4	
	Msalato	D400	28.7	
	Miyuji	D250	44.8	

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
	Mnadani	D300	14.7	
	Chang'ombe	D300	5.3	
	Makole	D250	2.7	
	Ipagala	D300	88.8	
	Dodoma Makulu	D350	56.3	
	Nzuguni	D400	157.7	
	Nkuhungu	D350	111.4	
	Tambukareli	D250	15.9	
	Iyumbu	D300	55.2	
	Sub-total		615.4	
Zone 3 Mbabala(N) & Mbabala(S)	Nala	D300	398.0	5,990
	Nkuhungu	D250	64.4	
	Kizota	-	-	
	Zuzu	D300	32.5	
	Mkonze	D300	156.9	
	Sub-total		651.8	
Zone 4 - Chinangali	Chamwino Ikulu(except State House Zone)	D300	9.6	837
	Msanga	D300	4.6	
	Chahwa	D250	57.4	
	Sub-total		71.6	
Zone 5 - Hombolo	Nzuguni	D250	-	775
	Chahwa	D250	18.8	
	Sub-total		18.8	
Zone 6 - Mpunguzi	Mkonze	D250	6.0	343
	Matumbulu	D250	15.1	
	Ntyuka	D250	0.9	
	Sub-total		22.0	
Zone 7 - Udom	Iyumbu	-	-	268
	N'gh'ongh'onha	D350	18.8	
	Sub-total		18.8	
Total		D250	391.8	18,785
		D300	777.8	
		D350	216.1	
		D400	315.3	
		Total	1,701.9	

- Long-term phase (2036 - 2040)

The reticulation sewers for the eight (8) wards mentioned above were planned to be implemented in the long-term phase (2036 - 2040).

The below table shows a summarized plan on the reticulation sewers to be implemented in the long-term phase (2036 – 2040).

Table 120. Reticulation Sewers to be Implemented in the Long-term Phase (2036 – 2040)

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 2 - Nzuguni	Chihanga	D400	31.6	316
Zone 3– Mbabala(N) and Mbabala(S)	Mbalawala	D350	76.6	5,263
	Chigongwe	D250	63.1	
	Mbabala	D350	103.2	
Zone 5 - Hombolo	Hombolo Makulu	D300	104.7	3,108
	Hombolo Bwawani	D350	90.1	
	Chihanga	D300	63.8	
	Ipala	D250	52.2	
Zone 6 - Mpunguzi	Mpunguzi	D350	87.8	878
Total		D250	115.3	9,565
		D300	168.5	
		D350	357.7	
		D400	31.6	
		Total	673.1	

Wards to be Served by Phased Reticulation Sewer Installation

The below table shows the wards to be served by phased reticulation sewer installation.

Table 121. List of Wards to be Served by Phased Reticulation Sewer Installation

S/No.	Name of Ward	Present	Short-term phase (2020 – 2025)	Medium-term phase (2026 – 2035)	Long-term Phase (2036-2040)
1	Viwandani	◎	◎		
2	Uhuru	◎	◎		
3	Chamwino	◎	◎		
4	Kiwanja cha ndege	◎	◎		
5	Makole	◎	◎	◎	
6	Miyuji			◎	
7	Msalato			◎	
8	Makutopora			◎	
9	Chihanga				◎
10	Hombolo Makulu				◎
11	Hombolo Bwawani				◎
12	Ipala				◎
13	Chahwa			◎	
14	Nzuguni			◎	
15	Dodoma Makulu			◎	
16	Mtumba		◎	◎	
17	Ihumwa			◎	
18	Kikombo			◎	
19	Ngh’ongh’ohna		◎	◎	

S/No.	Name of Ward	Present	Short-term phase (2020 – 2025)	Medium-term phase (2026 – 2035)	Long-term Phase (2036-2040)
20	Mpunguzi				◎
21	Matumbulu			◎	
22	Tambukareli	◎	◎	◎	
23	Kilimani	◎	◎		
24	Kikuyu Kasikazini	◎	◎		
25	Kikuyu Kusini		◎		
26	Mkonze		◎	◎	
27	Mbabala				◎
28	Zuzu			◎	
29	Hazina	◎	◎		
30	Madukani	◎	◎		
31	Majengo	◎	◎		
32	Kizota	◎		◎	
33	Nkuhungu			◎	
34	Nala			◎	
35	Mbalawala				◎
36	Ntyuka		◎	◎	
37	Chigongwe				◎
38	Chang’ombe			◎	
39	Iyumbu			◎	
40	Mnadani			◎	
41	Ipagala		◎	◎	
42	Chamwino Ikulu		◎	◎	
43	Msanga			◎	
44	Buigiri		◎	◎	

6.4. A Plan on Wastewater Treatment Plants

6.4.1. Proposed Locations of WWTPs

The consultant proposes eight wastewater treatment plants which will cover the whole city. These wastewater treatments will be located in Nzuguni, Buigiri, Mbabala(1), Mbabala(2), Chinangali, Hombolo, Matumbulu, UDOM wastewater treatment zones (Table 122). These wastewater treatment plants will serve the following areas:

- **Nzuguni wastewater treatment plant**

Nzuguni wastewater treatment will receive wastewater from Chihanga; Makutupora; Msalato; Nzuguni; Miyuji; Mnadani; Nkuhungu; Ipagala; Dodoma Makulu; Iyumbu; Ngh’ongh’onha; Ntyuka; Mkonze; Kizota; Chang’ombe; Hazina; Kikuyu Kaskazini; Kikuyu

Kusini; Kilimani; Tambukareli; Madukani; Uhuru; Majengo; Viwandani; Chamwino; Kiwanja cha ndege and Makole wards.

- **Buigiri wastewater treatment plant**

Buigiri wastewater treatment plant will receive wastewater from the government city, Chahwa, Ihumwa, Iyumbu, Nzuguni, Mtumba, Ngh’ongh’onha, Buigiri ward and Kikombo wards

- **Mbabala(N) wastewater treatment plant**

Mbabala (1) wastewater treatment plant will receive wastewater from Chigongwe, Nkuhungu, Zuzu, Nala, and Mbalawala wards. This will also include wastewater from Industries and institutions proposed to be located in the Nala ward.

- **Mbabala(S) wastewater treatment plant**

Mbabala wastewater treatment plant will receive wastewater from Mkonze, Zuzu, Mbabala, Kizota, Nkuhungu and a small part of Nala wards.

- **Chinangali wastewater treatment plant**

Chinangali wastewater treatment plant will receive wastewater from Msanga, Chamwino Ikulu, Chahwa and Buigiri wards.

- **Hombolo wastewater treatment plant**

Hombolo wastewater treatment plant will receive wastewater from Hombolo Makulu, Hombolo Bwawani, Chihanga, Ipala, Nzuguni and Chahwa wards. Hombolo already has high learning institution; the City Master Plan has proposed some areas for Institutions.

- **Matumbulu wastewater treatment plant**

This wastewater treatment plant will receive wastewater from Matumbulu, Mpunguzi Ntyuka and a small part of Mkonze wards. And, the area is also planned to have industries and sport complex which commands high water use.

- **University of Dodoma (UDOM) wastewater treatment plant**

University of Dodoma wastewater treatment plant receives wastewater generated in different campuses of the institution. The systems will also receive wastewater from Ng’hong’honha and Iyumbu wards.

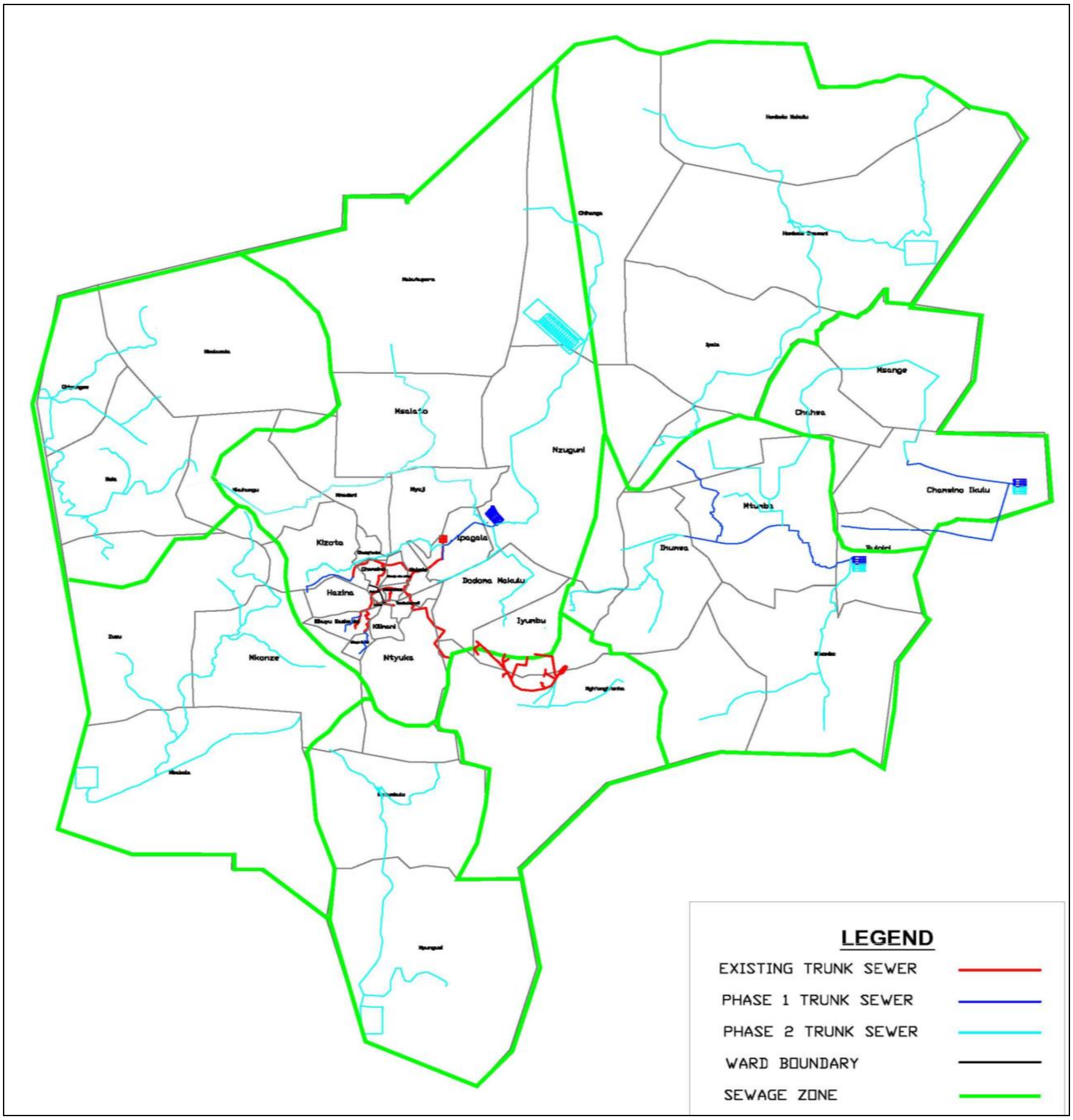

Fig. 128 Modified Wastewater Management Plan

6.4.2. Proposed Capacities of the WWTPs

Based on the results of wastewater flow projection, the capacities of the WWTPs were proposed as follows:

Table 122. Proposed Capacities of WWTPs by Phase

Treatment Zone	Facilities Name	Wastewater Flow (m^3/d)		Capacity (m^3/d)	Type	Phase
		2025	2040			
Zone 1 – Buigiri	Buigiri	9,209	17,822	18,000	New	Short-term
		13,364	23,924	24,000	Expansion	Medium-term
	Sub-total	22,573	41,746	42,000	-	-

Treatment Zone	Facilities Name	Wastewater Flow (m^3/d)		Capacity (m^3/d)	Type	Phase
		2025	2040			
Zone 2 – Nzuguni	Nzuguni	17,523	33,654	34,000	New	Short-term
	Chihanga	56,015	116,672	117,000	New	Medium-term
	Sub-total	73,538	150,326	151,000	-	-
Zone 3 & 4 – Mbabala(N) & Mbabala(S)	Mbabala(N)	7,918	16,470	16,000	New	Medium-term
	Mbabala(S)	7,777	16,248	16,000	New	Medium-term
	Sub-total	15,695	32,718	32,000	-	-
Zone 5 – Chinangali	Chamwino Ikulu	2,587	5,435	6,000	New	Short-term
		2,936	6,278	6,000	Expansion	Medium-term
	Sub-total	5,523	11,713	12,000	-	-
Zone 6 – Hombolo	Hombolo	9,612	19,996	20,000	New	Medium-term
Zone 7 – Mpunguzi	Mpunguzi	5,043	10,421	10,000	New	Medium-term
Zone 8 – Udom	Udom	3,482	6,611	9,000	Existing	-
Total		135,467	273,930	267,000	-	-

6.4.3. Practical Options of Wastewater Treatment Methods

Treatment Process Used in Tanzania

Most common technology used to treat wastewater in Tanzania is the Waste Stabilization Ponds (WSPs). And, it is reported that the Constructed Wetlands for final polishing of the effluent from WSPs before discharged to the environment is being used in Iringa and Moshi.

Selection Criteria

The general criteria for technology selection comprise:

- Average, or typical, efficiency and performance of the technology

This is usually the criterion considered to be best in comparative studies. The possibility that the technology might remove other contaminants than those which were the prime target should also be considered an advantage. Similarly, the pathways and fate of the removed pollutants after treatment should be analysed, especially with regard to the disposal options for the sludges in which the micro-pollutants tend to concentrate.

- Reliability of the technology

The process should, preferably, be stable and resilient against shock loading, i.e. it should be able to continue operation and to produce an acceptable effluent under unusual conditions. Therefore, the system must accommodate the normal inflow variations, as well as infrequent, yet expected, more extreme conditions. This pertains to the wastewater characteristics (e.g. occasional illegal discharges, variations in flow and concentrations, high or low temperatures) as well as to the operational conditions (e.g. power failure, pump failure, poor maintenance). During the design phase, "what if scenarios should be considered. Once disturbed, the process should be fairly easy to repair and to restart.

- Institutional manageability

In developing countries few governmental agencies are adequately equipped for wastewater management. In order to plan, design, construct, operate and maintain treatment plants, appropriate technical and managerial expertise must be present. This could require the availability of a substantial number of engineers with postgraduate education in wastewater engineering, access to a local network of research for scientific support and problem solving, access to good quality laboratories, and experience in management and cost recovery. In addition, all technologies (including those thought "simple") require devoted and experienced operators and technicians who must be generated through extensive education and training.

- Financial sustainability

The lower the financial costs, the more attractive the technology. However, even a low-cost option may not be financially sustainable, because this is determined by the true availability of funds provided by the polluter. In the case of domestic sanitation, the people must be willing and able to cover at least the operation and maintenance cost of the total expenses. The ultimate goal should be full cost recovery although, initially, this may need special financing schemes, such as cross-subsidisation, revolving funds, and phased investment programmes.

- Application in reuse schemes

Resource recovery contributes to environmental as well as to financial sustainability. It can include agricultural irrigation, aqua- and pisciculture, industrial cooling and process water re-use, or low-quality applications such as toilet flushing. The use of generated sludges can only be considered as crop fertilisers or for reclamation if the micro-pollutant concentration is not prohibitive, or the health risks are not acceptable.

Comparison of Applicable Wastewater Treatment Methods

The below table shows the comparison of applicable wastewater treatment methods: Primary Sedimentation Tanks (PST), Up flow Anaerobic Sludge Bed (UASB), Waste

Stabilization Ponds (WSP), Trickling Filters (TF) and Activated Sludge (AS) system. Among them, the WSPs are the most suitable to the WWTPs in Dodoma city because they have comparative advantages in terms of operation and maintenance.

Table 123. Comparison of Applicable Wastewater Treatment Methods

Item	PST	UASB	WSPs			TF	AS
Environmental Conditions	Anaerobic	Anaerobic	Anaerobic	Facultative	Maturation	Aerobic	Aerobic
Suited for raw sewage	++	+	++	++	–	+	++
Suited for settled sewage	–	++	++	++	–	++	++
Wastewater temperature	> 5℃	> 20℃	> 5℃	> 5℃	> 5℃	> 5℃	> 5℃
BOD removal efficiency	30-40%	> 70%	> 50%	> 70%	> 50%	80 – 90%	> 90%
Nutrient (N, P) removal efficiency	–	–	–	–	–	+	+
Coliform Removal	25 – 75%	90%	90%	90 – 99%	> 99%	90 – 95%	90 – 98%
Helminth egg removal	90%	90%	99%	99%	99%	90 – 99%	90 – 99%
Typical HRT	1 – 2h	Approx. 6h	> 1d	> 4d	> 3d	Approx. 6h	Approx. 15h
Odour Nuisance	+	++	+	+	++	++	++
Energy Demand & Gas Production	++	++	++	++	++	+	–
Land Requirement	++	++	+	–	–	+	+
Requiring Skilled Operation	++	–	++	++	++	+	–
Investment Cost	++	++	++	+	+	+	–
Selection			◎				

6.4.4. Description of Waste Stabilization Ponds

Waste Stabilization Ponds (WSP) have proven to be effective alternatives for treating wastewater, and the construction of low energy-consuming ecosystems that use natural processes. WSPs are now well-established methods for wastewater treatment in tropical climates and they have many advantages including: simplicity, low cost, low maintenance, low energy consumption, robustness, and sustainability.

WSPs are large, shallow basins in which raw sewage is treated entirely by natural processes involving both algae and bacteria. They are used for sewage treatment in temperate and tropical climates, and represent one of the most cost-effective, reliable and easily-operated methods for treating domestic and industrial wastewater. Waste stabilization ponds are very effective in the removal of faecal coliform bacteria. Sunlight energy is the only requirement for its operation. Further, it requires minimum supervision for daily operation, by simply cleaning the outlets and inlet works. The temperature and duration of sunlight in tropical countries offer an excellent opportunity for high efficiency and satisfactory performance for this type of water-cleaning system. They are well-suited for low-income tropical countries where conventional wastewater treatment cannot be achieved due to the lack of a reliable energy source. Further, the advantage of these systems, in terms of removal of pathogens, is one of the most important reasons for its use.

WSP systems comprise a single string of anaerobic, facultative and maturation ponds in series, or several such series in parallel. In essence, anaerobic and facultative ponds are designed for removal of Biochemical Oxygen Demand (BOD), and maturation ponds for pathogen removal, although some BOD removal also occurs in maturation ponds and some pathogen removal in anaerobic and facultative ponds. In most cases, only anaerobic and facultative ponds will be needed for BOD removal when the effluent is to be used for restricted crop irrigation and fish pond fertilization, as well as when weak sewage is to be treated prior to its discharge to surface waters. Maturation ponds are only required when the effluent is to be used for unrestricted irrigation, thereby having to comply with the WHO guideline of >1000 faecal coliform bacteria/100 ml. The WSP does not require mechanical mixing, needing only /sunlight to supply most of its oxygenation. Its performance may be measured in terms of its removal of BOD and faecal coliform bacteria.

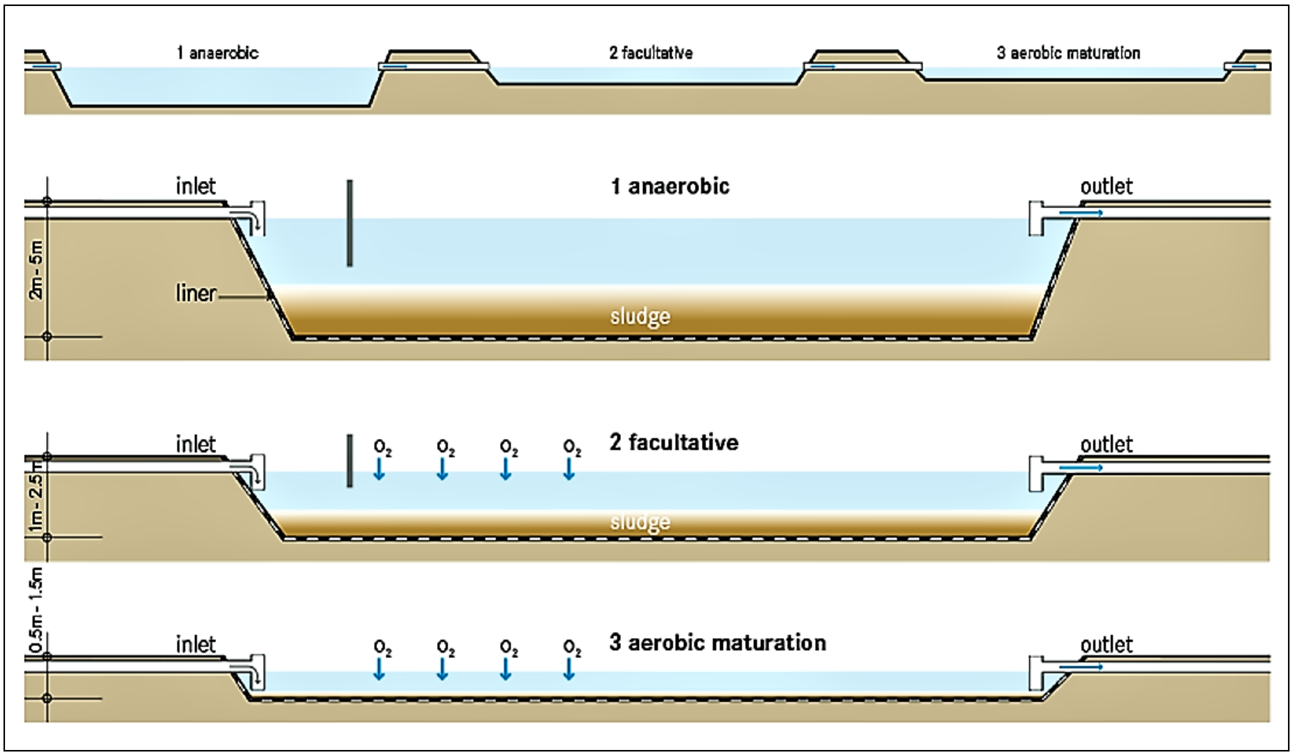

Fig. 129 Typical Scheme of a Waste Stabilization Ponds System

Table 124. Typical Features of WSPs

Typical Feature	Anaerobic Pond	Facultative Pond	Maturation Pond
Objective	TSS Removal	BOD Removal	Nutrient and Pathogen Removal
Loading Rate	0.1 ~ 0.3 kg BOD/m3·d	100 ~ 350 kg BOD/ha·d	At least two ponds in series, each 5 days retention
Typical Depth	2 ~ 5 m	1 ~ 2 m	1 ~ 1.5 m
Treatment Efficiency	TSS: 50 ~ 70%	TSS: increase	TSS: 20 ~ 30%
	BOD: 30 ~ 60%	BOD: 50 ~ 70%	BOD: 20 ~ 50%
	Coliforms: 1 order of magnitude	Coliforms: 1~2 orders of magnitude	Coliforms: 3~4 orders of magnitude
Problems	Odour Release	Algal & TSS increase	Area Requirement

6.4.5. Design of Waste Stabilization Ponds

Design Parameter

There are four important design parameters for WSPs, including temperature, net evaporation, flow and BOD. The climate also is important inasmuch as the processes responsible for BOD_5 and fecal bacterial removal are temperature-dependent. Further, algal photosynthesis depends on solar insulation, itself a function of latitude and cloud cover. Cloud cover periods are seldom a problem because the solar insulation during the day in tropical and sub-tropical regions generally greatly exceeds the saturation light intensity of the algae in the ponds. The design temperature usually is the mean air temperature in the coolest month (or quarter). The pond water is usually 2 to 3℃ warmer than the air temperature in the cool season, with the reverse also being true. Considering the mean low air temperature (13.6℃) in July, the consultant applies 17℃ to the design temperature.

Because the bacteria responsible for treatment are mesophilic, high temperatures are not a problem. However, low temperatures can be since they slow down the treatment process. In the case of the methanogenic bacteria (crucial to anaerobic digestion), methane production virtually ceases below temperatures of 15℃. Thus, in areas where the pond temperature remains below 15℃ for more than a couple of months of the year, careful consideration should be given to deciding whether or not anaerobic units are needed. Net evaporation (evaporation minus rainfall) must be taken into account during the design of facultative and maturation ponds, but not for anaerobic ponds. Anaerobic ponds generally have a scum layer, which effectively prevents significant evaporation.

The ultimate standard of effluent to be achieved will vary depending on whether or not the effluent is used for irrigation or dilution of the receiving waters. The required standards are summarized in the table below:

Table 125. Standard for Effluent from Sewage Treatment Works

Discharge	BOD (mg/l)	TSS (mg/l)	Fecal Coliform/100 ml
To Rivers	25	50	5,000
Unrestricted Irrigation (WHO)	25	50	1,000

The requirement for the above effluent standard is dictated by several factors:

- at times of low river flow dilution of the final effluent may be low. Ideally it should not be less than 8:1, and where it is more stringent standards may be required.
- river levels are lowest in the dry season when the demand for irrigation water may be highest.
- in some of the rivers there is access to the water for laundry and cleaning purposes.
- for rivers which may be dry for parts of the year special consideration is always required.

Design of Inlet Works

- Coarse Screens

The manually cleaned screens are designed for a flow velocity ranged from 0.3 to 0.45m/s. They consist of wedge bars (5mm width) fixed at 20mm interval across the channel and inclined at an angle of 60° to the horizontal. It is proposed that the screens will be raked out manually to a concrete channel at the top end, along which they will then be pushed to a trailer stationed on the pavement for onward disposal.

- Grit Chamber

Grit removal will be necessary in order to prevent accumulation of grit in the wastewater stabilization ponds. Grit chambers have long narrow channels that are designed to slow down the flow so that solids such as sand, grits and eggshells will settle out of the water. Two (2) grit collection channels are proposed and designed to attain the required average velocity of 0.3m/s.

- Flow Metering Device (Parshall Plume)

The parshall plume which is followed by anaerobic ponds is used to measure volumetric flow rate of influent in WSPs. The Parshall flume accelerates flow through a contraction of both the parallel sidewalls and a drop in the floor at the flume throat. Under free-flow conditions the depth of water at specified location upstream of the flume throat can be converted to a rate of flow. An appropriate size of parshall plume will be chosen among 22 standard sizes of them which have been developed, covering flow ranges from 0.1416 to 92,890 l/s.

Design of Anaerobic Ponds

The anaerobic ponds are designed on the basis of volumetric loading (λ_v, g/m^3/d), which is given by:

$$\lambda_v = L_i Q/V_a \quad \text{(3.1)}$$

Where,

L_i = *influent BOD (mg/l);*

Q = *flow rate (m^3/day), and;*

V_a = *anaerobic pond volume (m^3).*

The volumetric loading should be 100 to 400 g/m^3/day, in order to maintain anaerobic conditions. Once the organic loading is selected, the volume of the pond is then determined with the use of the above equation. The hydraulic retention time is then calculated, using the below equation as follows:

$$t_{an} = V_a/Q \quad \text{(3.2)}$$

A retention time less than one day should not be used for anaerobic ponds; if it occurs, however, a retention time of one day should be used, and the volume of the pond should be recalculated. The Table 126 illustrates the permissible loadings to the anaerobic ponds.

Table 126. Design Value of Permissible Volumetric BOD loadings on, and Percentage BOD removal in, Anaerobic Ponds at Various Temperatures

Temperature (℃)	Volumetric Loading (g/m^3/day)	BOD removal (%)
< 10	100	40
10 – 20	20T – 100	2T + 20
20 – 25	10T + 100	2T + 20
> 25	350	70

Design of Facultative Ponds (Kinetic Models)

The rate at which the organic matter is oxidized by bacteria is a fundamental parameter in the rational design of biological wastewater treatment systems. It has been found that BOD removal often approximates first-order kinetics; that is, the rate of BOD removal (rate of oxidation of organic matter) at any time is proportional to the quantity of BOD (organic matter) present in the system at that time. This is expressed mathematically in the below equation as:

$$dL/dt = -k_1 L \quad \text{(3.3)}$$

Where,

L = quantity of BOD remaining (= organic matter to be oxidized) at time "t", and;

k_1 = first-order rate constant for BOD removal (day-1).

The simple approach to the rational design of facultative ponds assumes they are completely mixed reactors in which BOD_5 removal follows first-order kinetics. The rational equation for the design is illustrated in the below equation:

$$L_e / L_i = 1/(1+k_1 t) \quad \text{(3.4)}$$

Rearranging the equation as follows:

$$t = (L_i / L_e - 1)(1/k_1) \quad \text{(3.5)}$$

Where, t = the retention time (days).

The mid-depth area of the pond is calculated using the below equation:

$$A = Q \cdot t / D \quad \text{(3.6)}$$

Where,

Q = the volumetric flow rate (m^3/day);

D = the pond depth (m), and;

A = the mid-depth area (m^2);

t = the retention time (days) (from the above equation).

Rearranging the equation, the mid-depth area of the pond will be:

$$A = (Q/Dk_1)(L_i / L_e - 1) \quad \text{(3.7)}$$

The value for k_1 at 20°C was found to be 0.3 day^{-1}, while the value of k_T is calculated using the below equation. Note that the rate (k_1) is a gross measure of bacterial activity and, consistent with almost all parameters that describe a biological growth process, its value is strongly temperature-dependent. Its variation with temperature is usually described by an Arrhenius equation as follows:

$$k_T = k_{20}\,\theta^{(T-20)} \quad \cdots\cdots (3.8)$$

Where, θ *= the Arrhenius constant (typical value : 1.05 to 1.09 for WSPs)*

Design of Facultative Ponds (Empirical Models)

Although several methods are available for designing facultative ponds, Mara (1976) recommended that facultative ponds should be designed on the basis of surface loading (λ_s, kg/ha/day), which is given by:

$$\lambda_s = 10L_i\,Q/A_f \quad \cdots\cdots (3.9)$$

Where,

L_i *= the concentration of influent sewage (mg/l), and;*

A_f *= the facultative pond area* (m^2).

The selection of the permissible design value of λ_s is usually based on the temperature. The temperature dependence indicates that the design values of λ_s increases with temperature. The earliest relationship between λ_s and temperature was given by Mara (1976). The Mara (1976) equation is as shown in the below equation:

$$\lambda_s = 20T - 120 \quad \cdots\cdots (3.10)$$

However, an appropriate λs and temperature relationship is presented by Mara (1987) as:

$$\lambda_s = 350[1.107 - 0.002T]^{(T-20)} \quad \cdots\cdots (3.11)$$

Once the surface loading has been selected, the area of the facultative pond can be calculated from equation 3.9, and its retention time (θ_f, day) is calculated from the below equation:

$$\theta_f = A_f D/Q_m \quad \cdots\cdots (3.12)$$

Where,

D = the pond depth (usually 1.5m), and;

Q_m *= the mean flow* (m^3/day).

The mean flow is the mean of the influent and effluent flows (Q_i and Q_e), the latter being the former less net evaporation and seepage. Thus equation 3.12 becomes:

$$\theta_f = \frac{A_f D}{\left[\frac{1}{2}(Q_i + Q_e)\right]} \quad \text{......} (3.13)$$

If seepage is negligible, Q_e is given by:

$$Q_e = Q_i - 0.001 A_f e \quad \text{......} (3.14)$$

Where,

e = net evaporation rate (mm/day).

Thus, Equation 3.13 becomes:

$$\theta_f = \frac{2A_f D}{[2Q_i - 0.001 A_f e]} \quad \text{......} (3.15)$$

A minimum retention time value of 5 days should be adopted for temperatures below 20℃, and 4 days for temperature above 20℃. This is to minimize hydraulic short-circuiting, and to give algae sufficient time to multiply (i.e., to prevent algal washout).

Design of Maturation Ponds for Fecal Coliform Removal

The method of Marais (1974) is generally used to design a pond series for fecal coliform removal. This assumes that faecal coliform removal can be reasonably well represented by a first-order kinetic model in a completely-mixed reactor. The resulting equation for a single pond is given by:

$$N_e = \frac{N_i}{(1 + k_T \theta)} \quad \text{......} (3.16)$$

Where,

N_e = the number of faecal coliform/100 ml in the effluent;

N_i = the number of faecal coliform/100 ml in the influent;

k_T = the first-order rate constant for faecal coliform removal (d^{-1}), and;

θ = retention time (day).

For a series of anaerobic, facultative and maturation ponds, the above equation becomes:

$$N_e = \frac{N_i}{[(1 + k_T \theta_a)(1 + k_T \theta_f)(1 + k_T \theta_M)^n]} \quad \text{......} (3.17)$$

Where,

The sub-scripts, a, f and m, refer to the anaerobic, facultative and maturation ponds, and;

n = the number of maturation ponds.

The above equation assumes that all the maturation ponds are equally-sized, which is the most efficient configuration (Marais, 1974), but which may not be topographically possible (in which case, the last term of the denominator in the equation is replaced by: $[(1+k_T\theta_{m1})(1+k_T\theta_{m2}) \ldots\ldots.(1+k_T\theta_{mn})]$).

However, the above equation shows that it contains two unknowns (θ_m and n), since by this stage of the design process, θ_a and θ_f will have been calculated, N_i measured or estimated, N_e set (e.g., 1000/100 ml for unrestricted irrigation), and k_T calculated from the below equation.

$$k_T = 2.6(1.19)^{T-20} \quad \text{(3.18)}$$

The best approach to solving the equation is to calculate the values of θ_m corresponding to n = 1, 2, 3, etc., and then adopt the following rules to select the most appropriate combination of θ_m and n, namely: $\theta_m^{min} < \theta_m < \theta_f$

Where θ_m^{min} is the minimum acceptable retention time in a maturation pond. This term is introduced to minimize hydraulic short-circuiting and prevent algal washout. Marais (1974) recommends a value of 3 days, although at temperatures below 20°C, values of 4 to 5 days are preferable. The remaining pairs of θ_m and n, together with the pair θ_m^{min} and ñ, where ñ is the first value of n for which θ_m is less than θ_m^{min}, are then compared, and the one with the least product selected, since this will identify the least land area requirements. The BOD loading on the first maturation pond must be checked, and must not be higher than that on the preceding facultative pond; in fact, it is preferable that it be significantly lower. The maximum BOD loading in the first maturation pond should be 75% of that on the preceding facultative pond. It is not necessary to check the BOD loadings on subsequent maturation ponds, as the non-algal BOD contribution to the load on them is very low.

The loading on the first maturation pond is calculated on the assumption that 70% of unfiltered BOD has been removed in the preceding anaerobic and facultative ponds (or 80% for temperatures above 20°C). Mara and Pearson, (1987) also suggested that 90% cumulative removal in anaerobic and facultative ponds, and then 25% in each maturation pond, for temperatures above 25°C (80% and 20%, respectively, for temperatures below 20°C), when the BOD is based on filtered BOD values. Thus:

$$\lambda_{s(m1)} = \frac{10(0.3L_i)Q}{A_{m1}} \quad \text{(3.19)}$$

Or, since $Q\theta_{m1} = A_{m1}D$:

$$\lambda_{s(m1)} = 10(0.3L_i)D/\theta_{m1} \quad (3.20)$$

The maturation pond area is calculated from a rearrangement of Equation 3.15, as follows:

$$A_m = 2Q_i\theta_m/(2D+0.001e\theta_m) \quad (3.21)$$

Ponds Embankments

- Fill Material and Lining

In order to prevent leakage of sewage from the ponds, black clayey soil, which is largely found at the proposed site, is recommended as fill material to the pond's embankment and bases. To achieve an effective construction to produce maximum impermeability with coefficients of the order of $1x10^{-5}$ cm/s, it is recommended that all fill layers of the embankments including the 150mm layer at the bottom of the ponds be compacted to at least 95% MDD (Standard proctor compaction T99) at optimum moisture content. And, 500g polythene sheets will be applied on it.

- Sides Slopes

A slope of 1 in 1 has been adopted for both the internal and external sides of the pond's embankments. This is considered sufficient for the soil conditions expected.

- Sides Protection

A 100mm thick concrete slab is recommended along the embankment slopes in order to prevent erosion of the embankments by waves, reduce growth of vegetation down the slopes and thus prevent breeding of mosquitoes. The slab will comprise Class 25 concrete reinforced with Mesh A142. Additionally, the top of the embankment will be grassed.

6.4.6. Design Results of the Proposed WSPs

The below table shows the design results about required areas and amount of sludge to be generated from the proposed WSPs and the calculation processes of them are specified in the Annex. 05.

Table 127. Design Results of the Proposed WSPs

Treatment Zone	Facilities Name	Capacity (m^3/d)	Dimension of Ponds (mL×mW×mHe×No. of Ponds)			Sludge Drying Beds (m^2)	Required Area(ha)
			Anaerobic	Facultative	Maturation		
Zone 1 – Buigiri	Buigiri	18,000	75×50×3.5×2	220×200×2×2	250×210×1×2	12,130	35

Treatment Zone	Facilities Name	Capacity (m^3/d)	Dimension of Ponds (mL×mW×mHe×No. of Ponds)			Sludge Drying Beds (m^2)	Required Area(ha)
			Anaerobic	Facultative	Maturation		
		24,000	80×65×3.5×2	250×235×2×2	280×250×1×2	16,170	46
Zone 2 – Nzuguni	Nzuguni	34,000	100×70×3.5×2	300×275×2×2	330×300×1×2	22,900	61
	Chihanga	117,000	170×145×3.5×2	550×515×2×2	600×570×1×2	78,800	155
Zone 3 – Mbabala	Mbabala(N)	16,000	70×50×3.5×2	210×185×2×2	230×205×1×2	10,780	33
	Mbabala(S)	16,000	70×50×3.5×2	210×185×2×2	230×205×1×2	10,780	33
Zone 4 – Chinangali	Chamwino Ikulu	6,000	40×32×3.5×2	130×115×2×2	140×125×1×2	4,040	16
		6,000	40×32×3.5×2	130×115×2×2	140×125×1×2	4,040	16
Zone 5 – Hombolo	Hombolo	20,000	70×60×3.5×2	230×215×2×2	260×225×1×2	13,480	40
Zone 6 – Mpunguzi	Mpunguzi	10,000	50×45×3.5×2	170×145×2×2	180×165×1×2	6,740	23

6.4.7. Sludge Drying Beds

The sludge drying bed has dimensions of 6 m width and 30 m length, with 30cm gravel layer and 10cm sand layer depth. The sand should have an effective size of 0.2 to 0.6 mm. The sludge is placed on the bed in 40 cm layers and allowed to dry. Sludge cake removal is manual by shoveling into wheel-barrows, trucks or scraper, etc. The drying period is 10-15 days, and the moisture content of the cake is about 70%. Sludge loading rate is 0.7 kg dry solids/m^2/day for uncovered beds.

6.4.8. Auxiliary Works

- **Roadworks**

Internal roads adopted for various sections of the proposed Sewage Treatment Works have been designed as per the Design Criteria. In addition, service roads are recommended on the ponds' embankments to allow easy access for desludging and other maintenance vehicles. The service roads are to be minimum 5.0m wide and to comprise 150mm thick compacted murram falling at a camber or cross-fall of 4% towards the ponds in each case. The California Bearing Ratios (CBR’s) of the borrow pit material are of sufficient magnitude to allow for this traffic.

- **Office Building**

A site office building is proposed and it will include four Office, Night-duty Room, Laboratory, Bathroom, Toilet and Workshop/Garage.

Site Works

Other site works proposed at the new Sewage Treatment Works include stormwater cut-off drains, fencing and gates. The fencing is proposed to comprise strained barbed wire on pre-cast concrete posts and struts at regular intervals. It is considered that this type of fence will be effective in controlling the ingress of unauthorized people and animals into the pond area. The proposed two (2) main gates are to be fabricated from suitable RHS steel sections and to be firmly held to reinforced concrete foundation bases and beams.

6.5. Operation and Maintenance of WSPs

6.5.1. Overview

The proper O&M approach will enhance the quality of the services and extend the useful lives of the facilities. It will also overcome most common problems and the unnecessary inconvenience of the users and negative impact on the environment.

The details provided in this Section should be considered as a preliminary and broad indication of the operational and maintenance requirements. An operation manual for the WSPs will be prepared as part of the construction and commissioning process. The manual will incorporate specific data from the selection of mechanical and electrical equipment during the design and construction of the upgrade.

6.5.2. Routine O&M Activities

Potential problems with the operation of the waste stabilization ponds may be mitigated by regular operation and maintenance. Regular O&M activities may include the following:

- Removal of screenings and grit from the pretreatment units. Check particularly after storm events.
- Check the performance of all mechanical and electrical equipment at least once a week.
- Removal of any material blocking the pond inlets and outlets
- Periodically cutting the grass on the pond embankments
- Removal of scum and floating matter from the surface of the facultative pond. This is done to maximize the light reaching the pond algae, increase surface re-aeration, and to prevent fly and mosquito breeding
- Repair of any damage to the embankments caused by rodents or other burrowing animals

- Repair of any damage to fences and gates
- Routine monitoring requirements for the facultative ponds should include pond dissolved oxygen, chlorophyll-a, pond color, odour, etc.

The routine O&M should be carried out continuously according to rational pre-established schedules and reviewed with the use of a check sheet.

6.5.3. Major Periodical O&M Activities

The major periodical maintenance activity is the systematic desludging of the ponds. It should be carried out regularly but definitely not later than when the ponds are around one-third full of sludge, say at an estimated 4 to 6 years intervals. With two anaerobic ponds, it is recommended that each pond should be desludged every 2 to 3 years. Take the pond off-line by inserting a stop board at the inlet works grit channel. Pond sludge should be air dried over the dry season until the sludge reaches approx. 50% DS which will be a cake consistency. At this point it can be excavated and transported to the sludge drying bed. At this point it can be excavated and transported to the sludge disposal area. However, in this context, it is noted that it could be more economical and practical to operate a pontoon mounted floating slurry pump to make the desludging process more or less a continuous operation. And, a layer of sludge, approx. 150 mm, should be left in the pond in order to seed the pond when it is refilled

And, the quality of the final effluent should be monitored for compliance with environmental regulations at regular intervals. Representative samples should be taken at 2 to 4 weekly intervals. They need to be analyzed for those parameters for which the effluent standards have been set, i.e. flow rate, BOD, suspended solids and fecal coliforms, etc.

6.6. A Plan on Fecal Sludge Treatment and Reuse

6.6.1. Fecal Sludge Treatment

Fecal Sludge collected by sewerage system and vacuum tankers from onsite sanitation systems will be discharged into the WSPs finally. The fecal sludge has normally high-strength load and variable characteristics which may cause failure of wastewater treatment mechanism in the treatment facility. But we can expect that the fecal sludge collected from onsite sanitation system would be pretreated in the anaerobic condition of septic tanks and that delivered by sewerage system would be diluted by greywater, which can reduce the load of typical fresh fecal sludge. And the actual characteristics of fecal sludge identified by DUWASA are as shown in the below table.

Table 128. Average Characteristics of Fecal Sludge Dischaged to WSPs

BOD (mg/l)	COD (mg/l)	Fecal Coliform (per 100ml)	Nitrate (mg/l)	Phosphorus (mg/l)	Total Suspended Solids(mg/l)
346	616	$1x10^8$	157	34	280

Based on the characteristics above, the proposed WSPs was designed to be able to treat the fecal sludge by them.

6.6.2. Sludge Reuse

Sludge drying beds in the site of WSPs, if suitably designed and operated, can produce a solids product, which may be used either as soil conditioner or fertiliser in agriculture after composting. The composted sludge can be applied on land including in farm lands and silviculture uses such as application to parks, golf courses and public lands, etc.

And, the fully dried sludge can also be used for the production of biogas, charcoal, biodiesel, powdered industrial fuel and electricity by being combusted with solid waste. The remaining ashes will be disposed in the sanitary landfill.

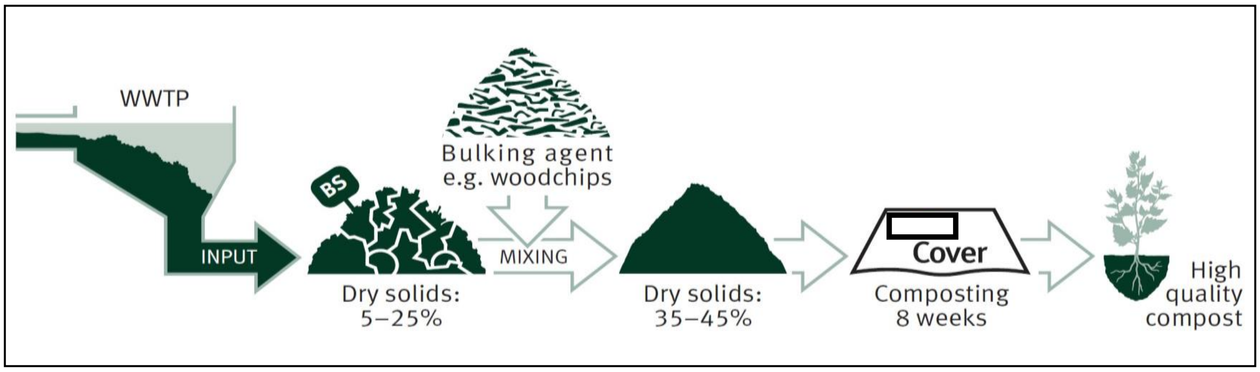

Fig. 130 Composting of Wastewater Treatment Sludge

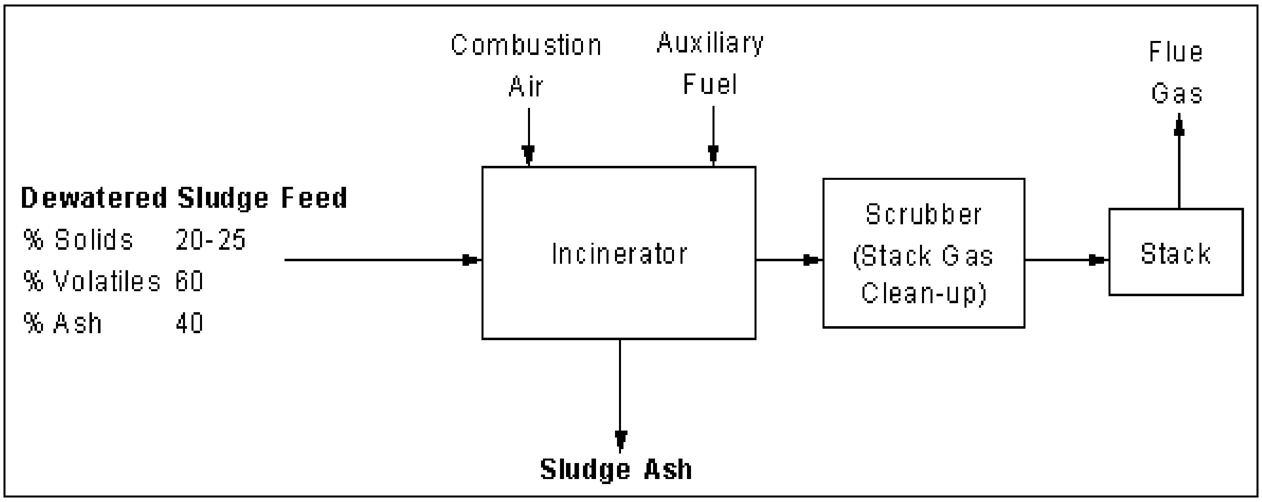

Fig. 131 Combusting of Wastewater Treatment Sludge

6.7. A Plan on Reuse of Treated Wastewater

Wastewater reuse is considered as one of the potential alternatives to various purposes such as cooling, gardening, recreational, irrigation and impoundment, etc. The choice as to what application should water be reused depends on many factors such as quality of treated wastewater, the water availability, human perceptions, existing laws and regulations.

Water reuse for irrigation is now receiving much attention as it can improve food production. Tanzania is among the countries that face drought conditions and the rain fed agriculture has become non-dependable due to unpredicted rainfall patterns, hence considering water reuse options for irrigation purposes is inevitable. If treated effluent from wastewater is used for irrigation purposes it can supply nutrients that can be recycled to soil at the same time protecting the environment from nutrient loading hence avoid eutrophication.

However, its use for agricultural purposes is faced with several challenges. Lack of legislation on reuse and lack of a properly defined institutional framework that would govern water reuse for irrigation purposes is another challenge. Despite the presence of international guidelines such as the World Health Organisation (WHO) guideline on reuse for agriculture that would simply provide the basis for development of national guidelines, Tanzania does not have their own guidelines yet. The required standards for unrestricted irrigation which is mentioned by WHO are summarized in the table below.

Table 129. Standards of Reused Wastewater for Unrestricted Irrigation (WHO)

Item	BOD (mg/l)	TSS (mg/l)	E.Coli/100 ml
Unrestricted Irrigation (WHO)	25	50	1,000

Furthermore, other guidelines that can be borrowed are Environmental Protection Agency guideline on water reuse and Australian Environmental guideline on use of effluent by irrigation.

The local policies and legislations speak in a nutshell about the water reuse or wastewater treatment and reuse issue and some policy statements are fragmented in some national policies and acts as indicated in the below table. Most of the statements provide statements in favour of irrigation but do not expose the issue of water reuse comprehensively. This raises a need for development of a water reuse policy.

Table 130. Policies and Laws Supporting Water Reuse Considerations in Tanzania

S/N	Policy or legislation	Statement Supporting Water Reuse or Irrigation
1	Agricultural and Livestock Policy, 1997	• Irrigation systems should be developed as a strategy for Agricultural

S/N	Policy or legislation	Statement Supporting Water Reuse or Irrigation
		development.
2	National Water Policy, 2002	• Promotes irrigated agriculture to protects against drought and ensures food security. • Promotes wastewater recycling and desalination of seawater a means of increasing the availability of water resources. • Urban Water Supply and Sewerage entities shall cooperate with industries and other institutions in the research and development of least cost technologies for wastewater treatment and recycling.
3	National Environmental POLICY, 1997	• Sets an objective of promotion of the use of the environmentally sound technologies that protect the environments. • Sets another objective to promote technology for efficient water use particularly for water and wastewater treatment and recycling.
4	Irrigation Policy, 2009	• Recognises the fact that dependency on rain-fed agriculture has led to low production and productivity, reliance of the country on irrigated agriculture is inevitable.
5	The water Utilization (Control and Regulation) Act, Cap-331	• Puts a fine to anyone who pollutes the water in any river stream or water course or in any body of surface water to such extent to be likely to injure directly or indirectly to public health.
6	Environmental Management Act. 2004	• Gives mandate to the local government to ensure that sewage is properly treated before discharged to the water body or open land and in ensuring that there is compliance of the treatment works.

The other challenge is the negative perception and poor acceptability of water reuse by the community members that can lead to difficulty in its implementation. This is because the public will not accept to consume the crops irrigated using treated effluent. Therefore, it is very essential to address this challenge before embarking on full implementation of water reuse project. Research on perception and acceptability of water reuse products need to be done for each community and develop some strategies for raising awareness on the benefits of water reuse.

The challenges include the health risks when used for irrigating crops as most of the conventional treatment technologies do not completely remove the pathogens and chemical constituents such as heavy metals present in wastewater. Presence of pathogens can cause some serious health effects to the people who come into contact or use the crops irrigated with such water. Normally the conventional wastewater treatment technologies are usually meant to primarily protect public health and prevent environmental pollution but when considering reuse, treatment will in addition consider provision of suitable effluent for irrigation. Research on how the available treatment options can be modifies or integrated to meet the irrigation requirements is important to be undertaken. The advanced oxidation processes, activated sludge, extended aeration process, constructed wetlands are some of the technologies that have already been investigated. In case of Tanzania, the most widely used conventional wastewater treatment is the WSP. However, currently there are some ongoing researches integrating this technology with constructed wetland. The constructed wetland systems enable further polishing of the effluent for wastewater reuse. The advantages include the fact that it can be easily constructed, operated and maintained and that can be able to handle variable wastewater loadings. But also, that it has proven to remove a number of pollutants including pathogens especially the fecal coli form, BOD, nitrogen and phosphorus.

III. Financial Analysis

1. Capital Expenditure (CAPEX)

The Government of the United Republic of Tanzania through credit from the International Development Association (IDA) is conducting a study and design on storm water drainage system and preparation of Drainage & Sanitation Development Plan (DSDP) for Dodoma City for a period of 2020-2040. One of the key issues is Identification of Capital Expenditure (CAPEX) that will facilitate towards planning and design stages.

Generally, CAPEX is the capital invested or planned to be invested in constructing or purchasing of fixed assets. Normally they include essential ancillary equipment, vehicles or even office buildings that support the operation of drainage and sanitation systems. CAPEX does not only cover hardware but includes the costs of one-off work with stakeholders prior to construction or implementation, extension, enhancement and augmentation (including costs of one-off capacity building). Therefore, total CAPEX for the masterplan is estimated at **TZS 3,679,892,451,115** as elaborated in Table 131**.**

Table 131. Summary of CAPEX

<table>
<tr><th></th><th>Item</th><th>Short term period</th><th>Medium term period</th><th>Long term period</th><th colspan="2">Total</th></tr>
<tr><td rowspan="4">Sanitation Development Sector</td><td>Trunk sewer</td><td>89,363,498,637</td><td>302,350,499,585</td><td>-</td><td rowspan="4">2,840,361,683,121</td><td rowspan="9">3,679,892,451,115</td></tr>
<tr><td>Reticulation sewer</td><td>292,294,494,200</td><td>1,079,385,365,795</td><td>412,631,410,973</td></tr>
<tr><td>Treatment plant</td><td>181,731,977,522</td><td>482,604,436,409</td><td>-</td></tr>
<tr><td>Sub total</td><td>563,389,970,359</td><td>1,864,340,301,789</td><td>412,631,410,973</td></tr>
<tr><td rowspan="5">Storm Water Drainage Development Sector</td><td>Storm water</td><td>81,563,089,495</td><td>611,014,457,538</td><td>-</td><td rowspan="5">839,530,767,994</td></tr>
<tr><td>Ponds</td><td>61,913,465,993</td><td>80,034,670,218</td><td></td></tr>
<tr><td>Bridge</td><td>-</td><td>-</td><td>1,766,500,500</td></tr>
<tr><td>Foot Bridge</td><td>2,355,334,000</td><td></td><td>883,250,250</td></tr>
<tr><td>Sub total</td><td>145,831,889,488</td><td>691,049,127,756</td><td>2,649,750,750</td></tr>
</table>

2. Operation Expenditure (OPEX)

Operational Expenditure (OPEX) are the funds a company spends on ongoing day-to-day basis in order to run a business or system. It includes employee wages, inventory handling costs, and expenditures for office supplies that are operating expenses. Depending upon the industry, these expenses can range from the ink used to print documents to the wages paid to employees.

Various literature points out that OPEX runs between 5% and 20% of capital investments but for experienced organization's OPEX can be calculated from their reports. According to available data, the ratio between CAPEX and OPEX of the proposed investments for storm water and drainage masterplan is less than 5%. This implies OPEX also includes minor maintenance routines needed to keep systems running at design performance, but does not include major repairs or renewals which are recognized as not recurrent. Sometimes the distinction between these categories is less than clear. Operating expenses include such things as payroll, sales commissions, employee benefits and pension contributions, transportation and travel, amortization and depreciation, rent, repairs, and taxes. These expenses are usually subdivided into selling expenses, administrative and general expenses

The estimated OPEX amounts to a total of TZS 37,396,160,476 in long term and when arranged to short, medium and long term is TZS 31,024,914,210; 32,803,649,540; and TZS 37,396,160,476 respectively as shown in the Table 132.

Table 132. Summary of OPEX

ITEM	SHORT TERM	MEDIUM TERM	LONG TERM
Direct Production Cost	2,129,985,730	2,321,684,500	2,646,720,330
Employment Benefits	20,967,619,090	21,761,927,800	24,808,597,692
Administration Expenses	3,254,457,430	3,579,900,560	4,081,086,638
Other Expenses	4,672,851,960	5,140,136,680	5,859,755,815
TOTAL	**31,024,914,210**	**32,803,649,540**	**37,396,160,476**

2.1. Sustainability Considerations

The authority charged with the overall responsibility of operations and management of water supply and sanitation services in Dodoma Urban is DUWASA. Analysis of financial statements of DUWASA for the past ten years (Table 133), show that the total revenues of the authority to be **87,154,418,000** and total operation expenditure to be **62,761,783,000.**

Table 133. DUWASA Financial Performance

Year	Purchase of property, plant and equipment	Depreciation	CAPEX	OPEX	Revenue
2008/09	1,739,635,000	602,330,000	2,341,965,000	4,476,609,000	3,845,949,000
2009/10	18,856,901,000	729,596,000	19,586,497,000	5,094,008,000	3,921,976,000
2010/11	2,536,400,000	829,721,000	3,366,121,000	5,692,702,000	4,974,093,000
2011/12	5,350,558,000	892,062,000	6,242,620,000	6,330,776,000	5,892,363,000
2012/13	588,975,000	796,628,000	1,385,603,000	6,924,281,000	7,294,193,000
2013/14	228,634,000	830,539,000	1,059,173,000	5,052,121,000	8,119,564,000
2014/15	55,992,000	762,966,000	818,958,000	7,889,744,000	9,414,622,000
2015/16	77,832,000	105,975,000	183,807,000	6,352,738,000	12,411,010,000
2016/17	143,215,000	311,990,000	455,205,000	7,405,923,000	15,583,327,000
2017/18	318,288,000	1,014,634,000	1,332,922,000	7,542,881,000	15,697,321,000
Total	**29,896,430,000**	**6,876,441,000**	**23,019,989,000**	**62,761,783,000**	**87,154,418,000**

The financial performance shows that the authority can sustainably run operations even in the new expanded sanitation facilities expected to have expanded revenue collection as a result of increased customer base, currently the sewerage system is serving only **20%** of the population of Dodoma urban due to lack of adequate lateral sewers.

3. Financing Sources

Water and sanitation are generally considered to be the part of public infrastructure posing the greatest financing challenge in developing countries. Water and sanitation services are on the boundary between economic infrastructure (e.g. transport, electricity, telecommunications) and purely social infrastructure (e.g. health and education). In economic infrastructure there is either a high degree of user charging (e.g. power, public transport, ports, and telecommunications) or substantial public budgetary provision (roads). In social infrastructure there is normally exclusive or heavy reliance on public finance.

Water and Sanitation falls between these cases; politicians and water users alike are ambivalent about how far this service should be treated as a basic right, whether it should be provided free or with a subsidy, or whether it is a commercial service to be charged for. The result is often an uneasy compromise where water and sanitation services are priced below economic levels and the sector is chronically under financed. Due to the nature of the services it hereby proposed to have the following methods for financing the sewerage and storm water management masterplan for Dodoma city:

3.1. Transfers (Aid, Donations, Subsidies)

Transfers are funding provided by external aid agencies. Considering experience obtained during implementation of Water Sector Development Program (WSDP), external aid commitments for water and sanitation in the country has brought about commendable results. With that spirit, it is possible to continue accessing financing for sewerage and storm water infrastructure implementation through this arrangement.

3.2. Central Government Budget

Water and sanitation revenues normally accrue in local currency that entails a devaluation risk where debt for the borrower is enamored. It clear that providing water and sanitation infrastructure in the twenty-first century poses enormous challenges for most nations of the developing world. Financing water and sanitation projects from central government due to inability of the local government and some government authorities for this kind of project is inescapable since all the most prosperous cities lack the resources to fund such projects from their current revenues.

3.3. PPP Arrangements

Due to public sector being overwhelmed by societies' needs, and the run of public infrastructure and public services being essential for economic development, there is a need to reconsider private sector participation. This fact has been demonstrated in many developing countries around the world and also applies to Tanzania. Public-Private Partnerships (PPPs), in turn, are a powerful tool for the efficient delivery of public infrastructure and services to citizens and local companies. The "unleashing of the power of the market and the private sector" is one of the key principles of the development framework of the Tanzania Development Vision 2025. To play an effective role in the development of Tanzania PPP needs to be applied in this undertaking.

3.4. Bonds

A municipal/city bond is a debt security issued by a city council to finance its capital expenditures, including the construction of highways, bridges, water and sanitation projects or schools. They can be thought of as loans that investors make to local governments. City bonds are exempt from federal taxes and most state and local taxes, making them especially attractive to people in high income tax brackets. In this case, implementation of the projects may be funded through this arrangement. The advantage of this is that the beneficiary of the undertaking and hence payers of the loan are within the area of jurisdiction instead of those who are indirect beneficiaries.

4. Cost Recovery Strategy

4.1. Tariffs / User Fees

Revenues received from water supply and provision of sewerage services in the course of the Authorities' activities will be collected and used in cost recovery. These revenues are from customers from Domestic, Commercial Institutions, Religious and Kiosks. The other revenues are from sewerage disposal services currently charged at 40% of water consumption. Expansion of water supply and sewerage services customer base with the application of modern technologies to reduce costs and improve operations will greatly enhance cost recovery.

4.2. Taxes / Levies

Under normal circumstances, the local government is responsible to make sure that all basic needs to its society are being provided at the highest possible quantity and quality. Through that spirit, it is assumed that the Local Government, hereby referred as Dodoma city, to engage in finding various sources of funds so as to finance this important and necessary project. Since the authority is mandated to make bylaws, then imposing some kind of levies to those able and willing to pay within the area of jurisdiction can serve as one of the important sources of financing.

5. Institutional and Financial Arrangement

Dodoma city has three key players when it comes to sanitation and storm water management. The players include Local Government Authority (Dodoma City Council) partly for construction of infrastructure concerning waste management, DUWASA on the other hand deals with sewerage and sewage while Private Sector including individual households play an important role in sanitation issues at that level. For effective implementation of plans there is a need to have Memorandum of Understanding between DUWASA and Local Government that will describe in details responsibilities of parties in question.

IV. Monitoring and Evaluation

1. Storm Water Drainage Sector

Monitoring is the process of observing and checking the progress or quality of stormwater infrastructure over a period of time; keep under systematic review. Evaluation is the process of determining the merit, worth or value of the stormwater management. It helps in determining whether Stormwater system, is meeting its intended objectives, or in answering other management questions.

1.1. Existing situation

Currently, the city council of Dodoma is the one responsible for the stormwater management without having specific department or specific personnel responsible for handling the system.

1.2. Establishment of Monitoring and Evaluation system for Drainage Sector

It is suggested that, there should be a department in Dodoma City responsible for the supervision of the stormwater drainage system. They should carry out site visits, recording of conditions found on site and proposing measures according to different conditions found at site. Also, there should be meetings held with report writing so as to limit the damage to storm-water infrastructure.

There should be a state law that is responsible for the management of stormwater infrastructure on sites that are one acre and larger. This department should set laws that are to be followed by construction companies even during applying for General Stormwater Construction Permit so as to monitor them not to damage stormwater systems.

The specific permit requirements of any size of the construction site, should include performing site inspections and sampling stormwater leaving the site. The record and report of monitoring results should be submitted to the department responsible for permit.

The monitoring and evaluation of Stormwater Drainage System will help to regularly check on the progress of the construction and maintenance of the stormwater drains. This makes it easy to know whether the stormwater system is functioning as intended or not. Monitoring and evaluation help to know if failure in any of the stormwater drains has occurred as well as to plan maintenance as soon as possible so as to ensure it is repaired as soon as possible. Silt accumulation and soil erosion are some of the issues that hinders the stormwater system from functioning as intended. If this happens the structure should be repaired built.

Monitoring and Evaluation of Stormwater Systems helps to reduce or limit floods by knowing the areas stormwater drainage system is introduced and where it is necessary to be introduced so as to control floods.

1.3. Strengthening M&E system for Drainage Sector in Dodoma City

Upon establishing a Monitoring and Evaluation of Stormwater systems, the following can be done in order to strengthen the established Monitoring and Evaluation System.

- **Investing in Monitoring and Evaluation,**

The organization to be responsible for Stormwater system, should Invest in data sources and collection methods, country should focus on the capacity to disaggregate, analyze and use data for program quality improvement and impact.

- **Stormwater system assessments**

The assessment of the existing stormwater system. This is carried out by country itself through the organization responsible for stormwater and ideally should be done every two to three years. Stormwater system assessments serve to:

- Determine the status of the implementation of the national monitoring and evaluation plan
- Identify any weaknesses in the monitoring and evaluation system
- Build on and strengthen existing monitoring and evaluation efforts

Based on the results of the system assessment, country will then be able to develop a costed monitoring and evaluation plan, implement it, and follow up on the implementation process. The results of the system assessment can then support the inclusion of system strengthening activities in the monitoring and evaluation plan and be supported with funding from a Global Fund grant.

- **Stormwater system Program reviews.**

A Stormwater system program review is a periodic assessment of an ongoing stormwater system program. Stormwater system program reviews provide decision-makers an opportunity to evaluate program performance against the priorities identified in the strategic plans, review lessons learned, identify areas for further improvement and inform planning and future implementation.

Table 134. Targeted Rate of Flood Prone Areas in Dodoma city

Item	Current	Short-Term (2025)	Medium – Term (2035)	Long-Term (2040)
Dodoma City (km^2)	2,671.5			
Flood Prone Area (km^2)	890.4	744.7	153.6	
Rate of Flood Prone Area (%)	33.3%	27.9%	5.8%	

2. Sanitation Sector

2.1. On-site sanitation sector

On-site sanitation is managed by Health department within the City Council of Dodoma (CCD) under the public health act no 1, 2009 and amended by-laws made by the councils. The health department is divided into a curative health department unit and preventive health department unit. Monitoring and evaluation are done by Health department team members to the ongoing and the completed projects.

The health department has a duty to check the designs and drawing of houses on-site sanitation facilities submitted in the office for approval before construction. The department unit using the available public health officer advice about good health sanitation practices to the important areas like on the methods, design, type of treatment facility, slope, location as per by-laws and acts.

2.2. Off-site sanitation

Off-site sanitation is managed by Dodoma Urban Water Supply and Sanitation (DUWASA). The duties of the authority regarding sanitation are Sewer line services, construction of new sewer network, rehabilitation of existing sewerage network, the connection of new houses to the sewer network system. The authority is practicing Monitoring and Evaluation on the existing sewerage system and its services so as to be sustainable and to meet the intended objectives and goals. The authority also applies Monitoring and Evaluation to any ongoing project regarding the sanitation sector.

There are no current ongoing projects regarding sanitation in Dodoma, therefore M & E tool is applied only to the existing sanitation situations under management decisions. Due to presence of onsite and offsite sanitation infrastructure like sewer network, septic tanks, pit latrines and treatment facilities, Health department in CCD and DUWASA practice Monitoring and Evaluation to safeguard the health of people, and to provide adequate sewerage service to the people without any adverse impacts to the environment and to the human health in general.

Table 135. M&E practices in Dodoma sanitation sector

	M&E practices in Dodoma sanitation sector	Intervals	Responsible
CCD (Health department) & DUWASA	Meetings (Normal meeting, multi-sectoral meeting)	Monthly	Stakeholders, Staff meeting
	Field visit	Daily, Weekly	Technical staff, community
	Communication	Daily, Any emergency	Service center, Receptionists
	Inspection	Daily, Weekly & Monthly	Technical staff member e.g. Engineers, technicians
	Program or project report	Quarterly, Yearly, incidentally	Staff members, managers

- **Field visit**

The technical teams usually visit the site to see the real situation and condition of sewers, Manholes, and treatment facilities. Field visit of the treatment facility at Swaswa and the sewer lines is conducted daily by DUWASA sewerage section team to observe the problems and inconsistencies of the system.

- **Periodic Internal Meeting**

Meetings are done with stakeholders and users of the sanitation system to get any rising issues about the existing services and the infrastructures in general.

- **Multi-sectorial collaboration Meeting**

According to Council health officer and DUWASA, there is a meeting to discuss the risen issues, existing problems or emergencies concerning onsite and offsite sanitation issues. The multi-sectorial meetings mostly involve the key stakeholders which are DUWASA, RUWASA, Community, ward and sub-ward health officers, and the city health department.

- **Communication**

Using Public contact number which is available 24 hours and a complaint book, the people can report any issue regarding sanitation to the office at any time. Technical staff can attend to the incidence at any time do inspections or surveys for solving the reported problem.

Inspection

The inspection to monitor and evaluate the designs and plans of the sanitation system in Dodoma is practiced. Inspection to the existing sanitation facilities to ensure the adequate provision of services and health improvement to the people. The inspection of the sites is divided into three types.

- The routine inspection.

This is the normal type of inspection done by the Health department preventive unit that follows the programs and plans made by the department.

- Incidental Inspection.

This is another type of inspection done by both council and DUWASA to attend the site after an incidence occurred to specific areas, for example, sudden overflow and spills of the sewage out of the sewer line to the community. This incident is very dangerous to community health hence an emergency inspection is done by the authority and health department to observe the situation for remediation.

Annual Project Report

Each year the report is prepared for the ongoing and completed projects. DUWASA and CCD department prepare report each and every year and submit to the service manager and to the management for monitoring, evaluation, analysis and future plans of other coming projects.

2.3. Monitoring and Evaluation Challenges and Problems in Dodoma sanitation sector

2.3.1. Challenges facing Dodoma sanitation sector in conducting Monitoring and Evaluation

The monitoring and evaluation practices sanitation sector are not effectively applied by DUWASA and Health department in CCD to validate the objective of their projects or existing sanitation programs. The findings showed that, Sanitation projects face challenges in implementing M&E practices including;

- Low budgetary allocation in M&E activities,
- Lack of technical M&E staffs,
- Low central government support,
- Poor project reports and information systems,
- Poor community participation.

- Absence of an independent M&E section in the DUWASA technical department since the Technical Department is responsible for production, treatment, transportation and distribution of water to customers. It is also responsible for the collection of sewage from customers and the treatment of the same before being disposed to the environment. The department also deals with Designing of water supply and sewerage projects, repair of leaking pipes as well as maintenance of motor vehicles and motorcycle. (http://www.duwasa.go.tz)
- The use of unqualified and untrained M&E staffs.

2.3.2. Observed problems during monitoring practices by DUWASA

The following are the problems observed to be facing the sewerage system when conducting monitoring;

- Vandalism of cast iron manhole covers and frames
- Blockage of truck sewers at various areas with deleterious matte such as worn-out clothes and plastic bags
- Burying of sewer manholes with construction materials in areas where buildings and civil works are ongoing have recently been completed which resulted in the topsoil, cement, aggregate, and other such sediments finding their way into the sewer system through manholes.

2.4. Strengthening M&E System in Dodoma sanitation sector

For the sustainability of the sanitation sector, the Dodoma Urban Water Supply and Sanitation Authority (DUWASA) and City Council of Dodoma (CCD) should have a Monitoring and Evaluation plan document. A monitoring and evaluation (M&E) plan in sanitation is a document that will help to track and assess the results of the interventions throughout the life of a sanitation program or project in Dodoma city. It is a living document that should be referred to and updated on a regular basis by team or technical staff. While the specifics of each program's M&E plan will look different, they should all follow the same basic structure and include the same key elements. An M&E plan should be developed by the team or staff with research experience, with inputs from program or project staff involved in designing and implementing the program or project.

Table 136. Showing Steps to make and strengthen M&E in the sanitation sector

S/No.	Steps	Action Plans
1	Introduction to program or project	Sanitation program goals and objectives
		Logic model, Logical framework, Theory of change
2	Define Indicators	Table with data sources, collection timing and the staff member responsible for monitoring and evaluation
3	Roles and Responsibilities	Description of each staff members role in M&E data collection, analysis, and or reporting
4	Reporting	Analysis plan
		Reporting template table
5	Dissemination Plan	Description of how and when data will be disseminated internally and externally

Table 137. Proposed program goals and objectives in sanitation sector

Sanitation problem	Lacking proper sanitation and wastewater treatment facilities
Solution	Establishment of sanitation development plan and measures
Targets	Increased number of people to access proper sanitation and wastewater treatment facilities by 25.6% in the year 2025, 81.1% by 2035 and 98.9% by 2040.

Table 138. Monitoring indicators and Data collection sources

Process indicators	Outcome indicators	Data sources	Timing	Responsible
One training each month to the community about the importance of proper sanitation	100% of people educated and willing to be connected into the public sewer and access to proper onsite sanitation facilities	Training attendance sheets	Month	CCD and DUWASA Sanitation training staff
One Project for detail design of the sewerage system in Dodoma city	A complete report in place by the end of 2020	FGD, Literature review	1year	DUWASA sewerage section staff, Research assistants
Two projects for construction of the new sewerage systems and rehabilitation of the existing sewerage systems	25.6% coverage by the end of the 2025 year	FGD, population-based survey	1year	Field M&E officers

Table 139. Sanitation Analysis Plan

Indicators	Baseline	Time	Lifetime target	% of target achieved
100% of people educated and willing to be connected into the public sewer and access to proper onsite sanitation facilities	0	1 year	2025	100%
A detail design project complete report in place by the end of 2020	0	1 year	2020	100%
25.6% coverage by the end of the 2025 year	6%	5 years	2025	25.6%

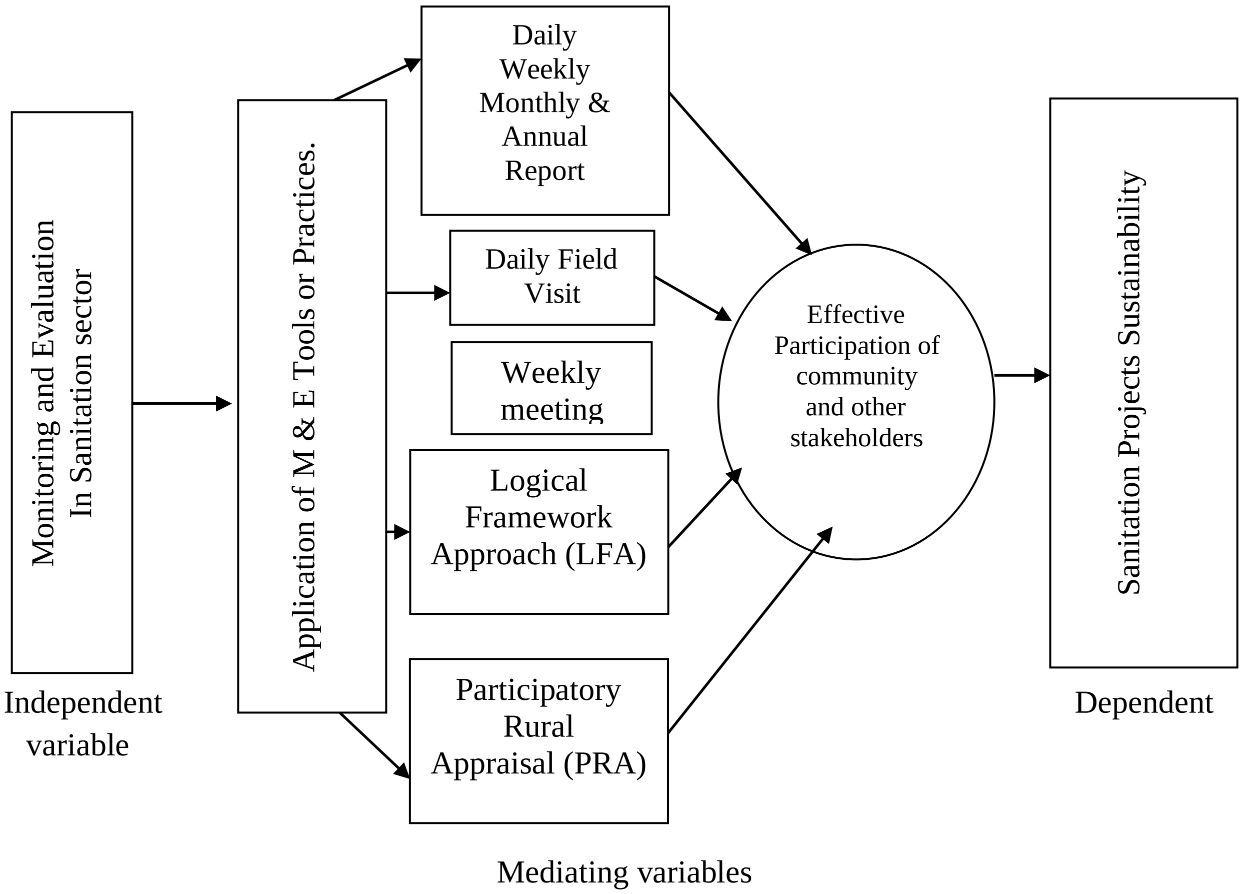

Fig. 132 Proposed Conceptual Framework for Monitoring and Evaluation in Dodoma sanitation sector

These are the proposed best approaches to strengthen M&E systems in the Dodoma sanitation sector.

- Capacity building and training programs. Capacity building to technical staff on how to conduct and practice monitoring and evaluation to the existing project or plan or program. There is also the need to promote health education to the public through radio, television, and newspapers.

- The change of National policies and plans from Infrastructure to service-oriented or approach,
- To maintain a well-coordinated, organized and supervised cleansing and flushing sanitation program after every three months.
- The use of telescopic cameras and physical checks in every day to enhance proper management and monitoring of the sewerage system.
- To establish an Independent M&E section in DUWASA and adopting Participatory approach. The section should be given enough capability in terms of resources so as to work for the benefit and sustainability of projects and objectives.

2.5. Decision support system to monitor progress of Sewerage System

Table 140. Coverage Rate Served by Sewerage

Item	Current	Short-Term (2025)	Medium-Term (2035)	Long-Term (2040)
Population	612,193	844.118	1,441,875	1,884,473
Population served by sewerage	36,732	215,734	1,168,697	1,864,057
Coverage Rate (%)	6.0%	25.6%	81.1%	98.9%

Table 141. Tread Rate of Wastewater Flow to be Generated

Item	Current	Short-Term (2025)	Medium-Term (2035)	Long-Term (2040)
Total Wastewater Flow (m^3/day)	90,940	135,467	216,623	273,930
Treatment Capacity (m^3/day)	6,120	58,000	276,000	276,000
Treated Rate (%)	6.73%	42.81	100%	100%

V. Priority Projects

1. Storm Water Drainage Sector

1.1. Priority Project (1): Rehabilitation of existing stormwater drains in Dodoma city

1.1.1. Background

The drainage system comprises of about 10 main Storm water drains with some smaller ones. The main drains in the Dodoma City area are as follows: Pombe River, Mkalama River, Kikuyu River, Imagi River, Mwangaza - Nzuguni Storm Water Drain, Nkuhungu Storm Water Drain, Sabasaba Storm water Drain, Ilazo - Ipagala - Hombolo Storm Water Drain, Kisasa Storm Water Drain and Kizota Storm Water Drain. These storm water drains are faced with a challenge of bank erosion, siltation, insufficiency due to inability to accommodate all the runoff.

1.1.2. Project Purpose

To rehabilitate the existing stormwater drains for their sufficiency and solve the problem of floods.

1.1.3. Project Overview

- **Gabions (Length – 41 km)**
- **Closed Rectangular drain: (Length 0.2 km)**
- **Trapezoidal drain: (Length-3.1 km)**
- **DE siltation: (27.4 km)**
- **Vegetation: (5.1 km)**

1.1.4. Project Area

The project area is at the center of the city since it is the location for all these rivers and stormwater drains. (Please find Annex 06).

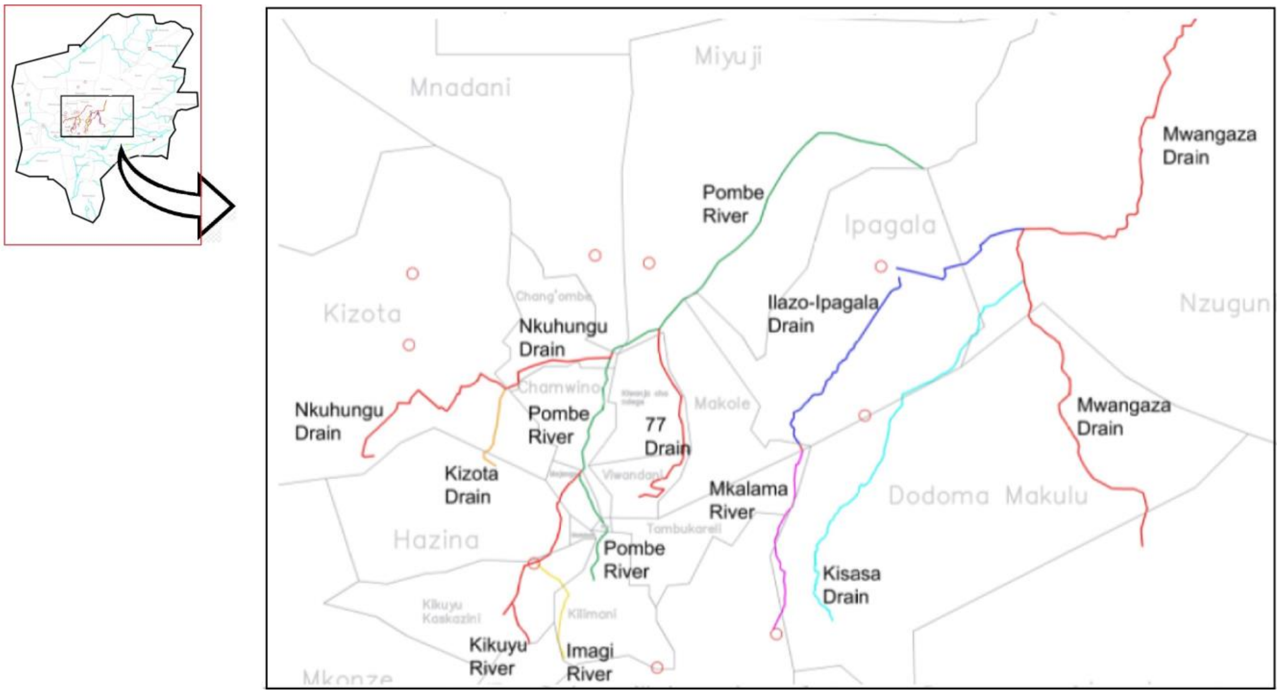

Fig. 133 Project of Rehabilitation of Existing Stormwater Drains in Dodoma city

1.1.5. Project Details

Gabions

The total length for gabions for the rehabilitation of the existing rivers and stormwater drains is 41 km with its details as shown in the table below.

Table 142. Details for the Lengths of Gabions for Storm Water Drains

No.	Name of river or storm water drain	Length (km)
1	Pombe river	14.0
2	Kikuyu river	3.8
3	Imagi river	1.1
4	Mkalama river	6.0
5	Mwangaza stormwater drain	7.5
6	Kisasa stormwater drain	5.6
7	Sabasaba stormwater drain	3.0
8	Kizota stormwater drain	0
9	Nkuhungu stormwater drain	0
10	Ilazo ipagala stormwater drain	0
Total Length		**41**

Trapezoidal and Closed Rectangular Drains

The total length for closed rectangular drains is 0.2 km and for trapezoidal drain is 3.1 km for the rehabilitation of the existing stormwater drains. The details are specified in the table below.

Table 143. Details for lengths of trapezoidal and closed rectangular drains

No.	Name of river or storm water drain	Trapezoidal drain Length(km)	Closed rectangular drain Length (km)
1	Pombe river	0	0
2	Kikuyu river	0	0
3	Imagi river	0.1	0
4	Mkalama river	0	0
5	Mwangaza stormwater drain	0	0
6	Kisasa stormwater drain	0	0
7	Sabasaba stormwater drain	0.5	0
8	Kizota stormwater drain	1.0	0.2
9	Nkuhungu stormwater drain	1.5	0
10	Ilazo ipagala stormwater drain	0	0
Total Length		**3.1**	**0.2**

Desiltation and Vegetation Planting

The total length for desiltation is 27.4 km and vegetation planting 5.1 km for the rehabilitation of existing stormwater drains and rivers. The details are specified in the table below.

Table 144. Description of lengths for desiltation and vegetation planting for existing stormwater drains

No.	Name of river or storm water drain	De siltation Length (km)	Planting vegetation (km)
1	Pombe river	7.7	0.8
2	Kikuyu river	1.6	0
3	Imagi river	1.9	0.1
4	Mkalama river	1.3	2.4
5	Mwangaza stormwater drain	8.3	1.3
6	Kisasa stormwater drain	1.3	0
7	Sabasaba stormwater drain	2.2	0.5
8	Kizota stormwater drain	1.1	0
9	Nkuhungu stormwater drain	2.0	0
10	Ilazo ipagala stormwater drain	0	0
Total Length		**27.4**	**5.1**

1.2. Priority Project (2): Rehabilitation of the existing water retention ponds in Dodoma City.

1.2.1. Background

Dodoma has many ponds, naturally formed and constructed ones. Most of these ponds have been affected by siltation; hence they remain with very small depth, leading to very small retention volumes.

1.2.2. Project Purpose

To rehabilitate the ponds by increasing their depth for storage of large amount of storm water to reduce runoff.

1.2.3. Project Overview

- **Gabions**
- **Dredging**
- **Vegetation**
- **Improvements of Outlets**

1.2.4. Project Area (Please find Annex 06).

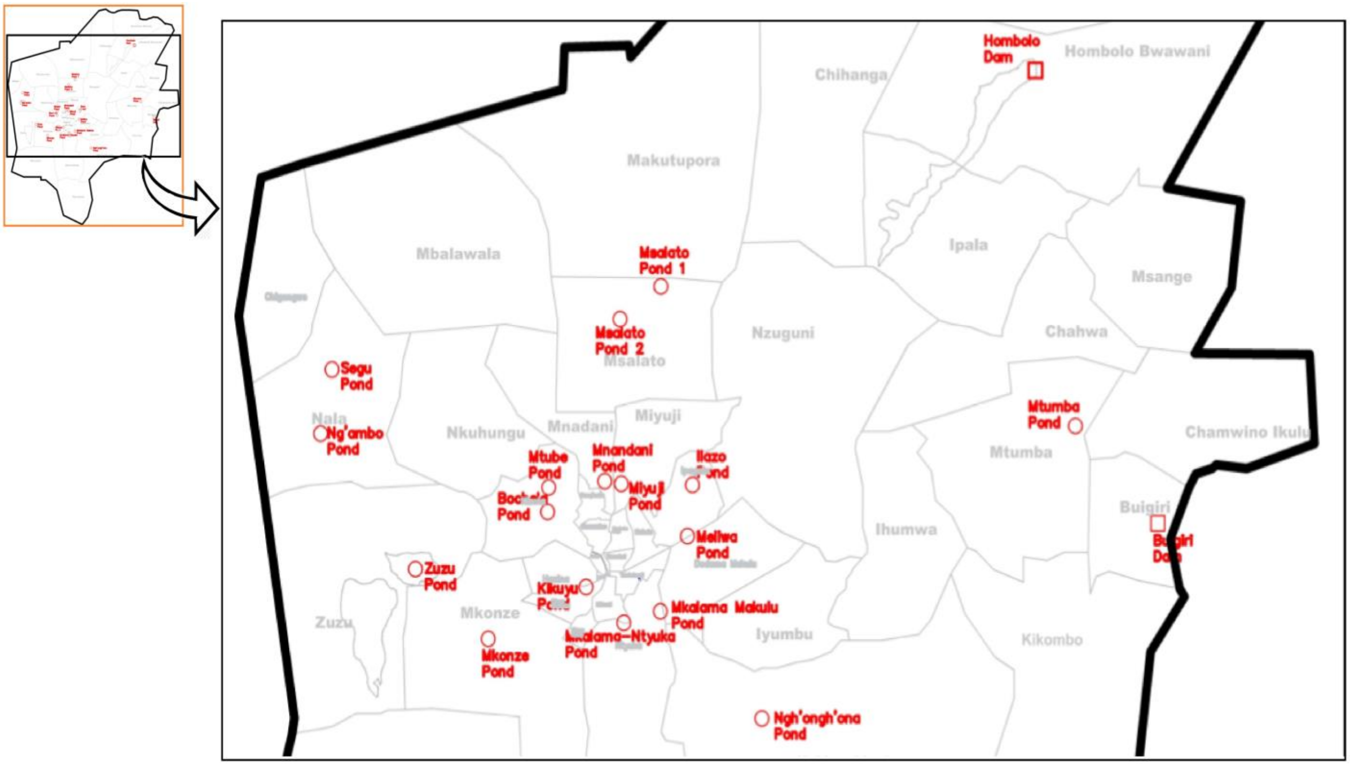

Fig. 134 A project on rehabilitation of existing ponds in Dodoma city

1.2.5. Project Details

Gabions

The total length of the gabions for the ponds is 58.2 km as detailed in the table below.

Table 145. Details for the Lengths of Gabions for Existing Ponds

S/No.	Pond name	Circumference (Km)
1	Bochela	0.6
2	Buigiri	6.7
3	Ilazo water pond	0.4
4	Iwelewele	0.5
5	Kikuyu	3.0
6	Meliwa	1.2
7	Miyuji	0.6
8	Mkalama-Makulu	3.5
9	Mkalama-Ntyuka	2.4
10	Mkalama	0.9
11	Mnadani	0.6
12	Msalato	0.7
13	Msalato pond2	3.2
14	Mtube	0.6
15	Mtumba	4.5
16	Mwegamile	0.5
17	Ng'ambo	0.5
18	Ng'hong'hona	0.5
19	Nguji	0.5
20	Ntyuka	0.7
21	Segu	1.0
22	Zuzu	25.1
TOTAL		**58.2**

Dredging

Table 146. Details for the Lengths of Dredging for Existing Ponds

S/No	Pond name	Circumference (Km)
1	Bochela	0.6
2	Buigiri	6.7
3	Ilazo water pond	0.4
4	Iwelewele	0.5
5	Kikuyu	3.0
6	Meliwa	1.2
7	Miyuji	0.6
8	Mkalama-Makulu	3.5
9	Mkalama-Ntyuka	2.4
10	Mkalama	0.1

S/No	Pond name	Circumference (Km)
11	Mnadani	0.6
12	Msalato	0.7
13	Msalato pond2	3.2
14	Mtube	0.6
15	Mtumba	4.5
16	Mwegamile	0.5
17	Ng'ambo	0.5
18	Ng'hong'hona	0.5
19	Nguji	0.5
20	Ntyuka	0.7
21	Segu	1.0
22	Zuzu	25.1
TOTAL		**58.2**

1.3. Priority Project (3): Project for construction of new stormwater system in the central part of Dodoma City (Drains and Water retention ponds)

1.3.1. Background

The new drainage system will involve the construction of new stormwater drains and new water retention ponds. The construction will be based on the existing degraded lands, ravines, and natural depression. The construction will concentrate on the central area which is most built area to solve the problem of flooding.

1.3.2. Project Purpose

To solve the problem of flooding which is the most built up area of Dodoma City.

1.3.3. Project overview

- **Gabions (Length 10.7 Km)**
- **Vegetation (Length 33.4 Km)**
- **Trapezoidal drains (Length 10.1 Km)**

1.3.4. **Project Area** (Please find Annex 06).

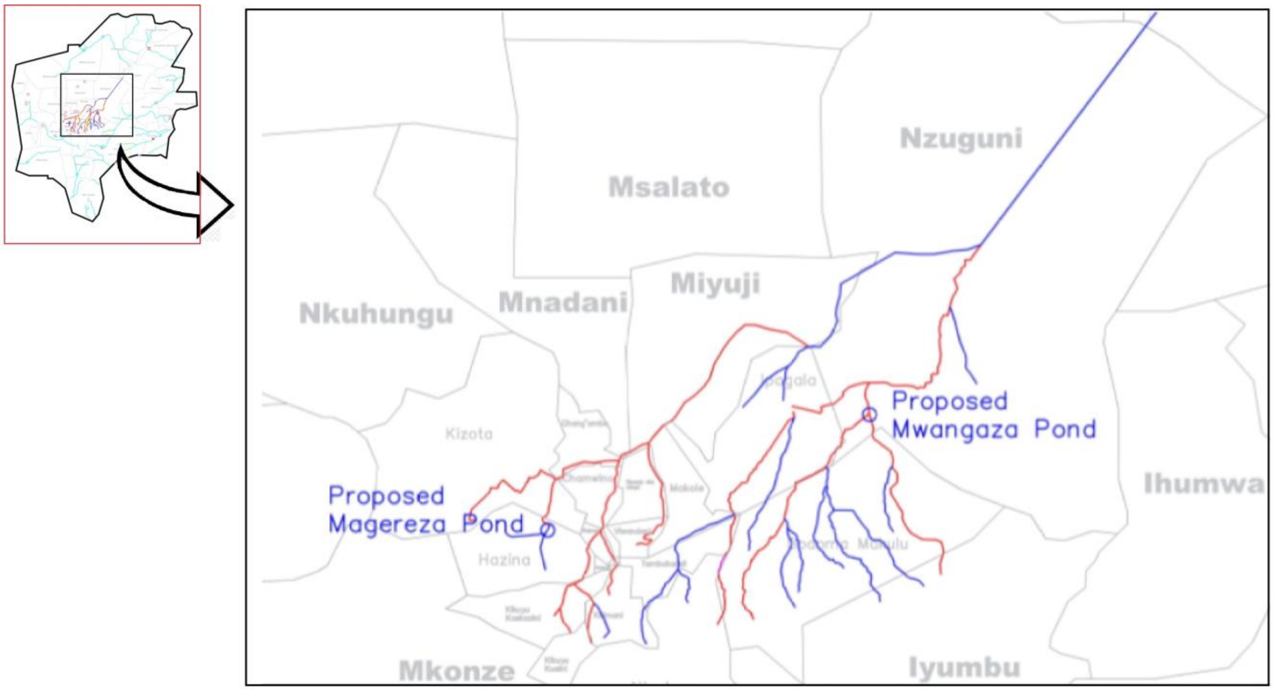

Fig. 135 Project for construction of new stormwater system in the central part of Dodoma City (Drains and Water retention ponds)

1.3.5. **Project Details**

The total length of the gabions is 10.7 km, vegetation planting is 33.4 km trapezoidal drain is 10.1 km as described in the table below.

Table 147. Detailed lengths for trapezoidal drains, vegetation planting and gabions for new storm water drains

Drain Name	Ward	Trapezoidal Length (km)	Vegetation Planting (km)	Gabion (km)
P1-01	Dodoma Makulu	0	2.2	0
P1-02	Iyumbu	0	0.7	0
P1-02	Dodoma Makulu	0	3.1	0
P1-03	Iyumbu	0	0.4	0
P1-03	Dodoma Makulu	0	1.8	0
P1-03	Dodoma Makulu	2.2	0	0
P1-04	Dodoma Makulu	0	0.3	0
P1-04	Dodoma Makulu	3.3	0	0
P1-05	Dodoma Makulu	0	0.7	0
P1-05	Dodoma Makulu	1.5	0	0
P1-06	Dodoma Makulu	0	1.2	0
P1-06	Dodoma Makulu	1.7	0	0
P1-07	Dodoma Makulu	0	0	1.7

Drain Name	Ward	Trapezoidal Length (km)	Vegetation Planting (km)	Gabion (km)
P1-07	Ipagala	0	0	2.6
P1-08	Ntyuka	0	1.1	0
P1-09	Kilimani	0	0.8	0
P1-09	Kilimani	0	0	0.3
P1-09	Tambukareli	0	0	2.3
P1-09	Makole	0	0	2.0
P1-10	Ipagala	0	0	1.8
P1-11	Ipagala	0.7	0	0
P1-11	Ipagala	0	1.3	0
P1-12	Miyuji	0	2.2	0
P1-12	Nzuguni	0	3.8	0
P1-13	Nzuguni	0	8.1	0
P1-13	Ipala	0	0.6	0
P1-14	Viwandani	0.7	0	0
P1-15	Hazina	0	1.4	0
P1-16	Hazina	0	1.2	0
P1-17	Nzuguni	0	2.5	0
Total length		**10.1**	**33.4**	**10.7**

2. Sanitation Sector

2.1. Priority Project (4): Installation of Sewerage System at the Government City

2.1.1. Background

The Government City is currently under construction at Mtumba Ward under the capital relocation plan.

However, considering the fact that the Government City is being constructed without a sewerage system and that no one has even set up a plan for it, it is deemed reasonable to set up a sewerage system for Government City as a priority project for the DSDP.

2.1.2. Project Purpose

To provide sewerage service to the Government City.

2.1.3. Project Overview

- **Trunk Sewers: D250-1200, L=26.8km**
- **Reticulation Sewers: D250-400, L=29.5km**

- **Wastewater Treatment Facility: Q=18,000m³/day**

2.1.4. Project Area

The project area is the Government City under construction at Mtumba Ward in the Buigiri wastewater treatment zone, whose location is shown in the Figure below (Please find Annex 6).

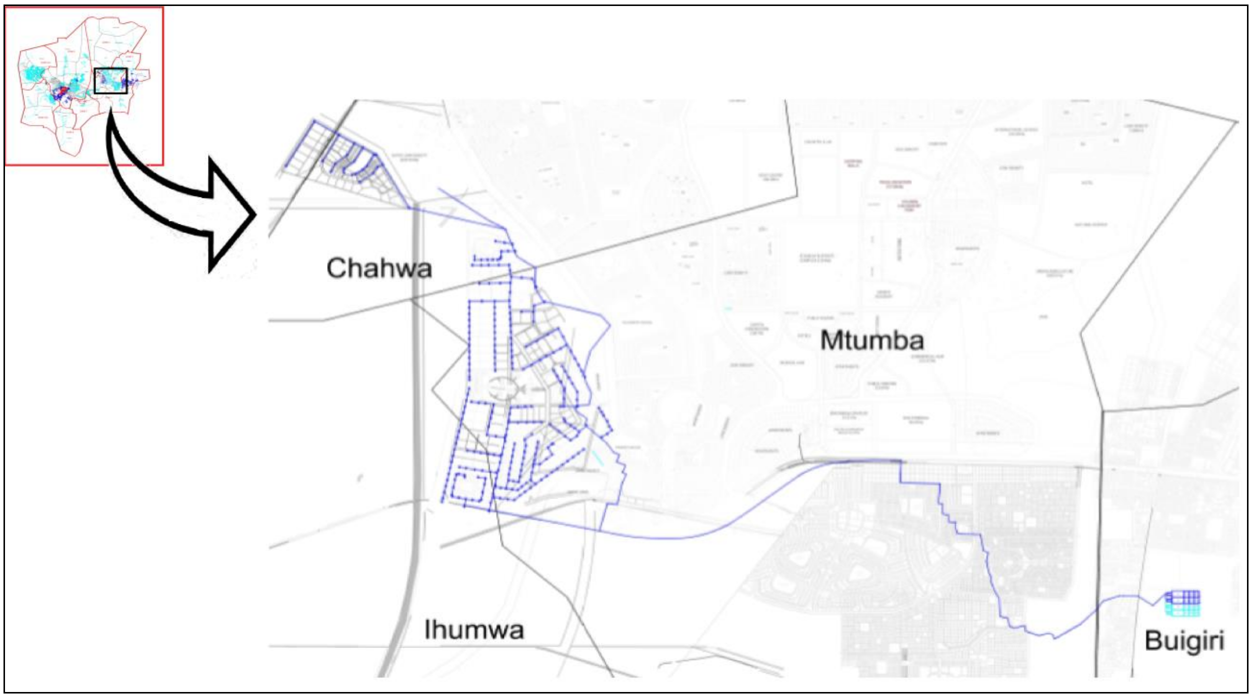

Fig. 136 Project for the Installation of Sewerage System at the Government City

2.1.5. Project Details

- **Trunk Sewers**

The total length of the trunk sewers for the Government City is 26.8 km, with details as the following table.

Table 148. Details of Trunk Sewers for the Government City

Treatment Zone	Sewers Name	Service Area	Diameter (mm)	Length (km)	No. of M/H
Zone1-Buigiri	Z1-P1-01	Government City	D400	0.5	38
			D500	2.6	
			D630	0.7	
			D700	5.9	126
			D900	0.4	
			D1,200	6.3	
	Z1-P1-02	Government City	D250	4.0	77

Treatment Zone	Sewers Name	Service Area	Diameter (mm)	Length (km)	No. of M/H
			D600	3.7	
			D700	0.8	27
			D800	1.9	
	Sub-total			26.8	268

Reticulation Sewers

The total length of the reticulation sewers for the Government City is 29.5 km, with details as the following table.

Table 149. Details of Reticulation Sewers for the Government City

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone 1-Buigiri	Government City	D400	29.5	548

Buigiri Wastewater Treatment Facility

The capacity of the Buigiri wastewater treatment facility, which will be installed for Government City as a priority project, is 18,000 m^3/day, and will be expanded 42,000 m^3/day through the medium-term Period in the future.

Table 150. Details of Buigiri Wastewater Treatment Facility

Treatment Zone	Facility Name	Wastewater Flow (m^3/day)		Capacity (m^3/day)	Type	Period
		2025	2040			
Zone1-Buigiri	Buigiri	9,209	17,822	18,000	New	Short-term
		13,364	23,924	24,000	Expansion	Medium-term

2.2. Priority Project (5): The Expansion of Existing Sewerage System at Central Dodoma City

2.2.1. Background

Among the seven wastewater treatment zones for this project, Nzuguni Zone consists of 27 wards, including Central Dodoma City, with a population of approximately 350,000, making up 57% of the total population of Dodoma City. Existing sewerage system also exists in this Zone. And, while existing trunk sewers cover 15 words, existing reticulation sewers have an incomplete sewerage system that covers only 12 words.

Therefore, expansion of existing sewerage systems in Central Dodoma City can be a good way to increase the number of sewerage users in an economical way.

2.2.2. Project Overview

- **Trunk Sewers: D250-1800, L=12.5km**
- **Reticulation Sewers: D250-300, L=263.9km**
- **Wastewater Treatment Facility: Q=34,000m^3/day**

2.2.3. Project Area

The project area is the Central Dodoma City in the Nzuguni waste treatment zone, whose location is shown in the figure below (Please find Annex 6).

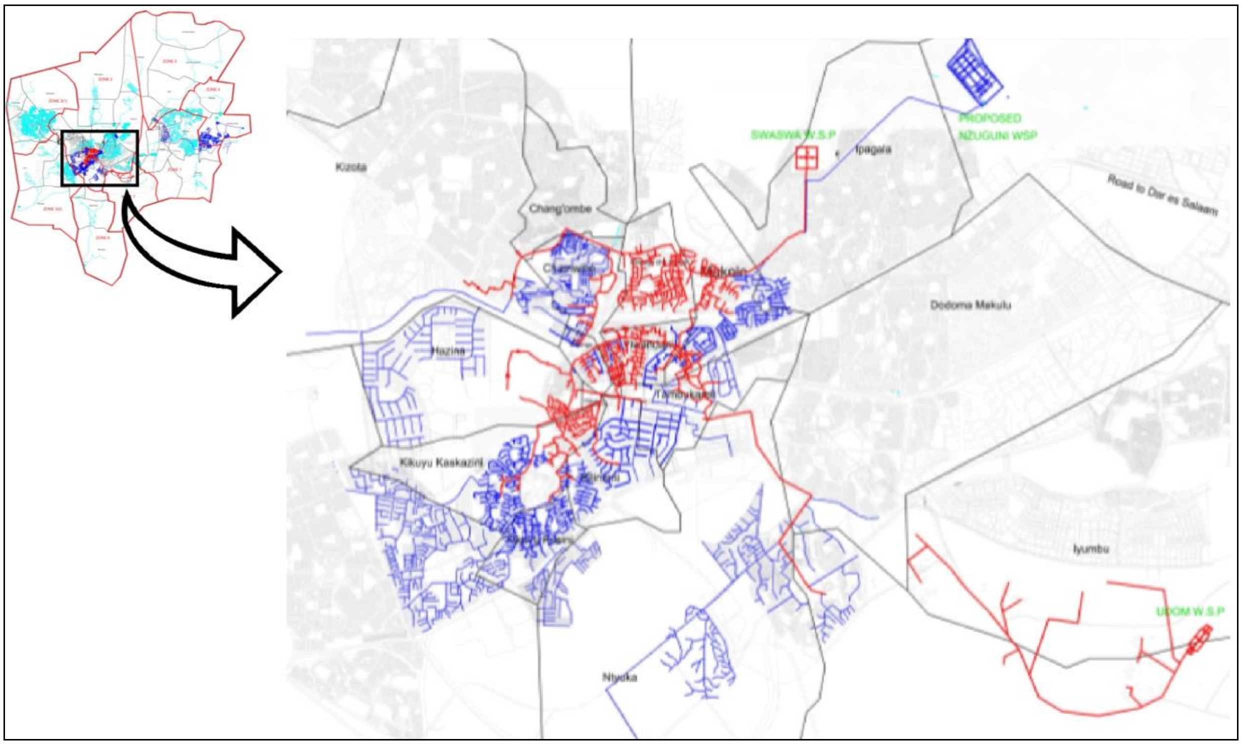

Fig. 137 Project for the Expansion of Existing Sewerage System at Central Dodoma City

2.2.4. Project Details

- **Extensions of the Existing Trunk Sewers**

The proposed extensions fall on existing trunk sewers 'I', 'K', 'SK' and 'M'. Their reviewed design and technical detail are summarized in the table below

Table 151. Extensions of Existing Trunk Sewers

Treatment Zone	Existing Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone2-Nzuguni	Trunk 'I'	Hazina	450	3.1	75
			500	0.6	

Treatment Zone	Existing Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
	Trunk 'K'	Kikuyu Kaskasini	450	1.9	
	Trunk SK'	Kikuyu Kusini	250	1.9	
	Trunk 'M'	Ipagala, Nzuguni	1400	1.0	50
			1500	3.6	
			1800	0.4	
Total				**12.5**	**125**

Reticulation Sewers to the Existing Trunk Sewers

In this project, the plan for reticulation sewers for 16 wards is established, and the detail plan for reticulation sewers for each of the ward is shown in the table below.

Table 152. Summary of Reticulation Sewers to the Existing or Extended Trunk Sewers

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone2-Nzuguni	Viwandani	D250	4.0	5,643
	Uhuru	D300	0.7	
	Chamwino	D250	24.6	
	Kiwanja Cha Ndege	D250	8.8	
	Makole	D250	15.5	
	Tambukareli	D250	10.2	
	Kilimani	D250	12.8	
	Kikuyu Kasikazani	D250	18.7	
	Mkonze	D250	41.3	
	Kikuyu Kusini	D250	25.5	
	Hazina	D250	22.5	
	Madukani	D250	1.0	
	Majengo	D250	1.1	
	N'gh'ongh'onha	D250	7.3	
	Ntiyuka	D300	40.8	
	Ipagala	D250	29.1	
Total			**263.9**	**5,643**

Nzuguni Wastewater Treatment Facility

The capacity of the Nzuguni wastewater treatment facility, which will be installed for the central city areas as a priority project, is 34,000 m^3/day. And, the existing Swaswa wastewater treatment ponds will be abandoned after completion of the Nzuguni wastewater treatment facility's construction.

And, Chihanga wastewater treatment facility was planned to be installed at 117,000 m^3/day in the medium-term period.

Table 153. Details of Nzuguni Wastewater Treatment Facility

Treatment Zone	Facility Name	Wastewater Flow (m^3/day)		Capacity (m^3/day)	Type	Period
		2025	2040			
Zone1-Nzuguni	Nzuguni	17,523	33,654	34,000	New	Short-term
	Chihanga	56,015	116,672	117,000	New	Medium-term

2.2.5. Population Served by the Sewerage System for Central Area

The increasing number of people using sewage is shown in the table below.

Table 154. Population Served by the Sewerage System for Central Area

Item	Current	2025	Remark
Total Population	349,515	481,927	
Sewerage Population	47,931	178,144	
Sewerage Rate (%)	13.7%	37.0	

2.3. Priority Project (6): Installation of Sewerage System in Chamwino Area for the State House

2.3.1. Background

Currently, the State House is to be built in Chamwino Ikulu according to the capital relocation plan, and it is necessary to provide sewerage service to the area upon completion of the construction of the State House.

2.3.2. Project Purpose

To provide sewerage service to the Chamwino Ikulu Area including the State House.

2.3.3. Project Overview

- **Trunk Sewers: D250-700, L=21.6km**
- **Reticulation Sewers: D250-300, L=199.1km**
- **Wastewater Treatment Facility: Q=6,000m^3/day**

2.3.4. Project Area

The project area is the Chamwino Ikulu area, which includes The State House, and its location is as the following figure (Please find Annex 06).

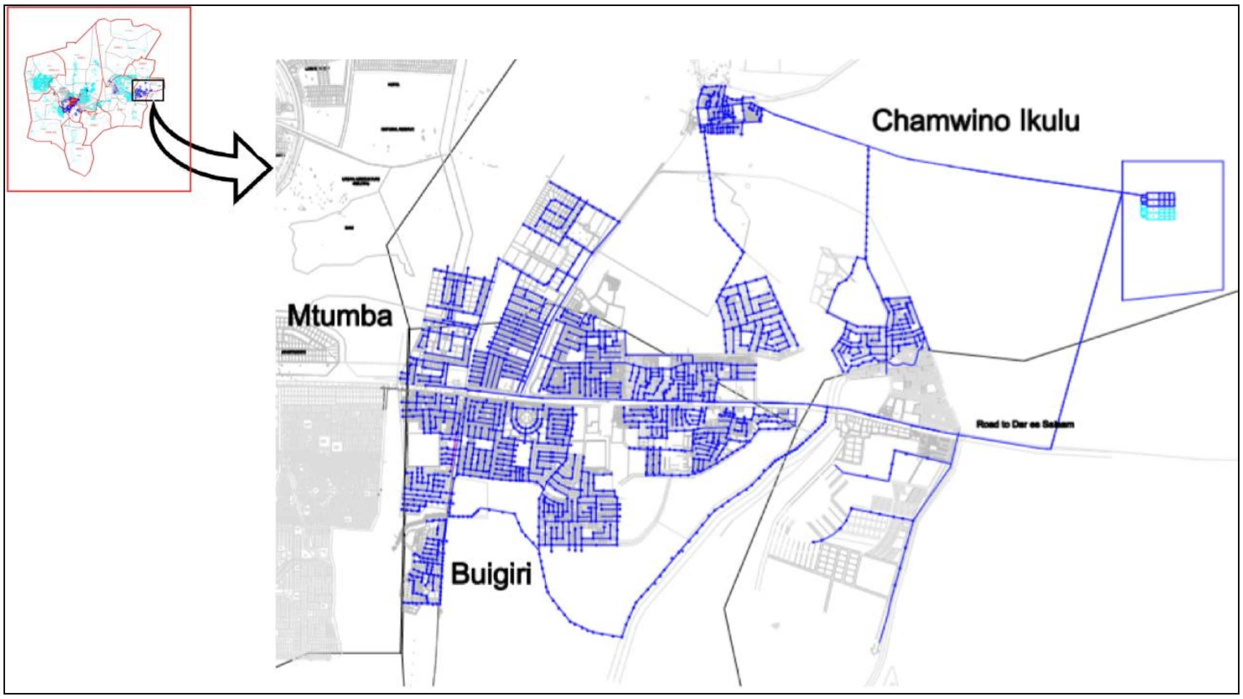

Fig. 138 Project for the Installation of Sewerage System in Chamwino Area for the State House

2.3.5. Project Details

Trunk Sewers

The total length of the trunk sewers for the Chamwino Ikulu Area is 21.6 km, with details as the following table.

Table 155. Details of Trunk Sewers for the Chamwino Ikulu Area

Treatment Zone	Sewer Name	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone4-Chinangali	Z4-P1-01	Buigiri	D300	1.4	98
		Chamwino Ikulu	D300	4.7	
			D450	1.9	
			D550	0.9	
			D600	0.5	
			D700	5.3	54
	Z4-P1-02	Chamwino Ikulu	D250	6.9	70
	Sub-total			21.6	222

Reticulation Sewers

The total length of the reticulation sewers for the Chamwino Ikulu Area is 199.1 km, with details as the following table.

Table 156. Details of Reticulation Sewers for the Chamwino Ikulu Area

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Zone4-	Chamwino Ikulu(for State House Zone)	D300	59.2	1,781

Treatment Zone	Service Ward	Diameter (mm)	Length (Km)	No. of M/H
Chinangali	Buigiri	D250	139.9	
	Sub-total		199.1	1,781

Chinangali Wastewater Treatment Facility

The capacity of the Chinangali wastewater treatment facility, which will be installed for the State House as a priority project, is 6,000 m^3/day, and will be expanded to 12,000 m^3/day in the medium-term Period.

Table 157. Details of Chinangali Wastewater Treatment Facility

Treatment Zone	Facility Name	Wastewater Flow (m^3/day)		Capacity (m^3/day)	Type	Period
		2025	2040			
Zone 4 - Chinangali	Chinangali	2,587	5,435	6,000	New	Short-term
		2,936	6,278	6,000	Expansion	Medium-term

APPENDIX

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