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Composite Water Resource Management Planning Framework

For Localising Water Security and Climate Adaptation in Rural India (WASCA)

A Handbook for Practitioners

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Foreword

Mahatma Gandhi National Rural Employment Guarantee Act (Mahatma Gandhi NREGA) has been providing guaranteed wage employment of up to 100 days in a financial year to every rural Indian household whose adult members are willing to do unskilled manual labour. The programme has contributed towards creation of durable assets and strengthening the livelihood resource base across rural India, since 2006. As of July 2020, 8.52 crore households of the 14.26 crore households registered under the programme, are active workers. The programme received the highest ever budget allocation of Rs.1,05,000 crore in FY 2020-21, including an additional allocation of Rs.40,000 crore to support infrastructure development and livelihood augmentation during the Covid-19 situation.

Mahatma Gandhi NREGA has immense focus on improving natural resource management and water conservation and management in rural areas. In this regard, the Mission Water Conservation was launched in 2016 as a convergent initiative with Ministry of Water Resources and Ministry of Agriculture and Farmer's Welfare, for allocating 65% programme expenditure on NRM and water-related works in the 2,129 water-stressed blocks across the country. In subsequent years, the programme supported the Jal Shakti Abhiyan and Jal Jeevan Mission initiatives of the Ministry of Jal Shakti.

The Indo-German project on Water Security and Climate Adaptation in Rural India (WASCA) is in partnership with Ministry of Rural Development and Ministry of Jal Shakti. The project has a key focus on climate-resilient water resource management and is being implemented in selected districts of four states namely, Rajasthan, Madhya Pradesh, Uttar Pradesh and Tamil Nadu.

Composite Water Resources Management (CWRM) planning framework is a key contribution of the project that is now being piloted in the project areas. The planning framework has been developed on the principles of Integrated Water Resources Management (IWRM). It brings together the concepts of four waters including surface water, soil moisture, confined and unconfined aquifers in consideration of water quality and water use efficiency, while giving climate data importance. The bottom-up planning process that starts at a village level is further consolidated up to district level, to further support convergent financing and implementation of appropriate measures.

This handbook provides an overview of the planning process, detailed inputs on each of the components, technical terminologies and processes that will enable a planner to undertake CWRM for his/ her district with the help of geo-spatial tools. I hope this will be of great use to the technical staff of Mahatma Gandhi NREGA and other programmes to initiate CWRM planning process in their respective areas.

Best wishes,

Rohit Kumar

Joint Secretary (Mahatma Gandhi NREGA)

Ministry of Rural Development

Foreword

Greetings from National Water Mission!

National Water Mission (NWM) was set up in 2011 with the objective of "conservation of water, minimising wastage & ensuring its more equitable distribution both across and within the states through integrated water resource development and management."

Keeping with the overarching objectives of its 5 main goals, NWM has initiated two separate campaigns–

'Sahi-Fasal' to nudge farmers in the water stressed areas to grow crops which are not water intensive, but use water very efficiently; and are economically remunerative; are healthy and nutritious; suited to the agro-climatic-hydro characteristics of the area; and are environmentally friendly. Under this, a series of workshops are being organised in the water stressed areas of the country.

"Catch the rain" with an aim to nudge all stake-holders to create Rain Water Harvesting Structures (RWHS) suitable to the climatic conditions and sub-soil strata, before the onset of monsoon, to ensure storage of rain water; while utilising MNREGA funds for the water conservation works, drives, for rooftop RWHS, maintenance of catchment areas and to put water back into aquifers.

With the use of Composite Water Resource Management (CWRM) framework, the Indo-German project on Water Security and Climate Adaptation in Rural India (WASCA) in partnership with Ministry of Rural Development and Ministry of Jal Shakti, through the NWM tangibly contributes to the targets under the 3rd, 4th and 5th Goals of NWM, while also making use of Mahatma Gandhi NREGA works in social programmes; and in their publications they highlight the importance of demand side management in water use planning, becoming a knowledge product that aims to identify financing and convergence opportunities.

With regards,

G. Asok Kumar

Additional Secretary & Mission Director

National Water Mission

Message

The German Development Cooperation (GIZ) is the implementing agency of Technical Cooperation for the German Government and is currently present in over 120 countries worldwide. The Indo-German cooperation is 62 years young and works with the Governments and other organisations on issues of environment, climate change, sustainable agriculture, energy, social security among others.

GIZ India has been implementing the Indo-German project on 'Water Security and Climate Adaptation in Rural India' (WASCA) with the Ministry of Rural Development (MoRD) and the Ministry of Jal Shakti (MoJS) since 2019. Commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ), the project aims to improve water security and rural climate adaptation through better management of rural water resources.

The project's intended outputs include:

1. Improved convergence of existing planning and financing approaches to strengthen water security.
2. Demonstration of convergent planning, financing and implementation at local level.
3. Cooperation with the private sector.

These interventions are particularly significant in India, which experiences high water stress, and is one of the worst hit countries by climate change. It is in this context that WASCA has developed this Composite Water Resource Management (CWRM) framework as a synthesis of learnings from various Indo-German projects and rural development programmes in India. This framework is an approach developed on the principles of Integrated Water Resource Management (IWRM), integrating the assessments of 4-waters including surface water, groundwater from confined and unconfined aquifers and soil moisture, climate science and socio-economic indicators, thus providing a sustainable and holistic district level water plan developed through a bottom-up participatory approach.

CWRM plans aim towards developing climate-resilient infrastructure with a view to sustainable land and soil development, water harvesting and conservation, and protection against extreme weather events, such as drought and flooding.

I hope that this CWRM framework is a useful input for improving the scope and implementation of the various rural development programmes such as Mahatma Gandhi NREGA, Jal Jeevan Mission, State Specific Action Plans for water, State Action Plans for Climate Change among others. We look forward to sharing the results and evidence from the piloting process in WASCA project locations and supporting our Ministerial and state government partners in further upscaling and mainstreaming CWRM countrywide.

Best regards,

Rajeev Ahal

Director, Natural Resource Management

and Agroecology

GIZ India

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Abbreviations and Acronyms

AER	Agro-Ecological Region
BCM	billion cubic metres
CBO	Community-Based organisations
CCA	Cultivable Command Area
CORDEX	Coordinated Regional Downscaling Experiment
CRIDA	Central Research Institute for Dryland Agriculture
CWC	Central Water Commission
CWRM	Composite Water Resource Management
CWRMP	Composite Water Resource Management Plan
ET	Evapotranspiration
FHTC	Functional Household Tap Connection
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GP	Gram Panchayat
ICAR	Indian Council of Agricultural Research (ICAR)
IEC	Information, Education and Communication
IMD	India Meteorological Department
IMTI	Tamil Nadu Irrigation Management Training Institute
IWMP	Integrated Watershed Management Programme
IWRM	Integrated Water Resources Management
LPCD	Litres per capita per day
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MIDH	Mission on Integrated Development of Horticulture
MLALADS	Member of Legislative Assembly Local Area Development Scheme
MoEFCC	Ministry of Environment, Forest and Climate Change
MoJS	Ministry of Jal Shakti
MoRD	Ministry of Rural Development
MPLADS	Members of Parliament Local Area Development Scheme

NAP	National Afforestation Programme
NCIWRD	National Commission on Integrated Water Resources Development
NHM	National Horticulture Mission
NIRD & PR	National Institute of Rural Development & Panchayati Raj
NRLM	National Rural Livelihood Mission
NRSC	National Remote Sensing Centre
NWM	National Water Mission
PHED	Public Health Engineering Department
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PRI	Panchayati Raj Institutions
PRM	Participatory Rural Management
RKVY	Rashtriya Krishi Vikas Yojana
RS	Remote Sensing
UPNRM	Umbrella Programme for Natural Resource Management
WASCA	Water Security and Climate Adaptation in Rural India
WLMI	Water and Land Management Institute

Executive Summary

This handbook is aimed at helping decision-makers, technical functionaries and staff mainly at local and district levels, and other interested personnel localise water security and climate adaptation through the Composite Water Resource Management (CWRM) planning framework. Further, it focusses on enabling participatory and decentralised processes for achieving key outputs such as improving the existing planning and financing mechanisms, building capacities, and strengthening cooperation between sectors, departments, and all other implementing functionaries – all in a manner that is climate-resilient, adaptive, and leaves no one behind. The book is structured in the following manner.

CHAPTER 1 details the WASCA Project, highlighting the key stakeholders, i.e. GIZ India and the Government of India's Ministries of Rural Development and Jal Shakti, the expected outcomes of the project, the process of intervention area selection, and how the project also contributes to international agreements on climate adaptation and sustainability.

CHAPTER 2 delves into the CWRM Framework itself, including the components, themes, and sub-themes of the process, including but not limited to defining the areas for interventions, developing capacities, the institutional mechanisms for ownership, creation of an enabling environment, and the process of preparation, implementation and monitoring of the plan.

CHAPTER 3 is a deep dive into the water sector, where the demand, supply, and water quality issues are discussed in detail in order to situate the previous chapter in real-world the context and priorities. It discusses different water sources, prevalence, and data points as per the Census of India that are relevant for a comprehensive understanding of the sector.

CHAPTER 4 comprehensively offers the reader a technical grounding in the concepts, terminology and characteristics that are essential for effectively planning and implementing measures on the ground, as well as to gain an understanding of the relationship between water, land, and soil resources. The central points discussed include agricultural land use in India, common property resources, land use classification, wasteland and forest classification systems, land use concerns, and soils, among others.

CHAPTER 5 explains how a CWRM Plan is prepared on the ground, at the administrative unit – often the Gram Panchayat, detailing a participatory planning approach that facilitates identification, preparation and design of community projects based on the criteria decided by its members, making them the centre of the planning process itself.

CHAPTER 6 explores the critical factors of sustainable convergence and governance, focusing on the need for a comprehensive and sustainable water security by bringing together governance and capacity building through local solutions. It explores the convergence of water interventions with Mahatma Gandhi NREGA, which, by being not only the largest public employment schemes in the world but also one that places significant focus on works related to natural resource management, is ideal for the same. The chapter details various schemes that can be explored for such a convergence and co-financing.

CHAPTER 7 explains the increasing significance of the emerging GIS and remote sensing technologies and their significance in CWRM planning, focusing on thematic maps, their types, uses, significance and contribution to the planning process itself. It also explains the purpose, usage, features, and other elements of the Bhuvan portal of the National Remote Sensing Centre (NRSC) which will be useful for all functionaries who seek to undertake spatial data analysis.

Chapter 1
Introduction to the Indo-German project on 'Water Security and Climate Adaptation in Rural India' (WASCA)

This chapter details the WASCA Project, highlighting the key stakeholders, i.e. the Government of India's Ministries of Rural Development and Jal Shakti, the pilot states and GIZ India, the expected outcomes of the project and how the project also contributes to international agreements on climate adaptation and sustainability.

1.1 Introduction

Water Security and Climate Adaptation in Rural India (WASCA) is a three-year Indo-German project, from April 2019 to March 2022. Its key objective is that "water resource management is enhanced through an integrated approach at national, state and local levels with regard to water security and climate adaptation in rural areas." The project is commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) in partnership with the Ministry of Rural Development (MoRD) and Ministry of Jal Shakti (MoJS) in India and is being implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The project is operational at the national level as well as in 8 select districts of four states - namely Madhya Pradesh, Rajasthan, Tamil Nadu and Uttar Pradesh. WASCA also supports two districts in Karnataka through a special project 'Technical support to Jalamrutha scheme and

Government of Karnataka for water security'. The project has three key outputs:

i. Improved convergence of existing planning and financing approaches to strengthen water security
ii. Demonstration of convergent planning, financing and implementation ot local level
iii. Strengthening cooperation with the private sector

The project strengthens the knowledge and capacity of public and private institutions, as well as of stakeholders at different levels, to plan and implement water resources management actions. Parallel to this, the project aims to promote collaboration between various government departments and other stakeholders to improve the financing of climate-adapted water security. Holistic pilot measures at sub-basin/catchment level will be taken up in select districts to achieve this. Successful approaches will be scaled-up to the state and national levels. In addition, given the private sector footprint in water, greater cooperation with them is envisaged to leverage public private financing and improve sustainable practices for local water security.

1.2 Selection of Intervention Areas

Scoping assessments were undertaken by WASCA to assess the water-climate scenario based on scientific indicators. Assessments incorporating spatial and non-spatial data were conducted to rank hotspot districts based on water scenarios and climatic vulnerabilities, and these were finalised with the state governments.

Scoping of water resources in all river basins: Surface and groundwater data, water surplus and gaps, inter-district transfers, soil data	Climate hotspot data based on IMD observed grid data; CORDEX scenarios	Mapping of existing schemes, projects and policies related to water security and climate adaptation	Mapping potential private sector partnerships through CSR, reducing water & carbon footprints of industrial units	Ranking of top hotspot districts based on mentioned indicators, and finalising with the state governments

The list of pilot districts in the five states are as follows:

MADHYA PRADESH Barwani Tikamgarh	**RAJASTHAN** Dungarpur Jodhpur	**UTTAR PRADESH** Barabanki Mathura	**TAMIL NADU** Ramanathapuram Tiruvannamalai	**KARNATAKA** Shivamogga Tumkur

1.3 Key WASCA Stakeholders

The **Ministry of Rural Development (MoRD)** is the principal partner for most of the development and social programmes in rural India. MoRD is investing Rs 101,500 crores (EUR 12 billion) in the **Mahatma Gandhi National Rural Employment Guarantee Act (Mahatma Gandhi NREGA)** during 2020-21, thereby making a substantial contribution to rural infrastructure development and rural livelihoods. More than half of the Mahatma Gandhi NREGA expenditure goes towards sustainable natural resource management including land and soil development, water harvesting and conservation, and protection against extreme weather events, such as drought and flooding, thus creating significant climate adaptation and mitigation co-benefits.

The **Ministry of Jal Shakti (MoJS),** newly formed in May 2019, is the nodal ministry for water in India, and now brings all the national agencies working on water including the National Water Mission, Central Water Commission, Central Ground Water Board, River Boards, Department of Drinking Water and Sanitation, etc. under one umbrella.

On 1 July 2019, MoJS launched the Jal Shakti Abhiyan in convergence with MoRD, Ministry of Environment, Forest and Climate Change (MoEFCC) and other ministries.

Table1.1: Salient Features of WASCA Pilot Districts in India

S No	States	Districts	No of Blocks	No of GPs	No of Villages	Total Area in KM^2	Population in Lacs	No of Catchment / River Sub-basin
1	Rajasthan	Jodhpur	16	466	1846	22850	36.9	6 (Mithri, Bandi, Jojri, Golasmi, Guniamata and Bastua)
		Dungarpur	10	291	980	3770	13.9	12 (Jhakham, Majhham, Vatrak, Bhader, Gangli, Sapan, Very Ganga, Nagdari, Phallu, Padar, Mahaya and Kadva Bagaria.)
2	Tamil Nadu	Ramanahtapuram	11	429	400	4068	13.5	6 (Vaigai, Gundar, Virusuli, Reghunatha Cauveri, Kottakariyar & Uppar)
		Tiruvannamalai	18	824	1117	6191	24.6	6 (Cheyyar, Sughanadhi, Thenpennai, Mrigandanadhi, Kamandalanaga Nadhi, Thurinjalaru)
3	Madhya Pradesh	Tikamgarh	6	458	976	5048	14.5	9 (Betwa, Jamni, Dhasan, Dhukuwa, Parischa, Ur, Sukhnai, Lakheri and Chainch)
		Barwani	7	413	724	5427	13.9	7 (Narmada, Goi, Deb, Tapti, Tori, Churi and Dudhikheda)

S No	States	Districts	No of Blocks	No of GPs	No of Villages	Total Area in KM^2	Population in Lacs	No of Catchment / River Sub-basin
4	Karnataka	Shimogha	7	262	1539	8495	17.5	7 (Tunga, Bhadra, Varada, Sharavati, Kumadvati, Varada and Kumudvati)
		Tumkur	10	322	2727	10597	26.8	9 (Pennar, Lower Cauvery, Lower Tungabhadra, Jayamangala, Kumudvathi, North Pinakini, Shimsha, Vedavathi and Suvarnamukhi)
5	Uttar Pradesh	Mathura	10	478	901	3340	25.5	2 (Yamuna and Patwaha)
		Barabanki	15	1023	1845	4402	32.6	6 (Ghaghra, Gomti, Kalyani Nadi, Reth and Bel Nalas.)
	5 states	10	110	4966	13055	74188	219.7	70 Catchments

Contribution to International & National Agreements on Water and Climate Action

WASCA contributes to the Sustainable Development Goals (SDGs);

Chapter 2

The Composite Water Resource Management (CWRM) Framework

This chapter delves into the CWRM Framework itself, including the components, themes, and sub-themes of the process, including but not limited to defining the areas for interventions, developing capacities, the institutional mechanisms for ownership, creation of an enabling environment, and the process of preparation, implementation and monitoring of the plan.

2.1 Introduction

According to India's Composite Water Management Index (2018), 600 million people in the country (44% of the total population) face water scarcity. A shrinking and sometimes contaminated water supply, heavy reliance on rainfall and lack of efficient irrigation systems are major problems in rural areas, where almost 70% of the Indian population live. India is one of the most affected countries by climate change and occupies the sixth place in the Global Climate Risk Index 2018. In this changing climate scenario, water security is a prime concern.

The CWRM framework has been developed by the WASCA project by synthesising experiences from Mahatma Gandhi NREGA, Integrated Watershed Management Programme (IWMP), Jal Jeevan Mission, National Water Mission, Composite Water Management Index of NITI Aayog, and WASCA's predecessor project 'Environmental Benefits through Mahatma Gandhi NREGA.'

A collaborative process with experts across government departments and technical resource agencies associated with WASCA contributed to the preparation of the framework. This was further finalised in the National Consultation Workshop organised by WASCA in February 2020 at New Delhi, involving ministerial partners, officials from all state governments, the National Remote Sensing Centre (NRSC) , National Institute of Rural Development and Panchayati Raj (NIRD & PR) and Confederation of Indian Industry (CII).

CWRM planning is a tool to develop and implement sustainable plans at the lowest administrative and hydrological unit in a catchment or river sub-basin. The framework has 4 components, 17 themes and 57 sub-themes based on the key elements of Integrated Water Resources Management (IWRM) and climate adaptation.

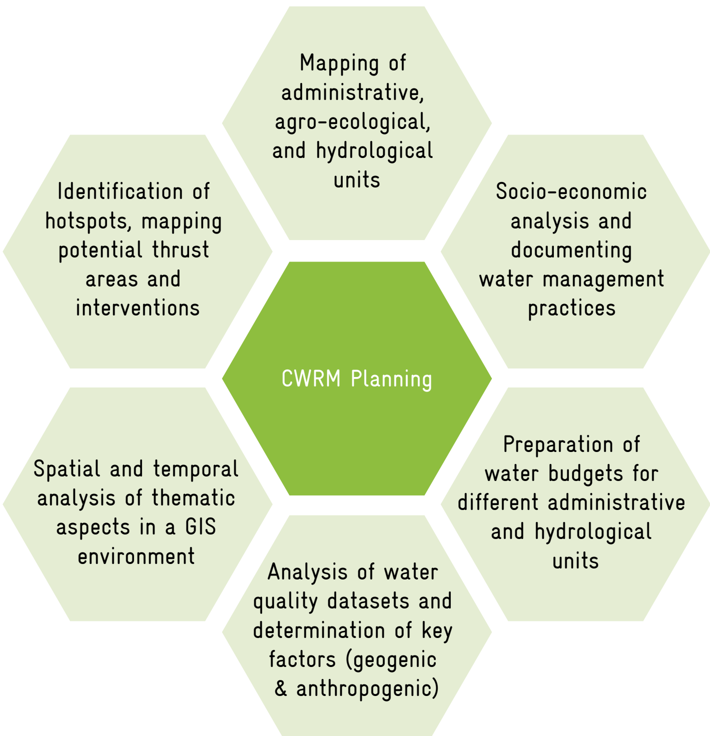
The process involves characterisation of the landscape, assessment of natural resources and local life support systems in a systematic and scientific manner for effective planning, financing and cooperation at local, regional and national levels. The framework provides simplified tools using remote sensing, GIS and non-statistical data on land, water, soil, forest, climate vegetation and pastoral resources. The following table provides the components, themes and sub-themes of CWRM planning.

Table 2.1: Components, themes and sub-themes of CWRM Planning

Component 1 – Interpreting the AoI (Area of Interest)	
Theme	Sub-Themes
1.1 Characterising project areas	1.1.1 Assessment of scenarios in a GIS (Geographic Information System) environment
	1.1.2 Geo-processing of spatial and non-spatial datasets
	1.1.3 Temporal analysis of relevant parameters and projection for upcoming scenarios
1.2 Estimating water resources	1.2.1 Quantifying surface water resources in different units
	1.2.2 Quantifying sub-surface (soil) moisture regime in different units
	1.2.3 Quantifying groundwater resources in different units
	1.2.4 Assessment of existing demand
	1.2.5 Preparation of water budget at different administrative and hydrological units
1.3 Documenting water management practices	1.3.1 Mapping of water management practices
	1.3.2 Contextualising water use pattern in each unit
	1.3.3 Status of recycling/reuse of water
	1.3.4 Assessment of grey water disposal practices
	1.3.5 Scoping for optimisation of water use & reuse patterns
1.4 Assessing water quality	1.4.1 Analysing water quality datasets
	1.4.2 Determining key factors (geogenic and anthropogenic) leading to water contamination problems
	1.4.3 In situ comprehensive surveillance mechanism
	1.4.4 Exploring appropriate alternatives
1.5 Capturing climatic/ atmospheric conditions (30 years cycle)	1.5.1 Inter and Intra-annual patterns of precipitation, temperature, wind and humidity
	1.5.2 Assessment of extent and intensity of Evapotranspiration (ET)
	1.5.3 Exploring options for enhancing adaptive capacities and community livelihood resilience

Component 2: Capacity Development and Institutional Mechanisms	
2.1 Stakeholder mapping (People, Public & Private)	2.1.1 Gram Panchayat (GP) level
	2.1.2 Block Level
	2.1.3 District Level
	2.1.4 State Level
2.2 Promoting the cadre of planners	2.2.1 Capacity development of facilitators
	2.2.3 Instituting necessary infrastructure and facilities for anchoring the process
	2.2.4 Linkage with agencies/experts for technical backstopping of the cadre
2.3 Creating an enabling environment	2.3.1 Perspective development of identified stakeholders
	2.3.2 Capturing community's aspiration
	2.3.3 Identifying interventions for achieving the community's aspirations
	2.3.4 Assessing expected outcomes of the interventions
	2.3.5 Prioritisation of the interventions for implementations
	2.3.6 Consolidation and Synthesis at Hydrological level
	2.3.7 Knowledge generation, documentation and exchange
	2.3.8 Creating platforms for stakeholder engagement and promoting convergence
	2.3.9 Developing essential knowledge and IEC products and dissemination
Component 3: Preparation of Composite Water Resource Management Plan (CWRMP)	
3.1 Projections of emerging scenarios	3.1.1 Spatial, non-spatial, temporal behaviour of natural resources and production systems
	3.1.2 Water budgeting for arriving at water surplus/ deficiency
	3.1.3 Identifying corrective measures for water surplus/deficiency
	3.1.4 Management of Corrective Measures Water surplus/ deficiency
3.2 Scoping and Mapping	3.2.1 Water use efficiency (focus in Agriculture, Domestic)
	3.2.2 Optimisation of water productivity
	3.2.3 Enhancing climate adaptive capacities and livelihood resilience
3.3 Composite Water Resource Management Plan (CWRMP): Action Plans	3.3.1 For smallest unit (e.g. GP/ micro/ sub-watershed)
	3.3.2 Consolidating the action plans into water management plans at next higher scale (block/ watersheds)
	3.3.3 Synthesising the water management plans at district level/ sub-catchment
	3.3.4 Finalising the implementation plan and estimating expected outcomes
	3.3.5 Preparing a convergence plan at district level for proposed actions
	3.3.6 Resource pooling (Financial, Human, Knowledge, Technological)

Component 4: Implementation mechanisms	
4.1 Enabling the implementation cadre	4.1.1 Ensuring access to technical know-how
	4.1.2 Providing essential knowledge (instruments and soft tools)
	4.1.3 Skilling for designing and application of tools
4.2 Preparation of shelf of projects for proposed actions	4.2.1 Design
	4.2.2 Supplies for technological solutions
	4.2.3 Costing
	4.2.4 Responsibilities for execution
4.3 Monitoring and supervision	4.3.1 Record-keeping
	4.3.2 Quality assurance
4.4 Institutional arrangements	4.4.1 Finalising project implementing agency (PIA)
	4.4.2 Engaging concerned departments/ agencies/ private players for resource and knowledge pooling
	4.4.3 Involving Panchayati Raj Institutions (PRI) and local community-based organisations (CBO)
4.5 Depicting activities on online portals and impact monitoring	4.5.1 Development of online portals at district level or state Level
	4.5.2 Provisions for progress and impact monitoring
4.6Sustainability mechanisms	4.6.1 Development of Standard Operating Procedures (SoP) for operationalising
	4.6.2 Development of Standard Operating Procedures (SoP) for maintenance
	4.6.3 E-Jal for Enhancing Water Security: Development of a digital tool for providing comprehensive technical solutions on water resources management



2.2 Localising CWRM through Local Level Planning

This section explains the science and technology behind various aspects of water security and climate adaptation under CWRM planning that is essential to collection of data, assessing the data, and analysing it to make well informed decisions that ensure necessary actions with community involvement and participation of all key stakeholders in the CWRM process.

It is important to understand watersheds at the outset. A watershed is defined as a geo-hydrological unit of an area draining to a common outlet point. The undulating land area of any region forms several such units, each of which forms a watershed. In a watershed, the slopes fall from the ridge to the beginning of the plain/arable area called the ridge area.

The scientific method to treat degraded land under the watershed method is to begin at the top and come down the slope. The approach intends to conserve every drop of water starting at the ridge and reduce both the surface runoff volume and the velocity of water to a considerable extent. This, in turn, allows better management of water flowing from the ridge to the valley and ensures efficacy, economic stability and durability of soil and water conservation structures downstream. It leads to natural resource conservation such as reduction in soil erosion, conservation and harvest of rainwater, increase in the productivity of land, employment generation and social upliftment of the communities.

Most of the works permitted under Para No. 4(1) of Schedule 1, Mahatma Gandhi NREGA are such that the rainfed area can be developed to bring the area under production and to increase the productivity through watershed management works. While planning for sub/micro-watersheds, the area covering a Gram Panchayat or a village can be a unit for planning purposes.

2.3 Understanding Administrative and Natural Units for Water Security Projects

For projects working on water, it is essential to understand the hydrological aspects as well as the administrative units. Defining regions for planning purposes requires that administrative convenience assumes paramount importance. This gains prominence because the existing administrative boundaries cannot be easily ignored during the implementation of plans. Political realities as well as the availability of data for specific administrative units make it practically essential to understand these boundaries.

However, while noting practical and administrative considerations, one must also keep in mind the importance of homogeneity and hydrological units since neglecting these factors can lead to distortions in the water security planning process.

While characterising an area, it is important to identify the administrative unit that is close to the hydrological unit, which may be the sub/micro-watershed area covering a Gram Panchayat or a village. While planning works, the revenue map of the village should be superimposed on a Watershed Atlas of the area by enlarging or reducing the scale of the maps to bring them to a similar scale for superimposition (Rubber Sheeting Method).

Similarly, the characterisation should have homogeneous factors - socio-economic, cultural, hydrological, agro-ecological, agro-climatic, as well as topographical homogeneity to ensure proper implementation of water security plans. The actual delineation of a unit for planning purposes requires a balance between the considerations of homogeneity, natural boundaries, and administrative boundaries.

2.3.1 Hydrological units and Micro-Level Delineation

The terms region, basin, catchment, watershed etc. are widely used to denote hydrological units. Even though these terms have similar meanings in the popular sense, they are technically different.

The entire country has been divided into a total of six Water Resources Regions and 34 river basins coinciding with the basins as delineated in Watershed Atlas of India. The delineation and codification will follow a similar system based on stream hierarchy and codification from downstream upward that allows one to get a micro-watershed of 500 to 1,500 ha size viable enough for implementation of soil and water conservation programmes.

The beauty of such delineation and codification is that it can be recognised with a national code with seven digits and symbolised as 1A2B3a1 where "a" stands for sub-watershed and "1" denotes the micro-watershed. Thus, 1A2B3a1 stands for a national code of a micro-watershed which belongs to Water Resource Region "1", Basin "1A", Catchment "1A2", Sub-catchment "1A2B", Watershed "1A2B3", Sub-watershed "1A2B3a" and Micro-watershed "1A2B3a1". The following table provides average size ranges for Hydrological Units.

Table 2.2: Average Size Ranges for Hydrological Units

#	Category of Hydrologic Units	Code	Size Range (ha)	Average Size (ha)
1.	Water Resource Region	2	270,00,000-1130,00,000	5,50,00,000
2.	Basins	A	30,00,000-300,00,000	95,00,000
3.	Catchments	1	10,00,000-50,00,000	30,00,000
4.	Sub-catchments	A	200,000-10,00,000	7,00,000
5.	Watersheds	2	20,000-300,000	1,00,000
6.	Sub-watersheds	a	5,000-9,000	7,000
7.	Micro watersheds	2	500-1,500	1,000

Source: http://slusi.dacnet.nic.in/dwainew.html

2.4 Classification of Agro-Climatic Zones and Agro-Ecological Regions

Agro-climatic zones are land units delineated in terms of major climates, suitable for a certain range of crops and cultivars. Agro-climatic conditions mainly refer to soil types, rainfall, temperature, and water availability which influence the type of vegetation in that area.

Several attempts have been made to delineate major agro-ecological regions with respect to soils, climate, physiographic and natural vegetation for macro-level planning on a more scientific basis. They are as follows.

i. Agro-climatic regions by the Planning Commission

ii. Agro-climatic zones under National Agricultural Research Project (NARP)

iii. Agro-ecological regions by the National Bureau of Soil Survey & Land Use Planning (NBSS & LUP)

Agro-ecological regions (AER) are land units on the earth's surface, carved out of an agro-climatic region by superimposing climate on landforms and soils, which are the modifiers of climate and length of growing period. They are designed to address issues related to agricultural production by delineating agriculturally potential areas suitable for particular genotypes.

They are essential to achieving the optimum production potential of a crop, crop variety, and delineating agro-ecologically comparable regions for generating and transferring various agrotechnologies.[1] Agricultural regions, forest regions, and livestock-rearing zones are fully controlled by a set of interrelated geographic factors. They are:

- Climatic factors
- Soil properties
- Physiographic settings (topography & drainage).

The Planning Commission divided India into **15 broad agro-climatic zones** based on physiography and climate[2]. Based on the following four parameters i.e. a) physiographic features, b) soil characteristics, c) bio-climatic features, d) the length of growing period, the land area of India is divided into **20 agro-ecological regions.**

The revision of agro-ecological region maps of the country indicates that climate change is a reality and that arid regions are increasing in terms of extent and severity at the cost of humid and sub-humid regions. Therefore, a strong resource base of land use planning is necessary to combat climate change and ensure food security. The **Indian Council of Agricultural Research** (ICAR) has recently taken initiative and framed AER as the basis for district level planning to help double the income of farmers by 2022.

2. 5 Climate Change Adaptation and CWRM

Climate, in a narrow sense is usually defined as the weather (statistical description) in terms of the mean and variability of relevant quantities over a period for 30 years[3] (as per the World Meteorological Organization).

Climate change refers to changes in climate which can be attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and which is in addition to natural climate variability observed over comparable time periods (defined by United Nation Framework Convention on Climate Change (UNFCCC)).

2.5.1 Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC) is the UN body for assessing the science related to climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988. IPCC assessments provide governments, at all levels, with scientific information that they can use to develop climate policies. The IPCC has three working groups: Working Group I (the physical science basis of climate change); Working Group II (impacts, adaptation and vulnerability); and Working Group III (mitigation of climate change).

1 Delineating Agro-Ecological Regions, D.K. Mandal, C. Mandal and S.K. Singh, ICAR-NBSSLUP TECHNOLOGY
2 Ministry of Jal Shakti, retrieved from http://mowr.gov.in/agro-climatic-zones
3 World Meteorological Organization, retrieved from https://public.wmo.int/en/

Table 2.3: Categories of climate adaptation options

Category	Option	May assist both adaptation and mitigation
Institutional	Support integrated water resources management, including the integrated management of land considering specifically negative and positive impacts of climate change	X
	Promote synergy of water and energy savings and efficient use	X
	Identify "low-regret policies" and build a portfolio of relevant solutions for adaptation	X
	Increase resilience by forming water utility network working teams	
	Build adaptive capacity	
	Improve and share information	X
	Adapt the legal framework to make it instrumental for addressing climate change impacts	X
	Develop financial tools (credit, subsidies, and public investment) for the sustainable management of water, and for considering poverty eradication and equity	
Design and operation	Design and apply decision-making tools that consider uncertainty and fulfill multiple objectives	
	Revise design criteria of water infrastructure to optimize flexibility, redundancy, and robustness	
	Ensure plans and services are robust, adaptable, or modular; give good value; are maintainable; and have long-term benefi ts, especially in lowincome countries	X
	Operate water infrastructure so as to increase resilience to climate change for all users and sectors	
	When and where water resources increase, alter dam operations to allow freshwater ecosystems to benefit	
	Take advantage of hard and soft adaptation measures	X
	Carry out programs to protect water resources in quantity and quality	
	Increase resilience to climate change by diversifying water sources and improving reservoir management	X
	Reduce demand by controlling leaks, implementing water-saving programs, cascading and reusing water	X
	Improve design and operation of sewers, sanitation, and wastewater treatment infrastructure to cope with variations in influent quantity and quality	
	Provide universal sanitation with technology locally adapted, and provide for proper disposal and reintegration of used water into the environment or for its reuse	

Category	Option	May assist both adaptation and mitigation
Reduce impact of natural disasters	Implement monitoring and early warning systems	
	Develop contingency plans	
	Improve defenses and site selection for key infrastructure that is at risk of floods	
	Design cities and rural settlements to be resilient to floods	
	Seek and secure water from a diversity (spatially and source-type) of sources to reduce impacts of droughts and variability in water availability	
	Promote both the reduction of water demand and the effi cient use of water by all users	
	Promote switching to more appropriate crops (drought-resistant, salt-resistant; low water demand)	X
	Plant flood- or drought-resistant crop varieties	X
Agricultural irrigation	Improve irrigation efficiency and reduce demand for irrigation water	X
	Reuse wastewater to irrigate crops and use soil for carbon sequestration	X
	When selecting alternative sources of energy, assess the need for water	X
	Relocate water-thirsty industries and crops to water-rich areas	
	Implement industrial water efficiency certifications	X

Source: IPCC- AR-5, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability

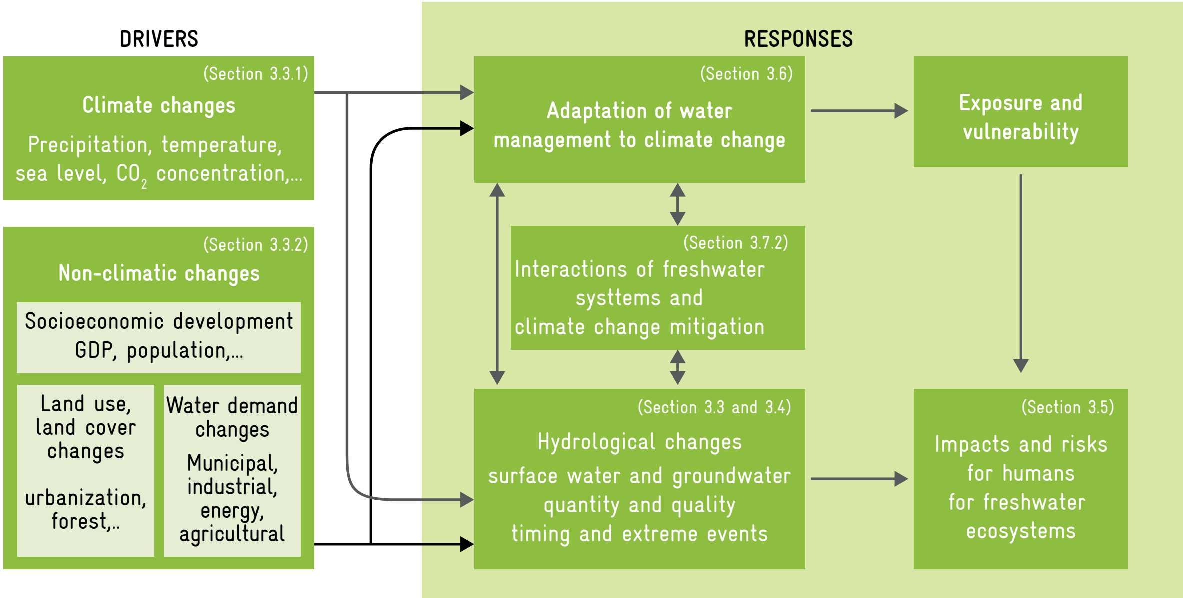
2.5.2 Impact of Climate Change on Water

- Water is the primary agent through which the impacts of climate change is felt to the society through its effect on agriculture and other sectors. Even though water moves through the hydrological cycle, it is a locally variable resource.
- Vulnerabilities to water-related hazards such as floods and droughts differ between regions.
- Anthropogenic climate change is one of the many stressors of water resources. Non-climatic drivers such as population increase, economic development, urbanisation, and land use or natural geomorphic changes also challenge the sustainability of resources by decreasing water supply or increasing demand.
- Climate change is projected to reduce renewable surface water and groundwater resources significantly in most dry subtropical regions and intensify competition for water among agriculture, ecosystems, domestic requirements, industry, and energy production, and food security[4].
- All climate projections imply variations in the frequency of floods, and flood hazards are projected to increase in parts of South, South-East, and North-East Asia; tropical Africa; and South America.
- Climate change is likely to increase the frequency of meteorological droughts (less rainfall) and agricultural droughts (less soil moisture) in presently dry regions by the end of the 21st Century. This is likely to increase the frequency of short hydrological droughts (less surface water and groundwater).
- It negatively impacts freshwater ecosystems by changing streamflow and water quality.
- It is projected to reduce raw water quality, posing risks to drinking water quality even with conventional treatment (medium evidence, high agreement).

4 Freshwater resources. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability, IPCC AR5

- In many regions, increase in temperature along with changing precipitation patterns alters hydrological systems and affects the quantity and quality of water resources (IPCC AR5).[5]

The framework below (boxes) and linkages (arrows) show impacts of climatic and social changes on freshwater systems, and consequent impacts on and risks for humans and freshwater ecosystems.



Source: IPCC, Action Report 5, 2014

Water demand and use for food and livestock feed production is governed not only by crop management and its efficiency, but also by the balance between atmospheric moisture deficit and soil water supply. Thus, changes in climate (precipitation, temperature, radiation) affect the water demand of crops grown in both irrigated and rainfed systems.

Rainfed agriculture is vulnerable to increasing precipitation variability. Differences in yield and yield variability between rainfed and irrigated land may increase with changes in climate and its variability.

In the face of hydrological changes and freshwater-related impacts, vulnerability, and risks due to climate change, there is a need for adaptation and for increasing resilience. Managing changing risks due to the impacts of climate change are key to adaptation in the water sector (IPCC, 2012), and risk management should be part of decision-making. Integrated Water Resource Management continues to be a promising instrument for exploring adaptation to climate change.

5 Scoping Study-WASCA: GIZ- CCCDM, Anna University, 2019

Chapter 3
Understanding Water Supply, Demand, and Quality to Optimise Water Use Efficiency and Productivity

This chapter explores the water sector, and the demand, supply, and water quality issues are discussed in detail in order to situate the previous chapter in the real-world context and priorities. It discusses different water sources, prevalence, and data points as per the Census of India that are relevant for a comprehensive understanding of the sector.

3.1 Introduction

By 2022-23, India's water resources management strategy should facilitate water security to ensure adequate availability of water for life, agriculture, economic development, ecology and environment. This broader vision can be achieved by attaining the following sectoral goals:[1]

1. Provide adequate (rural: 40 litres per capita per day (lpcd); urban 135 lpcd and safe drinking water (piped) and water for sanitation for citizens and livestock.
2. Provide irrigation to all farms (*Har Khet Ko Pani*) with improved on-farm water-use efficiency (more crop per drop).

1 Strategy for New India@75 Niti Aayog, 2018

3. Provide water to industries, encourage industries to utilise recycled/treated water and ensure zero discharge of untreated effluents from industrial units.
4. Ensure *Aviral* and *Nirmal Dhara* (continuous and unpolluted flow) in the Ganga and other rivers along with their tributaries.
5. Create additional water storage capacity to ensure full utilisation of the utilisable surface water resources potential of 690 billion cubic metres (BCM).
6. Ensure long-term sustainability of finite groundwater resources.
7. Ensure proper operation and maintenance of water infrastructure with active participation of farmers/consumers.
8. Promote R&D to facilitate adoption of the latest technologies in the water sector.

The average annual precipitation in India is 4000 BCM. Average precipitation during monsoon is 3000 BCM (during June to September). The natural runoff is 1986.5 BCM and estimated useable surface water resources is 690 BCM. Utilisable groundwater is 433 BCM and per-capita water availability is 1720.29 cubic metres. Out of 183 million hectares of cultivable land, the net irrigated area is 55.1 million ha. [2]

In India, the dominant form of water utilisation comes from the agricultural sector which accounts for 69% use of the total water use (70% of the surface water resources and 30% groundwater resources). To meet the increased food production requirements of the future and to achieve food security, the agriculture sector is expected to command a quantum jump in water utilisation and double by the year 2050. Significant gaps exist in the ultimate irrigation potential, its creation and utilisation. In addition, it is reported that the water-use efficiency in the country is only 25-30%.

As per the Central Water Commission's (CWC) 2019 assessment, the average annual water resource of the river basins of India for a study period of 30 years (1985-2015) is 1999.20 BCM. The mean annual rainfall of the basins for this period is 3880 BCM. It is estimated that owing to topographic, hydrological and other constraints, the utilisable water with conventional approach is 1137 BCM which comprises of 690 BCM of surface water and 447 BCM of replenishable groundwater resources.

These resources are renewed through a continuous cycle of evaporation, precipitation and runoff. The water cycle is driven by global and climatic forces that introduce variability in precipitation and evaporation, which in turn define runoff patterns and water availability over space and time (modulated by natural and artificial storage). Observations over the past decades and projections from climate change scenarios point towards an exacerbation of the spatial and temporal variations of water cycle dynamics (IPCC, 2013). As a result, discrepancies in water supply and demand are becoming increasingly aggravated.

On the basis of the water balance approach, it is possible to make a quantitative evaluation of water resources in basins and their change under the influence of human activities[3]. Climate change presents India with major challenges. Over the course of the 20th century, the average temperature in the country increased by 0.6°C, and the trend continues upward. Rainfall is becoming less frequent but more intense, which is increasingly affecting the use of natural resources and agricultural production.

3.1 Understanding the Supply Side

3.1.1 Surface Water Sources

Surface water refers to the collection of water on the ground or in a stream, river, lake, wetland, or ocean. It is naturally replenished by precipitation, and naturally lost through discharge to evaporation and sub-surface seepage into groundwater[4]. The availability of surface water in a watershed depends upon the precipitation within the watershed, storage capacity of the watershed (lakes, wetlands and artificial reservoirs), permeability of the soil, runoff characteristics of the land, timing of precipitation and the local evaporation rates etc.

2 Central Water Commission, Government of India, Website
3 Reassessment of water availability in basins using space inputs, CWC, 2019
4 Indian Hydrology Project, http://hydrology-project.gov.in/SurfaceWater.html#Q1.

Scenario

There are four major sources of surface water. These are rivers, lakes, ponds, and tanks. In the country, there are about 10,360 rivers and tributaries which are longer than 1.6 km each. The mean annual flow in all the river basins in India is estimated to be 1,869 cubic km. However, due to topographical, hydrological and other constraints, only about 690 cubic km (32 percent) of the available surface water can be utilised.

Water flow in a river depends on the size of its catchment area or river basin and rainfall within its catchment area. Irrigation schemes using either groundwater or surface water and having a Culturable Command Area (CCA) of less than 2000 hectares individually are categorised as Minor Irrigation (MI) Schemes. The schemes have been categorised broadly into six major types: (1) Dug wells (2) Shallow Tube wells (3) Medium Tube wells (4) Deep tube wells (5) Surface flow schemes and (6) Surface lift schemes, the first four categories belonging to groundwater and the latter two under surface water schemes[5].

Surface water schemes comprise of surface flow schemes and surface lift irrigation schemes. The former typically consist of tanks, check-dams and structures. They can serve as water conservation cum groundwater recharge schemes and are generally prevalent in hilly regions.

Surface lift schemes are generally built in regions where the topography does not permit direct flow irrigation from rivers and streams, due to which water has to be lifted into irrigation channels. These works are similar to diversion schemes, but in addition, pumps are installed and pump-houses are constructed as well.

Surface Water Resource Schemes: Some Key Terms

Minor Irrigation (M.I.) Scheme: A scheme having CCA of up to 2,000 hectares individually is classified as a minor irrigation scheme.

Medium Irrigation Scheme: A scheme having CCA of more than 2,000 hectares and up to 10,000 hectares individually is classified as a medium irrigation scheme.

Major Irrigation Scheme: A scheme having CCA more than 10,000 hectares is classified as a major irrigation scheme.

Water body: All natural or artificial units with some or no masonry work used for storing water for irrigation or other purposes are called water bodies. There are various types of these water bodies, and they are known by different names including tanks, reservoirs, ponds, Bundhies etc. The distinction among various types, however, is not very explicit.

Pond: A small body of water, usually earthen (though masonry dykes are also included) and shallow, made through excavations which represent a restricted environment. Ponds usually describe small bodies of water that generally would not require a boat to cross.

Tank: A shallow water unit, usually larger than a pond created by constructing earthen or masonry barricades which receives water either from tube wells or rains.

Reservoir: A large man-made impoundment of varying magnitude created by erecting, bunds, dams, barrages, or other hydraulic structures across streams or rivers serving one or more purposes such as irrigation, power generation, flood control or other water resource development projects

5 Census of Minor Irrigation Schemes Report, MoJS, 2017 (formerly MoWR & RDGR)

Surface Flow Schemes

These schemes use rainwater for irrigation purposes either by storing it, or by diverting it from a stream, *nalah* or river. Permanent diversions are constructed for utilising the flowing water of a stream or river; temporary diversions are constructed in areas which are usually washed away during the rainy season. Their small storage tanks are called ponds or *bundhis,* which are mostly community owned. The command areas of such schemes are 20 hectares or less. Larger storage tanks whose command varies from 20 to 2000 hectares are generally constructed by government departments or local bodies; these are the biggest items of surface minor irrigation works.

Key Numbers:

1. The number of surface flow schemes has declined from 6.01 lakhs in 2006-07 to 5.92 lakhs in 2013-14.

2. These are operational in in 661 districts of the country and are irrigating 4.89 million ha of land.

3. A majority of these surface flow schemes are in Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Jharkhand, Tamil Nadu, and Uttarakhand.

4. In surface flow schemes, tanks/ ponds have largest share of 41%, followed by reservoirs (14%) and temporary diversions (10%). 75% of surface flow schemes are largely held in public ownership (54%), with the remaining 46% being owned by private entities.

5. The government owns a majority (75%) of public owned surface flow schemes, followed by Panchayats (17%). In the case of privately owned surface flow schemes, a majority (73%) are owned by individual farmers and only 27% are owned by groups of farmers. Marginal and small farmers have the largest share in individual ownership of surface flow schemes (58%).

6. Regarding social status of ownership, about 11.1% of such schemes belong to those belonging to the Scheduled Caste community, followed by Scheduled Tribe (27.9%), a further 29.6% to Other Backward Castes (OBCs), and 31.4% of such schemes belong to "Others".

7. With regard to the status of these surface flow schemes, 78% of those 'in use' are functioning without any constraints in utilisation of potential. Of the remaining 22% which have constraints in utilisation, the predominant reasons for underutilisation are, 'others' (45.7%) followed by 'storage not filled up fully' (19.3%) and 'less discharge of water' (16.7%)

Surface Lift Schemes

In regions where the topography does not permit direct flow irrigation from rivers and streams, water must be lifted into the irrigation channels. These works are similar to diversion schemes, but in addition, pumps are installed, and pump houses are constructed. These schemes, being costly in operation, are feasible only in areas where

- Gravity flow irrigation is not possible,
- There is keen demand for irrigation and cultivators are enthusiastic,

- Water is available in the streams for at least about 200 days in a year,
- Cheap electric power is available.

Installation of diesel-operated pump sets for lifting water makes the operation and maintenance cost of these schemes exorbitantly high. However, for lifting a small order of discharge by individual cultivators, portable diesel engine pump sets are feasible as they provide greater flexibility and mobility for installation at different points of the water source or sources. Solar Pumps are also used in some areas. The CCA of such schemes be up to 20 hectares.

Key Numbers:

1 The number of surface lift schemes has declined from 6.47 lakhs in 2006-07 to 6.0 lakhs in 2013-14.

2 These surface lift schemes are operational in 661 districts of the country, irrigating 3 million ha of land.

3 A majority of these surface lift schemes are located in Maharashtra, Karnataka, Madhya Pradesh, Odisha, West Bengal and Gujarat.

4 Three-fourth of surface lift schemes are in rivers (36%) followed by tanks/ ponds/ reservoirs/ check dams (25%), streams (17%) and drains/ canals (13%).

5 Three-fourth of Surface lift schemes are dominantly owned by private entities (80%). Out of these, about 81% surface lift schemes are owned by individual farmers and only 19% are owned by group of farmers. Marginal and small farmers have the largest share in ownership of surface lift schemes (58%).

6 With regard to the social status of the farmers owning surface lift schemes, about 40.9% schemes belong to 'Others' social group followed by Other Backward Castes (OBCs) (33.1%), Scheduled Tribe (14.8%) and Scheduled Caste (11.2%).

7 Around 94% surface lift schemes have single lifting device in which about 58% are centrifugal pumps followed by submersible pumps (35%). Around 91% surface lift schemes are having single source of energy in which electricity is dominating (68%) followed by diesel (29%).

Storage Schemes (Tanks and Others)

Storage schemes include tanks and reservoirs which impound water from streams and rivers for irrigation purposes. After wells, tanks occupy a very important place under the minor irrigation programme. They provide nearly two-thirds of the total irrigation from minor sources in the states of Andhra Pradesh, Karnataka, Kerala, Maharashtra, Orissa and Tamil Nadu. Tracts with undulating topography and rocky substrata are eminently suitable for tank irrigation. Besides this, there exists scope for further construction of tanks in many areas.

Many existing tanks in the southern states have gone into disuse due to long neglect of repairs. The renovation of these tanks to restore their lost irrigation potential is being accorded priority under the minor irrigation programme. The essential features of these schemes are as follows.

- A bund or a dam which is generally made of earth, but also sometimes partly or fully of masonry,
- *Anicut* and feeder channels to divert water from adjoining catchments,
- Waste weir to dispose of surplus flood water,
- Sluices to let out water for irrigation, and
- A conveyance and distribution system.

Storage size is determined by the runoff expected based on dependable monsoon rainfall in the catchment, and by whether the rainfall and cropping patterns will permit more than one filling of the tank.

Diversion Schemes:

These schemes aim at providing gravity flow irrigation by diverting stream water supply without creating any storage. As compared to storage schemes, they are economical. Their feasibility, however, is dependent on the presence of flow in the stream at the time of actual irrigation requirements. Essentially such schemes consist of the following.

- An obstruction (weir) or bund constructed across the stream for raising and diverting water; the weir being called *Anicut* in the South, *Bandhara* in Maharashtra and Gujarat, and *Bandh* in the Assam region, and
- An artificial channel, known as *Kul* in the hilly areas, *Pyne* in Chhota Nagpur and Bihar and *Dong* in the Assam region.

The irrigation capacity of diversion schemes is dependent on the actual flow in the stream at the time the irrigation is required. The cold weather and the hot weather flow, therefore, need to be ascertained carefully before deciding on the feasibility and economics of these schemes.

Water Conservation-cum-Groundwater Recharging Schemes

These are schemes which serve primarily one or more of the following purposes:

- Submerging agricultural land during monsoon for sowing post-monsoon crops,
- Improving the moisture regime of adjoining fields downstream for raising post-monsoon crops without irrigation and replenishing groundwater.

An additional advantage of these schemes is that they help to conserve soil. When constructed in the headwater region that serves the catchment area of tanks below, they serve an important purpose of retarding the silting rate of these tanks. This system of water conservation through field embankments is peculiar to central Indian tracts and is commonly practised in northern Madhya Pradesh, Bundelkhand region of Uttar Pradesh and eastern Rajasthan.

In the Bundelkhand region, these works are popularly known as '*Bundhies*', which consist of earthen embankments thrown across gently sloping ground. During the rainy season, water is stored upstream and the land gets submerged. If the land slope is gradual, large areas often get submerged even by low embankments. Ordinarily, no direct irrigation is carried out and the benefit is mostly due to submergence.

The soil is generally black and moisture-retentive in nearly all these areas. When it remains submerged underwater during the rainy season, it retains enough moisture to grow good rabi crops. The remaining water is let out, and the submerged land is released for cultivation. The other advantage of submerging land in this manner is that the first flood brings a lot of silt which acts as rich manure. By preventing free flow of water across steep gradient, the soil of the land is also conserved.

Percolation tanks primarily constructed for the purpose of recharging groundwater are in vogue in Maharashtra, Tamil Nadu, Kerala and Rajasthan. Check-dams or *rapats* are in vogue in Rajasthan. They consist of bunds constructed across streams for the purpose of retarding the surface flow (and also the sub-surface flow to some extent) by flattening the bed slope of the stream. This results in increased percolation of water in the sub-soil with consequent increase of the groundwater supply.

Datasets to be captured under CWRM planning

Land Use Statistics

The information on area irrigated is an ancillary product from the Land Use Statistics. The net area irrigated by the government canals, private canals, tanks, tube wells, other wells and other sources are compiled for village/tehsil/district and the State level. Similarly, area irrigated more than once under different crops are also compiled. The Directorate of Economics and Statistics, Ministry of Agriculture Farmer's Welfare, Government of India publishes regularly the national level information with time lag of about 3 to 4 years. The primary data for LUS are collected by village *patwaris* in prescribed forms by plot to plot enumeration in certain States and are estimated on the basis of sample surveys in other States. The basic enumeration forms are not the same in the States and the instructions for obtaining details of area under irrigation and its sources are inadequate. In a few States, no separate columns for the sources of irrigation have been provided in the prescribed *Khasra* forms.

3.1.2 Groundwater Sources

The main source of replenishable groundwater resources is recharge through rainfall which contributes to nearly 67% of the total annual replenishable resources. India receives about 1200 mm of rain in a year. Most parts of India receive rainfall mainly during South-West (SW) monsoon. Major parts of the country including Northern, Central and Eastern India receive annual normal rainfall ranging between 750 and 1500 mm.[6]

The properties of rock formations are significant to groundwater recharge. Porous formations like alluvial formations in the Indo-Ganga-Brahmaputra basin which have high specific yield values are the most important repository of groundwater resources. Groundwater occurrences in the fissured formations which occupy almost two-third part of the country including peninsular India, on the other hand, are limited to weathered, jointed and fractured portions of the rocks.

Aquifer Systems of India

An aquifer is a body of earth material that contains sufficient permeable material to yield significant quantities of water to wells. Aquifers in direct connection to the atmosphere are unconfined or water-table aquifers. Confined aquifers are separated from the atmosphere by a confining unit.

Unsaturated Zone (Soil Moisture)

The unsaturated zone, sometimes referred to as the vadose zone or zone of aeration, encompasses the earth materials that lie between the land surface and the water table. The thickness of this zone varies spatially and temporally and may range from 0 to more than 1000 m. In general, thicker unsaturated zones are found in more arid regions. No known estimates exist for water stored in unsaturated zones. The importance of this zone as a storage reservoir is often overlooked because the water held here is generally not extractable for human use. However, this zone is the primary source of water for vegetation, and therefore plays a critical role in the hydrologic cycle. An estimated 76% of precipitation infiltrates the subsurface.

Water moves through the unsaturated zone at a relatively slow rate. Due to this, plants can extract this water over extended periods of time. About 85% of the water that infiltrates the soil surface returns to the atmosphere either by evaporation from soil or by plant transpiration. Water storage within the unsaturated zone is determined by measuring moisture content at different depths between the land surface and the water table.

6 Dynamic groundwater resources of India, CGWB, 2017

Repeated measurements over time can be used to infer rates of storage change. Moisture content can be measured directly by collecting samples in the field and weighing the sample before and after oven drying. Indirect techniques, which are more conducive to automatic recording, take advantage of electrical or physical properties of the sediment-water continuum (for example, time domain reflectometry and neutron moderation). Infiltrated water moves predominantly in a downward direction through the unsaturated zone toward the water table. Water also can move upward (in response to evaporative demand) or laterally (in the case of impeding layers of soil). Rates of water movement are notoriously difficult to measure directly because of problematic measurement techniques.

A principal difficulty in quantifying the movement and storage of water in the subsurface is the natural variability in the physical and hydrologic properties of earth materials at all spatial scales. For convenience, discussion of subsurface hydrology is divided into the unsaturated zone (where open spaces or voids in the earth materials are partly filled with water and partly filled with air) and the saturated zone (where voids in the earth materials are completely filled with water).

Soil moisture is one of the essential climatic variables that plays an important role in partitioning the rainfall into infiltration and runoff components. Using remote sensing, NRSC has derived data base on surface soil moisture. The surface soil moisture is available in standard format with 25 km resolution with India coverage once in two days. The data is available in WRIS web tools, discussed in subsequent sections.

Saturated Zone

Groundwater, water stored within the saturated zone, constitutes the largest reservoir of extractable freshwater on Earth. The saturated zone is bounded above by the water table or by the fixed interfaces at the bottom of surface-water bodies. The lower boundary of the saturated zone is difficult to define. There is a tendency for pores in earth materials to become smaller and fewer with depth, thus limiting the availability of the stored water to humans. Saline groundwater underlies fresh groundwater in most areas.

Inflow to the saturated zone, often referred to as groundwater recharge, occurs when water from precipitation (and irrigation) percolates downwards through the unsaturated zone or when water moves from surface-water bodies to the water table. Outflow from the saturated zone occurs naturally to surface water bodies (for example, through seeps or springs) and to the atmosphere by evapotranspiration.

Various rock formations with different hydrogeological characteristics act as distinct aquifer systems of varying dimensions. The aquifer systems of India can be broadly categorised as follows.

Alluvial aquifers: The Quaternary rocks comprising Recent Alluvium, Older Alluvium, Aeolian Alluvium (Silt/Sand) and Coastal Alluvium of Bay of Bengal are by and large important unconsolidated formations comprising major alluvial aquifers. These sediments are essentially composed of clays, silts, sands, pebbles, *Kankar* etc. These are by far the most significant groundwater reservoirs for large scale and extensive development. The hydrogeological environment and groundwater regime in the Indo-Ganga-Brahmaputra basin indicate the existence of potential aquifers having enormous fresh groundwater reserves. Bestowed with high incidence of rainfall and covered by a thick pile of porous sediments, these groundwater reservoirs get replenished every year and are being used heavily.

In these areas, in addition to the Annual Replenishable Groundwater Resources available in the zone of Water Level Fluctuation (Dynamic Groundwater Resource), there exists a huge groundwater reserve in the deeper part below the zone of fluctuation, as well as in the deeper confined aquifers, which are nearly unexplored. The coastal aquifers show wide variation in water quality, both laterally and vertically, thus imposing quality constraints for groundwater development.

Laterites: Laterites are formed from the leaching (chemical weathering) of parent sedimentary rocks (sandstones, clays, limestones); metamorphic rocks (schists, gneisses, migmatites) and igneous rocks (granites, basalts, gabbros, and peridotites). They are rich in iron and aluminium and formed in hot and wet tropical areas.

They are the most widespread and extensively developed aquifers, especially in the peninsular states of India. Laterites form potential aquifers along valleys and topographic lows where the thickness of the saturated zone is more and can sustain large diameter open wells for domestic and irrigation use.

Sandstone and Shale aquifers: Sandstone and shale aquifers generally belong to the group of rocks ranging in age from Carboniferous to Mio-Pliocene. The terrestrial freshwater deposits belonging to Gondwana System and the tertiary deposits along the west and east coast of the peninsular region are included under this category. The Gondwana sandstones form highly potential aquifers locally. Elsewhere, they have moderate potential, and in places they yield meagre supplies. The Gondwanas, Lathis, Tipams, and Cuddalore sandstones and their equivalents are the most extensive productive aquifers in this category.

Limestone aquifers: The consolidated sedimentary rocks include carbonate rocks such as limestones, dolomite and marble. Among the carbonate rocks, limestones occupy the largest area. In the carbonate rocks, the principal water bearing zones are the fractures and solution cavities. Consolidated sedimentary rocks of Cuddapah and Vindhyan sub-groups and their equivalents consist of limestones/dolomites apart from other major litho-units such as conglomerates, sandstones, shales, slates and quartzites.

Basalt aquifers: Basalt is a basic volcanic rock which forms alternate layers of compact and vesicular beds of lava flows as seen in the Deccan Trap area. The groundwater occurrence in basalts are controlled by nature and extent of weathering, presence of vesicles and lava tubes, thickness of flows, number of flows and the nature of inter and intra-trappean layers. Basaltic aquifers usually have medium to low permeability. Groundwater occurrence in the Deccan Traps is controlled by the contrasting water-bearing properties of different flow units, thus resulting in multiple aquifer systems, at places. The water-bearing zones are the weathered and fractured zones.

Crystalline aquifers: The crystalline hard rock aquifers such as granite, gneisses and high-grade metamorphic rocks such as charnockites and khondalites constitute a good repository of groundwater. Most of the results of groundwater exploration projects have proven that hard rocks neither receive nor transmit water unless they are weathered and/or fractured. The aquifers are the weathered zone or the fracture system.

The fracture system includes fractures, joints, bedding planes, and solution holes. These openings do not have an even distribution and are rather localised. The weathered zone is underlain by semi-weathered rock, fractured rock, followed by bedrock. The depth of the bed rock varies from 30-100 m. In hard rock terrains, groundwater occurs under phreatic condition in the mantle of weathered rock, overlying the hard rock, while within the fissures, fractures, cracks, joints within the hard rock, groundwater is mostly under semi-confined or in the confined state.

Compared to the volume of water stored under semi-confined condition within the body of the hard rock, the storage in the overlying phreatic aquifer is often much greater. In such cases, the network of fissures and fractures serves as a permeable conduit feeding this water to the well. Groundwater flow rarely occurs across the topographical water divides and each basin or sub-basin can be treated as a separate hydrogeological unit for planning the development of groundwater resources.[7]

Artificial recharge of aquifers

In areas where groundwater is an important component of the water supply, and rainfall variability does not allow for a sufficient level of aquifer recharge by natural means, artificial recharge technologies provide for the enhancement of the natural recharge. Storage of surface runoff in underground aquifers in arid and semi-arid areas has the advantage of minimizing evaporative losses. However, use of these technologies requires an appropriate geological structure. In areas underlain by igneous rock, the natural fracture lines can be expanded by injection of water under pressure and infusion of a sand slurry into the gaps thus created. Given the cost of this latter measure, however, use of natural limestone or sandstone formations is preferred and most cost-effective.

7 CGWB, 2017

The use of artificial recharge to store surplus surface water underground can be expected to increase as growing populations demand more water. For example, artificial recharge may be used to store treated sewage effluent and excess stormwater runoff for later use. Groundwater recharge may also be used to mitigate or control saltwater intrusion into coastal aquifers. However, in order to accomplish the uses without deleterious environmental consequences, the optimum combination of treatment methodologies before recharge and after recovery from the aquifer must be identified. It will also be necessary to consider the sustainability of soil-aquifer treatment and health effects of water reuse when using treated wastewater as the recharge medium.

The main purpose of artificial aquifer recharge technology is to store excess water for later use, while improving water quality (decreasing the salinity level) by recharging the aquifer with better water. There are several artificial recharge techniques in use including infiltration basins and canals, water traps, cutwaters, surface runoff drainage wells, septic-tank-effluent disposal wells, and diversion of excess flows from irrigation canals into sinkholes.

Water Traps: Water traps are used to increase infiltration in streambeds. The traps are earthen dams of variable height, usually 1 m to 3 m, that are constructed out of locally available materials. They are normally perpendicular to riverbanks, depending on the characteristics of the stream.

Cutwaters: This technology can be used in areas where there are no rivers and creeks. Cutwaters are excavations of variable dimensions, used as reservoirs, built in low-lying areas. Their primary objective is the harvesting of surface waters. Those intended be used for artificial recharge are built on top of permeable strata; those for surface water storage are built on impermeable substrates.

Drainage Wells: Drainage wells, or “suckwells” are used to dispose of drainage waters. The depth of the drainage wells is determined by the well digger and is based on reaching an adequate fissure or “suck” in the rock. They are provided with guard walls of concrete or coral stone above the ground surface and drainage ports or underground pipes or culverts to conduct runoff into the wells.

Septic Tanks and Effluent Disposal Wells: Another source of artificial groundwater recharge is effluents from septic tanks, using soakaways. The soakaways used for this purpose are very similar to suckwells in design and construction, except that they are used in conjunction with septic tanks and are always covered.

Sinkhole Injection of Excess Surface Flows: Excess surface runoff is treated and discharged into sinkholes in karstic limestone aquifers. These aquifers are commonly associated with seawater intrusion and are highly saline. The recharged water is monitored through a series of monitoring and production wells. Monitoring is carried out to measure changes in groundwater levels and water quality (salinity levels).

Scenario

The groundwater recharge is estimated season-wise both for monsoon and non-monsoon seasons separately. The following recharge and discharge components are assessed in the resource assessment - recharge from rainfall, recharge from canal, return flow from irrigation, recharge from tanks & ponds and recharge from water conservations structures and discharge through groundwater draft.

Table 3.1: Groundwater Recharge

Parameter[1]	Source of Recharge	Range of Parameters
Canal Seepage Factor	Unlined Canals	15 to 30 ham/day/sq.km. of wetted area
	Lined Canals & canals in hard rock terrain	3 to 6 ham/day/sq.km. of wetted area

Parameter[1]	Source of Recharge	Range of Parameters
Return flow factor	Surface water Irrigation	0.10 – 0.50
	Groundwater Irrigation	0.05 – 0.45
Seepage from tanks and ponds	1.4 mm/day over the average water spread area	
Water conservation structures	50% of the Gross Storage. Out of this, 50% is during monsoon season and the remaining 50% during non-monsoon season	

Source: Ministry of Water Resources, 1997

Rain gauge stations are established and maintained by different departments and undertakings of central and state governments and by private parties as per their specific data requirements. Though the period of seasons varies from place to place, for climatological purposes, especially for rainfall, a year is divided into 4 seasons: Winter (January and February), Pre-Monsoon (March to May), South-West Monsoon (June to September) and Post-Monsoon (October to December).

With regard to groundwater schemes, Uttar Pradesh possesses the largest number of schemes followed by Maharashtra, Tamil Nadu, Madhya Pradesh and Telangana. In With regard to surface water schemes, Maharashtra possesses the largest number of schemes followed by Karnataka, Madhya Pradesh, Odisha and West Bengal.

Dug wells: Refers to ordinary open wells of varying dimensions dug or sunk from the ground surface into water-bearing stratum to extract water for irrigation purposes. These are broadly dug-cum-bore wells nowadays or masonry wells/ *kuccha* wells, from which water is lifted.

Most of such schemes are of a private nature belonging to individual cultivators. The width of the well ranges between 2 to 6 meters and the depth between 8 and 15 meters. CCA of a well operated with the help of human/ animals generally varies from 1 to 2 hectares.

There are total of 87.8 lakh dug wells in 661 districts of the country irrigating 168 lakh ha of land. In dug wells, *pucca* dug wells have a majority share of 67%, *kuccha* dug wells (21%), dug-cum-borewells 10%, and others have 2%. Dug-cum borewells have recorded an increase from 4% in the 4th Census to 10% in the 5th census. Dug wells are dominantly owned by private entities (98.3%). Out of these, about 78% dug wells are owned by individual farmers and 22% are owned by groups of farmers.

Ownership by groups of farmers is concentrated in Rajasthan, Tamil Nadu, Maharashtra and Madhya Pradesh. Marginal and small farmers have the largest share in ownership of dug wells (68%). With regard to the farmers who own dug wells: about 50% schemes belong to Other Backward Castes (OBCs) followed by others (30%), Scheduled Tribe (11%) and Scheduled Caste (9%).

Shallow Tube wells: A shallow tube well consists of a bore hole built into the ground with the purpose of tapping groundwater from porous zones. In sedimentary formations, the depth of a shallow tube well does not exceed 35 meters. These shallow tube wells are generally operated for 6 to 8 hours during irrigation season and yield 100-200 cubic meters per day, which is roughly 2 times that of a dug well. Their CCA may go up to 10 hectares.

There are total of 59 lakh shallow tube wells in the country, irrigating 222 lakh ha of land. Shallow tube wells are dominantly owned by private entities (99%). Out of these, about 96% shallow tube wells are owned by individual farmers and only 4% are owned by groups of farmers.

Marginal and small farmers have the largest share in ownership of shallow tube wells (73%). With regard to the farmers who own shallow tube wells: about 47% schemes belong to Other Backward Castes (OBCs) followed by others (34.2%), Scheduled Caste (14.7%) and Scheduled Tribe (4.1%).

Medium Tube wells: A medium tube well consists of a bore hole built into ground with the purpose of tapping groundwater from porous zones. In sedimentary formations, the depth of a medium tube well is in the range of 35-70 meters. The medium tube wells are generally operated for 8-10 hours during irrigation season and give yield of 200-300 cubic meters per day, which is roughly 3 times that of a dug well. Their CCA may go from 1015 hectares.

There is a total of 31.7 lakh medium tube wells in the country, irrigating 116 lakh ha of land. Three-fourths of all medium tube wells are dominantly owned by private entities (99.3%). Out of these, about 94% medium tube wells are owned by individual farmers and only 6% are owned by groups of farmers. Marginal and small farmers have the largest share in ownership of shallow tube wells (61%). With regard to the social status of the farmers owning medium tube wells, about 44.3% schemes belong to Others followed by Other Backward Castes (OBCs) (42.8%), Scheduled Caste (7.4%) and Scheduled Tribe (5.5%).

Deep Tube wells: These usually extend to a depth of 70 metres or more and are designed to give a discharge of 100 to 200 cubic meters per hour. These tube wells operate round the clock during the irrigation season, depending upon the availability of power. Their annual output is roughly 15 times that of an average shallow tube well and are usually constructed as public schemes which are owned and operated by government departments or corporations.

There are total of 26 lakh deep tube wells in the country, irrigating 126.8 lakh ha of land. Deep tube wells have grown rapidly in number from 1 lakh in 1987 to 5 lakh in 2000-01, 14.5 lakh in 2006-07 and more than 26 lakh in 2013-14. Most of them are in Punjab, Rajasthan, Andhra Pradesh, Telangana, Tamil Nadu, Haryana, Madhya Pradesh, Maharashtra and Karnataka. Three-fourths of these deep tube wells are dominantly owned by private entities (98.5%). Out of these, about 81% are owned by individual farmers and only 19% are owned by group of farmers. Marginal and small farmers have the largest share in (50%). With regard to the social status of the farmers who own deep tube wells, about 50.2% schemes belong to Others followed by Other Backward Castes (OBCs) (38.6%), Scheduled Caste (6.7%) and Scheduled Tribe (4.5%).

Issues

Rainfall is the main source of groundwater recharge in the country. However, the distribution of rainfall has a wide variation both in space and time. The development of groundwater in different areas of the country has not been uniform. Out of 6584 assessment units (Blocks/ Mandal's/ Talukas/ Firkas) in the country, 1034 units in various States have been categorised as 'Over-exploited' i.e. the annual groundwater extraction exceeds the net annual groundwater availability and significant decline in long term groundwater level trend has been observed either in pre-monsoon or post- monsoon or both. In addition, 253 units are 'Critical' i.e. the stage of groundwater development is above 90% and within 100% of net annual groundwater availability and significant decline is observed in the long-term water level trend in both pre-monsoon and post-monsoon periods. There are 681 semi-critical units, where the stage of groundwater development is between 70% and 100% and significant decline in long term water level trend has been recorded in either Pre-monsoon or Post-monsoon. 4520 assessment units are Safe where there is no decline in long term groundwater level trend. Apart from this, there are 96 assessment units, which has been categorised as 'saline' as major part of the groundwater in phreatic aquifers is brackish or saline. [8]

3.2 Understanding Water Demand Dimensions

3.2.1 Drinking Water:

As on 1 April 2019, the data from Ministry of Jal Shakti (D*epartment of Drinking Water and Sanitation*), shows that 81% of rural habitations in the country have potable drinking water through various schemes. Additionally, 46% of rural habitations and 54% of rural population have piped water supply with provisions of at least 40 litres per capita per day (lpcd). This includes household tap connections and stand posts. In 2017, out of 731 districts, in 256 districts and 1592 blocks were classified as water stressed. This needs special attention and strategy.

8 CGWB, 2017

Under the Jal Jeevan Mission (JJM), States/ UTs are to plan for achieving drinking water security and to provide Functional Household Tap Connection (FHTC) to every rural household. It may not be feasible for the state government/ departments to manage water supply to every household. Therefore, the role of Gram Panchayat and/ or its sub-committee/ local community becomes critical in planning, implementation, management, operation and maintenance of water supply within the villages.

Moreover, Panchayats have a constitutional mandate to manage drinking water. Further, it is necessary that within the villages, local community/ Gram Panchayat and/ or its sub-committee, i.e. VWSC/ Paani Samiti/ User Group, etc. plays the key role for O&M, cost recovery, and good governance.

For achieving the objectives of JJM, communities are expected to utilise to make the best of this opportunity and ensure that every rural household has FHTC delivering water in adequate quantity (minimum 55 lpcd) of prescribed quality (BIS:10500) and on regular basis.

Issues and Concerns related to Drinking Water and WASCA

Certain strategies are adopted to achieve the objective of JJM. Under CWRM, a few of these strategies are of importance for planning and implementation. They are as follows:

- In villages with sufficient groundwater availability of prescribed quality within the village boundary, the same local water source is to be used; Under CWRMP – WASCA, this is the area of interest (AoI). Identifying such sources and source stabilisation through watershed approach is the action.
- In hills and mountains, springs as a reliable source for drinking water are to be explored. Under CWRMP – WASCA, mapping of such sources and works for stabilisation of such sources are to be undertaken.
- In hot and cold deserts, innovative approaches and possible technological interventions will be explored.
- In villages with enough groundwater availability but with quality issues, in-situ suitable treatment technologies may be explored.
- In villages falling in drought-prone areas, conjunctive use of multiple sources of water can be explored (such as ponds, lakes, rivers, groundwater), supply from long distance, rainwater harvesting and/ or artificial recharge.
- In villages with water quality issues as well as non-availability of suitable surface water sources in nearby areas, it may be more appropriate to transfer bulk water from long distance. Further, in drought-prone and desert areas, where it is not possible to have water supply through conjunctive use, a similar approach to transfer bulk water from long distance may be adopted.
- In water quality-affected habitations, especially with Arsenic and Fluoride contaminants, potable water must be ensured on priority. Since planning and implementation of a piped water supply scheme based on a safe water source will take time, as a purely interim measure, Community Water Purification Plants (CWPPs) may be taken up to provide 8-10 lpcd potable water to meet drinking and cooking needs of every household residing in such villages/ habitations.
- In states with water-scarce areas/ areas lying in rain shadow region with inadequate rainfall, it is necessary to plan for regional water supply schemes covering both urban and rural areas by sourcing water from a perennial surface source.
- In cases of high-altitude cold deserts, areas facing extreme terrain challenges, sparsely populated hot deserts, etc., it might not be feasible to provide FHTC to every rural household. In such areas, as mentioned in points local innovations to be explored.

For Drinking water sources under CWRM planning, the guidelines of Jal Jeevan Mission provide the scope for identification of works and suitable sites for recharging (e.g.: dedicated bore well), recharge structures, rain water recharge, rejuvenation of existing water bodies, etc. adopting using watershed/ spring-shed principles, in convergence with other schemes such as Mahatma Gandhi NREGS, IWMP, Finance Commission grants, state schemes, MPLAD, MLALAD, and CSR.

Datasets to be captured under CWRM planning

The data required for CWRM planning for drinking water is related to current demand, current sources for drinking water, their functionality, demand forecasting, and areas of interventions for source stabilisation.

The data can be taken from the Public Health Engineering Department (PHED) datasets of respective states, or from the 2011 Census and extrapolated to future demand as recommended under Jal Jeevan Mission's Village Action Plan guidelines.

Indicators under CWRM planning

- Number of Sources (Groundwater) identified for Source Stabilisation
- Number of Sources (Surface) identified for Source Stabilisation
- Number of Activities identified for Source Stabilisation (GW)
- Number of Activities identified for Source Stabilisation (SW)
- Number of innovations identified for works in difficult areas

Water for agricultural use

Agriculture is characterised by an extremely fragmented landholding structure with an average farm size of 1.15 hectares and the predominance of small and marginal farmers, with those holdings less than 2 hectares[9] account for 85% of agricultural households. This makes it difficult for them to access credit or new technology, severely affecting farm productivity and hence, farmers' incomes.

India is already categorised as a water stressed country in terms of per capita freshwater availability (1544 cubic meter in 2011). Out of the 4% share of global freshwater availability in India, almost 78% of water is consumed by the agriculture sector. According to the Central Water Commission (CWC), by 2050, the total water demand will overshoot supply in the country and the share of irrigation will come down to 68% World Resource Institute (WRI), on the other hand, has estimated that 54% of the country's areas face extreme water stress. Therefore, improving water use efficiency is the key priority of Indian Agriculture. [10]

Water availability for agricultural use has reached a critical level as the country uses more than 80% of the surface water for this sector alone. On the other hand, inefficient and dilapidated canal irrigation systems have led to a spurt in groundwater development. India is the largest user of groundwater in the world with over 60% of irrigated agriculture and 8 % of drinking water supplies dependent on aquifers.[11]

Crops need water for transpiration and evaporation. The plant roots suck or extract water from the soil to live and grow. Most of this water does not remain in the plant but escapes to the atmosphere as vapour through the plant's leaves and stems. This process is called transpiration. Transpiration happens mainly during the daytime.

The water need of a crop is usually expressed in mm/day, mm/month or mm/season. Suppose the water need of a certain crop in a very hot, dry climate is 10 mm/day. This means that each day, the crop needs a water layer of 10 mm over the whole area on which the crop is grown.

It does not mean that this 10 mm has to indeed be supplied by rain or irrigation every day. It is, of course, still possible to supply, for example, 50 mm of irrigation water every 5 days. The irrigation water will then be stored in the root zone and gradually be used by the plants: every day 10 mm. The crop water need mainly depends on[12]:

9 Strategy for new Indai@75, NITI Aayog, 2018
10 Water productivity mapping of major Indian crops, NABARD, 2018
11 India Water Portal. Retrieved from https://www.indiawaterportal.org/topics/agriculture
12 Crop water needs, FAO

The climate	For example, crops in a sunny and hot climate need more water per day than those in a cloudy and cool climate
The crop type:	Crops like rice or sugarcane need more water than crops like beans and wheat
The growth stage:	Grown crops need more water than crops that have just been planted

Effect of major climatic factors on crop water needs

A certain crop grown in a sunny and hot climate needs more water per day than the same crop grown in a cloudy and cooler climate. There are, however, other climatic factors apart from sunshine and temperature which influence the crop water needs. These factors are humidity and the wind speed. When it is dry, the crop water needs are higher than when it is humid. In windy climates, crops use more water than in calm climates.

The highest crop water needs are thus found in areas which are hot, dry, windy and sunny. The lowest values are found when it is cool, humid and cloudy with little or no wind. From the above, it is clear that one crop grown in different climatic zones will have different water needs. For example, a certain maize variety grown in a cool climate will need less water per day than the same maize variety grown in a hotter climate. It is therefore useful to take a certain standard crop or reference crop and determine how much water this crop needs per day in the various climatic regions. As a standard crop or reference crop grass has been chosen.

The influence of the crop type on crop water needs is important in two ways:

- The crop type has an influence on the daily water needs of a fully-grown crop; i.e. the peak daily water needs: a fully developed maize crop will need more water per day than a fully developed crop of onions.
- The crop type has an influence on the duration of the total growing season of the crop. There are short duration crops, e.g. peas, with a total growing season of 90-100 days and longer duration crops, e.g. melons, with a total growing season of 120-160 days. And then there are, of course, the perennial crops that are in the field for many years, such as fruit trees.

The crop type not only has an influence on the daily water needs of a fully-grown crop, i.e. the daily peak water need, but also on the duration of the total growing season of the crop, and thus on the seasonal water needs. The duration of the total growing season has an enormous influence on the seasonal crop water need. There are, for example, many rice varieties, some with a short growing cycle (e.g. 90 days) and others with a long growing cycle (e.g. 150 days).

This has a strong influence on the seasonal rice water needs: a rice crop which is in the field for 150 days will need, in total, much more water than a rice crop which is only in the field for 90 days. Of course, the daily peak water need for the two rice crops may still be the same, but the 150-day crop will need this daily amount for a longer period. The time of the year during which crops are grown is also very important. A certain crop variety grown during the cooler months will need substantially less water than the same crop variety grown during the hotter months.

Determination of crop water requirement (CWR)

It is important for appropriate estimation of CWR, which will facilitate better planning of water resources projects, hydrologic water balance studies, water assessment, and design of irrigation systems. It also eliminates over-irrigation, leading to better water use efficiency and conservation of irrigation water, resulting in more water availability for other sectors. The following institutes are dealing with crop water requirements and assessments:

- Indian Institute of Water Management (IIWM), Bhubaneswar
- Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad
- Indian Agricultural Research Institute (IARI), New Delhi
- Indian Council of Agricultural Research (ICAR)- various Centres
- Water and Land Management Institute (WALMI) - various Centres
- Irrigation Management Training Institute (IMTI) - various Centres

Issues

India has about 140 million ha of cultivable land[13] . 42% of this land lies in drought-prone areas/districts. Moreover, 54% of India's net sown areas are dependent on rain, and rain fed agriculture plays an important role in the country's economy. A dearth of storage procedures, lack of adequate infrastructure, and inappropriate water management has created a situation where only 18-20% of the water is used.

India's annual rainfall is around 1183 mm, out of which 75% is received in a short span of four months during monsoon (July to September). This results in runoffs during the monsoon and calls for irrigation investments for rest of the year.

The population of India is likely to be 1.6 billion by 2050, resulting in increased demand for water, food and energy. This calls for infrastructure expansion and improved resource utilisation[14].

The availability and demand for water resources in India show sizeable variations from one region to another. There is an inefficient and inequitable use of and distribution of water. Nearly 90% of the India population live in areas with some form of water stress or food production deficit. Groundwater has been relatively abundant in most parts of India. However, in some regions, it is becoming one of the most serious resource issues.

Other issues on agriculture and water identified by National Water Mission, MoJS:

- India uses 2-3 times the water to produce one unit of major food crops compared to other major agricultural countries like China, Brazil and USA.
- It extracts more groundwater than USA and China put together.
- It largely uses flood irrigation techniques which result in huge wastage of water.
- It has water intensive crops like paddy and sugarcane together grown over one-fourth of the gross cropped area.

Water use efficiency

Different approaches have been put forward for enhancing water use efficiently. The method of irrigation followed in the country is flood irrigation, which results in a lot of water loss. Greater efficiency in irrigation can be achieved through the following.

- Proper designing of irrigation systems to reduce water conveyance loss.
- Adoption of water saving technologies such as sprinkler and drip irrigation systems, which have proven extremely effective in not just water conservation but also leading to higher yields.
- New agronomic practices like raised bed planting, ridge-furrow method of sowing, sub-surface irrigation, and precision farming which offer a vast scope for economising water use.

In this context, the Indian government has tried to inculcate new policies and schemes to improve agricultural productivity, while simultaneously increasing water use efficiency. *Sahi fasal* is a campaign launched by the National Water Mission with the goal of raising incomes of farmers with appropriate agriculture produce using less amount of water on a sustainable basis and:

- Intervene proactively to reduce the area under water-intensive crops like paddy, sugarcane, and cotton; farmers to grow alternate crops like corn, millets, soybean, vegetables or horticulture.
- Provide support in terms of seeds, technical help, and markets to promote crop diversification.
- Better and strengthened procurement policy that promotes purchase of traditional crops. Incentivise farmers for use of less water and electricity in agriculture.

Increase yield per unit of water by-

- Improving non-water inputs that increase production per unit of water consumed.
- Changing to new/ different crop varieties with higher yield per unit of water consumed.
- Using micro-irrigation (drip, sprinklers and micro-sprinklers).

13 BMEL, India country report, 2016
14 Water and Agriculture in India Background paper for the South Asia expert panel during the Global Forum for Food and Agriculture (GFFA) 2017; BMZ

Reduce non-beneficial depletion and increase the intensity of water use by-

- Restricting evaporation from bare soil and from fallow land,
- Reducing water flows to sinks (deep percolation and surface runoff),
- Minimizing salinisation of recoverable return flows,
- Better Storage, conveyance, and distribution efficiency,
- Adopt better agriculture/ industrial practices that reduce water use,
- Appropriate pricing of water to make people aware of "Water's Value",
- Reallocate water from lower to higher value uses within or between sectors,
- Co-manage water by promoting multiple uses,
- Mantras of 3Rs--Reduce, Reuse, Recycle.

Datasets to be captured under CWRM planning

The data under CWRM planning for agriculture water requirement for irrigated and dry land areas is collected and collated in the data sheet. The data provides auto-calculation of agriculture and horticulture crops. This provides the necessary water requirement for agriculture and helps in arriving at the thrust areas for work in water management and areas for improvement for water use efficiency.

Indicators under CWRM planning

- Baseline data for agriculture crop requirement and major crops
- Identification of areas for implementing water use efficiency
- Identification of intervention areas for bringing in water use efficiency with climate resilience
- Additional areas brought under productive use with climate resilience

Moisture regime management practices under ET for climate resilience will provide a set of practices and works for efficient water management.

Water for livestock

India has a large and rising livestock population comprising of cattle, buffaloes, goats, sheep, camels etc. Draught power for agriculture and dairy milk production are the two main purposes for rearing bovines while small ruminants are reared in a low input intensity manner taking advantage of the forest and common lands.

Livestock composition is seen to be influenced by numerous factors: prevalence of forests, availability of irrigation, advent of mechanisation and development of remunerative markets for livestock products. Water is required for direct consumption by livestock as well as for supporting the production of biomass on which livestock thrives.

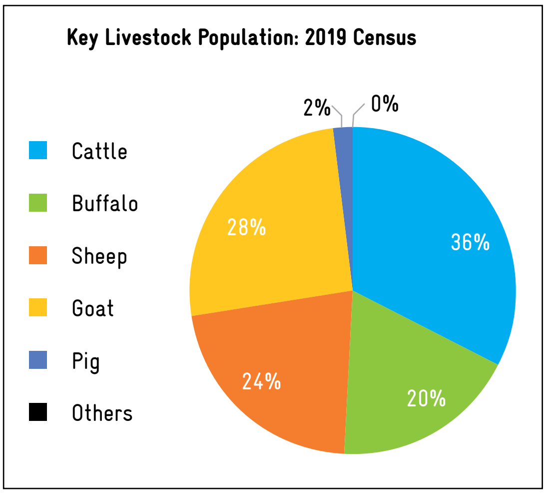
The estimate of 5 billion cubic meters of water for livestock as done by the National Commission for Integrated Water Resources Development is possibly on the lower side when both these factors are considered. Livestock contributes significantly to the household economy of the poor, but they own no water sources to support their livestock[15]. The water requirement of livestock has an important dimension of social equity. Additionally, water quality and livestock production appear to have a two-way interaction.

The Department of Animal Husbandry and Dairying (DAHD) released a census report of livestock population for the year 2019 on October 16. The data revealed that the livestock population in India has grown by 4.6% from 51.2 crore in 2012 to about 53.6 crore in 2019. The population of cows showed an impressive increase of 18% over the previous census. The numbers of other cattle have marginally increased, but cows are accounted for one-fourth count of total livestock population of India.

15 Livestock-Water Interaction: Status and Issues, IWMI, Anand

The Indian livestock production system is fragmented. Small livestock herds are maintained by a large number of farmers engaged in mixed rather than specialised farming. While there are specialised livestock producers especially for poultry, sheep and goat, most livestock owners keep the stock along with their farming operations.

The average herd size in case of bovines rarely exceeds single digits while the herd sizes for small ruminants are slightly larger. Small landholders and landless households are seen keeping small herds of goats that graze off common lands. This nature of livestock rearing in India makes the sector significantly important to poor rural households.



Livestock need water for three purposes - as all living beings for mere survival, water for growing feed and fodder for the livestock, and water for cleaning etc. The presence of open water bodies for buffaloes to bathe in the summer is considered helpful for a proper reproductive cycle. Some of these needs (e.g. in case of free grazing livestock that graze or browse on wastelands and forests) are met from green water while stored (blue) water has to be deliberately diverted to meet the other needs. Water is used in cleaning or bathing of livestock non-consumptively.

The subject of the water needs of livestock is important in view of their importance the national economy, and the even greater importance of livestock production systems to the household economies of poor households as well as to households in drought prone areas. Poor households usually do not have their own source of water and must depend on water obtained from wells or other sources either belonging to other households or to the public agencies. The complex interactions involved in these transactions are important to the socio-economic conditions surrounding the livestock sector.[16]

Providing quality water is essential for good livestock husbandry. Water makes up 80% of the blood, regulates body temperature and is vital for organ functions such as digestion, waste removal and the absorption of nutrients. Understanding daily livestock water needs is key to designing a livestock watering system. The animal's size and growth stage will have a strong influence on daily water intake. Consumption rates can be affected by environmental and management factors. The water requirement for livestock is generally:

- Water requirement for drinking and washing/cleaning
- Water requirement for feed and fodder (green fodder, straw/Stover/crop residues, protein and energy source) production.

A livestock unit is a convenient unit for calculating needs of all the animals. It is based on the live weight of a matured cow. The livestock unit figure can be used to estimate livestock feed, fodder, water requirements over certain period of time.

1 Cow (400-500kg) = 1 Livestock Unit (LU); 1 Bull = 0.8 LU; 6 sheep and goat = 1LU; 200 chicken=1 LU. Likewise, all the LUs are defined.

The sources of information on livestock are livestock census data which can be downloaded from *farmer.gov.in*. Other important information on livestock can be taken from the economics and statistical handbooks of respective states and from their respective agriculture university portals. The important schemes and aspects related to livestock management are provided under the Department of Animal Husbandry and Dairying at *www.dahd.nic.in*.

16 Livestock-Water Interaction: Status And Issues, Tata Water Policy Programme, Anand, India

Issues

- To meet the green fodder and concentrate requirement of livestock 161.81 and 142.76, 157.67 and 172.04 BCM water is required in the years 2020 and 2025, respectively.[17] Nearly 29% of the water in agriculture is directly or indirectly used for animal production. Livestock water productivity for the unit animal product is influenced by 3 factors - namely feed conversion efficiency (amount of feed consumed per unit of meat/milk produced), diet composition (roughage to concentrate ratio), and the feed origin.
- To produce the maintenance diet for 1 tropical livestock unit (TLU: measured at 250 kg live weight), about 450m^3 of water is required annually.
- For buffalo/cattle 30 litres/day of water for drinking and another 30 litres/day for other purposes were considered. It is assumed that sheep and goats require 4.0 and 4.5 litre water/day for drinking, and 1 litre water is required for processing each kg of meat.
- The green fodder production in the country is insufficient to meet the requirements of a growing livestock population, and forages offered to animal are mostly of poor quality. At present, the country faces a net deficit of 10.95% dry crop residues, 35.6 % green fodder and 44% concentrate feed ingredients[18]

State Governments have been requested to dovetail the fodder and feed development programmes with the Mahatma Gandhi NREGA, the guidelines of which provide for location-specific grassland development to ensure adequate fodder supply. The guidelines for the new/additional works permitted under the scheme also prescribe various livestock related works, including construction of fodder trough (manger) and Azolla units.

It is suggested that all the beneficiaries who receive or have received the chaff cutters under any of the government schemes be aided under Mahatma Gandhi NREGA for construction of fodder troughs and Azolla.

Datasets to be captured under CWRM planning

Data tables are created to estimate the water requirement under CWRM planning for every type of animal with standard Livestock Unit as prescribed by the Department of Animal Husbandry and Dairying (DAHD). Based on the data available in the livestock census, the estimates for every village are arrived at. The livestock census data can be downloaded from farmer.gov.in as given below:

Source: www.farmer.gov.in

17 Water requirement estimates of feed and fodder production for Indian livestock vis a vis livestock water productivity, Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh, 2014

18 Strategies to increase quality and availability of green fodder production in eastern region of India: A review, Department of Agronomy, Bihar Agricultural University

Indicators under CWRM planning

- Water requirement for livestock is assessed
- Special site-specific works for meeting livestock water demands are identified for demonstration.

Rural Industry Water (Value Chain of Agriculture, Horticulture, Poultry, etc.)

In rural areas, industries and businesses operate differently and are mostly a part of the eco-system of products emerging from the associated natural resource base and some parts of the value chain. The primary businesses and industry in rural areas which have significant linkage with water sector are:

- Agriculture industry (Including Agriculture, Horticulture, Floriculture, Sericulture, Coir etc.)
- Milk and Meat industries
- Wool-making
- Jute Fibre making
- Handloom industries
- Water Supply (RO)
- Food Industry
- Oilseed processing value chain
- Tourism
- Forest-based products industries
- Electrical, mechanical, and electronic sheds

The most prominent rural agriculture industry is the rice mills industry.

Rice Mills

Typically, the rice processing units in the country are categorised into small, medium and large by size, and most of them are situated in the paddy producing regions spread over various states in India.

Typically, mills with a capacity of less than 3 tonne/hr can be categorised as small mills, 3 to 15 tonne/hr as medium, and those with capacity greater than 15 tonne/hr as large. Most of the large and medium units generally produce both Parboiled and White (Raw) Rice using separate production lines, while most small-scale units generally produce White (Raw) rice alone. Wastewater generation is higher in rice mills producing Parboiled rice and it is a big challenge in small and medium mills. Further, if White rice Mills do not take care of landfill management for water disposal, it may lead to pollution of water bodies.

District Industry Centre (DIC)

Information on the village industries is to be collected from the District Industry Centre database. The micro, small and medium enterprises are supported by DIC (MSMEs). Additionally, it provides training and capacity development. Additionally, the central and state Pollution Control Boards provide necessary guidelines and monitor the pollution levels.

Issues

The major issues surrounding rural industry sector with respect to water security are

- Wastewater disposal
- Land filling
- Constructions leading to obstruction to water channels, natural drainages and streams

Datasets to be captured under CWRM planning

- Identification of the nature of rural industry within the village boundary
- Estimation of water requirement unit-wise through data obtained by the concerned Managers of DICs
- Assessment of measures for wastewater treatment, disposal and recycling.

Indicators under CWRM planning

- Demand estimation of water for rural industries
- Source sustainability
- Technologies for water efficiency
- Technologies for recycling and reuse of water

Evapotranspiration (ET)

Evapotranspiration (ET) is an important component of the water cycle and is composed of two sub-processes: evaporation from soil and vegetation surfaces, and transpiration that consists of the exchange of moisture between plants and the atmosphere. Here, evapotranspiration is defined as the water lost to the atmosphere from the ground surface, due to evaporation from the capillary fringe of the groundwater table, and the transpiration of groundwater by plants whose roots tap the capillary fringe of the groundwater table.

The transpiration aspect of evapotranspiration is essentially evaporation of water from plant leaves. Studies have revealed that transpiration accounts for about 10% of the moisture in the atmosphere, with oceans, seas, and other bodies of water (lakes, rivers, streams) providing nearly 90%, and a tiny amount coming from sublimation (ice changing into water vapour without first becoming liquid).

Plants put down roots into the soil to draw water and nutrients up into their stems and leaves. Some of this water is returned to the air by transpiration. Transpiration rates vary widely depending on weather conditions such as temperature, humidity, sunlight availability and intensity, precipitation, soil type and saturation, wind, and land slope.

During dry periods, transpiration can contribute to the loss of moisture in the upper soil zone, which can influence vegetation and food-crop fields. The amount of water that plants transpire varies greatly geographically and over time. There are several factors that determine transpiration rates:[19]

Temperature: Transpiration rates go up as temperature goes up, especially during the growing season when the air is warmer due to stronger sunlight and warmer air masses. Higher temperatures cause the plant cells which control the openings (stoma) where water is released to the atmosphere to open, whereas colder temperatures cause the openings to close.

Relative humidity: As the relative humidity of the air surrounding the plant rises, the transpiration rate falls. It is easier for water to evaporate into drier air than into more saturated air.

Wind and air movement: Increased movement of the air around a plant will result in a higher transpiration rate. Wind will move the air around, with the result that the more saturated air close to the leaf is replaced by drier air.

Soil-moisture availability: When moisture is lacking, plants can begin to senesce (premature aging, which can result in leaf loss) and transpire less water.

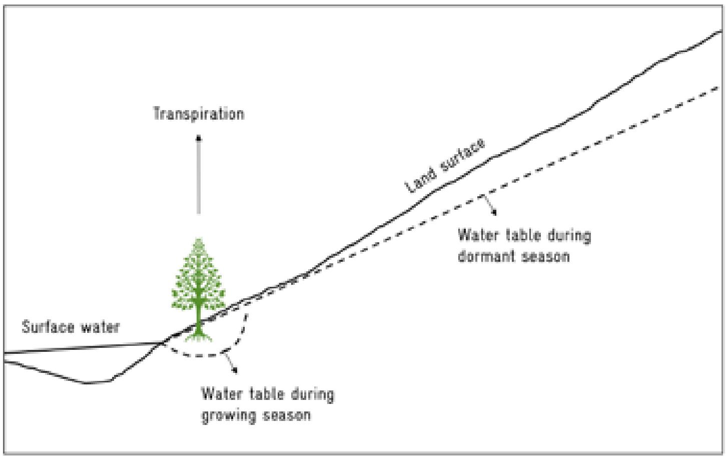
Type of plant: Plants transpire water at different rates. Some plants which grow in arid regions, such as cacti and succulents, conserve precious water by transpiring less water than other plants.

19 Evapotranspiration and the Water Cycle, USGS.

Transpiration and groundwater

In many places, the top layer of the soil where plant roots are located is above the water table and thus is often wet to some extent but is not totally saturated like soil below the water table. The soil above the water table gets wet when it rains as water infiltrates into it from the surface. It will, however, dry out without additional precipitation.

Since the water table is usually below the depth of the plant roots, plants are dependent on water supplied by precipitation. As this diagram shows, in places where the water table is near the land surface, such as next to lakes and oceans, plant roots can penetrate into the saturated zone below the water table, allowing the plants to transpire water directly from the groundwater system. Here, transpiration of groundwater commonly results in a drawdown of the water table, much like the effect of a pumped well (cone of depression—the dotted line surrounding the plant roots in the diagram).



A useful way to detect the response of ET to climate variability accurately is by using ground-based ET observations. However, due to limited spatial representation by ground observations and a relatively sparse ground observation network in India, it is very difficult to upscale it to understand ET dynamics at a national scale. Considerable efforts have been made all over the world to understand ET dynamics using a weather data-driven approach, soil moisture measurements, and surface energy balance methods. These approaches provide relatively precise ET estimates, but require a substantial amount of soil, vegetation and climate related data.

Issues

Climate change has emerged as the most prominent of the global environmental issue, and there is a need to evaluate its impact on the agriculture as the temperature is projected to increase in near future. Furthermore, climate change provides more energy that causes changes from liquid to gaseous forms, as well as increased evaporation (E) to which reduces the share of transpiration.

Evaporation is the unproductive loss of water and is mainly responsible for the lower land as well as water productivity, while transpiration (T) is the desired component, as greater the transpiration (T), the greater is the nutrient inflow along with the water, resulting in higher grain yields. For E, three things are required, viz. sufficient soil moisture, vapour pressure gradient and energy, to cause the phase change. Lack of either of these factors will lead to Evaporation not happening. Among different soil water balance components, Evapotranspiration (ET) is the one which further decides the water use efficiency.

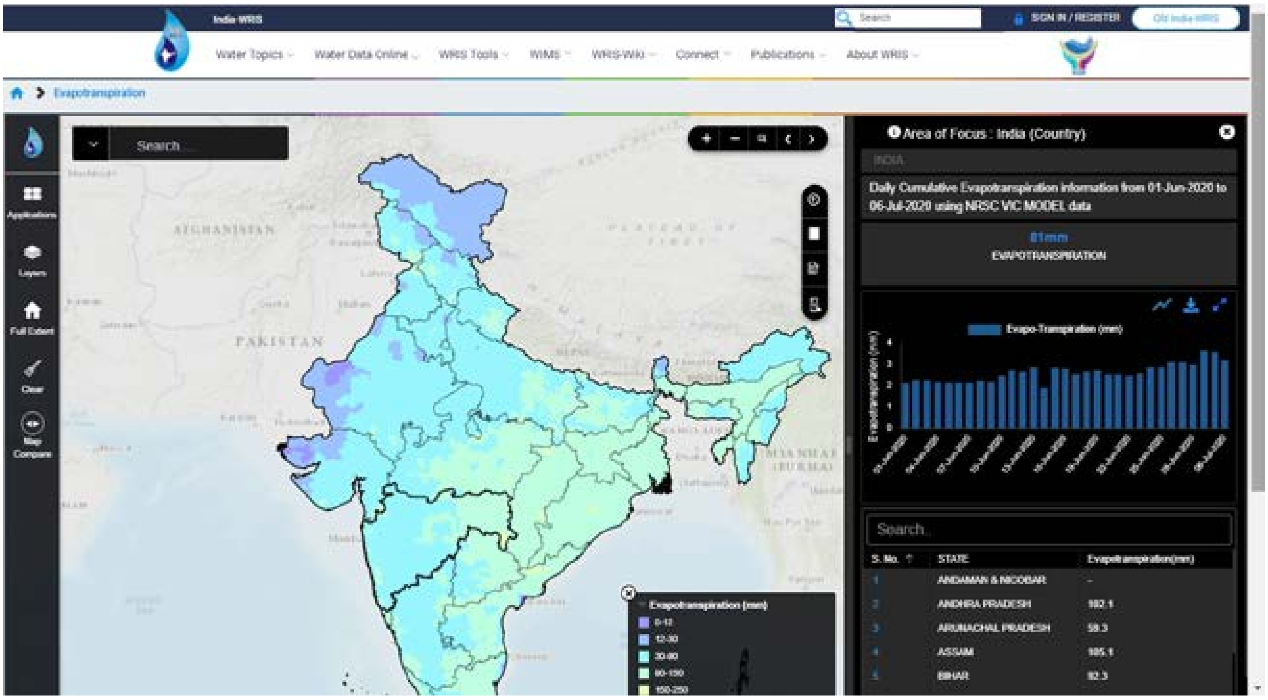
While on one hand, climate change impacts soil-water balance that leads to change in evaporation and plant transpiration, increasing temperatures, lack of precipitation and soils water unavailability will lead to a decrease in crop production on the other (through shortening of the crop growth cycle). Therefore, it is important to understand evaporation, transpiration as well as evapotranspiration to mitigate their adverse effects under changing climates in the future.

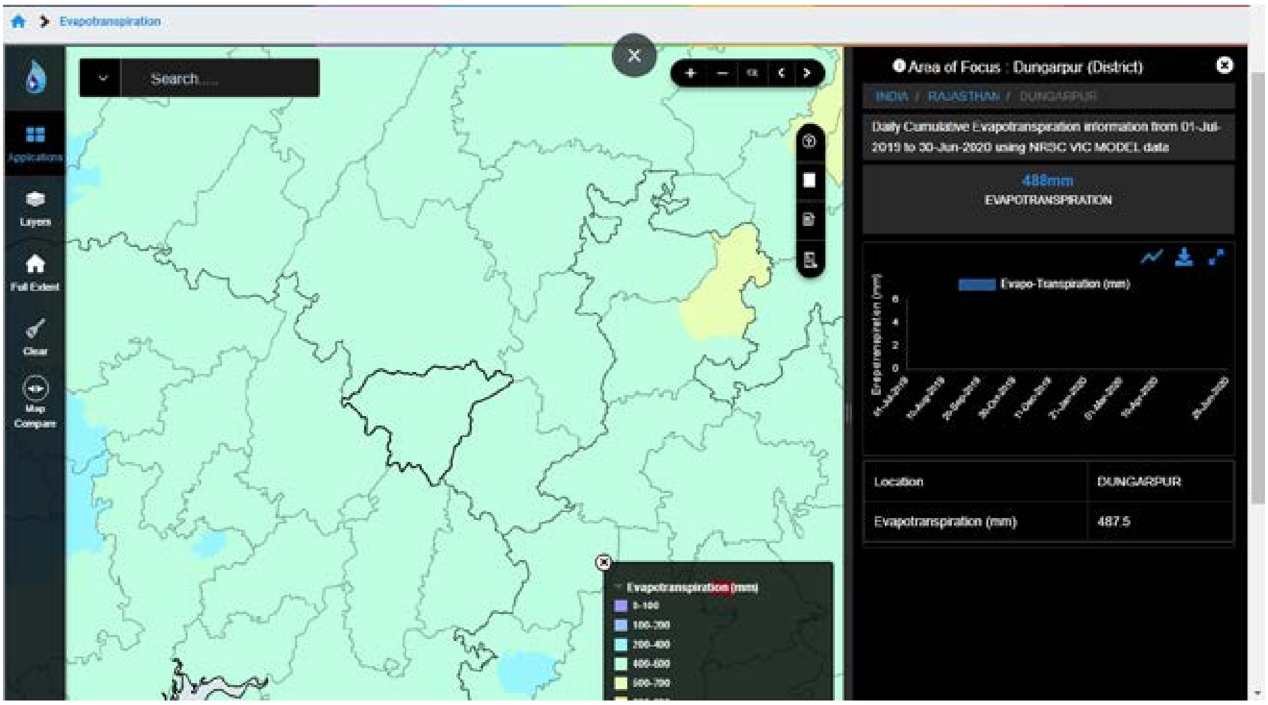
Datasets to be captured under CWRM planning

The key datasets for the understanding of ET are:

- Rainfall data (30 years) from IMD
- Soil types
- Cropping patterns

These are to be compared with the GIS data provided under the India WRIS.(http://indiawris.gov.in/wris/#/waterData). Analysis of these datasets will provide areas of interventions, primarily focusing on productivity increase through water use efficiency in agriculture and horticulture. Combined with soil moisture regime management practices under ET for climate resilience, this data will provide a set of practices and a works list for efficient water management.





Source: India WRIS.(http://indiawris.gov.in/wris/#/waterData)

Indicators under CWRM planning

- Number of technology interventions identified for reducing ET effect on productivity and increasing water use efficiency with climate resilience
- Number of demonstration of technologies in field
- Effect of technology on overall water balance and climate resilience

3.3 Water Quality and Grey Water Concerns

Scenario

Water in its chemically pure form rarely occurs in nature. In fact, water is commonly found to carry a variety of constituents. When water in its precipitate form reaches the surface of the earth, it has already collected several substances and properties that characterise natural water. Gases have been absorbed or dissolved, dust particles have been picked up, and it has obtained a certain temperature. In case of a high radioactive washout or high acidity pickup, atmospheric water may not even be clean in the general sense and may not be suitable for some uses.[20]

Atmospheric water is subject to further changes of quality both upon reaching the earth's surface and during its travel underground. The ability to dissolve salts is gained in the topsoil, where carbon dioxide is released by bacterial action on organic matter. The soil water becomes charged with carbon dioxide resulting in formation of carbonic acid. Under the acidic conditions that develop, many soil and rock constituents are dissolved.

Human influence on the quality of water is quite apparent and is now a major concern. Mixing with municipal and industrial wastewater may result in drastic changes in the water quality of natural water. Agriculturally oriented activities such as irrigation, use of fertiliser, pesticides, herbicides, etc., may lead to diffuse pollution of both surface water and groundwater. Irrigation return waters also tend to increase total salts in the receiving water. Construction schemes such as those connected with river draining, flood control, low flow augmentation, etc. considerably influence the quality regime. Mining activities often cause substantial water quality changes.

The water quality management in India is performed under the provisions of the Water (Prevention and Control of Pollution) Act, 1974. The basic objective of this Act is to maintain and restore the goodness of national aquatic resources by prevention and control of pollution. It prescribes various functions of the Central Pollution Control Board (CPCB) at the apex level and State Pollution Control Boards at the state level.

Issues

There are a great range of water quality parameters that can be used to characterise water. Largely, the water quality measurement objectives and the previous history of the water body determine the selection of parameters. It is true, however, that some parameters are of special importance and deserve frequent attention.

Table 3.2: Parameters influencing the quality of surface water bodies

Parameter	Pointers	Concerns
Temperature	Solubility, growth of aquatic organisms; Warm temperatures; Decreased solubility	Nutrient mix may lead to eutrophication
Colour	Green, yellow-brown or red colour,	a result of presence of microorganisms; Suspended inorganic matter
Odour	Decomposable organic material industrial wastes Excessive growth of algae and other plants	Pronounced when the dissolved oxygen in water is less than about 25% of its saturation value.
Suspended solids	Silt, clay and fine inorganic and organic particles.	Turbidity

20 Water quality activities in CCC, MoJS

Parameter	Pointers	Concerns
Total dissolved solids (TDS)	The ratio of the contribution of the overland flow to the subsoil flow.	Vary from less than 50 mg/L to a few thousand mg/L. evaporation in arid climates, agricultural return waters increase the TDS considerably
Conductivity or electrical conductivity (EC)	The presence of salts, which dissociate into cations and anions	Higher presence of salts leads to increased EC
Ph value	The pH value of natural waters mostly depends on free carbon dioxide, bicarbonates and carbonate ions	Affected by the presence of naturally present humic substances and various acids and alkalis, which may be discharged into the body of water through wastes.
Dissolved oxygen (DO	Ranges from 15 mg/L at 0oC to 7.5 mg/L at 30 degree C normal biological activity, ranges from 80% to 100% of saturation DO level	Lower levels indicate presence of organic pollution. DO in grossly polluted waters may be less than 25% of the saturation value
Nitrogen compounds	Total ammonia concentration in surface waters typically range between 0.1 and 2 mgN/L. In fresh waters nitrate nitrogen concentration seldom exceeds 0.1 mg N/L	Higher values may indicate pollution Concentrations of undissociated ammonia upto 1 mgN/L may be tolerated by most fishes. eutrophication phenomenon, waters having oxidised nitrogen in excess of 0.2 to 0.5 mgN/L are prone to algal blooms
Phosphorus compounds	The sources of phosphorus are : mainly the drainage from phosphate bearing rocks, agricultural runoff and decomposing organic matter. pollution from domestic municipal and industrial wastes.	Higher concentrations indicate presence of pollution and may result in the eutrophication of the water body.
Organic matter	The BOD of unpolluted waters is usually less than 2 mg/L COD of unpolluted surface waters is typically lower than 20 mg/L ToC value of unpolluted surface water is less than 10mg/L	The BOD of domestic and municipal wastes ranges between 150 and 400 mg/L. COD value of domestic and municipal wastes ranges between 400 and 800 mg/L.

Parameter	Pointers	Concerns
Major ions	The ionic species are derived from the contact of water from various mineral deposits Boron in excess of 2.0 mg/L in irrigation water is deleterious to plants. Some sensitive crops may be adversely affected by concentrations as low as 0.5 mg/L. Drinking waters should not contain more than 1.0 mg/L Metals in waters can exist in dissolved, colloidal and suspended forms, as precipitates or adsorbed on other particles	Silica content of natural waters ranges between 1 and 30 mg/L Fluoride, in concentration range between 1.5 and 2 mg/L in drinking water, results in mottling of teeth. Higher concentrations may cause bone diseases The concentration of different metals in unpolluted waters varies over a wide range,0.001 – 0.1 µg/L.
Other inorganics	Concentration of pesticides in water bodies may range from 10-5 to 10-2 mg/L.	The major source of these chemicals in surface water is agricultural runoff.
Biological	Total count of coliforms in unpolluted stretches of rivers may vary between 10 to100 MPN/100 m	Pollutants reaches the count may increase to 103 MPN/100 mL or even 106 MPN/100 mL, depending on the extent of pollution

3.3.1 Groundwater Quality Scenario[21]

Monitoring of groundwater quality is an effort to obtain information on chemical quality through representative sampling in different hydrogeological units. The chemical quality is being monitored by Central Ground Water Board once a year through observation wells located all over the country, as part of a regular monitoring programme.

Aside from these observation wells, the quality is also monitored through various studies like groundwater management studies, groundwater exploration etc. The monitoring activity is aimed at generating background data of different chemical constituents in groundwater on a regional scale.

Groundwater is potable in major parts of the country. However, some water quality issues have been reported from isolated pockets from various parts of the country. Higher levels of constituents like Arsenic, Fluoride, Iron, and salinity in groundwater are due to natural geological phenomena. These are geogenic contaminants found in groundwater. Human activities like mining, disposal of industrial waste, and untreated domestic waste are responsible for contamination by nitrates and heavy metals.

Fluoride in groundwater

As mandated by the BIS, the maximum permissible limit for fluoride in drinking water is 1.5 mg/l. Main source of fluoride in groundwater is fluoride-bearing minerals such as fluorspar (CaF_2), fluorapatite [$Ca_5(PO_4)^3F$], cryolite, and hydroxylapatite in rocks. Some anthropogenic activities such as the use of fertilisers, pesticides and sewage and sludge etc. for agriculture have also been indicated to cause an increase in fluoride concentration in groundwater.

Fluoride, if consumed in excess of 1.5 mg/L over long periods of time produces severe effects on human health such as dental and skeletal fluorosis (crippling bond), osteoporosis, hip fractures, arthritis, intellectual disabilities etc. Fluoride concentration above permissible limits in groundwater has been reported from parts of 20 States (Andhra Pradesh, Assam, Bihar, Chhattisgarh, Delhi, Gujarat, Haryana, Jharkhand, Jammu & Kashmir, **Karnataka**, Kerala, **Madhya Pradesh**, Maharashtra, Orissa, Punjab, **Rajasthan**, **Tamil Nadu**, Telangana, **Uttar Pradesh** and West Bengal).

21 http://mowr.gov.in/ground-water-quality-scenario

Arsenic in groundwater: As per BIS recommendations (IS:10500,2012), the permissible limit of Arsenic in drinking water is 0.01mg/l with no relaxation. Chronic exposure to drinking water with arsenic contamination beyond permissible limits may cause several skin problems including arsenicoses characterised by dark spots on body and limbs, thickening of palms and soles, Bowen's disease, non-healing ulcers etc. Elevated levels (>0.05 mg/l) of Arsenic in groundwater has been reported from parts of 10 States of West Bengal, Assam, Bihar, Jharkhand, **Uttar Pradesh,** Punjab, Haryana, Chhattisgarh, **Karnataka** & Manipur). A recent survey by CGWB has shown Arsenic concentration in excess of 0.01 mg/l in patches from an additional 11 States. In these areas, arsenic occurrence has been reported only from limited samples, and resampling is envisaged.

Salinity in groundwater: Salinity is the saltiness or dissolved salt contents of a water body. It is mostly influenced by aquifer material, solubility of minerals, duration of contact and factors such as permeability of soil, drainage facilities, quantity of rainfall and above all, the climate of the area. The salinity of groundwater in coastal areas may be due to airborne salts originating from air-water interface over the sea, and due to over-pumping of freshwater which overlays saline water in coastal aquifer systems.

The problem of salinity (EC>3000 micro-siemens/cm) has been observed in 15 states (Andhra Pradesh, Delhi, Gujarat, Haryana, **Karnataka**, Kerala, **Madhya Pradesh**, Maharsahtra, Odisha, Punjab, **Rajasthan**, **Tamil Nadu**, Telangana, **Uttar Pradesh**, and West Bengal).

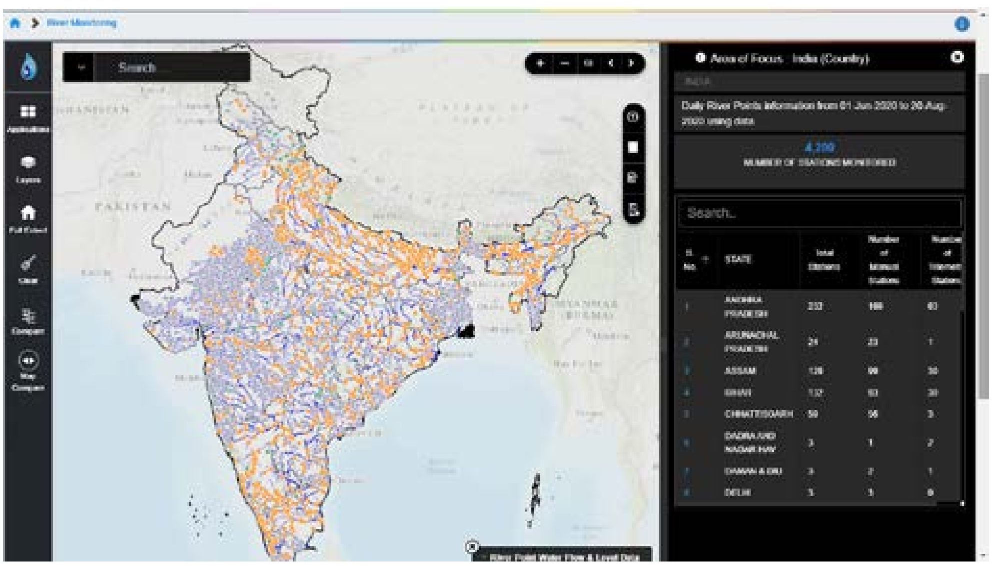
Nitrates in groundwater: A high concentration i.e. (above BIS norms of 45 mg/l) of nitrates in groundwater has been observed in 21 states, namely Andhra Pradesh, Telangana , Bihar, Chhattisgarh, Delhi, Gujarat, Haryana, Himachal Pradesh, J&K, Jharkhand, **Karnataka**, Kerala, **Madhya Pradesh**, Maharashtra, Orissa, Punjab, **Rajasthan**, **Tamil Nadu**, **Uttar Pradesh**, Uttarakhand, West Bengal.

Iron in groundwater: High concentrations of iron, above the BIS permissible limit of 1mg/l in groundwater has been observed in the states of Andhra Pradesh, Assam, Arunachal Pradesh, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Jharkhand, **Karnataka**, Kerala, **Madhya Pradesh**, Maharashtra, Manipur, Meghalaya, Nagaland, Odisha, Punjab, **Rajasthan**, **Tamil Nadu**, Telangana, Tripura, **Uttar Pradesh,** West Bengal & Andaman & Nicobar.

Datasets to be captured under CWRM planning

The data sources include information available on various online portals of the Central Ground Water Board, central and state pollution control boards, Public Health Engineering department or any other departments in charge of public health and drinking water in states, and CWC reports.

For CWRMP, the data source used is India WRIS. This provides a data analysis at the district level in a GIS environment. Further, the mobile application of CGWB can provide information on water quality of a particular area (*Mera Bhujal* and *Jal Sanchayan*).



Indicators under CWRM Planning

- Identification of major water quality issues in the catchment or watershed
- Identifying a framework for redressal of water quality issues
- Scoping works under Mahatma Gandhi NREGA which can address water quality issues

Solid and Liquid Waste Management – CWRM convergence with SBM (G)

The Department of Drinking Water and Sanitation (DDWS), Ministry of Jal Shakti launched the 10-year Rural Sanitation Strategy (2019-2029), which focuses on sustaining the sanitation behavioural change that has been achieved under the Swachh Bharat Mission Grameen (SBM-G), ensuring that no one is left behind, and by increasing access to solid and liquid waste management.

Since the launch of the SBM-G in 2014, over 10 crore toilets have been built in rural areas; over 5.9 lakh villages, 699 districts, and 35 States/UTs have declared themselves Open Defecation Free (ODF). This strategy has been prepared by DDWS in consultation with state governments and other stakeholders, and lays down a framework to guide local governments, policy makers, implementers and other relevant stakeholders in their planning for ODF Plus, where everyone uses a toilet and every village has access to solid and liquid waste management.

Solid and Liquid Waste Management: The objective of SBM-G is to bring about improvement in the cleanliness, hygiene and the general quality of life in rural areas. Solid and Liquid Waste Management (SLWM) is one of the key components of the programme.

SLWM is to be taken up in project mode for each Gram Panchayat (GP) with financial assistance capped for a GP on a number of households' basis to enable all GPs to implement sustainable SLWM projects. The total assistance under SBM-G for SLWM projects shall be worked out on the basis of the total number of households in each GP, subject to a maximum of Rs. 7 lakh for a GP having up to 150 households, Rs.12 lakh up to 300 households, Rs. 15 lakh up to 500 households and Rs. 20 lakh for GPs having more than 500 households. Funding for SLWM project under SBM-G is provided by the central and state governments in the ratio of 75:25. Any additional cost requirement is to be met with funds from the states/ GP, and from other sources like Finance Commission funding, CSR, Swachh Bharat Kosh, and through the PPP model.[22]

Liquid Waste Management[23]

Methods adopted for the management of liquid waste may focus on maximum reuse of such waste for agricultural purposes with least operation and maintenance costs as follows.

- Collection of wastewater, building low cost drainage/ small bore systems, soakage pits may be adopted.
- Treatment of wastewater using the following technologies may inter-alia be considered. However, states are encouraged to to identify suitable technologies.
  - Waste Stabilisation Pond (WSP) technology
  - Duckweed-based wastewater treatment
  - Phytorid Technology [developed by National Environmental Engineering Research Institute (NEERI)]
  - Anaerobic decentralised wastewater treatment

Solid Waste Management:

It is essential to undertake solid water management to ensure water bodies are free from litter and garbage dumping This helps in protecting surface water bodies near the village vicinity from any quality issues, and also stops further loss to of the water body due to eutrophication or stopping from other forms of contamination. It includes the following.

22 SBM-Grameen Guidelines, Govt of India
23 SBM(G) Manual for district level functionaries 2017

- Collection, segregation, and safe disposal of household garbage; decentralised systems like household compost and biogas plants shall be permitted.
- Activities related to maximum reuse of organic solid waste as manure should be adopted. Such technologies may include vermi-composting or any other composting method, as well as individual and community biogas plants.
- Funds allocated for SLWM may be used to implement safe disposal solutions and collection mechanisms for menstrual waste (used sanitary cloths and pads) and setting up incinerators in schools, women's community sanitary complexes, Primary Health Centre (PHCs), or in any other suitable place in villages.
- Community sanitary complexes comprising of an appropriate number of toilet seats, bathing cubicles, washing platforms, wash basins etc. are set up in a place in the village acceptable and accessible to all. Maintenance of such Complexes is essential, for which Gram Panchayat should own the ultimate responsibility and their Operation and Maintenance (O&M) should be assured.

Issues in Solid and Liquid Waste Management and Water Contamination

Issues with Grey Water: [24]

Grey water is the category of wastewater that is not contaminated with faecal or urinal matter. This broad category includes post-use water from most domestic purposes like bathing, washing dishes, laundry etc. It is hazardous by nature and a breeding ground for diseases. When mixed with faecal matter and other toilet waste, becomes black water, and carries a substantially greater threat of disease.

Drains in rural areas are not common; 63% of rural households don't have drains within their premises. 31% of households have open drains, leaving them susceptible to dumping of other kinds of waste. Only 6% of households actually have closed drainage systems[25]. Draining of grey water into water bodies or wetlands leads to loss of diversity and causes damage of the microenvironment.

Most rural areas in the country let domestic runoffs of grey water collect in open areas, or flow into water bodies. This is, in part, responsible for an environment where diseases and pathogens breed. Grey water contains Total solids (TS), as well as Total Suspended Solids (TSS) which are bigger than 0.2μm, and settleable and colloidal solids. It also contains 60% to 70% of readily degradable organic solids and 30% of inorganic solids.

Its temperature ranges between 18 and 35°C, and the rather high temperature may be originating from warm water used for personal hygiene and cooking activities. These high temperatures favour microbiological growth, which is undesirable and may also cause precipitation of certain carbonates such as $CaCO_3$ and other inorganic salts which become less soluble at high temperatures. The TSS concentration of can range between 190–537 mg/L[26].

While substantially less harmful than black water, grey water still contains potentially hazardous chemical and biological particles. Additionally, untreated grey water is a wasted resource, that could otherwise have been used to provide relief from acute water stress in many parts of India. If harnessed with the right scientific techniques and treated carefully, grey water can become a potent resource for several non-potable uses.

Issues with solid waste disposal in rural areas

- Domestic solid waste dumping into open wells, streams and water bodies leads to health hazards and also loss of water bodies
- Agricultural waste dumping into streams and water bodies

24 Grey Water Management Resource Book, GoI, Department of DW, Dpt of DW and Sanitation, MoJS (Formerly Ministry of DWS)
25 MoJS, DWS
26 Greywater Characteristics, Treatment Systems, Reuse Strategies and User Perception

Datasets to be captured under CWRM planning

Solid Waste Management

- System for collection,
- System of segregation, and
- System of safe disposal of household garbage

Liquid Waste Management

- Presence of drainage facilities,
- Waste stabilisation ponds, household soak pits or any other mechanism for liquid waste management in the village,
- Community Sanitary Complexes if any,
- Roof water harvesting (institutional,)
- Rural industry or other wastewater disposal

Indicators under CWRM planning

- Number of water bodies and streams freed from water dumping
- Number of villages which have complete solid and liquid water management systems

Chapter 4
Interpreting the Water, Land, and Soil Resources Relationship

This chapter comprehensively provides the reader with a technical grounding in the concepts, terminology and characteristics that are essential for effectively planning and implementing measures on the ground, as well as to gain an understanding of the relationship between water, land, and soil resources. The central points discussed include agricultural land use in India, common property resources, land use classification, wasteland and forest classification systems, land use concerns, and soils, among others.

4.1 Land: Important Concepts

Agricultural Land Use in India

Land resources are extremely crucial to the livelihoods of the people depending on agriculture for the following reasons.

1. Agriculture is a purely land-based activity unlike secondary and tertiary activities. In other words, the contribution of land of agricultural output is larger, as compared to its contribution to the outputs of other sectors. Thus, a lack of access to land is directly correlated with incidence of poverty in rural areas.
2. The quality of land has a direct bearing on the productivity of agriculture, which is not true for other activities. In rural areas, aside from its value as a productive factor, land ownership has a social value and serves as security for credit, natural hazards or life contingencies, and adds to one's social status.

Common Property Resources (CPR)

Land can broadly be classified under two broad heads according to its ownership – private land and common property resources (CPR). While the former is owned by an individual or a group of individuals, the latter is owned by the state meant for the use of the community. CPRs provide fodder for the livestock and fuel for households along with other minor forest products like fruits, nuts, fibre, medicinal plants, etc.

In rural areas, the CPR category is of special relevance to the livelihoods of landless and marginal farmers as well as other weaker sections of society. This is because many of them depend on income from their livestock as they have limited access to land. CPRs are also important for women as most of the fodder and fuel collection is undertaken by them in rural areas – a degraded CPR leads to long hours in collecting fuel and fodder.

CPRs can be defined as community's natural resource where every member has rights of access and usage with specified obligations, without anybody having property rights over them. Community forests, pasture lands, village water bodies and other public spaces where a group larger than a household or family unit exercises rights of use and carries responsibility of management are examples of CPRs.

4.2 Land Use Classification: Concepts & Definitions

1. **Forest Area:** This includes all land classified as a forest either under any legal enactment, or administered as a forest, whether State-owned or private, and whether wooded or maintained as potential forest land. The area of crops raised in the forest and grazing lands or areas open for grazing within the forests remain included under the "forest area".
2. **Area Under Non-agricultural Uses:** This includes all land occupied by buildings, roads and railways or under water, e.g. rivers and canals, and other land put to uses other than agriculture.
3. **Barren and Un-culturable Land:** This includes all land covered by mountains, deserts, etc. Land which cannot be brought under cultivation except at an exorbitant cost is classified as unculturable, whether such land is in isolated blocks or within cultivated holdings.
4. **Permanent Pasture and Other Grazing Land:** This includes all grazing land whether it is permanent pasture/ meadows or not. Village common grazing land is included under this category.
5. **Land under Miscellaneous Tree Crops:** This includes all cultivable land, which is not included in 'net area sown' but is put to some agricultural use. Land under casuarina trees, thatching grasses, bamboo bushes and other groves for fuel, etc. which are not included under 'Orchards' are classified under this category.
6. **Culturable Waste Land:** This includes land available for cultivation, whether taken up or not taken up for cultivation once, but not cultivated during the last five years or more in succession including the current year for some reason or the other. Such land may be either fallow or covered with shrubs and jungles, which are not put to any use. It may be accessible or inaccessible and may lie in isolated blocks or within cultivated holdings.
7. **Fallow Lands other than Current Fallows:** This includes all land which was taken up for cultivation but is temporarily out of cultivation for a period of not less than one year and not more than five years.
8. **Current Fallows:** This represents cropped area, which is kept fallow during the current year.
9. **Net Area Sown:** This represents the total area sown with crops and orchards. Area sown more than once in the same year is counted only once.
10. **Gross Cropped Area:** This represents the total area sown once and/or more than once in a particular year, i.e. the area is counted as many times as there are sowings in a year. This total area is also known as total cropped area or total area sown.
11. **Area Sown more than once:** This represents the areas on which crops are cultivated more than once during the agricultural year. This is obtained by deducting Net Area Sown from Gross Cropped Area.

12. **Irrigated Area:** The area is assumed to be irrigated for cultivation through such sources as canals (Govt. & Private), tanks, tube-wells, other wells and other sources. It is divided into two categories:
    a. Net Irrigated Area: It is the area irrigated through any source once in a year for a particular crop.
    b. Total Net unirrigated Area: It is the area arrived at by deducting the net irrigated area from net sown area.
13. **Total/Gross Irrigated Area:** It is the total area under crops, irrigated once and/or more than once in a year. It is counted as many times as the number of times the areas are cropped and irrigated in a year
14. **Total/Gross unirrigated Area:** It is the area arrived at by deducting the gross irrigated area from the gross sown area.
15. **Cropping Intensity:** It is the ratio of Total Cropped Area to Net Area Sown.
16. **Agricultural Land/Total Culturable Land /Total Cultivable Area/Total Arable land:** This consists of net area sown, current fallows, fallow lands other than current fallows, culturable wasteland and land under miscellaneous tree crops.
17. **Total uncultivable Area/Land:** It is the area arrived at by deducting the total cultivable area from the total reported area.
18. **Total Cultivated Area/Land:** This consists of net area sown and current fallows.
19. **Total Un-Cultivated Area/Land:** It is the area arrived at by deducting the total cultivated area from the total reported area.
20. **Cultivable Command Area (CCA):** The area which can be irrigated from a scheme and is fit for cultivation.
21. **Cultivable area:** It consists of net area sown, current fallow, fallow lands, other lands, current fallow, culturable wasteland and land under miscellaneous tree crops.
22. **Irrigation Potential Created (IPC):** The total gross area proposed to be irrigated under different crops during a year by a scheme. The area proposed to be irrigated under more than one crop during the same year is counted as many times as the number of crops grown and irrigated. If original Irrigation Potential of the scheme is not known, then the maximum area irrigated during the past five years or so may be taken as the IPC.
23. **Irrigation Potential Utilised (IPU):** The gross area actually irrigated during reference year out of the gross proposed area to be irrigated by the scheme during the year.

4.3 Wastelands Classification System

- The total wasteland area of the country was observed to be 5,57,665.51 sq. km. (16.96 % to TGA) in 2015-16, while it was 5,66,070.36 sq. km. in 2008-09 (17.22%). During this period, 14536 sq. km. of wastelands were converted into non-wastelands categories.
- There has been a net conversion of 8,404.86 sq. km. (0.26%) of different wasteland categories in the country during 2008-09 to 2015-16.
- A reduction in wastelands area was observed in the following categories: Land with Dense Scrub, Waterlogged and Marshy land, Sandy areas, Degraded pastures/grazing land and Gullied and/or ravenous land.
- Wastelands are classified as follows:

Table 4.1: Wetlands Classification

Gullied and/or ravinous land (Medium)	Under-utilised/degraded forest (Scrub domain)
Gullied and/or ravinous land (Deep)	Under - utilised/degraded forest (Agriculture)
Land with Dense Scrub	Degraded pastures/grazing land
Land with Open Scrub	Degraded pastures/grazing land

Waterlogged and Marshy land (Permanent)	Degraded land under plantation crop
Waterlogged and Marshy land (Seasonal)	Sands Riverine
Land affected by salinity/alkalinity (Medium)	Sands Coastal
Land affected by salinity/alkalinity (Strong)	Sands-Desertic
Shifting Cultivation Current Jhum	Sands-Semi Stab>40m
Shifting Cultivation Abandoned Jhum	Sands-Semi Stab 15- 40m
Mining Wastelands	Industrial Wastelands
Barren Rocky/Stony waste	Snow covered/Glacial area

Source: Wastelands Atlas of India 2011 (https://dolr.gov.in/documents/wasteland-atlas-of-india)

4.4 Forest Land Classification

The country's forest cover includes all patches of land with a tree canopy density of more than 10% and more than 1 ha area, irrespective of land use, ownership, and species of trees. It is assessed by wall to wall mapping exercises using remote sensing followed by ground truthing. Based on this, nationwide forest cover maps on 1:50,000 scale in three canopy density classes are arrived at (Dense, Moderately Dense and Open).

The forest cover is broadly classified into 4 classes, namely - very dense forest, moderately dense forest, open forest and scrub. The classification is based on internationally adopted norms of classification. Mangroves have been separately classified because of their characteristic tone and texture and unique ecological functions. The other class is that of non-forest. These classes are defined as below[1]

Very dense Forest	All Lands with tree cover (Including mangrove cover) of canopy density of 70% and above	
Mod Dense forest	All lands with tree cover (Including mangrove cover) of canopy density between 40% and 70% above	
Open forest	All lands with tree cover (Including mangrove cover) of canopy density between 10% and 40%	
Scrub	All forest lands with poor tree growth mainly of small or stunted trees having canopy density less than 10 percent	
Non-Forest	Any area not included in the above classes	

The total forest cover of the country is 21.67% of its geographical area. The forest cover in hill districts is 40.30% of the total geographical area of the districts. Mangroves in the country have increased by 1.10% as compared to the previous assessment year (current year of report is 2019). There are 62,466 wetlands covering 3.83% of the geographical area. The total number of wetlands present within Recorded Forest Area/ Green Wash (RFA/GW) is 8.13%.

Statistics of land use are compiled from the village land records maintained by the *patwari*. The information is available according to each survey number and recorded under nine categories: (a) Forests, (b) Area under Non-Agricultural use, (c) Barren and Uncultured Land, (d) Permanent Pastures and other Grazing Land, (e) Miscellaneous Tree Crops, (f) Culturable Waste Land, (g) Fallow Land other than Current Fallows, (h) Current Fallows, and (i) Net Area Sown. Another source is the Census 2011 dataset available online platforms.

1 Forest Survey of India, http://www.fsi.nic.in/scheme-of-classification

4.5 Land Use: Issues

Desertification is the most significant land use issue. It is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities leading to loss of productive ecosystems and biodiversity. There is an urgent need to stop and reverse the process of land degradation. Sustainable management of soil, water, and biodiversity are required to protect the land from further degradation.[2]

The analysis reveals that 96.40 mha area of the country is undergoing degradation. There is a cumulative increase of 1.87 mha area undergoing process of land degradation i.e., 29.32% of the Total Geographic Area desertification/land degradation in the country.

The most significant process of desertification/ land degradation in the country is water erosion (10.98% in 2011-13). The second most significant process is vegetation degradation (8.91% in 2011-13), followed by wind erosion (5.55 % in 2011-13).

Analysis shows that around 23.95% (2011-13) of area under desertification (arid, semi-arid and dry sub-humid regions of desertification/land degradation with respect to TGA is contributed the country) during 2011-13 is 82.64 mha;

Drivers and causes of land degradation and desertification in India at a broad level, which are the driving forces behind land resources may be described as follows. Some of the drivers are natural, others are anthropogenic[3]. Even the "natural" drivers may have anthropogenic influences that may modify or exacerbate the drivers and the impacts:

- Wind erosion
- Water erosion (fluvial, meteoric)
- Chemical (natural occurrence of alkaline chemicals, movement of subsoil chemicals (e.g. salinity) to the surface, as well as artificial addition of chemicals, including fertilisers or industrial pollutants)
- Physical (waterlogging, geomorphological changes caused by mining or other activity)

Direct anthropogenic influences and drivers include:

- Agriculture and related activities
- Livestock related activities (grazing)
- Biotic pressures (for fuelwood and fodder and MFP)
- Land use changes (urbanisation, mining, infrastructure, etc.)

Vegetation degradation: Vegetation degradation is observed mainly as deforestation / forest-blanks / shifting cultivation and degradation in grazing / grassland as well as in scrubland. In certain areas, agriculture taking place within forest lands is observed, and this has also been classified under vegetation degradation within forest areas.

Vegetation is an important factor in the protection of soil and soil fertility. Destruction of vegetation, most often by human activities accelerates soil degradation leading to desertification. When a soil loses vegetation cover, it becomes more susceptible to wind and water erosion. Removal of topsoil by water or wind erosion results in loss of organic material leading to decrease in soil aggregation and stability, and hence soil fertility. The water-holding capacity and the nutrient content of the soil are reduced when organic material is lost, which is an additional strain on vegetation survival.

Wind erosion: Wind erosion pertains to the Aeolian activities. It denotes the spread of sand by various processes, even up to the lofty altitudes of the Himalayas. Wind can erode the soil very selectively and intensively by three transporting methods, namely suspension, saltation and soil creep. Soil is more vulnerable to wind erosion in conditions such as very sparse or no vegetative cover, increasing wind speed, in the case of loose, dry, fine or very light soil, a smooth soil surface, large exposed area, etc. Wind erosion removes topsoil which is rich in all plant nutrients

2 SAC-ISRO- DESERTIFICATION ATLAS, ISRO, 2016
3 TERI reports

and bacterial activities, which in turn reduces the capacity of the soil to function and restricts its ability to sustain future uses. Moreover, windblown dust or sand is deposited in cultivated land and buries the lands, thus reducing production. Various kinds of sand cover and their severity are classified based on the depth and spread of sand sheet/ dunes and barchans.

Water erosion: Water erosion is loss of soil cover mainly due to rainfall and surface runoff water. It is observed in both hot and cold desert areas, across various land covers and with varying severity levels. The sheet erosion (mostly within agricultural lands) and rills are categorised under the "slight" category, the narrow and shallow gullies are categorised as "moderate" erosion, while the deep / wide gullies and ravines are classified as "severe" erosion. Particularly in the context of desertification or land degradation, water erosion does not refer to river erosion.

Waterlogging: Undrained land parcels tend to accumulate standing water for longer durations of time on the surface, and this condition is called water logging – eg. ox-bow lakes, low-lying areas, and even the shallow water tables. The severity of waterlogging is determined based on the period of time the water remains stagnant. Several situations can be responsible for the rise in water table like floods, salt-rich hard pans, excess irrigation, wrong drainage planning etc. Waterlogging may lead to salinisation as well.

Salinity / Alkalinity: Salinity or alkalinity is fundamentally a chemical property of soils. It occurs mostly in cultivated lands, especially in the irrigated areas. In certain places, salinity is clearly observed on satellite images, whereas the alkalinisation is not seen and is mostly inferred based on ground truth, soil sample analysis as well as information/ published maps.

Soil salinity refers to the water-soluble salts present in soil. It can develop naturally, or be human-induced. The main causes are excess evapotranspiration, drought, excess irrigation, increase in toxicity, and rise in groundwater table. Salinity in dry lands occurs when the water table is between 2 to 3 meters from the soil surface. The salts from the groundwater are raised by capillary action and come to the surface of the soil. Over time, water evaporates, and the salt remains on the surface. Salinity in irrigated land can occur due to over irrigation and excess use of fertilisers and other chemicals.

Mass Movement: The spontaneous downward movement of soil and rock under the influence of gravity (but without the dynamic action of moving fluids) is included under the general term mass movement. This includes all forms of down slope movement of soils, overburden, or bedrock under the direct influence of gravity. It represents the spontaneous yielding of earth materials when gravitational force exceeds the internal strength of the material. It involves sliding, rolling and flowage of masses of soil, overburden and bedrock.

Frost Heaving: Frost heaving is the process of ice lens formation beneath the soil surface during freezing conditions in the atmosphere. The ice grows in the direction of heat loss (vertically towards the surface), starting at the freezing front or boundary in the soil. It requires a water supply to keep feeding the ice crystal growth. The growing ice is restrained by overlying soil, which applies a load that limits its vertical growth and promotes the formation of a lens-shaped area of ice within the soil. The force of one or more growing ice lenses is enough to lift a layer of soil as much as 30 cm or more.

Table 4:2 Processes of Degradation

Process of Degradation	Area under Desertification (mha)							
	2011-13				2003-05			
	Arid	Semi Arid	Sub-Humid	Total	Arid	Semi-Arid	Sub-Humid	Total
Vegetation Degradation	2.86	13.48	6.65	22.99	2.81	13.39	6.34	22.55

Water Erosion	3.03	17.51	8.97	29.51	3.12	17.07	8.91	29.11
Wind Erosion	17.63	0.56	0.00	18.19	17.72	0.57	0.00	18.30
Salinity / Alkalinity	2.52	0.86	0.09	3.48	2.52	1.07	0.21	3.80
Water Logging	0.02	0.08	0.31	0.42	0.02	0.08	0.25	0.36
Mass Movement	0.84	0.11	–	0.96	0.76	0.11	–	0.87
Frost Shattering	2.94	0.46	0.01	3.41	2.74	0.43	0.01	3.18
Man Made	0.04	0.14	0.16	0.35	0.04	0.14	0.14	0.32
Barren	0.25	0.28	0.05	0.58	0.25	0.28	0.05	0.58
Rocky	0.30	0.97	0.02	1.29	0.29	0.97	0.02	1.28
Settlement	0.11	0.93	0.44	1.47	0.07	0.75	0.33	1.15
Grand Total	30.54	35.40	16.70	82.64	30.35	34.85	16.28	81.48

Source: NRSC-ISRO

4.6 Soils & Soil Health

Soil degradation in India is estimated to be occurring on 147 million hectares (Mha) of land, including **94 Mha from water erosion**, 16 Mha from acidification, **14 Mha from flooding**, 9 Mha from wind erosion, 6 Mha from salinity, and 7 Mha from a combination of factors. This is extremely serious because India supports 18% of the world's human population and 15% of the world's livestock population but has only 2.4% of the world's land area. Despite its low proportional land area, India ranks second worldwide in farm output. Agriculture, forestry, and fisheries account for 17% of the Gross Domestic Product, and employ about 50% of the total workforce of the country.

Causes of soil degradation are both natural and human-induced. Natural causes include earthquakes, tsunamis, droughts, avalanches, landslides, volcanic eruptions, floods, tornadoes, and wildfires. Human-induced soil degradation results from land clearing and deforestation, inappropriate agricultural practices, improper management of industrial effluents and wastes, over-grazing, careless management of forests, surface mining, urban sprawl, and commercial/industrial development. Inappropriate agricultural practices include excessive tillage and use of heavy machinery, excessive and unbalanced use of inorganic fertilisers, poor irrigation and water management techniques, pesticide overuse, inadequate crop residue and/or organic carbon inputs, and poor crop cycle planning. Some underlying social causes of soil degradation in India are land shortage, decline in per capita land availability, economic pressure on land, land tenancy, poverty, and population increase. In this review of land degradation in India. [4]

4 Soil Degradation in India: Challenges and Potential Solutions: Ranjan Battacharya, PK Mishra et al.

India has varied relief features, landforms, climatic realms and vegetation types. These have contributed to the development of various types of soils in India. In ancient times, soils used to be classified into two main groups – *Urvara* and *Usara*, which were fertile and sterile, respectively. In 16th century A.D., soils were classified on the basis of their inherent characteristics and external features such as texture, colour, slope of land and moisture content in the soil. Based on texture, main soil types were identified as sandy, clayey, silty and loam, etc. On the basis of colour, they were red, yellow, black, etc.

Composition of Soil: The chief components of soil are inorganic matter 40%, organic matter 10%, soil water 25%, and soil air 25% (approximately.).

Soil Organisms: These include the Protozoans, mites, nematodes, rotifiers, blue green or green, soil bacteria, fungi arthropods like mite, myriapods, spiders, insect larvae and collembola.

The Indian Council of Agricultural Research (ICAR) has undertaken many studies on Indian soils. In their effort to study soil and to make it comparable at the international level, the ICAR has classified the Indian soils on the basis of their nature and character as per the United States Department of Agriculture (USDA) Soil Taxonomy.

Table 4.3 ICAR Soil Taxonomy

S No.	Order	Area (in Thousand Hectares)	Percentage
1	Inceptisols	130372.90	39.74
2	Entisols	92131.71	28.08
3	Alfisols	44448.68	13.55
4	Vertisols	27960.00	8.52
5	Aridisols	14069.00	4.28
6	Ultisols	8250.00	2.51
7	Mollisols	1320.00	0.40
8	Others	9503.10	2.92

Source: Soils of India, National Bureau of Soil Survey and Land Use Planning,

On the basis of genesis, colour, composition and location, the soils of India have been classified into: (i) Alluvial soils (ii) Black soils (iii) Red and Yellow soils (iv) Laterite soils (v) Arid soils (vi) Saline soils (vii) Peaty soils (viii) Forest soils.

Table 4.4 Soil Features

Type	Features (formation, composition) Distribution		Predominant Crops
Alluvial Soil pH range: 6.5-8.4	Khaddar- light in color, more siliceous. Bhaggar- the older alluvium is composed of lime nodules and has clayey composition. It is dark in color.	Ganga and Brahmaputra river valleys; Plains of Uttar Pradesh, Uttaranchal, Punjab, Haryana, West Bengal and Bihar.	Rice, Wheat, Sugarcane, oilseeds
Desert Soil pH range: 7.6-8.4	Contain a high percentage of soluble salts but are poor in organic matter; rich enough in phosphate though poor in nitrogen	Rajasthan, Northern Gujarat and southern Punjab	Wheat, grams, melon, bajra (with irrigation)

Type	Features (formation, composition)	Distribution	Predominant Crops
Black Soil pH range: 6.5-8.4	The soils are derived from basalts of Deccan trap. They derive their name from their black color which may be owing to presence of titanium, iron. Consist of calcium and magnesium carbonates; high quantities of iron, aluminum, lime and magnesia.	Maharashtra and Malwa plateaus, Kathiawar peninsula, Telengana and Rayalasema region of Andhra and northern part of Karnataka	Cotton, millets (include Jowar, Bajra and ragi), tobacco, sugarcane
Red Soil pH range: below 5.5-7.5	Mainly formed due to decomposition of ancient crystalline rocks like granites and gneisses and from rock type rich in minerals such as iron and magnesium. Siliceous and aluminous in nature. Clay fraction of the red soils generally consists of Kaolinitic minerals.	Eastern parts Deccan plateau, southern states of Kerala , Tamil Nadu and Karnataka and Chota Nagpur plateau (Jharkhand)	Wheat, Rice , Cotton , Sugarcane, pulses
Grey and Brown pH range: 7.6above 8.5		Semi- arid tract of Rajasthan and Gujarat	Cotton, oilseeds
Laterite Soil pH range: below 5.5	Composed mainly of hydrated oxides of iron and aluminum; loss of silica from the soil profile	Assam hills, hill of summits of Kerala and Karnataka and eastern Ghats region of Orissa	Coffee, rubber, cashew nut, tapioca
Mountain soil pH range: 5.0-6.5		Coniferous forest belt of Jammu and Kashmir, Himachal Pradesh, Uttaranchal and Sikkim	Fruit, tea

4.7 Soil Issues

Soil degradation: In a broad sense, soil degradation can be defined as the decline in soil fertility when the nutritional status declines and depth of the soil goes down due to erosion and misuse. It is the main factor leading to the depleting soil resource base in India. The degree of soil degradation varies from place to place according to the topography, wind velocity and amount of the rainfall.

Soil erosion: The destruction of the soil cover is described as soil erosion. The soil forming processes and the erosional processes of running water and wind go on simultaneously. But generally, there is a balance between these two processes. The rate of removal of fine particles from the surface is the same as the rate of addition of particles to the soil layer.

Wind and water are powerful agents of soil erosion because of their ability to remove soil and transport it. Wind erosion is significant in arid and semi-arid regions. In regions with heavy rainfall and steep slopes, erosion by running water is more significant. Water erosion, which is more serious and occurs extensively in different parts of India, takes place mainly in the form of sheet and gully erosion. Sheet erosion takes place on level lands after a heavy shower and the soil removal is not easily noticeable, but it is harmful since it removes the finer and more fertile top soil. Gully erosion is common on steep slopes. Gullies deepen with rainfall, cut the agricultural lands into small fragments and make them unfit for cultivation. A region with a large number of deep gullies or ravines is called a badland topography. **Ravines are widespread in the Chambal basin.** Besides this, they are also found in Tamil Nadu and West Bengal. The country is losing about 8,000 hectares of land to ravines every year.

Soil Salinity: A fairly large area of arable land in the irrigated zones of India is becoming saline because of over-irrigation. The salt lodged in the lower profiles of the soil comes up to the surface and destroys its fertility. Chemical fertilisers in the absence of organic manures are also harmful to the soil.

Unless the soil gets enough humus, chemicals harden it and reduce its fertility in the long run. **This problem is common in all the command areas of the river valley projects** which were the first beneficiaries of the Green Revolution. According to estimates, about half of the total land of India is under some degree of degradation. Every year, India loses millions of tonnes of soil and its nutrients to the agents of its degradation, which adversely affects our national productivity. It is therefore imperative to initiate immediate steps to reclaim and conserve soil.

Chapter 5
CWRM Plan Preparation

This chapter explains how a CWRM Plan is prepared on the ground, at the administrative unit – often the Gram Panchayat, detailing a participatory planning approach that facilitates identification, preparation and design of community projects based on the criteria decided by its members, making them the centre of the planning process itself.

5.1.1 Gram Panchayat Level CWRM Plan

The plan should be developed at habitation/ward level and consolidated at GP level, aligned with its labour budget & annual action plan. It is important to identify the macro and micro-watersheds belonging to GP areas. GP areas at village level should be analysed to understand watershed behaviour through characterisation of the area. Micro-watershed characteristics can be referred to while documenting the relevance of various interventions in an area treatment mode. A holistic and composite watershed principle based CWRM plan must be developed to comply with mandatory provisions of the Mahatma Gandhi NREGA.

5.1.2 Prospective Programmes and Schemes for CWRM Plan Preparation

Several Line Departments (LDs) are trying to develop rural areas through a variety of programmes and schemes. The efforts of these departments/agencies, however, are limited by programme guidelines to achieve desired

results. Programmes, activities, funds and technical guidance may also available with other LDs to help bridge such gaps. Proper convergence helps to pool these resources, achieve development, and generate positive change together. Several works/sub-programmes may converge within the overall programme to achieve the objectives of all the schemes, especially those listed below:

1. Mahatma Gandhi NREGA
2. National Rural Livelihood Mission (NRLM)
3. Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)
4. Integrated Watershed Management Programme (IWMP)
5. Rashtriya Krishi VikasYojana (RKVY)
6. National Afforestation Programme (NAP)/Green India Mission
7. Mission on Integrated Development of Horticulture (MIDH), previously known as National Horticulture Mission (NHM)
8. Schemes of Rubber Board/ Coconut Development Board/ Silk Board
9. Lac Development Scheme
10. Schemes for the promotion of Cashew Development
11. Central/State Finance Commission Grants

5.1.3 Participatory Planning Approach

Participatory planning is an approach that helps identify community problems and plan for solutions with the active participation of community members. The participatory approach facilitates identification, preparation and design of community projects based on the criteria decided by its members. It is not merely a method of 'consulting' the community but one that brings their contributions to the very centre of the planning process. In short, it is a people-centric process that puts the poorest first. Its key features are as follows:

- Mobilises the community to help them understand the situation and resolve their own problems. It raises consciousness of their rights and entitlements.
- Informs people of the possibilities of planning and executing local development interventions so that they identify their development needs, both collective and individual.
- Promotes greater inclusiveness by using Participatory Resource Mapping (PRM) exercises that are easily accessible and understood.
- Builds trust and understanding between different groups in a community by creating spaces for each perspective to be heard.
- Promotes greater transparency since members are involved in collective decision-making, where all members get a chance to comment, criticise and revise proposals and plans.
- Acknowledges power differentials within the community and ensures that the voice of the 'last is heard first' and that these voices are reflected in the plans are prepared and prioritised.
- Acknowledges that it is not a stand-alone process but leads to increased participation in implementation and oversight.
- Teaches skills which last beyond the planning process. People learn to run meetings, to analyse data, to construct strategic plans - in short, to become community resource persons and leaders.
- Shifts control of development from a few to the larger community and increases ownership.
- Increases credibility of the projects that are taken up because they have emerged from a collective decision-making process.

- All participants own the plan.
- Resources available with all participants are converged into the plan.
- The best way to begin the process is by involving everybody in undertaking a general appraisal of the requirements of the Panchayat area.
- Wide publicity within the Panchayat should be given to the PRM exercise to ensure that everybody participates in it.

5.1.4 Consultative process for Prospecting and Identifying Potential for NRM Works

The consultative processes are organised at hamlet, ward, village and GP levels for participatory planning. The planning team conducts meetings for concept seeding using secondary information collected from the village residents to understand the objectives and process of developing MWC Plans at village/ward level. Printouts of thematic maps are shown or displayed using a projector for rational and scientific planning to identify of potential NRM works and sites. Identified works are analysed on economic, environmental and social aspects before prioritisation and mapping. The identified works are then listed and mapped on watershed principles.

The ward member/s and the youth/SHG members are intimated in advance for their assistance in the planning process. The information drawn from secondary data and GIS theme maps that have been generated may be used to share the findings among the participants through the PRM exercise.

This exercise enables the community to express local needs into spatial information and further into plans, actions and results. It also ensures active participation of community, and management of the CWRM Plan.

Feedback about thematic maps is also useful to validate results with information providers, or to enable their participation in applying the results. The GP needs to be able to the grasp wider spatial relevance of micro-level knowledge. Further, where it is engaged in area planning and management, it needs to be able to develop links that enable participation. In order to communicate spatial information to stakeholders, the following should be considered:

- GIS computer files can be shared with the larger community through a projector.
- Maps can be printed (and may be permanently displayed if so needed) especially in remote locations. Maps should be produced in large formats like A2 or A1. For planning purposes, A3 is the minimum size for practical use.
- Overlays should be clear and restricted to the most important variables and main features, eliminating irrelevant detail.
- Providing too much information in a single map should be avoided. Different overlays can be produced to highlight different features.
- Map legends and symbols should be clear, simple, and always depicted in a map.

5.1.5 Publicity and Dissemination of CWRM Plan

Based on the available resources and taking into consideration the needs of all sections of the society, a draft plan is prepared. Thia plan should be publicised widely and discussed extensively Gram Sabhas and within the community. This will generate a sense of ownership of the plan within the community.

Gram Sabhas should constantly be involved in periodic evaluations of the implementation progress of the plan in their respective communities. Further, innovative ways must be facilitated for the Panchayats and the Gram Sabhas to check whether they have succeeded or failed in attaining their goals. Gram Sabhas as well as individual citizens should be encouraged to give report cards on implementation.

5.1.6 Inventory of Proposals for CWRM Plan

Proposals for CWRM Plan can be prepared following watershed principles according to the landscape. For a complete watershed approach, one has to bring soil conservation measures, water conservation and storage measures, dryland farming, animal husbandry, afforestation, and minor irrigation together as part of a coordinated approach.

In order to plan a proper watershed approach, basic physical features of the watershed like physiography, land slope, nature and depth of soil, and the hydrological behaviour of soil and the slopes in the watershed must first be studied and analysed.

A watershed management approach and plan are normally based on the rainfall precipitation within the watershed. All other aspects of planning like soil and water conservation, cropping, etc. will naturally follow this basic factor. Location-specific measures and implementing agencies are mentioned as below.

Table 5.1: Location-specific measures and implementing agencies

S. No	Location	Interventions/works	Implementing Agency
1	Upper reaches & Forest areas: Hilly/ high slope areas or uplands	Soil Moisture & Conservation 1. CCTs, SgCTs, WATs and, 2. Afforestation and Tree Plantation	Forest Department
2	Medium lands (Pastures & Open Areas):	Land development works in Wastelands/ Permanent fallows 1. Stone bund/ Stand wall terrace 2. Diversion Drains 3. Afforestation and Tree Plantation	Gram Panchayat
3	Works in Drainage lines	1. Loose boulder check 2. Gabion or Rock Fill Dam (RFD)	Gram Panchayat/ Watershed
4	Water harvesting structures	1. Earthen Gully Plug 2. Mini Percolation Tank (MPT) 3. Percolation Tank (PT) 4. Renovation of water bodies 5. Check Dam/ Stop Dam	Gram Panchayat/ Watershed
5	Lowlands (Farmlands): Works for Agriculture Fields	1. Bunding: Contour Bunds/Graded Bunds 2. Desilting and Silt application 3. Farm Pond/Dug out Pond 4. Diversion drains in waterlogged areas 5. Afforestation and Tree Plantation	Gram Panchayat/ Beneficiaries
6	Strengthening Irrigation Networks to minimise water losses	1. Repairing & construction of minor, sub-minor and field channels	Irrigation Department/ Gram Panchayat

5.1.7 Scoping of IWRM Works

All works that are to be executed by the Gram Panchayats shall be identified and placed before them. Works which are to be executed by the intermediate panchayats or other implementing agencies shall be placed before the intermediate or District panchayats.

Alongside this, the expected outcomes as per the operational guidelines (which lay down elaborate procedures as to how the participatory planning exercise will take place under Mahatma Gandhi NREGA) are also mentioned. The participatory process for convergent planning should be followed. The consultative process should be organised at hamlet, ward, village and GP level to achieve the core objectives of participatory planning.

Secondary Information Collection and Analysis (Non-Spatial)

Various departmental information is required for the preparation of village/GP-level CWRM Plan. While deciding on information collection methods, the planning team should keep in mind three types of information viz., primary, secondary, and online as follows:

- Published and made available information in digital and hard copies,
- Published but not available in Public domain like topo-sheet & cadastral maps,
- Information available on online sources.

The core of the village/GP-level CWRM Plan consists of facts and figures of the village/GP related to natural resources, production systems, and human-natural resources interactions. Such information can be collected from various sources either in primary or secondary form. Various online sources provide access to important datasets. The collected datasets are further processed to make them relevant to the planning process.

Data Sources

Agriculture Contingency Plan

- Agriculture Contingency Plan – India
  - http://agricoop.nic.in/agriculture-contingency-plan-listing
- Download the following data for Districts as applicable from the above portal
  - Agro-Climatic Region (Planning Commission)
  - Agro-Climatic Zone (NARP)
  - Agro-Ecological Sub-region (ICAR)
  - Rainfall and Climate Information
  - Soil Profile Information
  - Soil profile Map

General Links

For Madhya Pradesh

- For Crop Inventory - http://saara.mp.gov.in/saaraweb/reports.html
- (WMS users) http://geoportal.mp.gov.in/Content/Download/WMSURLList.pdf
- (WMS users) http://www.mpwrd.gov.in/
- Vulnerable Population List http://samagra.gov.in/Public/Population/District_Dashboard.aspx

For Uttar Pradesh

- Land Records http://upbhulekh.gov.in/
- Revenue Maps http://upbhunaksha.gov.in/
- Vulnerable Population List https://nfsa.up.gov.in/Food/citizen/Default.aspx

For Rajasthan

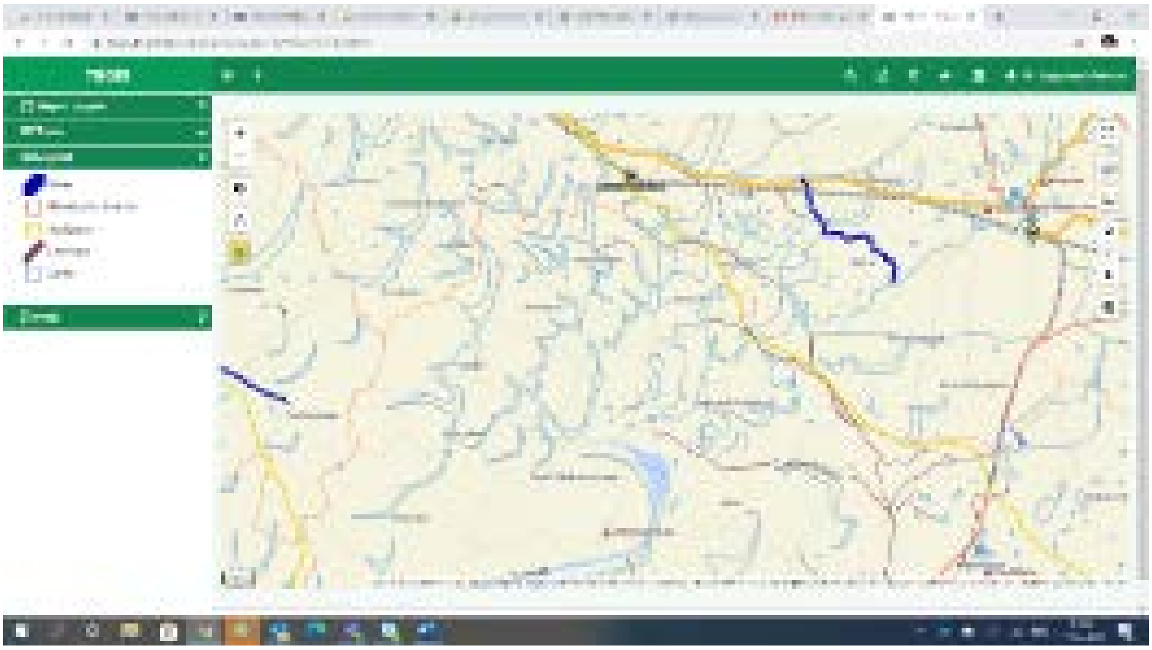
- Land Records http://apnakhata.raj.nic.in/
- Revenue Maps http://bhunaksha.raj.nic.in/bhunaksha/
- Vulnerable Population List https://food.raj.nic.in/PanchayatWiseCategoryDetails.aspx
- Forest Resources https://forest.rajasthan.gov.in/content/raj/forest/en/forest-department/departmental-wings/forest-devlopment/districtwise-forest-blocks-google-earth.html

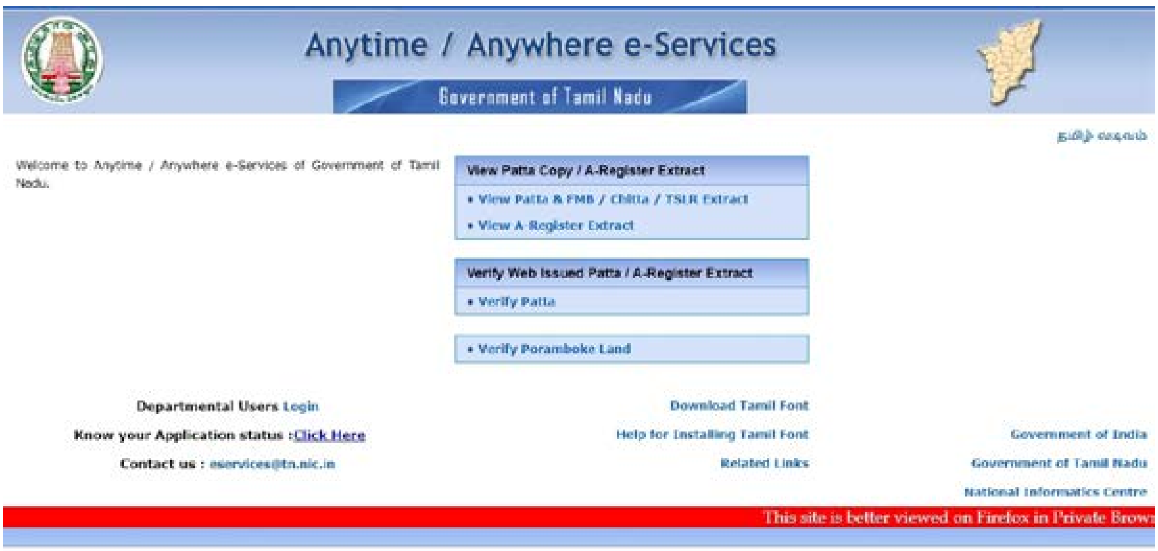
For Tamil Nadu

- Tamil Nadu GIS web portal https://tngis.tn.gov.in/tngismaps/map.php?g=Water%20bodies#
- Forest Resources https://www.forests.tn.gov.in/pages/view/tn-districtwise-profile
- Record of Rights https://eservices.tn.gov.in/eservicesnew/home.html

For Karnataka

- Working Plan Forest https://aranya.gov.in/aranyacms/English/WorkingPlan.aspx
- Land Records https://landrecords.karnataka.gov.in/service2/RTC.aspx
- Cadastral Maps https://www.landrecords.karnataka.gov.in/service3/





Presentation of Secondary Information for Profiling of Village/Gram Panchayat-level CWRM Plan

This section provides the outline of the village/GP-level CWRM plan document. This consists of all table templates that are required for its preparation, along with suggested thematic outputs in GIS format from *Bhuvan* portal as described in later sections. The collected information from secondary and primary sources is to be processed and presented as statistical information in suggested tables templates, described as follows:

A. General Details

General administrative information of units to be planned under CWRM

Village:	Amartiya
Gram Panchayat:	Amartiya
Block:	Aspur
District:	Dungrapur
State:	Rajasthan

Summary

The information in the table below provides basic information about the village/GP which is important to understand NRM in general and water resources in particular, and also the relevance of watershed principles with reference to CWRM interventions.

These cells and rows show the summary of the Area of Interest.

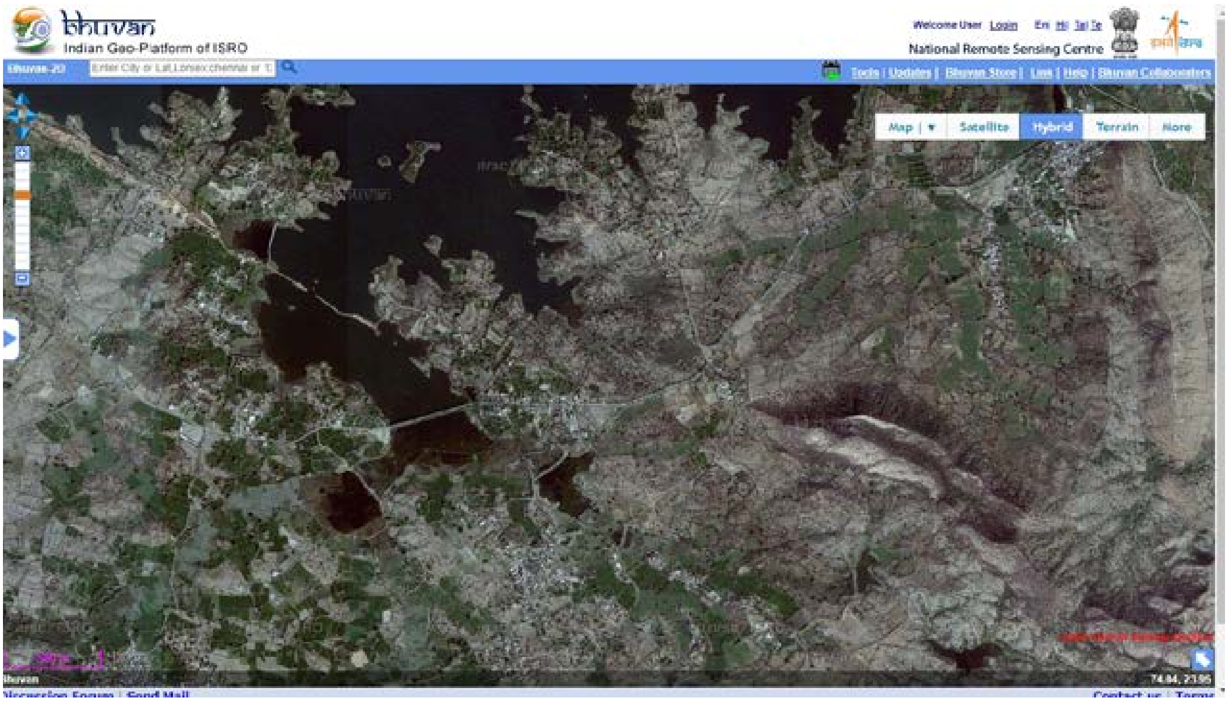
- Administrative area
- Geographical area
- Latitude & Longitude
- Agro-Climatic Zone/ Ecological units
- Climatic details
- Soil moisture and Evapotranspiration
- Status of Groundwater

Name of Village	Amartiya		
Name of Gram Panchayat	Amartiya		
Block, District & State	Aspur, Dungrapur, Rajasthan		
Geographical area of Village	578 Ha		
Latitude* (From To)	23.979617°	To	23.941989°
Longitude* (From To)	74.019931°	To	74.047999°
Numbers of Habitations in the village			5
Name of Catchment** (as per river basin)			Mahi
Agro-Climatic Region*** (Planning Commission)			Central Plateau & Hill Region VIII
Agro-climatic Zone*** (NARP)			Humid Southern Plain Zone (IV-B)

Agro Ecological Sub-Region*** (ICAR)		Arid Western Plain Zone – VI
Annual Average Soil Moisture Content upto 15cm depth (in%) (Source: WRIS/Water Data Online)		12%
Annual Evapotranspiration (Source: WRIS/Water Data Online)		418 mm
Temperature of the Area (over last 30 Years i.e. 1989-2018) (Source: IMD)	Maximum	45 °C
	Minimum	0 °C
	Average	25 °C
Rainfall of the Area (over last 30 Years i.e. 1989-2018) (Source: WRIS/Water Data Online)	Maximum	1494 mm
	Minimum	300 mm
	Average	776 mm
Groundwater level of the Area (over last 20 Years i.e. 1999-2018) (Source: WRIS/Water Data Online) in meter below ground level	Maximum	16.60 m
	Minimum	6.89 m
	Average	11.70 m
Status of Groundwater [Over-exploited, Critical & Semi-Critical) (Source: CGWB)		Safe

1. **Satellite Map**

Description: The aerial satellite view in True Colour Composite gives a real-time picture of any geographic area. Remote Sensing Satellites broadly work on collecting and interpreting information about a target without being in physical contact with the object. The data collected by this system is commonly presented in the form of an image.



Map Interpretation

- Visual interpretation can be divided into a few steps, namely - detection of an object, interpretation, recognition, and classification.
- Satellite image interpretation is the process of meaningfully identifying various features.
- Satellite image classification involves interpretation of remote sensing images, studying various land cover features such as agriculture, forests, etc.

Relevance of CWRM planning

- The satellite image provides information about the selected geographical area.
- Landforms and their characteristics can be easily visualised and provide objective understanding of the context.
- Periodic images help us capture temporal trends.
- Seasonality of land use/land cover can be tracked, and suitability of interventions can be accordingly determined.

B. Population and Mahatma Gandhi NREGA details

Population and Household Information *(Source: Census 2011)*

The socio-economic information derived from the census records and updated information about demography from the GP provides insights for scoping of CWRM plan in terms of immediate water scarcities, as well as addressing concerns of local populations.

Total Population			Total House Holds	Category wise Population			Key Observations
Female	Male	Total		SCs	STs	Total	
604	607	1211	262	113	163	276	

Source: Census 2011

- Click on "Village Amenities" to get a complete census.
- After downloading, filter by District and copy into a new Workbook.
- Please update Block data and Gram Panchayat columns on the sheet while working.
- The following tables can be addressed from this data:
  - Information on land use
  - Status if Irrigation facilities
  - Water application practices

Mahatma Gandhi NREGA Job Card Holders (Source: MIS – Mahatma Gandhi NREGA)

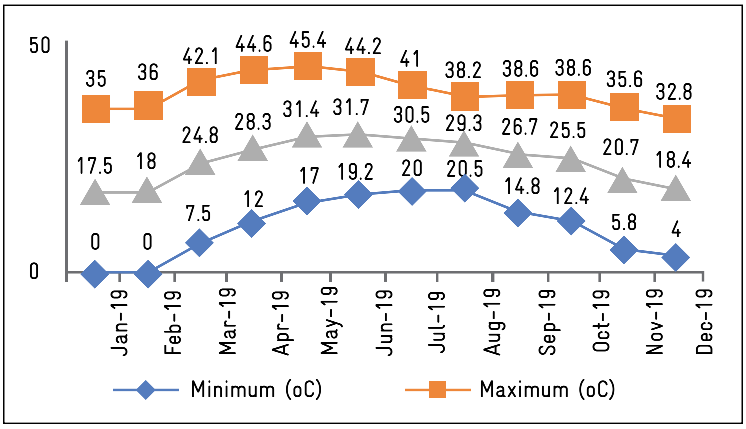
The Mahatma Gandhi NREGA performance varies based on local conditions and effective uses of the delivery mechanism. It is important to grasp the status of Mahatma Gandhi NREGA, particularly to get an idea of the scale of financial allocation in order to scope works accordingly. Mahatma Gandhi NREGA data from MIS is referred to in order to access information on labour, and regarding previous investments in rural development since inception of the scheme.

Registered Job cards		Active Job Cards		Expenditure Since Inception	Expenditure Last Year	Key Observations
HHs	Person	HHs	Person			

C. Climatic Features

Temperature

Climate profile especially the Temperature data taken from IMD is overlooked for the basic understanding of the Area of Interest.

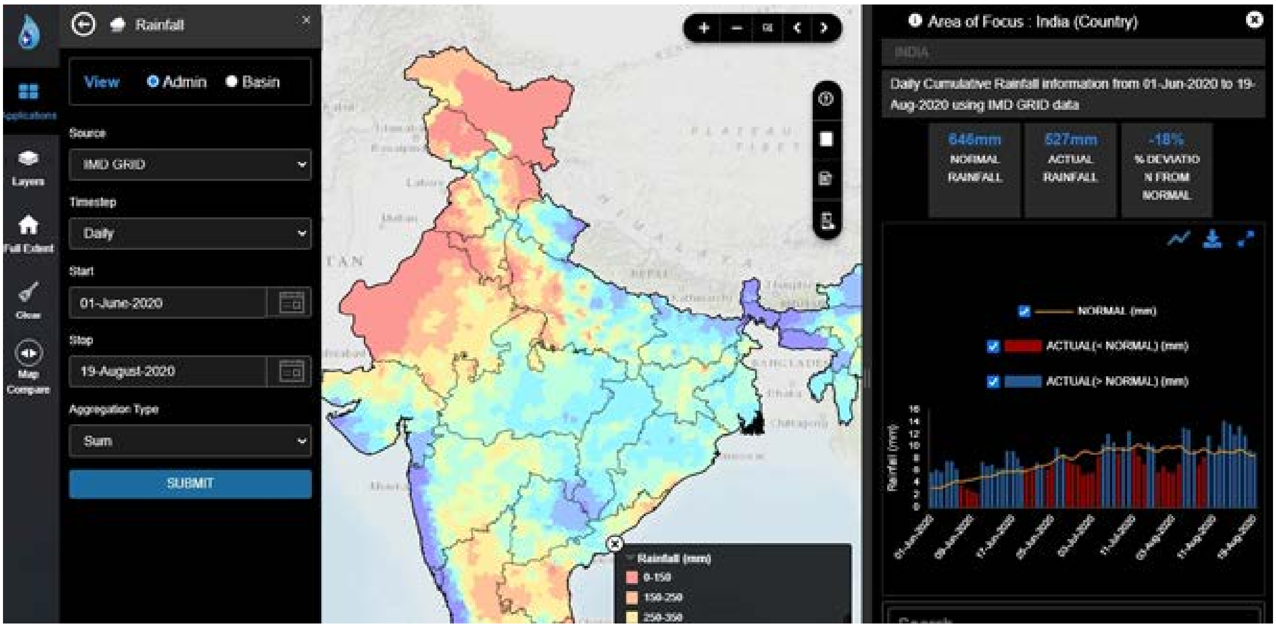


Months	Minimum (°C)	Maximum (°C)	Average (°C)	Key Observations
Jan-19	0	35	17.5	
Feb-19	0	36	18	
Mar-19	7.5	42.1	24.8	
Apr-19	12	44.6	28.3	
May-19	17.4	45.4	31.4	
Jun-19	19.2	44.2	31.7	
Jul-19	20	41	30.5	
Aug-19	20.5	38.2	29.35	
Sep-19	14.8	38.6	26.7	
Oct-19	12.4	38.6	25.5	
Nov-19	5.8	35.6	20.7	
Dec-19	4	32.8	18.4	

Rainfall

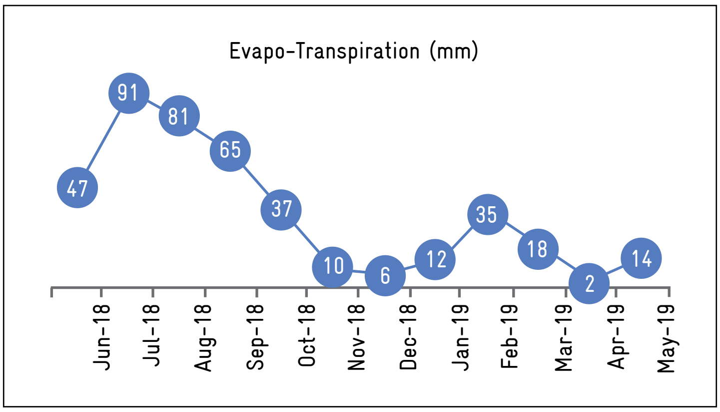
Rainfall data is gathered from Agriculture Contingency Plan, which is prepared for all District throughout the country.

Rainfall	Normal Rainfall (mm)	Normal Rainy days (No.)	Normal Onset (Specify week and month)	Normal Cessation (Specify week and month)	Key Observations
SW monsoon (June-Sept)	713.2	30.8	25th Standard week	37th Standard week	
NE Monsoon (Oct-Dec)	33.2	1.7	-	-	
Winter (Jan-Mar)	4.2	0.3	Jan	Occasional	
Summer (Apr-May)	9.6	0.5			
Annual	760.2	33.3			



Evapotranspiration

Month	ET (mm)	Key Observations
Jun-18	47	
Jul-18	91	
Aug-18	81	
Sep-18	65	
Oct-18	37	
Nov-18	10	
Dec-18	6	
Jan-19	12	
Feb-19	35	
Mar-19	18	
Apr-19	2	
May-19	14	
	417	



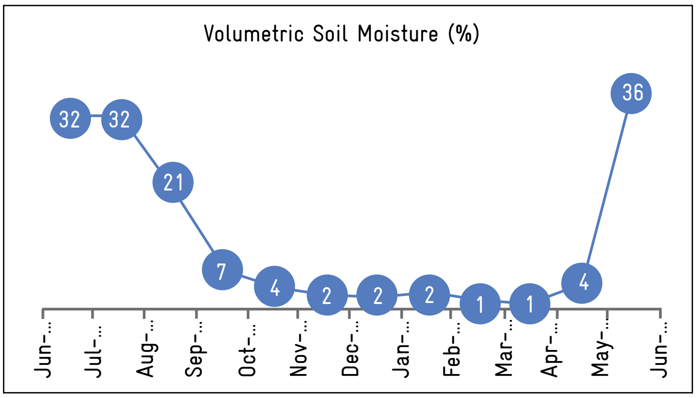
Evapotranspiration data is taken from WRIS Portal of *Bhuvan*. The period from June 2018 to May 2019 has to be selected. It has to be operated as follows. Select parameter – then select period – then select State – District to display the exact chart. Now enlarge the chart and download as CSV to operate / analyse in Excel.

- Search for India WRIS – Water Data Online
- Go to the link http://indiawris.gov.in/wris/#/waterData
- Click on "Application – Evapotranspiration".
- Select "Monthly Data".
- Give the Period and click "Submit ".
- Select State – District
- Click on "Graph" and download data in XLS

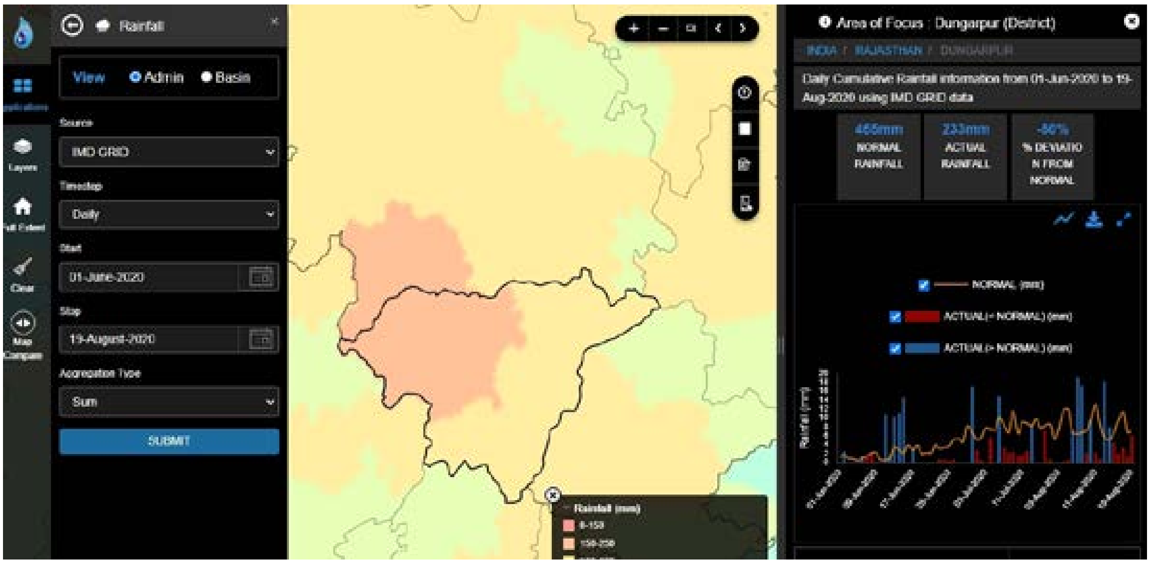
Soil Moisture

Soil moisture data is taken from the WRIS Portal of *Bhuvan*. The period has to be selected from June 2018 to May 2019. It has to be operated as follows - select Parameter – then select Period – then select State – District to display the exact chart. Now enlarge the chart and download as CSV to operate / analyse in Excel.

Month	Soil Moisture (%)	Key Observations
Jul-18	32	
Aug-18	32	
Sep-18	21	
Oct-18	7	
Nov-18	4	
Dec-18	2	
Jan-19	2	
Feb-19	2	
Mar-19	1	
Apr-19	1	
May-19	4	
Jun-19	36	
	12	



- Search India WRIS – Water Data Online
- Go to the link http://indiawris.gov.in/wris/#/waterData
- Click on "Application – Soil Moisture".
- Select "Monthly data".
- Give the Period and "Submit".
- Select State – District
- Click on "Graph" and download data in XLS



Identification of climate adaptation measures

Parameter		Future projections	Implications	Required interventions for adaptations
Temperature and related extreme events	Peak maximum temp (°C)			
	Lowest minimum temp (°C)			
	Heat Wave (Avg number of days in a year)			
	Cold Wave (Avg number of days in a year)			
Rainfall and related extreme events	Highest rainfall (in a single day) (mm)			
	Fluctuation/shift in monsoon arrival			
	Fluctuation/shift in monsoon departure			
	No of rainy days (annual)			
	No of rainy days (monsoon)			
	Number of intense (>normal) rainfall days			
	Longest duration of dry spell			
	Draught frequency			
	Flood Frequency			
	Frequency of cyclones			
	Hailstorm			

Parameter		Future projections	Implications	Required interventions for adaptations
Evapotranspiration	Number of months with high (>normal) ET (mm)			
	Number of months with low (<normal) ET (mm)			
Soil moisture (%)	Number of months with high (>normal) ET (%)			
	Number of months with low (<normal) (%)			
Atmospheric humidity	Lowest (<normal) humidity level (aridity) (%)			
	Highest (>normal) humidity level (%)			
The A1B scenario describes a future world of very rapid economic growth, low population growth, and the rapid introduction of new and more efficient technologies, with a balanced emphasis on all energy sources.				

D. Land Resources

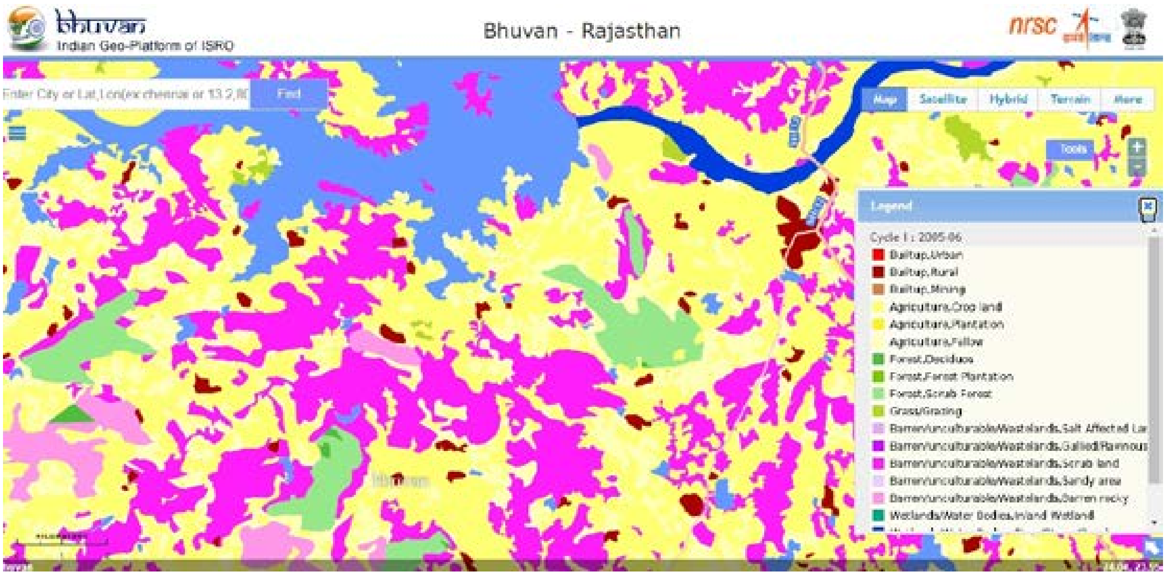
D.1 Information of Land Use (Ha.) (Source: Census 2011)

Land use information will help understand the village/GP geography and plan interventions for specific requirements better. This data has to retrieved from Census 2011 with 9-fold classification of land use. It is used for the calculating the water budget as well as for runoff calculations in the water budget section. The data also shows the prevailing types of land use and land cover in the area.

Classification	Area in Ha	Key Observations
Forest Area	61	
Area under Non-Agricultural Uses	42.99	
Barren & Un-cultivable Land Area	124.04	
Permanent Pastures and Other Grazing Land Area	0	
Land Under Miscellaneous Tree Crops etc. Area	0	
Culturable Waste Land Area	129.99	
Fallows Land other than Current Fallows Area	15.99	
Current Fallows Area	8.99	
Total Unirrigated Land Area	157.85	
Area Irrigated by Source	37.14	
Total	577.99	

7. Land use Land Cover Map (LULC)

Description: Land use/land cover (**LULC**) is most important component of the earth surface, which interacts with the atmosphere and lithosphere simultaneously. **LULC** information is crucial in areas such as natural resource management, environmental impact assessment and risk management [Aydinoglu and Gungor, 2010]. However, land use shows nature human interaction such as settlements, road networks, crop land, mining and irrigation networks, etc. LULC maps are developed by NRSC for whole country and are available on 1:2,50,000, 1: 50,000 and 1:10,000 scale at intervals of 1, 5 & 10 years, respectively.



Map Interpretation

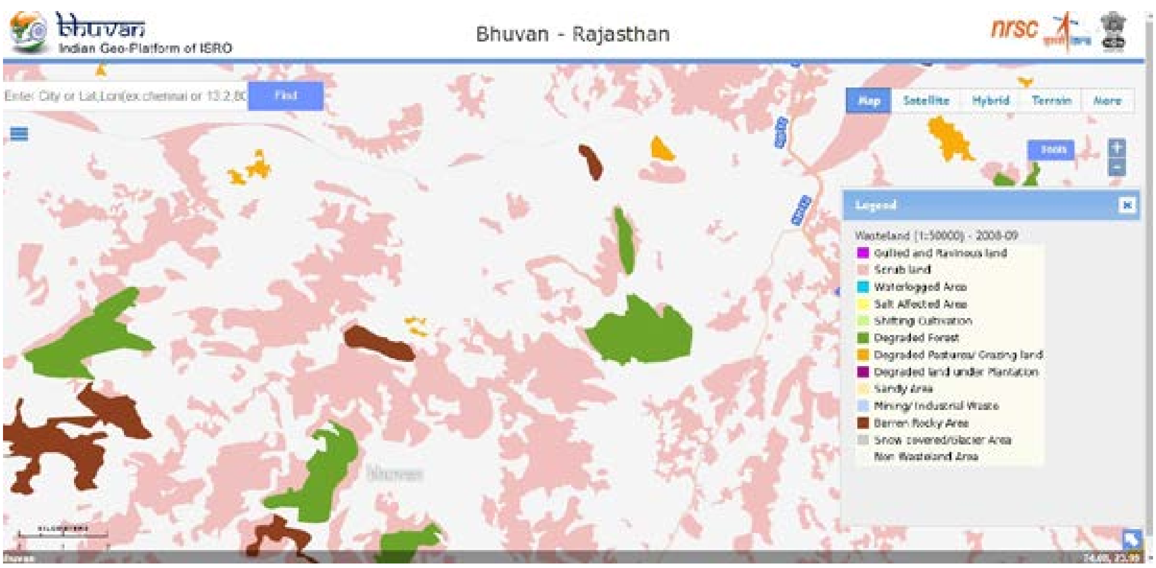
- The map shows that most of the area is used as crop land (in yellow).
- The two villages (in red) are mostly surrounded by crop land.
- A number of dispersed settlements can be seen (in brown).
- Large patches of scrub are shown (in pink).

Relevance to CWRM Planning

- The land use pattern affects all parameters such as t runoff, rate of erosion, etc.
- The information about the existing land use and land cover helps decision makers choose the types, modes and sites of activities.
- Barren areas can be made productive by terracing and plantation.
- Vegetation cover indicates the status of infiltration and nature of erosion. Vegetation reduces the peak flow.

Wastelands Map

Description: Wastelands indicate temporary or permanent degradation because of the deterioration of physical, chemical and biological parameters. Land, agriculture, and ecology are intrinsically related and govern our agricultural systems holistically. An inclusive approach is necessary to conserve natural resources for sustainable food production,



Source: https://bhuvan-app1.nrsc.gov.in/state/KA

Map Interpretation

- Large patches of scrubland require urgent action to improve their productivity.
- The notified forest land in the GP is mostly degraded forest and lies in the upper slopes and treatment of such areas should hence be prioritised.

Relevance to CWRM Planning

- The information about the extent and spatial distribution of various kinds of degraded lands is, therefore, essential for planning the development of degraded lands.
- Development of degraded lands is one of the options available to increase food production for a growing population, and to restore the fragile ecosystem.
- Land degradation has numerous environmental, economic, social, and ecological consequences such as decline in land productivity, reduced agricultural or forestry production, siltation of rivers, canals and drainage systems, decline in income of agriculture, etc.

D.2 Detail of Micro Watersheds (Source: Watershed Atlas)

Micro and Macro watershed details need to be calculated using the Watershed Atlas available in WRIS portal or using a physical copy of the Atlas available with the Watershed Department for purchase. This is extremely useful in gaining an understanding of the natural hydrological units of the AoI.

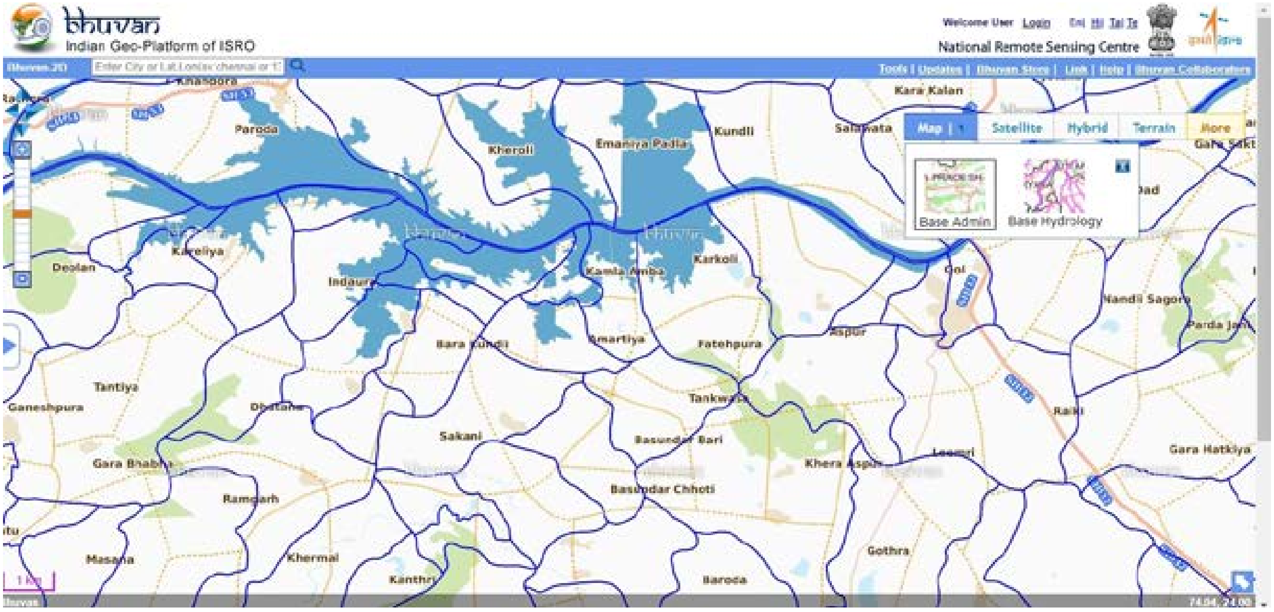
S. NO	Macro Watershed Name	Macro No.	Area (Ha.)	Micro W/s No.	Area (Ha)	Key Observations
1	Amartha	1306140105	1081	130614010501	572	
2	Amartha	1306140105	1081	130614010502	509	
3						
4						
5						

Watershed Atlas of India

- https://slusi.dacnet.nic.in/mwanew.html
- Select State – District – Watershed Map
- Generate Micro-watershed maps in PDF

Watershed Map

Description: The MWC focuses on the watershed approach, and expects the works to be undertaken keeping it in mind. For GP level planning, it is important to analyse the relationship between administrative and natural boundaries and plan accordingly to harmonise both the scalers. Bhuvan has the provision to generate Watershed Map of the AoI and overlay with other thematic layers.



Source: https://bhuvan-app1.nrsc.gov.in/state/RJ

Map Interpretation

- The map above shows that there are several micro watersheds within the GP boundary.
- There are some watersheds that partly belong to the GP. Depending upon the location, some ridge areas are part of the select GP, but the valley part belongs to an adjoining GP or vice versa.

Relevance of CWRM planning

- The micro watershed boundaries explain the extent and runoff characteristics in given conditions.
- The drainage lines and the size of the watershed reveal the kind of interventions that need to be undertaken.
- The map guides the prioritisation of interventions based on ridge to valley concept and sequencing the plan accordingly.

Soil Health

The soil health dashboard supplies the data for village wise soil major and micro-nutrients along with physical and chemical contaminants. This data is extremely useful for area treatment plan to address the deficit nutrients and type of agronomic interventions.

Major Nutrients	Very Low (VL)	Low (L)	Medium (M)	High (H)	Very High (VH)	Key Observations
Nitrogen (N)	Data N/A	Data N/A	Data N/A	Data N/A	Data N/A	
Phosphorus (P)	5	2	34	3	0	
Potassium (K)	0	3	41	0	0	
Organic Carbon	15	21	8	0	0	

Micronutrients	Sufficient (S)	Deficient (D)	Total Sample	Key Observations
Boron (B)	Data N/A	Data N/A	0	
Copper (Cu)	44	0	44	
Iron (Fe)	18	26	44	

Micronutrients	Sufficient (S)	Deficient (D)	Total Sample	Key Observations
Manganese (Mn)	33	11	44	
Sulphur (S)	44	0	44	
Zinc (Zn)	4	40	44	

Physical Parameter	pH	Values	EC	Key Observations
Acidic Sulphate (AS)	0	<4 Sodic Soil		
Strongly Acidic (SrAc)	0	<4 Sodic Soil		
Highly Acidic (HAc)	0	<4 Sodic Soil		
Moderately Acidic (MAc)	12	<4 Sodic Soil		
Slighly Acidic (SlAc)	6	<4 Sodic Soil		
Neutral (N)	0	=4 Normal Soil	44	
Moderately Alkaline (MAl)	24	>4 Saline Soil		
Strongly Alkaline (SlAl)	2	>4 Saline Sodic		

Soil Health Dashboard

- Go to https://soilhealth.dac.gov.in/NewHomePage/StateWiseNPKChart
- Select "Table" or browse for a particular table.
- For the villages where soil health information is unavailable, use the nearby villages from GP.

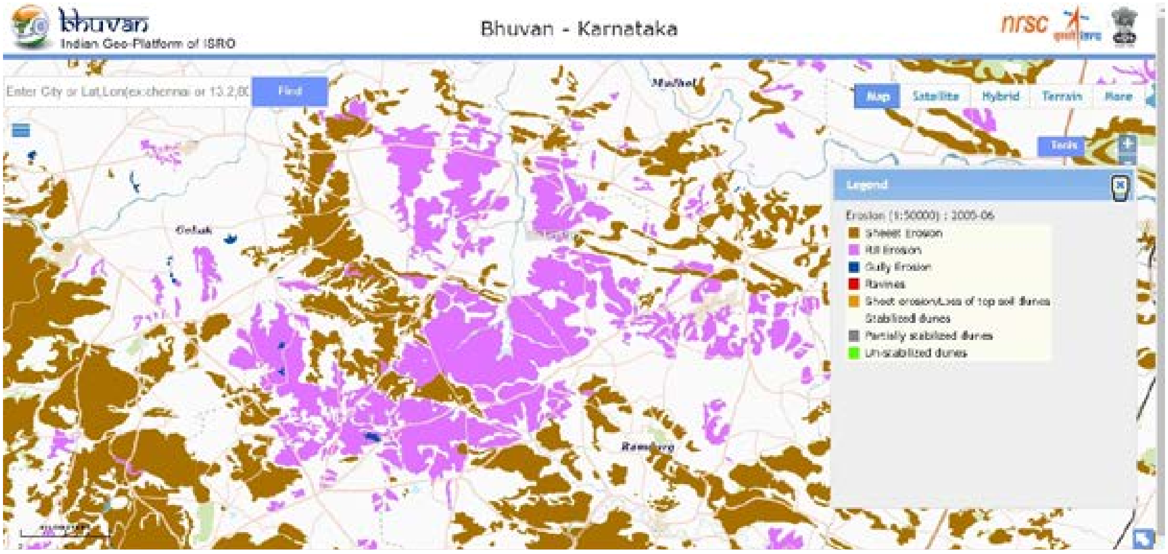
D 4 A. Soil Profile (Source: Agriculture Contingency Plan for District)

Soil profile data available in the agriculture contingency plan for Districts gives an overview of the soil texture and types of soils in the AoI.

S. No.	Type of Soil	Presence	Key Observations
1	Deep brown loamy		
2	Medium brown loamy		
3	Red gravely loam hilly soil	577.99	
4	Medium red loamy		
5	Shallow red gravelly loam		
6	Others (Specify Name)		

Soil Erosion Map

Description: Soil erosion impacts the fertility of agricultural land and quality of water. It will further aggravate with increasing demand, over-utilisation of natural resources, faulty land and water management practices. Evaluating soil erosion risks is a difficult task due to several concurrent processes, which vary with time and space. In general, the deformation status and overall erosion within a given area can be assessed using the soil erosion maps provided by Bhuvan.



Source: https://bhuvan-app1.nrsc.gov.in/state/RJ

Map Interpretation

- The information on land degradation is necessary to plan reclamation programs, to bring additional areas under cultivation, and to improve productivity.
- The map above shows displacement of soil material by water, resulting in either loss of topsoil or terrain deformation. This includes processes such as sheet, rill, and gully erosion.
- Sheet erosion results from loss of topsoil. The soil particles are removed from the soil surface on a fairly uniform basis in the form of thin layers. Gully erosion occurs when sheet erosion is severe, and the surface runoff goes in the form of a concentric flow. As a result, water channels called rills are formed the fields.

Relevance of CWRM Planning

- Soil erosion maps generated using RS and GIS indicate the extent of erosion classes. Corrective measures are to be taken to ensure that more such areas do not transform into the 'severe' erosion class.
- The map reveals whether a critical area is erosion prone, which indicates that soil conservation measures should be accorded high priority.
- Spatial distribution of soil loss is useful in developing management scenarios and guidelines for planners to develop measures for soil erosion prevention and control.

D 5. Forest Resources (Source: Forest Departments of States)

Details available with forest departments may vary from state to state in India (since forests are a state subject). This data is useful to treat the default higher slopes and gain an understanding of the ecology of the area.

S. No.	Type of Forest	Area in Ha	Key Observations
1	Protected Forest		
2	Reserve Forest		
3	Open Forest/Jungle		
4	Degraded Forest		
5	Village Forest		
6	Community Conserved Area		
	Total		

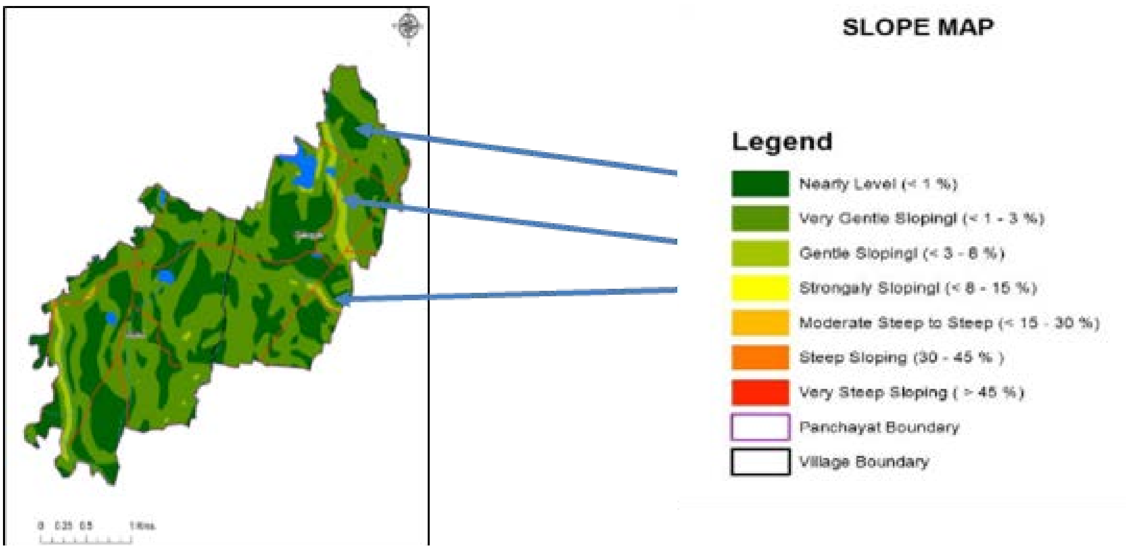
D6A. Amount of Runoff (To be calculated using Strange's Table Method)

Amount of runoff is calculated using the Modified Strange Table with the type of Landforms in place in the AoI. Land use information will help understand the local conditions and plan interventions for specific requirements

	Rainfall:	776 mm			
Types of Runoff	Area (Hect.)	% of Runoff	runoff (Cum)	runoff (Ha.M)	Key Observations
Good Catchment Area	228.03	27.4	2123.5	48.4	
Average Catchment Area	129.99	20.5	1580	20.5	
Bad Catchment Area	219.97	13.7	1061.75	23.4	
Total	577.99			92.3	

4. Slope Map

Description: Slope is the measure of steepness of the landforms of an area, and one of the major causes of soil erosion, degradation, landslides and runoff. The CARTOSAT-DEM datasets are available from Bhuvan and a registered user can access them freely for AoI. The slope directly affects runoff, infiltration, and land management conditions.



Source: https://bhuvan-app1.nrsc.gov.in/state/RJ

Map Interpretation

- The map shows that the slope here ranges from less than 1% to 8%, which depicts nearly plain at most places (areas with green shades).
- are gentle slopes of not more than 8% at very few places.
- The slope in this case is mostly gentle which implies that the runoff percentage is not very high.
- These sites are quite suitable for the establishment of water harvesting structures.

Relevance of CWRM planning

- Slope is the most important parameter that directly affects the watershed system. If the slope is high, the velocity of water is more, and as a result, the rainwater drains very quickly.
- As the slope rises, the amount of runoff and soil erosion increases. It is one of the most important data points required for the foundation of drainage line structures.
- Slope plays a vital role in positioning the water harvesting structures.

D6B. Existing Water Harvesting Structures

This information will assist in the assessment of water availability in existing water harvesting structures of the area and accordingly determine the required interventions to achieve water sufficiency.

S. No.	Name of Structure	Existing Structures				
		No.	Area in Ha	Storage Capacity (Ha.M)	Type of Uses	Key Issues
1	Pond (Talab/Naadi)	2	16.83	12.6225		
2	Oorani					
3	MPT					
4	Anicut					
5	Checkdam	2	0.93	0.465		
6	Gabion					
7	Gully Plug					
8	Farm Pond					
9	RTRWHS					
10	Tanka					
	Total			13.09		

D6C. Description of Natural Drainage Lines

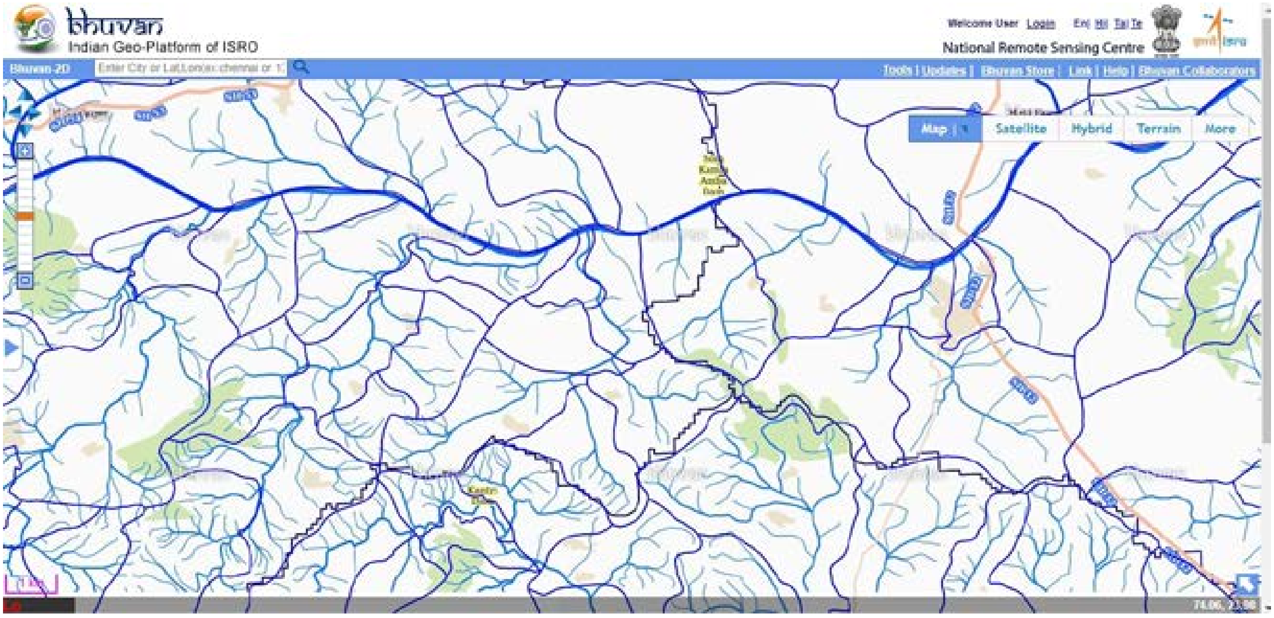
Natural drainage linescan be traced from Google Earth, Survey of India maps, or the Bhuvan portal. Their names can be retrieved from local people. This is necessary to understand the drains and calculate the amount of runoff into the drains, as well as type of drain (whether they are "Influent or Effluent" drains).

S. No.	Name / Details	Length in Village Area (m)	Type of Use	key Issues
1	1 st Order Streams	7446.63	Rain water Drain	
2	2nd Order Streams	2733.71	Rain water Drain	
3	3rd Order Streams	1803.82	Rain water Drain	
	Total	11984.16		

Source: Gram Panchayat/ Irrigation Department.

Drainage Map

Description: Drainage patterns and texture seen on images are good indicators of landform and bedrock types. For example, dendritic drainage patterns are most commonly found in nature. Drainage patterns show the direction of water flowing in the area. Since water flows from higher to lower levels, the contour helps us mark the uplands (from where the water flows) and lowlands (till where the water flows).



Source: https://bhuvan-app1.nrsc.gov.in/bhuvan2d/bhuvan/bhuvan2d.php

Map interpretation

- The area which has first, second and third order streams is finally converging with the major river passing along the GP boundary.
- The streams are mostly east-flowing whereas the major river is north-flowing.
- All the drainage lines originate from the upper slopes of hills passing through the GP.
- The drainage pattern clearly reveals the possible risks of soil losses from upper slopes.

Relevance of CWRM planning

- Drainage directly affects the runoff, infiltration and land management conditions.
- The drainage map shows the drainage order, pattern and destination. It also shows the spread and extent of surface water bodies.
- Different water harvesting structures are suitable for different drainage orders. For instance, temporary check dams are put on small streams, and larger or permanent gabion structures are more suitable for rivers.

D6D. Canal Network (GP/Irrigation Department)

Canal networks need to be understood for the details of waterlogging or related issues prevailing in the AoI. This understanding will also help increase the irrigation network or distributary planning to possible command areas, while also providing an understanding of the supply side of water.

S. No.	Type	Length in Village (m)	Type of Use	Key Issues
1	Main Canal	4333.99	Irrigation	
2	Minor	3564.74	Irrigation	
3	Distributaries			
4	Water Courses (Field Channels)			
	Total	7898.73		

D6E. Availability of Drinking water (Department of Public Health Engineering)

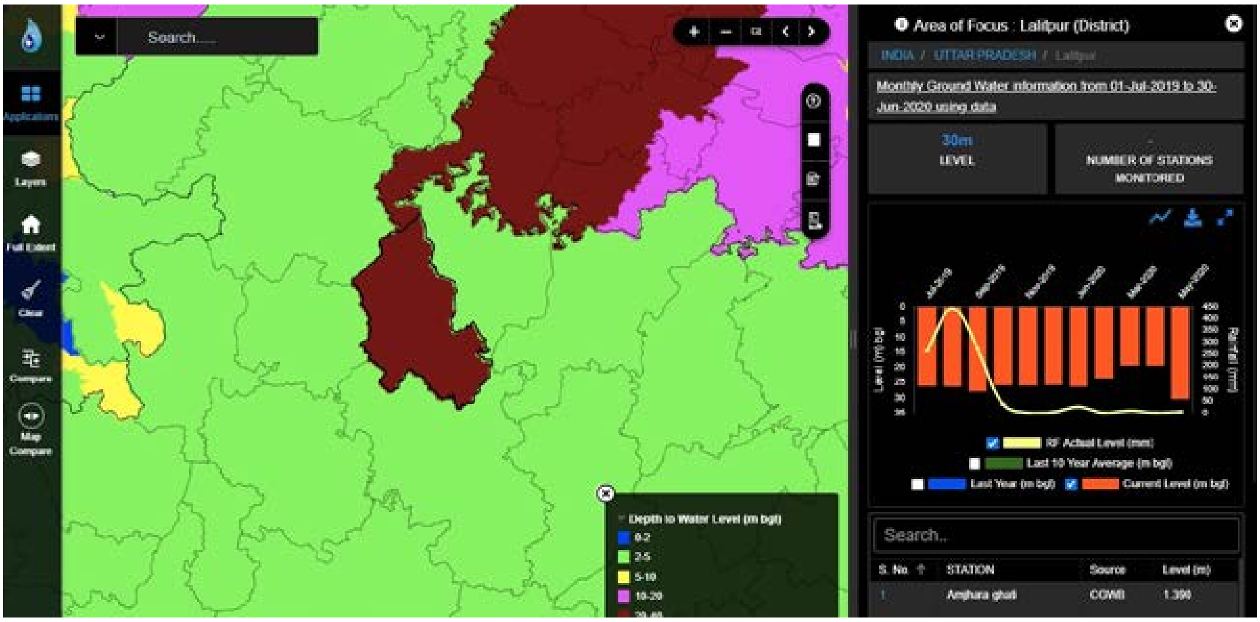
Information about available sources for drinking water is of utmost necessity to figure out the current scenario and to understand the need of interventions and ensure maximum coverage.

Type	Functional in No.	Households dependent	Key Observation
Tap Supply	Household		
	Public	2	60
RTRWHS / Tanka			
Handpump	21	100	
Openwell	2	20	
Borewell	1	40	
Tank/ Pond/ Oorani			
Springs			
River/ Streams			

Source: Public Health and Engineering Department

Groundwater

- Search for India WRIS – Water Data Online.
- Go to the link http://indiawris.gov.in/wris/#/waterData
- Click on "Application – Groundwater".
- Select "Yearly data".
- Give the period and click "Submit".
- Select State – District.
- Click on Graph and download data in XLS.



Source: http://indiawris.gov.in/wris/#/waterData

Availability of Drinking Water & Quality

- Gram Panchayat-Wise tested sources
- District Quality Profile

D6F. Status of Irrigation Facilities- Surface Water (Source: Census 2011)

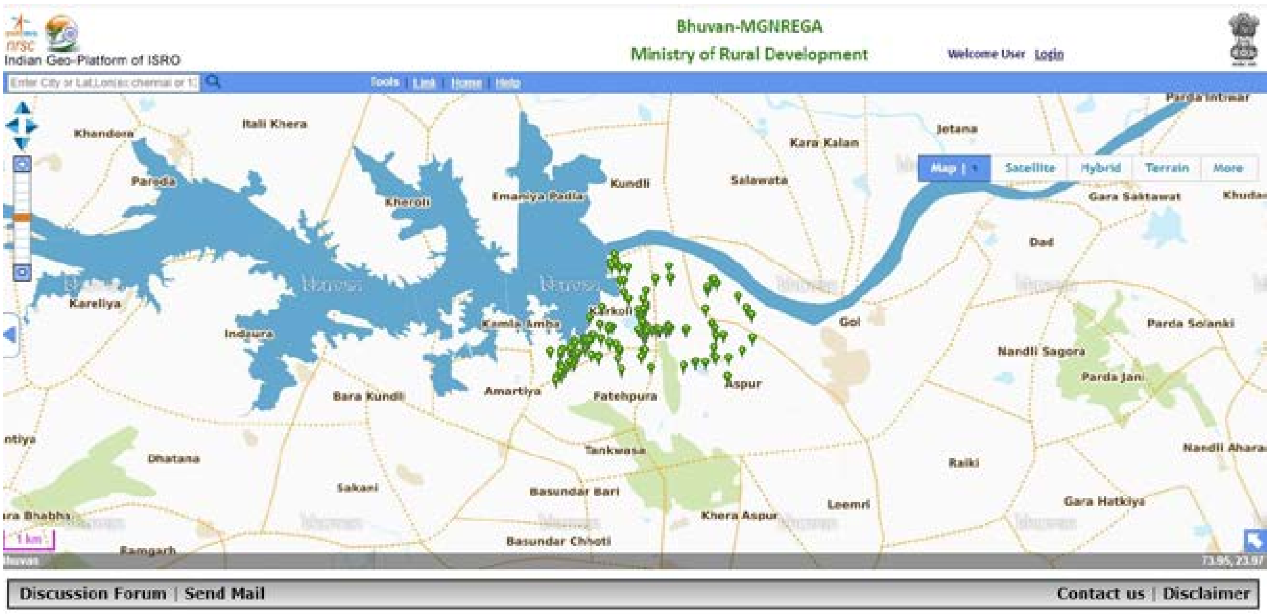
The supply from canals and their command area has to be understood in a manner that helps us calculate the pressure on the resources and manage the same in more efficient manner. The data is available in Census Handbook 2011.

Type	Area Irrigated (Ha)	Available (Months)	Key Issues
Canals Area (in Hectares)	37.14	4	
Wells/Tube Wells Area (in Hectares)	0	0	
Tanks/Lakes Area (in Hectares)	0	0	
Waterfall Area (in Hectares)	0	0	
Other Source (specify) Area (in Hectares)	0	0	
Total	37.14		

Source: Census Handbook 2011

Existing Mahatma Gandhi NREGA Assets Map:

Description: The existing NRM assets map can be derived from Mahatma Gandhi NREGA-Bhuvan portal. It depicts various activities completed and assets created during previous years under the programme. The map also indicates the level of treatment already taking place, and the potential/need for comprehensively treating the area to contribute to local livelihoods.



Source: https://bhuvan-app2.nrsc.gov.in/mgnrega/mgnrega_phase2.php

Map Interpretation

- The map shows that the works completed are scattered in the GP area.
- There are areas that have lacked any kind of intervention during the previous years.
- The upper slopes of the hillock extending North-East to South-West are not yet covered, although these areas are important from a watershed perspective.
- Drainage lines exist in the GP. This needs specific attention to leverage water harvesting potential.

Relevance of CWRM Planning

- The spatial distribution of NRM assets determine the importance of works undertaken and the relevance of particular asset in a particular location.
- According to the watershed approach, interventions should be undertaken in accordance with the ridge to valley concept. The map helps in identifying critical gaps and assessing the requirement for suitable activities.
- It also assists in identifying complementary interventions to leverage the full potential of assets that have already been created.
- Prioritising the areas left out so far due to various reasons to ensure inclusive delivery of the programme.

Means of Water Extraction

Information about the means of water extraction is a kind of primary data. It collected using a primary survey of the area during the planning exercise. This will help understand the area in a way that is most suitable and efficient in terms of management and to avoid contamination.

Type		No. of Sources	Purpose	Target Area if for agriculture)	Target population (if for drinking)	Key Issues
Gravity based		2	Agriculture	40		
Siphoning						
Lifting	Electric Power	65	Agriculture	90		
	Solar Power					
	Diesel Power	90	Agriculture	165		
	Draught power					

Water Application Practices for Irrigation

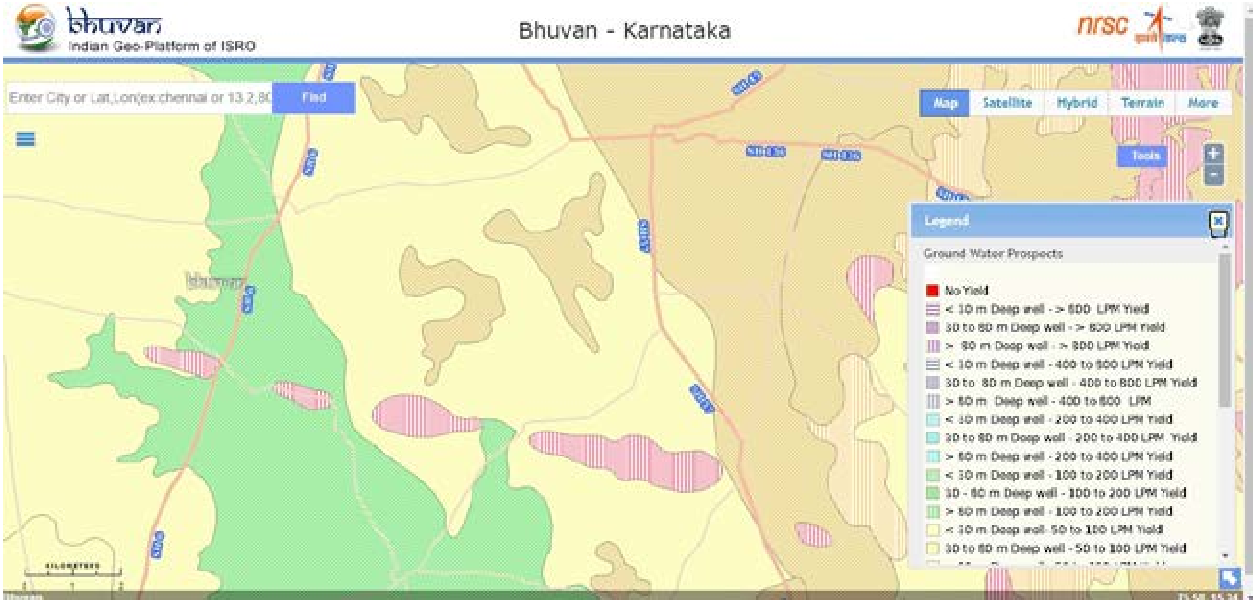
The prevailing agriculture practices are still an age-old one and not much improvement has been seen in the current scenario. This data will help us understand the AoI for managing this better and will provide information about the availability scenario for critical periods.

S. No.	Details of Practices	Water Source	Extraction Method	Area in Ha	Key Issues
1	Wild Flooding	Canal	Gravity	40	
2	Control Flooding	Tube Wells	Electric	90	
3	Furrow Method	Open Wells	Diesel	165	
4	Contour Farming				
5	Sprinkler Irrigation	Tube Well	Electric	5	
6	Drip Irrigation				

Source: Gram Panchayat Data

11. Groundwater Prospects Map

Description: It is important to understand the groundwater scenario of the AoI scientifically. The areas identified under Mission Water Conservation suffer from over-extraction of groundwater to meet local needs. The programme has a special focus on groundwater recharge and water harvesting, and hence it is important to know the groundwater potential and determine activities accordingly.



Map Interpretation

- This map provides the required information on geological parameters connected to groundwater exploration and the probable groundwater prospects.
- It helps in identification of sites for planning recharge structures to address water scarcity in a more effective manner.
- It facilitates identification of prospective groundwater zones for systematic selection of appropriate sites for drilling.
- It also reveals the stages of groundwater development, and the scope of extracting groundwater for critical purposes.

Relevance of CWRM Planning

- Groundwater maps play an important role as they examine the suitability of proposed actions in a particular location and determine expected outcomes.
- Through the analysis of this map, decision makers can provide inputs on suitable sites and structures.

W 1. Water Quality Profile

Water quality data is important since it will determine the intervention towards safe sources both for drinking and agricultural uses.

Chemical Contaminants (Nos. of Sources with Single Chemical Contaminants)

Iron	Fluoride	Salinity	Nitrate	Arsenic	Key Observations
	4	8	12		Tot 21 Samples

Bacterial and Other Contaminants (Nos. of Sources with Bacteriological Contaminants)

Faecal Coliform	TDS	Hardness	Chloride	Sulphates	Key Observations
	18	4	6		

(Source:https://ejalshakti.gov.in/IMISReports/Reports/WaterQuality/WQ/rpt_WQ_DistrictProfile_S.aspx?Rep=0&RP=Y {District Quality Profile})

Availability of Drinking Water & Quality

- Gram Panchayat Wise Tested Sources
- District Quality Profile

Source:https://ejalshakti.gov.in/IMISReports/NRDWP_MIS_NationalRuralDrinkingWaterProgramme.html

Assessment of Grey Water Generation

This calculation gives an idea of grey water generation and of the existing management practices to improve health and sanitation of the area of interest.

Wastewater generation Source	Per day/unit wastewater generation in L	Daily volume of Grey water in L	Annual Grey water in CuM	Key Observations
Bathing	15	18165	6630.225	
Washing	10	12110	4420.15	
Toilet	10	12110	4420.15	
Cleaning	5	6055	2210.075	
Cooking and cleaning Utensils	5	6055	2210.075	
Others	5	6055	2210.075	
Total	50	60550	22100.75	
Annual Grey water generated in HaM	2.210075			

5. Details of Domestic Grey Water Drains

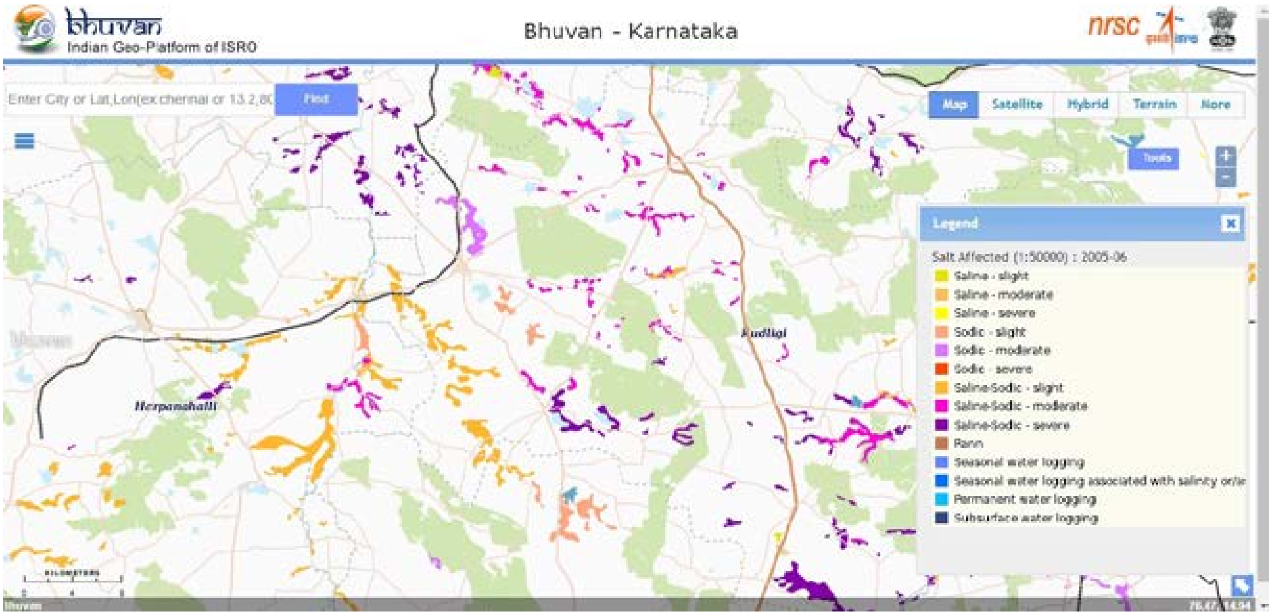
The grey water drains available in the AoI are either not sufficient, or not designed to dispose of it in the correct manner away from settlements. These details also give us an idea of the recycle and reuse of the same with efficient manner.

Details of existing Drain	Total Length of drain in villge (m)	Termination point (waterbody/ Natural Drainage/ Open space	Key Issues
Drain 1	900	Waterbody	
Drain 2	1300	Waterbody	
Drain 3	750	Open Space	
Drain 4	550	Open Space	
Drain 5	1100	Open Space	
Total	4600		

Salt Affected Areas Map

Description: The widespread deforestation of the past is considered to be the main cause of accumulation of salt deposits from lower strata up to the soil surface. This, despite various control measures, has resulted in the rapid expansion of salt-affected areas.

Salinisation can result due to improper management of canal irrigation water, resulting in the rise of the water table and consequent accumulation of salt in the root zone in arid, semi-arid and sub-humid (dry) conditions. It is also caused by sea water ingression in coastal regions and/or use of high salt containing groundwater. Salt-affected soils have been identified as one of the main hurdles affecting crop production.



Source: https://bhuvan-app1.nrsc.gov.in/state/KA

Map Interpretation

- Salt-affected areas are one of the most important degraded areas where soil productivity is reduced due to either salinisation or sodicity or both.
- The map also indicates that there is standing water during post-monsoon season in low-lying areas.

Relevance of CWRM Planning

- Assessment of salt-affected and water-logged areas is an important pre-requisite for planning reclamation and improving land productivity.
- Salinity can be controlled in some situations once its specific causes are understood.
- In the recharge area, improved drainage and water-efficient crop management practices will reduce the amount of water that enters the groundwater system.
- In the discharge area, where salinity appears, it is important to enhance the vegetative cover.

E. Agriculture and Water Resources

Agriculture is a major water demanding sector and issues related to water resources are directly linked to the cropping patterns of a particular area. The crop water requirements help in arriving at the volume of water utilised for irrigation purposes and defining deficiency or surplus of storage of surface water as well as groundwater recharged. It also indicates the nature of interventions required for bringing about water use efficiency.

S. No.	Crop	Irrigated Area (ha)	Rainfed area (ha)	WR (m) - irrigated	WR (m) - Rainfed)	Volume in HaM (Irrigated)	volume in HaM (Rainfed)	Total volume in HaM
1	Paddy		25	1.5	1	0	25	25
2	Jowar			0.55	0.5	0	0	0
3	Bajra			0.4	0.35	0	0	0
4	Maize		112	0.6	0.55	0	61.6	61.6
5	Ragi			0.45	0.4	0	0	0
6	Wheat	58		0.55	0.45	31.9	0	31.9
7	Minor Millets			0.35	0.3	0	0	0
8	Bengal gram			0.45	0.4	0	0	0
9	Red gram			0.7	0.65	0	0	0
10	Other pulses		20	0.4	0.35	0	7	7
11	Groundnut			0.6	0.5	0	0	0
12	Castor			0.7	0.65	0	0	0
13	Sunflower			0.6	0.5	0	0	0
14	Soybean		55	0.55	0.45	0	24.75	24.75
15	Sesamum			0.45	0.35	0	0	0
16	Mustard	12		0.45	0.35	5.4	0	5.4
17	Safflower			0.45	0.35	0	0	0
18	Linseed			0.5	0.4	0	0	0
19	Niger			0.4	0.3	0	0	0
20	Sugar cane			2	1.7	0	0	0
21	Cotton			0.85	0.75	0	0	0
22	Tobacco			0.5	0.45	0	0	0
23	Mulberry			1.2	0.8	0	0	0
24	Mango			0.6	0.6	0	0	0
25	Banana			2.2	2.2	0	0	0
26	Lemon			0.9	0.9	0	0	0
27	Guava			0.6	0.6	0	0	0
28	Sapota			0.5	0.5	0	0	0
29	Pomogranate			0.6	0.9	0	0	0
30	Papaya			0.9	0.6	0	0	0

S. No.	Crop	Irrigated Area (ha)	Rainfed area (ha)	WR (m) - irrigated	WR (m) - Rainfed)	Volume in HaM (Irrigated)	volume in HaM (Rainfed)	Total volume in HaM
31	Grapes			0.9	0.9	0	0	0
32	Other fruits			0.6	0.6	0	0	0
33	Potato			0.6	0.5	0	0	0
34	Tomato			0.7	0.7	0	0	0
35	Brinjal			0.7	0.7	0	0	0
36	Beans			0.5	0.5	0	0	0
37	Onion			0.6	0.5	0	0	0
38	Green chillies			0.6	0.6	0	0	0
39	Cole crops			0.6	0.6	0	0	0
40	Ladies finger			0.5	0.5	0	0	0
41	Radish			0.3	0.3	0	0	0
42	Carot			0.4	0.4	0	0	0
43	Water melon			0.3	0.3	0	0	0
44	Total leafy vegetables			0.3	0.3	0	0	0
45	Total gaurds			0.4	0.4	0	0	0
46	Other vegetables			0.45	0.45	0	0	0
47	Pepper			1	1	0	0	0
48	Cardamum			1	1	0	0	0
49	Tamarind			0.6	0.6	0	0	0
50	Dry Ginger			0.9	0.9	0	0	0
51	Turmeric			0.9	0.9	0	0	0
52	Garlic			0.6	0.6	0	0	0
53	Dry chilli			0.5	0.65	0	0	0
54	Coriander			0.6	0.6	0	0	0
55	Other spices			0.7	0.7	0	0	0
56	Coconut			0.5	0.5	0	0	0
57	Arecanut			0.7	0.7	0	0	0
58	Coffee			1	1	0	0	0
59	Oil palm			0.5	0.7	0	0	0
60	Cashew			0.5	0.5	0	0	0

S. No.	Crop	Irrigated Area (ha)	Rainfed area (ha)	WR (m) - irrigated	WR (m) - Rainfed)	Volume in HaM (Irrigated)	volume in HaM (Rainfed)	Total volume in HaM
61	Other plantation crops			0.5	0.5	0	0	0
62	Total flower crops			0.7	0.7	0	0	0
63	Medicinal plants			0.7	0.7	0	0	0
64	Aromatic crops			0.7	0.7	0	0	0
65	Forest			0.45	0.45	0	0	0
Total	70	212			37.3	118.35	155.65	

Livestock and Water Resources

Livestock details are taken from the farmer.gov.in portal for the entire AoI. This is also necessary for accurate planning and management of natural resources to cater to drinking water needs, as well as in planning for fodder and feed for animals.

Type of Animal	Numbers	Water Req. (HaM)
Cattle (Indigenous)	230	0.84
Cattle (Cross breed)		0.00
Buffaloes	449	2.46
Sheep		0.00
Goat	219	0.08
Horses and Camels		0.00
Pigs		0.00
Poultry	800	0.01
Dogs		0.00
Rabits		0.00
Total	1698	3.39

Source: https://www.farmer.gov.in/livestockcensus.aspx

- **Livestock Details village-wise are available at**
- https://www.farmer.gov.in/livestockcensus.aspx
- Click on State – District – Block (list of villages will be shown at this stage)
- Download in excel format (Block wise) and use the data.
- Kindly rename excel as soon as it has been downloaded (since every file will be of same name from server)

Water Demand Estimation (Primary Information)

This information will help in planning and maintenance of drinking water assets, and quality of water for alternate sources of drinking water such as rainwater harvesting and surface storage. Water demand calculation for annual requirement for animals and humans need to be understood using the data available, with probable increase of 10% of population increase in each type of population.

Water Users	Total Annual Requirement (HaM)	Requirement met by Gr. Water	Requirement met by S. Water	Key Observations
Human	3.32			
Animals	3.39			
Agriculture	155.65	37.30	118.35	
Industry				
Other (specify)				

F.6 Village-Wise Water Budgeting (Ha.M)

The water budget calculation is automated and it has been derived from the data filled in various cells above from authenticated sources. The calculation clearly mentions the individual water requirement to village-wise water requirement, and also the availability through runoff calculations. It also shows the harvested water, and status as surplus or deficient as per the nature of the AoI.

S. No.		Volume (Ha.M)	Key Observation
1	Water for Human use	3.32	
2	Water for Agriculture	155.7	
3	Water for Animals	3.39	
4	Water for Industry	0.00	
5	Water for Other Purposes	0.00	
6	Village-wise water required (1 to 5)	162.4	
7	Available runoff from rainwater	92.3	
8	Harvested Runoff from Water Harvesting Activities	13.1	
9	Potential Harvesting from proposed Interventions		
10	Total Water harvested	13.1	
11	Water deficiency/Surplus (10-6)	-149.3	

Key Water Challenges

The key challenges have been derived from key observations of each field of data and have been summarised together in this table to give information about the Area of Interest at a glance.

S. No.	Title	Key Challenges
1	B.1 Population and Household Information (Source: Census 2011)	
2	C.1 Mahatma Gandhi NREGA Job card Holders (Source: MIS – Mahatma Gandhi NREGA)	
3	Climatic profile	
4	Rainfall	
5	Evapotranspiration (http://indiawris.gov.in/wris/#/waterData)	
6	Soil Moisture	
7	D.1 Information of Land Use (Ha.) (Source: Census 2011)	
8	D.2 Land Use Detail of Micro Watersheds (Source: Watershed Atlas)	
9	D.3 Soil Resource (Source: https://soilhealth.dac.gov.in/NewHomePage/NutriPage)	
10	D 4 A. Soil Profile (Source: Agriculture Contingency Plan for District)	
11	D 5. Forest Resources (Source: Department of Forest)	
12	D6A. Amount of runoff (To be calculated from Strange's table method)	
13	D6B. Existing Water Harvesting Structures	
14	D6C. Description of Natural Drainage Lines (Source: Gram Panchayat/ Irrigation & Minor Irrigation department)	
15	D6D. Canal Network (Source: GP/Irrigation department)	
16	D6E. Availability of Drinking water (Department of Public Health Engineering)	
17	D6F. Status of Irrigation Facilities-Surface Water (Source: Census 2011)	
18	Means of Water Extraction	
19	Water Application practices for Irrigation	
20	Chemical Contaminants (Nos. of Sources with Single Chemical Contaminants)	
21	Bacterial and Other Contaminants (Nos. of Sources with Bacteriological Contaminants)	
22	Assessment of Grey Water Generation	
23	5. Details of Domestic Grey Water Drains	
24	Water Demand Estimation (Primary Information)	
25	F.6 Village Wise Water Budgeting (Ha.M)	

Description of Proposed Works

The process of identification of potential NRM works will commence with the assessment and listing of the NRM works that have been completed in the GP under Mahatma Gandhi NREGA, IWMP, and other state specific schemes i.e. MJSA (Rajasthan) & Neeru Chettu (Andhra Pradesh).

Identified works are analysed on economic, environmental and social aspects scientifically before prioritisation. They are then planned accordingly. The identified works are listed and planned on watershed principles to ensure their execution takes place in a systematic manner.

Therefore, an annual action plan will be prepared under Mahatma Gandhi NREGA for the coming years in a sequential order. The longitude and latitude of the identified potential assets are to be taken for the application of modern techniques like remote sensing and GIS as suggested for the use of area-based planning for NRM-related works under Mission Water Conservation (under Mahatma Gandhi NREGA). The proposed NRM works have been tabulated as follows:

C. Composite Action Plan for Water Resources

The Action plans according to the key challenges and issues identified above.

1. Action Plan for existing waterbodies/tanks/ponds/oornis/WHS

S. No.	Name & Location of Structure	Storage Capacity (Ha.M)	Interventions Required				
			Deepening/ Desilting / Bund strengthening	Inlet development with silt trap	Surplus/ waste weir construction	Bund Plantation & Grass-turfing	Estimated Cost
1	Jakri Tabal	9.82	10	500	1	0.5	
2	Khada Pasor Talab	1.87	1.5	229	1	0.5	

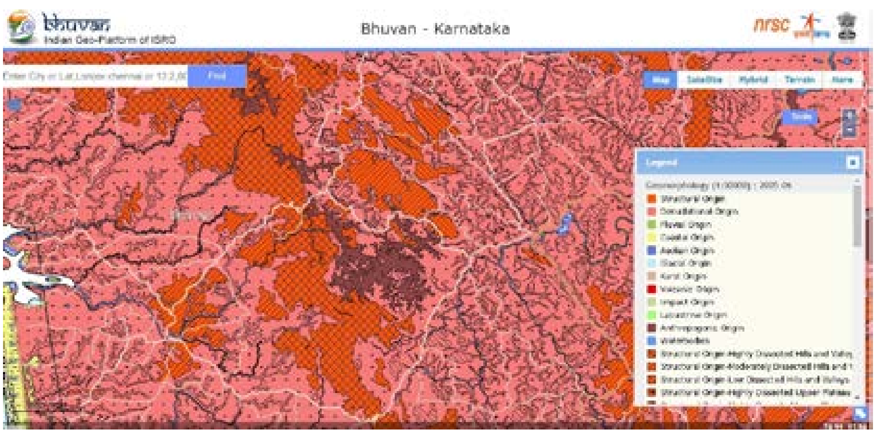
Action Plan for New Water Bodies/Farm Ponds (Source: Gram Panchayat)

2 a) Action Plan for New Water Bodies on Common land

S. No.	Nature of Storage/Location	Area (Hectares)	Storage Capacity (HaM)	Estimated Cost
1	NCD 1	0.46	0.23	
2	NCD 2	0.46	0.23	

Geomorphology Map

Description: Geomorphology deals with landforms which help in understanding the erosion process and hazards. The geomorphology of this area is very conspicuous and guided by the composition of the rocks. There are four major divisions in geomorphology i.e. structural hill, denudation hill, pediment, alluvial plain and aeolian plain. Structural hills are formed as the result of regional deformation.



Source: https://bhuvan-app1.nrsc.gov.in/

Map Interpretation

- The map shows that highly dissected hills and valleys make the up-ridge areas (areas with deeper shades of orange with inclined hatches).

- At a few places near the riverbed, younger alluvial plain and flood plain (areas with green) exist.
- A small portion of the terrain shows anthropogenic activities (area with brown).

Relevance of CWRM planning

- Suitability of any intervention will certainly be influenced by geomorphological conditions. Hence, it needs to be closely examined.
- Geomorphology determines the character of soil, vegetation, water percolation, and land cover.
- The geomorphic and geologic conditions help guide us towards undertaking appropriate work in a particular location to reap maximum benefits.

2 b) Action Plan for Farm Ponds on Individual Beneficiary land

S. No.	Name of Individual Beneficiary & Site Location	Storage Capacity (HaM)	Estimated Cost
1			
2			

3. Action Plan for Roof top Rainwater Harvesting for Storage (Source: Gram Panchayat)

(School, Heath Centre, Anganwadi, Gram Panchayat Bhawan etc)

S. No.	Nature of Storage/Location	Storage Capacity (liters)	Estimated Cost
1	Govt. Senior Sec. School	25000	
2	PSC	25000	
3	Gram Panchayat Building	15000	

4. Action Plan for Canal Network (Source: GP/Irrigation Department)

S. No.	Type	Interventions Required					
		Slit removal (Desilting)/Bed levelling	Restoration / Minor repair of cracks	Repairing outlets, gates & regulators	Canal side plantation	Canal service roads	Estimated Cost
1	Main Canal	4334	4000	15	4334		
2	Branch Canal						
3	Distributary						
4	Minor	3565	3500	18	3654.74		
	Total						

5. Action Plan for Water Courses (Source: GP/Irrigation Department)

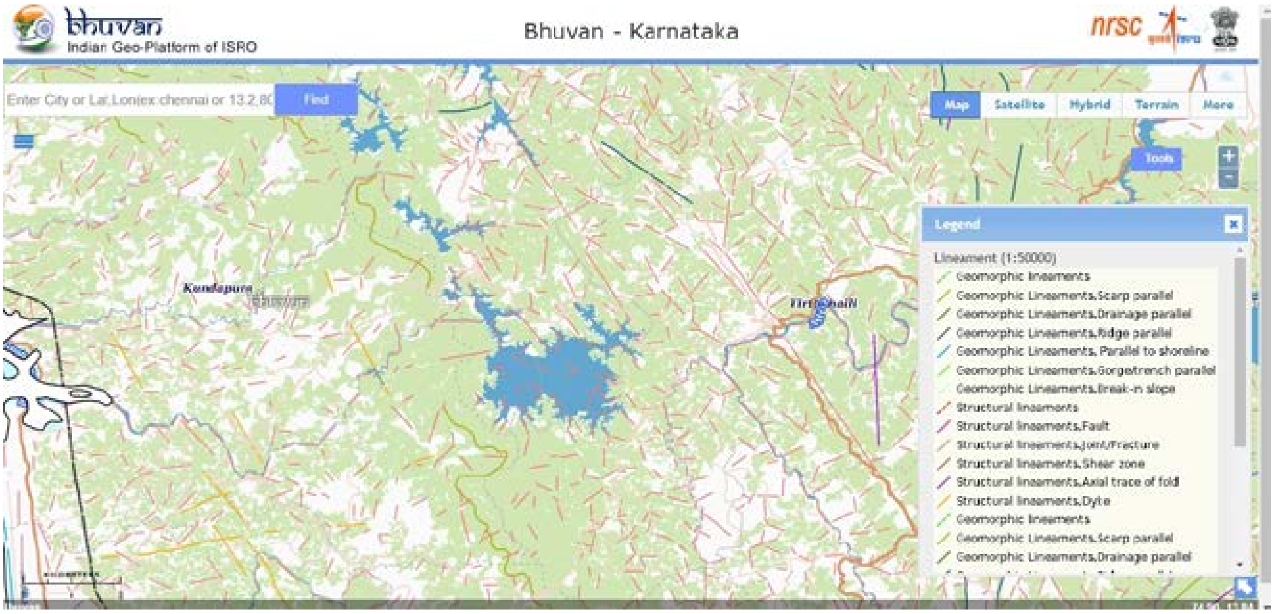
S. No.	Site Location/ Name	Interventions Required					
		Renovation	Silt removal (Desilting)	Strengthening and lining	Estimated Cost	Bund plantation & Grass-turfing	Estimated Cost
1							
2							
	Total						

6. Structural Geology Map

Description: Structural features are important for making decisions related to water conservation, harvesting and recharge measures. The lineament map depicts the distribution of rocks, bedding planes, folds, faults and lineaments present in an area. Lithology affects the runoff percentage. A large part of water will flow underground where the rocks have cracks.

Map Interpretation

- Green lines show ridge parallel lineament trending from South-East to North-East.
- Pink lines show structural deformities marked by a fault line between Bada Kheda and Gandheri villages.
- Orange line depicts structural lineament and has drainage parallel along the main Banas River.
- Purple lines depict the axial fold traces adjoining the GP boundary.



Source: https://bhuvan-app1.nrsc.gov.in/state/KA

Relevance of CWRM planning

- The structural geology influences the landscape, surface and groundwater regimes significantly.
- Surface runoff and storage of water are determined by the types of structural formations within the area.
- For undertaking water conservation and harvesting measures, it is important to understand types of formations and their implications in terms of site suitability either for water impounding or groundwater recharge.
- The lineaments show the scope and nature of water-related works.

6. Interventions Required for Natural Drainage Network (Source: Gram Panchayat)

S. No.	Name	Interventions Required				
		Deepening/ Desilting	Silt traps	Check dams/ Site specific Water harvesting Structures	Recharge structures/ Sub Surface Barriers	Connecting water bodies
1						
2						
	Total					

Consolidated Proposed Activities for Water Security

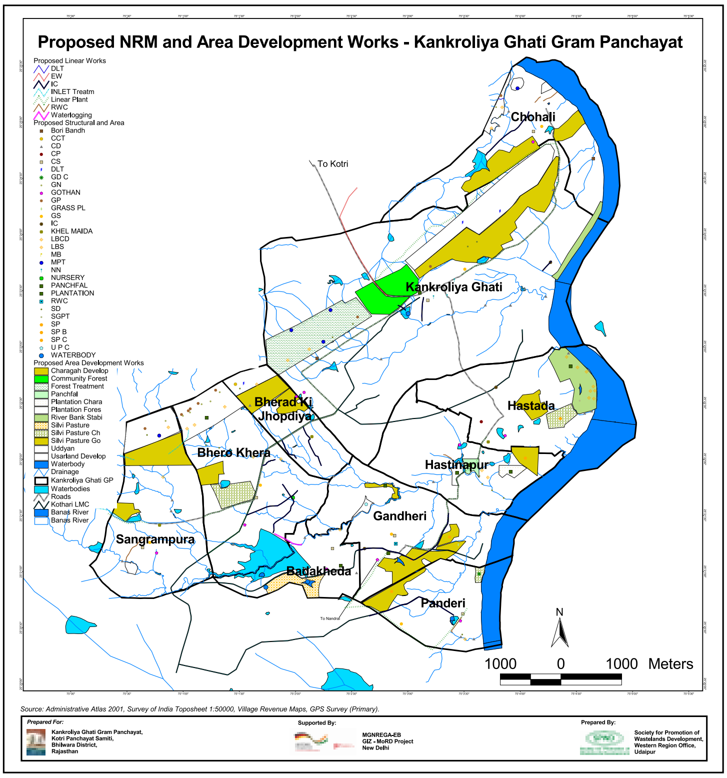
Activity	Numbers	Area In Ha	Estimated Cost	Expected Outcomes
Treatment measures of upper slopes				
Afforestation				
Continuous contour trenches (CCT)				
Water point				
Gabion				

Activity	Numbers	Area In Ha	Estimated Cost	Expected Outcomes
Contour Continuous Bunds (CCB)				
Drainage Line Treatment (DLT)				
Gully Plugs				
Treatment measures of middle slopes				
Loose Stone Check Dam (LSCD)				
Mini Percolation Tank (MPT)				
Staggered Contour Trenches (SgCT)				
Water Absorption Trench (WAT)				
Water Harvesting Structure (WHS)				
Silvi-pasture Development				
Linear Plantation				
Avenue plantation				
Block Plantation				
Fencing				
Grass seeding				
Treatment measures of gentle slopes				
Deepening of waterbodies				
Desiltation of waterbodies				
Waterbody Bund strengthening				
Inlet development with silt trap (Waterbodies)				
Surplus/waste weir				
Sub surface barriers				
Artificial recharge structure				
Treatment measures for canal network				
Repairing outlets, gates & regulators of Canal				
Minor repair of cracks in canals				
Canal Bed levelling				
Canal Bund Plantation				
Irrigation channels				
Canal side plantation				
Treatment measures for farmlands				
Composting				
Farm Bunding				
Micro Irrigation				
Construction of farm ponds				
Construction/renovation open well				
Nursery development				
Silt application				

Activity	Numbers	Area In Ha	Estimated Cost	Expected Outcomes
Mulching				
Land development				
Field terracing				
Drinking water measures				
Rooftop Rainwater Harvesting				
Drinking Water Scheme Panghat				
Grey water management				
Drain for Regulating Domestic wastewater flow				
Wastewater drains				
soak pits				

Action Plan Map

Description: It is the final map depicting the proposed suitable structures on the sites. All parameters such as elevation, land use, depth, etc. are related to each other and influence each other. This means the decision should be based on all the parameters and not just one. Hence, all the parameters are overlaid together and sensitive areas are marked. After prioritising the areas of concern, suitable structures are decided and suitable sites are delineated.



Map Interpretation

- Gabions and stop dams fulfil the requirements of gentle or moderate slopes as well as those of degraded forests, barren lands, etc.
- Check dams have been proposed on the sites that satisfy lithology with no faults or joints and where sites are away from drainage lines and finally on low permeable soil.
- Through the analysis of this map, the decision maker can get direction to view suitable sites and structures which would otherwise involve a lot of time and labour.

Chapter 6
Exploring Convergence and Co-financing for Localising CWRM

This chapter explores the convergence of water interventions with Mahatma Gandhi NREGA, which, by being not only the largest public employment schemes in the world but also one that places significant focus on works related to natural resource management, is ideal for the same. The chapter details various schemes that can be explored for such a convergence and co-financing.

6.1 Introduction

Water security, as an integral component of sustainable development, has always been largely a governance challenge even though India has emerged as a top-ranking nation in terms of water sector investments.

However, the focus areas of most programmes focus are often confined in isolation only to drinking water security & irrigation; they often do not address the critical factors of sustainable convergence and governance. It is necessary to demonstrate a comprehensive and sustainable water security programme through a bottom-up and adaptive planning process by bringing together governance and capacity building, and by providing local solutions to global concerns of climate change adaptability.

6.2 Convergence of Mahatma Gandhi NREGA with other Schemes in the area

Several Line Departments (LDs) are trying to develop rural areas through a variety of programmes and schemes. Though their efforts are extensive, they are limited by programme guidelines in case there are critical gaps in project activities to achieve the desired end results. Programmes, activities, funds and technical guidance might be available with other LDs to bridge such gaps. Proper convergence helps to pool and bring to achieve development and generate positive change together.

The Mahatma Gandhi NREGA is a good opportunity for natural resources management, watershed management, agricultural development, and the creation of rural infrastructure. Unlike several other programmes that are time-bound and only operational in a few areas, Mahatma Gandhi NREGA is a unique opportunity as discussed below.

6.3 Why Convergence with Mahatma Gandhi NREGA:

- Most water-related works required in rural areas are permitted under Mahatma Gandhi NREGA,
- It can take up any labour component related to building natural assets for the poor,
- It is open-ended i.e. no physical & financial norms,
- Follow physical, technical & financial norms of the scheme to be converged with
- No budget limits, it is as per demand for work under Mahatma Gandhi NREGA,
- Mahatma Gandhi NREGA is being implemented in every GP of the country,
- Every household in a rural area can have a Job Card for unskilled work and thus work under Mahatma Gandhi NREGA,
- Decisions related to the programme lie with the Gram Sabha, and
- It can be integrated into many other programmes.

To increase effectiveness of investments from Mahatma Gandhi NREGA in terms of developing assets as well as asset-based income for wage dependent families, Mahatma Gandhi NREGA can work in convergence with other programmes. The convergence can be facilitated through following ways:

- Gap filling (budget/ investment convergence) for value addition
- Purpose or objective-based convergence: forward linkages/ value addition.

6.4 Convergence: Steps for Implementation

Planning at GP level

- Activity identification
- Prioritisation
- Budget estimation
- Exploring schemes/departments
- Matching fund
- Administrative sanctions

Work execution

- Role clarity
- Sequencing of works
- Execution
- Measurements
- Recording
- Payments

Management, monitoring and reporting

- Preparing activity / work execution calendar
- Coordinating with the functionaries of different line departments/schemes
- Material management
- Mandatory check measurement by respective departments /agencies

Potential Programmes and Schemes for Convergence and Co-financing

Department of Rural Development	Department of Panchayati Raj	Dept. of Water Resources	Groundwater Department	Public Health and Engineering Department	Department of Agriculture /AH	Department of Land Resources	Department of Forest	Department of Horticulture
Mahatma Gandhi NREGA	SFC	Major / minor Irrigation Schemes	Atal Bhujal Yojana	Jal Jeevan Mission	RKVY	NRLMP	CAMPA	NHM
MP/MLA - LAD	14 FC	PMKSY	Groundwater quality monitoring	Drinking water quality monitoring	PMKSY	IWMP-PMKSY	Forest Working Plan	PMKSY
State Area Development Program	SBM	AIBP	Groundwater estimation & budgeting	Rural drinking water schemes	NMSA	NWDPRA	District/ River Ravine area Programme	NMSA
NRLM/ SRLM	RDWP	State-specific schemes		O & M of existing schemes	RADP	DPAP	NAEB	NSM
RURBAN	State Specific PR schemes				AFDP	DDP	GIM	
Swachh Gram					Agriculture Contingency Plan	IWDP	Externally Aided Project	

A typical exercise to identify all the works/ activities to be covered under Mahatma Gandhi NREGA and under watershed development programme / other similar programme, separately, with the size of area/ work, estimated cost and the year in which proposed.

S. No.	Work/Activity	Kind of Area	Programme under which proposed
A	Watershed Management		
	a. **RIDGE AREA TREATMENT:** All activities required to restore the health of the catchment are by reducing the volume and velocity of surface runoff, including regeneration of vegetative cover in forests, common land afforestation, staggered trenching, contour and graded bunding, bench terracing etc.	Individual land/ common land/forest land	Mahatma Gandhi NREGA

S. No.	Work/Activity	Kind of Area	Programme under which proposed
	b. DRAINAGE LINE TREATMENT: With a combination of vegetative and engineering structure, 1) Earthen checks, 2) Brushwood checks, 3) Gully plugs, 4) Loose boulder checks, 5) Gabion structures, 6) Underground dykes etc. 7) Pucca check dam/ Anicut /Drop spillway/ Stop dam-cum causeway 8) Sub-surface water harvesting structure in in coastal area	Individual land/ Common land/forest land	Mahatma Gandhi NREGA
	c. DEVELOPMENT OF WATER HARVESTING STRUCTURES: Including 1) farm ponds, 2) nalla bunds, 3) percolation tanks and 4) groundwater recharge through wells, bore wells and other measures	Individual land/ Common land/forest land	Mahatma Gandhi NREGA
	d. NURSERY RAISING: for fodder, fuel, timber and horticulture species	Individual land/ common land/forest land	Mahatma Gandhi NREGA
	e. LAND DEVELOPMENT: including in –situ soil and moisture conservation and drainage management measures like 1) Field bunds, 2) Contour and graded bunds fortified with plantation, 3) Bench terracing in hilly terrain etc.	Individual land/ common land/forest land	Mahatma Gandhi NREGA
	f. CROP DEMONSTRATION: for popularising new crops/ technologies such as drip irrigation or innovative management practices	Individual land/ common land/forest land	Mahatma Gandhi NREGA/PMKSY
	g. PASTURE DEVELOPMENT: sericulture, bee keeping, back yard poultry, small ruminant, other livestock and micro-enterprises	Individual land/ common land/forest land	Mahatma Gandhi NREGA/PMKSY
	h. VETERINARY SERVICES: for livestock and livestock improvement measures	Individual land/ common land/forest land	IWMP
	i. FISHERIES DEVELOPMENT: in village ponds/ tanks, farm ponds etc.	Individual land/ common land/forest land	Mahatma Gandhi NREGA
	j. PROMOTION AND PROPAGATION OF NON-CONVENTIONAL ENERGY SAVING DEVICES: energy conservation measures, biofuel plantation etc.	Individual land/ common land/forest land	IWMP

S. No.	Work/Activity	Kind of Area	Programme under which proposed
	a) TREE PLANTATION 1) Boundary plantation 2) Agro-forestry	Individual land as permitted at Para 5 of schedule-1	Mahatma Gandhi NREGA
		Individual land of other than permitted under Mahatma Gandhi NREGA	IWMP/RKVY
	b) **HORTICULTURE PLANTATION** 1) Block plantation 2) Agro-horticulture plantation	Individual land as permitted at Para 5 of schedule-1	Mahatma Gandhi NREGA
	1) Block plantation 2) Dry horticulture plantation	Individual land of other than permitted under Mahatma Gandhi NREGA	IWMP/RKVY
C	**LAND DEVELOPMENT**		
	a) Reclamation of salt-affected land	Individual land as permitted at Para 5 of schedule-1	Mahatma Gandhi NREGA
	b) Reclamation of salt affected land	Individual land of other than permitted under Mahatma Gandhi NREGA	IWMP/RKVY

Typical exercise for planning convergence

Line Dept.	Work Type	Activities		Physical	Financial	Funding		
		By MGNREGA	By Line department			By MGNREGA	By Line department	Beneficiary contribution

The LDs which are converging works with Mahatma Gandhi NREGA have to prepare district-wise plans indicating their share in the project amount which will be involved in the programme.

Guidelines issued by the ministry and are relevant to convergence:

S.NO	SUBJECT	LETTERNO	DATE of Issue
1	Guidelines for providing inputs under the schemes of by ICAR and its field institutions like KVKs, etc.	J-11019/12/2008-NREGA (ICAR)	24th Dec.2008
2	Guidelines for convergence between Mahatma Gandhi NREGA and the scheme of the Ministry of Environment & Forest	J-11019/2/2008-NREGA	19th Jan. 2009
3	Guidelines for convergence of Mahatma Gandhi NREGA with the schemes of Ministry of water Resources	J-11019/2/2008-NREGA	18th Feb. 2009
4	Guidelines for Convergence NREGA with Programmes of MOA for Development of Agriculture and Allied sector.	J-11019/2/2008-NREGA	12th Oct. 2009

S.NO	SUBJECT	LETTERNO	DATE of Issue
5	Construction of Play fields under Mahatma Gandhi NREGA Scheme	J-12055/1/2007-NREGA	11th Feb,2013
6	Additional Convergence guidelines Mahatma Gandhi NREGA & Programme of Ministry of Agriculture	J-13011/1/2009-Mahatma Gandhi NREGA	13th June.2013
7	Guidelines for taking up Rubber Plantation through Convergence of Mahatma Gandhi NREGA & Schemes of Rubber Board, Ministry of Commerce & Industry	J-11017/17/2013-MGNREGA (UN)(Part-III)	2nd Aug. 2013
8	Guidelines on, "Watershed Management works taken up independently under Mahatma Gandhi NREGA or in convergence with IWMP"	J-11017/17/2008-NREGA (UN)	11th Aug 2014
9	"Guidelines for Convergence Mahatma Gandhi NREGA with Catalytic Development Programmes of Ministry of Textiles"	J-11017/17/2013-MGNREGA (UN)(Part-II)	8th Oct.2013
10	"Convergence Guidelines for Mahatma Gandhi NREGA & PMGSY"	J-11060/1/2011-MGNREGA	7th Nov. 2013
11	Convergence guidelines Mahatma Gandhi NREGA & PMGSY	J-11060/1/2011-MGNREGA	7th Nov, 2013
12	Guidelines for construction of Houses (Sanctioned under IAY or such other State or Central Government scheme) under Mahatma Gandhi NREGA	J-11017/40/2011-MGNREGA (UN)	30th June, 2014
13	Guidelines on watershed management works taken up independently under Mahatma Gandhi NREGA or in convergence with IWMP	J-11017/17/2008-NREGA (UN)	11th Aug 2014
14	Advisory on, "Convergence of Mahatma Gandhi NREGA and Railways"	J-11017/42/2013-MGNREGA (UN)	21st Sep. 2014
15	Guidelines for taking up Coconut plantation through convergence of Mahatma Gandhi NREGA & Expansion of Area under coconut (AEP) scheme of Coconut Development Board, MOA	J-11017/48/2014-MGNREGA (UN)	20th Feb. 2015
16	Guidelines for convergence Mahatma Gandhi NREGA with Green India Mission (GIM) of MoEFCC	9-5/2015/GIM/ MGNREGA	3rd March 2015
17	**Mission Water Conservation** In convergence with Prime Minister's Irrigation Programme (PMKSY) and Integrated Watershed Management Programme (IWMP)		1st November, 2016
18	Advisory on promotion of Agri Nutri garden under farm livelihood	F.No K-11060/02/ 2019/NRLM (livelihood) part 1, MoRD (RL) Division	10th December, 2019

An Example of a Successful Convergence and Co-financing Initiative
Mukhyamantri Jal Swavlamban Abhiyan (MJSA) – Rajasthan

CONVERGENCE

Departments planning for water utilisation


Mahatma Gandhi NREGA & RD-PR


Watershed Department


Water Resources Department


Afforestation

PHED


Agriculture


Horticulture


Groundwater

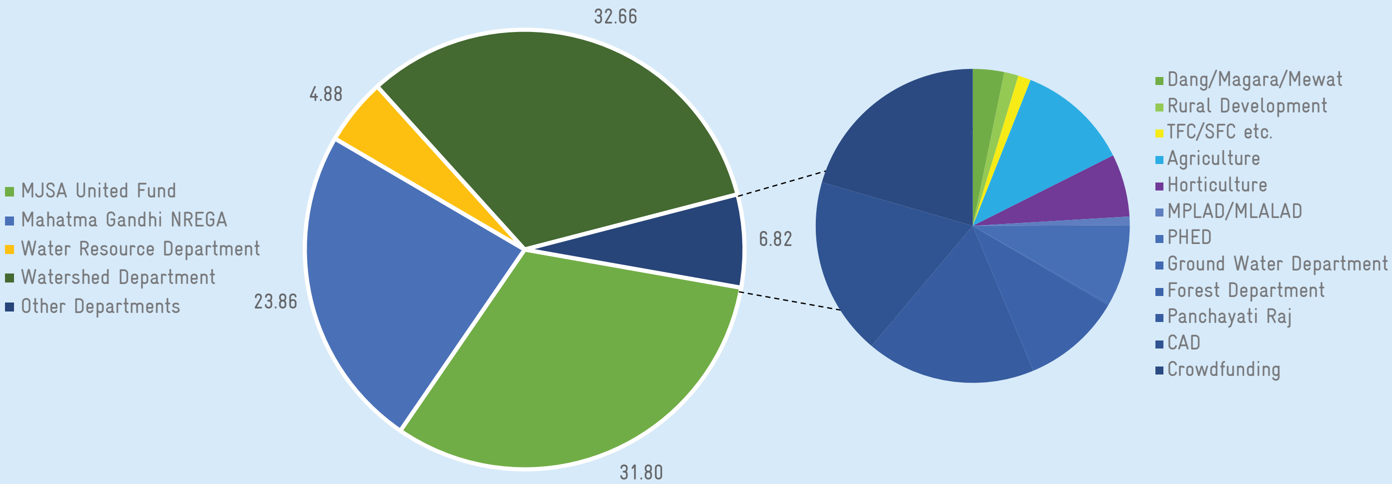

TECHNICAL SUPPORT

Departments planning for water harvesting

Leadership of Hon'ble CM

DPR OF MJSA

MJSA Convergence – Percentage Contribution (By Department)



CONVERGENCE - PHASE 1 CONTRIBUTIONS OF VARIOUS DEPARTMENTS TO MJSA (%)				
Department	Contribution		“Other Department” Details	Contribution
MJSA United Fund	31.80		Dang/Magara/Mewat	0.22
Mahatma Gandhi NREGA	23.86		Rural Development	0.10
Water Resource Department	4.88		TFC/SFC etc.	0.09
Watershed Department	32.66		Agriculture	0.79
Other Departments	6.82		Horticulture	0.44
			MPLAD/MLALAD	0.06
			PHED	0.57
			Ground Water Department	0.01
			Forest Department	0.70
			Panchayati Raj	1.19
			CAD	1.25
			Crowdfunding	1.40

मुख्यमंत्री
जल स्वावलम्बन
अभियान

Source: Mukhya Mantri Jal Swawalamban Abhiyan, Government of Rajasthan.

Chapter 7
Tools for Spatial Data Analysis

This chapter explains the increasing significance of the emerging GIS and remote sensing technologies and their significance in CWRM planning, focusing on thematic maps, their types, uses, significance and contribution to the planning process itself.
It also explains the purpose, usage, features, and other elements of the Bhuvan portal which will be useful for all functionaries who seek to undertake spatial data analysis.

7. 1 GIS and Remote Sensing (RS)

Spatial information is expected to provide the essential elements for effective natural resources management. GIS provides a critical framework for covering these spatial aspects. Presently, there is no adequate spatial information available at Gram Panchayat/ village level.

In recent years, GIS technology has made great strides and contributed significantly to the management of natural resources. Identification of suitable sites for IWRM interventions is dependent on various parameters like the nature of terrain, runoff potential, hydrogeology, soil and drainage by using GIS techniques. Additionally, the identification of water conservation and harvesting sites are inter-dependent on various elements like nature of terrain, runoff potential, hydrogeology, soil and drainage. The GP area can be classified into suitability of sites for particular intervention based on the above parameters using GIS tools.

7.2 Expected GIS & RS Outputs for CWRM Planning

The maps used in CWRM plan preparation have been generated from the information available on the *Bhuvan* portal of NRSC. Support for Decentralised Planning (SIS-DP), a recent initiative by NRSC, provides desired services for CWRM plan generation. It also enables us to generate a map book of the GP area with required thematic layers as to be used in the CWRM plan. One can select the GP from the drop-down option and also select types of thematic maps required and then generate the map book for the CWRM plan purpose. The thematic layers and related datasets can also be accessed from the *Bhuvan* repository and may be processed further (if required) with the help of Quantum GIS software (open source).

7.3 GIS & RS Outputs in the Form of Thematic Maps

A thematic map is a special-purpose, single-topic or statistical map. It focuses on spatial variability of a specific distribution or theme (such as population density or land use pattern). Thematic maps normally include some locational or reference information, such as place names or major water bodies to help map readers familiarise themselves with the geographic area covered on the map.

Such maps represent characteristics or themes of a geographical area. For instance, the slope map shows the condition of slope in an area, and the land use land cover map shows the distribution of lands in an area. Similarly, a thematic map explains the detailed conditions in a target area.

RS & GIS technologies are used to increase the efficiency of the planning process. The work of watershed management is based on establishing watershed structures on suitable sites where maximum outputs will be obtained. The planning starts by collecting information about village terrain characteristics. GIS is then used to process the raw satellite data and turn it into an informative thematic map. The benefits of using thematic maps for CWRM planning include the following:

- Helps in assessment of spatial distribution of features such as agricultural fields, rivers, other water bodies, drainage lines, etc. This helps in overall mapping of the project area.
- Enables assessment of elevation features without any manual labour, such as status of slope in an area, contours, drainage pattern, etc. This provides the knowledge required for seeking the suitable elevation for a water harvesting structure.
- Analysis of suitable locations for water harvesting structures such as distance of the farm pond from the drainage line, distance of the drainage line from the crop fields, etc.
- Useful for Participatory Rural Mapping (PRM) involving both technical support team and villagers to together analyse the situation and come up with a proposal of interventions.

Table 7.1: Elements of GIS Thematic Maps

Elements	Description
Size	– Size means the areal extent of a watershed – Characteristics of watershed varies in terms of runoff – Geographical area of watershed can be derived accurately from GIS outputs
Shape	– Watersheds can have varied shapes, e.g. square, palm shape, rectangular, oval, etc. – The shape of watershed affects the runoff characteristics – GIS outputs can help in identifying the shape of given area
Slope	– This determines runoff volume, soil loss, infiltration, etc. – Based on slope site and selection of area, treatment measures need to be planned – CARTOSAT DEM datasets provide information on slope

Elements	Description
Drainage	– The drainage pattern determines characteristic of watersheds – It also consists of stream orders and provides information about runoff – Superimposing the geomorphology and drainage thematic layers helps in identification of CWRM measures
Geo-hydrology	– The geo-hydrological conditions determine water recharge capabilities – GIS outputs of CGWB and NRSC provide information to determine water harvesting and recharge measures
Soils	– Soil classification indicates degree of limitation on land use – For watershed development, various soil parameters such as depth, texture, slope and erodibility are critical – The GIS outputs offered by NBSS & LUP provides important thematic layers
Land Use	– Land use reflects the physical conditions and production capabilities of existing natural resources in the watershed – One of the major components of monitoring the impact of watershed development is the change in land use & land cover pattern over a period of time

7.4 Stages of Planning and Decision-Making

- **Recognition** (of geographic problems or resource conditions in a village): Spatial features by visual identification of the structure on the basis of satellite imageries.
- **Prioritisation of works:** Satellite image or Digital Elevation Model-based contour data is used to find out the nature of the ground, catchment area and quantity of water flow.
- **Need-specific and area-specific CWRM plan:** After ground truthing, contour information from satellite image, stop dams, gabions, farm ponds, afforestation works are planned and then implemented.
- **Impact evaluation (of implemented interventions):** Satellite imageries of pre- and post- implementation of planned works are taken and compared. The change that has taken place is then detected.
- **Selection of project area:** Demarcation of village boundaries and Gram Panchayat.
- **Identification:** Identifying the characteristics/parameters of the area through thematic maps. This is done by reading thematic map contents such as slope, drainage line, Land use land cover etc. and visualizing it in context to the real world.
- **Analysis and visualisation:** Analysing each characteristic and its impact on the area. This is done by elaborately reading each thematic map and looking at its impact percentage on the ground. For example, it analyses how much slope affects an area.
- **Prioritisation:** The areas will be divided into very good, good, moderate, poor and poor categories. The very poor zones shall be prioritised followed by poor and moderate since these areas will require immediate concern. For instance, if an area has sensitive slopes along with weak rock structure and barren land, or if an area is far from the drainage line, barren and facing drought, these areas are sensitive zones and need immediate attention.
- **Site Suitability:** A map showcasing suitable sites and structures will be made, and an analysis of the site conditions and suitability for watershed structures will be done. Different sites are suitable for different structures. For example, to construct a farm pond, the area should be away from the drainage, and have low slope percentage (<10%) to be useful for collecting and storing rainwater. A farm pond cannot be made on a steep slope, and a farm pond just next to a drainage line is useless.
- **Proposed structures:** Proposing the most suitable structures based on all requirements.
- **Ground Truthing:** Checking on-field if the structures will be suitable and accurate and taking GPS points.
- **Implementation:** Execution of watershed structures.

Thematic maps are used in two prime phases of planning:

1. To analyse the characteristics of the area
2. To find the scope and possibilities

Analysing the characteristics of an area

The characteristics of each geographical area based on detailed analysis of

1. The highest and lowest elevation
2. Slope of the area
3. Soil texture and depth
4. Land use patterns
5. Rainfall percentage, etc.

Finding the scope according to the geographical characteristics

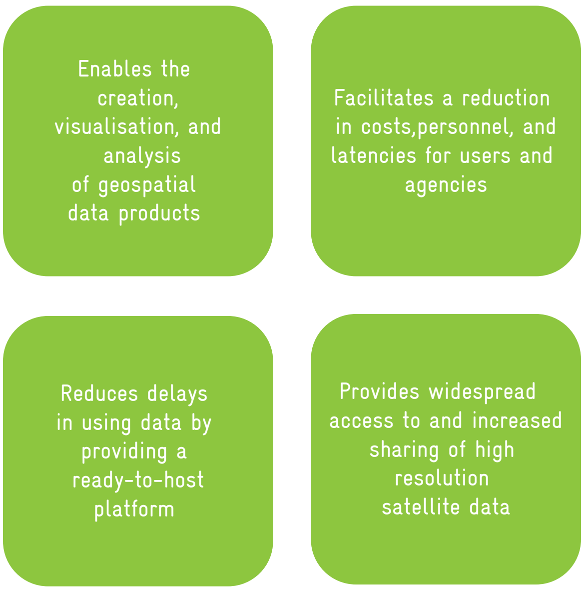
- If the area has high elevation and steep slopes, terracing can be proposed,
- If the runoff water percentage is very high, structures like gabions can be proposed.

7.5 Generation of Thematic Maps through the Bhuvan Portal

7.5.1 Geo-spatial services available on the Bhuvan portal

The *Bhuvan* portal of NRSC provides a platform to create, visualise, share, and analyse geospatial data products and services towards spatial mashups. Any government agency can disseminate data through the platform and host domain-specific applications on *Bhuvan* and its own website. It helps the organisations reduce costs, personnel, and latency of creating and hosting infrastructure or their own data centre.

Bhuvan also reduces delays in using data since the operational platform is ready for hosting. It can act like cloud storage for line departments and has high resolution satellite data of 2.5 metre resolution for the entire country.



7.6 Accessing Bhuvan

7.6.1 How to open Bhuvan?

Click on the link **www.bhuvan.nrsc.gov.in** and you will find the screenshot **as depicted below.**

How to open State portals?

1. Visit www.bhuvan.nrsc.gov.in, and you will find state portals on right side of the window. Click on the state in the drop-down list.

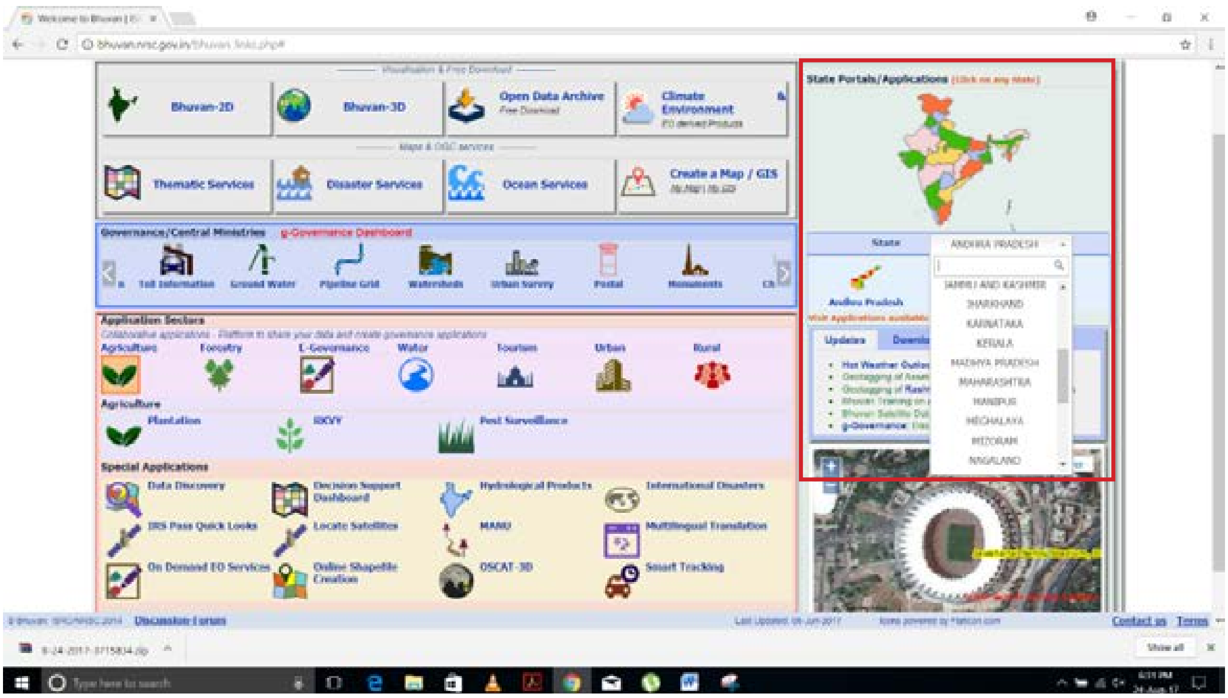
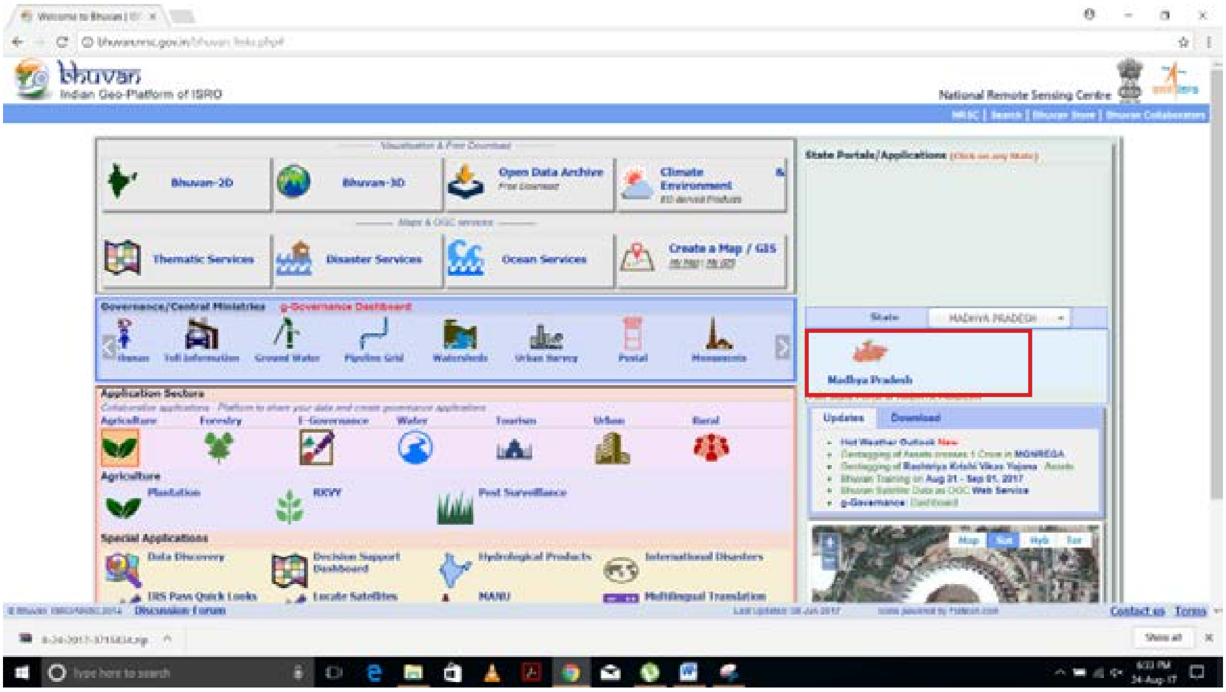
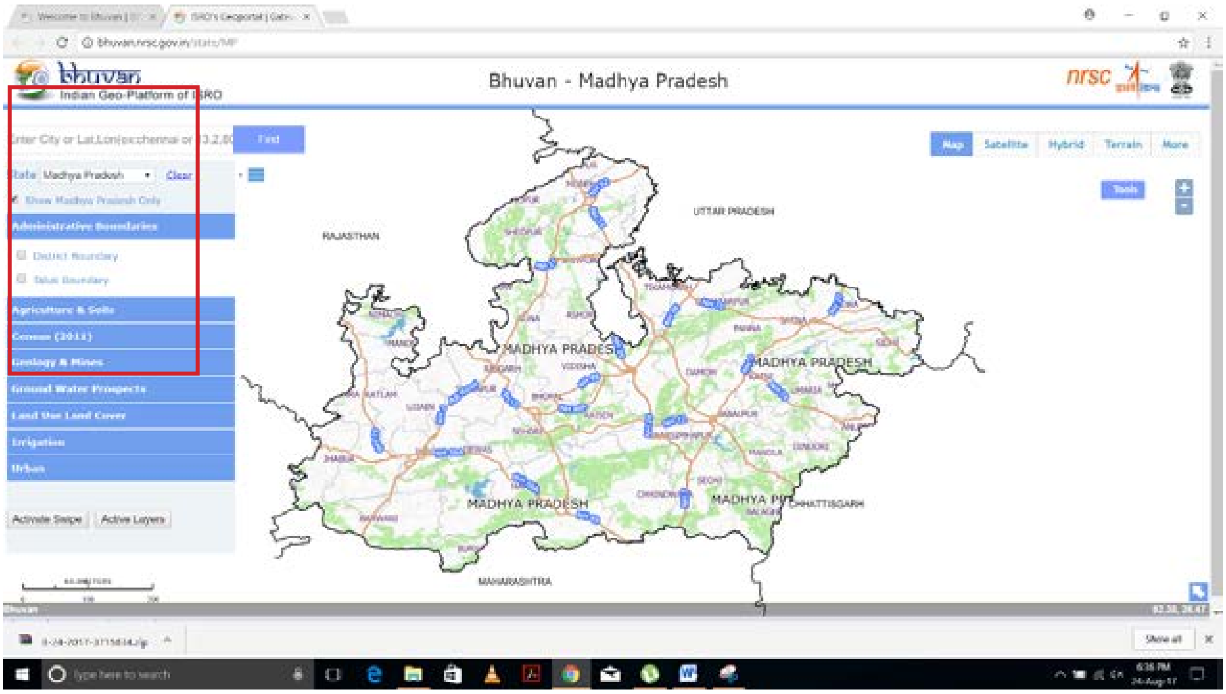


Image Source: All images in this chapter have been retrieved from the Bhuvan portal of the National Remote Sensing Centre (NRSC) via www.bhuvan.nrsc.gov.in,

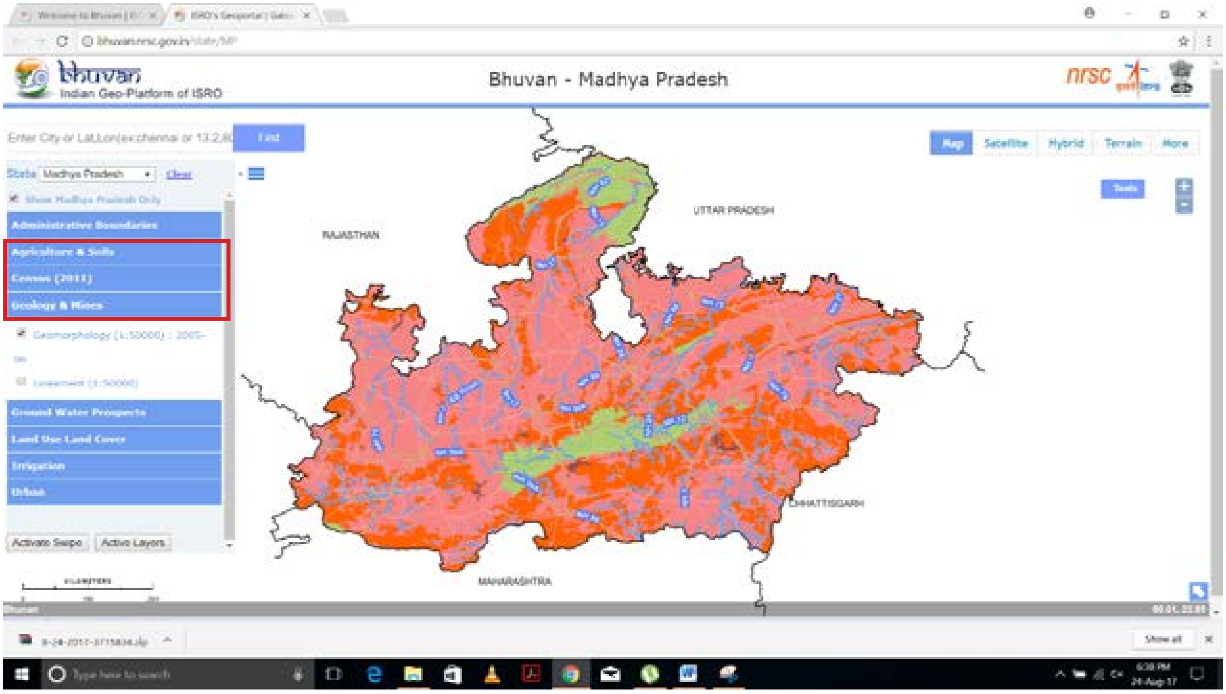
2. Now click on the state that you wish to select.



3. As you click on the link, a new window with all thematic layers available for the selected state is visible.



4. Now check the options (layers) available in the layers list to see the map of the selected layer.

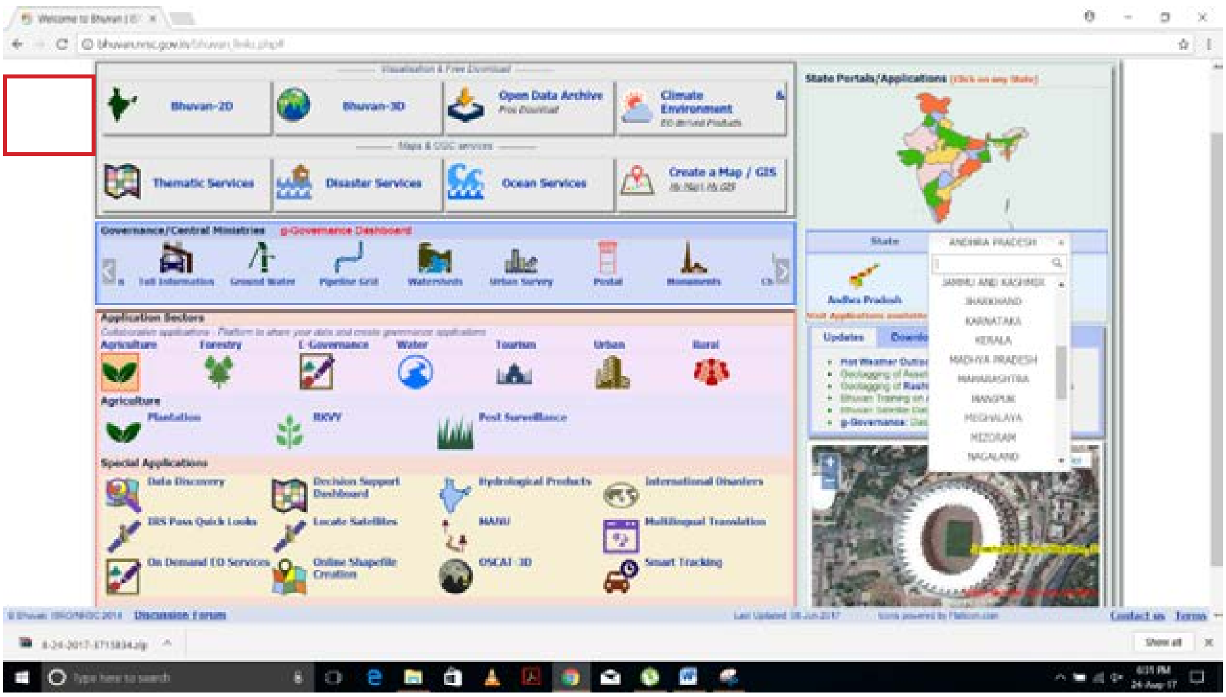


Note: For legend, please refer to the thematic layers window.

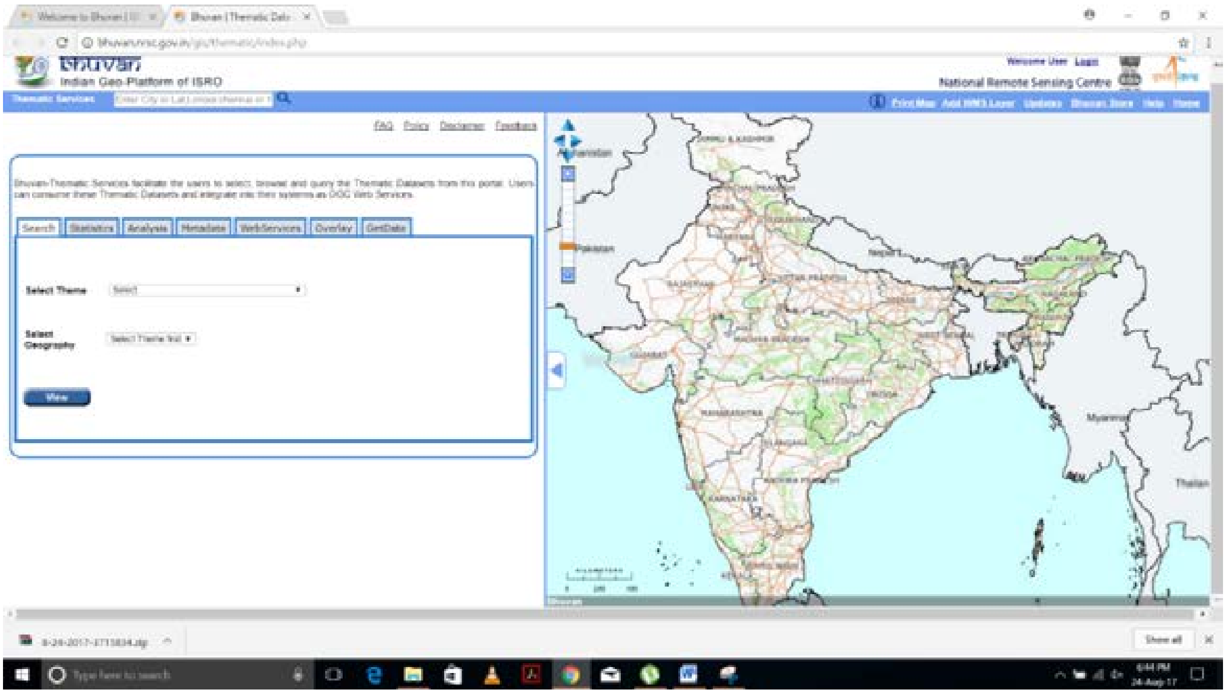
5. Please follow the same procedure for generating all other layers.

How to open Thematic Services?

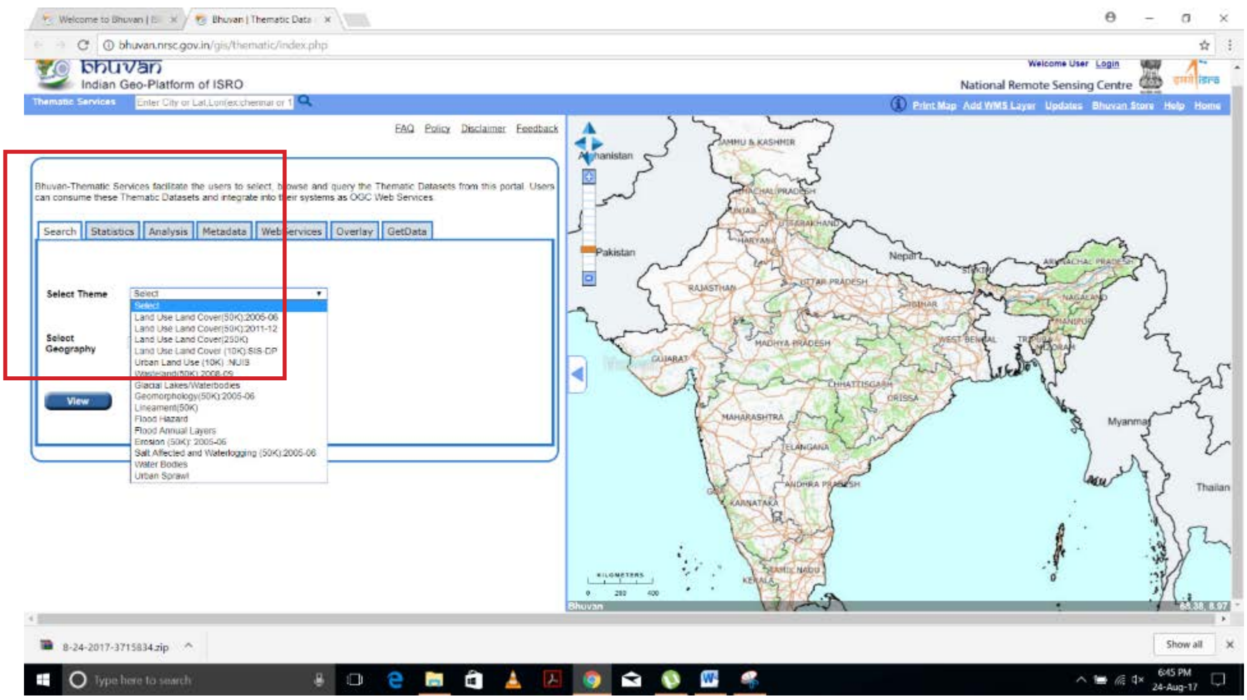
1. Visit www.bhuvan.nrsc.gov.in and you will find the Thematic Services box as below.



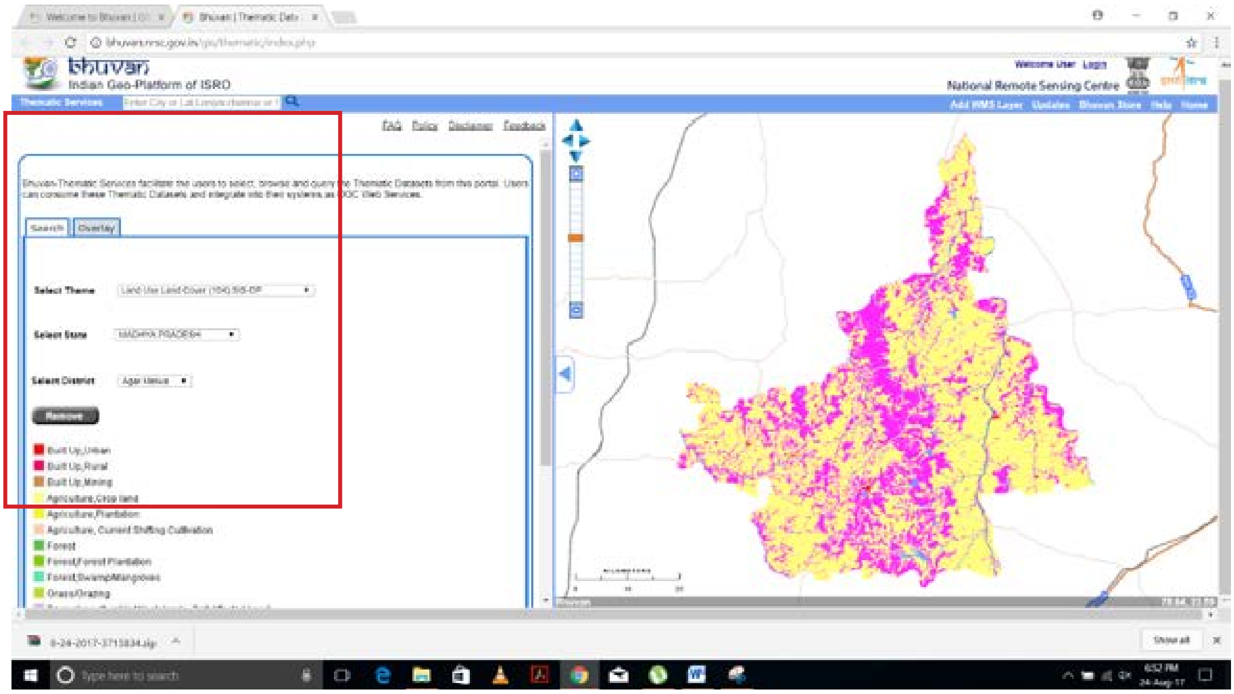
2. Once you click on the **thematic services** option, a new window appears as shown below:



3. Now select the theme from the drop-down list available.

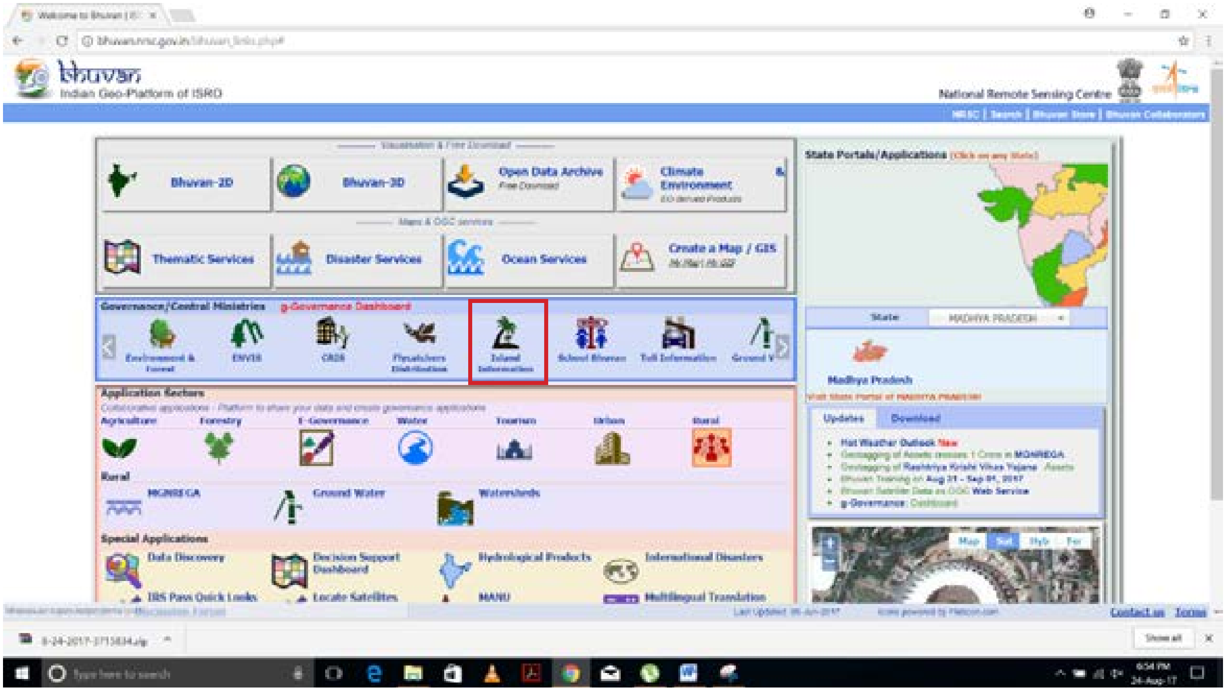


4. Once you select the theme, map appears on the screen and at the same time legend will appear on the left bottom corner as shown below.

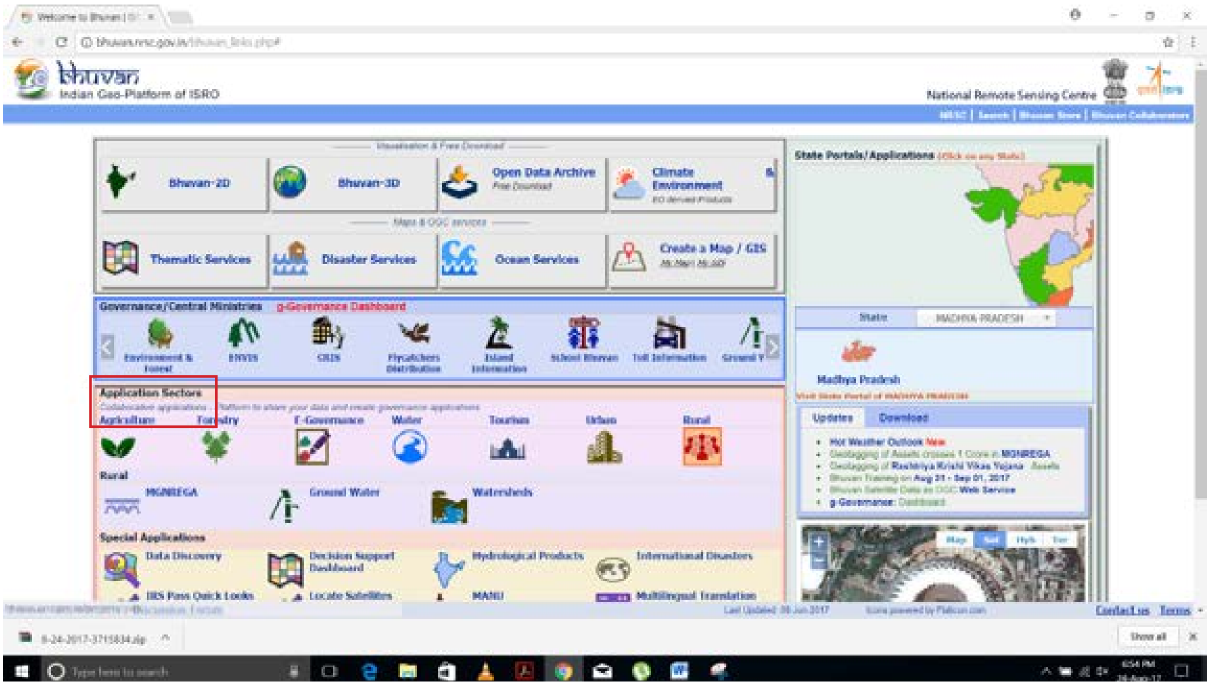


How to open MGNREGA portal in *Bhuvan*?

1. Go to www.bhuvan.nrsc.gov.in website. You will find Rural option in the Application sectors as indicated below.

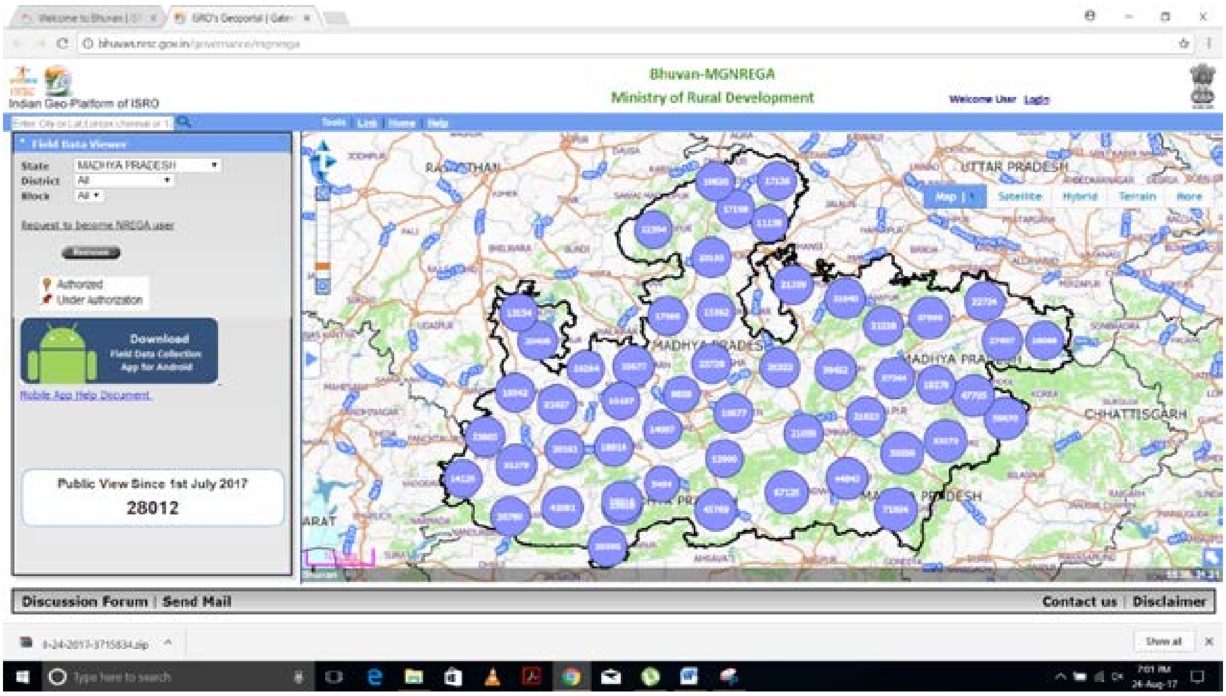


2. Once you click on **rural** option, you will find the **MGNREGA** option.



How to view Mahatma Gandhi NREGA assets in the MGNREGA portal?

1. Once the Mahatma Gandhi NREGA portal is opened, select the state/district/block option available on the left side of the portal. Click on view option, shown in the screenshot, to visualise the assets as per your requirement.



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