

# Purpose Driven Studies Under National Hydrology Project, India

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## ABSTRACT

Considering the peculiarities and large variation in the nature of problems associated with water resources planning, development and management, the issues involved in research related to particular region and specific project, there is a provision under National Hydrology Project (NHP) of India is to take up applied and action-oriented R&D studies by the implementing agencies. This article presents the details of purpose driven studies taken up by various implementing agencies under the National Hydrology Project of India.

**Keywords :** Hydrology, Water Resources, Research, NHP, PDS, NIH, World Bank

## I. INTRODUCTION

The Hydrology Project (HP) has been central to efforts in India to improve the planning, development and management of its water resources, as well as flood forecasting and reservoir operations in real-time. The project, having completed two phases (Phase I from 1996 to 2003 and Phase II from 2006 to 2014), has established the backbone of a comprehensive Hydrological Information System (HIS) in India, providing scientifically verified, uniformly accepted and widely accessed hydrological records covering all aspects of the hydrological cycle. Following on the success of the first two phases of the project, the third phase of the project i.e. National Hydrology Project (NHP) has been operational from March 2017 covering 37 States, 2 Union Territories, 9 Central Agencies and 2 River Basins organizations in India.

## II. NATIONAL HYDROLOGY PROJECT (NHP)

The development objective of the National Hydrology Project for India is to improve the extent, quality and accessibility of water resources information, and to

strengthen the capacity of water resources management institutions in India. The project duration is 15 March 2017 to 31 March 2025. It is funded by the World Bank (Project ID: P152698).

The project has two groups of direct beneficiaries: (i) central and state implementing agencies (IAs) responsible for surface and/or groundwater planning and management, including river basin organizations; and (ii) users of the WRIS across various sectors and around the World. The ultimate beneficiaries will be the selected farm communities benefited from pilot projects for water management; rural and urban water and power users, populations affected by floods and droughts, especially poor rural people, and farm families who may benefit from improved irrigation water supply and management; stakeholders across the energy, inland waterways, environment and agriculture ministries; research and educational institutions; students and researchers, NGOs, civil society organizations and the private sector.

The project comprises of four components. The first component 'A - Water Resource Monitoring and Data

Acquisition System' will focus on improving the extent, timeliness and reliability of water resources data. It will finance the establishment or upgrading of new and existing hydromet data systems including meteorology, streamflow, groundwater and water storage measurements, together with the construction of data centers that capture both water resources and uses. The component will be implemented by all state/UTs with the support of central implementing agencies.

The second component 'B - Water Resource Information System (WRIS)' will support strengthening of National and sub-national water information centers with web-enabled water resources information systems through standardization of databases and products from various data sources/departments; and make comprehensive, timely and integrated water resources information available to decision-makers for effective planning, decision making and operations. The sources of data/information will include the real-time data acquisition networks and centers under Component A, remote sensing data, topographical maps and knowledge products developed under Component C.

The third component 'C - Water Resources Operation and Planning System' will support the development of interactive analytical tools and decision support platform that would integrate database, models and scenario manager for hydrological flood forecasting, integrated reservoir operations and water resources accounting for improved operation, planning and management of both surface and groundwater. The component will provide interactive systems to analyze the impacts of alternative management scenarios and generate knowledge products using real-time data under component B.

The fourth component 'D - Water Resources Institutions Capacity Enhancement' aims to build capacity for knowledge-based water resources

management. It would support the establishment of water resources knowledge centers, professional development, project management and operations.

### III. PURPOSE DRIVEN STUDIES (PDS)

One of the main focuses of NHP is to take up R&D studies in the form of Purpose Driven Studies (PDS). The "Subcomponent C2: Purpose-driven Support" of the National Hydrology Project will support purpose-driven studies and analytical tools to fill critical water resources knowledge gaps. The purpose-driven support program is being managed by the National Institute of Hydrology, Roorkee (<http://nihroorkee.gov.in/>) in collaboration with implementing agencies and supported by Technical Assistance and Management Consultancy (TAMC).

Purpose Driven Studies would address the specific issues of water management problems identified within the area of operation of implementing agencies and of public concern. These are expected to cover a wide range of water management issues raised by agencies - for example, issues of water quality 'hotspots', groundwater issues, or problems of reservoir sedimentation and environmental flows. The following PDS have been undertaken by various central and state implementing agencies (NIH, CWPRS, Kerala, West Bengal, Telangana, Gujarat, Meghalaya, Himachal Pradesh, Uttarakhand, Andhra Pradesh, Rajasthan).

1. Measurement of Discharge of the Flowing Stream using Image Processing Techniques in Bharathapuzha Basin

Objectives of the study are to quantify the discharge of river stream based on acoustic and image techniques; to create a reference discharge station to Bharathapuzha basin; and develop improved algorithms to accurately measure the dissolved chemicals. This development will give a highly accurate and cost-effective system for the

measurement of discharge in rivers. It can also be suggested in remote locations with a trigger from a mobile at any time of the day. The methodology can be used for micro-level studies including flood studies, being a non-intrusive technique.

## 2. Hydrochemical & Mineralogical Evaluation of the Arsenic affected, Shallow (<50 m) Holocene Aquifers of West Bengal & its Effect on Food Chain, West Bengal India

The main emphasis of this study is to compare the geochemistry and mineralogy of aquifer sediments with the hydrochemistry and stable isotopes (O, H, and C) of groundwater and surface waters in contrasting groundwater arsenic bearing environments within Murshidabad district of West Bengal to decipher the mechanism of arsenic contamination in the area. This work is focused on five high arsenic zones, to the east of river Bhagirathi and three low arsenic zones to the west of river Bhagirathi. The complex geological and hydrogeological outlay of this area, with contrasting hydrologic and hydrogeochemical set-up on either side of the Bhagirathi river, makes this place a heaven for scientific investigations. With the proper understanding of the subsurface spatial distribution of the geogenic contaminants, geochemical processes involved therein and the possible extent of future pollution, which are the esteemed goal of the present study, will not only help us to validate the existing hypotheses of arsenic contamination by comparing the geochemistry and mineralogy of the aquifer sediments with hydrochemistry and stable isotopes of groundwater and surface waters in contrasting groundwater As-bearing environments within Murshidabad district of West Bengal, India, but will also enrich our knowledge pool on mechanism of geogenic contamination and it is also expected that the outcome of this work will set up a new integrated approach for study of similar problems at the regional scale.

## 3. Evaluation of Impacts of Rabi Irrigation in Ganga River Sub-Basin of Madhya Pradesh

Objectives of the study are evaluation of impacts of Rabi irrigation on hydrology, agricultural growth, economy and public health for selected irrigation projects in Ganga basin (health component added); performance evaluation of medium/minor irrigation projects; development of web-based dynamic application for performance evaluation of irrigation project; and recommendation of strategies to improve the performance of irrigation projects, dissemination of knowledge and findings through trainings and workshops.

## 4. Modelling of Tawa Reservoir Catchment and Development of Tawa Reservoir Operation Policy

Objectives of the study are an assessment of the present supply-demand scenario for Tawa reservoir; establishment of a comprehensive hydrological model for Tawa river basin up to Tawa reservoir; evaluation of future supply-demand scenario considering the population growth and changes in the cropping pattern; and reservoir operation for optimal utilization of available water resources. The proposed study shall try to focus on the comprehensive assessment of present supply-demand scenario in the Tawa reservoir catchment and the command area and investigate the impact of population growth and other factors on the water availability scenario in the Tawa reservoir in future. Based on the outlined objectives, this study envisages a comprehensive hydrological model set up capable of incorporating the Tawa dam to model the inflows and thereby frame reservoir operation policies for best use of the available water resources. The assessment of the future supply-demand scenario shall also be carried out based on the future population growth scenario as well as the planned development scenarios in the basin. This will help in the formulation of a reservoir operation policy for the future.

#### 5. Water Quality Assessment of Southwest Punjab Emphasizing Carcinogenic Contaminants and their Possible Remedial Measures

Objectives of the study are spatial and temporal variation of water quality parameters and carcinogenic contaminants; quantification of mutagenic potential (carcinogenicity) of water samples; source identification of major contaminants in the study area and impact assessment on human health; suggestions for possible remedial measures to reduce the impact of contaminants; and dissemination of knowledge and findings to field engineers/scientists and common people through the preparation of manuals, leaflets, booklets and by organizing workshops/training. The outcome of the project will be beneficial for the concerned departments in the sense that it will provide first-hand information on the water quality of the area related to carcinogenicity. This will also lead to preparing a protocol for monitoring the carcinogenicity of water and will be helpful for the monitoring agencies. The project will also suggest the remedial measure for providing safe water to the habitation, which can be implemented by concerned state government agencies.

#### 6. Sedimentation Study of Hirakud Reservoir, Odisha using Optic and Microwave Remote Sensing Technology

Objectives of the study are to assess the best approach between per-pixel, sub-pixel and super-resolution classifier for the reservoir sedimentation estimation of Hirakud reservoir; to evaluate the feasibility of using microwave satellite data for reservoir water-spread area estimation; and to estimate sediment yield and prepare watershed wise soil erosion maps of the Hirakud basin using soil erosion modelling approach. By having precise information about the amount of sediment deposited in the reservoir, remedial measures can be undertaken well in advance and a

reservoir operation schedule can be planned for optimum utilization of available water. The estimated rate of sedimentation would provide to calculate the useful life of the reservoir. From the siltation rate of reservoirs of the river basin, future design of the reservoir can be carried out. The data of sediment yield on sub-watershed would be useful to identify the vulnerable areas and to undertake the soil conservation measures. Thereby the reduction of capacity of the reservoir can be considerably reduced.

#### 7. Studies on Occurrence, Distribution and Sustainability of Natural Springs for Rural Water Supply in Parts of Western Ghats, India

Objectives of the study are to evaluate the impact of changes on physiography, climate parameters such as rainfall, evaporation, land use/land cover changes on hydrological regimes in selected watersheds in parts of Western Ghat region; to understand the role of unsaturated soil zone on hydrological responses of watersheds based on soil hydrological characteristics and monitoring of soil moisture variation during the study period; to develop a watershed model, which would help to quantify both streamflow and base flow; estimation of interflow in the selected catchments using field and analytical methods; estimation of recharge rates in the selected watersheds using spring flow, rainfall and Temperature data; to evaluate the sustainability of the springs in the changing scenario of land use/land covers and its (spring water) role in rural water supply schemes; assessment of water quality of spring water, groundwater and surface water; application of isotope techniques to understand the origin of springs and its source; and socio-economic impact caused due to change in spring water flow and land use/land cover changes.

#### 8. Investigating Water Stress using Hydrometeorological and Remote Sensing Data

Objectives of the study are characterizing water stress using hydro-meteorological, remotely sensed data and vadose zone modelling (Ramgarh, Rajasthan); analyzing changes in water stress conditions due to water response and mitigation measures; analysis of changes in water stress conditions due to drought response and mitigation measures; field level measurements of vadose zone moisture; forecasting and regionalizing drought indices; and devising reservoir operating policy. End-user department will be able to plan water releases for the drought response and mitigation measures. Using customized reservoir operating policies, the user department will be able to reduce water stress in the basin.

#### 9. Web GIS Based Spring Inventory for Vulnerability Assessment and Hydro-Geological Investigation of Selected Springs for Sustaining Local Water Demand in Ravi Catchment of Himachal Pradesh

Objectives of the study are creation of web-enabled database of the springs emerging in the catchment-based on extensive inventory of physical and hydro-chemical characteristics; mapping of vulnerable springs using hot-spot analysis; hydrogeological investigation of some selected springs, which are vulnerable and having high societal importance for identification of their spring-shed area and potential; to suggest adaptive strategies for selected hot-spot springs for spring sanctuary development to sustain the local water demand; and to build capacity among the local stakeholders through creating para-hydrogeologists for conserving and managing the springs. As of now, there is no inventory of springs in the Ravi basin, even though springs are the main water sources for about 85% population living in the vicinity of the catchment. At the same time, the majority of these traditional water resources are in poor condition and continuously drying. It is envisaged that this study may provide the present status of the springs of Ravi catchment and identify the vulnerable springs. The adaptive strategies

developed under the project for selected vulnerable springs having high social importance will provide a concrete scientific basis to rejuvenate these valuable resources.

#### 10. Groundwater Quality Assessment with Special Reference to Sulphate Contamination in Bemetara District of Chhattisgarh State and Ameliorative Measures

Objectives of the study are groundwater quality monitoring in pre-monsoon (April-May) and post-monsoon (October-November) season at identified locations; to map degraded groundwater quality zones and possible sources of pollution and identify specific parameters not conforming to drinking/ & irrigation water quality standards; to investigate the important geochemical processes responsible for the groundwater contamination; modeling flow and transport of sulphate contamination using MODFLOW and MT3D; to suggest ameliorative measures to restore the quality and sustainable use of groundwater for drinking/ & irrigation purpose by investigating the hydro-geology of the area; and dissemination of knowledge and findings to field engineers/scientists and common people through preparation of manual, leaflets, booklets and by organizing workshops/training. Very little work has been attempted on groundwater quality assessment and hydrogeochemical study in the Chhattisgarh region. The findings of present PDS will be helpful to policymakers in the water sector about sustainable groundwater supply for drinking purposes in the district. For any scheme of water supply in an area, it is mandatory to have the status of water quality of the water resources being used for supply. An extensive survey of groundwater quality monitoring of district Bemetara will provide knowledge about degraded groundwater quality zones and possible sources of pollution and specific parameters not conforming to drinking and irrigation water quality standards, which will help the policymakers and society. Further, present PDS will suggest ameliorative measures to

restore the quality and sustainable use of groundwater for drinking and irrigation purposes by investigating the hydrogeology of the area.

#### 11. Water Efficient Irrigation by using SCADA System for Major Irrigation Project (MIP) Shah Nehar

Objectives of the study are to develop monitoring, supervisory control and modernize system for agriculture irrigation water; paradigm shift in the approach from a supply-based system to a demand-based sustainable system; performance evaluation of Left Bank Canal and Right Bank Canal of MIP Shah Nehar Project; identify issues that need to be addressed to improve project performance; real-time monitoring of water availability at headworks; suggest measures to improve water use efficiency and sustainability up to farm level; and integrating warabandi with SCADA system. Complete analysis of the distribution system can be done effectively and efficiently and farmers will be benefited in terms of crop yield. Recently, a Medium Irrigation scheme constructed with SCADA in Mandi district has shown that farmers in the area are getting more cash crops and even frequently. The benefit to cost ratio is showing signs of improvement. The performance evaluation after implementation of SCADA will increase positively.

#### 12. Assessment of Surface Water Quality Status and evolving Mitigation Measures to Improve the Water Quality in Thrissur Corporation

Objectives of the study are to prepare pollution status of surface water bodies of the Thrissur Corporation area in a GIS platform; and to improve the quality of water by introducing mitigation measures, based on the present Water Quality status and projected pollution for the next 50 years. The quality of water can be improved. The information system developed can be effectively used for the future planning and management of the water resources of the corporation

area. The system will help to develop reliable and more accurate scientific methods/technologies for planning the mitigation measures. The effective implementation of the mitigation measures will improve the quality of water for drinking and other purposes. Baseline information will benefit the researchers and planners in the planning of drinking water schemes. The point sources of pollution can be identified and monitored regularly to ensure the standards of the effluents.

#### 13. Development of a Comprehensive Plan for Conservation and Sustainable Management of Bhimtal and Naukuchiatal Lakes, Uttarakhand

Objectives of the study are to assess the seasonal water availability of the lakes and assess its adequacy in meeting future demands; to assess the water quality of the lakes and possible causes of its degradation; to estimate sedimentation rate and expected life of the lake; and to suggest a comprehensive plan for conservation and sustainable management of the lakes. The specific recommendations for conservation and management of the lake and the conservation plan would be used by the State Irrigation Department for the preparation of DPR for the development/rejuvenation of these lakes. Since the lakes are of great economic significance being sources of drinking water supply, recreation, and biodiversity hotspot, their conservation shall be of immense benefit for the society in general.

#### 14. Assessment of Impacts of Groundwater Salinity on Regional Groundwater Resources, Current and Future Situation in Mewat, Haryana – Possible Remedy and Resilience Building Measures

Objectives of the study are assessment of lowering of water table (depletion in groundwater level) in the salinity impacted area using the historical data; detailed qualitative analysis of the area and the aquifer depth impacted by higher salinity levels, and

preparation of maps; to monitor influx of saline groundwater into freshwater zone; to assess the impact of groundwater salinity on socio-economic aspects; and to develop and demonstrate management and resilience-building measures. In the Mewat district in Haryana, groundwater salinization issues have debilitated the already struggling local economy that relies primarily on groundwater irrigation for farming. The area is devoid of perennial surface water sources making availability of groundwater the critical factor in defining the sustainability of the agro-ecosystem. The work will be carried out at a pilot scale, considered an interesting contribution to the study of groundwater resources with a regional scope. Based on the results of the present study, a systematic salinity characterization of the impacted aquifer can be done. In addition to this, suitable approaches and strategies can be developed for site remediation and future protection of drinking water sources. These measures will also be useful for other salinity affected areas of India.

#### 15. Impact Assessment of the Upcoming Irrigation Projects and Climate Change on the Droughts and Desertification Scenario for Chambal Basin in Western Madhya Pradesh

Objectives of the study are assessment of climate change signals in Chambal basin; evaluation of drought characteristics and investigation of the desertification; hydrologic modeling for simulation of the hydrological processes in the basin; assessment of the impact of climate change under alternate climate scenarios on the future water availability, drought and desertification; evaluation of the impacts of upcoming irrigation projects on the drought and desertification; and integrated assessment of vulnerability to drought, desertification and climate change. The research outcome shall benefit the various stakeholders, decision-makers, and the scientific community by helping them to understand the issues of climate change and help in developing water resources management strategies under

changing climate, droughts and the likely possibilities of desertification. The results of the study will directly benefit all the districts in Western Madhya Pradesh subjected to regular droughts and desertification. The recommendations of the study will help the State to harness and sustainably develop the water resources by having foresight into the water availability and occurrence of extreme events under the future scenarios of climate change. This will help the communities and societies to adapt to the changing climate scenario and make them more resilient towards the adverse effects of these anticipated changes.

#### 16. Ganges Aquifer Management in the Context of Monsoon Runoff Conservation for Sustainable River Ecosystem Services – A Pilot Study

The study area comprises of Sot River Basin, a tributary of the Ganga River. Objectives of the study are the hydro-geological characterization of the area; analysis of meteorological and hydrological variables vis-a-vis cessation of river flows during the lean season; estimation of surface water and groundwater availability; analysis of stream-aquifer interaction; and aquifer management measures for enhancing river flow during the lean season. The study can provide a sustainable solution on water resources to the agriculture and domestic water supply in the study area, which is presently suffering from severe water scarcity problem particularly during the non-monsoon season. The results of the analysis will be helpful for the planned development of both rain-fed and irrigated agriculture and focusing more resources in the hotspots to be identified by the vulnerability analysis. Also, the study will suggest appropriate mitigation and adaptation mechanisms cope up with the projected climatic change. Therefore, this study shall address the issues related to future problems on water availability, cessation of river flows, declining groundwater levels and shall provide a sustained solution by managing excess monsoonal runoff for use in the non-monsoon season.

### 17. Hydro-geochemical Evolution and Arsenic Occurrence in Aquifer of Central Ganges Basin

Objectives of the study are determination of the spatio-temporal variation of arsenic along with other water quality parameters in groundwater (Bhojpur district, Bihar); delineation of arsenic safe zone for drinking water supply; evaluation of the controls of regional and local hydrology on arsenic contamination through monitoring of contaminated aquifer; and evaluation of the mechanism of transport of arsenic in geo-environmental through a column experiment. The outcome of the study would be very helpful for state and central government agencies to formulate water resource management policies for choosing appropriate sustainable water sources in Bhojpur District. At present, because of the lack of knowledge about the source and mechanism of movement of As, the decision making agencies are trying to design policies to remediate the contamination in the short term and temporarily alleviate the suffering of millions of people. So, the definitive knowledge of the hydrological processes and subsurface geochemical processes in the proposed study area may lead to a good and sustainable water management policy for the society.

### 18. Integrated Study on Groundwater Dynamics in the Coastal Aquifers of West Bengal for Sustainable Groundwater Management

The study area comprises four coastal districts of West Bengal - Purba Medinipur, Howrah, South 24 Pargana and North 24 Pargana. Objectives of the study are assessment of spatio-temporal variables (sea-level change, variation in groundwater levels, rainfall trend, etc.) influencing dynamics between seawater and groundwater interface using archival data; spatio-temporal variation map of freshwater – saline water interface from the present observations; identification of source of salinity in groundwater; identification of groundwater recharges sources and flow pattern and

temporal and spatial pattern of excess surface water available in the coastal zone for artificial recharge measures; and management measures for safe and sustainable coastal groundwater use. As of now, there is no status report on coastal groundwater dynamics of West Bengal is available. The project involves the exchange of knowledge, new data and field-based management strategies that can be implemented to improve and sustainment of groundwater condition of the state. The highlight of the results will be disseminated to stakeholders through joint interactive programs.

### 19. Chemical & Isotopic Characterization of Deep Aquifers of Middle Ganga Basin

Objectives of the study are to identify the various aquifers present in Upper / Middle Ganga plains; to identify the source of recharge of deep aquifers; to assess the interaction of deep aquifer with overlying aquifers; water quality of deep aquifer; and sustainability of deep aquifer for its exploration and future use. As of now, there is no chemical/bacteriological/isotopic data available for the deep aquifers of the Ganga basin. The study will provide a status report on the dependability on these aquifers for future groundwater use and the risk of contamination of these aquifers from overlying aquifers. How old are these groundwater and where are the recharge areas of groundwater of these aquifers are located? These are some of the questions, which will be investigated in this project. Answers to these questions will be useful to the State Groundwater Department in drilling wells in these aquifers for all future use. The project also involves the import of new isotopic technologies to India through knowledge transfer from IAEA, Vienna. The project thus will benefit to the society as well as it will help in knowledge up-gradation.

### 20. Groundwater Salinity Source Identification in Godavari Delta, A.P.



Objectives of the study are an identification of groundwater salinity zones within the Godavari delta; salinity source identification using an integrated approach; and remedial measures to control groundwater salinization in Godavari delta. The main contribution from the project would be the identification of saline groundwater zones and its source identification. This will enable planners and decision-makers to improve the groundwater quality conditions. The methodology adopted in this study may be extended to other coastal regions of India. This will also help us in understanding sub-surface seawater intrusion and the location of groundwater discharge zones. The new formation of the AP state requires this methodology because most of the districts are along the Bay of Bengal. The output of the study will provide a detailed understanding of the salinization process in the Godavari delta. Some of the apprehensions on the impact of aquaculture, backwater effect through creeks, pumping of groundwater from deeper aquifers and reduction in groundwater recharge would be addressed clearly in this proposed study. Due to an increase in groundwater salinity in Godavari delta, shallow freshwater potentials have been decreased significantly. This situation can be linked to the utility of RO based drinking water systems over a period of time in the Godavari delta. The public awareness of groundwater salinization provides active participation of the public in protecting groundwater quality.

#### 21. Study of Surface and Subsurface Water Interaction using Remote Sensing, Geohydrological and Geophysical Techniques and its Modeling

Objectives of the study are to map geology and identify lineaments of the area by using remotely sensed data (Midlands and plains of the Bhima basin); to map subsurface structures by geophysical methods; establishing relationship between geoelectric and hydraulic parameters for estimating the spatial

distribution of hydraulic conductivity of the subsurface by conducting infiltration and pumping tests along with geoelectrical studies; establishing leakance factor of the surface waters by conducting underwater single-channel seismic reflection survey and underwater electrical imaging survey; to evaluate impact of land use/ land cover change on groundwater recharge in the area; to estimate surface and subsurface water interaction by hydrological modeling of catchment; and to propose recharge sites based on remote sensing, geophysical and geohydrological results. The study aims at mapping the subsurface flow regime and evaluating its spatial interaction with surface water hydrogeologically. It will be helpful in proposing recharge sites. Surface and subsurface flow components would be evaluated by modeling of catchment runoff with models such as Soil and Water Assessment Tool (SWAT). The study further contributes to assessing the competency of the reservoir and canals from a geotechnical point of view.

#### 22. River Rejuvenation of Mutha River Reach Flowing through Pune City and Suburbs, Maharashtra

Objectives of the study are simulation of water quality variables like DO, BOD, coliforms and nutrients, and water quality management; generation of scenarios for best water quality management for different purposes - assessment of level of treatment required to meet these conditions or design the schedule for water releases from Khadakwasla dam for dilution of pollution to bring the quality to acceptable level; recommendation of policy action for preventing release of pollutants into river. It includes the model study of water quality of Mutha and Mula-Mutha river reach from downstream of the Khadakwasla reservoir, up to Kharadi (using the Ecolab model of MIKE 11 software). The model studies help to take up studies in the same line, for other rivers that are facing water quality problems. A calibrated and verified water quality model is the

deliverable to further study the futuristic scenarios under various stress conditions and requirements.

### 23. Sea Water Intrusion in Coast of Kerala State

Objectives of the study are saline ingress study in the river system to identify the intensity, propagation of salinity during different months and extent of affected areas; and identify suitable locations for saline control structures. There has been no study conducted to collect salinity data along the river. The public has been requesting the authorities to address the situation. Therefore, the project will be beneficial to management agencies to carry out countermeasures. The data collected from the project can be utilized by the management agencies to propose and implement countermeasures like construction of regulators, check dams, shutters/gates to control saline ingress into the river.

### 24. Mapping of Groundwater Quality in the Industrial Belt of Ernakulam District

Objectives of the study are to study the type and extent of industrial pollution in the study area; identify critical area requiring immediate attention; identification of hazardous organic and inorganic pollutant in different selected sites of industrial area; putting the data generated in GIS platform for interpretation and planning for the future developmental activities; and future activities like restoring water quality. The research findings of the study can apply in similar geology and serve as a platform to make a comparison with other terrains. While setting up industries, we can put some geological barriers for the prevention of contaminant transport. Keeping the sustainability issues and environmental ethics in mind, the technologies encompassing natural chemistry, bioremediation and biosorption are recommended to be adopted in appropriate cases. In many places, two or more techniques can work synergistically for better results. Mitigation measures that suit the geo-environmental

setting will be recommended to the public for the protection and maintaining the quality of water. The data generated can serve as a platform for future prediction.

### 25. Environmental Impact Assessment of Pesticide Residues in Cardamom Cultivating Area in Idukki District, Kerala

Objectives of the study are monitoring of pesticide residues in groundwater bodies located in cardamom and tea plantations and study the soil physical and hydraulic properties of that locations; conduct unsaturated soil column studies under controlled and field conditions using lysimeter to study the mobility of different classes of pesticides through the soil and confirmation of the findings by isotope technology; and mathematical modeling of solute (pesticide) transport in groundwater can be developed based on the soil physico-chemical properties and solute transport. The indiscriminate usage of agrochemicals especially pesticides contaminates the environment and there are chances of leaching of these molecules to water bodies. Seasonal and temporal variations may occur in water bodies due to rainfall and runoff. Hence, a detailed study is required to measure the extent of contamination of water bodies by pesticide residues via leaching and runoff. Simultaneous studies on solute transport will yield valuable information on the transport mechanism of these contaminants and could able to predict the possible mechanism of water pollution. Similarly, the solute transport will also help to evolve a mathematical model for soil properties and contaminant migration. This work can also be used for the solute transport of agrochemical contamination of Kuttanad paddy fields in the Alappuzha district. The study will provide complete and accurate data on the status of pesticide residues in water bodies, its mode of transport in different soil type and can elucidate a model which is suited to all type of crops.

26. Impact of Urbanization on Groundwater Quality & Quantity and its Management in Greater Hyderabad Municipal Corporation (GHMC), Hyderabad

Objectives of the study are to understand the groundwater regime in urban aquifer of GHMC area; identify the type of contaminants and sources which poses a threat to groundwater, the environment and health in urban aquifers of Hyderabad city; formulate strategies for protection of groundwater resources from potential contaminants; and establish a data information system on Hyderabad City groundwater conditions. The expected outcome of this study is a comprehensive understanding of the groundwater status in terms of quantity and quality in Hyderabad city and surroundings (GHMC) and preparation of groundwater quality index maps for the GHMC area. This will help the GHMC and HMDA (Hyderabad Metropolitan Development Authority) area for having proper urban planning and environmental management.

27. To Study Surface – Ground Water Interaction to develop a Comprehensive Hydrogeological Frame Work to manage Groundwater Resource in an Over Exploited Groundwater Assessment Unit

The study area is Lingala Ghanpur micro basin in Jangoan District, Telangana. Objectives of the study are to characterize hydro-geology of an aquifer system of an experimental watershed using combined static cum time-lapse ERT and saline tracer experiments; to estimate hydraulic and storage properties of a fractured rock aquifer system using transient HT experiments; to delineate aquifer geometry, preferential groundwater flow paths, regions suitable for groundwater pumping, recharge & Recovery, at high spatial resolution; to develop a well-calibrated numerical groundwater flow (and transport) model of the aquifer system, and coupled with a hydrologic / crop yield model; to evaluate the

impact of various management practices (including resource availability, changed cropping pattern, tank restoration, etc.) on groundwater levels, flows, and exchanges; and to develop a real-time modeling tool to provide management decisions in response to farmers' / stakeholders' existing / proposed field practices for improved crop yield and water use efficiency. The outcome of the project will help in understanding the surface water - groundwater interaction under different scenarios in the hard rock system of Telangana state. It also helps in developing a decision support system to sustain and manage the groundwater resources in an aquifer drained with a chain of the tank systems.

28. Study of the Behavior of Multi-Aquifer System & Aquifer Mapping for an Effective Groundwater Management in Gunderu Sub-Basin, West Godavari District, AP

Objectives of the study are to prepare a status report on the water resources and development in the multi-aquifer system in the basin; to develop conceptual hydro-geological model setup of aquifer system to establish boundary conditions of the multi aquifer system; to establish aquifer characteristics and prepare database for groundwater flow model; to study groundwater flow and suitable artificial recharge intervention as a management practice in multi-aquifer system; and development of suitable groundwater flow model of Gunderu Sub-basin from conceptual 3D multi aquifer system. The outcome of the study will be a management tool to manage the groundwater and its availability in the basin; a computer model of groundwater flow to simulate artificial recharge and undertake development in the basin; and a methodology to plan and operate the multilayered aquifer as a better underground water storage reservoir.

29. Assessing Effect of Coastal Process and Catchment Behavior near River Mouth of

### Ambika and Auranga Rivers (Tapi River Basin in South Gujarat)

Objectives of the study are to define changes along the shoreline due to coastal process as per the force exerted by coastal wave; to predict the littoral flow as per the coastal parameters such as coastal wave directions, wave height and wave period; to assess the effect of coastal process on inhabitants and existing protection work (Existing infrastructures); to assess rate of siltation/depletion along shoreline and vulnerable locations of coastal erosion near river mouth; effect of intrusion of extent of tidal flow in the river reach on river morphology; and suggestion for new protection work against the coastal process. Villages situated very near to the coastline at the sea mouth of Ambika and Auranga river would be protected from severe erosion of coastline, thereby seawater intruding into the land and washing away fertile land as well as raising of the saline water table will be overcome to a large extent. The problem faced by the population of coastal regions necessitates a permanent solution to the problem of erosion. It is widely accepted that hard measures such as protection bund all along do not provide long-term solutions. Instead such as groins, guide bunds, mangrove plantation at strategic locations can offer durable long term self-sustaining solution.

### 30. Effective Flood Protection Works in Vulnerable Tail Reaches of Rivers Tapi, Damanganga & Mahi of Gujarat State

Objectives of the study are to determine the maximum flood in each rivers considering the flood frequency of 100 years; to select the number of gauge stations in the catchment of tail reach of these rivers for making the network to compute the rainfall-runoff relationship and using that the estimation of maximum flood will be taken; to locate the length of bank which are most vulnerable about the spillover and the flow in the meander reach; to collect the topographical, hydrological and the structural details

of these rivers if not available a fresh survey is required to be taken to obtain the latest topographical details; to suggest the locations for measuring discharge versus water level so that effective constant monitoring of floods can be established; to suggest the type of protection work at different reaches of river under study; and to evaluate the performance of suggested protection work on physical models. Various structures are constructed across these rivers for different purposes, the performance of these structures is required to be assessed in terms of upstream water level and downstream tailwater level. The impact of these structures on the water level at different floods is to be ascertained. For the entire tail reach of Tapi, Mahi, Panam and damanganga rivers of Gujarat, flow pattern at different discharges, water levels, velocities and maximum scour depth will be readily made available to the scientific community. Using the hydraulic parameters, the design of suitable bank protection work will be made easy. The afflux caused due to the construction of various hydraulic structures will be assessed which will help in deciding the height of embankments along the bank considering suitable freeboard. Cities and villages situated close to the bank line at the sea mouth of Tapi and Mahi river would be protected from severe erosion of bank considering high flood in the river and at the same time the highest tide level in the sea. The problem faced by the population of coastal regions necessitates a permanent solution to the problem of bank erosion. Short term solutions such as groins, guide bunds, at the strategic locations can also be suggested. In the river reach which passes through city and villages, durable long term self-sustaining solution would be suggested. Cities and villages situated on the banks of the river at the tail reach of Tapi, Mahi and Damanganga would be protected from severe erosion of bank line, the flood water intruding into the land and washing away fertile land as well as rise of the water table will be overcome to a large extent. Bank protection, as well as the flood protection works, will be assessed to protect the cities, villages on the banks and fertile land close to the bank.

### 31. Assessing Efficacy of Piano Key Weirs on Low Height Existing Weirs to Increase the Spillway Discharge Capacity

The objectives of the study are assessing the performance of the Piano key experimentally with different lengths, width, inclination and height on already existing weir top. The maximum drop of water level using the combination best suitable length and spacing derived experimentally would be suggested. A Piano Key Weir can increase storage and discharge capacity as well as the flood control efficiency of existing and new dams. A Piano Key Weir can pass the same discharge at low head compare to Ogee weir. The sloping floor of Piano Key Weir provides passage for sediment from the reservoir area is an additional benefit to decrease the siltation. This innovative Piano Key Weir has a considerably higher specific flow.

### 32. Study of River Network, Water Quantity and Quality for Assessment of Environmental Flow Requirement for Sustenance of the Sundarbans Ecosystem

Objectives of the study are to trace the present river network for determining the flow pathways and obstructions, if any; to assess the hydro-morphological status of the rivers including water level, discharge, water quality like salinity etc; to select suitable method for establishing the relationship between flow, ecosystem function and ecosystem service and to assess the environmental flows (e-flows) for the Sundarbans ecosystem required to attend the salinity level and supply fresh water for irrigation; and to derive and suggest policy options and methods for arranging the e-flows for the sustenance of the ecosystem services of Sundarbans. Assessment of the environmental flow requirement for the ecosystem of the Sundarbans is worthwhile before taking any management option to improve the freshwater availability within the region. The ecosystem of Sundarbans performs a variety of

ecosystem services. Huge numbers of people are directly or indirectly engaged in resource utilization (for example, extraction of fish, honey, wax, wood and leaves of trees, etc.) of the forest area. Simultaneously the mangrove forest serves as a global carbon sink. Augmentation of freshwater flow will help to improve the services, both direct (like food fodder) and indirect (carbon sink, eco-tourism) of the ecosystem of Sundarbans. Improving ecosystem services leads to economic development and the social welfare of the local people and global commons.

### 33. Development of DSS for Operation of Kangsabati Reservoir in the Context of Ghatal Master Plan

Objectives of the study are to develop a hydrological model of the study basin using HEC-HMS model for quantifying the inflow to the reservoir and for forecasting flood; to determine hydrograph and inundation at downstream points (Ghatal Master Plan region) using MIKE-FLOOD model for various flood control and pre-depletion options; to develop Guide Curve of reservoir (including delineation of pre-depletion and operation of reservoir for flood control) using Evolutionary Algorithm in the context of Ghatal Master Plan; and to develop a DSS for operation of the reservoir. The study deals with development of a Decision Support System (DSS) comprising a hydrological model of the catchment area, upstream the reservoir for quantifying the inflow to the reservoir, development of Guide Curve of the reservoir in conjunction with the development of a model to determine flood hydrograph at downstream points of the reservoir for operation of the Kangsabati Reservoir in the context of Ghatal Master Plan. From this study, it may generate the 'what if' scenarios to provide answers to problems of inundation and drainage congestion up to Ghatak Master Plan action area under the DSS framework. The Master Plan has been prepared by the Government of West Bengal for mitigation of flood problems as well as those arising out of drainage congestion. The outcome of the study would act as a

guideline to work out the policy options related to judicious use of water available in the Kangsabati basin towards sustainable development of the basin by providing adequate water for irrigation and other purposes as well as flood mitigation in the downstream areas mainly Ghatal region and this will, in turn, benefit the society.

#### 34. Development of Decision Tool for Efficient Utilization of Water Resource in Parwati Canal & Dholpur Piped Irrigation Project of Rajasthan

Objectives of the study are to assess and compare irrigation efficiencies in open channel system and pressurized pipe irrigation systems; to develop a decision support tool for demand-based irrigation using a participatory approach; and capacity building of stakeholders for adapting efficient irrigation practices. Rajasthan state lies in the arid zone of the country and due to limited water resources keep trying to improve the system through the application of modern technology. The assessment of efficiencies of two distinct systems enables water resource managers to take adaptive options to reduce losses and use water optimally. The development of a mobile-based application and scientifically designed decision support will be useful to develop a mechanism to deal with adverse climatic conditions and make the system capable of taking advance decisions to minimize the losses. The study will be helpful for irrigation management and planning of releases based on real-time data and scenarios generated will be helpful to develop adaptive management policies. The mobile application developed through this study will be helpful for irrigation planning and getting real-time information and manage available water for irrigation and other purposes optimally. The model developed for this water resource project can be used with suitable modification to other projects also. The scientific exposure to water resource managers/engineers and awareness in farmers will enable the reduction of various losses and increased crop production in the region.

#### 35. Hydrological Modeling for Evaluation of Return Flow and Irrigation Planning for Optimal Utilization of Water Resource in the Command of Sanjay Sagar Project in Madhya Pradesh

Objectives of the study are assessment of different components of hydrological cycle for computation of irrigation return flow coefficient and rejuvenated flow from the command; investigation of various scenarios including conjunctive use, irrigation water management, cropping pattern changes, variable climate etc. for irrigation planning and reservoir operation in command; development of web/mobile application for WR managers and farmers for optimal release and management of water resources; and capacity building and development of public awareness through workshop, conference, seminars and preparation of manuals, leaflets etc. Very limited studies have been carried out on irrigation return flow in India and abroad because of considerable effort and scientific inputs. The estimation of regenerated flows in the river can be used for planning of downstream water resources projects, while the recharge of groundwater due to irrigation can be useful to estimate groundwater recharge. The present study can be used for the minimization of losses and efficient utilization of available resources. The irrigation return flow can be used to design irrigation projects and downstream water availability. The scenarios based assessment of irrigation planning can be used by water resource managers to operate a reservoir for optimal production under climate change, conjunctive use, efficiencies conditions. The real-time collection of weather information and model application will help decide irrigation releases from reservoirs. The mobile-based application developed under this study can be used to transfer information and issuing advice and suggestion to farmers for efficient management of existing water resources.

#### 36. Delineating the Boundary of Shallow Saline Zones Encountered in Poyya, Karalam, Adat and

### Tholur Panchayats in Thrissur District, Kerala and Investigating Their Origin and Possibility of Any Underlying Fresh Water Aquifers through Geophysical Surveys

Groundwater investigations in the past have revealed saline aquifers of unknown thickness, presumably of about one to two meters thick in the fractured granite gneiss basement below a thickness of 40 to 45 m comprising a top laterite cover and sands and clays. We have specific information regarding the presence of such saline zones in Poyya, Karalam, Adat and Tholur Panchayats in Thrissur district. No efforts have been made so far to estimate the degree of salinity and its variation from place to place within this district. It is important to investigate whether the salinity gradually increases in these pockets or whether these pockets have a sharp boundary. A second aspect to be investigated is whether these saline zones are underlain by any freshwater aquifer. The study will generate new data on the origin and extent of the saline zones in the four Panchayats; investigate the possibility of freshwater zone above/below this depth at any locations in the area so that it could be of great use for the people of the Panchayat. Apart from providing a freshwater source to the people of these Panchayats, the scientific community will now have an example of a unique salinity condition and its specific characteristics and origin.

### 37. Water Quality of Rivers in East Jaintia Hills District of Meghalaya with Specific Study on Change of Colour of Lunar-Lubha River at Certain Periods of the Year

The objectives of the study are to document the variation of the water quality of both the Lunar and Lubha rivers over season and space by analyzing their physio-chemical parameters; to identify the point and non-point sources discharging into the Lunar and Lubha rivers; to detect the changes in the land use and land cover in the catchments of the Lunar and

Lubha rivers; and to give recommendations for ameliorative measures after ascertaining and finalizing the findings of the study. The prime objective of the water resources sector is the protection of the water bodies as well as to prevent pollution of these water bodies. But identifying the cause of the pollution of the Lunar and Lubha rivers and their tributaries, the water quality may be restored with a proper action plan, thus allowing their better utilization. Through this project, it is expected that the point of origin and the cause of the blue colour of the Lunar river will be identified. This will enable the Water Resources Department to tackle the cause of the problem. This will lead to better management of the water resources of the Lunar river and its tributaries. Furthermore, by preventing the pollution of the river, organisms living in the Lunar River can also be protected.

### 38. Study on Behavior of Flooding and Unexpected Drought Like Situation in Garo Hills District of Meghalaya

Objectives of the study are to assess land use and land cover change for the past two decades (2000-2020) in Garo Hills; to assess the frequency of occurrence and severity of drought and dry spells in Garo Hills; to identify areas vulnerable to drought risk in Garo Hills using physical social and climatic factors including satellite rainfall data and other thematic information; to carry out flood frequency analysis and to map the flood inundated areas in Garo Hills using Rainfall-Runoff-Inundation (RRI model); and to prepare region-specific plan for drought mitigation and flood management in Garo Hills. The study will help in the demarcation of areas vulnerable to drought and flood inundation. It will help in quantifying the availability of water resources in space and time in the catchments of Garo Hills by addressing the effect of extreme events on drought and flood in the region. This research outcome is expected to be very valuable for those who are engaged in the planning and design

of water resources utilization and management of floods and droughts in Garo Hills Districts.

### 39. Leachate Transport Modeling for Gazipur Landfill Site for Suggesting Ameliorative Measures

Objectives of the study are understanding of hydrodynamics of groundwater flow in the study area; chemical characterization of leachate; isotopic characterization of leachate and its variation due to recharge and extraction of groundwater; assessment of micro-plastic and metals (Hg, Ni, Co) in landfill leachate; modelling of leachate migration pattern in groundwater in space and time; suggesting ameliorative measures for contaminant plume migration; and dissemination of knowledge and findings to stakeholders through manuals, leaflets, booklets and workshops/training programs. Dumping sites have always been seen as a source of groundwater pollution but no serious attempt has been made so far to quantify the extent of this problem and to pay attention to technically feasible remedial measures. The study along with the extensive survey on groundwater quality will help in differentiating the groundwater pollution caused by landfills from those of other sources of pollution. Thus, the study can act as a tool in the hands of policymakers for appropriate management of landfills and providing sustainable drinking water along with alienating the fears associated with the landfills. The study will also help in arriving at the vulnerable areas and hot spots that need greater attention for groundwater protection and taking measures for associated health risks.

### 40. Urban Hydrological Studies of Pilot Area using Hydrological Instruments in Greater Hyderabad Municipal Corporation (GHMC) Area, Hyderabad

Objectives of the study are evaluation of urban stormwater network and develop flood mapping in pilot area of GHMC, Hyderabad; to develop the IDF

curves and simulate the model for design storm using historical storm data in the pilot area; assessment of runoff pattern in the GHMC study area due to climate change; and dissemination of results of the project to the concerned departments of GHMC and Irrigation & CAD. The expected output would be the scientific evaluation of existing stormwater drainage network in the pilot area of GHMC and to simulate various short term rainfall events impact on present stormwater drainage systems. The micro-level stormwater studies results would be useful for planning of the macro drainage system in the study area to plan water management of the Musi River basin. The output of the study will be useful in GHMC and in strengthening the existing stormwater drainage network in the study area.

## IV. CONCLUDING REMARKS

The purpose driven studies are expected to fill water resource development and management knowledge gaps and develop analytical tools to support hydrologic analyses. It will allow water managers to develop cost-effective measures to address water management and environmental objectives. In particular, this component will facilitate the development of tools for improved water resources assessment and flood management. The outcomes of the purpose driven studies are expected to provide feasible and cost-effective methodologies for replication in other areas situated in similar hydrological and hydro-geological setup.

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**Cite this article as :**

C. P. Kumar, "Purpose Driven Studies Under National Hydrology Project, India", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 6 Issue 5, pp. 213-229, September-October 2019. Available at doi : <https://doi.org/10.32628/IJSRSET1196522>  
Journal URL : <http://ijsrset.com/IJSRSET1196522>