Government of India
Ministry of Jal Shakti
Department of Water Resources,
River Development and Ganga Rejuvenation

सत्यमेव जयते

7th IWW 2022

7th INDIA WATER WEEK 2022

1 - 5 NOVEMBER, 2022

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FOREWORD

Greetings at the Seventh edition of India Water Week-2022 being organized by Ministry of Jal Shakti, Govt. of India during 1-5 November, 2022 at India Expo Center, Greater Noida. This time the theme of India Water Week- 2022 is "Water Security for Sustainable Development with Equity" focusing on various aspects of water security and related challenges for equitable development. The India Water Week is a forum for all stakeholders to deliberate all related issues, sharing experiences, showcasing technological advancements/ achievements learning from best practices and identifying the best course of actions for future.

The India Water Week will have various events in form of Seminars, Panel Discussions, special events by various national and international organisations and partner countries, presentation of various schemes/programmes of various central and state organisations, presentation by civil society, exhibition by industry and other organizations, programme by students etc. making the event truly inclusive for all stakeholders working in water sector.

This volume of Technical Proceedings compiles the synopsis of papers received for ten sessions of Seminars and ten Panel Discussions received from professionals, academia and scientists from within the country and abroad for elucidating their ideas. As an Organizing Secretary, it gives me and my team immense satisfaction that as many as 195 synopsis were received. In addition, there will be more presentations by various experts and professionals during the event, which we plan to compile session wise in electronic form along with full length papers and presentations and make available to the participants on the last day of the event and later in the post-event proceedings.

I express my sincere gratitude to the Organizing Committee, headed by Shri Pankaj Kumar, Secretary and Smt. Debashree Mukherjee, Special Secretary, (DoWR, RD & GR), Ministry of Jal Shakti and all its members. I also express my sincere gratitude to Dr. R.K. Gupta, Chairman, CWC for his valuable guidance as Chairman of the Scientific Committee. Thanks are also due to all members of the Scientific Committee and particularly to Shri M.E. Haque; Shri A.B. Pandya and Shri S. M. Husain for their valuable contributions.

My sincere thanks are also due to the reviewing and session management groups in the content management and IWW Secretariat for their untiring efforts. We, the organizing group hope that this volume will serve as valuable source of information for all the stake holders working in water sector.

(Bhopal Singh)
Director General, NWDA
and Organising Secretary

डॉ.आर.के. गुप्ता
अध्यक्ष
तथा पदेन सचिव, भारत सरकार

DR. R.K. GUPTA
CHAIRMAN
& *ex-officio* Secretary
to the Government of India

सत्यमेव जयते

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन नदी विकास एवं गंगा संरक्षण विभाग
केन्द्रीय जल आयोग
Government of India
Ministry of Jal Shakti
Deptt. of Water Resources
River Development and Ganga Rejuvenation
Central Water Commission

MESSAGE

Greetings at the Seventh edition of India Water Week-2022. The event has established itself as a key dialogue opportunity for water resources sector with a comprehensive coverage of the subject and involvement of a broad spectrum of professionals, researchers and thinkers on the subject.

We had earlier six events addressing topics like **"Water, Energy and Food Security";"Efficient Management of Water"; "Water Management for Sustainable Development";"Water for All: Striving Together"; "Water and Energy for Inclusive Growth" and "Water Cooperation-Coping with 21st Century Challenges"**. The theme for this edition is **"Water Security for Sustainable Development with equity"**.

India is going through the phase of evolution and transformation in water sector. Through various initiatives, the country could display significant progress in water management in the last few decades. However, there is a long way to go in order to effectively tackle India's future water challenges, which are several like water security for potable, agriculture, industrial and environmental needs, water pollution, climate change etc. The need of the hour to cope with the situation is improved knowledge sharing amongst all stakeholders to enable them learn from each other and solidify water management practices across the board through mutual cooperation.

The event attempts to cover the entire theme through a series of 10 Seminars, 10 Panel Discussions, 12 Special Events/Side Events by national and international organisations, Events on key programmes/schemes of the Ministries and 1 Study Tour. The community across the world has actively contributed to the proceedings and have provided more than 171 papers and other presentations. The volume provides glimpse of the contents of the full length papers in form of abstracts. The papers have been published separately in electronic form for conserving the paper and improve accessibility. The organizer will also make the other presentations and the submissions not covered in this volume in form of post-session proceedings and will make them available for reference of the community through our web portal www.indiawaterweek.in.

We have had participation of more than 1000 delegates and professionals over a period of 5 days and the output would not have become possible without their wholehearted cooperation and enthusiasm. As chairman of the Technical Committee, I take this opportunity to express our gratitude to all of them.

RK Gupta

(Dr. R. K. Gupta)

द्वितीय तल (द), सेवा भवन,
आर.के. पुरम, नई दिल्ली-110066
दूरभाष : 011-26715351, 26195415
फैक्स : 011-26108614

2nd Floor (S), Sewa Bhawan
R.K. Puram, New Delhi-110066
Tel. : 011-26715351, 26195415
Fax : 011-26108614
E-mail : chairman-cwc@nic.in

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NWDA, Lucknow

Chief Engineer (HQ)
NWDA, New Delhi

Member Secretary

Shri Bhopal Singh
Director General, NWDA
New Delhi

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SEMINAR

S1:

Sustainable Agriculture and Water Management
- Key to Economic Development

Economic Growth and Poverty Alleviation through Water Security: Global Evidence and Implications for India

M. Dinesh Kumar
Executive Director
Institute for Resource Analysis and Policy (IRAP)
Hyderabad

Keywords

Water Poverty Index, Sustainable Water Use Index, decomposed Human Development Index, per capita GDP, Global Hunger Index, per capita dam storage, Income Inequity, Human Poverty Index, Human Development Path

Synopsis

In this work, an attempt is made first to analyze the nature of linkage between water scenario of a country and its economic growth. For this, data on sustainable water use index derived from Water Poverty Index (WPI); human development and per capita GDP for 145 countries, human poverty index for 113 countries, and global hunger index (GHI) for 117 countries were analyzed. In order to illustrate how creating water storages supports economic growth of countries which fall in hot and arid, tropical climates index, data on per capita dam storage were analyzed for 24 countries. Sustainable Water Use Index (SWUI) was derived from WPI to reliably assess the water situation of a country.

The analysis shows that improving water situation of a country can trigger economic growth, as indicated by the exponential relationship between SWUI and per capita GDP (R2=0.69). This phenomenon is explained by the linear relationship between SWUI and HDI (R2 =0.80), with improvement in water situation raising the value of HDI. While it is known that all the three sub-indices of human development have the potential to trigger economic growth in a country, the exponential relation between HDI and per capita GDP (R2=0.90) further reinforce this fact. Whereas the regression between per capita GDP and decomposed HDI showed a logarithmic relationship (R2=0.75), suggesting that a country's progress in human development has little to do with its economic prosperity and that good human development can be achieved even at low levels of economic growth through welfare-oriented policies which encourage investments in water, health and education infrastructure.

The causality of SWUI acting as a driver of economic growth was tested by running two-stage least square method with HDI as the instrumental variable, SWUI as the predictor variable and per capita GDP as independent variable, which showed a regression coefficient of 0.50.

This growth is inclusive, as shown by low income inequality and low human poverty indices displayed by countries with better water security and HDI. The relationship between SWUI and income inequality, and HDI and income inequality were inverse linear for countries in the medium to high SWUI and HDI ranges. A stronger relationship was found between SWUI and human poverty index when countries in all ranges of water security were included in the analysis. Further analysis suggest that countries which fall in tropical semi-arid and arid climate such as India can and should improve their water security through enhancing their per capita storage by building large water resource systems and fuel economic growth, as suggested by the relationship between per capita reservoir storage and SWUI, and per capita reservoir storage and per capita GDP of 24 countries. Enhanced water security through investments in reservoir storage and water transfer infrastructure for irrigation, energy production and water supply will improve agricultural growth and food security, reduces water-borne diseases, and triggers rural prosperity.

ITC's Climate Smart Agriculture Programme for Resource Efficiency and Livelihood Improvement

Mr. Vijay Vardhan Vasireddy
General Manager –
Social Investments Programme.
ITC Limited
India

Dr. Jagriti Singh
Programme Manager –
Research & Communication.
ITC Limited
India

Keywords

Climate Smart Agriculture, Water Stewardship, Sustainable Agriculture, Crop water use Efficiency, Supply augmentation, Drought Proofing Agriculture

Synopsis

Sustainable agriculture must nurture healthy ecosystems and support the sustainable management of land, water and natural resources, along with meeting the needs of present and future generations for its products and services, while ensuring profitability, environmental health and social and economic equity.

Water, land (soil & soil health) and biodiversity are critical resources for achieving desired yields, reducing dependence on external resources and for continuous provision of eco-system services such as pollinators, predators, etc. The three natural resources are interconnected such that the health of one of them is directly responsible for other one. For example, improvement of soil organic carbon improves soil health and also the water retention capacity of soil. Biodiversity is an important tool for regulating hydrological cycle by holding water during monsoons and releasing it post monsoon. Hence, any action for improving water resources has to be planned on the lines of comprehensive natural resources management.

Increasing population, growing urbanization and rapid industrialization combined with the need for raising agricultural production generates competing demands for water. Contribution of ground water is nearly 62% in irrigation, which emphasizes the fact that both surface and groundwater resources are highly important for any planning of sustainable agriculture.

In addition to pressures on natural resources, in recent years, the rapidly changing climatic aspects due to climate change are adversely impacting agri livelihoods by causing frequent crop failures. At this juncture it is highly critical that agriculture need to significantly improve on productivity to meet the increasing needs of global population without depleting the natural resources and should adapt to climate change impacts. Apart from adapting to climate change, agriculture also has a significant role in mitigating climate change by reducing emissions and carbon sequestration. Such an agriculture is also referred as Regenerative agriculture and Climate Smart Agriculture in global agricultural parlance.

ITC limited is a diversified Indian conglomerate with significant stakes in large agri-value chains. ITC considers that continuous improvement of livelihoods of agrarian communities along with positive footprints on natural resources is critical for the value chain sustainability and accordingly works for nurturing green and inclusive agri-value chains.

ITC's comprehensive Climate Smart Agriculture (CSA) program focusses on farmer capability building for sustainable & climate smart way of productivity improvement and on natural resources management for replenishing water, soil and biodiversity.

The programme is aligned to national priorities and several sustainable development goals related to no poverty, zero hunger, clean water, climate action, life on land, partnerships for goals, etc.

With respect to water, ITC follows comprehensive eco-systems approach for sustainability, scale & coverage comprising of following key tenets:

a)Capacity building, enabling participation & contribution from community for ownership and sustainability;

b) Linkages with suppliers, banks, women SHGs & other community institutions;

c) Forming knowledge partnership for access to contemporary knowledge & solutions;

d) Creating successful demonstrations & replicable templates; and

e) Forming partnerships with government for scale and amplification.

ITC works in active partnership with communities, knowledge partners and Government is aimed at sustainable management of assets, achieving higher scale and for knowledge upgradation.

Further, ITC has designed and is implementing a technical approach to drought proof agriculture and to create positive water balance in each catchment through focusing both on supply augmentation and demand management.

- Supply augmentation focusses on storing water in three forms – a) Rainwater harvesting for surface storage; b) Catchment treatment and biodiversity conservation for soil moisture improvement; and c) Managed Aquifer Recharge for groundwater storage.
- Work for demand management focuses upon promoting agronomical and micro irrigation technologies for improving crop water use efficiency and improving yields and incomes.

In pursuance of its objectives, ITC has trained 2.46 lakh farmers till date on sustainable climate smart agri practices aimed at promoting practices that are resource efficient and deliver higher yields at lower costs.

For water and other natural resources management, on supply side ITC has till date created 45.27 million cu.m. of additional water storage, covered 13.3 lakh acres through soil and moisture conservation, promoted biodiversity conservation in 1.3 lakh acres and constructed over 2,500 water harvesting and groundwater recharge structures. The programme is spread across 16 states of India.

On demand management front, ITC has promoted water use efficient practices such as Direct Seeding of Rice, Zero tillage (no-till) in wheat, seedling plantation in sugarcane, micro irrigation in various crops. These practices were adopted in 7.28 lakh acres of 14 crops in last year resulting in water saving of 496.5 million cu.m. in one year.

ITC also promotes at significant scale practices such as tank silt application in fields, organic manure usage and green manuring etc. which contribute to water resources and soil health improvement.

ITC has forged 46 partnerships so far with Government and knowledge partnerships with reputed ICAR institutes and with institutes of global repute such as Consultative Group for International Agricultural Research (CGIAR), International Water Management Institute (IWMI), International Union for Conservation of Nature (IUCN), World Wide Fund for Nature (WWF) etc.

As per various third party studies, ITC's programmes have led to improvement in groundwater tables up to 40%, cropping intensity up to 184%, crop yields in a range of 20-25% and income in a range of 22 to 36% in various cropping systems. At the same time these programs have resulted in reduction of costs in a range of 25-30% and crop water requirement by up to 50% and Green House Gas (GHG) emission intensity by up to 66%.

ITC considers that the productivity and net incomes of agricultural production systems have to constantly improve to meet the emerging needs and to be profitable for dependent communities. At the same time to be sustainable on long-term these production systems need to have positive footprints on three critical natural resources water, soil and biodiversity. Additionally, agriculture need to be GHG efficient to reduce carbon footprints and help in mitigating global warming and climate change. For achieving these objectives at a scale that matters to globe, multi-stakeholder partnerships are very crucial. ITC has developed state action plans in partnership with CGIAR to implement climate smart agriculture practices at large scale and is currently implementing the same in Madhya Pradesh, Rajasthan and Maharashtra.

Evaluation of Bio-Complementary Production Packages for Organic Rice-Blackgram Cropping System

Dr M Thiyagarajan
Faculty
The DHAN Academy
DHAN Foundation, Madurai

Keywords

Cropping system, increased productivity, organic cultivation, field experiment, rice-blackgram

Synopsis

Field experiments were conducted at farmers field Thoppur, Madurai, during samba and summer seasons of 2016 - 2017 and 2017 - 2018 to evaluate the bio complementary organic production practices in rice-blackgram cropping sequence. The field experiments were laid out in randomized block design with three replications. The experiment consisted of twelve treatments comprising seven organic sources and their combinations (green manure, enriched FYM, tamarind seed powder, neem cake, Panchagavya spray, herbal pest repellent spray and multi varietal seed technique) absolute control and also with state recommendations.

The pre-season green manuring of Tephrosia purpurea (kolunchi) was incorporated before transplanting of rice. The rice variety, Co (R) 48 & Co (R) 51 was raised during samba while in summer, blackgram variety VBN 6 was raised.

Appreciable improvement in growth parameters and yield attributes of rice were evidenced due to the application of green manure @ 6.25 t ha-1 + split application of vermicompost in four equal splits @ 4 t ha-1 as basal, at active tillering , panicle initiation and flowering stages + Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages, resulted in higher grain yield (7465 kg ha-1 during samba 2016 and 6419 kg ha-1 during samba 2017) and straw yield (8715 and 7751 kg ha-1 in samba 2016 and 2017), which was however comparable with state recommendation.

Organic manure incorporation showed favourable residual effect on the growth parameters, yield attributes and yield, besides nutrient uptake in rice fallow blackgram. The effect was more pronounced with green manure @ 6.25 t ha-1 + split application of vermicompost in four equal splits @ 4 t ha-1 as basal, at active tillering, panicle initiation and flowering stages + Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages than the other treatments. Higher system productivity and per day production were recorded with the same treatment.

Improvement in macro (N, P and K) and micronutrient (Fe, Mn) uptake and enrichment in soil available N, P & K status at the end of two year cropping sequence were observed with the application of green manure @ 6.25 t ha-1 + split application of vermicompost in four equal splits @ 4 t ha-1 as basal, at active tillering, panicle initiation and flowering stages + Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages. Among the organic manures, higher net gain in soil available N of 42 kg ha-1 and -6 kg ha-1 at the end of two years of cropping sequence was recorded with aforementioned treatment.

The microbial (bacteria, fungi and actinomycetes) and soil enzyme activity (dehydrogenase and phosphatase) activity were greater due to application of green manure @ 6.25 t ha-1 + split application of vermicompost in four equal splits @ 4 t ha-1 as basal, at active tillering, panicle initiation and flowering stages + Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages.

Improved milling characteristics of paddy, amylose content and cooking characteristics of milled rice were observed in the same treatment. Application of green manure @ 6.25 t ha-1 + split application of vermicompost in four equal splits @ 4 t ha-1 as basal, at active tillering, panicle initiation and flowering stages + Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages improved the colour, texture, taste and overall acceptability score than recommended NPK fertilizer.

Considering the cropping sequence as a whole during 2016 - 2017 and 2017 - 2018, the net income and B:C ratio of application of green manure @ 6.25 t ha-1 + split application of vermicompost in four equal splits @ 4 t ha-1 as basal, at active tillering, panicle initiation and flowering stages + Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages outshone the existing recommended NPK fertilizers. The net return and B: C ratio (`2,04,995 ha-1 and 2.66 during 2016 - 2017; `166344 ha-1 and 2.20 during 2017 - 2018) were highest in the aforesaid treatment followed by state recommendation.

From the study, it could be concluded that the application of green manure @ 6.25 t ha-1 and split application of vermicompost in four equal splits @ 4 t ha-1 as basal, at active tillering, panicle initiation and flowering stages along with Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages is the best organic nutrient management practice in rice-blackgram cropping sequence for higher growth, yield attributes and yield through improved soil fertility and desirable economic incentives.

Prediction of Seasonal and Annual Rainfall for Pune and Mahabaleshwar Regions using Multiple Linear Regression Models

N. Vivekanandan
Scientist-B
Central Water and Power Research Station,
Pune, Maharashtra, India

Aayushi Ghule
B.E. Student, Department of Civil Engineering,
Sinhgad College of Engineering,
Pune, Maharashtra, India

Vaishnavi Darade
B.E. Student, Department of Civil Engineering
Sinhgad College of Engineering
Pune, Maharashtra, India

Keywords

Correlation coefficient, Nash–Sutcliffe model efficiency, Regression, Rainfall, Mean squared error

Synopsis

Prediction of seasonal and annual rainfall for a river basin is of utmost importance for planning and design of irrigation and drainage systems as also for command area development. Since the distribution of rainfall varies over space and time, it is required to analyze the data covering long periods and recorded at various locations to arrive at reliable information for decision support. Further, such data need to be analyzed in different ways, depending on the issue under consideration. For example, analysis of consecutive days of rainfall is more relevant for drainage design of agricultural lands whereas of monthly, seasonal and annual analysis data analysis is more useful for water management practices. In this paper, an attempt has been made to develop multiple linear regression (MLR) models with different combination of meteorological variables that is used for prediction of rainfall.

The meteorological data viz., rainfall (RFL), maximum temperature (Tmax) and minimum temperature (Tmin), average wind speed (AWS) and relative humidity (RH) observed at Pune and Mahabaleshwar for the period 1997 to 2019 is collected from India Meteorological Department and used. The seasonal (monsoon and post-monsoon) and annual rainfall series is extracted from the daily data and used in rainfall prediction with reference to the other meteorological variables considered in the study. The performance of the developed MLR models adopted in rainfall prediction is evaluated through correlation coefficient (CC), Nash-Sutcliffe model efficiency (NSE) and root mean squared error (RMSE).

The study shows that the RMSE on predicted seasonal and annual rainfall using MLR model with all meteorological variables (viz., RFL, Tmax, Tmin, AWS and RH) is minimum than those values of MLR models developed with different combinations of meteorological variables for Pune and Mahabaleshwar. The CC values in seasonal and annual rainfall prediction using MLR vary from 0.906 to 0.973 for Pune while 0.963 to 0.987 for Mahabaleshwar. The study also shows that the NSE obtained from MLR model with all meteorological variables are higher than those values of other MLR models developed with different combinations of meteorological variables applied in rainfall prediction. The results presented in the paper would be useful for stakeholders for planning, design and management of water resources projects in the respective regions.

Optimization of Tungabhadra Reservoir Operation and Integrated Tungabhadra Sub Basin Management

G Naga Mohan
M.Tech (IIT-M)
Secretary
Tungabhadra Board, India

Synopsis

Water management decisions depend mainly on Rainfall / Runoff forecasts apart from many other aspects including availability of water in the Reservoirs. The inflow forecasts for 24 hours/48 hours at various places all along the Rivers and to the Reservoirs like Tungabhadra Dam, Srisailam Dam, Hirakud Dam etc., are being provided by Central Water Commission. But, as on date, there is no inflow forecast for the season as a whole to these Reservoirs. A Case Study of TUNGABHADRA SUB BASIN reservoirs is discussed in this paper, which gives insight into how to optimize the benefits from these multipurpose Bhadra and TB dams apart from increasing the Abstraction of Irrigation water from these Reservoirs. With seasonal rainfall forecast from IMD/Accuweather and others knowing in advance, inflows assessment can be made and earliest dates for releasing of water into the canals can be decided. Early release of water into the canals during Kharif season i.e., w.e.f. 15th June for Bhadra Dam and 01st July for Tungabhadra Dam (as per the recent 10 years trend) will not only increase the abstraction from these Reservoirs but augment power generation from these projects. If this water management strategy is adopted for the Reservoirs in the Peninsular India / India in general and for Krishna basin as a whole in particular, it will be more beneficial to the Farmers and the Country.

Water- Energy- Food Nexus Harmonization: A Way Towards a Climate and Income Smart Sustainable Agriculture

Narendra Tyagi
Independent Researcher
Former Director CSSRI
Karnal

Synopsis

India, like similarly placed other regions in the developing world, is facing major transitions in terms of population growth, urbanization, change in food choices and climate change. As a result, two scenarios are emerging simultaneously- the demands for water, energy and food (WEF) are rapidly growing; while the safe limits of resources use including those of land, water, biodiversity are getting violated. WEF systems are highly interlinked, because they draw resources from a common pool. The achievement of sustainability is decided by the nature and extent of harmonization of WEF nexus, requiring understanding of the interdependencies, constraints (imposing conditions or a trade-off) and synergies (reinforcing or having shared benefits).

This paper explores the feasibility of adopting the water–energy–food (WEF) nexus approach though a case study of the state of Haryana ,which is faced with multiple stresses in respect of declining and degrading land and water resources. It involves reallocation of water resources and crop diversification, adoption of well tested agro-hydro-technologies and energy efficient water pumping to achieve reduced water and energy footprints and increase in farmers' income. The case study leads to the following are important inferences.

The ecologically compatible cropping pattern involving reduction in areas under rice, wheat and cotton and its reallocation among maize, pulses oilseeds, fruits and vegetables, supported by water and energy efficient irrigation systems (laser levelling, zero till and micro irrigation) has the potential to reduce irrigation demands to the extent 10 BCM in the state of Haryana. The proposed cropping, which will not only check fall in water table and reduce water pumping requirement, but will also result in higher crop productivity, lower cost production and higher income by 15-30 %.

Further, the improvement in groundwater pumping system by introduction of BEE labelled energy efficient pumps may bring down the energy consumption by 2213 million kWh. The combined suit of crop diversification, agro-hydro-technologies and improved pumping system may reduce the annual greenhouse gasses (GHGs) production by 3.38 million tons CO2e.

This study concludes that safe handling of the five major transition is technically feasible and economically viable through adoption of recommended ecologically compliant agronomic and hydro technologies. Faster adaption of the desired technologies by the farmers would require support for water and climate technologies, and a relook at water, energy and crop pricing policies.

SRI - A Water Saving Technology in addition to Enhanced BC to Rice Farmers

Palanisamy M
Programme Leader
DHAN Foundation
India

Keywords

System Rice Intensification, cost of cultivation, cost benefit ratio, water saving technology productivity enhancement

Synopsis

Rice is one of the chief grains of India. Moreover, India has the largest area under rice cultivation. As it is one of the principal food crops, it is, in fact, the dominant crop of the country. India is one of the leading producers of this crop. Rice is the basic food crop and being a tropical plant, it flourishes comfortably in a hot and humid climate. Rice is mainly grown in rain-fed areas that receive heavy annual rainfall. That is why it is fundamentally a kharif crop in India. It demands a temperature of around 25 degrees Celsius and above, and rainfall of more than 100 cm. Rice is also grown through irrigation in those areas that receive comparatively less rainfall. Rice is the staple food of eastern and southern parts of India. In India rice is grown in 43.86 million ha, the production level is 104.80 million tones and the productivity is about 2390 kg/ha.

Rice can be cultivated by different methods based on the type of region. But in India, traditional methods are still in use for harvesting rice. The fields are initially plowed and fertilizer is applied which typically consists of cow dung, and then the field is smoothed. The seeds are transplanted by hand and then through proper irrigation, the seeds are cultivated. Cost of cultivation is keep of increasing in the conventional method of rice cultivation. More over crop failure is common because scarcity of water resources. It is important to ensure better return to the rice farmers with lesser use of water.

The System of Rice Intensification (SRI) involves cultivating rice with as much organic manure as possible, starting with young seedlings planted singly at wider spacing in a square pattern; and with intermittent irrigation that keeps the soil moist but not inundated, and frequent inter cultivation with weeder that actively aerates the soil. SRI is not a standardised, fixed technological method. It is rather a set of ideas, a methodology for comprehensively managing and conserving resources by changing the way that land, seeds, water, nutrients, and human labour are used to increase productivity from a small but well-tended number of seeds. As Father de Laulanié observed, SRI is an amalgamation of multiple beneficial practices.

This paper elicits the experiences in promoting SRI in Gudiyatham block of Vellore district, Tamil Nadu State under the Integrated Community Development Project (ICDP) implemented by DHAN Foundation in the year 2019-2021with the CSR funding support of Larsen and Toubro (L & T). The economies of SRI method of rice cultivation in comparison over conventional method of rice cultivation and water saved in SRI method rice cultivation has been very well explained in this paper. Farmers were interacted well and SRI cases with farmers were given to explain the water economics in SRI method of rice cultivation.

Assessment and Classification of Evapotranspiration using WA+ Tool for Water Management in Upper Yamuna Basin

Prakhar Sharma
Junior Research Fellow
National Institute of Hydrology
India

P. K. Mishra
Scientist D
National Institute of Hydrology
India

Anupma Sharma
Scientist F
National Institute of Hydrology
India

Keywords

Remote sensing, Water Accounting, Land Use, Water Resources, Upper Yamuna Basin

Synopsis

Water supplies are depleting around the world, and demand for proper water management strategies and decision processes is increasing as competition for water resources intensifies. Evapotranspiration (ET) is a critical component of water balance; thus, understanding ET management, the impact of land use on ET, and the options for reducing the negative consequences of water depletion while increasing the benefits are all critical for better water resource management. We may accomplish this by utilizing Water Accounting Plus (WA+) framework, which is a systematic assessment of the current state and trends in water supply, demand, accessibility, and consumption in specific areas. The WA+ is a python based framework that is developed by IHE-Delft in partnership with IWMI, FAO, and the World Water Assessment Program (WWAP). The WA+ framework uses spatially distributed satellite inputs to manage a basin's land and water resources. In this study, the WA+ framework is used to assess and classify ET for water management in the Upper Yamuna Basin (UYB). For this purpose, a Water Accounting based Land Use (WALU) map of the UYB is generated by integrating eight open data sources. In addition to WALU, satellite data such as precipitation from TRMM, ET from The Operational Simplified Surface Energy

Balance (SSEBop) and Leaf Area Index (LAI), Primary Productivity (NPP and GPP) from MODIS were used to divide total ET into Evaporation, Transpiration, and Interception. Using these inputs, ET was further classified as (manageable, non-manageable, and managed) and (beneficial and non-beneficial) for water resource management. Management actions to improve land and water productivity are possible with manageable ET because it occurs from land uses that have had minor anthropological interventions, such as savanna (for grazing) and forests (for wood). Because non-manageable ET originates in a protected area, no interventions are permitted, whereas managed ET originates from already managed land uses such as cropland, residential areas, plantations, and so on. ET classification was carried out for each water year (May to June) from the 20-year data sets from period 2001 to 2020. Total ET was determined to be 46 km3/year for the dry year (2002-03) and 47.3 km3/year for the wet year (2010-2011). In the dry year, 24.13% of total ET is manageable, 1.52% is non-manageable and 74.57% is managed, whereas in the wet year, 23.89% of total ET is manageable, 1.48% is non - manageable and 74.63% is managed. The manageable component of ET can be modified for better utilization and management of water resources.

Sustaining Groundwater resources for stabilising agrarian livelihood: A case study of South-western Haryana

Partik Kumar
Senior Research Associate,
Ashoka Trust for Research in Ecology
and the Environment (ATREE), India

Keywords

Groundwater, Agronomy, Sustainability, Water Management, Haryana

Synopsis

The study was conducted to understand, how and whether the changes in agriculture had led to the depletion of water resources in the semi-arid region of Southwestern Haryana, India and at the same time, what are the socio-economic-ecological implications of water depletion in the region.

The water, as well as the land resources in southwestern Haryana, are accelerating towards an unpleasant slope. The detrition of groundwater and soil health is impacting human health as well as incurring a high ecological cost in form of increasing desertification.

A Mixed-method approach was adopted to conduct this study and Multi-stage sampling was used during this study. The study region i.e. south-western Haryana was selected because it was facing a high rate of groundwater depletion and had the highest water table in whole Haryana. Also, it is topography and livelihood pattern are different from the other parts of the state. The study block was selected through the purposive sample and as Badhra is the 'Dark Zone' and Notified by the CGWB, so selected. The three sample villages were also selected through purposive sampling based on their location in context to the canal system and the Aravali Hills. The sampling for the respondents was stratified sampling based on class and caste. A total of 53 samples were taken for the survey. To get the sample among a particular class as well as caste snowball sampling was used. The survey, FGDs and semi-structured interviews were used as a research tool for this study. This study was conducted from April 2017 to February 2018, so both cropping seasons could be covered.

A data set of study villages was taken, where the village level agricultural records of cropping pattern and irrigation sources of past 45 years was analyzed apart from the various other agrarian policies and found that the cropping pattern had changed post 70's towards more water-intensive crops like Cotton, Wheat and Mustard in place of Bajra, Ragi and Gram. Also, the great shift was also found on the irrigation side, wherein pre 70's era, the whole cropping system was rain-fed but later completely shifted to irrigated one. This shift was supported by agrarian policies such as a subsidy for HYV seeds, subsidy for agricultural consumption of electricity and a monetary incentive for shifting to groundwater-based irrigation in place of rain-fed agriculture in the semiarid zones. During the same period of time, the technological advancement for accessing the aquifers had also backed these changes in cropping pattern. These changes were also pushed by the unreliable rainfall in the region and continuously changing nature in terms of its timing of occurrence and the reducing number of rainy days. For some initial years, this shift had benefited the farmers by increasing the farm production but over the years as the Cost of cultivation started increasing due to depleting water table and lowering fertility of the soil, the profit margin started declining and slowly made agriculture an economically non-viable venture in the region. The impact of these externalities of agrarian policies and technological advancement are mainly affecting the marginalized farmers in the region i.e. marginal and small land operator as well as the scheduled case farmers. As an outcome, the marginalized are becoming resource-poor day by day. As the groundwater is the only source of drinking water, domestic water and irrigation, so its declining state is a concern of the life and livelihood of many people in the semi-arid region of Haryana and has the potential to lead a large-scale migration with equal impact on the ecology.

Irrigation scheduling at phenological stages improves growth and yield of capsicum under protected conditions

R S Spehia
Associate Professor
Dr Y S Parmar University of Horticulture and Forestry,
Himachal Pradesh, India

J C Sharma
Professor and Head
Dr Y S Parmar University of Horticulture and Forestry,
Himachal Pradesh, India

Sudhir Verma
Principal Scientist and Head
KVK, Tabo, Lahaul & Spiti,
Dr Y S Parmar University of Horticulture and Forestry,
Himachal Pradesh, India

Keywords

Phenological growth stages, capsicum irrigation requirement, protected cultivation, Water use efficiency

Synopsis

Water efficiency means "doing more and better with less" by obtaining more value with the available water at every stage of the crop. In case of open field conditions, there can be no one size fits all solution, rather a range of location-specific requirements. However, under protected cultivation, the variables affecting the inputs availability and requirement are reduced to maximum extent and solution for a crop in one area can be easily adopted elsewhere as the crop requirements remain same. Water requirement of a crop is most important parameter for its growth and development and its precise application based on the crop growth stages may help in decreasing its wastage while improving crop quality. Based on this, present investigations were conducted to determine water requirement of capsicum for different phenological growth stages (vegetative (1 to 25 Days After Transplanting (DAT), flowering (26 to 42-DAT), fruit set (43 to 57 DAT), fruit growth and development (58 to 84 DAT) and harvesting (85 to 231 DAT) stages) under protected conditions. The experiment was laid out with five irrigation treatments and replicated four times in Complete Randomized Block Design. Drip irrigation at 100 (T1), 90 (T2), 80 (T3), 70 (T4) and 60 (T5) % of crop evapotranspiration (ETc) were used as the treatments of the study which were applied to all the phenological growth stages, respectively. Different treatments registered significant differences in respect of growth and yield parameters of capsicum under polyhouse. Significantly higher plant height and LAI under T1 and T2 indicated higher vegetative growth under these treatments. Number of fruits per plant, fruit weight and yield of capsicum registered highest value under T1 but was at par with T2 and T3, while being significantly higher than other tried treatments. WUE under different treatments ranged from 4.62 t ha-1 cm-1 (irrigation at 60% Etc) to 5.83 t ha-1 cm-1 (irrigation at 80% Etc). A total of 38.69 cm of irrigation water at different phonological stages was optimum for capsicum production under polyhouse conditions. Results of the study, therefore, established that 20% water can be saved by irrigating capsicum at different phenological growth stages.

Water–food–energy-environment nexus in India and challenges for sustainable development

Sharad K Jain
Civil Engineering Department
Indian Institute of Technology
Roorkee, India

Synopsis

The population of India is continuously rising for a long time, causing an increase in the demand for water, food, energy, various types of goods and services. Although the rate of population increase has fallen in recent times, the demands for energy, goods, and services is rising faster than before. Many natural resources are required to meet these growing demands but among all, water is the key natural resource. The use and role of water is critical across a number of sectors, e.g., food, energy, environment and ecology, sanitation, industry, etc.

Keeping in view the past occurrences of hunger and malnutrition, after independence, providing food security was a priority of the Government of India. Due to persisting and sincere efforts, the nation has been able to produce enough food to meet domestic needs and is now in a position to export agricultural products. However, food security has been accompanied by harms to some related sectors. Currently, water is inefficiently used in agriculture and at various other places. Many farmers are growing "water guzzler" crops that are not suitable for that agro-climatic zone. At most places, farmers get water or electricity to pump water almost free and thus, the incentive to efficiently use water is lacking. Withdrawals /diversions from surface and sub-surface water bodies, mainly to meet demands from the agricultural sector, have been unsustainable in numerous cases. Due to the use of fertilizers and pesticides in doses exceeding the requirements, return flows from farms often contain pollutants that are harmful to the receiving water bodies as well as human health and make the eco-systems unhealthy. As groundwater levels are falling and water quality is degrading, more energy is required to pump and treat water.

A large segment of the population of India depends on agriculture for their livelihood. Therefore, agriculture sector has a central place in sustainable and equitable economic growth of the nation. With this view, a number of studies have examined the problems of water, food, and energy sectors and have suggested solutions to overcome the problems. However, the conditions at the ground have not improved significantly. It is, therefore, felt that studies that take an integrated view of water, food, energy and environment sectors, or the so-called water-food-energy- environment nexus are necessary in India. Such studies should be best undertaken by involving the stakeholders and the objective should be to implement the solutions emerging from the studies.

The present talk will summarize the water management problem in agriculture and related sectors in India, and the utility of nexus studies. It will also highlight the key challenges in addressing the problems and possible solutions.

Socio Economic Impact Analysis of Kukadi Irrigation Project

Dr. H. T. Dhumal
Chief Engineer
Water Resources Department
India

P. P. Kaduskar
Executive Engineer
Water Resources Department
India

S. U. Dumbre
Executive Engineer
Water Resources Department
India

Keywords

Standard of living, socio economic impact analysis, agricultural productivity

Synopsis

The Kukadi irrigation project, which consists of a network of 5 reservoirs and 8 canals, is situated in the Krishna Basin in Maharashtra. It is eventually located in a tropical area where rains only fall annually from June to October during the monsoon season. The project provides water for industry, drinking, and primarily for agriculture in drought-prone areas of Pune, Ahmednagar, and Solapur Districts of Maharashtra. The project region experiences rainfall that ranges from 3500 mm to 400 mm. While the supply or command area is prone to draughts, the reservoirs are situated in an area with high rainfall. Construction on the project began in 1964 and continued until 2015. Total water utilization of Kukadi Project is 1101.45 Mcum. The project's major effects on the command area's population's standard of living, water use, the expansion of cash crops, per capita income, cattle, and other factors have been revealed over the period of time. Additionally, there are improvements in crop output, effective water usage, and per capita agricultural revenue. This paper discusses how the project will affect the local population's way of life, standard of living, source of income, capital growth, level of infrastructure development, etc. It is a typical illustration of an evaluation of an irrigation project in a draught-prone area. The aspects taken into account for the impact analysis are the rise of agro-based allied industries, changes in cropping patterns, changes in people's lifestyles, and agricultural productivity. Agro product yields per hectare are increasing. 6.54 million Tonnes of sugarcane were produced in the study area, with a value of Rs. 16367 million (excluding other bio products and allied industries) and Rs. 13503 million from APMCs for other agricultural products. Taking into account a 25% profit margin when sold in the open market, the actual value is then Rs. 16879 million. As a result, all irrigation projects in the State can use the socio economic impact analysis of the study area as a pilot project.

Sustainable Agriculture by Water Management for Economic Development in the Sina basin of Maharashtra

Dr Hanumant Tukaram Dhumal
Chief Engineer
WRD, Govt. of Maharashtra

Synopsis

The western Maharashtra region in India lies in a tropical region which receives water from the monsoon. In the region, there is a large variation in annual rainfall from 6000 mm to 260 mm. The Sahyadri mountain ridge divides Western Maharashtra into Konkan and other Maharashtra. The Konkan and the ridge receive rainfall as high as 6000 mm. The eastward rivers originate on this ridge and flow perpendicular to the Sahyadri ridge and meet the Bay of Bengal. The Krishna and Godavari are major rivers of such kind. The Sina sub-basin of the Krishna basin lies on the Plateau between the Godavari and the Bhima (sub-basin of Krishna). The Sina sub-basin lies in a drought-prone area, highly deficient and receives an annual rainfall of 577 mm. Most of the area is rural and the population is dependent on the agricultural sector. The 75 % dependable yield available for the entire sub-basin is 584 Mm3. The yield in this sub-basin suffers from extreme fluctuation. The ratio between 10% dependable yield and that of 90% (excluding availability in high rainfall and acute scarcity years) is nearly 11. The same between 50% dependable and that of 75% is 1.82. It means projects can be planned based on water available with lesser than 50% dependability. Further, if this available water is converted into per capita and per hectare, it comes to as low as 63 Cum per capita and 458 Cum per ha. which is far below the minimum requirement for sustainable agriculture (Minimum water for sustainable agriculture is 1000 Cum per capita or 3000 cum per ha). Hence a lot of migration happened from these rural areas into urban areas in search of work, water and food. There are geographical constraints for giving water to this area by gravity. The Maharashtra Water Regulation Act 2005 has given authority to make the water available to the drought-prone areas of the State and recommended making funds available to drought-prone on priority. Integrated State Water Plan has also recommended implementing Economically viable inter-basin water transfer on priority.

There are geographical constraints for giving water to this area by gravity. The government of Maharashtra has undertaken Sakalai LIS, an inter-basin transfer of water from abundant submission to scarce submission. The present paper shows how such schemes are designed and implemented for sustainable agricultural development of the such scarce region which will be key to economical development and stop migration in search of water, job, and food.

Rainfall-Runoff Modelling of Sabarmati River Sub- Basin Using SWAT

Keyur Jaiswal
Former P.G. Student,
Water Resources Engg. & Mgmt. Institute
The Maharaja Sayajirao University of Baroda,
Vadodara, India

T.M.V. Suryanarayana
Director
Water Resources Engg. & Mgmt. Institute
The Maharaja Sayajirao University of Baroda,
Vadodara, India

Keywords

Hydrology, Rainfall- runoff, Modelling, QGIS, Soil Water Assessment Tool (SWAT+), SWAT+

Synopsis

Water is the most valuable gift of nature yet it is growing scarce day by day and we need to be conscious that it has to be maintained. In India, where most river basins are ungauged, reliable runoff data is hard to come by, making it difficult for water resource engineers and hydrologists to estimate runoff in a catchment. The Soil Water Assessment Tool (SWAT+) model was created for the Sabarmati river-Gandhinagar sub basin (8132.4 km2) in this study, and monthly stream flows were simulated for a 35-year period The model uses data from the Digital Elevation Model (DEM), land use land cover (LULC), soil data (FAO soils), and temperature, rainfall, relative humidity, sunlight, and wind speed to predict monthly runoff at the watershed outflow and estimate water balance components. Thematic maps of the watershed were created using remote sensing data and QGIS. Actual flow data from the Gandhinagar-outlet from 1980 to 2007 were used to calibrate the model, which was then validated using a comparison of simulated and observed flow rates from 2008 to 2014. In the "SWAT+ Toolbox," a sensitivity analysis approach was used to analyses factors that were anticipated to impact stream discharge estimates. SCS Curve number, slope length, channel length, Manning's coefficient "n", saturated hydraulic conductivity, and soil available water capacity were among the factors identified. Performance indicators such as Coefficient of determination (R2), Nash-Sutcliff Efficiency (NSE), Root Mean Square Error (RMSE), and Percent bias were used to assess the findings (PBIAS). Before calibration, The R2 between Rainfall and Discharge (Flow out) was 0.68, but after calibration and validation, it increased to 0.81 and 0.74, respectively. NSE was 0.57 and improved to 0.81 and 0.76 After calibration and Validation respectively. The Percent bias (PBIAS) was 6.74 % and resulted as 4.26 % and -8.66 % After calibration and Validation respectively. The SWAT+ model produces good outcomes, according to the findings. The study reveals that combining QGIS, QSWAT+, and the SWAT+ Toolbox to estimate runoff from ungauged watersheds is a valuable tool for better watershed management and conservation.

Existential and Economic Value of Water in Indian Perspective

Vivek P. Kapadia
Director
Sardar Sarovar Narmada Nigam Limited
Gujarat, India

Keywords

Economy, Existence, Food security, Growth, Sustainability

Synopsis

Every nation has been given a unique set of questions by nature and accordingly it has to prepare for attainment of sustainable development. India has been given a challenge of feeding millions of people right from its independence with limitations of a relatively smaller land parcel and scanty resources. When sustenance is a challenge, development obviously slips down in the priority. However, India has shown to the world that the way to development passes through sustenance i.e., food security which is a net fallout of its cogent water management. India, soon after independence, focused on water conservation and attained food security within a short period of three decades. It recorded creation of water storage potential of 200 BCM by way of constructing more than 4000 dams during this period and owing to this accomplishment that the annual food grain production went up to 305.44 million Tons (MT) in 2020-21 from a meager 50.8 MT in 1950.51. The same way, installed capacity for power generation that was merely 4000 Mega Watt (MW) got to rise to 4,03,760 MW. Water use pattern suggests that 87% of total water used for industrial purpose goes to the energy sector. India has accomplished a road network of 5,472,144 kilometers which is the second largest in the world. Railway network was about 66,00 kilometer long in 1950-51 most of which was narrow gauge got expanded to be over 1,20,000 kilometers and in parallel got upgraded in to broad gauge in 70 years. All infrastructural development and manufacturing require water either directly or through electricity utilization. This infrastructural development, manufacturing sector and agricultural sector contribute to 46.11% to the national GDP at present which require 85% of the annual water resources available in India. In short, the growth story of India that says the GDP that stood at ₹ 2.7 lakh crore at independence has reached ₹ 135.13 lakh crore today owes a lot to the water resource management of India with albeit, a lot of scope to further improve. One more aspect merits a special note here. The recent pandemic situation disrupted economy of the entire world and many nations have not been able to stand up again thereafter. But India's situation is different in a sense that India could rise again in a very short period. All this is thanks to the water management. During the pandemic period when the GDP nosedived to -23.9%, agriculture reported its contribution as +3.4% which takes 73% of water annually available. This accomplishment not only sustained India in bad times but also helped it in economic revival from almost a nadir. The paper aims at underlining the fact that water has not been brought in to the real pricing realm in India and therefore its contribution is not directly counted through economic parameters but in real sense, it is the life and soul of all the limbs of the Indian economy. Urgent attention for further reforms in water sector is the need of the hour so as to continue the growth story of this ancient and eternal nation.

S2:

Challenges for Sustainability of Ground Water Resources

Trend Analysis and Spatio-Temporal Variability Mapping of Groundwater Table Depth in Central Punjab, India

Manish Debnath
Scientist
ICAR-NRRI
Cuttack, Odisha, India

A.Sarangi
Principal Scientist
Water Technology Centre, ICAR-IARI
New Delhi-12, India

D.K. Singh
Professor,
Division of Agricultural Engineering, ICAR-IARI
New Delhi-12, India

Dr D.R. Sena
Principal Scientist
Division of Agricultural Engineering, ICAR-IARI
New Delhi-12, India

Keywords

Ground water, Innovative Trend analysis, Geostatistics, Semi-variogram, Central Punjab

Synopsis

The trend analysis and spatio-temporal variability mapping of water table depth for 20 years (1998-2017) was undertaken in five districts of central Punjab, India viz. Moga, Barnala, Patiala, Sangrur and Ludhiana. Modified Mann-Kendall trend test and Innovative Trend Analysis indicated a decreasing trend of groundwater table depth (GWTD) for all districts at 1% level of significance ($P<0.01$). The Sen's slope estimator (SS) showed highest rate of decline in GWTD for Sangrur district (≥1.3m/year) followed by Barnala (≥1.1m/year), Patiala (≥0.9m/year), Moga (≥0.8/year) and Ludhiana (≥0.4m/year) for both the pre and post monsoon periods, respectively. Spatial variability maps of ground water table depth (GWTD) during both pre and post-monsoon periods for the year 2009, 2015, and 2018 were generated using geostatistical techniques. Gaussian semi-variogram model was observed to be the best with R2 values ranging from 0.685-0.987 and 0.646-0.989 for the pre and post-monsoon periods, respectively. Generated spatial variability maps indicated a decline of water table depth by 10m in 43% of the study area, 10-20m in 34.7% area, and 20-30m in 9.8% area and ≥30m in2.2% area during pre-monsoon period in year 2018 as compared to the year 2009. Moreover, during the post-monsoon period such depth variations were observed in about 26% and 36.9%, 15.9%, and 6.3% areas during 2018 compared to 2009. Nonetheless, the trend analysis and spatio-temporal variability analysis of water table depth will assist researchers, policy makers, and stakeholders in water table depth management through adoption of judicious agricultural water management technologies.

Challenges in Sustainability of Ground Water Resources in a Crystalline Granitic terrain: A study from drought-prone Ananthapur District, Andhra Pradesh, South India

Caroline Louis
Scientist B
Central Ground Water Board
India

Resma S.Pillai
Scientist B
Central Ground Water Board
India

Ravi Kumar Gumma
Scientist D
Central Ground Water Board
India

Rani. V. R
Scientist D
Central Ground Water Board
India

Keywords

Shallow aquifer, Desaturation, Artificial Recharge, and Sustainability

Synopsis

Groundwater plays a key component in the socio-economic development of the country. The highly varied geological setup, as well as climatic conditions, resulted in the uneven distribution of groundwater resources in India. In addition, unbridled exploitation of groundwater has created desaturation of shallow aquifers and decline in groundwater levels which in turn disturb the natural groundwater regime. This situation highly warrants the formulation of groundwater management to address the deteriorating groundwater status. Low rainfall and high dependence on groundwater led to a steady fall in water levels and desaturation of the weathered zone in some parts, raising questions on the sustainability of existing groundwater structures, food, and drinking water security. In view of this, the groundwater scenario of Ananthapuramu district in Andhra Pradesh state is analyzed, as it's an arid, drought-prone, low rainfall area with a high dependency on groundwater. To understand the extent of desaturation in the shallow aquifer (Aquifer-1), formulated a methodology to demarcate the dried-out shallow aquifer and quantified its desaturation volume. The methodology involves the comparison of shallow aquifer thickness with the decadal water level of the area incorporating the hydrogeological parameters of the aquifer. This integrated approach helps to identify the subsurface scenario of shallow aquifers, ie, shallow aquifer of 70% area in the study area is de-saturated during pre-monsoon season and 57% of the area during post-monsoon season. If this issue is not tackled through proper management strategy, it will soon affect the sustainability of the deeper aquifer. The estimated unsaturated volume of the entire district with a recharge potential of 3272 MCM is highly crucial for the effective implementation of artificial recharge and water conservation measures in the area. Therefore, it is identified that 391 Villages in the area require immediate Intervention for Ground Water Conservation through Integrated Water Management Plan (IWMP), Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) Scheme, and Pradhan Mantri Krishi Sinchayee Yojana (PMKSY).

Realtime and Intensive monitoring of Groundwater Water Level for Water Resource Management

Mr. Dhirenkumar Chavda
Groundwater Management & Modelling Expert,
TAMC
National Hydrology Project
MoJal Shakti, Govt. of India

Mr. Sunil Patil
Instrumentation Expert,
TAMC
National Hydrology Project
MoJal Shakti, Govt. of India

Dr. D. Gnanasunder
Senior Joint Commissioner
NPMU, National Hydrology Project
MoJal Shakti, Govt. of India

Mr. Jiten Singh
Deputy Director
National Hydrology Project
MoJal Shakti, Govt. of India

Keywords

Groundwater level depletion, Groundwater level monitoring, automatization

Synopsis

Groundwater level depletion, Groundwater level monitoring, automatizationExtensive need of groundwater in human life creates demand for the various type of data on groundwater availability and quality. Groundwater is not a renewable resource, in this status importance of auditing groundwater use, depletion of quantity and quality are become priority. Groundwater level is one of the simple ways to monitor status of resources against rainfall and consumption over the period. Depletion in groundwater level or drying up of unconfined aquifers represent the increasing extraction of groundwater and world's highest consumption in India. Total annual ground water extraction for the year 2020 has been estimated as 61.59 % out of annual extractable ground Water Resources. Groundwater has been monitoring by the central agency extensively across the country and state agencies has been monitoring groundwater in the state at various extent as requirement and stage of groundwater development like Punjab has 149% while NE states has less than 3%. Most of stations monitoring done by human resources which may be quarterly or half-yearly and this system does not able to provide enough data to resolve issues thoroughly for the issues of groundwater level depletion. Extensive and rapid groundwater development and water level depletion over the seasons / periods generated need of more frequent data which required to 1) identify the zones of water level depletion and 2) measures to maintain water level. The situation leads to automatization of water level monitoring aquifer wise. The document envisioned to suggest technological options for automatization of groundwater level monitoring.

Groundwater monitoring, resource assessment: a case study from Punjab, India

Gopal Krishan
Scientist D
National Institute of Hydrology
Roorkee, India

Alan M MacDonald
Principal Hydrogeologist
British Geological Survey
The Lyell Centre, Edinburgh, UK

DJ Lapworth
Principal Hydrogeochemist British Geological Survey
Maclean Building Wallingford
OX10 8BB, UK

Daren Gooddy
Groundwater Processes Team Leader
British Geological Survey
Maclean Building, Wallingford
OX10 8BB, UK

MS Rao
Scientist F
National Institute of Hydrology
Roorkee, India

Surjeet Singh
Scientist F
National Institute of Hydrology
Roorkee, India

Keywords

Groundwater, declining water levels, contaminations, resource management, Punjab

Synopsis

Groundwater is the largest freshwater store and is crucial for sustaining surface water bodies such as rivers and lakes and also wetlands and dependent ecosystems. There is continuous exchange of flow between the groundwater reservoir and surface water bodies depending upon availability and need and playing an active role in replenishment of hydrological cycle. Its incessant flow believed as a conveyor system for chemicals of geogenic (natural), as well as anthropogenic (human-made) origin.

The amount and distribution of these chemicals guides its suitability for drinking and irrigation use. Apart from the springs, the only way the groundwater can be accessed is by pumping and it is estimated that its over extraction has increased by four times during last five decades globally and continuous extraction will be a danger for its sustainability. Therefore, monitoring of quality as well as quantity this resource is very important for societal point of view.

Recent studies carried out in Punjab, India clearly show that there are issues of degradation of groundwater quality as well as the serious depletion of groundwater levels in the state. In most parts of the state the water levels are declining at a rapid rate due to high extraction. In south-west Punjab groundwater is highly saline and has been found contaminated with heavy metals such as arsenic, iron etc. in the Majha region and in pockets of some other regions.

Since groundwater is a renewable resource and there is a possibility of its development as a desirable societal outcome. Its societal management is necessary to prevent further degradation in terms of quality as well as quantity by balancing the use of this resource with safe and sustainable yields.

Recharge Potential Zone of Aquifer for Sustainable Management through Remote Sensing and Geographical Information System in Aspirational Virudhunagar District Tamil Nadu

Dr. K. Raja Rajan
Scientist
Central Ground Water Board
India

Keywords

Recharge Potential zone, Aquifer, Management, GIS, Very good zone

Synopsis

Virudhunagar district of Tamil Nadu state has been identified as one of the Aspirational district of Tamil Nadu by Niti Aayog, Government of India to improve various sectors such Health, Agriculture and Water Resources, Education, Finance and basic infrastructures. Based on the Ground Water Resources Estimation -2013 and 2017, The groundwater extraction stage is increased from 9 over exploited and critical firkas to 14 over exploited and critical firkas out of 36 and 39 firkas respectively in the district. It is more common that the heavy pumping of groundwater is always unrestricted from high potential aquifers. It leads to declining of water level, less sub surface flow within aquifer system and reducing the yield. It is high time to understand the recharge potential of the aquifer for sustainable management plan. Recharge potential zone of aquifer (unconfined aquifer) has been demarcated through integration of spatial data by adopting Index overlay model in GIS environ.. The potentials recharge zones are classified as very poor, poor, moderate, good and very good. The very good and good zones are formed by thick alluvium and occurring in the recharge area of the district. The managed aquifer recharge is planned in the very good and good recharge zones for sustainability of the aquifer system in the district.

Impact Assessment of Ponds on Groundwater Quality in Vicinity Area of District Ropar, Punjab

Kalzang Chhoden
Panjab University
Chandigarh
India

Chhavi K. Manchanda
Panjab University
Chandigarh
India

Keywords

Pond water, Ground water, physico-chemical, Microbiological, Piper diagram

Synopsis

Village ponds used to be lifeline of the people in rural areas and used for collection of rain water and runoff water stored in ponds for the drinking and bathing of animals. Over the period of time wastewater from households, septic tank discharge into the village pond. Thus ponds receive wastewater for the whole year. Therefore, water from the ponds keep on percolating through subsoil and deteriorate the quality of ground water.

The present study investigates the physico-chemical and microbiological analysis of various ponds and ground water samples collected from the vicinity area of ponds. Results of the study showed pond water is excess of phosphate, BOD, COD, NO3-, Nh4+. Effect of age, distance and depth of water sources on level of contamination was assessed by considering main tracer parameters like NH4+, NO3-, PO4-, COD. It was observed that the high Nitrate was reported in lower depth 1-40 ft. high concentration of NH4+, COD, PO4- were reported showing the infiltration of contamination at different depths. Further, result showed changes in concentration of different parameters at various distance. It is reported that samples collected from the close to the ponds have high concentration of COD, NH4+ and PO4+. Based upon the study it was observed that ground water sources nearby the ponds have greater effect as compare to the far distance samples. Piper trilinear diagram showed the dominance of Ca-HCO3 and Ca-Mg-Cl type of water in study area. The study revealed that the pond water is contaminated and due to which the sources of ground water nearby the pond is also affecting.

Challenges for Gujarat's Ground Water Resources – A Case Study of Salinity Ingress in Coastal Region of Saurashtra.

ER. Kirit B. Trivedi
B.E.(Mech.), MBA (Marketing), CDM, M.I.E, F.I.V
D.E.E. (Mech.), Retired.
Government of Gujarat
Gandhinagar-Gujarat

Keywords

Salinity Ingress, HLC-I & II, Salinity Control, Spreading Channels, Ground Water Management

Synopsis

The Prosperity of mankind is always governed by the environment. The natural conditions on earth are not uniform throughout and it has placed the man in different conditions of habitation. With the progress of civilization mankind tried to utilize the surface and ground water resources where and when available. Since time immemorial man has been trying to device more and more infallible methods for locating ground water. Exploitation of ground water by adopting esoteric method is carried where necessity is felt and resources compromised.

Ground Water makes up about 20% of the world's fresh water supply, which is about 0.61% of the entire world's water, including oceans and permanent ice. Ground Water is naturally replenished by surface water from precipitation, streams and rivers, when this recharge reaches the water table. Certain problem has beset the use of ground water around the world. Just as river water has been over-used and polluted-so, too have aquifers. The big difference is that aquifers are out of site.

Ground Water Quality Scenario in India

Indian Sub- Continent is endowed with diverse geological formations from oldest Achaeans to Recent alluviums and characterized by varying climatic conditions in different parts of the country. The natural chemical content of ground water is influenced by depth of the soils and sub-surface geological formations through which ground water remains in contact. In general, greater part of the country, ground water is of good quality and suitable for drinking, agricultural or industrial purposes. Though there are basic issues of contamination-regarding the ground water quality in India, which includes-Salinity, Fluoride Iron: Nitrate.

Challenges for Gujarat's Ground Water

The state of Gujarat is having various issues regarding ground water, which includes Salinity ingress also.Salinity affects approximately 20% of irrigated land worldwide. Controlling salinity and reclaiming saline land is an urgent priority in order to increase productivity of existing land, make better use of irrigation and demonstrate that new irrigation areas can be managed in a sustainable manner.¬ The State of Gujarat has longest coastline of 1600 km, out of this about 765 kms. by Saurashtra region.

Salinity Ingress in the coast of Saurashtra has created many problems in the vicinity of the coastal area, particularly for the irrigation land, ground water quality, surface water including drinking water etc.The main reasons for salinity ingress in the region are less and irregular rain fall, porous geographical formation, less natural water filling and weak land management. The problem of salinity ingress has aggravated over the years due to heavy withdrawal and non scientific exploitation of ground water. All these ultimately affected the ground water availability and above this the intrusion of saline water in the coastal region of Saurashtra of Gujarat State and thus ruined the life of people economically in a very great extent, Migration of people started at last.

Main Causes of Salinity Ingress in Saurashtra Region

Geological formation, No perennial river, Scarce and uneven rainfall, Large scale pumping of ground water by farmers in the Coastal Region, Imbalance between water recharge and water withdrawal, Unawareness/ carelessness in usage of precious water, all these led to Salinity ingress in Coastal belt. The problem was brought to the notice of the Government. Considering the situation, importance of combating salinity in the saurashtra region, Government formed two HIGH LEVEL COMMITTEES in the year '76 and '78 respectively to investigate the problem of salinity ingress and to give suggestions for its remedial measures. Solutions suggested by them were construction of Tidal Regulators, Bandharas, Check dams, Spreading channels, a forestation and some management techniques which include regulation of lifting of underground water and change of crop pattern and coastal land Reclamation bunds.

As per the suggestions given by the committees, various infrastructure development plan had taken place through constructions of Bandharas, Tidal regulators, Recharge reservoirs, Recharge Tanks, Check Dams and Spreading Channels and Coastal Bunds in the Districts of the Saurashtra region by the Government of Gujarat in last about 40 years & as such benefits have been obtained, which includes, increase in irrigation potential for land and the increase in the quantity of benefited areas of cultivable land. Migration of the population has been arrested and in majority of the cases the migrated people have returned and restored to their respective villages and professions. The prices of agriculture land have also improved considerably. This has direct bearing on the improvement of economic prosperity of the region. After successful implementation of salinity control program an overall improvement in environmental and socio-economic conditions of the area has been recorded.

The efforts made by the Government of Gujarat have changed the scenario of rural people, who were suffering from the problem of salinity for a long time. Now they witnessed the development. The future is bright in the coming years. We have to save every drop of water, and have to use water as per requirement, adopt proper water harvesting technology and rain water harvesting must be promoted. Let us work together for combating the deteriorated ground water and help the mankind.

In my full length paper, I shall be presenting detailed information about the various types of works carried out by the Government of Gujarat to combat salinity in the coastal region of saurashtra and the benefits occurred by great efforts for the rural people of this region and put them into the main stream of beautiful life once again. I Hope that the committee will find my inputs valuable and provide me an opportunity to present the same. Jai-Hind.

Groundwater Pricing strategies as a tool for Groundwater Management: Case of Kanpur city, India

Kriti Trivedi
Junior Research Fellow
Maulana Azad National Institute of Technology
Bhopal, India

Keywords

water stress, groundwater management, water pricing, groundwater value, sustainable water usage

Synopsis

With the high pace of economic development and population growth, water demands are rapidly increasing, and water resources are becoming scarce in many regions of the world posing stress on groundwater resources. In Indian scenario, groundwater is many a times preferred over surface water sources due to its universal availability, reliability which has resulted in indiscriminate extraction and the declining groundwater levels. India is the highest user of groundwater in the world, at 260 cubic km/annum. It is estimated that the country consumes 25 % of the total groundwater extracted globally, much ahead of China and USA. However, out of the total groundwater consumption 90 % is used for agriculture and only 10 % is utilized for urban water demands. Due to the rapidly increasing urban water demand and increasing reliance on groundwater for domestic consumption coupled with unreliable and inadequate municipal water supply, there is an urgent need to direct focus on groundwater management in urban areas to ensure long term resource sustainability and water security. The major challenge arises due to the invisibility of the groundwater resource, it hinders the realisation among the water users that the resource is getting depleted as a result of their continued water extraction practices. Moreover, a false sense of groundwater recharge is inculcated after satisfactory rainfalls without understanding the declining groundwater recharge rates due to the concretisation and hardscaping of surfaces in urban areas.

In order to reduce the possibility of irreversible overexploitation of aquifers in growing Indian cities, there is a need to implement robust and effective groundwater management strategies as a first step towards ensuring groundwater resource sustainability. In this regard, as a part of multidisciplinary groundwater governance, the study aims at developing strategies for pricing groundwater in urban areas for controlling groundwater exploitation in urban areas. It proposes differential pricing to address the spatial variations in terms of water consumption, resource availability and vulnerability. Volumetric charging for water usage and factor of groundwater resource criticality are considered for groundwater price determination.

The pressure on the groundwater resources available to the country requires sound, scientifically based regulations to prescribe sustainable use and accountable behaviour. Setting a price on consumption of a resource such as groundwater can be one of the way to encourage user to use resource more efficiently i.e., pay more as you use more. Henceforth, in this study groundwater pricing is selected as a tool for limiting groundwater exploitation by understanding the water consumption dynamics and prioritizing aquifers based on their criticality level. For setting a price for groundwater usage, modified hedonic pricing model for spatial analysis is adopted for determining groundwater value. In this case criticality of the resource is estimated by evaluating the groundwater resource characteristics, its availability, quality etcetera.

Use of GIS tool for weighted-overlay facilitates integration of different layers representing spatial characteristics of a resource to obtain cumulative impact on resource criticality. This factor of resource criticality when multiplied by the tariff gives the value of the resource.

Kanpur city in the Indo-Gangetic basin in India is selected for the study for its unique characteristic of lying in the highest groundwater potential area of the country yet extremely high-water stressed area, rendering the aquifers vulnerable to irreversible exploitation under a business-as-usual scenario. In order to set up the prices for groundwater extraction, the cumulative assessment of existing groundwater levels, groundwater recharge potential, groundwater availability, groundwater consumption patterns along with external factors such as availability and quality of water-supply infrastructure, considering ward as a spatial unit is done for calculating groundwater resource criticality factor. The obtained groundwater criticality factor in addition to the volumetric consumption becomes the basis for the differential part of the groundwater pricing model for effective and coherent groundwater management. Henceforth, the tariff will be directly proportional to the extent of negative externality caused by the act groundwater extraction beyond sustainable limits, ensuring the conservation of invisible common pool of source, extremely important for maintaining the ecological.

Effective groundwater management in urban areas can be achieved by employing consumption-based differential groundwater pricing as a tool for discouraging overexploitation while taking into account the physical, social and natural dynamics of groundwater. This is done by multiplying the factor of groundwater resource criticality to the tariff. The resultant pricing strategies will help to regulate groundwater usage corresponding to the level of groundwater resource criticality in that area in order to maintain sustainable groundwater levels. Additional incentives for promoting decentralised water management approaches such as rainwater harvesting measures for groundwater recharge are also incorporated in the tariff for motivating the water users. Such strategies are not only needed in the declared groundwater stress hotspots but also in areas where water demand is expected to grow substantially. The pricing strategies identified in the current study provide a holistic framework for groundwater management through pricing as a tool while considering the practical implications and challenges likely to arise at the implementation stage. Thereafter ensuring sustainable groundwater extraction in urban areas by controlling the groundwater dependence in a rational and equitable way by altering their consumption behaviour.

Mitigating the Geogenic contamination of fluoride in Dongargarh granite of Bastar Craton in Chhattisgarh State

Mukesh Anand

Dr. Prabir K. Naik

Prachi Gupta

Mukesh Anand

Uddeshya Kumar

Rakesh Dewangan
(North Central Chhattisgarh Region
Central Ground Water Board
Raipur, Chhattisgarh, India)

Keywords

Pond water, Ground water, physico-chemical, Microbiological, Piper diagram

Synopsis

Both surface and ground water contain Fluoride(F-) in traces to excess. Natural water concentrations of Flouride are influenced by a variety of factors, including temperature, pH, solubility of fluorine-bearing minerals, anion exchange capacity of aquifer materials (OH - & F -), geological formations drained by water, and how long water is in contact with a particular formation. Fluorite, apatite, mica, amphiboles, clays and villiamite have the greatest effect on fluoride's hydrogeochemistry.

The Bastar craton of central India is an important cratonic nuclei of the Archean global record (Radhakrishnan and Naqvi,1986, Bleeker,2003). The region is bounded by a ENE-WSW trending Central Indian Tectonic Zone (CITZ) at the north, Mahanadi and Godavari grabens at the east, and the Eastern Ghats Mobile Belt at the south. The N-S trending Neoarchaean/Palaeoproterozoic collage of mobile belts along with batholithic granitoids, termed the Kotri-Doingargarh Mobile Belt (KDMB) geographically corresponds with the Kotri lineament, a deep crustal dislocation in the Bastar craton (Rajurkar et al., 1990).

An exploratory drill was conducted at Pond village in Gariyaband district (20.766325 and 81.945130) up to a depth of 102.4m. The area is exposed to fragments of granite. Gray granite was encountered first, followed by brown granite. Fractured was encountered at 102.40 m depth. The fluoride concentration of 2 bore wells is 1.5 & 1.52 mg/l. The water is Ca – HCO3 type. Fluoride above the permissible limit of 1.5 mg/l and intake for a longer period such as more than 5-6 years causes dental/skeletal fluorosis. Although the EW is a great success in mitigating the water scarcity in the nearby area with a high discharge of 10.4 lps but the quality issues should always be on top priority.

The Dongargarh granites have intruded into the Amgaon gneisses and the bimodal volcanic suite of Nandgaon Group. The Dongargarh granites are unconformably overlain by the Khairagarh Group. The Dongargarh granite complex is devoid of pegmatites and contains rounded microgranular enclaves, syn-plutonic porphyritic dolerite dykes having feldspar phenocrysts and minor gabbro bodies. The Dongargarh coarse equigranular granite displays hypidiomorphic granular texture with pink K-feldspar(orthoclase-microperthite), plagioclase, smoky quartz, amphibole and biotite along with accessory ilmenite, sphene, magnetite, zircon, apatite and allanite (Narayan et al.,2000). Minerals like amphibole, biotite and apatite are enriched with high fluoride.

In the study 100 percent inventoried of drinking water sources has to be made to delineate high fluoride wells. Ingestion of large amount of F-contaminated water is likely to cause fluorosis – a disease that leads to embrittlement of cartilage/bones /teeth. Blending can be done to make the high fluoride wells potable and alternative source of drinking water supply like surface water and water from low fluoride bore wells can be made. Proper nutrient rich in Ca should be provided to rural people to have less impact on health.

Managing Alluvial Aquifers: Key contemporary challenges in Groundwater governance

Partik Kumar
Senior Research Associate,
Ashoka Trust for Research in Ecology and the Environment (ATREE)
India

Keywords

Groundwater, Alluvial Aquifers, Sustainability, Participatory Governance, Indo-Gangetic Plain

Synopsis

The study was conducted to find the key contemporary challenges in managing the alluvial aquifers in India. The challenges are derived from a theoretical framework considering the Bio-physical characteristics of resource units, socio-economic conditions of users, geopolitical circumstances of state and ecological concerns of the geographical region. Though the prominent challenges are listed as pointers, they are highly interdependent and mutually influential.

A total of 1114 assessment units are overexploited, as per the National Compilation on Dynamic GroundWater Resources of India, 2020. Out of these 1114 over-exploited assessment units, more than 4/5th of them are of alluvial aquifers. The overexploited areas prominently lie in the Punjab, Haryana, Rajasthan and part of Uttar Pradesh. Multivariable correlation analysis suggest that the looming groundwater crisis is a high risk to the food security of the country, the livelihood of millions of agrarian families, the livelihood of agrarian labour from the country's poorest states, the habitational crisis in NCR and ecological well-being. Thus, managing alluvial aquifers should be the top priority of groundwater governance in the country.

The research study concluded with defining the prominent challenges for sustainability of groundwater resources in alluvial aquifers.

Key Findings

Spread and Size of the aquifer (resource unit): A typical alluvial aquifer could be spread across hundreds of kilometres in its length and breadth with a depth up to a few hundred meters. This means, it covers multiple administrative boundaries (Gram Panchayat, blocks, districts and even states), various forms of users (farmers, urban habitations, industries, riverine ecosystem etc.) and could be different environmental conditions. In case we wish to make an impactful intervention, the intervention should be practised across the common resource unit (aquifer). And in the case of alluvial aquifers, the aforementioned conditions will make it a challenging task.

Resource-rich stakeholders: Close to 4/5th of the total extracted groundwater from alluvial aquifers is used in agriculture. The farmers in the region of alluvial aquifers are relatively resource rich in terms of average landholding, productivity per unit area as well as income per household. According to the agricultural census 2015-16, the average landholding in Haryana and Punjab is almost thrice of the national average. Also, the average yield in these two states is almost double as compared to the national average. Further, the average monthly receipt for crop production per agricultural household is approx four times higher than the national average. Mancur Olson's Collective action theory suggests that resource richness leads to the problem of free riders and thus hinder participatory management.

Absentee landlord and tenants: A significant section of the operational area is leased in the states of alluvial aquifers dominance. According to the NSSO report, in Punjab and Haryana, the percentage of leased-in area to operational area is 15.2% and 26% respectively. Also, in 82% of cases, the terms of the lease are in the form of fixed money. The cumulation of these two facts suggests that the tenants' primary interest lies in financial output rather than sustainability of groundwater resources.

Absenteeism of stakeholders institutions: At present, there is no significant community institution in place to deal with the challenges and management of groundwater in the region of alluvial aquifers. The only relatable institutions are either the Water user's association (WUA) or the Village water and sanitation committee. But both sorts of institutions are either defunct on the ground or lack the institutional capacities to take up the role of groundwater management. In absence of participatory stakeholders institutions, the management of alluvial aquifers will remain an unattainable target.

The agrarian market is the driver: The alluvial aquifers in India majorly lie across riverine plains popularly known as the great plains of India or food bowl of India. The agrarian practice played the most vital role in bringing the alluvial aquifers into their current form. A dissection of this suggests that it is led by the cultivation of water-intensive crops and that are directed by the existing procurement regime. As the procurement on minimum support price is primarily for the water-intensive crops like wheat and maize, thus farmers prefer to go by the same. In the long run, this results in the depletion of groundwater resources. Data suggest that out of total procurement, the combined share of Haryana and Punjab in total procurement of rice and wheat was 38% and 76% respectively. So, the other biggest challenge in managing the alluvial aquifers is the orientation of the agrarian procurement system towards the less water-intensive production system.

Convergence between Surface Water, Groundwater and traditional sources: The alluvial aquifer coincides with regions with rich surface water management systems and traditional sources in the form of 'johads' and alike. This is also because the human civilisation initiated from the river banks and thus emerged the needs, practices and system in the periphery. Historically as well as in contemporary times, the surface water, groundwater and traditional sources backed up each other in their emergence and utility. The same needs to be framed to systemize the contextualized conjunctive use to mitigate the emerging needs.

Limited learnings and proof of concepts: The biggest challenge is that the aforesaid challenges lack efficient and effective approaches or methods to mitigate the same. There is hardly any proof of concept to answer the challenges of alluvial aquifers. The prominent managemental tools practised in alluvial aquifers are mainly taken from the basalt or other form of hard rock aquifers. Whether that is the watershed approach for groundwater management or the stand-alone practise of rooftop rainwater harvesting structures. They may work as ad-hoc tools but certainly fail to mitigate the quantum and scale of governance challenges of alluvial aquifers.

Conclusion:

Alluvial aquifers are the life and livelihood of millions and more importantly, the vital elements for ecological wellbeing. But groundwater development practices of the past few decades had made a significant dent in such an essential resource. Sustainable groundwater governance in alluvial aquifers is the need of the hour but with a caution i.e. "they are alluvial aquifers and they are notably different from any other form of aquifer".

It is important to configure the managemental intervention into the alluvial aquifers considering the biophysical characteristics of resource units, socio-economic conditions of users, geopolitical circumstances of state and ecological concerns of the geographical region as stated above. Ignorance of any such factors or just copy-pasting the mainstream groundwater management practices might end up futile.

River Bank Filtration (RBF) – A Source for Safe Drinking Water Security

Y R Satyaji Rao
Scientist G
National Institute of Hydrology,
India

Y Siva Prasad
Research Scientist
National Institute of Hydrology
India

NC Ghosh
Professor
Bengal Institute of Technology
India

T Vijay
Scientist B
National Institute of Hydrology
India

Keywords

RBF, Salinity, Groundwater, Varaha River

Synopsis

The discharge of untreated wastewater into surface waters is a common practice in developing countries. The conventional treatment of surface water by municipal corporations is cumbersome and required high maintenance. An alternative is a natural treatment through River Bank Filtration (RBF), in this process, river water is induced to flow through the adjacent subsurface and into the RBF well. RBF technique is used worldwide where suitable hydrogeological conditions exist such as sufficient thickness and hydraulic conductivity of the aquifer, the hydraulic connection between the river and aquifer, and good filtering properties of the riverbed and the aquifer. Providing safe drinking for every citizen of the country is a constitutional mandate in India and in this direction, the Govt. of India launched the program Har Ghar Nal Se Jal Yojana. To reach this constitutional mandate, various programs like the interlinking of rivers, construction of new ponds, and new treatment plants are initiated. In India, most of the major and minor rivers are having flow during monsoon only. In the coastal zones of Andhra Pradesh state, groundwater is the primary source of drinking water due to the erratic rainfall patterns and scarcity of surface water resources during the summer period. Major and minor reservoirs, ponds, and lakes serve as drinking water sources during the summer months. However, in coastal regions where the groundwater is saline and rivers are ephemeral, there is an insecurity of treated water supply and high demand from

the coastal villages, therefore people are depending on commercial Reverse Osmosis (RO) plants. To avoid the dependency on RO plants, there is a possibility of RBF wells for secured water supply to the coastal villages. The feasibility of RBF wells has been explored in the present study for potable water supply in a coastal region.

The RBF technology is demonstrated at the Varaha river bank, coastal region of Andhra Pradesh, India where the river is ephemeral and groundwater is saline. The groundwater of many dug wells and tube wells along the Varaha river in the coastal region is brackish with TDS of more than 2000 mg/L which is not suitable for drinking purposes. Geologically, the river alluvium in this region is predominantly comprised of thick silty clay minerals which are saline in nature. Most of the production wells drilled by local people produce saline water due to discontinuities in fresh sandy aquifer zone or heterogeneous subsurface layers in the coastal aquifer therefore identifying fresh groundwater to support local communities is a critical task. An integrated approach has been implemented by using tomography surveys, groundwater flow modeling, and particle tracking techniques.

A favourable hydrogeological layer (low salinity) of the resistivity range of 15–30 Ω.m. has been identified from the tomography surveys. By taking proper good construction methods, RBF well has been drilled in this coarse sand layer (river-aquifer interaction zone between 6–15 m depth) which is less vulnerable to geogenic contamination (paleo marine). Analysis of the particle tracking technique at the RBF site has confirmed the suitability of the RBF well location on the Varaha riverbank with a maximum of river-induced water among other surrounding pumping wells. The RBF well yield and aquifer productivity are assessed during pumping test analysis. The Electrical Conductivity (EC) values of the RBF well during the pumping test are between 720–850 μS/cm throughout the pumping period (5 hrs). The comparison of hydrochemistry between river water, groundwater, and RBF water confirms that RBF water is safe for drinking with minimum disinfection methods. The quality of RBF well water satisfies all drinking water specifications (BIS, 2012) of bacteria and chemical parameters after installing a disinfectant treatment facility at RBF well. At present, the RBF well is successfully supplying potable drinking water to nearby villages. Based on the particle tracking technique, it is revealed that the installed RBF well could yield about 61% river water through bank filtration and the remaining from the groundwater. Further, the groundwater flow model is used to optimize the pumping rates from the RBF well without compromising the water quality of the bank filtrate water and no long-term decline in groundwater levels within the RBF well field. The optimum pumping rate has been estimated at 31.2 m3/h for 5 h pumping per day (150 m3/day) to maintain stable groundwater without violating the water quality of the bank filtrate water. During the monsoon period, even when the river is running at full capacity, higher pumping rates beyond the optimum rates are not recommended because of the risk of deteriorating water quality. The feedback received from departments and the local public highlights the usefulness of the RBF technique and for scaling it up into other areas of the State where there is a limited supply of potable water. This RBF technology may be implemented along the river reaches under favourable hydrogeological conditions elsewhere. This technology would help with water security as a sustainable source of potable water for villages and hamlets during the summer months.

S3:
Impact of Climate Change and Adaptation Strategies

Effect of Climate Change on Crop Production and its Mitigation with regards to Development of Climate Resilient varieties with Special reference to Rainfed Agriculture

Anjali Joshi
Arid Forest Research Institute
Jodhpur (342005), Rajasthan

Aditi Tailor
Arid Forest Research Institute
Jodhpur (342005), Rajasthan

Pooja Sharma
Arid Forest Research Institute
Jodhpur (342005), Rajasthan

Tanmaya Kumar Bhoi
Arid Forest Research Institute
Jodhpur (342005), Rajasthan

Keywords

Climate change, rainfed agriculture, resilient varieties, cereals, pulses, oilseeds

Synopsis

Agriculture is an important sector in India contributing nearly 19.9 % to the total GDP of the country and providing 45.6 % employment. This sector is predominated by rainfed agriculture which occupies almost 50.9 % of the countries' net sown area and contributes 40 % of the total food grain production. Rainfed agriculture refers to the crop cultivation wherein majority of the water requirement of the plant is met by rainfall with minimum irrigation interventions. It has been theorized that even if the full irrigation potential of the country is used up, 50 % of the net sown area will still depend on the rainfall for fulfilling the water requirement of the crop. This shows the importance of rainfed agriculture in the Indian scenario. Crops including coarse cereals, pulses and oilseeds are mainly grown under rainfed conditions and hence their production depends largely on the amount of rainfall received during the crop season. Global climate is changing continuously with the passage of time. Presently, the global mean temperature is increasing at a much faster rate than the global temperature changes that have occurred in the past due to natural climatic variations. The changes in the surface temperatures of sea especially in the tropical oceans induces a strong effect on the rainfall received by south west monsoons in India, which is the backbone for cultivation of the rainfed crops in the country. Therefore, the vagaries of monsoon in India emanating as a result of climate change have resulted in variability and instability in crop yields especially in rainfed areas. The introduction of climate resilient varieties has to a great extent helped in muzzling the effect of environment and maintained crop production under adverse conditions. Keeping in perspective the importance of rainfed agriculture in Indian economy and the significance of rainfall in sustenance of rainfed agriculture, the relationship between production of rainfed crops and fluctuating rainfall amount and pattern over the years must be assessed so as to have a better understanding of the impact of climate change on crop production. Also, the climate resilient varieties, one of the most effective interventions to mitigate the effect of climate change must be documented. This assessment would be helpful in maintaining as well as enhancing production of crop in future and hence sustain one of the most important aspects of Indian economy: the rainfed agriculture.

Climate Change Adaptation via Cross Cutting Methods

Dr. Arvind Kumar
President
India Water Foundation
India

Keywords

Ecosystem restoration, ecosystem based adaptation, climate resilience,
cross cutting methods, carbon sequestration

Synopsis

The world is already experiencing changes in average temperature, shifts in the seasons and an increasing frequency of extreme weather events and other climate change impacts and slow onset events. Though we often think about human-induced climate change as something that will happen in the future, it is an ongoing process. Ecosystems and communities around the world are being impacted today. The faster the climate changes and the longer adaptation efforts are put off, the more difficult and expensive it could be.

In this paper the author attempts to present the cross-cutting role that climate change plays in varied sectors and how concepts like ecosystem based adaptation is a strategy that if adopted timely will address and fulfill achievement of all 17 Sustainable Development Goals by 2030. These ambitious goals are ideals for any civilized society in an attempt to eradicate poverty, ensure food security, health, education, gender parity, livelihood generation, peace and justice. The author underscores the significance of adaptation and to ultimately arrive at the successful completion of all targets set in 2015, over a period of 15 years, of which only 8 years remain.

The author presents the Case Study of Meghalaya State in North-East India as an example of integrated synergies amongst water, food, livelihood, education, gender equality and ecosystem restoration to achieve peace, partnership and prosperity and combat climate change. India Water Foundation in collaboration with Meghalaya Basin Development Authority ideated upon rasing resilience and adopting adaptation through IBDLP Programme that transformed a subsistence-based community into entrepreneurs , empowered with entrepreneurial capacity as they took ownership of their lands for optimum, sustainable utilization. Meghalaya Model serves as an example for regional South-South cooperation and implementation in neighbouring States of Sikkim, Mizoram and Nagaland through localization and ecosystem based adaptation. Political will remains integral to achieve success.

The cross cutting adaptation technology interventions made were in the sectors of Agriculture and forestry- Although being a vital sector, agriculture contributes significantly to climate change through greenhouse gas emissions. At the same time, agriculture is highly exposed to climate change, as farming activities directly depend on climatic conditions. Climate change also increases forest disturbances and occurrence of invasive species.

Early Warning and Environmental Assessments- As climate change increases the likelihood of unexpected weather patterns and natural disasters, communities need tools and methods to adapt to increased drought, floods, landslides, and other climate-induced hazards. An important climate adaptation strategy is to be equipped with better data and environmental information such as assessments of water resources and invasive species, as they are an important basis for decision-makers.

Human Health- There are innovative greenhouse gas reduction approaches available for the health and social services sector today that could already be applied to buildings, facilities, food services, work practices and vehicle fleets. We found the right climate technologies to reduce the carbon footprint of operations while adapting to the effects of climate change on human health. Adaptation techniques such as education of health personnel and prevention and health risk monitoring can increase the resilience of communities to the potential impacts of climate change.

Infrastructure and Urban Planning- As different parts of countries become drier, wetter or hotter, green infrastructure can help improve community resilience through smart urban planning and intelligent urban transport systems. We worked towards developing climate resilient infrastructure and foster green buildings for low-carbon societies. By adapting cities, transport systems and buildings to climate change impacts, to mitigate related costs and risks

Water- Access to freshwater is essential for our fundamental health and welfare. Water is also essential for sustaining agricultural productivity, and acts as a lubricant and coolant for many industrial processes. We work to increase resilience to the impacts of climate change on water resources through partnering with organizations, research institutions and businesses. Together they provide established and innovative climate adaptation technologies such as water supply management using GIS, waste water treatment and capacity building activities to strengthen vulnerability assessments in communities

Forestry- Forests are complex systems that are the home to people, plants, animals, and insects. They provide us with many important ecosystem services and thanks to their ability to absorb carbon dioxide and release oxygen the forests of the world are often described as the lungs of the Earth. The sector can play an active role in reducing greenhouse gas emissions caused by deforestation and land use changes. Sustainable forestry and agroforestry practices can provide innovative sustainable landscape management to safeguard multiple ecosystem services for the provision of economic opportunities that support local livelihoods

Renewable Energy- The renewable energy sector creates opportunities to reduce greenhouse gas emissions while stimulating economic opportunities, alleviating poverty, and increasing resilience to the impacts of climate change. Energy technologies encompass tools and techniques to generate and use energy in every segment of our societies, from powering the places we live, work and play, to fueling our transportation vehicles and industries.

Transport- The CO2 emissions from the transport sector account for about 20% of the total human-induced greenhouse emissions worldwide. The sector spans transport systems for commercial use and leisure, and vehicles used on land, air, inland waterways, and seas. With a view to providing sustainable transport and mitigate climate change impacts we brought relevant stakeholders together to provide technical assistance through a combination of well-established and innovative climate technology solutions.

Waste Management- A sustainable handling of waste is key to improving not only health and quality of life by reducing vectors for disease transmission, but also to ensure reduced climate impact. Technologies that allow for a more circular utilization of resources through recycling and reuse, and minimized methane emissions from waste dump sites, in effect also contribute to more healthy communities. This cross-sectorial link provides many development co-benefits. The realization has led to innovations such as methane capturing for biogas used in devices ranging from cooking stoves to biofuel engines, and innovative waste-to-energy technologies.

Exploring the dependency between climatic variables and aridity index in a Semi-arid Basin in India

Alka Sharma
Senior Research Fellow
Department of Civil Engineering
Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat
India – 395007

Dr. P. L. Patel
Professor
Department of Civil Engineering
Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat
India – 395007

Keywords

Climate Change, Multi-model ensemble, CMIP5, Semi-arid, Aridity Index

Synopsis

Arid and semi-arid regions occupy significant portion of land surface on the Earth. Water scarcity is more severe in such region due to large populations and their associated water usage; and are highly vulnerable to climate change and human activity. Climatic indices are frequently used tools to understand various climate mechanisms. The aridity index is one of the climatic indices which can be used for monitoring the impacts on the hydrological cycle, water resources management, and ecosystem in the region. Basically, it is defined as the numerical indicator for the degree of dryness of the climate at a given location and classifies the type of climate in relation to water availability. The higher the aridity indices of a region, the greater would be the water resources variability. The temperature and precipitation are very useful parameters to study the impact of climate change, and useful in defining the aridity or humidity index.

The present study examines projected changes in aridity index and its dependency with extreme climatic indices over Sabarmati River Basin (SRB). The SRB is water scarce, and densely populated basin, largely dependent on agriculture and exhibits arid climate type (91%). The present study utilizes IMD gridded daily rainfall and temperature data of 0.50 × 0.50 for the baseline period (1951-2019). The multi-model ensemble of five GCM models (BNUESM, CCCmaCanESM2, CNRMCM5, MPIESM-LR, MPIESM-MR) are investigated for RCP4.5 and RCP8.5 scenario for future period (2020-2100). Further, three precipitation indices (PRCP, RD, CDD) and three temperature indices (Tmax, Tmin, Tavg) defined by Expert Team on Climate Change Detection and Indices (ETCCDI), are analysed for the baseline period and future period. Statistical trend analysis technique, namely, Modified Mann–Kendall test are used to detect the trend at 5% significance level. The selected climate indices have been calculated on an annual scale to improve knowledge and understanding of inter-annual extreme temperature and precipitation variability in SRB. The study estimates the potential evapotranspiration (PET) using the Hargrave's method for baseline and future periods. The aridity index P/PET (P is Precipitation and PET is Potential Evapo-transpiration) has been calculated for baseline and future periods.

The study shows an increase (decrease) in PRCP and RD (CDD) for the future period with respect to baseline period. Compared to the baseline period, increase in Tmax, Tmin and Tavg are noticed for both RCP scenarios for future periods. Due to pronounced increase in the warming in the future period, the increase in PET by the end of the century under RCP4.5 and RCP8.5 scenarios (Figure 1) is noted. The aridity index anomaly in the baseline period varies within the range of 0.30-0.50 (Figure 2). In Figure (2), the percentage difference is the difference between AI of future period and base line period and expressed in percentage in terms of AI of base line period. Relative to the baseline period, strong dependency between the climatic variables and aridity index is detected in the SRB under RCP4.5, RCP8.5.

The projected AI is observed to increase by 72.86% and 30.29% across the basin with reference to baseline period for RCP4.5 and RCP8.5 scenarios respectively (Figure 2). The future AI projections at the end of twentieth century, using ensemble mean simulations from 5 GCM, show that humid conditions are expected to establish in SRB due to increase in rainfall. With decreasing aridity in the SRB, the water deficiency may decreases which would help the agricultural growth in the basin. At the same time, the alarming increase in temperature in the basin may have adverse impact on human health due to heat stress. The findings of the present study would help in sustainable planning of water resources and better decision-making policy framework in the study area.

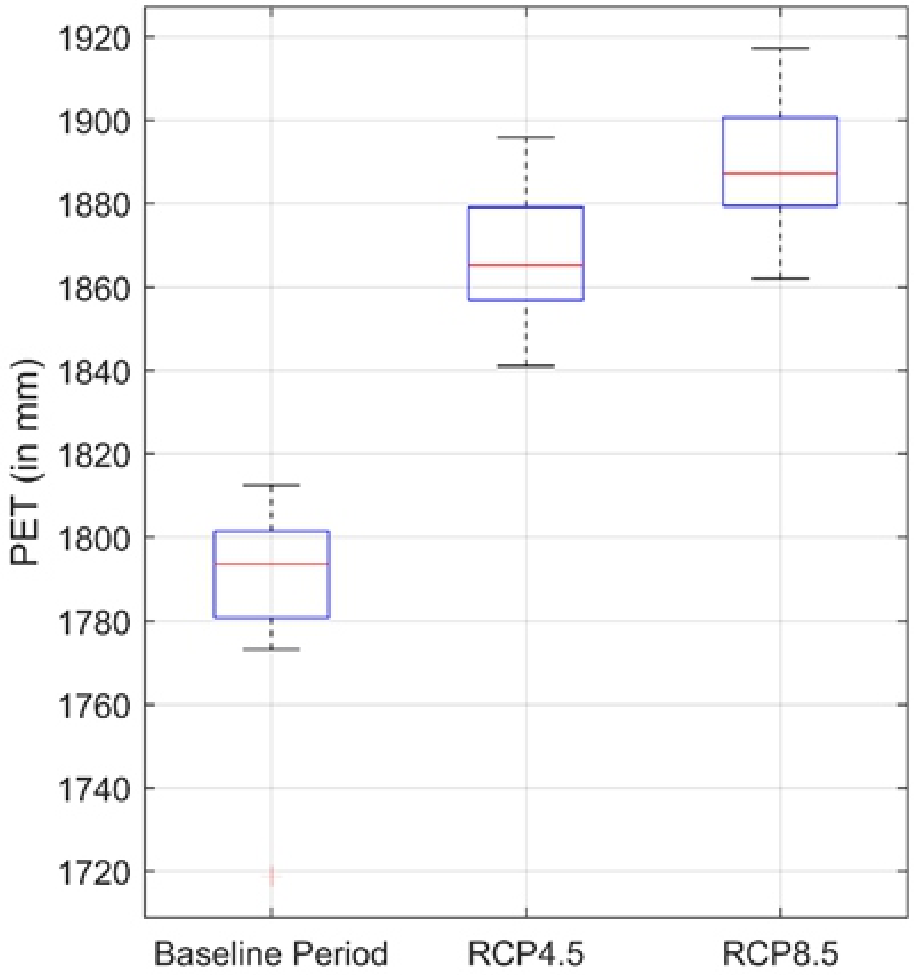

Figure 1 Variability of projected annual potential evapotranspiration with respect to baseline period.

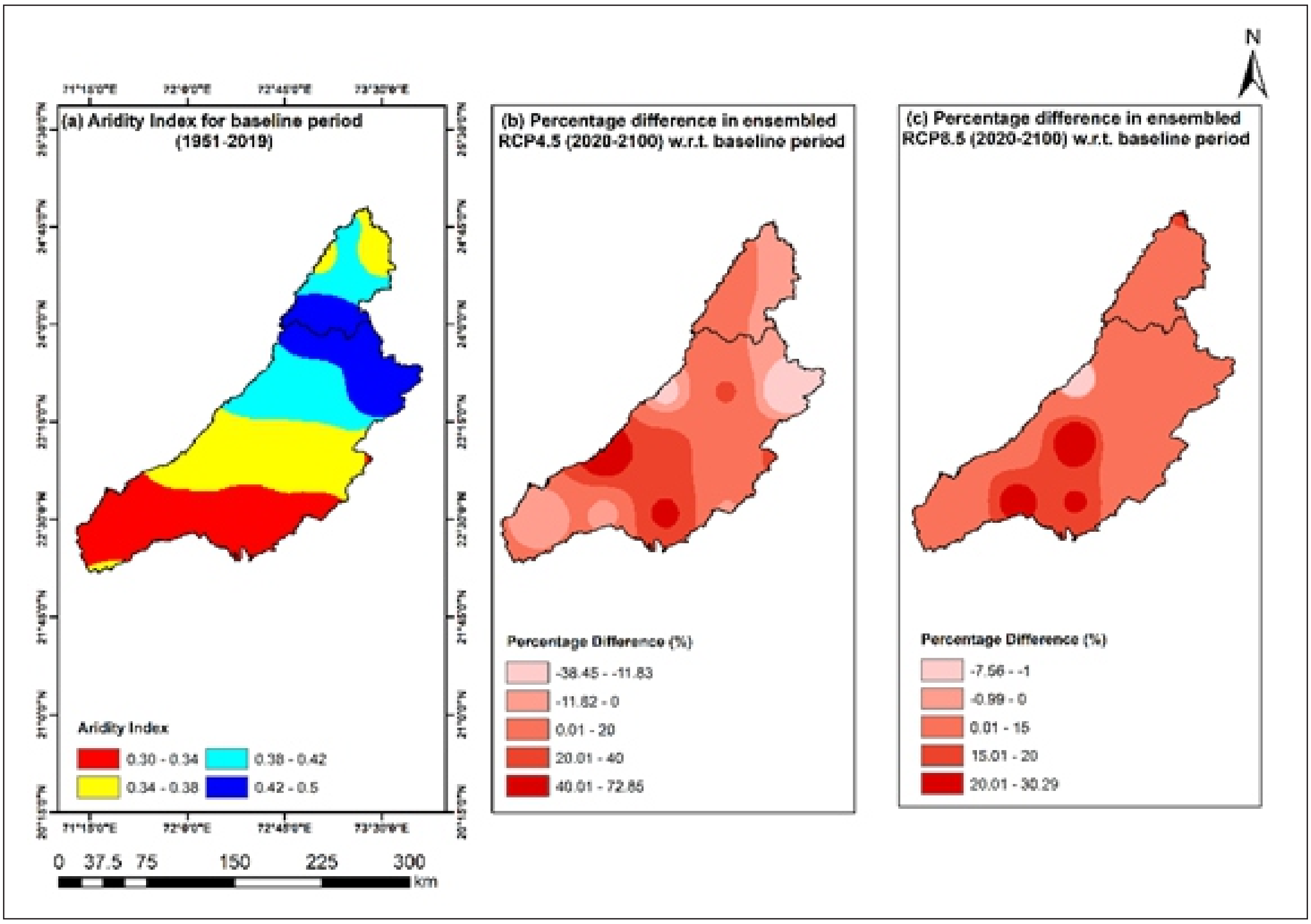

Figure 2 (a) Aridity index of baseline period, (b) Relative percentage change for ensemble RCP4.5 w.r.t. to baseline period and (c) Relative percentage change for ensemble RCP8.5 w.r.t. to baseline period.

Assessment of Future Rainfall Characteristics over Heterogeneous Tapi River Basin, India

P L Patel
Professor
Sardar Vallabhbhai National Institute of Technology Surat
India

Lalit Kumar Gehlot
Research Scholar
Sardar Vallabhbhai National Institute of Technology Surat
India

P V Timbadiya
Associate Professor
Sardar Vallabhbhai National Institute of Technology Surat
India

Keywords

Tapi River basin, Kernel Regression, Rainfall Indices, Climate Change.

Synopsis

The present study explores the impact of climate change on average rainfall scenarios and its temporal variability over the three physio-climatologically heterogeneous sub-basins of the Tapi River basin (TRB). The future rainfall data of five global climate models (GCM), statistically downscaled using the Kernel Regression method and bias-corrected using Quantile Mapping, have been used. The mean values of five rainfall indices (ensembled using reliability ensemble averaging) were derived for the reference period 1951-2005 from IMD data and GCM historical (GCMH) data (Fig.1). The difference between rainfall indices, obtained from IMD and statistically downscaled rainfall data, has been found to deviate within ±10% except consecutive wet days (CWD). The spatially averaged values for near-, mid- and far-future (NF: 2011-2040; MF: 2041:2070; and FF-2071-2100 respectively) under RCP 4.5 scenarios were calculated for Upper (UTB), Middle (MTB), and Lower (LTB) Tapi basins. The total rainfall (PRCPTOT) would likely to rise by 14.5% in UTB, 24.8% in MTB, and 26.3% in LTB by the end of 21st century with respect to GCMH. On contrary, the corresponding rise in rainy days (RD) is 14.7%, 5.3%, and 2.6% respectively. This results into remarkable rise in daily rainfall intensity (SDII) in MTB and LTB, i.e., 22.5% and 22.7%, respectively while the UTB showed 1.7% rise. Considering the longest dry spells (CDD), the UTB and MTB would experience decreasing CDD by 29.9% and 14.9%, respectively while LTB shows a rise of 0.6% by the end of 21st century. The longest wet spells (CWD) in UTB, MTB and LTB would rise by 6.8%, 7.3% and 2.3% respectively.

The temporal variability for the baseline period (1951-2010) and future period (2011-2100) under RCP 4.5 are estimated using the Modified Mann-Kendall Test at 5% significance level. The following inferences are drawn from the aforesaid analyses (Fig.2):

(a) It is likely that UTB and MTB would have significant increasing trend in PRCPTOT at 66.1% and 64.8% grids respectively in future. This would be favorable for MTB and part of UTB (Purna sub-catchment) wherein the existing rainfall is below the average rainfall of the TRB.

(b) Similarly, the RD may likely have significant increasing trend in MTB and UTB at 39.4% and 59.7% grids respectively in future. This trend reversal of RD from base line scenario to future scenario would be favorable for crop growth in the sub-basins.

(c) The SDII may likely to have significant increasing trend in future period in UTB and MTB at 56.5% and 81.7% grids respectively. This significant increase in SDII in UTB and MTB may likely to have flash flooding in the basin, particularly, in urban centers.

(d) The reversal of trend of CDD from significantly increasing (22.6% grids at UTB and 28.2% grids at MTB) in baseline scenario to significantly decreasing trend (100% grids at UTB and 78.9% grids at MTB). Similarly, the reversal of trend of CWD from significantly decreasing (40.3% grids at UTB and 14.1% grids at MTB) in baseline scenario to significantly increasing trend (33.9% grids at UTB and 43.7% grids at MTB) indicates that UTB and MTB is likely to move from dry regime to wet regime wherein more uniform distribution of rainfall maybe prevailing.

The present assessment clearly indicates that the UTB and MTB are likely to experience significant changes in the rainfall patterns while the mean rainfall conditions over LTB persisting over the region. The likely increase in total rainfall in MTB and UTB would help better crop growth in the above basins. At the same time, the significant rise in SDII over the said regions may cause flash flooding situation, particularly, in urban areas, while suitable agricultural measures are required to prevent the impacts of intense rainfall events on crops. The transitions of TRB towards wet regime in future is also evident from decreasing CDD and increasing CWD. The rising PRCPTOT, RD, CWD and decreasing CDD are likely indicators of uniform distribution of rainfall over a water year in TRB.

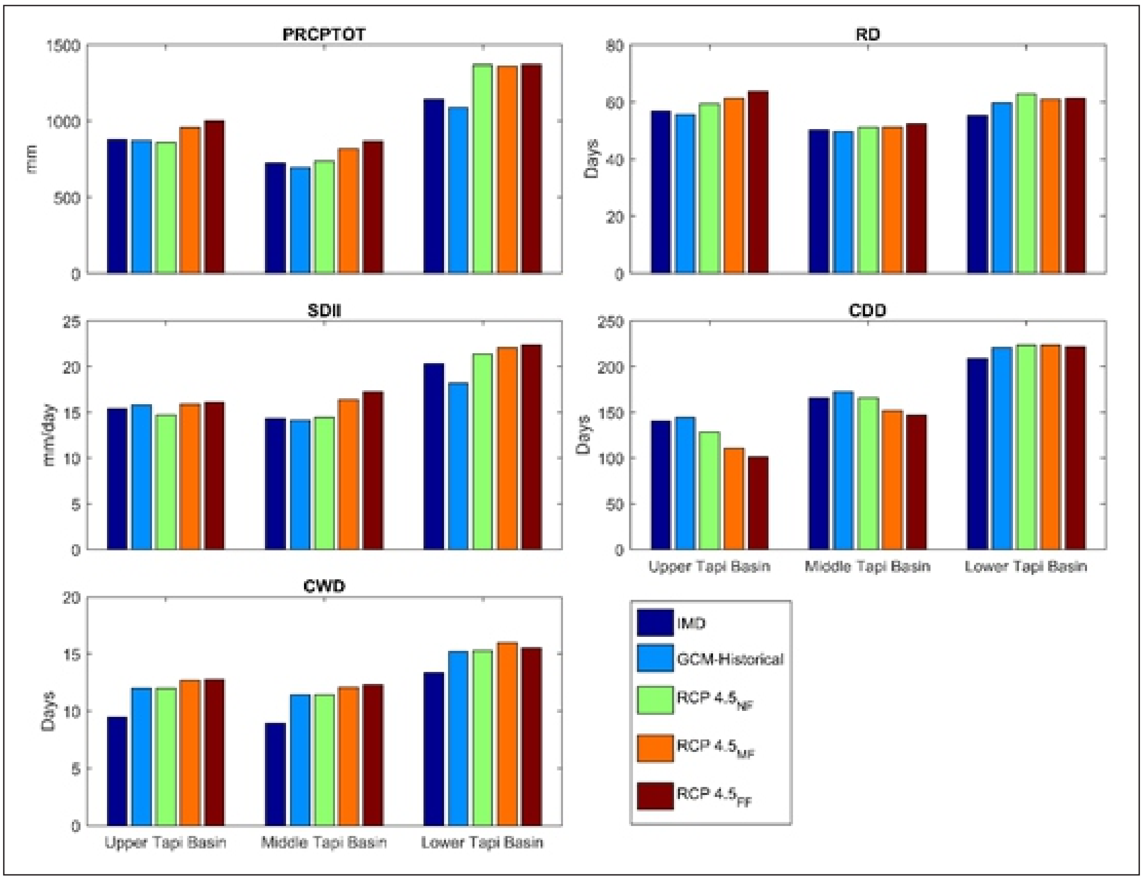

Figure 1 Mean values of rainfall indicators over Tapi River basin during the reference and future periods

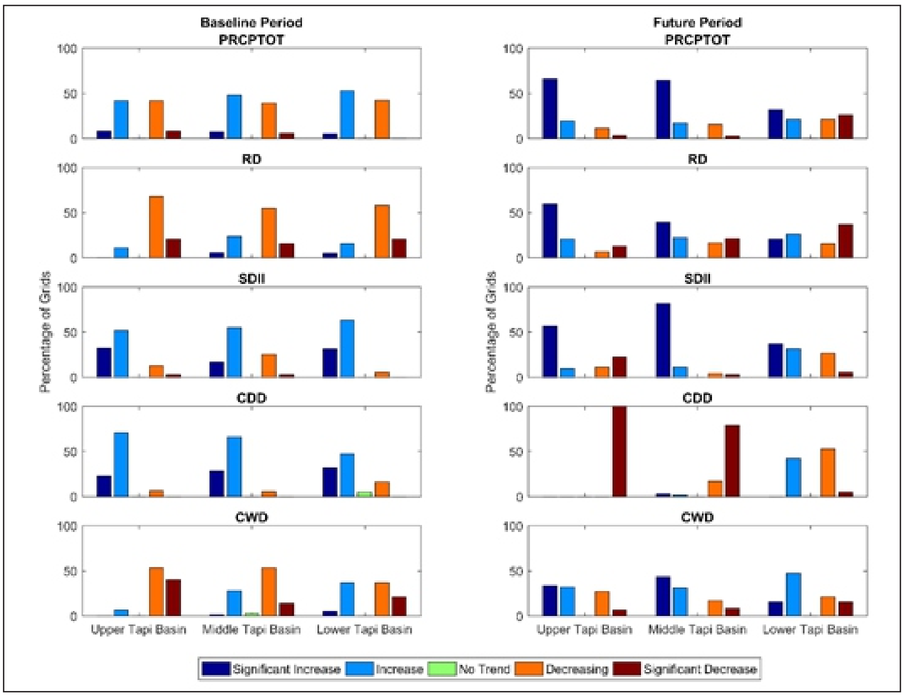

Figure 2 Trends in rainfall indicators over Tapi River basin during the baseline and future period

Role of Water Sensitive Behaviour at Household Level towards Climate Change adaptation in Indian cities

Kriti Trivedi
Junior Research Fellow
Maulana Azad National Institute of Technology
Bhopal, India

Keywords

water stress, water resource management, water sensitive cities, water use behaviour, capabilities approach

Synopsis

Water stress due to increasing water needs, growing urbanisation and development activities, especially in the secondary cities of India due to their fast pace of growth. It gets further exacerbated by the climate change impacts. These disproportionate impacts of climate change have resulted in contrasting water issues such as scarcity and flooding in urban areas. Handling the widening demand supply gap becomes a challenge for city's outdated or nascent under construction water supply infrastructure to deal with. The management of supply side of the system also has its own technical, economical and environmental limitations to maintain a long term sustainability and societal well-being. Hence, the demand side of the system that focuses on managing the water requirements to deal with the water stress comes into picture, it can either be done by shifting reliance on sources of water other than freshwater resources or by simply reducing the wastage of water, minimising unjustifiable water demands and overexploitation of water resources. Basically transitioning towards positive water actions performed by each individual at micro level.

Water Sensitive cities paradigm for water resource management focuses on social capital in the form of sophisticated and engaged community supportive of a sustainable lifestyle in terms of water. Water Sensitive Cities serve as a potential water supply catchment, provide ecosystem services and a healthy natural environment and consist of water sensitive communities. The study focuses on the role of society constituting of the water users to combat the water stress issues at the household by adopting water sensitive behaviours. Conceptually, water sensitive users have water related knowledge and desire to make wise choices about water, are actively engaged in decision-making, and demonstrate positive behaviour. The study aims to conceptualise the role of sensitive behaviour at individual level in Indian cities. The concept being coined in the global north is observed to lack the local and contextual nuances of developing countries of global south. In this regard, the study aims to review the existing literature on water sensitive cities and sensitive behaviour and super impose it on the Indian context for its water behaviour validation and gap assessment to understand the determinants of water sensitive behaviour. In this study, the literature on social psychology of environmentalism has been linked with scholarship on water sensitive cities to understand positive water behaviour of users and their level of sensitivity in Indian context.

While diverting the focus from the conventional ways of supply centric water management approaches the study also looks at ways for enabling water sensitive behaviour at individual level as a solution towards combating issues posed by climate change impacts. Such behavioural tendencies further complimented by constant social motivation, environmental awareness, opportunities and avenues to act in the form of capabilities for the citizens increase their chances to display water sensitive behaviours for a longer period without compromising with their willingness.

Along with the contextual conceptualisation of water sensitive behaviours the study also identifies the key determinants of such behaviour and influencing factors and capabilities. Capabilities have been defined as the enabling conducive conditions and choices necessary for absolute display of water sensitive behaviours. Hence, the positive water actions influenced by psychological, social and behavioural factors when performed in the presence of necessary capabilities are termed as water sensitive behaviours. In simple words, positive water action such as judicious water usage by choice when sufficient water is available is termed as absolute sensitivity. Such solutions at citizen level in addition to the efforts made by the city level water managers makes it easier to adapt with the urban water challenges. It is expected that positive water behaviour by a user at household level will percolate into other sectors and levels (scale wise) and have a greater cumulative impact.

Climate Resilient Development and Water Resources Management: Empirical learnings from the field of Indo-German bilateral Project 'Water Security and Climate Adaptation in Rural India'

V.R. Sowmithri

P. Radha Priya

Krishan Tyagi

Jagdish Kumar Purohit

Rajeev Ahal

R. Nagarajan

R. Rengalakshmi

Keywords

Climate change, Composite water Resources Management Plan, Bottom-up approach, science-based tools, Climate resilience strategy

Synopsis

Climate change is intensifying the hydrological cycle and water stress that adversely impacts the livelihoods, ecology, and economies in a variety of ways. Food security, ecology, human health, energy and economic development are primarily dependent on water resources and thus vulnerable to increasing climate risks. However, the management of water resources supports to address both adaptation and mitigation to climate crisis/change which is crucial for sustainable development. The UN report on World Water Development Report, 2020 reiterates the interconnectedness between water and climate change resilient development pathways for sustainable future. It is evident from the important global commitments for 2030 Agenda for Sustainable Development namely UN Sustainable Development Goals, UN Sendai Framework for Disaster Risk Reduction, UNFCC's Paris agreement and Nationally Determined Contributions.

In this backdrop, Composite Water Resources Management tool under Indo- German bilateral Project, 'Water Security and Climate Adaptation in Rural India', embedded with social, climate, agriculture and water vulnerabilities has been piloted at the district scale (Ramanathapuram and Tiruvannamalai districts in the state of Tamil Nadu, India) to address the climate risks through innovative climate resilient pathways and strategies. The tool (http://65.1.201.178/cwrmwebapp/) is designed to adopt bottom-up approach in planning, science-based inputs to identify water security risks, hazards and evolve locally relevant climate resilient development measures and participatory approach in the whole developmental process.

In addition, the climate monitoring tool is also developed to assess the impact of various climate resilient models on water resources. The piloted core climate resilient models that have an impact on water resources are restoring the cascade of tanks including drainage line treatments, different types of plantations suitable to the location like mini forests with diverse tree species, greening of hillocks and massive tree plantations, stabilizing the river bunds and sand dunes with vegetation, farm ponds, recharge shafts and other ground water recharging technologies, spring-sheds in the hilly terrains, restoring the fallow lands with agroforestry and silvi-pasture systems, river rejuvenation, community based grey water treatment for recycling and reuse of water and rainwater harvesting and storage structures. These models are identified by assessing potential climate risks at the decentralized scales

(gram panchayat and blocks as well as micro watersheds and sub-basins) and demonstrated at the field level. At the implementation level, key available government schemes and resources are mapped and mobilized for action adopting convergence approach. The paper will elaborate the innovative science-based tools for planning the climate resilient strategies and the process of implementation in the field and its impacts on the water resources management.

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1. Technical Advisor, Water Security & Climate Adaptation in Rural India (WASCA), GIZ India
2. Technical Advisor, Water Security & Climate Adaptation in Rural India (WASCA-II), GIZ India
3. Project Manager, Water Security & Climate Adaptation in Rural India (WASCA- II), GIZ India
4. Technical Advisor, Water Security & Climate Adaptation in Rural India (WASCA- II), GIZ India
5. Director, Natural Resource Management and Agroecology, GIZ India
6. GIS Cell Head, M.S.Swaminathan Research Foundation, Chennai, India
7. Director Eco Technology, M.S.Swaminathan Research Foundation, Chennai, India

Impact of Climate Change on Water Bodies

Dr. Srinivas Billakanti
Scientist 'B'
Central Water and Power Research Station,
Khadakwasla, Pune - 411024,
Maharashtra, India

Nishchay Malhotra
Scientist 'B'.
Central Water and Power Research Station,
Khadakwasla, Pune - 411024
Maharashtra, India

Dudekula Nikhil Kumar
Research Assistant
Central Water and Power Research Station,
Khadakwasla, Pune - 411024,
Maharashtra, India

R B Deogade
Scientist 'E'.
Central Water and Power Research Station,
Khadakwasla, Pune - 411024
Maharashtra, India

Keywords

Climate change; adaptation strategies; temperature; mitigation; India

Synopsis

Rapid urbanization and industrialization has remarkably increasing the environmental pollution levels and resulted in climate change. Water bodies have been serving as lifeline for the urban population as they help in sustenance of cities by fulfilling the water needs as well as recharging the ground water. A recent survey report by Nature Publication states that the scientists around the world are calling the present situation as a "crisis" or "emergency," and very accurately "climate crisis". The latest report about climate change and climate commitments already concluded that, by the end of this century nations would put our world on a path towards 2.7 - 3 °C of warming; The absence of mitigation and adaptation measures may affect human health, fresh water and marine ecosystem and economy of the Nation. We have to act responsibly to limiting the warming to close to 1.5 °C or even 2° C by rapid and large-scale reductions in greenhouse gas emissions. India has started its actions to mitigate the climate changes and its adaptation strategies. In 2021, India grabs eyeballs across the world at United Nations COP 26 at Glasgow by taking bold pledges under the commitments of the Paris Agreement to combat climate change and environmental policies. Importantly pledging to become net zero emitter of carbon by 2070, Achieving 500 gigawatts non-fossil energy capacity by 2030, Fulfilling 50 per cent of its energy requirements from renewable energy sources by 2030, there are various initiatives taken by government to harness the solar energy, India also launched 'One Sun, One World, One Grid' (OSOWOG), Floating solar panels with an aim to generate solar energy and minimize water evaporation. This paper will be highlighting measures of adaptive and mitigative strategies adopted by India including prevention of water pollution, soil erosion, linking of rivers, national water policy etc. This paper will also evaluate the measure which have been undertaken by India and will recommend how this mitigation measure can be made more effective in achieving our goal of sustainable development and combat climate change.

Emerging water management paradigms for climate change adaptation

Tanya Dwivedi
Research Scholar
Maulana Azad National Institute of Technology
Bhopal, India

Keywords

Water management, water sensitive cities, water extremes

Synopsis

Water, in essence, is the basis of all life forms on earth. In addition to its physical form as water bodies or precipitation, or chemical form as a liquid (H2O), water also has a spatial-temporal dimension, which considers it as a resource distributed across geography and time, an economic dimension, supporting the livelihood of people through economic opportunities and a socio-cultural dimension, interacting with society through traditions and rituals. Through these many dimensions, water is intrinsically related to peoples' life and livelihood across the globe. As a result, many climate change effects are also experienced through water.

Impacts of climate change on water

A rapidly changing climate is evident across the world in warming temperatures, changing precipitation patterns, sea level rise and glacial ice melt. As per IPCC's Technical Paper on Climate Change and Water (2008), extreme events related to water (floods and droughts) are becoming more severe as well as more frequent. While some areas are experiencing water scarcity, so much so as to declare 'Day 0', other areas are experiencing water excess in form of flash floods. Nearly 1.69 to 2.37 billion urban population are estimated to be facing water scarcity by 2050, with an estimated increase of 152-422 million people in India alone (He et al., 2021) and likelihood of water scarcity driven by climate change is as high as 30-50 percent for India (Vinke et al., 2017). In areas experiencing high variations in precipitations driven by climate change, impacts on human health, agriculture, conflicts driven by water and migration are observed (Kosow et al., 2022). The conventional approach to water management in cities often fails to acknowledge water cycle in a holistic manner which results in unsustainable water use. In this context, better management of water resources is crucial especially with a backdrop of changing climate and its impacts (IPCC, 2008) that are disproportionately borne by urban poor and other vulnerable groups in the city.

Water management paradigms in context of changing climate

The provision of water through piped networks was the primary focus of early water management strategies since late 19th century and is still one of the most popular water management approaches today, in different capacities in countries around the world. However, these modern infrastructure strategies fell short of acknowledging the water cycle as a holistic system with intrinsic relationship with society and environment. Integrated Water Resource Management (IWRM) was proposed, in the late 1980s, as a holistic governance of water which strived for a balance between different aspects of water resource - environment, society and economy and is still followed in many of the countries around the world. However, by the late 1990s and early 2000s, pressures of climate change and rapidly growing population were felt across the world with significant impact to water systems in form of insufficient, unreliable, unsafe and unsustainable water services. This led to then incorporating coping mechanism for externalities in various water management paradigms, one of which was Water Sensitive Cities.

Water Sensitive Cities : An adaptive approach to climate change crisis

Many Asian cities face “social, institutional, technological and economic barriers” to adopting sustainable urban water management (Barron et al., 2017). To overcome these barriers, newer water management concepts that factor for the growing pressures on urban water systems like climate change, growing population and urbanization, aged infrastructure, depleted and polluted resources and an increased frequency of disruptive events are an appealing approach. A "water sensitive city" integrates normative ‘Sustainable Urban Water Management Approach’ values of environmental protection, equity, rehabilitation, and sustainability with necessary water services, such as supply security, flood control, and public health, as well as additional advantages like food security, energy savings, amenity, and urban climate change resilience (Wong & Brown, 2009). Water Sensitive City paradigm integrates three key water sensitive aspects - urban design, urban planning, and urban management (Carden & Fell, 2021) and is firmly supported by three pillars. These pillars consider cities as water supply catchments, which acknowledge the complete water cycle, as providing ecosystem services for built and natural environment and as comprising of water-sensitive communities with robust water institutions and citizens’ water sensitive behaviours (Wong et al., 2020). The paradigm asserts that a water sensitive city doesn’t exist in isolation and builds up on the local context consisting of unique “geo-morphology, hydrology, urban form and microclimate, the local operating environment, and the key social and institutional conditions”(Wong et al., 2020). Water sensitive city paradigm can thus be considered a prime adaptive approach to climate change crisis.

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Framework of Methodology for Impact of Climate Change and Adaptation Strategies for a River Basin

Dr. Viraj Loliyana
CEO
FAMS Design Solution Private Limited
India

Keywords

Climate Change, Adaptation, River Basin, Hazard, Risk, Vulnerability, Flood, Drought

Synopsis

India is the seventh-most vulnerable country with respect to climate extremes (Germanwatch 2020). Climate action needs to be scaled up both at the sub-national and district levels to mitigate the impact of extreme events. The frequency and intensity of extreme climate events in India have increased significantly since 2005. Our policymakers, industry leaders and citizens may use the climate adaptation strategies to make effective risk-informed decisions. The Risks and Adaptation must examine both local and global environmental risks in order to develop strategies to mitigate them. Here, the framework of the analysis has been presented for a river basin for evaluating and taking sustainable adaptive measures against impact of climate risks on water, agriculture, energy and infrastructure, the links between clean energy and water, other human development priorities. The framework of methodology for Impact of Climate Change and Adaptation strategies for a river basin, is depicted as follows:

1. **Identification Climatic Extremes at Country Scale**
    a. Climate Variability Indices Historical

Indicator	Indicator name	Indicator definitions	Units
PRCPTOT	Annual total rainfall	Annual total rainfall from days ≥ 2.5 mm	mm
RD	Rainy days	Number of days when rainfall ≥ 2.5 mm	days
SDII	Simple daily intensity index	The ratio of annual total rainfall to the number of rainy days	mm/day
Rx1day	Maximum 1-day rainfall amount	Annual maximum 1-day rainfall	mm
Rx5day	Maximum 5-day rainfall amount	Annual maximum consecutive 5-day rainfall	mm
R99p	Extremely wet days	Annual total rainfall from days > 99th percentile	mm
R95p	Very wet days	Annual total rainfall from days > 95th percentile	mm
R5TOT	Rainfall extreme proportion	Proportion of annual rainfall from top 5 events in a year	%
Rmod	Number of moderate rainfall days	Number of days when annual rainfall ≥ 7.5 and < 64.5 mm	days
Rheavy	Number of heavy rainfall days	Number of days when annual rainfall ≥ 64.5 and < 124.5 mm	days
CDD	Consecutive dry days	Maximum number of consecutive days when rainfall < 2.5 mm	days
CWD	Consecutive wet days	Maximum number of consecutive days when rainfall ≥ 2.5 mm	days
TXx	Hottest day	Monthly/seasonal/annual maximum value of daily maximum temperature	°C
TXn	Coldest day	Monthly/seasonal/annual minimum value of daily maximum temperature	°C
TNx	Warmest night	Monthly/seasonal/annual maximum value of daily minimum temperature	°C
TNn	Coldest night	Monthly/seasonal/annual minimum value of daily minimum temperature	°C
DTR	Diurnal temperature range	Monthly/seasonal/annual mean difference between daily maximum and minimum temperature	°C

b. Climate Variability Indices Future

Make use of existing information, knowledge and expertise as input

a. Data on Population
b. Land use Mapping
c. Asset Mapping
d. Event databases on losses and damages
e. Climate data according to RCP 2.6, 4.5, 6.0 and 8.5 scenarios
    i. 5 years
    ii. 10 years
    iii. 15 years
    iv. 20 years
f. Ensemble Forecast at District Level

Potential Impacts

a. Hazards
   I. Cyclone
   ii. Flood
   iii. Drought
   iv. Heat Wave
   v. Monsoon
b. Exposure
c. Vulnerability

Assess Risk against Explicit values and Targets

a. Existing strategies linked to SDGs, development, sectors climate- and disaster risk
b. Existing planning mechanism
   i. Disaster risk reduction
   ii. Climate change adaptation
   iii. Land-use planning

GIS based Informed Risk Advisory Platform for a River Basin

a. Administrative Representation of River Basin
   I. Exposure
      1. Current Status of Exposure
      2. Current Status of Vulnerability
   ii. Projection 2020, 2025, 2030, 2040
   iii. Associated event projection

b. River Basin Representation
   I. Exposure
      1. Current Status of Exposure
      2. Current Status of Vulnerability
   ii. Projection 2020, 2025, 2030, 2040
   iii. Associated event projection

c. Land use
d. Topography
e. Population Projection
   I. 2011
   ii. 2021
   iii. 2031
   iv. 2041

f. Assets (Climate Proofing of Infrastructure)
g. Potential impacts of
   i. Hazard Indicators
   ii. Exposure Indicator
   iii. Vulnerability Indicator
   iv. Risk Indicator

A Quality Assessment of Global Satellite-Based Precipitation Datasets GPM: A comparison with IMD's Analysed Precipitation Dataset for Narmada Basin in India

Pratul Shrivastava
PhD Scholar
Jamia Millia Islamia, New Delhi
/DGM RMSI Pvt. Ltd.
Noida, India

Dr. Sirajuddin Ahmed
Professor
Department of Civil Engineering
Jamia Millia Islamia
New Delhi. India

Dr. Mohammad Sharif
Professor
Department of Civil Engineering
Jamia Millia Islamia
New Delhi, India

Keywords

Precipitation; GPM, TRMM; rainfall estimated by satellite

Synopsis

The availability of global satellite-based precipitation datasets provides an asset to accomplish precipitation dependent analysis where gauge based precipitation datasets are not available or limited. In this study, we have taken Global Precipitation Measurement [GPM] product GPM IMERG Precipitation L3 1 day 0.1 degree x 0. 1 degree resolution for 19 years (2001–2019) time-series durations to test their reliability across Narmada basin in India. The India Meteorological Department (IMD) observed daily gridded (0.25°×0.25°) precipitation data have been taken as reference data to compare the GPM daily precipitation datasets. Statistical indices used in this study are Relative Bias, Mean Square Error (MSE), Root Mean Square Error (RMSE), Most of the rainfall in the study area occurs in the months of June, July, August, September and October. The result showed that GPM data is over estimated in most of the cases..

Calculation of Climate indices using CMIP6 Climate data over Rajasthan State of India

Pooja Patle
Research Scholar
Indian Institute of Technology Roorkee,
India

Akansha Keshariya
Research Scholar
Indian Institute of Technology Roorkee,
India

Joshal K Bansal
Junior Research Fellow
National Institute of Technology Roorkee,
India

Keywords

Dry spell, Wet spell, SPI, SPEI and CMIP6

Synopsis

Climate change results in lower precipitation in some locations by altering the wind patterns and ocean currents that govern the global climate system. Increased precipitation will not necessarily result in more water being accessible for consumption, irrigation, and industry because warmer temperatures increase evaporation. Therefore, information on rainfall characteristics such as dry-spell, wet-spell, Standard Precipitation Index (SPI), Standardized Precipitation Evapotranspiration Index (SPEI), and others is required for proper planning and management of regional water resources. For the prediction of these indices, numerous GCM models have been created, and it is simple to retrieve the anticipated data from numerous websites. The study performed here is on Rajasthan state and the climate data from CMIP6 model has been used. A total of four climate models from CMIP6 (ACCESS-ESM-1, BCC-CSM2-MR, EC-Earth3 and MRI-ESM2-0) and three scenarios from each model (Historical (1951-2014), SSP245 (2015-2100) and SSP585 (2015-2100)) is considered. Based on the availability of data, historical scenario is considered from 1985-2015 where as SSP245 and SSP585 is divided into two parts i.e. Near Term (2020-2050) and Far term (2060-2090). The results show that Dry days are increasing and wet days are decreasing in the future. The results clearly show that precipitation is decreasing in the future. All the results presented here are computed using python.

S4:
Quality Challenges in Water Sector

Modernization of monitoring of river water quality program in India

Shri P M Scott
Member, River Mangement
Central Water Commission
New Delhi

Shri D P Mathuria
Chief Engineer, P&DO
Central Water Commission
New Delhi

Shri Deepak Kumar
Director (RDC-I) Directorate
Central Water Commission
New Delhi

Shri Altaf Hussain
Deputy Director (RDC-I) Directorate
Central Water Commission
New Delhi

Keywords

Satellite image, Sensors, Prediction, Real-time, Modelling, CWC, NMCG.

Synopsis

One of the essential elements of life on this planet is freshwater. Sustainable development therefore demands sustainable management of the world's limited freshwater resources. Due to the direct or indirect activities from natural and anthropogenic sources, Water quality on earth's surface such as of lakes, rivers, oceans, aquifers and groundwater etc. are getting deteriorated day by day. In comparison to groundwater the surface water gets polluted more easily as it is open to atmosphere and for which its quality monitoring is also a major concern. As water quality perturbations related to escalating human population growth and industry pressures continue to increase in coastal and inland areas, effective water quality monitoring has become critical for water resource management programs. Without accurate, intensive and long-term data acquisition, the state of the water resources cannot be adequately assessed; effective preservation and remediation programs cannot be run; and program success cannot be properly evaluated. Water quality monitoring is one of the most important components in environmental management of aquatic ecosystems. Monitoring of water quality provides water managers with the necessary information for sustainable water resources management and provides insight into complex dynamic environmental processes. Reliable, consistent and appropriate information is necessary to understand water resources. However, as demand for access to good quality water increasing day by day, there is a need to modernize the present water quality monitoring programs in India. This paper discusses the emerging technologies in the water quality monitoring program which includes satellite-based water quality monitoring, Real time monitoring of water quality through Sensors, Modelling and predication of river water quality and its suitability in India's prospect.

COVID-19 and River Water Quality: Impact of Lockdown on Water Quality of River Yamuna, India

Dr Jakir Hussain
Specialist Environment
Upper Yamuna River Board
India

Sanjay Kumar Gupta
Technical Superintendent, IIT
New Delhi

Keywords

Yamuna river, COVID-19, Lockdown, pollution, DO, BOD, Coliform

Synopsis

The water quality of the Yamuna River was studied in order to determine the impact of lock-down on the quality. During the lockdown, the pH of the river water ranged from 7.10 to 8.06, and it was within permissible limits. After meeting Shadra Drain during the lockdown period, dissolved oxygen was nil at Paltoon Pool, Kudesia Ghat, and D/s of Okhla Barrage. DO levels at other locations ranged from 1.2 to 8.3 mg/L. The DO concentration ranged from 5.4 to 7.4 mg/L between U/S Vrindavan and Agra during the lockdown period. BOD concentrations in the Delhi stretch varied from 2.8 to 57.0 mg/L prior to the closure, with a high of 57 mg/L near the Nazimuddin bridge. The BOD in the Yamuna stretch ranged from 2.0 to 25.0 mg/L during the lockdown period. The BOD was 5.6 mg/l at Nizamuddin Bridge in April 2020, compared to 57.0 mg/L during the pre-lockdown period (March 2020), indicating a 33 % improvement. However, the water quality is still below the acceptable norms (3 mg/L). The COD values decrease as well during the lockdown. As a result of the abundant rainfall in and around Delhi, the river flow Increased . The removal of pollutants is helped by increased river flow. During the lockdown, the water quality in the Yamuna River improved. Dilution of river water due to the release of abundant fresh water from the Wazirabad Barrage, which resulted in the washing out of bottom sediments and colloidal pollutants; minimal discharge of industrial effluents (only about 35.9MLD); and comparable higher penetration of solar radiation in the water body have all contributed to an overall improvement in river Yamuna water quality. Human activities such as dumping religious gifts, materials, and solid trash into the river, as well as swimming and washing clothes in the river, have all been decreased.

Water Quality Accounts

Kuwar Alok Singh Yadav
Deputy Director
Ministry of Statistics and Programme Implementation
New Delhi

Synopsis

Water is essential for the sustenance of human life and the economy. In context of a typical ecosystem, water has a dual role – it is not only a service from ecosystems but also a rich ecosystem in itself. Water is also closely related to socio-economic development of the country and human well-being. It has cross sectoral linkages with various sectors such as food, energy, agriculture, industries and urban development and others, thus, cannot be considered in isolation, making it challenging for the policy makers to apportion diminishing supplies between ever-increasing demands. Though the surface of the earth is mostly consisting of water, only a small part of it is usable, which makes this resource very limited. This precious and limited resource, therefore, must be used with prudence. As water is required for different purposes like drinking, agriculture & fishing, industry, etc., the suitability of it must be checked before use. Also, sources of water must be monitored regularly to determine whether they are in sound health or not. Poor condition of water bodies is not only the indictor of environmental degradation, it is also a threat to the ecosystem.

In this paper, a few experiences are shared on how Ministry of Statistics traversed the journey of basic compilation of water quality accounts and how it provided innovative approaches of data producers for working with seemingly incomparable datasets to enable evidence-based decision making using the environmental accounting framework [System of Environmental Economic Accounting- Water (SEEA-Water)].

Hydrochemical behaviour, its controlling processes and importance of p(CO_2) signature of meltwater of River Bhagirathi in Upper Ganga Basin, India

M. K. Sharma
National Institute of Hydrology
Roorkee-247667.Uttarakhand
India

Pradeep Kumar
National Institute of Hydrology
Roorkee-247667.Uttarakhand
India

Babita Sharma
National Institute of Hydrology
Roorkee-247667.Uttarakhand
India

Beena Prasad
National Institute of Hydrology
Roorkee-247667.Uttarakhand
India

Synopsis

The contribution of Himalaya rivers originating from snow and glacier fields of higher Himalaya play an important role in controlling the solutes levels in the River Ganges. As these mountain waters with significant amount of snow, glacier meltwaters and rainfall is characterised by low ionic concentrations and play a major role in diluting the high solute load emanating from the Ganga plain catchments. Hence any change in the quality and quantity of the Himalayan tributaries of River Ganga under the climate change regime will impact the quality parameters of River Ganga. Hence a clear understanding of the characteristics and process driving the chemical enrichment of the glacial meltwater and its instream modification in the high altitude region is essential for evaluating the role of Himalayan component of the Ganga river system in maintaining the quality of the Ganges water. In the present investigation, hydrochemical processes controlling the meltwater chemistry of the rivers Bhagirathi in the Upper Ganga Basin, India have been studied. For this purpose, an extensive water quality assessment in River Bhagirathi has been carried out by collecting water samples from river on monthly basis from September 2016 to May 2018 and analysing these samples for hydro-chemical parameters. Hydro-chemical characteristics revealed that sulphide oxidation and carbonation- the two proton producing reactions govern the chemical weathering processes pertaining in the rivers. One of the most peculiar findings of the study is the dominance of sulphide oxidation in River Bhagirathi upto Dabrani revealing the continuum of Gangotri glacial processes followed by carbonate dissolution upto Haridwar. In one of our earlier studies, it was observed that Higher value of sulphate **concentration was observed in the meltwater of River Bhagirathi at Gomukh followed by Gangotri and Bhojwasa suggesting that the sulphide oxidation attenuate from glacier portal to downstream**. The p(CO_2) signature of meltwater can be used to characterize different glacial hydrological weathering environments. When proton supply equals the consumption, the p(CO_2) of the solution remains in the equilibrium with the atmosphere i.e. $p(CO_2)(aq)=p(CO_2)(g)$, the system is said to be open. If pCO_2 of solutions are not equal to atmospheric pCO_2 (10-3.5atm) i.e. $p(CO_2)(aq)\neq p(CO_2)(g)$, it can be said to be in disequilibrium with respect to the atmosphere. When the supply of protons is more than their consumption, then high p(CO_2) conditions arise. Low p(CO_2) conditions arise when the demand of protons for chemical weathering is more than the rate of CO_2 diffusion into the solution indicating closed system weathering. In Gangotri glacier system, the continuum of closed system conditions prevails along the Bhagirathi stream reach from Gomukh to Gangotri.

Sediment bearing characteristics and development of subglacial system play important role in interpretating the hydrological weathering environments.

A Comprehensive Review of the status of Persistent Organic Pollutants under the Indian Scenario

Nishchay Malhotra
Scientist 'B'.
Central Water and Power Research Station,
Khadakwasla, Pune - 411024
Maharashtra, India

Dr. Akhil P S
Scientist 'B'.
Central Water and Power Research Station,
Khadakwasla, Pune - 411024
Maharashtra, India

Jitesh N Vyas
Scientist 'B'.
Central Water and Power Research Station,
Khadakwasla, Pune - 411024
Maharashtra, India

R B Deogade
Scientist 'E'.
Central Water and Power Research Station,
Pune - 411024, Maharashtra India

Keywords

Persistent Organic Pollutants, Pesticides, Ecological risk, Monitoring Assessment, Good Agricultural Practices.

Synopsis

In the natural environment, all chemicals are subject to physical, chemical and biological processes that can act on their chemical structure causing degradation and eventual removal or a considerable reduction in the potential for harmful effects. However, some chemicals do not break down or slowly break down in the environment. In addition, degradation processes might lead to the production of non-degradable by products. These substances are known as persistent chemicals and are long-lived under prevailing environmental conditions. The issue that arises in these circumstances is whether the presence of the residual concentrations of these chemicals represents a risk to man and to biota. Presently, India is considered as the largest pesticides producing country in Asia and 12th largest in the world with 90,000 tons of annual pesticide production. Both industrial and agricultural sources would contribute significant amount of these contaminants to the environment through seepage, disposal and evaporation. Although substantial fractions of applied pesticides are dissipated at the site of application through chemical and biological degradation processes. Besides, a reasonable fraction of the pesticide residues reaches the oceans through agricultural run-off, atmospheric transport and effluent discharge. Since they are known for their persistence, toxicity and bioaccumulation characteristics, there is a concern about their impact on the marine environment. Despite the fact that pesticide consumption is low in India compared to the other developed countries, the indiscriminate use of these pesticides has resulted in sporadic occurrence of the residues in biota and other abiotic compartments. The determination and quantification of those compounds existing in water and sediment may indicate the extent of aquatic contamination and the accumulation characteristics in the aquatic ecosystems. Despite being banned, residual concentrations still higher in the environment. A regular monitoring, assessment and reporting machineries should be implemented in accordance with appropriate environmental policies, laws and regulations. The Government and other related agencies should educate farmers and agriculture managers on Good Agricultural Practices (GAP). Furthermore, national and international monitoring programs helped to understand the relationship between the over use of chemicals in the environment.

Strengthening Quality Infrastructure for Monitoring of the River Ganga in India

Franziska Wende
Project Coordinator
PTB, Germany

D. P. Mathuria
Executive Director (Technical)
National Mission for Clean Ganga, India

Dr. Anil Saxena
Technical Expert
PTB, Germany

Pallavi Bishnoi
National Consultant
PTB, Germany

Keywords

Ganga, Water Pollution, Monitoring, Quality Infrastructure, Laboratories

Synopsis

The project "Strengthening Quality Infrastructure for Water Monitoring of the Ganges River" was launched in 2019 as a part of the bilateral cooperation between the Government of India and the Federal Republic of Germany. It was commissioned by the Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, BMZ) in the frame project of the Development Programme 'Sustainable Urban Development (SUD) in India'. The project is implemented by the National Metrology Institute of Germany (Physikalisch-Technische Bundesanstalt, PTB) in cooperation with the National Mission for Clean Ganga (NMCG).

The project area is the Ganges River basin. After the launch of the Indian government's Namami Gange flagship programme in 2014 and the rejuvenation efforts undertaken through methodical interventions supported by the availability of surplus funds from various development agencies, the surface water quality of the river has been enhanced (NMCG citation). Although, the river still remains heavily polluted due to weakly monitored anthropogenic activities, presenting a great threat to people and the environment as well as ecosystems and biodiversity in its catchment area (cGanga, 2017). The lack of reliable (quality assured) water monitoring data has been recognised as one of the decisive bottlenecks for the development of specific, appropriate, and well targeted pollution-mitigation measures as well as policy instruments for the river basin. The project has been conceived to address this issue by strengthening the capacities of relevant actors to produce credible and standardised water quality monitoring data.

Situation in the intervention area: As India's holiest river, the Ganges has a high cultural and spiritual significance. Its catchment area is home to over 450 million people, more than 40 % of India's population. The river is heavily polluted, mainly due to the discharge of inadequately treated municipal and industrial wastewater and the disposal of solid waste. This represents a great threat to people and the environment as well as ecosystems and biodiversity. Vulnerable population groups such as women, people with disabilities and members of marginalised groups suffer particularly from environmental pollution and poor water quality, which affects food supply and health care. This threatens the human right to water and sanitation, as well as to an adequate standard of living for these groups (Sanjay Dwivedi, 2018). The respective State Pollution Control Boards are responsible for monitoring river Ganga and providing quality analytical data.

Situation in the sector: For rejuvenating the river Ganges, the Indian government initiated the flagship programme "Namami Gange" in June 2014 with a volume of about 2.4 billion EUR for a duration of 10 years, managed and implemented by the National Mission for Clean Ganga (NMCG). Furthermore, international development partners, as the German Development Bank (Kreditanstalt für Wiederaufbau (KfW)) and World Bank have allocated funds for infrastructure projects (mainly for municipal sewerage and industrial effluent management systems) in the Ganga basin. For the development of specific, appropriate, and well targeted measures for fighting pollution and sustaining the rejuvenation of the river, reliable (quality assured) water monitoring data are needed to map concrete pollution sources and determine the respective quality and quantity of pollutants. However, today the quality of the analytic data required for the assessment and the monitoring of the water quality of the river Ganges is insufficient. The main reasons are a) deficient coordination of the assessment and analysis of data by the environmental authorities on both state and central level, b) the lack of a water monitoring strategy and c) inadequate equipment and lack of trained personnel in the central and regional laboratories responsible for monitoring water quality in the Ganga states. This significant gap in the availability of reliable water quality data also poses a bottleneck for scientific analysis and policymaking.

Main Project Achievements: In the beginning, the project focussed on the small state of Uttarakhand (about 10 million inhabitants) at the source of the river. Soon, this approach was widened to the much bigger state of Uttar Pradesh (about 200 million inhabitants) in agreement with both the partners and BMZ. Most of the municipal and industries pollution originates in Uttar Pradesh. So, expert visits were conducted to assess laboratory capabilities of the State Pollution Control Board offices in both states. Based on the findings and the identified gaps, trainings and capacity-building activities were undertaken by PTB experts in Uttarakhand and Uttar Pradesh. Furthermore, a comprehensive summary of the assessments with a set of recommendations was handed over to NMCG and CPCB for further action. In the meantime, eight regional laboratories in Uttar Pradesh have now been accredited in accordance the standard ISO/IEC 17025:2017 during project implementation. During its activities, the project brought together expertise from India and Europe, and linked the water monitoring bodies with other relevant institutions.

This paper will especially discuss the current situation in six selected Water Monitoring laboratories in Uttar Pradesh at Kanpur, Prayagraj and Varanasi, and Dehradun, Roorkee and Kashipur in Uttarakhand, highlighting the significant developments during the ongoing project phase and the expert recommendations for steering the future efforts within the project purview.

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Status of Trace and Toxic Metals in Indian Rivers

Sakshi Sharma
Assistant Director
Food Safety and Standards Authority of India
Govt. of India, India

Pankaj Kumar Sharma
Director
Central Water Commission
Govt. of India, India

Keywords

River Basin, Metals, Pollution, Water Quality, AAS

Synopsis

Heavy metals are one of the most widespread causes of pollution in water. Increasing levels of these metals concentration in the environment is causing serious concern in public opinion owing to their toxicity. To observe the current status of toxic metal content of Indian Rivers, 3113 no. of river water samples from 688 water quality monitoring stations spread over major river basins in India were collected during Aug 2018 to Dec 2020. These samples were analyzed for Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Iron and Zinc. The samples were collected in polyethylene containers and analysed by atomic absorption spectrophotometer. The study was carried out on Agilent 240FS atomic absorption spectrophotometer by graphite tube analyzer (GTA) using argon gas and Iron analyzed by flame operation using air and acetylene gas.

Arsenic (As): Total 2834 numbers of water samples were analyzed for arsenic content in Indian Rivers out of which 8 no. of samples of 8 water quality stations were found arsenic concentrations beyond the acceptable limit. The arsenic concentration varies from 0.00 to 13.33 µg/L. Maximum arsenic concentration (13.33 µg/L) was observed at Porakudi water quality monitoring station on Arasalar River (a tributary of Cauvery River) during Dec, 2019.

Cadmium (Cd): 3113 numbers of water samples were analysed for cadmium content in Indian Rivers out of which 11 no. of samples of 11 water quality stations were found cadmium concentrations beyond the acceptable limit. The cadmium concentration varies from 0.00 to 12.57 µg/L. Maximum cadmium concentration (12.57 µg/L) was observed at Todarpur water quality monitoring station on Sukheta River during Dec, 2020.

Chromium (Cr): 3106 numbers of water samples were analysed for Chromium content in Indian Rivers out of which 50 no. of samples of 46 water quality stations found Chromium concentrations beyond the acceptable limit. The Chromium concentration varies from 0.00 to 180.47 µg/L. Maximum Chromium concentration (180.47 µg/L) was observed at M.B.P.L. water quality monitoring station on Hasdeo River during Dec, 2019.

Copper (Cu): 3107 water samples from 688 water quality stations were analyzed for copper content out of which 17 water quality stations were found to contain copper concentrations above the acceptable limits. The Copper concentration varies from 0.00 to 132.64 µg/L. Maximum Copper concentration (132.64 µg/L) was observed at Badlapur water quality monitoring station on Ulhas River during Dec, 2019.

Iron (Fe): 3113 water samples from 688 water quality stations were analyzed for Iron content; 756 samples of 414 water quality stations were found to contain Iron concentrations above the acceptable limits. The Iron concentration varies from 0.00 to 11.24 mg/L.

Lead (Pb): 3111 water samples were analyzed for Lead content; 36 samples of 34 water quality stations were found to contain Lead concentrations above the acceptable limits. The Lead concentration varies from 0.00 to 67.55 µg/L. Maximum Lead concentration (67.55 µg/L) was observed at Chopan water quality monitoring station on Sone River during May, 2020.

Nickel (Ni): 3111 water samples were analyzed for Nickel content; 265 samples of 199 water quality stations were found to contain Nickel concentrations above the acceptable limits. The Nickel concentration varies from 0.00 to 242.90 µg/L. Maximum Nickel concentration (242.90 µg/L) was observed at Elunuthimangalam water quality monitoring station on Noyyal River during Dec, 2020.

Zinc (Zn): Total 3113 water samples from the 688 water quality monitoring stations were analyzed during the reporting period. Maximum Zinc concentration (1.70 mg/L) was observed at Belkheri water quality monitoring station on Sher River (Tributary of Narmada River) during May, 2020. In the study area, all the river water quality stations are reported to have zinc concentration well within the acceptable and permissible limits of Bureau of Indian Standards (BIS).

Further as per statistical analysis; it was found that 180 water quality stations were within the acceptable limit as far as toxic metals are concerned according to the BIS: 10500-2012. At 508 WQ Stations, 187 stations were found beyond the acceptable limits with respect to more than one toxic metal. Further, river water at 240 numbers of stations was found beyond the acceptable limit with respect to only Iron concentration according to the BIS: 10500-2012. Similarly, river water is found beyond the acceptable limit at 2 stations due to presence of only arsenic, 2 stations due to presence of only copper, 1 station due to presence of only cadmium, at 7 stations due to presence of only Chromium, at 61 stations due to presence of only nickel and 8 stations due to presence of only lead contamination. Summary of contamination of different toxic metals are given in Table 1 & 2:

Table 1: Analysis statistic

S. No	Metals	Total Samples Analysed	Total Contaminated Samples	Total Contaminated Stations	Total Contaminated Rivers
1	As	2834	8	8	8
2	Cd	3113	11	11	11
3	Cr	3106	50	46	33
4	Cu	3107	17	17	17
5	Pb	3111	36	34	24
6	Ni	3099	265	199	122
7	Fe	3113	756	414	234
8	Zn	3113	0	0	0

Table 2: Analysis statistic

S. No	Parameters	No. of Sites/Stations
1	Arsenic only	2
2	Cadmium only	1
3	Chromium only	7
4	Copper only	2
5	Lead only	8
6	Nickel only	61
7	Iron only	240
8	Two or More metals	187
Total Contaminated WQ Stations		508
Total WQ Stations where all toxic metals found within acceptable limits		180
Total Stations studied		688

It was concluded that water quality of the Indian rivers particularly at some identified stations have been affected adversely by presence of high concentration of heavy metals. Over the last decade, the concentration of these heavy metals in river water have been increasing at alarming rates. Consequently, concentrations of toxic metals in grains and vegetables grown with contaminated river water will be increasing. Hence, there is an urgent need for stringent Government policy and monitoring for the following activities to control the metal pollution in river water:

- Ore processing, smelting, and refining operations
- Heavy metals discharge in river system by natural or anthropogenic sources
- The metal containing unregulated enormous discharge of untreated industrial waste waters into riverine system
- Stormwater runoff from urbanized areas.

Water Quality Assessment of Yamuna River for its Impact on Durability of Concrete Structures along the Riverbed

Sameer Vyas
Scientist B.
CSMRS
India

Bhanupriya Sharma
Research Scholar.
Gautam Buddha University
India

RP Pathak
Scientist D
CSMRS
India

US Vidyarthi
Scientist E
CSMRS
India

Keywords

Water Quality, Durability, Pollution, Sewage & Industrial effluent, Concrete Structures

Synopsis

The Yamuna river is one of the most polluted river in the world. Due to rapid urbanization and industrialization, the discharge of untreated domestic and industrial effluents has affected the quality of Yamuna River and ruling out the possibility for underwater life and domestic supply. During the entire journey after its origin from Himalayas, Yamuna travels 48 Km in Delhi, out of which 22 km stretch is severely polluted due to discharges of sewage and effluent by more than 20 drains. Delhi stretch counts only 2% of the total length of the river however 80% of its pollution contributed by this stretch. More than 750 million gallons per day (MGD) sewage is generated daily in Delhi , out of which only 550 MGD sewage is treated by 36 Sewage Treatment Plants (STP) . Around 200 MGD untreated sewage discharges daily in to the river.

According to a study made by CPCB, only 45% of sewage and 55% of industrial effluents are treated up to secondary level before discharge into the Yamuna river. Due to complex nature of sewage and industrial effluents, the chemical properties of river water, ground water, top and sub soils in the adjoining areas are severely affected and altered. Impurities in the form of sewage, dirt and other floating materials contributed in downgrading water quality. In the same time, due to infrastructure development a large number of construction projects are upcoming in the catchment area of the river. The existing concrete structures adjoining the river bed like barrages, metro bridges, The Delhi secretariat, Akshardham temple, commonwealth Game Complex etc. will might be facing long term durability issues due to aggressive water quality of river. In this scenario, it is important to evaluate its water quality to envisage its effect on concrete durability. The Central Soil and Materials Research Station, CSMRS has studied the water quality of the Yamuna river and Nallahs situated in the catchment area of the river flowing in Delhi. Present study also highlights the seasonal change in water quality of river and nallahs to evaluate its suitability for use in concrete making and effect on long term durability of structures. Observations were made under different research schemes since 2014 clearly reveals that water quality degraded over the years particularly in between the Wazirabad to Okhla stretch. For comprehensive evaluation the observations were made in three different season's i.e. pre-monsoon, monsoon and post monsoon period.

The water samples were analysed at the site for various in-situ parameters however samples were brought to CSMRS laboratory for detail chemical analysis after proper preservation. Water samples were analyzed as per IS: 3025 standard procedures and interpretation of results were evaluated based on IS: 456 – 2000, ICOLD Bulletin No. 71 and other relevant International/National standards. The parameters like pH varies with seasonal variations, however pH value increases with the downstream shows more alkaline nature due to increasing sewage concentration discharges from different drains. The other parameters like electrical conductivity (EC), total dissolved solids (TDS), suspended solids, chloride, sulphate, and alkalinity were shows increasing trends of concentration at downstream of Wazirabad. Water quality at Okhla barrage shows river water unfit for use in drinking, irrigation and even concrete construction and may cause the durability problems in existing and upcoming civil engineering structures in long run. The Langelier Saturation Index (LSI) determines water is aggressive/corrosive in nature. Negative (LSI), shows leaching of lime from concrete structures while positive (LSI) shows scale-forming nature. Langelier Index values of the river samples were found negative in majority of river locations indicating the water is aggressive in nature.

The high values of suspended solids & alkalinity in the lean and pre-monsoon seasons at majority of locations makes the water unfit for construction as per IS 456 – 2000. Presence of higher amount of sulphate, chloride, soluble salts, hardness, sodium, potassium, calcium and other ions start deteriorating reactions which ultimately damage the structures in long term exposures. The other two parameters showing the health of the river i.e. dissolved oxygen (DO) and biochemical oxygen demand (BOD) were also monitored at different locations in the year 2022. The level of DO and BOD at Jagatpur, Wazirabad and Okhla differ dramatically. River shows good health at Jagatpur village while DO level continuously decreasing down stream of Wazirabad and ended in to level zero at Okhla. The level of BOD increases up to more than 70 mg/l at Okhla barrage. The study shows that there is a need of continuous monitoring of the river and drain water quality in different sessions and health evaluation of the existing structures will also to carried out for remedial measures. The mixed design approach for upcoming concrete structures should also be modified considering the all suitable measures with reference to aggressive water quality.

Assessment of surface water quality for using Water Quality Indices of Hindon River, India

Lalit Kumar Morya
National River Water Quality Laboratory
Yamuna Basin Organisation
Central Water Commission
New Delhi

Apoorva Singh
Sai Institute of Para Medical and
Allied Science
Dehradun

Sandeep Kumar Shukla
National River Water Quality Laboratory
Yamuna Basin Organisation
Central Water Commission
New Delhi

H.P. Chaurasia
Upper Yamuna Division,
Yamuna Basin Organisation
Central Water Commission
New Delhi

Keywords

Hindon River, Water Quality Parameters, WAWQI , CCMEWQI

Synopsis

Water is one of the basic requirements for every living being on our planet earth. If water quality is not maintained this may lead to the injurious and chronological impacts, so it is very important that the water quality must be balanced. Hindon River which is basically a tributary of one of the holy river called as Yamuna River having actual origin from Saharanpur, the range of Upper Sivalik in Uttar Pradesh, Shakumbhari Devi. It flows around 400 KM from Ganges & Yamuna rivers. Hindon river flowing through Muzaffarnagar, Meerut, Baghpat, Ghaziabad before it confluence with Yamuna at Noida of Uttar Pradesh. In this study the water sample were fetched up from the Galeta, Baleni, and Noida in season of monsoon, winter & summer from June 2021 to May 2022 and analysed to check the eleven core physico-chemical and biological water quality parameters such as pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Dissolve Solid (TDS), Total Hardness (TH), Calcium Hardness (CH), Magnesium Hardness (MH), Chloride (Cl), Fluoride (F),Sulphate(SO4), Nitrate (NO3) and Total Coliform (TC).

The water quality index is a single value that states the quality of water by incorporating the various water quality parameters and complex data. Its objective to provide an easy and concise way to stating the water quality for different applications. The calculation of the WQI was done using Weighted Arithmetic Water Quality Index (WAWQI) and Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) compares with Class C (BIS 2296:1982). The both Water Quality Index has been calculated for the all three locations of Hindon river and the results showed that the WAWQI were varying from 48.9 to 563.4 and CCMEWQI from 32.0 to 78.42. It is concluded from WAWQI and CCMEWQI the water of all season and all three locations of Hindon river and most of the times shown unsuitable and poor water quality with reference to class C.

The Correlation and Regression Analysis of Physicochemical Water Quality Parameters of Wainganga River, India

Sandeep K Shukla
National River Water Quality Laboratory
Yamuna Basin Organsation
Central Water Commission
New Delhi

Keywords

Correlation Coefficient, Regression Equation, Wainganga River

Synopsis

The Wainganga is main tributary of the Godavari and originating in the Mahadeo Hills in south-central Madhya Pradesh state near the village Gopalganj in Seoni. The river flows in a winding course through the states of Madhya Pradesh and Maharashtra, around 579 km. The Wainganga River is the key source of water in the cities such as Balaghat, Seoni of Madhya Pradesh and Bhandara, Gadchiroli of Maharashtra. The present study has determined the water quality assessment on the basis of eighteen physico-chemical parameters such as pH, Turbidity (Turb), Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium (Na), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulphate (SO4), Chloride (Cl), Nitrate (NO3), Bicarbonate (HCO3) Total alkalinity (TA), Total hardness (TH), Calcium Hardness (CaH), Magnesium Hardness (MgH), Percent Sodium (% Na) and Sodium Absorption Ratio (SAR) with the help of statistical method.

The statistical analysis used to calculate the correlation coefficients and to plot the regression equations of various pair of water quality parameters. The aim of the study was to identify the relation between eighteen water quality parameters with help of Correlation Matrix and Regression Analysis. The various water quality parameters have a significant effect on each other. The results proved to be a useful mean for rapid monitoring of water quality with the help of systematic calculations of correlation coefficient between water parameters and regression analysis. The statistical regression and Correlation analysis has been found to be a time saving and cost effective technique. Finding linear correlation between various physicochemical water parameters can be treated as a unique step ahead towards the drinking water quality management. In current study regression, equation established between two parameters, which can employ to forecast the value of one parameter if value of other is known.

Monitoring and detection of pesticide contaminants in freshwater through Sensor based Technology

Tanmaya Kumar Bhoi
Arid Forest Research Institute
Jodhpur, Rajasthan, India, 342005

Pooja Sharma
Arid Forest Research Institute
Jodhpur, Rajasthan, India, 342005

Anjali Joshi
Arid Forest Research Institute
Jodhpur, Rajasthan,
India, 342005

Ipsita Samal
Sri Sri University, Cuttack,
Odisha
India, 754 006

Keywords

Freshwaters, pesticide, ecosystem, pollutant, chemical

Synopsis

Water makes up 71% of the surface of our planet, and it is essential to all life as it currently exists. Despite making up less than 3% of the total amount of water on Earth, freshwater is more closely associated with daily life than saltwater. However, manmade activities have harmed numerous freshwater habitats, with human settlements, industries, and agriculture being the three main causes. For instance, there are currently more than 100,000 chemicals that have been registered, the majority of which are associated to our daily lives and can eventually enter freshwaters. Additionally, the environment is harmed by more than half of the overall chemical production. With serious repercussions on aquatic ecosystems at all scales, from the individual to the watershed, the degraded water quality adversely affected aquatic creatures and creates serious hazards to water bodies. More importantly, human health is also at risk if clean drinking water cannot be accessed. As a result, many ecological research, water quality control, and restoration still place a high priority on freshwater water quality monitoring. For the identification of pesticide pollutants in fresh water in such a situation, sensor technology is very reliable. To preserve aquatic ecosystems and human health, these sensors must increase their sensitivity and cover a wider range of pesticides, especially those harmful chemicals that are commonly utilised and found in freshwaters.

Holistic approach for Rejuvenation of Freshwater & Marine ecosystems from plastic pollution

Anil Kumar,
Sc-D.
DSIR MoS&T
India

AK Madhukar
Suptd Geophy.
CGWB-Ex Employee
India

Keywords

Mismanaged plastic waste, micro/macro plastic

Synopsis

Plastic that started as a symbol of progress a few decades ago has now overshadowed human civilization. Plastics are the largest, most harmful and most persistent fraction of marine litter, accounting for at least 85 per cent of total marine waste [1]. Approximately 7 billion of the 9.2 billion tons of plastic produced from 1950-2017 became plastic waste, ending up in landfills or dumped. Plastic production has risen exponentially in the last decades and now amounts to some 400 million tons per year– a figure set to double by 2040. The oceans receive at least 14 million tons of plastic each year and it may go up to 32 million tons by 2040 [2]. It is estimated that plastic pollution kills 100000 marine mammals every year.

Plastics are contributing micro plastics, synthetic and cellulosic micro fibers, toxic chemicals, metals and micro pollutants into waters, sediments and eventually marine food chains which cause lethal effects in marine creatures that play a major role in sequestering carbon, especially mangroves, sea grasses, corals and salt marshes and also altering the global carbon cycling and effect on plankton, primary production in marine, freshwater and terrestrial systems. Marine plastic waste created negative impacts on tourism, fisheries, and aquaculture sectors.

According to an estimate computed in 2016, 25,000 tons of plastic are generated every day in the country. Out of this, only 9,000 tons is recycled, the remaining is not even collected for processing. In India – the Indus, Ganga and Brahmaputra carries the highest amount of mismanaged plastic debris to the sea [5]. About 1000 rivers are accountable for nearly 80% of global annual plastic emissions, which range between 0.8 – 2.7 million metric tons per year [6]. Mismanaged plastic waste (MMPW) make their way into bodies of freshwater, underground aquifers and moving freshwaters through runoff and erosion.

Efforts to reduce the use of plastics, to promote plastic recycling and to reduce mismanaged plastic waste or plastic pollution are ongoing processes. Use of biodegradable plastics has many advantages and disadvantages. Used plastic medical equipment is incinerated rather than deposited in landfill causing air pollution as well as a cap on plastic production. Complete ban on single use plastics is a holistic approach with traditional methods, to be removing the plastic pollution in freshwater & marine ecosystems. Reduce the amount of plastic use, refuse single-use plastic items and reuse by choosing reusable alternatives over plastic pollution [11].

Note: Authors- views expressed are personal.

S5:

Dovetailing the Micro and Macro Intervention for Water Management

Assessment of the Developmental impact of the HNSS project in the Ananthapuramu District of Andhra Pradesh using space Inputs

Aariz Ahmed
Energy, Environment and Climate Change Program
National Institute of Advanced Studies
Indian Institute of Science Campus
Bengaluru 560012, India

R Srikanth
Manipal Academy of Higher Education (MAHE),
Manipal,
Karnataka 576104, India

Keywords

GIS techniques HNSS scheme; Multidisciplinary approach; Sustainable Development; SDG-6.

Synopsis

It is crucial to develop and implement interlinking of rivers projects to fulfil Sustainable Development Goals 1 (No Poverty) and 6 (Clean water) by transferring surplus water to deficit regions. The Handri Neeva Sujala Sravanti (HNSS) irrigation project launched by the government of Andhra Pradesh (A.P) is intended to provide irrigation facilities to the extent of 2.43 lakh hectares (Kharif) in the four districts of Rayalaseema including 86,990 Ha in the semi-arid region of the Ananthapuramu district and supply drinking water to about 3.3 million people, using 1132 Mm3 (40 TMC) of floodwater from the Krishan River. These regions receive a meagre 500 to 600 mm of annual rainfall. This lift irrigation project is a part of a program "to protect Rayalaseema from the ravages of drought and severe famine and to reverse the desertification process." While the Ananthapuramu district depends on Tungabhadra (T.B) water through the High-level canal (HLC) surface water system for irrigation and domestic purposes, due to the siltation of the T.B reservoir and other issues with the HLC system, the area does not get water as per its allocation. As a result, the Ananthapuramu district faces water crises very often. Apart from this state irrigation scheme, the National Water Development Agency has also prepared the feasibility report (F.R) for the Almatti-Pennar (A-P) interlinking of rivers (ILR) project which can be implemented immediately after the ongoing Polavaram project is completed by the Government of Andhra Pradesh. The A-P ILR project is a future water transfer scheme to combat the water crisis issues in the Ananthapuramu district by transferring 1342 Mm3 of water through a 587-km gravity canal.

However, the existing HNSS Phase II major irrigation project already serves the similar command area proposed by NWDA via the A-P ILR project between RD 386 km and RD 587 km. The HNSS Project has helped to increase the groundwater level across the district and improve the crop area through indirect benefits. In the dry part of the district, barren fields have reportedly become green, and the area is being used for cultivation. Hence this study tries to evaluate the developmental impact of the HNSS before and after the development of the HNSS phase II canal system in the Ananthapuramu, Chittoor, and Kadapa districts in Andhra Pradesh. Further, the authors will also use the latest cloud and machine learning-based remote sensing, GIS techniques, and ground data to quantify crop area change before and after the HNSS, which was intended to be served by the A-P IL link canal for the assessment of the developmental impact of such water projects. This multidisciplinary approach can be extended to other mega water transfer projects.

Inter Linking of Rivers"- Connecting India for Prosperity

ER. Kirit B. Trivedi
B.E.(Mech.), MBA (Marketing)
CDM, M.I.E, F.I.V
D.E.E. (Mech.)
Retired., Government of Gujarat
Gandhinagar-Gujarat

Keywords

Inter Linking, National Perspective Plan, Flood, Climate Change, Ecology and Biodiversity.

Synopsis

The issue of proper and useful water management in every respect is known to all over the world and India is also not lacking. Rain God gives plenty of water as a blessing to about 800 Crores children of this earth and yet all are witnessing floods and even draughts in many parts of our lovable Mother Earth. Now the time is reached to save every drop of rain to combat with floods or droughts or even to get more power generation. There are so many Big Dams, Major Dams or Medium Dams all over the world and even in India we have about 4710 Major-Large-Dams and about 390 are under pipeline. Even though we are having good storage capacity, it seems not sufficient.

In this situation here comes a tremendous and fruitful planning of "Inter Linking of Rivers" which in reality may make India more prosperous in every respect, i.e. More Water Storage & availability, flood Control, relief in drought, more power generation and Water Navigation etc. We can see this at a large scale, so called, Macro Planning for Water Management.

I am sure that this topic of "Dovetailing the Micro and Macro intervention for water management" would certainly be a crucial point to discuss. I am glad to receive this opportunity to share my point of view on this topic. In my full length paper, I shall be focusing on the topic of "Inter Linking of Rivers" and "Intra State Linking of Reservoirs" also as an ideal program in connection to the theme of session " dovetailing the micro and macro intervention for water management".

In the 1970s, Dr.K.L.Rao, a dams designer and former irrigation minister proposed "National Water Grid". He proposed that surplus water of Brahmaputra and Ganga basins to be diverted to areas of deficit like Central and South India. The other proposal put also forth by "Garland Canal" by Captain Dastur in addition of Dr. K.L.Rao, these proposals were not pursued further by the Government as they were not techno-economically feasible.

The then Ministry of Irrigation(now Jal Shakti) formulated a National Perspective Plan (NPP) for Water Resources Development in August 1980 envisaging inter basin water transfer in the country. Ministry of Water Resources came out with a report entitled "National Perspectives for Water Resources Development". This report split the water development project in two parts-the HIMALAYAN AND PENINSULAR COMPONENTS.

The Need--Drought, Floods and Shortage of Drinking Water:-

India receives about 4,000 cubic kilometres of rain annually, or about 1 million gallons of fresh water per person every year. However, about 85%, of rain is received during summer months through monsoons in the Himalayan catchments of the Ganges-Brahmaputra-Meghna basin.

The north eastern region receives heavy precipitation, in comparison with the north western, western and southern parts. The nation sees cycles of drought years and flood years, with large parts of west and south experiencing more deficits and large variations, resulting in immense hardship particularly the rural populations. The excess-scarcity regional disparity and flood-drought cycles have created the need for water resources management. Rivers inter-linking is one proposal to address that need.

Planning Aspects:-The National perspective plan envisions about 185 billion cubic metres of water storage along with building inter-links. These storages and the interlinks will add nearly 170 million acre feet of water for beneficial uses in India, enabling irrigation over an additional area of 35 million hectares, generation of 40,000 MW capacity hydro power, flood control and other benefits. Also some benefits of flood control would be achieved. The project may also contribute to food security to the anticipated population peak of India. Water is a scarce commodity and several basins such as Cauvery,Yamuna, Sutlej, Ravi and other smaller inter-State/intra-State rivers are short of water.

About 99 districts of the country are classified as drought prone; an area of about 40 million hectare is prone to recurring floods. The inter-link project is expected to help reduce the scale of this suffering and associated losses.

Present Status- Under the NPP, the National Water Development Agency (NWDA) has identified 30 links (16 under Peninsular Component & 14 under Himalayan Component) for preparation of Feasibility Reports (Frs). The Pre-Feasibility Reports (PFRs) and FRs and even Detailed Project Report (DPR) for many schemes have been finalized. The implementation of the projects will take varying periods of time. An ILR project would reach the implementation stage when all the statutory clearances are taken and an agreement is reached amongst party states from the implementation of the project.

Possible Positive Implications of ILR Plan:-

1- It will most likely lead to Improved and expanded irrigation i.e. the project claims to provide additional irrigation to 35 million hectares in the water-scarce western and peninsular regions.

2- The river interlinking project claims to generate total power of 34 GW out of which, 4,000 MW from the peninsular component & 30,000 MW from the Himalayan component. 3- It will lead to Ground water Recharging. 4- It will contribute to flood and drought hazard mitigation for India. 5- It aims at increasing food production from about 200 Mn. tones a year to 500 Mn tones and much more benefits will be achieved after the completion of such projects.

Challenges in Interlinking of Rivers?:- Impact of the Climate change: Human cost: Huge financial cost: Impact on ecology and biodiversity: International

Challenges: Political Challenges:

Other Challenges: The government is proposing a canal irrigation method for transmitting water from one area to the other. The maintenance of canals is also a great challenge, it includes preventing sedimentation, clearing logging of waters etc. Further, the government has to acquire large-scale lands for the smooth implementation of the project which is not easy.

In my full length paper, I shall be presenting a detailed approach specifically for some important aspects of Inter and Intra state Linking of Rivers. Hope that the committee will find my inputs valuable and provide me an opportunity to present the same. Jai-Hind.

Dovetail the Micro and Macro Intervention for Water Management – Experience in Pambar Kottakaraiar Basin

J.Mohan
Programme Leader
DHAN Foundation
India

Keywords

Tanks, Cascade, Basin, Sub-basin, Community Governance

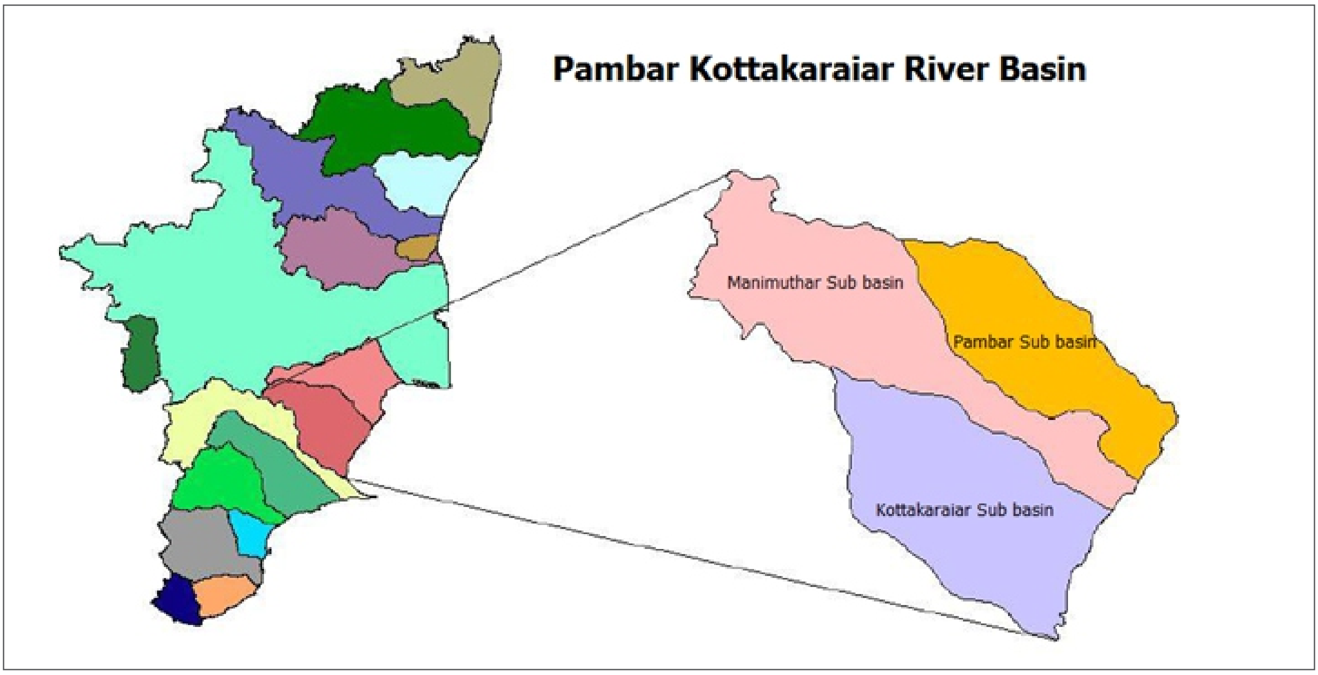
Synopsis

Water is a precious element in the universe for human, animals and other species survival, and also for Irrigation, Industrial uses, recreational, environmental activities. Watersheds face a range of degradation challenges associated with human activities, such as pollution, deforestation and changes in sediment generation. The way they are managed has a profound cascading effect on natural resources and communities in the wider basin.

The life style of the people of the rural villages in Tamil Nadu depends on the tanks and ponds which are the small scale water bodies in the watersheds. These traditional water bodies are degenerating due to the lack of the community participation, siltation, and lack regular maintenance by the government and other factors. This resulted in the declining of the tank fed agriculture leads to the livelihood and food insecurity issues to the poor. Without the development of Micro level water resource like tanks is not possible for Macro level development at basin level.

Pambar Kottakaraiyar basin:

Pambar Kottakaraiyar basin is one among the 17 river basin of Tamilnadu. It is located in the South Central Portion of Tamilnadu. It originates near hills surrounded by Natham and Sanarpatti blocks of Dindigul district and drains through the portion of Madurai, Dindigul, Sivagangai, Pudukottai and Ramanathapuram districts and finally drains at Bay of Bengal near Thondi of east coast.



This basin is not having perennial flow of water. The streams in the basin are ephemeral which are having flow only during monsoon period. The ancestors lived here created the tanks and ponds and connected the streams to harvest the rain water. Tanks/ponds have been playing very vital role in socio, cultural, economic and environment development. Tanks & Ponds are the common property and support the livelihoods of the marginalized community. Improving water bodies is an effective way to help reduce poverty among farmers.

The people governance from Tank level to basin level sustains the development interventions on the waterbodies and the increase the community participation which leads to effective management of the water resources. The constant support from the Axis Bank Foundation helped to impact at micro level from tanks and to strengthen the basin at Macro level.

Framework for sustainable rainwater harvesting in urban areas – A case study of Guntur, Andhra Pradesh

RNS Murthy
Assistant Professor
School of Planning and
Architecture Vijayawada
India

Srikonda Ramesh
Professor
School of Planning and
Architecture Vijayawada
India

Keywords

Rainwater harvesting, urban context, Analytical Hierarchy Process, LPCDs

Synopsis

The water is one of the SDGs as it has been recognized as a very prime liveability parameter for human settlements. A thorough study on demand and supply of water to residential sector by the local governing body will lead to shed more light on the rainwater harvesting (RWH) scenario and its implications in the future. The study objectives are to investigate micro level, miso and macro level considerations of a town in order to develop a framework to reduce water stress on municipal supplies while avoiding the use of ground water and other sources. Small and medium towns of India generally dominated by plotted development. Hence, the harvestable rainwater as one of the major parameters among six parameters of frame work, has been assessed in residential neighborhood focusing from plot level to Neighborhood and then to town. The rainwater runoff from plotted development related sub parameters such as Terrace runoff of buildings, runoff at setbacks of plots, runoff from Community spaces were addressed with due consideration to rational and SCS – curve number method. Further it has been assessed with respect to the Quantity, Quality and Management in AHP and found the weightage 0.47 for frame work attributes. Subsequently, other parameters such as 'technical knowhow' has been analyzed with respect to the plot level, Neighborhood level and town level with regard to Quantity, Quality and Management and found that it has 0.44 weightage as compared to other parameters. Similarly other parameters such as Monitoring [0.45], HRW storage [0.47], Institutional mechanism [0.52], and 'Urban engineering and Architecture' [0.47] yielded to work out a sustainable rainwater harvesting frame work.

Water audit-a scientific measure and tool to address water scarcity

Saubiya Sareshwala
Research Associate
Center for Water and Sanitation
India

Apoorva Bhate
Research Associate
Center for Water and Sanitation,
India

Dhruv Bhavsar
Senior Program Lead
Center for Water and Sanitation
India

Dr. Meera Mehta
Center Head
Center for Water and Sanitation
India

Dr. Dinesh Mehta
Center Head
Center for Water and Sanitation, India

Keywords

Water Audit, Water Conservation, Non-Revenue Water, Water Governance, Water Management

Synopsis

The global annual water loss quantity is predicted to be 126-billion-meter cube, costing over 3900 crore dollars each year. (Liemberger & Wyatt, 2019) The UN-mandated Sustainable Development Goal (SDG) 6 aims to "ensure availability and sustainable management of water and sanitation for all. At the COP26, water has been discussed at the central place. NITI Aayog (2018), mentions that India is undergoing the worst water crisis in its history and nearly 600 million people are facing high to extreme water stress. To address issues of water scarcity and management, scientific interventions are important as they become the necessary base to build political will. The city of Vadodara in Gujarat state in western India with a population of 2.1 million is facing issues of water scarcity, water losses and demand management. This allows to introduce "water audit" as a scientific measure and tool for the city to evaluate its water losses and non-revenue water reduction.

This paper assesses and explains the approach, process and key results of preliminary water audit that was undertaken in one of the pilot areas of Vadodara city.

Approach and Methodology

The water supply system of Vadodara Municipal Corporation (VMC) was studied based on site visits, discussions with city officials and desk-based secondary research analysis. To address the political water scarcity and assess the consumer water demand management, existing digital infrastructure systems like SCADA were studied in detail. Pilot area named Karelibaug which constituted 10% of the city's total connections was selected based on the results obtained from SCADA readings of water losses from source to water distribution stations and complaint redressal data of water pressure. Water audit was used as a scientific tool to assess pressure, leakages and losses at the Water Distribution Tank, in valves and pipelines and in the distribution network. Mapping of overall connections and high and low-pressure points was done.

Analysis and Key results of Water Audit Process:

The city daily supplies 539 MLD of water through its three major surface water sources. It has an existing water network of 1650 km with 32 elevated distribution stations and 0.3 million non-metered water connections. However, on the other end, the city receives complaints from its consumers related to inadequacy of water supply, low pressure and leakages. The preliminary calculated real water loss in the transmission network of the city from source and Water Treatment Plant (WTP) to the Water Distribution Stations (WDS) database were estimated to be around 18% based on SCADA readings. Detailed water audit of Karelibaug command area was undertaken in a scientific way. Measurements were taken through ultra-sonic flow meters at the source, distribution station, distribution network (pipelines and valves) and households to prepare water balance of the command area. Key observations from the preliminary water audit process determine an overall 40-45% losses reported at the tank, real losses due to leakages in valves and pipelines in the distribution network and unaccountable losses reported due to unauthorized water connections. The financial implication of the water losses is calculated equivalent to the quantity of treated water which can cater water demand for a certain population.

Image 1: Water losses in the distribution network

Conclusion and Way Forward:

Based on the observations made during the water audit and its results, a few key suggestions for improved measurement of NRW as well as for its reduction have been identified. Vadodara will be improving its water management by reducing the non-revenue water losses through key strategies like repairing its tank, existing valves, regularizing unauthorized connections through a policy framework etc. This will also be backed by performance-based contracts for the operations and management contract. Water audit will be scaled for all the Water Distribution Stations (WDS) of the city and strategies will be prioritized in phases. Water metering will be required at the outlet of distribution stations and at household level. This will be supported through a water meter policy framework to set appropriate tariffs. Institutional capacity building of city officials is required in terms of process improvements like monitoring using existing technologies and SCADA systems. Water security plan for Vadodara is prepared that captures reduction of non-revenue water, integrated water management through water conservation techniques like aquifer management, rainwater harvesting, rejuvenation of lakes and reuse potential of used water.

Enabling the Local Community for Reviving the Water Quality of Traditional Urban Pond

Lokesh S
Project Executive
DHAN Foundation, India

Elamuhil S
Project Executive
DHAN Foundation, India

Arulanatham A
Project Associate
DHAN Foundation, India

Keywords

Water quality, Urban waterbodies, Community driven, Integrated Water Management, Traditional waterbodies

Synopsis

Saravana Poigai, A Traditional sacred pond of Madurai City, is geologically, hydrologically, and Topographically not a conventional temple pond. The pond that harvested runoff from the 25 acres of catchment area in the Thirupankundram hills, which is a Chornakite type of metamorphic rock formation where anthropogenic activities led to the collapse of the tank ecosystem. The last two decades of silts are formed as 8-10feet depth of Clay sludge at bottom of the pond. Almost 90% of the catchment area is Solid rock which creates the highest runoff. The remaining 10% of the catchment area is with invasive plants and acts as the open defecation area.

The presence of Clay at the bottom and the usage of chemicals as a washing material leads to an increase in Turbidity up to 13NTU which affects the growth rate of algae (micro-aquatic plants) and reduces the photosynthesis process. This turbidity is reflected in the Alkalinity, where the pH was around 8.75. The minimal nitrogen cycle ensures the quality of surface water. But Saravana Poigai records very high Free ammonia, Nitrites, and Nitrates. This high level creates less scope for photosynthesis and reduces the dissolved oxygen level, and impacts the fish's health. Dissolved oxygen (DO) is one of the most important indicators of water quality for the survival of fish and other aquatic organisms. Dissolved oxygen which is less than 3.5 mg/L refers to the high pollution rate and stressful conditions for aquatic species. The Saravana poigai water is highly contaminated with organic loads which are found by the BOD value of 30mg/L. There is high contamination with fecal coliform. Technically, this creates the chances of waterborne diseases. Water quality is the physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water. According to the Central Pollution Control Board (CPCB) guidelines for the surface water quality parameters, they made 5 levels in concern to water quality from A to E. The Saravana Poigai sampled water comes below E level. This shows that serious intervention is needed for enhancing the water quality at Saravana Poigai. By the indication of 'greenish water' that smells bad and creates itching and rashes on the skin for its users. This not only affected the ‘holiness’ of the water but also pushed the tank-dependent communities in search of alternative water sources.

DHAN Foundation along with the Avvai Pengal Vattrra Kalanjiam, an SHGs federation of locals promoted by the DHAN Foundation in the Thiruparakundram area, this local community along with DHAN Foundation made a Participatory Learning exercise with all the stakeholders on different levels followed by several community level meetings. These continuous meetings lead to understanding the community-level action to enhance the water quality of Saravana Poigai. The possibilities to enhance the water quality are mapped by the community. The community estimates more than 10 feet from the bottom, the sludge/Slurry is present which host the organics.

They proposed methods to remove the slurry which is submitted to the Government of Tamil Nadu. Based on the demand of the community, the local administration deployed laborers to remove the Neylon clothes dropped by the devotees. As a Catchment area treatment, around three acres of land at the foothill are maintained by planting 950 native trees at the bottom. This intervention created an effective solution for arresting open defecation. But the final challenge is on restricting the Chemical Load of soap used for washing the clothes which is not accepted by the community where they expect an alternative source of domestic water needs to be supplied. This shows the urgency of holistic integrated water management to protect even traditional water ponds, in spite of their sacredness.

S6:

Emerging Technological Solutions for Efficient Water Management

Digital Water Allocation System in Surface Irrigation

Amit Kumar
Ph.D scholar, ICAR-IARI
New Delhi-12
India

A. Sarangi
Principal Scientist
Water Technology Centre
ICAR-IARI, New Delhi-12
India

D.K. Singh
Professor
Division of Agricultural Engineering
ICAR-IARI
New Delhi-12, India

M. Khanna
Principal Scientist, WTC
ICAR-IARI
New Delhi-12
India

K.K. Bandyopadhyay
Principal Scientist
Division of Agricultural Physics
ICAR-IARI, New Delhi-12
India

S. Dash
Senior Scientist
ICAR-IASRI
New Delhi-12
India

Keywords

Precision irrigation, Solar pump, Piped irrigation networks, Flow sensor, Water productivity

Synopsis

Precision irrigation ensures supply of measured quantity of water to meet crop water demand leading to enhanced agricultural water productivity. In India, about 88% (68Mha) of irrigated area is under surface irrigation with application efficiency of 30-40%. Therefore, with an aim to enhance the water application efficiency under surface irrigation, a digital water measurement and allocation system under piped irrigation network was developed to supply measured quantity of water as per the crop water requirement. Developed device consists of a pipe flow sensor, microcontroller, digital display unit, input keypad, relay switch and push buttons to supply water to cropped fields. The calibrated pipe flow sensor was used to measure the total volume of water supplied to field as per the crop water demand for subsequent switching off the solar pump through the relay switch. Keypad in the device was used to feed the required volume of irrigation water to be delivered to the farm unit. The required amount of irrigation water was computed using the IoT enabled soil moisture sensing system. The push button of the device can be used to reset the system, to select fields and to start the pump. Nonetheless, the developed digital irrigation water allocation system would assist the stakeholder in supply of the desired quantity of irrigation water leading to enhanced agricultural water productivity under surface irrigation.

Carlos Andres Rivera Villarreyes
Global Product
Specialist Fellow

Synopsis

For over 40 years, groundwater modellers have relied on FEFLOW to simulate flow, mass and heat transport processes in the subsurface. Unique meshing capabilities (structured and unstructured) in 2D and 3D allow for the highest degree of flexibility to account, in detail, for the most simple and complex geometrical configurations. FEFLOW's scope of application ranges from simple local-scale to complex largescale modelling. The software is used by leading research institutes, universities, consulting firms and government organisations all over the world in application areas such as water management, mine water, saltwater intrusion, geothermal energy, and variably saturated media.

To tackle recent challenges in groundwater resources management, emerging technologies in numerical modelling are needed. With the new incoming software release, FEFLOW 8.0 settles the next generation of groundwater modelling. FEFLOW in the MIKE release 2023 tackles several interesting aspects in groundwater modelling from model conceptualization, advanced surface water and groundwater coupled calculations, uncertainty quantification with PEST++, a new well manager, advanced 3D meshing and cloud computing.

Especially, FEFLOW's hybrid implementation closes the gap between classical desktop groundwater modelling and cloud computing, all this is especially required for quantifying the uncertainty behind groundwater issues. In this presentation, several applications ranging from mining, water resources, geothermal among others are discussed, where all these new FEFLOW's developments bring an additional support to groundwater modellers.

Significance of Advance Flow Measuring Device for Assessing Conveyance Efficiency of Canal Distribution Network of an Irrigation Project

Dr. Dilip G. Durbude
Professor and Head
Water and Land Management Institute, Aurangabad
India

Synopsis

WUE, Irrigation Project, ADCP, Conveyance Efficiency, Canal

Synopsis

In the present changing scenarios of climate, the management of available natural resources like soil and water is becoming a challenging task. Due to the climate change, there is a gap between water resources availability and demand. With the increasing demand on the water resources, the optimal use of available water resource is becoming one of the key issues in front of farmers and water managers in the country. Therefore, the Water Use Efficiency (WUE), which is the optimal utilisation of available water using acceptable best practices and benchmarks as measure has become vital important in water sector. With this background, the goal of improvement in WUE at least by 20% in all sectors of water use is identified by National Water Mission (NWM) under National Action Plan on Climate Change (NAPCC). In irrigation sector, water consumption is about 80-85%, while WUE of irrigation project is in the range of 30-35%. Hence, it is necessary to enhance the WUE of the major and medium irrigation projects throughout the country. As such, there are four major components of the overall WUE of an irrigation projects such as dam/reservoir filling efficiency, Conveyance Efficiency, On Farm Application Efficiency (OFAE), and Drainage Efficiency. Among these, conveyance efficiency is one of the most important components for supply side management of the water resources of an irrigation project. In assessing this efficiency, the flow measuring devices plays an important role. The quick and accurate evaluation of conveyance efficiency of Canal Distribution Network (CDN) depends upon the advancement in the flow measuring devices. For an accurate estimation of discharge in an open canal, it is generally recommended to measure the flow velocity simultaneously at a number of points in the measuring section. The traditional current-meter measures the velocity at the point of insertion whereas the advanced instrument like Acoustic Doppler Current Profiler (ADCP) could measures the velocities from distance and simultaneous at a large number of points within the canal section. Hence, the use of such advancement and modern instrument will make simplicity and helped to update the flow measurement regularly. Therefore, in the present study, an effort has been made to review the present status of an application of ADCP for discharge measurement from CDN. The findings will help to the researchers, academicians and field engineers to work out future strategy in the research and teaching and updating the discharge from canal network of major and medium irrigation projects.

Establishment of continuous Operating Reference Station (CORS), step towards for accurate, reliable and economical positioning

Harendra Kumar Tiwari
GIS & RS Expert, TAMC
National Hydrology Project

Keywords

Reference System, GNSS, rover, SOI, GPS, GLONASS, Galileo, Beidou, NavIC, Earthquake prediction

Synopsis

A satellite navigation is a system that uses satellites to provide autonomous geo-spatial positioning. It allows small electronic receivers to determine their location (longitude, latitude, and altitude/elevation) to high precision. A satellite navigation system with global coverage may be termed a global navigation satellite system (GNSS). GNSS provide autonomous geo-spatial positioning with global coverage and broadly include GPS (US), GLONASS (Russia), Galileo (EU), BeiDou (China), NavIC or IRNSS (India) and other regional systems. Accuracy of GNSS instrument is 3- 10 m.

Continuously Operating Reference Station (CORS) is an infrastructure that can solve the problem of accuracy and real-time data acquisition. CORS network is geodetic quality GNSS receivers and antennas that are permanently installed at a Reference Station (RS) having very accurately pre-determined coordinates with accuracy of 2.5 to 5 m.

Looking at the importance and usefulness of the technology, the Survey of India has started an initiative of establishing nationwide CORS network. Under NHP, 81 (73+8) CORS is established in Uttar Pradesh & Uttarakhand. About 960 CORS will be established in the entire India under different projects by the end of this year.

User can put his GNSS rover, on his point of interest, collect data in static survey mode and upload his data into online processing platform of SOI. Online processing platform will process data and provide coordinates of site along with Processing report. The CORS network is available 24 hours per day, 7 days a week and 365 days a year.

By the use of CORS observation time is reduced considerably and distance dependant errors are greatly reduced. Larger area is covered with few reference stations and get accurate, reliable results economically.

Applications of CORS data are in monitoring Sea Level Changes, monitoring of the motion of critical structures such as dams, bridges, monitoring horizontal and vertical crustal motion, plate tectonics for earthquake prediction etc.

Improving efficiency of pumping systems for public water supply

Patranjan Bhattacharya
Assistant General Manager
Secure Meters Limited
India

Keywords

Enter Maximum 5 Keywords separated by comma

Synopsis

Pumping systems in public water supply account for a massive chunk of the world's electrical energy demand and contribute to a sizable drain on electricity expenses in day-to-day operations. Energy and maintenance costs put together are typically about 70-80 per cent of a pump's life-cycle cost. Pumping systems that have been in operation for a long time may have experienced deterioration; even the pumping requirements change over their lifetime, as systems move away from their design conditions. Because of poor maintenance at public water utilities, pump efficiency keeps on deteriorating over a while, resulting in massive power wastage and reduction of the asset life. As energy costs are increasing rapidly, any effort to conserve energy in pumping operations can result in huge energy savings.

Today, in India, public water supply and related operations are among the areas where there is little technological intervention and focus. As a result, the existing and potential problems, concerning the pumping assets, often get neglected. At most of the pumping stations in India, monitoring is being done manually through a log sheet, which has a high human dependency, is error-prone, and cannot raise alerts in case of any issues.

A proper measurement and verification process through suitable technology deployment and appropriate preventive and corrective actions can go a long way in increasing the asset life of pumps. It reduces the operational expenses on account of electricity consumption. In this paper, the author intends to share his experiences and explain how proper monitoring of a pumping system can help take it back to its original design parameters and significantly improve the efficiency of the overall system. The paper also talks about how public-private collaboration at public water supply utilities can help address the often overlooked and neglected problems related to cost of operations.

Envisioning Digital Green Through IoT

Dr R N Sankhua
Chief Engineer (South)
NWDA, Ministry of Jal Shakti,
Govt of India

Keywords

IOT; Digital green;GPS

Synopsis

Interacting with generic objects based on radio frequency identification (RFID) tags, IP addresses for smart objects (IPSO), and sensor/sensing technologies is becoming the key to innovations in farming. Internet is an IPSO-based network, while things are objects that can be people, animals, products, or even a farm vehicle. The adoption rate of IoT technology, i.e, the Internet of Things (IoT), sensors and actuators, geo-positioning systems, Big Data, Unmanned Aerial Vehicles, robotics etc is skyrocketing across the board, and of worldwide enterprises have employed IoT applications in one way or the other, and agriculture and farming have no exception. IoT-oriented farming is now the future with promising applications and solutions which may include farm vehicle tracking, livestock monitoring, storage monitoring, crops/plants monitoring etc promising greater efficiency, less resources, less human intervention, automation, data-driven processes, increased production, water conservation, real-time data and production insights and accurate farm and field management, and many more. A key example being its use in fertilizing crops, where machine sensors gather information about the crops, and the GPS records the exact position it is applied on the field. The technology then aids the application of fertiliser only to the areas where it is needed and can vary the rate of application to target nutrient-deficient sites. This saves money on fertiliser product, as well as the environment from over application and runoff into local streams and rivers. Yet, with smart farming, some jobs are taken over by technology including sensors, drones, AI, and robotics to optimisation. This article articulates the use of digital technology in fostering an enhancement in the digital green.

Digital Initiatives in Water Resources Management

Dr R N Sankhua
Chief Engineer (South)
NWDA, Ministry of Jal Shakti,
Govt of India

Keywords

Digital initiative; water sector digitalization;

Synopsis

Intelligence amplification of water systems with increasingly digital maturity of water utility leads to improved capacity to adopt more innovative use of digital technologies, catalysing for safe, sustainable, resilient, and inclusive water management, where water professionals have a crucial role in the digital transformation of the water sector through a way which is fair, sustainable, equitable, and integrated manner. Managing ageing infrastructure and large networks of water systems are big challenges facing water organisations. A key priority on the horizon to improve asset management across the whole water cycle is the development of predictive maintenance solutions to mitigate the urban flooding, irrigation, and drinking water issues among other new digital solutions for water management. Field-scale phenotypic information can be quantified accurately and integrated with big data to develop predictive and prescriptive management tools. Digital is key to unlocking the systems approach to water management that's needed to address the diverse social, environmental and economic challenges facing the water industry. Internet of Things (IoT) technologies, such as data analysis, cloud computing, cognitive augmentation and blockchain entail new possibilities to analyse, automate, correct in real time, forecast, and minimise risks. They can help water and sanitation arena to address many of the challenges, such as extending the useful life of ageing assets; reducing leaks, attacks, and other anomalies in the distribution network; improving water quality, service levels and the reliability of the supply; promoting water conservation or increasing revenues through greater operational efficiency. Even though the uptake of digital technology has increased in the water sector, it still is behind other industries with regards to integrating new smart technologies and digital transformation. Digitalisation can provide diversity and modularity, by combining water as per usage with digital control to support data-driven models that can help integrate and optimise smart pumps, valves, sensors, and actuators. It can also enable each device to talk to each other, or for that matter to the utility and customers, and send real-time information that can be accessed and shared over the cloud. This article astutely synthesizes a sizable amount of prophetic insight to spotlight digital initiatives of water resources management in current and look ahead prospective.

“Maharashtra Pipeline Water Grid” Sustainable Solution for Water Crises

Dr. R. K. Suryawanshi
Emeritus Prof COEP
India

Raibbhann Sarnobbat
Research Scholar -COEP
India

Pritam Bhadane
Research Scholar- COEP
India

Vaibhav Markad
Research Scholar –COEP
India

Keywords

Water crises, Pipe line water grid, gravity flows, ArcGIS

Synopsis

Water crises of unprecedented nature being felt in Indian state of Maharashtra for last few years. There are peak floods during monsoon period but in the same region there is no water during summer months. Some regions chronically face droughts and the rivers currents have webbed. Some reservoirs overflow during monsoon whereas some do not even get filled up to designed capacities. Thus, spatio-temporal natural water distribution is highly uneven. On the other hand, water demands are increasing rapidly causing conflicting situations and socio-economic crises. In fact, water management is one of the biggest challenges the state is facing.

To overcome these issues, in this study an attempt is made to develop an “inter basin water transfer pipeline grid” for the river basins in the state of Maharashtra with the objective of transfer of water from surplus to deficits on both spatial and temporal scale. Major storages in all the river basins of Krishna, Godavari, Tapi and west flowing rivers of Konkan region in the state are tagged at the geo-referenced locations on the Digital Elevation Model (DEM) of Maharashtra. Using the DEM to contour maps, morphology of the basins, as well as FRL&DSL of each of the selected reservoirs, pipe line water grid is delineated using Arc-GIS for intra basin as well as inter basin regions of the state. An attempt is made to ensure gravity flows in the grid. The pipeline grid consists of 1.8 m diameter concrete pipes to be running alongside of the existing roads, state and national highways. The pipeline grid is to operate during monsoon so that waters can be transferred from spilling reservoirs to deficit reservoirs. It can also operate during non- monsoon periods to serve the scarcity regions. Since the pipeline grid is designed for gravity flow and no major land acquisition issues involved, the inter basin pipeline water grid can be an effective and sustainable solution to mitigate the water crises the state is facing.

SCADA Based Tube Well Automation in Himachal Pradesh & Bihar

Rakesh Bhat
SCADA Expert, TAMC
National Hydrology Project

Rakesh Kashyap
Senior Joint Commissioner
National Hydrology Project

Kushagra Sharma
Senior Joint Commissioner
National Hydrology Project

D. Ganansundar
Senior Joint Commissioner
National Hydrology Project

Raja Ram Purohit
Deputy Director
National Hydrology Project

Keywords

Ground water, Tube wells, Water management, Sustainability, Efficiency, IIOT, SCADA, Predictive & preventative diagnostics, Water accounting

Synopsis

The decline in ground water availability and its quality on account of rise in population, expansion of industrial and agricultural activities and climate change driven alterations to the hydrological cycle has become a global concern. Proper monitoring and conservation of water has now become imperative. It is the need of hour to develop optimal solutions for water accounting, reduction of Non-revenue water (NRW), optimization of process efficacy & judicious utilization of resources & machinery. There have been a lot of research & development activities by various agencies for more than a decade. To address these issues of ground water and to ensure proper water management, the concept of IIOT (industrial internet of things) & SCADA system in combination with development of various predictive & preventative diagnostic algorithms has been developed as a most innovative technological tool.

It is suggested that based on in depth experience of process knowledge to implement Instrumentation & Control systems along with Centralized SCADA (Supervisory Control and Data Acquisition) system in phased manner and then integrate all processes to develop a Centralized command centre for Generation (Tube wells, Water treatment plants), Distribution (Boosting stations, GSR, OHSR), DMA's, Consumer metering, Online water billing and Grievance redressal for overall water accounting.

SCADA based Tube Well Automation is the monitoring, control and optimization tool to fully understand problems and develop solutions for stabilization of ground water condition, development of reliable decision support system to achieve efficiency, equity and sustainability of ground water.

The objective of this study is to analyse how the implementation of SCADA based automation system under National Hydrology Project (NHP) in Tube well operations at Himachal Pradesh and Bihar has emerged as an optimal solution with significant improvement in water budgeting, reduction of NRW, online monitoring of process parameters (Electrical, pump efficiencies, Ground water levels etc.) on real time basis. Significant reduction of O&M charges on account of electricity charges & frequent failures of pump & other machinery are also anticipated.

SCADA Based Automation in Gang & Bhakra Canal Network

Rakesh Bhat
SCADA Expert
TAMC, National Hydrology Project

Keywords

Canal irrigation, Water management, demand prediction, Crop monitoring, SCADA, efficiency, equity, sustainability

Synopsis

Increase in water demand in India is a natural consequence of rise in population and robust economic growth which requires an efficient and optimal management of water resources (i.e Surface water & Ground water). Water is an essential input for the crops. About 80% of freshwater is used for agriculture purposes. It is essential that irrigation canals are to be operated to their maximum efficiency by minimizing the wastage of water and maximizing flexibility of its resources.

Managing canal irrigation system to achieve efficiency, equity and sustainability is a difficult task.

Implementation of SCADA based automation in Canal irrigation system with combination of crop monitoring system can play an important role in addressing these challenges. This requires a distributed network of sensors, control elements & satellite images which provide visibility into the resource availability, its consumption pattern and trends as well as impact of the environment.

By adopting an appropriate architecture and supporting technologies, it is possible to design a system that gathers real-time data that can be used for policy based control of the canal irrigation system and to build an empirical model for efficient utilization of water resources.

The objective of this study is to analyse how the SCADA based automation system implemented under NHP (National Hydrology Project) in existing canal irrigation schemes at Gang & Bhakra in Rajasthan without any structural changes has emerged as an optimal solution which supports in analysis of water demand prediction, water availability, water distribution, losses in canal system and accordingly evaluate the canal system efficiency & optimize the Canal operations.

The SCADA system has been implemented on existing canal structure at Gang & Bhakra main & Branch Canal networks on pilot basis using various control algorithms in combination with crop monitoring (satellite imaginary based) for water demand prediction based on cropping season, crop pattern & crop density. The way forward is to build the capacity of department & train the skilled man power to ensure effective use of SCADA based canal automation system & then in phased manner the entire canal network to be automated using the latest innovative technologies for efficient utilization of system.

Development of web based application for Kukadi Project Irrigation Rotation Status

Dr. H. T. Dhumal
Chief Engineer.
Water Resources Department
India

P. P. Kaduskar
Executive Engineer.
Water Resources Department
India

S. U. Dumbre
Executive Engineer
Water Resources Department
India

Keywords

integrated project, inventory of databases, visual representation

Synopsis

The Kukadi project is an integrated project that includes a canal network and five dams on Bhima River tributaries (Yedgaon, Manikdoh, Dimbhe, Wadaj, and Pimpalgaon Joge Dam). It includes the Kukadi Left Bank Canal (KLBC), which originates at Yedgaon Dam, the Dimbhe Left Bank Canal (DLBC), which originates at Dimbhe Dam, the Dimbhe Right Bank Canal (DRBC), which originates at Chainage Kilometer 2.75, the Ghod Branch Canal, which originates at Chainage Kilometer 41.6, the Meena Branch Canal, which originates at Chainage Kilometer 52.89, the Meena Feeder Canal, which originate at Wadaj Dam, Manikdoh Left Bank Canal, which originates at Manikdoh Dam and Pimpalgaon Joge Left Bank Canal, which originates at Pimpalgaon Joge Dam. The Kukadi project has a total irrigation capacity of 156278 hectares and a total water use of 1101.45 Mcum. A current inventory of databases and information that might aid in making decisions for a brighter future is essential in today's world and age of digital communications and reach. A good example of one of these projects is the Kukadi Canal Live Stream Project, which will assist the Irrigation Department in staying informed on the water flow in the canal system from the Dams and making decisions based on the current data. For canals to function properly from tail to head, design discharge must be kept both at the canal head and along the entire length of the canal. Therefore, updating distribution system information, such as gates opened, discharge released through them, time of opening & notifications regarding gate opened, discharge in cusecs, site photograph before & after opening, online chat facility, and GPS locations tracking, is the main goal of developing an app. This program included a unique method of gathering Canal Water Data and updating it in real time, visual representation on the map with pop-ups, online chat functionality, and a Special Notification Centre for making informed decisions.

Reservoir Sedimentation Assessment, a step towards better Water Management

Jaya Sood
Water Resource Management Expert
TAMC, National Hydrology Project

Rakesh Kashyap
Senior Joint Commissioner
National Hydrology Project

Kushagra Sharma
Senior Joint Commissioner
National Hydrology Project

Akriti Yadav
Technical Assistant , TAMC
National Hydrology Project

Keywords

Storage capacity, Capacity survey, Remote sensing technology, Water management, Sedimentation problem, silt removal

Synopsis

The problem of reservoir sedimentation needs clear understanding and careful consideration as it impairs the desired functionality of the reservoirs leading to storage loss for conservation uses, less flood cushion, increased silt load in conduits feeding turbines resulting in loss of hydropower, degradation of downstream channel and stream bank erosion. Unless proper assessment of the sediments being trapped in reservoirs is made, it is not possible to take remedial measures. While in India many reservoirs are periodically being surveyed to update the storage capacity, there are many reservoirs which though have serious siltation issues, however, assessment has not been made for a considerable period. There are a few reservoirs which have not at all been surveyed after the impoundment, hence the current capacity of these reservoirs is still unknown. In order to have a proper insight in to sedimentation problem, reservoirs sedimentation surveys of more than 450 no. of such reservoirs have been taken under National Hydrology Project.

These surveys are being carried out with the help of robotic boat equipped with bathymetry equipment's, GPS systems and associated software, for determination of the volume of silt deposited, its distribution, annual average sedimentation rates and update of the elevation-area-capacity curves. The pilot case study using the latest state of art technology based on remote sensing for selected reservoirs of Jharkhand and Odisha state have also been undertaken. Physical based mathematical model study for 7 numbers river basin of India viz. Narmada, Cauvery, Rāmgangā, Barak basin and 3 other sub basins from Kerala have also been taken up under NHP.

The outputs and analytics of this initiative will help the decision makers to understand the extent of sedimentation problem and to firm up mitigation measures. Concurrently, the assessment of current capacity would help the reservoir operators in preparing of more realistic water sharing plans. Results would also help in devising silt management policy and to explore the scope of silt removal through revenue generation along with other viable options of sediment management.

West Bengal Accelerated Development of Minor Irrigation Project Water Resource Investigation & Development Department Govt. of West Bengal

Prabhat Kumar Mishra
Principal Secretary,
Water Resources Investigation &
Development Department,
Government of West Bengal

Akhilesh Parey
Team Leader,
State Project Management Unit,
West Bengal Accelerated Development of
Minor Irrigation Project

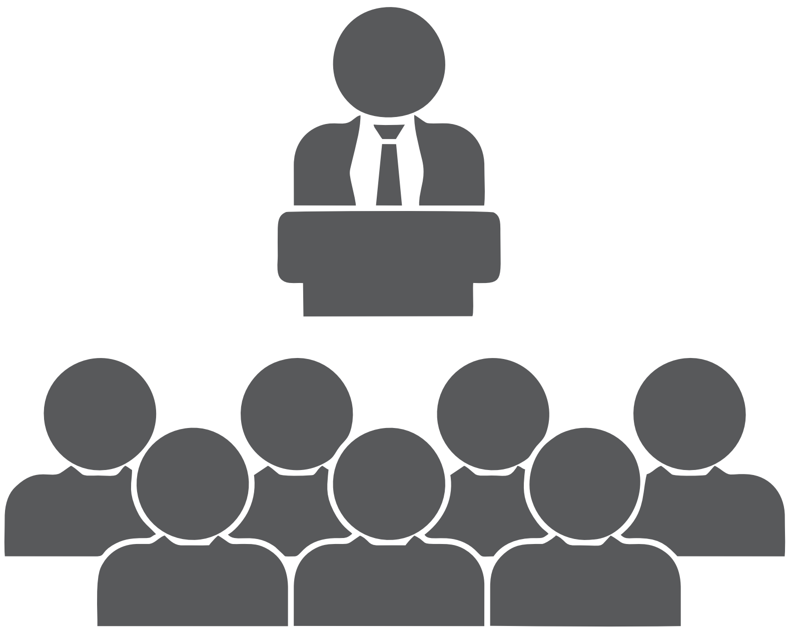
Saurabhjyoti Gogoi
Training & Communication Specialist,
State Project Management Unit,
West Bengal Accelerated Development of Minor Irrigation Project

Keywords

Water Security, Water Governance, Sustainable Development, Equity, Participatory Irrigation management, WBADMIP

Synopsis

West Bengal has 6 agro climatic zones with very diverse hydrogeomorphology. The impact of climate change in West Bengal is posing a grave threat to the water security; whether it is the intrusion of saline water in the southern districts or erratic rainfall in the dry lateritic belt of the Western districts. The alluvial districts are facing depletion of groundwater table and all these factors pose threat to the water security and could trigger environmental migration thus impacting the demographic landscape. The West Bengal Accelerated Development of Minor Irrigation project (WBADMIP) was launched in the year 2012 by Govt. of West Bengal with funding from the World Bank and the main objective of the Project was to increase agricultural production among the smaller and marginal landholders from rainfed areas through creation of minor irrigation structures, strengthening of community based institution for taking the ownership of the irrigation structures and agriculture support services to increase water productivity. In the existing system of governance these sectors were handled by different government departments which generally operate in silos resulting in limited impact. The Project experience demonstrated that community driven, decentralized approach with institutional support can strengthen the water governance and make the initiatives more inclusive. The minor irrigation schemes built under the project is entrusted with the democratically formed body called Water User Association. However, the process of democratizing the decision-making in water governance has to come up with the availability of clear operational guidelines, as well as a gestation period for strengthening the community capacity for water resources planning and management. This paper describes the key aspects of project strategies on water security and the role of local community in the water governance and sustainable development.



SPECIAL SESSION

S7:

Managing Water Related Disasters
- Floods and Draughts

Towards reducing flood risk disasters in the Pamba basin, Kerala by the development of a Flood Forecast and Integrated Reservoir Operations System

Arun C
Assistant Director
Irrigation Design & Research Board,
Kerala, India

Ashob Jacob
Assistant Director
Irrigation Design & Research Board
Kerala, India

Praseed N. S.
Team Lead
Flood forecast and Integrated Reservoir
operations system, IDRB Kerala, India

Priyesh R
Chief Engineer (FAC)
Irrigation Design & Research
Board Kerala, India

Keywords

Flood prediction, Run off, Flooding, Integrated flood management

Synopsis

The state of Kerala experienced a severe flood event during the month of August 2018. An extreme rainfall caused the reason for the flooding and a higher level of criticism were turn up that the authorities failed to manage the flood effectively. One of the worst affected basins, Pamba River Basin (PRB), received a 150-year return period rainfall. This study describes the development of Flood Forecast and Integrated Reservoir Operations System (FF and IROS) for Pamba basin forecasting flood risk in an area of 4276 km2, including a series of cascading reservoirs.

This study developed a flood forecasting system and evaluated in the Pamba basin to send early flood warning messages to ordinary people through the Kerala State Disaster Management Authority (KSDMA). The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) and River Analysis System (HEC-RAS) were used as the core of flood alert system. The implementation of the system includes the validation of observed water levels and database which includes the hydro metrological data, Land use patterns, and Reservoir data. The GIS model was developed for the basin and its refinement with actual cross-sections of the rivers and upgrading with the actual measured quantities in the field were done. The simulation and prediction of streamflow and inflows to Reservoir using HEC HMS software using the data from different weather forecasting agencies.

The system's forecast skill is calibrated and evaluated for two monsoon events selected after the statistical analysis of rainfall data observed over the basin from the year 2010. Results are encouraging for this initial operational stage, however, they also indicated that integrated hydro-metrological models are not yet mature tools. Flood risk predicted discharges at various location in the basin is assessed by driving the hydrologic model and hydraulic model with the forecasted rainfalls from the IMD GFS, NOAA GFS, ICONS and compared with the observed values in the field. The weaker part of flood risk assessment is the rainfall forecast, which underestimated cumulative depths and maximum intensities and overestimated duration.

Transforming Flood Forecasting in India – The NHP Way

Ashoke Basistha
Hydrologist, TAMC
NHP

Rakesh Kashyap
Senior Joint Commissioner I
NHP

Kushagra Sharma
Senior Joint Commissioner II
NHP

Keywords

Flood, Forecasting, Hydrologic modelling, Two-dimensional hydraulic modelling, Real Time Data Acquisition System

Synopsis

Floods bring untold miseries. Global experiences indicate flooding cannot be totally avoided through engineering measures, because of multiple reasons. However, flood losses, particularly loss of life due to flood can mostly be avoided through issue of reliable flood warnings in advance and evacuation of the people from areas under potential threat of inundation. Although common in some of the developed countries, inundation forecasting at functional level for the floodplains was not prevalent in India. Under NHP, attempt is being made to develop streamflow inflow forecast and flood forecasting system including inundation mapping at basin scales as well as well as to address the regional flooding issues for some of the states.

Two-dimensional modelling of flood flow is being coupled with meteorological forecasts, to increase the lead time available for evacuation. The best forecast product for the region would be selected based on an evaluation of the historical events for which observed rainfalls are available now, and bias correction applied if needed. The system will be frequently updated with the observations of rainfall and water levels captured through the Real Time Data Acquisition Systems installed under the NHP. Digital Terrain Models with high resolution and vertical accuracy are also being acquired under NHP which are vital for the inundation accuracy.

The accuracy of the meteorological forecasts has undergone phenomenal improvement. The accuracy of inundation forecast over the habituated floodplains is expected to gradually rise to meet the international standards in a few years. In addition to avoidance of flood deaths, this is expected to reduce damage to movable properties. The need of the hour is to establish a smooth coordination between the India Meteorological Department and the National Centre for Medium Range Weather Forecasting, the Water Resources Departments, the National and State Disaster Management Agencies across the state boundaries, to have a powerful and effective tool for mitigation of flood losses and associated trauma.

Using mathematical optimization to manage floods - a case study of Damodar River Basin

Nesa Ilich
TAMC
National Hydrology Project
New Delhi

Ashoke Basistha
TAMC
National Hydrology Project
New Delhi

Synopsis

Development of multi-purpose storage reservoirs in Damodar River Basin started in the 1950s, and it was primarily driven by a desire to introduce flood control capabilities in the lower part of the basin. Historically, the use of previous flood related models relied on established rule curves for reservoirs, which are not very useful for moderating reservoir operation during floods since each flood is unique. A new approach is presented in this paper that is based on short term flood forecasts and conjunctive use of all five reservoirs so as to minimize the negative effects of flooding downstream of Durgapur Barrage. Reservoir operation is determined by using the WEB.BM mathematical optimization program which takes into account forecast inflows and all relevant constraints, including the hydrological channel routing through the system. The results of this study show that all eleven catastrophic floods that happened between 1961 and 2018 could have been kept within the full bank capacity downstream of Durgapur Barrage if the reservoirs were operated based on the model solutions and based on the assumed reliable runoff forecast for a three-day time horizon. This is the first time an optimization-based model that takes into account reservoir and hydrological channel routing has been applied in India. It holds out a promise of better computerized real time management of floods in Damodar Basin, as well as in other basins where reliable short term runoff forecasts can be developed.

Flood Mitigation by Dams in Krishna Basin of Maharashtra State

Hanumant Tukaram Dhumal
Chief Engineer, WRD
Govt. of Maharashtra

Keywords

Flood Mitigation, Flood Inundation, Flood Absorption, Dam Releases, Intercepted Catchment.

Synopsis

The river Krishna originates in the western ghats of the State of Maharashtra in India. It flows through the Satara, Sangli and Kolhapur districts of Maharashtra, before meeting the Bay of Bengal. In 2019, widespread heavy rains occurred from 28th July to 12th August in the Krishna basin resulting in a flood situation. The flood situation started aggravating from 1st August and reached its worst on 8th, 9th and 10th August. Almost 2/3rd of the Sangli and Kolhapur districts were underwater for more than 10 days. The major flood-prone spots are Sangli, Kolhapur and Rajapur, which receive floods from free as well as dam intercepted catchments. There are 22 dams in the basin upstream of the above three spots on various tributaries. These dams have major storage below spillway crest and minor above it, against operatable gates. Dams across rivers, whether they create or absorb floods, has always been an issue of debate. This paper presents a study of the impact of flood releases from various reservoirs in the Krishna basin from 30th July to 17th August 2019, along with the role played by three major dams i.e., Koyana, Warna and Radhanagari. An ideal condition without dams is studied to assess the effect of reservoirs on downstream floods of the region.

The study reveals that during the above period, average flood values at Sangli and Rajapur have more contributions from free catchment areas, rather than dam spills. However, in critical flood situations from 6th to 9th August 2019 the major contribution in flood was from unavoidable dam spills. The flood absorption capacity of dams is classified into two stages. Stage I is till the water level reaches spillway crest level. Stage II is after the water level rises above spillway crest level and water is stored/released against gates. In Stage I, the upstream dams absorbed 3072 Mcum of water, mitigating the disaster in the flood-prone area. In Stage II, the peak discharge values were reduced for Koyna and Warna dams by 19% and 32% respectively. Also, the peaks were delayed by 2 days which contributed to flood mitigation. In the analysis of the condition (Without Upstream Dam Condition), the situation would have created an adverse impact on the flood-prone area.

Managing Water Related Disasters - Flood & Droughts "Rain Water Harvesting is a Need of the Day to Combat Floods"

ER. Kirit B. Trivedi,
B.E.(Mech.), MBA (Marketing),
CDM, M.I.E, F.I.V
D.E.E. (Mech.), Retired.,
Government of Gujarat,
Gandhinagar-Gujarat

Keywords

Flash Floods, Cloud burst, Climate Change, Sustainable Development Goals, Encroachments

Synopsis

As the insatiable needs of our society keep on increasing along with the advancement of science & technology, the entire world has faced abusive & unfair use of natural resources. As a result, today we are creating a time which we very fondly refer to as "Climate Change". In reality, our society has become more & more selfish and is leading to the destruction of natural resources just to full fill their endless desires.

It's not that the world is unaware that Mother Nature has not given us any warning signs, despite that we have been ignoring this for decades. Now when water has reached above our heads, everyone is becoming restless. As a result, we frequently witness various national & international seminars & conferences on this topic of climate change. Herein experts often discuss & share the various problems, solutions, policies & regulations.

Just recently, all the world leaders established 17 Sustainable Development Goals related to various climate challenges in the year 2015 and pledged to effectively implement the same. Today when we are gathering for the 7th edition of India Water Week and discussing various challenges related to water resources, I am sure that this topic of water related disasters would certainly be a crucial point to discuss. I am glad to receive this opportunity to share my point of view on this topic. In my full length paper, I shall be focusing mainly on the aspects of managing flood related disasters. I am happy to say that I will try to share some details on one of the divesting floods of Gujarat, which ruins Morbi City in the year-1979.

Managing Flood Disasters: Of all the deadly natural disasters such as Earthquakes, Floods, Droughts & Cyclones, floods are certainly the most unfortunate & pitiful for humankind. With the advancement of science, we now get very early warnings of floods, despite that the floods never fail to show their wrath. Floods lead to millions of dollars of losses to land, farms, buildings & industries. Mankind is left with no other option but to just helplessly be a witness to this disaster. Floods are not just a natural disaster, but in reality the response to all the atrocities that man has done to Mother Nature.

Be it a developing, under developed or a developed nation, the deadly impact of floods are seen everywhere. The key reasons behind these are deforestation, obstructing the natural flow of rivers, illegal construction on river banks, pollution of river water, plastic waste discharge in rivers, poor drainage systems and most importantly our reluctance in harvesting the gift of nature rain water, lack of efforts & lack of will power.

I believe that if we follow the tagline of the National Water Mission & Jal Shakti Ministry, "CATCH THE RAIN, WHEN IT FALLS, WHERE IT FALLS", then we can conserve each precious droplet of rain water and minimize the impact of floods. Early warning systems should not only be used for human resettlements but also for effective flood control systems & water harvesting systems. As we are unable to store rain water effectively, we witness the harmful ill effects of floods.

It is very important to regularly survey & monitor flood prone areas. Emphasizing on widening of rivers & strong willed removal of encroachments on the river banks are desperately the need of the hour. Metros & large cities need to properly conduct pre-monsoon inspection & maintenance of drainage systems.

When today the satellite imaging technology for predicting heavy rainfall and cloudburst is capable enough, can we also not conceptualize and develop a system of artificially propagating the clouds to areas distant from heavy human settlements? Or is it not possible to prematurely precipitate the clouds before a situation of cloudburst arises? Just food for thought! If we can create & control rain artificially through this medium, then we can potentially save the enormous damage to life, property and resources caused by floods. It seems very important to conduct detailed research & study on this topic.

If we look at a slightly different natural disaster i.e. Earthquakes, we might not be able to accurately & timely predict them, however we have become capable enough to design & construct buildings that can resist the harmful impact of earthquakes-all through a proper process of construction codes. Similarly, we need to create rules & codes for floods in order to protect human life. It is very important to implement construction of more water storage structures and desilting of rivers, ponds, minor dams, check dams etc.

It is unfortunate for India that we see many disparities & ideological differences in the acts for human welfare. In the midst of all these differences, many important projects get stalled and remain incomplete for decades.This is the main obstacle that slows down & creates hurdles for India's development.

Case in point, is the "Narmada Sardar Sarovar Dam"-NARMADA DAM" project that was initiated and foundation stone was laid on 5th April, 1961 and was successfully completed almost 5 decades later in the year-2017. Another such key project is the "INTER LINKING OF RIVERS" between different states & regions, wherein a lot of physical reports have come out positive. It is important to note that such key projects are approved only after thorough field & scientific reports only. My strong belief is that key projects such as these will play a huge role in resolving the challenges of flood & droughts.

The comprehensive development of any nation needs strong will power, a positive mindset, technical soundness, proper planning & implementation but most importantly a strong political will. When all these factors come together, the success & development of a nation is a 100% given.

In my full length paper, I shall be presenting a detailed approach specifically for managing & handling flood related disasters. Hope that the committee will find my inputs valuable and provide me an opportunity to present the same. Jai-Hind.

Inundation Flood Forecasting in Central Water Commission using Mathematical Modelling

Pranav Shukla
Deputy Director
Central Water Commission
India

Lovy Agarwal
Assistant Director
Central Water Commission
India

Shailendra Kumre
Hydrological Modeler
Central Water Commission
India

Keywords

Inundation Modelling, Flood Forecasting, Bathymetry

Synopsis

Inundation modelling is important for predicting flood events, particularly those with high magnitudes. The results derived from these forecasts constitute an important part of information for authorities, planners and the general public, for awareness, and to manage flooding and the risks associated with it. The main outputs from flood modelling are flood inundation and hazard maps that are used for visualizing the extents, depth, velocity and duration of flood water, which are all vital for determining and analysing areas that are at potential risk during a flood event.

Inundation Modelling is a two-dimensional modelling approach to study the hydrological processes, particularly the relationship between rainfall, runoff and channel flows to predict the areas which will be inundated due to the flood and the depth of water in river and inundated areas. In Central Water Commission, 1-D and 2-D Coupled Models developed using MIKE FLOOD software are being used for Inundation Modelling.

The salient features of the model are:

- River bathymetry is defined in 1-D model by observed cross-sections.
- Flood Plain bathymetry is defined in 2-D model by DEM.
- Computations inside the cross-section profile are done in 1-D model.
- Discharges are laterally transferred into 2-D model by cell-to-cell connection.
- 2-D model is run only for the concerned area decided using NDWI.

Models of flood prone areas of Brahmaputra, Yamuna, Cauvery, Tapi, Godavari, Mahanadi and Narmada basins have been developed by CWC so far. The models are currently being used to study past flood events. Flood Inundation Atlas and maps for Brahmaputra basin have been developed on the basis of 2, 3, 5, 10 & 25 year return period floods using the developed Inundation Model. These are used to publish inundation in Brahmaputra basin on real-time basis. Development of Early Flood Warning System (including inundation forecasting on real-time basis) for Ganga Basin is also in progress. CWC has planned to develop real-time inundation forecasting models of all basins in the near future.

Flood Prediction using an intelligent system of Machine Learning: Case Study of Gosikhurd Reservoir Project, Maharashtra

Vishnu Deo Roy
Director
Central Water Commission
New Delhi, India

Manjeet Kaur
Deputy Director
Central Water Commission
New Delhi, India

Suneet Bansal
Assistant Director
Central Water Commission
New Delhi, India

Rani. V. R
Assistant Director
Central Water Commission
New Delhi, India

Keywords

Flood Prediction, Machine learning, Artificial Neural Network, Adaptive Neuro-Fuzzy Inference, Training

Synopsis

The paper discusses the development of flood prediction model to predict peak inflow at Gosikhurd Reservoir Project on the river Wainganga, key structure in Godavari basin using major algorithms of machine learning (ML) techniques such as Artificial Neural Network (ANN) and Adaptive Neuro-Fuzzy Inference (ANFIS). The literature study also includes influence of variation in hydro meteorological parameters. The paper attempts to evaluate the ML methods to overcome the complex mathematical expression in development of floods model to conclude outcome with a higher degree of performance in addition to effective results.

The entire catchment of Gosikhurd Dam spread over 35827 sq km was divided in seven sub-catchments and distributed model approach was exercised. The peak moderation due to four reservoirs located at upstream of Gosikhurd Dam was captured through image processing and ML techniques. The storage capacity of all reservoirs has been assessed using remote sensing practices. Owing to varied climate features, ANN model has been analyzed from year 1901-2021 for various rainfall patterns using state-of-the-art weather prediction products to obtain the predicted output. The peak inflow dataset from year 2017-2021 as available, have been used to developed ANFIS model. The seventy percent dataset used for training while 30 percent dataset utilized for Validation purpose in ANFIS techniques to predict peak inflow at Gosikhurd Reservoir site. The potential of the ANFIS model is evaluated and compared with observed inflow dataset in both Training and Validation sets based on statistical indices such as Root Mean Square Error (RMSE), Correlation Coefficient (R), Coefficient of Determination (R2) and Discrepancy Ratio (D) in flood prediction. The outcome assessed from ANFIS model techniques for coefficient of correlation of observed peak inflow and predicted peak inflow for Training is 0.99 and for Validation is 0.97. The predicted peak inflow worked out at Gosikhurd Dam assessed in order of 35789 m3/s. Authors' findings highlight that ML model performance is highly contributing in the advancement of prediction systems and further can be implemented in operation of peak inflow flood forecasting purpose.

Intercomparison of Estimators of Seven Probability Distributions for Assessment of Peak Flood Discharge

N. Vivekanandan
Scientist-B
Central Water and Power Research Station Pune,
Maharashtra, India

C. Srishailam
Scientist-C
Central Water and Power Research Station Pune,
Maharashtra, India

R.G. Patil
Scientist-E
Central Water and Power Research Station
Pune, Maharashtra, India

Keywords

Chi-square, D-index, Extreme Value Type-1, Generalized Extreme Value, Kolmogorov-Smirnov, Peak flood, L-Moments

Synopsis

Flooding is the most common hazard among the environmental hazards that impose damage in hydraulic structures viz., dams, culverts, channels, barrages, etc. This is based on a design flood for a given region and return period that is computed from the observed stream flow data. This can be achieved through Flood Frequency Analysis (FFA), which involves fitting probability distribution to the series of observed Annual Maximum Discharge (AMD). These flood estimates have also been used to design the roads, bridges, water supply systems, sewage disposal and plinth level of commercial buildings.

Out of number of probability distributions, the 2-parameter Log Normal, Pearson Type-3, Log Pearson Type-3, Extreme Value Type-1 (EV1), Extreme Value Type-2, Generalized Extreme Value (GEV) and Pareto (PRT) distributions are commonly available for FFA and hence used. The parameters of the distributions are determined by method of moments, maximum likelihood method and method of L-Moments (LMO) wherever applicable. The adequacy of fitting probability distributions considered in FFA is examined by quantitative assessment using Goodness-of-Fit (viz., Chi-square and Kolmogorov-Smirnov) and diagnostic (viz., D-index) tests; and qualitative assessment using the fitted curves of the estimated peak flood discharge (PFD).

This paper presents a study on comparison of estimators of probability distributions adopted in FFA for assessment of PFD for rivers Sutlej at Powari and Cauvery at Kollegal sites. The AMD series is extracted from the daily stream flow data observed at Powari for the period 1999 to 2021 and Kollegal for the period 1990 to 2018, and used in FFA. The study shows that the GoF tests confirm the applicability of all seven distributions adopted in FFA for estimation of PFD. The diagnostic test results indicate the D-index value of PRT (LMO) is considerably minimum than those values of other distributions considered in FFA. However, the qualitative assessment weighed with D-index values indicate that GEV (LMO) is better suited for estimation of PFD for river Sutlej at Powari while EV1 (LMO) for river Cauvery at Kollegal. The outcome of the results would be helpful to the decision makers to arrive at a design flood for designing the civil structures as also for disaster management related activities in the respective regions.

Performance of various input data sets of flood forecast models for Gandhi Sagar Dam on Chambal River during August 2022 flood

Vishnu Deo Roy
Director
Central Water Commission
India

Piyush Kumar
Deputy Director
Central Water Commission
India

Nikol
Assistant Director
Central Water Commission
India

Vaibhav Shrivastava
Hydrological modeller
Central Water Commission
India

Keywords

Five-day flood advisory, Ensemble Forecast, Rainfall-Runoff Model, Flood moderation, Reservoir Operation.

Synopsis

Chambal River is a tributary of Yamuna River which is a major tributary of Ganga River system in Central India. It witnessed a severe hydro-meteorological event in August 2022. Gandhi Sagar dam is the largest and uppermost dam with a catchment area of 22,500 sq. km among several dams & barrages in cascade on the Chambal River which play a significant role in moderating such hydro-metrological events. Central Water Commission in India runs mathematical models every three hours and the five-day flood advisory is made available online for all the level & inflow flood forecasting stations. This is generated by using rainfall-runoff-based mathematical models at the basin level as well as the regional level which are ingested with available observed/estimated rainfall for the hindcast period and rainfall forecast products for the forecasted period. The source of such rainfall input data are India Meteorological Department (IMD), National Centre for Medium Range Weather Forecasting (NCMRWF), Central Water Commission (CWC), National Aeronautics and Space Administration (NASA) & Japan Aerospace Exploration Agency (JAXA). In addition, CWC also integrated Geoglows-ECMWF streamflow forecast. The current paper compares the simulated peak flood by various model/input datasets with observed peak flood during the August 2022 period. The average rainfall for Gandhi Sagar Dam catchment was extracted from daily gridded rainfall dataset of IMD. The average rainfall of Gandhi Sagar dam was below-normal (37% lower than fifty years average (1971-2020) in June, followed by a continuous and 36% above-normal rainfall in July. Under an unusual event in August 2022, very-heavy rainfall, as high as 491.8 mm, which is 57.63% higher than the fifty years average was observed in August. Almost 33% (164 mm) of total August rainfall occurred within 3 days from 21st to 23rd of August. This resulted in a huge inflow into the reservoirs, filling almost all of them up to their full capacity in the month of August. The excess rainfall and the subsequent dam release led to severe to extreme flood situations in Chambal, Yamuna and Ganga River. During this event, CWC utilized simulations from the following four kinds of models/input data sets for generating inflow forecasts:

1. Basin scale mathematical model 5-day automatic flood advisory with GPM & GsMap for hind cast period & GFS & WRF for forecast period
2. Regional rainfall-runoff model up to Gandhi Sagar Dam with IMD gridded rainfall for hindcast period and GFS for forecast period.

3. GEoGLOWS-ECMWF Streamflow forecast using ECMWF 51 members ensemble forecast for 15 days
4. Basin scale mathematical model with GPM & GsMap for hindcast period & NCMRWF 23 members ensemble rainfall forecast for 10 days.

The hydrological and hydrodynamic model used for dam inflow simulation and forecasting, during this event was able to give a satisfactory trend of inflow forecast and was able to prove their usability in the best possible ways. The forecasted peak inflow from most of the models was short of actual observed inflow at Gandhi Sagar Dam. However, the maximum peak discharge simulated from the NCMRWF ensemble rainfall forecast was found to be the nearest to the actual peak discharge followed by the regional model simulated peak inflow. Such evaluations for different conditions may help in considered decision for Integrated Reservoir Operation to minimise flooding in downstream.

Decision Support Systems for managing water related disasters with focus on floods and droughts

Oluf Z. Jessen
Vice President
International Development
DHI A/S, Denmark

Abhilash Ajaykumar
Country Manager
DHI India, India

Tirumaleswara Reddy Nemalidinne
Technical Director
DHI India, India

Keywords

DSS, Disaster management, Water Resources management, Flood forecast, drought forecast

Synopsis

Climate change is not only impacting India, but all of us. The effects of climate change are increasing the severity of water-related issues and the associated disasters – the extreme heat waves hitting India and the historical drought in Europe during 2022 just underline that this is truly a global issue.

But there are solutions and technologies that can help us overcome barriers for efficient and resilient water resource management where one example is emerging technologies as Decision Support Systems being able to compile data (sensor, hydro-met, earth observations etc.), local expertise, highly technical tools as numerical models into a decision framework where the complicated and technical information is transformed into decision indicators assisting decision makers towards resilient and sustainable decisions for the Indian Water sector. DSS can assist inclusive planning, foster international collaboration and monitor the impact of interventions. They have huge potential to support IWRM implementation in India

DSS are today often cloud-based analytical tool(s) that can help address these challenges by enabling people to simultaneously evaluate present and future economic, environmental and social development options within a catchment, country or transboundary river basin.

DSS support science-based decisions using modelling, hydrometeorological and Earth observation data, and indicators that provide decision guidance on specific issues. This systems-based approach enables people to make robust decisions that optimize water use and water security solutions in a sustainable and equitable manner.

Water managers, policymakers, planners and analysts can use DSS to better address the complexities of IWRM in a constantly changing world. They have been implemented by DHI in numerous river basins. Examples include the Nile Basin DSS used to foster cross-boundary water management and the Ayeyarwady DSS used to develop an IWRM Basin Master Plan as well as a range of examples from India.

This presentation will focus on the latest advances within DSS for managing water related disasters, present examples and lesson learned from recent international projects as well as propose how DSS could be adopted and used as an active tool supporting a sustainable and resilient water resource management in India.

Spatiotemporal Characterization of Hydro-Meteorological Disasters of Uttarakhand: An Approach for Disaster Resilience

Pankaj Kumar
Assistant Professor
College of Technology
GBPUA&T Pantnagar
India.

Alaknandada Ashok
Dean, College of Technology
GBPUA&T Pantnagar
India

Tithi Dutta
Project Fellow
GBPUA&T, India

Keywords

Hydro-meteorological disaster, clustering, Resilience, Uttarakhand

Synopsis

The monsoon, the world's largest show, has a significant impact on Uttarakhand. While the state receives a lot of rain during the monsoon season, the state's fragile mountainous ecosystem is frequently affected by natural disasters. The Himalayan region of Uttarakhand is prone to hydro-meteorological calamities such as floods, droughts, cloudbursts, and landslides. Hydrometeorological disasters (HMD) account for a large portion of all-natural hazards and occur in all parts of the state, albeit their frequency, intensity, and social susceptibility vary by location.

To optimize the handling and reduction of disasters in Uttarakhand, this study attempted to identify a group/cluster of places and map the risk areas based on the number of natural disasters that occur, no. casualties and frequency. The k-means approach is one of several clustering strategies suggested in this research. Clustering huge data sets with rapid outliers is a strength of the k-means algorithm. Once clusters have been identified, the state can be segmented into zones of varying danger. To better protect citizens, the government and policymakers of Uttarakhand need to know which areas are most vulnerable to natural disasters and what kinds of disasters are most common there. According to that pre-disaster, disaster and post-disaster preparedness are taken which helps to lessen the severity of the disaster.

The ability to recognise and comprehend natural disasters' spatial distribution patterns (SDPs), particularly any geographic heterogeneity present therein, is of critical importance. This is crucial for achieving the goals of increased resilience to disasters, decreased frequency of natural disasters, and long-term economic growth. Particularly, the spatial structure of Uttarakhand's natural catastrophes might assist global enterprises and organisations in limiting the loss of life and property. Increasing our understanding of the worldwide SDPs of several natural disasters from a systems approach will help us get there.

The majority of Uttarakhand is in Himalayan terrain, and the disaster-affected area is geologically located in the Lesser Himalaya, Central Crystallines, and Higher Himalaya. Geological history, ongoing tectonic activity, and high relative relief, along with unusual meteorological conditions, render the area exposed to a variety of hazards, the most common of which are HMDs like flash floods, landslides, Cloud bursts, and avalanches. Most agriculture in the region relies on the southwest monsoon and winter rains for sustenance. Any disruption to such systems, including reduced strength or delayed arrival, can lead to failed crops or reduced yields. Drought conditions have been common in recent years across the state.

The current study aimed to categorize the most significant hydro-meteorological disasters to have affected the Indian state of Uttarakhand during the past two centuries. 1). The impact of the state's topography, soil, climate, and drainage conditions on the geographical distribution throughout the state. 2). Clustering the HMDs to identify the most vulnerable disaster-prone areas, allowing for proper policy planning for disaster resilience across the state.

The study yielded a base of knowledge about the physiographic as well as climatic parameters affecting the HMD disasters. It was concluded that the subdivision of the state area into geomorphological zones is useful for analysing the disasters that occurred in the area and investigating the links between disaster occurrence and physiography. There is a clear relation between slope and the occurrence of disasters of hydrometeorological origin for the state as a whole. For the steeper slope units, the number of reported disasters per unit area is higher compared to a flat area. The study found that maximum casualties happen in the district of Rudraprayag and the most disaster-prone district is Chamoli. All thirteen districts have been ranked based on disaster proneness.

Impact of Large Reservoirs on Floods Moderation: A Simplistic Approach using Naturalization of Flow

Parmod Kumar
Deputy Director
Central Water Commission
India

Sharad Chandra
Director
Central Water Commission
India.

Keywords

Dams, Reservoir Operations, Floods, Naturalization of Flow, Ganga Basin

Synopsis

Presence of dams has been a topic of debate from the point of view of its ecological footprints and more recently, floods downstream of dams have been attributed to the presence or wrong operation of dams.

Benefits of dams/water storages are obvious as they act as savings during good times so that needs can be met in difficult times. Huge investment is made after a rigorous efforts to meet the cost benefit ratio criteria. Apart from acting as storages for lean periods dams do provide cushion to absorb floods. The importance of such cushion is more relevant with increasing events of high intensity rainfall in a shorter time and with climate change and such events are expected to continue to increase. The present study aims at understanding the impact of presence of dams by comparing the natural flows with the regulated flows in one of the most flood prone basins in India i.e. Ganga basin. The study provides a simplistic approach to understand the impact of large storages on natural flow regimes of the rivers.

For the present study data of gauge sites upstream and downstream of ten major reservoirs at most upstream locations have been used. Naturalization of flow using correlation technique has provided insights into change in river regime due to presence of these large dams. It is observed that the discharge during high flow periods has reduced in all the cases while in some cases flow during low lean period has increased. Thus, presence of these dams shows benefit both in terms of conservations as well as flood moderation.

Methodology

1) Gauge and discharge data of … … … sites is analysed for the period before and after the operationalisation of dam.
2) The same has been co-related to u/s site data of … … … respectively.
3) The data for yearly maximum and low flow period for the years as shown in the table below has been used in the analysis. The data has been co-related for both the scenarios i.e. natural and after dam construction.

Conclusion

It is found that the presence of dams has not only reduced the peak flows but also improved low flows in the d/s reach of the river. Hence, in the case studies presented

Storm water drainage network modelling for Mithi Basin considering peak storm event of July 2005 in Mumbai

Poonam Sindansing
Research Scholar,
COEP, Pune (India)

Dr. R. K. Suryawanshi
Emeritus Prof
COEP, Pune (India)

Keywords

Extreme storm event, peak flood hydrograph, HEC-HMS model,HEC-RAS model, SWDnetworkmodel

Synopsis

The storm event 26th and 27th July 2005 that occurred over Mumbai is one of the extreme rainfall events ever recorded in the history of the city, with the return period greater than200 years. Huge areas of Mumbai city got inundated during this flood event for long duration causing massive destruction to life and property. Mithi river being the largest river that flows right through the core areas of Mumbai city has the catchment area of 66 sq. km. It drains the eastern and western suburbs and meets the sea at Mahim creek which is the area that was most severely affected during this flood event. One of the reasons identified for such large-scale inundation for long duration can be the inadequacy of the existing storm water drainage network. It is seen that the exiting Storm Water Drainage (SWD) network design is more than 150 years old, based on 25 mm/hr rainfall intensity and 0.5 runoff coefficient as design parameters. Thus, in view of this observed storm event, review of the existing network is now essential.

In this study an attempt is made to check the adequacy of the existing network strengthen it by additional network considering parameters of July 2005 flood event. Downloading the Digital Elevation Model (DEM) data from Bhuvan site, Mithi basin area is delineated and morphological analysis is carried out using Arc-GIS. The revised SWD design proposed is based on 1 in 30 years rainfall intensity of 125mm/hr for the duration of 3hours and runoff co efficient of 0.95 for built up area.

The flood hydrograph of the event with peak discharge of 1660 cumec at the river outfall point near Mahim creek is developed using verified HEC-HMS model using the observed parameters of the storm event. The SWD network model is developed in Sewer-GEMs for the areas found to be flood vulnerable. The flood vulnerability of the area is verified using the steady flow analysis in HEC-RAS. The network is designed for these floods vulnerable catchment with total area is 660 hectares. The total length of the proposed network is 11.5km.with outfall located in Mithi river. The rectangular channel sections with spans of 2.5m to 8.2m and rise 0.9m to 2,5m. are proposed. Diameter of circular conduits varied between1.2m to 1.5m. It is expected that this additional facility will ease out the situation considerably.

Geo-tourism for sustainable development in the sensitive and fragile hilly terrains of the Himalayas

Prabir Kr. Naik
Central Ground Water Board
North Central Chhattisgarh Region
Central Ground Water Board
Raipur

Rakesh Rana
North Western Region
Central Ground Water Board
Chandigarh

Sidhanta Kr. Sahu
Central Ground Water Board
North Central Chhattisgarh Region
Central Ground Water Board
Raipur

Mukesh Anand
Central Ground Water Board
North Central Chhattisgarh Region
Central Ground Water Board
Raipur

Shweta Mohanty
Central Ground Water Board
North Central Chhattisgarh Region
Central Ground Water Board
Raipur

Synopsis

Geo-tourism is an emerging form of tourism that may be a great step towards the sustainable development worldwide. Our nation is gifted with the mighty Himalayas which are a lap to mesmerizing and beautiful geo-tourism sites. Tirthan valley is a heavenly beautiful valley located in the Kullu district of Himachal Pradesh which is created by the pristine Tirthan River. This beautiful valley marks its presence in the Great Himalayan National Park. The valley is located 1600 meters above mean sea level between the coordinates longitude 77.4168E & latitude 31.6399N.

But in the last century, there has been a fivefold escalation in the population of India, as a result, the pressure on natural resources like soil, water, and forest resources has been elevated and resulting in ecosystem imbalance. Due to increasing anthropogenic activities done for increasing tourism and habitation purpose, the sensitive and fragile ecosystem of the area has been disturbed. Global warming has also created great climatic havoc in the last decade and is the main reason behind the melting of glaciers and likewise the rainfall and snowfall pattern has also been erratic.

Springs are the great gift of mother earth which act as the source of groundwater in the hilly terrains. Springs in the Tirthan valley which is now a day meets the domestic water requirements for the local people. Tirthan river flow is perennial in the valley which is fed by glacier. Trout fish is found in the river which is generally found in hilly streams. Different fruit found in the area are persimmon, apple, pear, and plum. People earn their livelihood from stay home tourists, and fruits from orchards called Bagan in the local language. Every house has a cow that meets its requirement. The locals are living with full Indian culture.

Also due to development activities like the construction of roads and hydroelectric projects, tunnels the natural slope is disturbed leading to landslides. To exaggerate the tourism there has been a great surge in anthropogenic activities for the development of hotels which also affected the natural drainage pattern. The groundwater resources in hilly areas are very limited. Due to development activities on hilly slopes, there is a disturbance in the catchment area of spring resulting in decrease in its discharge.

Different afforestation measures have to be taken along the hill slopes for stabilization of slope. There should be clear guidelines for sustainable development/tourism in hilly areas. For catering to the needs of the increasing population, area-specific livelihood must be planned for the local people by the local administration. Stakeholders like people/farmers and Panchayati Raj institutions must be made aware to minimize the impact of climate change through participatory groundwater management and other practices.

AI/ML based Flood Warning through Gate Control Techniques

Dr. M. Selva Balan
Scientist 'E'
Central Water and Power Research Station, Khadakwasla, Pune - 411024
Maharashtra, India

Dr. Raghuchandra Garimella
Scientist 'B'
Central Water and Power Research Station, Khadakwasla, Pune - 411024
Maharashtra, India

Keywords

Water Level based Rain Gauge, Temperature probe(s), LoRA communication, MEMS, Artificial Intelligence/Machine Learning

Synopsis

Sudden floods are occurring in all sections of India in recent times due to climate change, which is highly non linear and dynamic in nature. In present scenario the damages due to flood is directly connected to lack of advance warning information which is turn depends on the lack of automatic gauging stations in the catchment area. Advanced instrumentation today includes low cost reliable sensors with low power consumption. These installations will enhance more data available in a short span. With a trained DNN model these data models will provide proper warning in advance which will help the dam authorities to operate the gate in a programmed manner so that the flood is controlled with advance warning to the downstream. The authors propose to develop an Artificial Intelligence/Machine Learning model that takes inputs from a battery-operated, low-cost indigenous device for acquiring soil moisture, rainfall, and weather data and transmits that data via a user-independent LoRA communication network. Based on the existing gate operation rules and the additional inputs, the data-driven model generates gate operation logic using artificial intelligence and machine learning techniques. Once this model has been tested at a particular location, it may be adjusted for use at any location across India using the variable parameter as a coefficient. The system's final output would be the transmission of gate operating rules and early warning systems based on the most cutting-edge AI methodology. This project uses an innovative approach that is well-known in the automation industry: low-cost sensor-based IIOT technology with LoRA and MEMS along with discharge calculations through image processing techniques. These techniques are not in use for flood warning as the technology involves multi domain expertise. Therefore, this model would be a breakthrough and enhance the flood control approach effectively from a national perspective. The proposed system is more trustworthy, and the prediction warning is based on a data-driven approach with an AI/ML platform. CWPRS has already working on this concept for the dams under DRIP project for the state of Tamil Nadu.

Inflow Forecast at Subansiri Lower Hydroelectric Project

Vishnu Deo Roy
Director
Central Water Commission
India

Manjeet Kaur
Deputy Director
Central Water Commission
India

Suneet Bansal
Assistant Director
Central Water Commission
India

Vaibhav Shrivastava
Hydrological modeller
Central Water Commission,
India

Keywords

Five-day flood advisory, Subansiri Lower Hydroelectric Project, Rainfall-Runoff Model, Reservoir Operation

Synopsis

Forecasting reservoir inflow is essential for effective reservoir management, particularly during the flood season. Maintaining a planned reservoir level and volume in the reservoir is vital for the uninterrupted operation of all the functions that are to be served by such systems. Central Water Commission (CWC) under one of its initiative generates a five-day flood advisory at all its Level Flood Forecasting & Inflow forecasting stations, for which hydrological and hydrodynamic models of the rivers here been developed and ingested with various rainfall products available from several agencies. The outputs from such mathematical models serve in various river and dam flow management activities, while this also plays a very crucial role in mitigating floods. Under this initiative, one such mathematical model has been developed using MIKE software for forecasting inflow for Subansiri Lower Hydroelectric Project (SLHEP), being constructed on the Subansiri river. It is one of the important and largest Trans-Himalayan north bank tributary of the mighty Brahmaputra River which originates from Tibetan Plateaus and flows through the state of Arunachal Pradesh in India to finally join the Brahmaputra River in the state of Assam. The SLHEP is the biggest hydroelectric project of India in terms of installed capacity, which is a run-of-the-river hydroelectric project that will generate 2,000 MW of electricity. The performance of this model is calibrated (2018-2019), R2 ~ 0.74 and validated (2020-2021), R2 ~ 0.62 as per the past observed inflow at the dam location. The model is able to give a satisfactory match with the observed discharge and is able to predict most of the peak discharges accurately.

The model results were made available to project implementing agency i.e. NHPC Ltd. During construction on pilot basis for safety of construction team and resources . The calibrated model outputs will be continuously shared with the project authority during its operation after commissioning shortly.

Infrastructure Risk against Flood in a Changing Climate: A Case Study for Solar Energy Infrastructure Site

Rahul Kumar
Post-Doctoral Fellow
Florida Atlantic University
USA

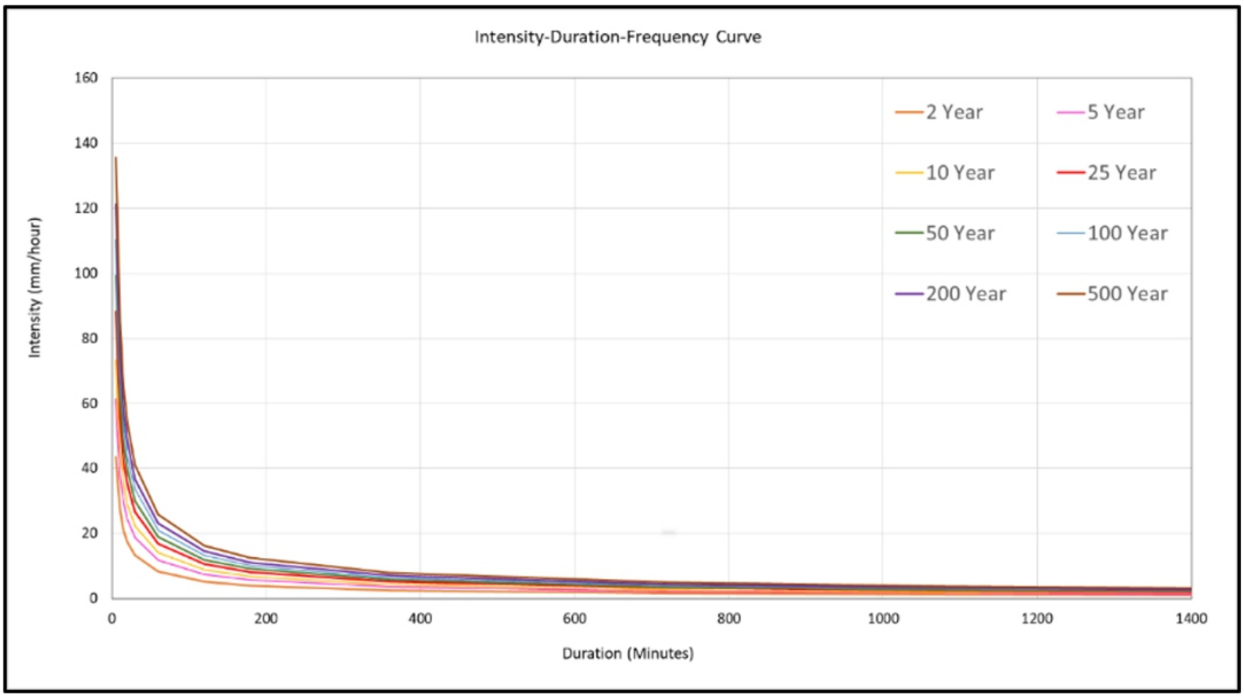
Viraj Loliyana
CEO
FAMS Design Solution Private Limited India

Keywords

Flood risk; hydraulic model; Infrastructure at risk; Climate Variability

Synopsis

Estimating economic losses caused on industrial sites and interruption of industrial business operations due to flooding events is often a difficult task. The accuracy of the estimate is affected by the availability of detailed data regarding the return period of the flooding event, vulnerability of exposed assets, and type of economy run in the affected area. This paper aims to provide a quantitative methodology for the assessment of economic losses associated with flood scenarios. The proposed methodology was performed for an urban area in Mexico which is prone to climate variability and flooding. At first, the main physical characteristics of the area such as rainfall, land use, roughness, and slopes of the area under investigation were estimated in order to obtain input for flooding simulations. Afterwards, the analysis focused on the spatial variability incidence of the rainfall parameters in flood events. The hydraulic modelling provided different flood hazard scenarios. The risk curve obtained by plotting economic consequences vs. the return period for each hazard scenario can be a useful tool for local authorities to identify adequate risk mitigation measures and therefore prioritize the economic resources necessary for the implementation of such mitigation measures. Also, historical climate variability analysis was performed. Based on projected climate variability and floods, we identified significant flood risk hazard for the site in Mexico, which may cause significant losses to halted operations during floods. Our study highlights the need to assess the economic impacts of climate change at infrastructure sites.



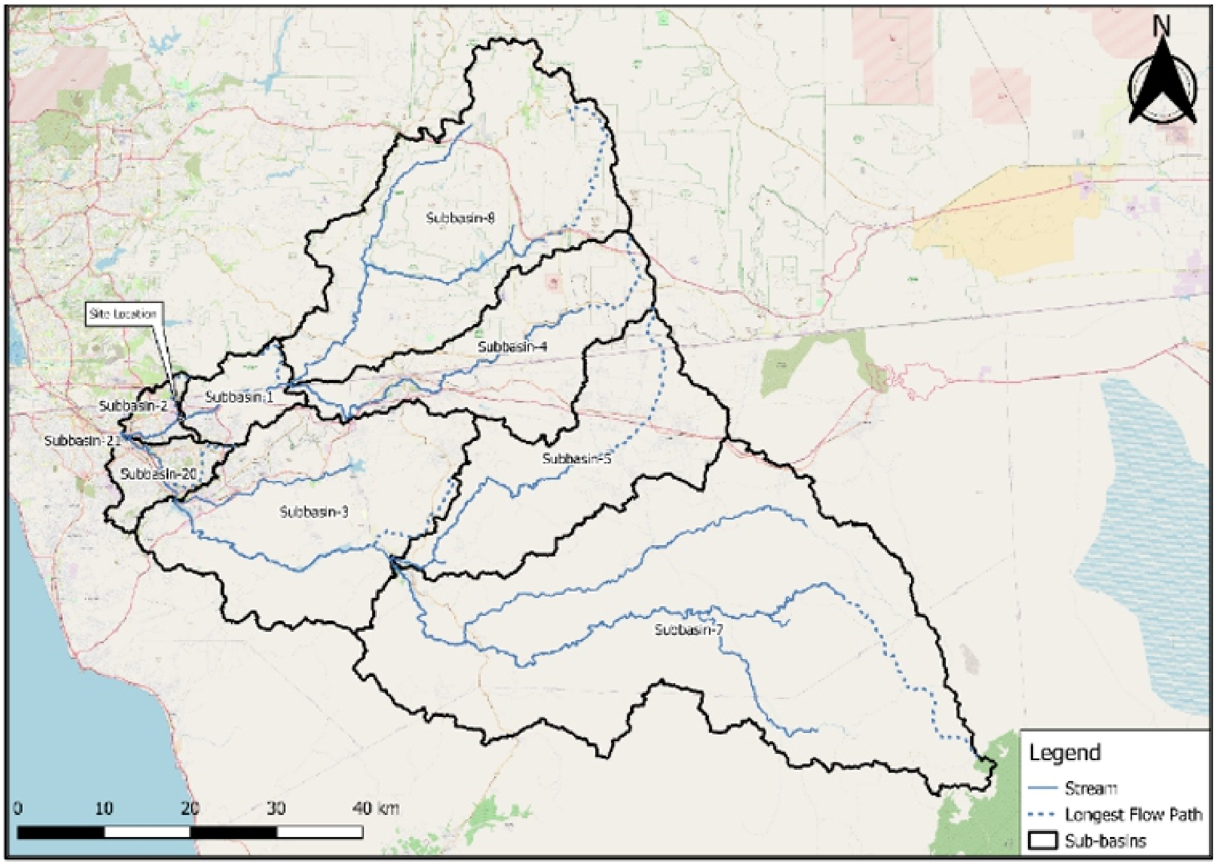


Figure 1: IDF Curves for input into Hydrological Model (HEC-HMS)

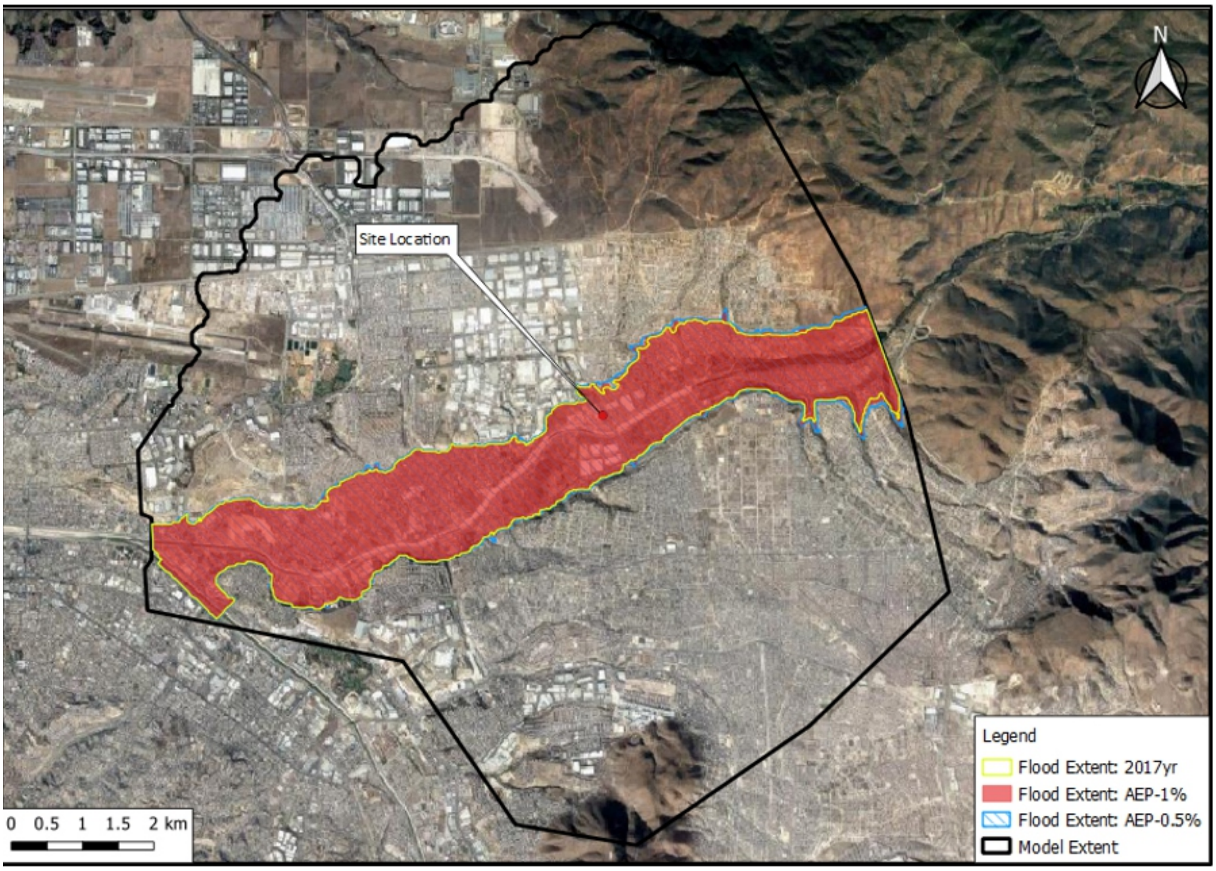


Figure 2: Flood Inundation Mapping (HEC-RAS 2D) for Historical Events

Early Warning System for Flood Prediction in the River Basins of India

Yogesh Kumar Singh
Associate Director
Centre for Development of Advanced Computing,
Pune, India

Upasana Dutta
Centre for Development of Advanced Computing
Pune, India

Murugesh Prabu
Centre for Development of Advanced Computing
Pune, India

Girish Y
Centre for Development of Advanced Computing
Pune, India

Rahul Yadav
Centre for Development of Advanced Computing
Pune, India

Rohini Kale
Centre for Development of Advanced Computing
Pune, India

Binay Kumar
Centre for Development of Advanced Computing
Pune, India

Manoj Khare
Centre for Development of Advanced Computing
Pune, India

Keywords

Hydrodynamic modelling, Flood Prediction, High Performance Computing, SAR, FOSS

Synopsis

Centre for Development of Advanced Computing Pune, has been carrying out a project viz., 'Early Warning System for Flood Prediction for River Basins of India' under the National Supercomputing Mission of MeitY and DST, Govt. of India.

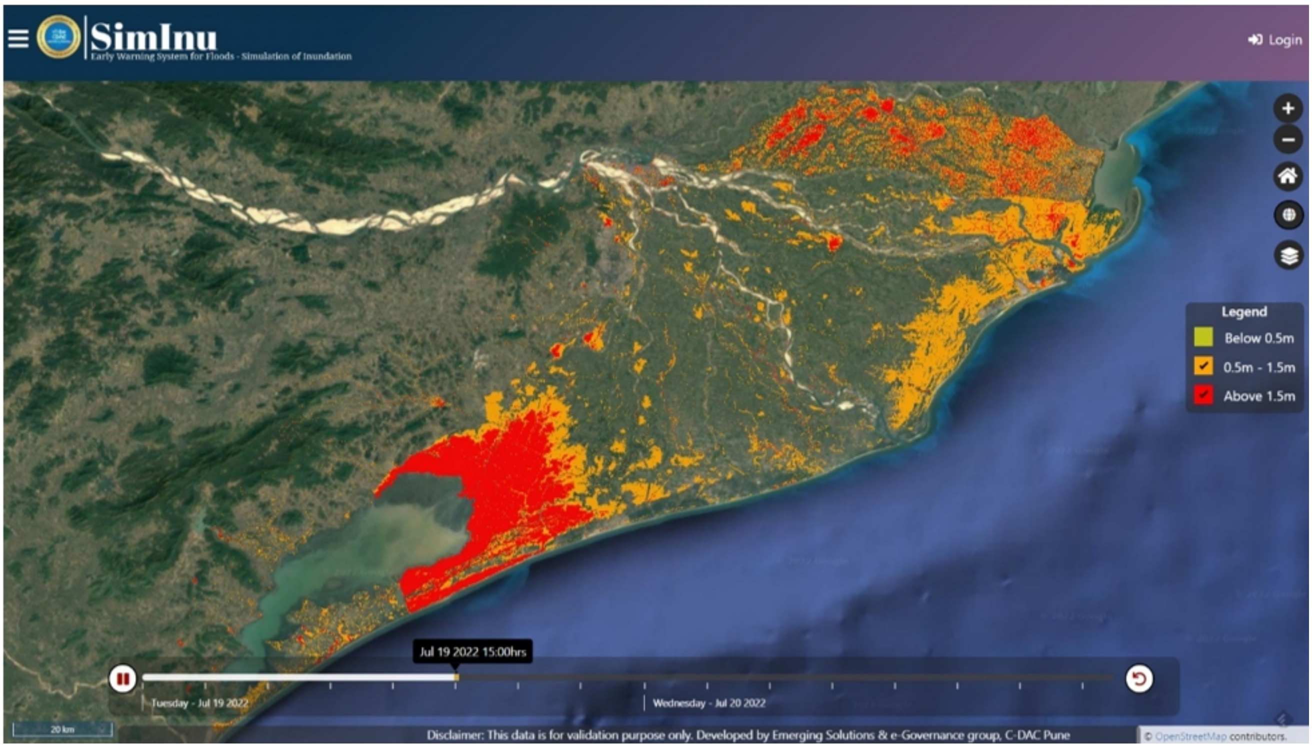
Flood Prediction and Early Warning, Reservoir Operations and Sediment transport modelling and Data dissemination to end user are major verticals under this project. Central Water Commission (CWC) is both the user and collaborator for this project.

At the behest of the user agency (CWC) the project is currently being implemented in Mahanadi River Basin. After successful completion and validation of results, it may be replicated for other River Basins of India.

State-of-the-art NSM HPC resources are being used for carrying out the daily simulation runs. Current runs are being carried out using 40 nodes of PARAM Seva (833 TF) hosted in IIT Hyderabad. The HPC resources have helped in increasing the lead time of prediction. And, as such, in the current runs, it is taking on an average 1 hour to complete 1 day prediction simulation for the current area of 11,372 sq km (Mahanadi Delta region) using 900 sqm mesh. Daily flood predictions have been started from June 1, 2022.

The prediction simulation is being aided by -a free and open-source software tool for 2D hydrodynamic modelling, viz., ANUGA Hydro suitable for predicting the consequences of riverine flooding.

The results are being shared with State Water Resources Department for validations. CWC Delhi is currently porting the simulated predicted output in their portal. Both Odisha State Water Resources Department and Central Water Commission Bhubaneshwar have been part of this project. Simulation result of 3-days forecast, Inundation extent maps and Water level and Village level percentage inundation information are being shared daily with Central Water Commission.



Prospective Agricultural Technology solutions for flood-prone and Waterlogged Ecosystems

K.G. Mandal
Director
ICAR-Mahatma Gandhi Integrated Farming Research Institute
Piprakothi- 845429
Motihari, Bihar, India

Keywords

Flood, Waterlogging, Integrated Farming, Pots-Flood Cropping

Synopsis

Floods and waterlogging are the most challenging with respect to natural resource management and agricultural growth in the country. The cyclic anaerobic and aerobic soils have different nutrient availability and soil health than short-term waterlogging soils. The situation of the problem of waterlogging in some areas has increased over time due to both natural and anthropogenic factors. Floods cause damage in vast areas, and destruction to the infrastructure, human settlements, public life, and the economy. India is particularly prone to floods and the major flood-prone area is about 41.13 million ha, which is 13% of 329 million ha of the geographic area as per a reliable estimate. It is a misery to about 113 million people i.e., about 9% of the population in India. Major flood-prone states in the country are Uttar Pradesh, Bihar, Assam, West Bengal and Odisha. It affects agricultural lands, forest lands, crops, livestock, and human life. Floods mostly occur due to high rainfall (i.e., fluvial floods), riverine floods and flash floods (i.e., pluvial floods). The damage from a river flood is widespread in Bihar, as the overflow affects smaller rivers in downstream. The degree of riverine flood is increased due to continuous rainfall and high intensity in the river catchment areas. Coastal flooding (i.e., storm surge) is also a frequent occurrence in coastal areas in the country. Vast stretches of the coastal area get inundated by seawater intrusion due to intense windstorms, high tide, and different intensities of cyclonic events. On average, floods of different types cause waterlogging (perennial and seasonal) in about 11.6 million ha in the country. The low-lying areas are mostly affected. There is a need to provide technology solutions for the waterlogging ecosystems. In this presentation, efforts have been made to elucidate the perspectives of different approaches: land shaping techniques for crop diversification, water conservation and storage in farm ponds and adoption of site-specific pond-based farming systems, diversified systems and ecoregional farming with crop-fish-animal components, rice-fish coculture systems, post-flood efficient water management for increasing cropping intensity and enhancing the productivity of agricultural lands. The technology solutions would focus on cropping to farming in flood-prone areas, ensuring food and nutrition security, and increasing farmers' income.

Diversion of West Flowing Flood Waters to the East of the Westernghats to serve the Rain Shadow Areas

K Simhachalam Naidu
Assistant Director
National Water Development Agency

Keywords

Southwest monsoon, Rain shadow areas, storages, Conveyance system, Lifting arrangements

Synopsis

Southwest monsoon strikes the westernghats and pours plenty of rainfall which floods into Arabian sea through enormous number of streams in few hours. The eastern side of westernghats, at the same time, remains as rain shadow and reels under persisting droughts. The aim of this paper is to how best these floodwaters of Damanganga can be utilized in Godavari basin through inter basin water transfer.

The Damanganga (Ekdare) - Godavari (Waghad) link project envisages utilization of 143 MCM of west flowing Damanganga waters to utilize 138.60 MCM Upper Godavari basin, to serve the drought prone Marathwada region in Maharashtra and to utilize 4.4 MCM in local projects viz Ekdare, Nirgude, Aad and Lingavane.

The link system comprises of the headworks viz the proposed Ekdare dam (FRL:374m), Hatti Weir (CL: 461.50m), Nirgude weir (CL 440.0m), Circular sump (FPL 560.0m) and the existing Inambari (FPL:516.0m), Jharlipada diversion scheme (FPL 672.4m) and Waghad (FRL: 668.50m). The conveyance system comprises of 3.04m dia approach tunnel of length 50m from Ekdare reservoir to sumpwell of Stage I lifting, 10.42 km long 5 to 6 RCC raising mains of 1.40m dia between Ekdare and existing Jharlipada diversion scheme via Nirgude weir and Circular sump; the existing link cut of Jharlipada dversion scheme of 1.30km up to Kadwa river, the 1.90 km long natural Kadwa river stream upto Waghad existing dam. The augmentation storages of Hatti and Inambari are connected to main conveyance at Nirgude with 800m and 5.0km conveyance respectively. The distribution to Aad and Lingavane is proposed from Circular sump through 12.0km long RCC pipe. The discharge in the conveyance varies between 11.66 cumec and 13.28 cumec. The diversion is proposed to be in during the months June to November. Lifting arrangements comprises sump, pump house and delivery cistern, at Ekdare, Nirgude and Circular sump with static head of 109.13m, 126 m, and 111.40 m respectively.

Out of the total diversion, 105.40 MCM will be used for irrigation, 20.82 MCM for domestic, 13.88 MCM for industrial uses and the remaining 3 MCM will be lost in transmission. The link project will provide irrigation to about 19050 ha annually (600 ha in local Ekdare, Nirgude, Aad and Lingavane) and 18450 ha in Aurangabad district under Jayakwadi command besides providing domestic water supply to 1.17 lakh population. The link project requires annual energy of 134.63MU and 274 ha of land of which 45 ha is under forest. The total cost of the link system at 2020-21 price level will be about 1599.07 crore and the benefit cost ratio will be around 2.00.

Hazard Potential Classification of Dams, India

Pramod Narayan
Director
Central Water Commission
New Delhi

Saurabh Sharan
Deputy Director
Central Water Commission
New Delhi

Teertha Ravi
Former CPMU Consultant
Dam Rehabilitation & Improvement Project
Central Water Commission, New Delhi

Keywords

Hazard potential, consequence index, fuzziness

Synopsis

Hazard potential classification of dam determines the importance of the dam which in turn provides a preliminary prioritization tool for rehabilitation works in existing dams. Hazard classification analyses involve computer modelling of a failure and the estimation of consequences. The new approach is based on critical aspects such as estimated population at risk, wave arrival time, economic and environmental consequences. In order to manage the fuzziness on the definition process of the thresholds between hazard classes, a scoring system approach with a final potential consequences index has been used, which will improve the hazard classification near the classes' boundaries. Considering the status of development in the field of risk management of dams in India, four hazard categories have been proposed in the recently published Guidelines by Central Water Commission. With the advent of advanced computing platforms and software, along with the effortless availability of temporal and spatial information, detailed analysis for estimation of the losses have become much simpler. In this study the detailed description about new hazard potential classification approach based on consequence index are explained and also hazard potential class and Inflow design flood of Ukai dam, Maneri Dam, Upper Bhavani dam, Meenkara dam, and R.A. Headworks in India are determined. This gives the comparison of design flood estimation done for these hydraulic structures as per conventional guidelines as well as based on hazard potential classification.

Also, recently enacted Dam Safety Act 2021, envisages the hazard potential classification of large dams to be completed within five years. This is a challenging task for Indian dam owners keeping in view current level of expertise and resources available with them. However, a beginning can be made with a focus on long term strategy in dam safety management. Also, this approach can be used to plan linked activities and planning for a given dam depending upon the class of hazard like frequency for updation of dam specific O&M manual, emergency action plan, risk analysis etc.

Predictive Control of the Ganga Reservoir System for Flood Mitigation

Parmod Kumar
Deputy Director
Central Water Commission, India

Sharad Chandra
Director
Central Water Commission, India

Dr. Dirk Schwanenberg
Kisters AG Germany

Dr. Mohammad Fahimuddin
M/s Tractebel Engg. Pvt Ltd

Keywords

Multi-reservoir operations, Optimization, Flood, DSS

Synopsis

India operates a large number of reservoirs for water supply, flood management, hydropower generation, among others. Given this extensive infrastructure, India can partially mitigate climate variability and the general (and possibly increasing) scarcity of water through improved dam operations. This requires a shift from the currently practiced static and individual reservoir operations to an adaptive approach that encompasses entire systems of reservoirs. Modern hydrometeorological data observation techniques, meteorological and hydrological forecasts and advanced data analytics are critical in support of this modern reservoir management approach.

Under the India National Hydrology Project (NHP), Central Water Commission (CWC) in implementing predictive multi-reservoir operations technology in the Ganga basin. This will equip CWC with a near real-time Integrated Reservoir Operation Decision Support System (IRO DSS) that provides guidance to operate major reservoirs in the Ganga Basin to reduce the fluvial flood crisis in downstream reaches by operating the reservoirs based on current as well as forecasted inflows into the reservoirs and the downstream river system. The IRO DSS will help authorities to operate their reservoirs in tandem and schedule their releases considering their current and forecasted hydraulic regimes of rivers and reservoirs. Such multiple reservoir adaptive operations, based on real-time observations from India's hydrometeorological data network and national and international weather forecasts, and including state-of-the art reservoir operations modelling and optimization techniques, will reduce the flood risks in downstream reaches and increase the conservation benefits along large parts of the Ganga river. Similar DSS can be implemented on other India river systems to protect lives, livelihood, and nature in all of India.

In this paper, we will introduce the components of the IRO DSS and describe the workings of such technology from observation network to actionable reservoir operations guidance. Based on historical flood events in the Ganga Basin, we will present hindcasting experiments to demonstrate the practical benefit of the reservoir management in several subsystem of the basin and how the predictive and coordinated approach leads to a reduction of flood peaks without jeopardising the water supply goals of the system.

S8:
Establishing a Collaborative Water Governance Regime

Legal aspects of water resources management in India

Avinash Kumar Chaudhary
Student, LLB,
Delhi University

Keywords

Flood, Waterlogging, Integrated Farming, Pots-Flood Cropping

Synopsis

There is a saying that "Jal hi Jeevan hai". It is not possible for any life to sustain, survive and prosper without water on this earth. According to Article 21 of Indian Constitution Protection of life and personal liberty: - No person shall be deprived of his life or personal liberty except according to procedure established by law. The Constitution of India has not specifically mentioned the right to water as fundamental rights but Honorable Supreme Court of India many times in its judgment observed that right to water is implied in right to life (Article 21). In spite of this, laws related to Water protection and management are not as evolved as they should be.

Laws making power related to water resources are vested with state governments in India. Unfortunately, the state government is more concerned about exploitation of water resources rather than its conservation and equitable usage. India accounts for 16.7 % of the total population in the world and 4 % of the water resources of the world. It's high time that we should think about framing uniform laws for the conservation and management of water resources. This paper is highlighting the flaws and available grey areas in existing laws/procedures with the regulatory authority in the Indian states. It also presents robust procedures and discusses the requirement of additional regulatory laws for authorities and stakeholders to mitigate existing chaos in water resource management in India.

Corporate Social Responsibility Scheme to address the water issues: A case study

Nishchay Malhotra
Scientist 'B'
Central Water and Power Research Station
Khadakwasla, Pune-411024,
Maharashtra, India

Dr. Srinivas Billakanti
Scientist 'B'
Central Water and Power Research Station,
Khadakwasla, Pune-411024, Maharashtra, India.

Dr. Supriya Nath
Research Assistant
Central Water and Power Research
Station
Khadakwasla, Pune-411024
Maharashtra, India.

R B Deogade
Scientist 'E'
Central Water and Power Research
Station
Khadakwasla, Pune-411024
Maharashtra, India.

Keywords

Corporate Social responsibility, waste water management, water crisis, Bangalore, India

Synopsis

The availability of freshwater resources is critical to the growth of society. Surface water resources such as rivers, lakes, and water bodies are being contaminated due to urbanization. Reductions in rainfall and climate change are further deteriorating the quality of water bodies. The loss of water depth in lakes, the reduction of watershed area, and the fall of water tables are other consequences associated with climate change. Bangalore which is also known as India's Silicon Valley is under immense pressure from water scarcity and pollution. The infrastructure for water pollution management in the city has not grown in tandem with population growth. As a result, storm water drains that carried precipitation into lakes were carrying untreated wastewater. Over the decades, environmental activists, NGO's, and groups of volunteers have raised the issue of waste management. The Karnataka government's policy framework for roping in institutions, industry, and corporates to solve the water crisis was an immense success. The adoption, financing, and rejuvenation of lakes as part of their corporate social responsibility (CSR) is a turning point in the management of water-related problems in the city of Bangalore. This paper highlights the work done under the CSR scheme for managing the Bangalore water problem, and the same may be replicated across India. The paper will also highlight few successful case studies of water bodies rejuvenated in Karnataka.

Tackling Challenges in Water Sector through Inclusive Governance Approach in the State of Haryana, India

Sanjay Marwaha
Member
Haryana Water Resources Authority

Synopsis

Haryana a tiny State of India, having land mass area of just over 1 per cent of total area of the country is facing water crisis on all fronts. The current cropping intensity is 194 % which is largely due to assured surface & Gound water irrigation (irrigation intensity - 95 % v/s 51% all India), has contributed in a big way towards ensuring food security in the State. However, over dependence on rice - wheat agriculture cycle coupled with poor agriculture practices has taken its toll on the water resources of the State which are dwindling day-by-day. As per latest Ground water Resource assessment (March, 20) the overall Stage of extraction of groundwater is 135 per cent. Around 79 per cent of total blocks are either in over-exploited or critical/semi-critical stage of groundwater extraction. There are around 14 per cent of villages where depth of water level is shallow (within 05 mtrs.), making these areas highly vulnerable to water logging conditions. Thus, large swath of areas either have depleted water levels or water logged - both needing urgent attention so that the sustainability of water and agriculture is achieved. Steps initiated towards good governance by the State Government are such that, areas experiencing decline of ground water have more water availability and areas experiencing rise of water level (near water logged area) are put to fruitful agriculture outputs. At Macro level, the Government constituted 'Haryana Water Resources Authority' for conservation, Regulations and Management of the water; Reorganised 'MICADA' (earlier CADA) for increasing water productivity ensuring efficient water use through micro-irrigation. All-around inclusive governance at Micro level is being undertaken highly innovative initiatives of the State Government incentive -based schemes such as Mera Pani Mera Virasat, Direct seed of rice (DSR), natural farming, on farm tank construction, Mukhya Mantri Pragatisheel Kisan Samman Yojana. Optimal use of treated water water; Recharge through wells; Land reclamation and rehabilitation of water logged areas; Individual farmer scheme based sprinkler, mini-sprinkler and drip irrigation are other measures so that every drop of water is put to its maximum use. Regulation of groundwater withdrawal by industries, infrastructure and mining sector is also being undertaken by the side. Inclusive Governance directed towards making macro and micro level efforts will result in enhanced availability and sustainability of water resources at various levels.

Understanding the challenges for Sustainability of Groundwater Resources and its Recharge mechanism with the help of PRS- Model Developed via Indo-German Bilateral Project 'Water Security and Climate Adaptation in Rural India'

Devendra Joshi
Scientist Groundwater
Amay Environmental Consultancies

Dr. Ashok Viswakarma
Scientist Groundwater
Amay Environmental Consultancies

Sourav Pahari
Technical Advisor
GIZ India

Sanchari Banerjee
GIS Analyst
Jan Madhyam

Keywords

Groundwater, Recharge Model, PRS- Model, Pre-feasibility Assessment, MGNREGA, Water level, Depletion of water level.

Synopsis

According to the Central Groundwater Board (CGWB) Report 2020, 84 Blocks in Madhya Pradesh were identified to be in water stressed condition and they are further categorised into Over Exploited, Critical, Semi- critical categories based on the percentage of water drafted from the sub surface aquifers. Keeping the above water stressed condition in purview, Groundwater Intervention Management Plan (GWIMP) has been developed with the help of the Percolation Recharge and Sub- Surface Retardation Model (PRS- Model) in a Ridge to Valley approach. This model aims for understanding the accurate zones for developing structures that would amplify the processes of Percolation and Recharge and along with that, structures that would be able to develop a backward flow of ground water highlighting the process of retardation.

With the help of this comprehensive model of groundwater recharge, Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) in Madhya Pradesh have adopted the planning mechanism for developing their Groundwater Recharge Plans and their after-quality implementation of the same on the field. The planning mechanism has been penetrated down to the technical and field functionaries of MGNREGA so as to develop Groundwater Intervention Management Plan and thereafter implement the structures on the field. The planning process includes developing various thematic data sets for understanding the overall scenario of the area of interest, identifying the declining trend of water level at the same area and thereafter proposing structures such as Percolation Tanks, Recharge Shafts, Recharge Trenches, Groundwater Tamming and Sub- surface dykes at zones that will augment the process of recharge and will provide benefit to the dwellers of the nearby region.

Hilsa fish passage through Farakka Navigation Lock-A Socio-ecological Approach

Sanjay Kumar Gangwar
Director M&A CWC Raipur
Monitering And Apparisal Dte,CWC, Raipur

Synopsis

Earlier Hilsa fish used to reach up to the then Allahabad (now Prayagraj). However, the movement of Hilsa stopped from Hoogly-Bhagirathi-River system to Ganga river upstream and vice-versa after the Farakka Navigation Lock came up in 1976.

After 40 years, the fish passage was envisaged for the unrestricted movement of Hilsa on Hoogly-Bhagirathi-River system to Ganga through Farakka Navigation Lock under Jal Marg Vikas Pariyojana of Indian Waterways Authority of India (IWAI).

A new approach/ methodology in consultation with Central Water Commission, Farraka Barrage Project Authority and Central Inland Fisheries Research Institute has been devised in IWAI and implemented successfully.

Under new approach, which is different from the conventional methods of fish passage, the new passage of Hilsa fish has been ensured/ enabled through existing Farakka Navigation Lock by synchronizing the operation of Lock gates and flow to meet the requirements of Hilsa fish movement.

The breeding of Hilsa in the upstream of the Farraka in river Ganga will not only help in restoring the fragile ecology of the river but also ensure livelihood for the local community (fisherman). It will have lasting positive impact on the socio-ecology of Ganga River system.

From Field to Realtime: Empowering Water Governance with Smart Technology

Amit Mishra
Vice President, Marketing
Vassar Labs
5th Floor, Tower 9, Mindspace IT Park, Madhapur Hyderabad,
Telangana, India - 500 081

Amruta Kar
Marketing Executive
Vassar Labs
5th Floor, Tower 9, Mindspace IT Park, Madhapur Hyderabad,
Telangana, India - 500 081

Synopsis

Climate change is dynamic in nature and its effects are imposing challenges on the environment which cannot be avoided. One of the visible challenges is the crisis of water: too much, too little or too dirty, affecting the nexus of food, water and energy. A viable measure to address this problem is to put forth efficient governance of available water resources. With the current state of affairs, correcting measures still can be taken to avoid the crisis to be worsening. There is an increasing awareness that our freshwater resources are limited and need to be protected both in terms of quantity and quality. This water challenge affects not only the water community but also decision-makers and every citizen. "Water is everybody's business" and that's what inspired Vassar Labs to bring visibility of water resources to everyone for enabling decision making, user awareness and efficient governance.

Water Resources Information and Management System (WRIMS) is an implementation of our solution, a single window access point for all water resources related information, which assists stakeholders (policymakers, managers, water-users) to visualize real-time information on weather patterns, water resources, insights on storage, inflow forecasts etc. for accounting and planning of sector wise water use i.e., demand and supply of water. The system also empowers seamless decision making when it comes to water related risk mitigation (floods) as well as disaster management. There are user-specific dashboards and advisories. The User Interface is done in GIS (Geographic information system) & easy MIS (Management Information System) formats for the user to comprehend.

Our aim is to empower decision making- balancing water use among sectors and increase water productivity for better governance; over abstraction of surface & ground water and sustainable levels of abstraction; multiple-use dams/reservoirs further enriching the cohesivity of water as a sustainable resource. The system is so envisaged that its usage helps in better planning for water allocation, efficient in season operations with fulfilled targets as well as automation of annual water accounting.

Our objective is to spread awareness in regards to Smart Water Governance, with a cloud-based system that uses a combination of emerging technologies like AI/ML, IoT, GIS etc, for data driven decision making. Integrated Water Resource Management Systems can unify data to cite current water levels, reservoir storage data, avoid flood losses, maximize equitable deficit sharing, inflow forecasts, irrigation potential, reduce demand deficit as well as reports on extreme events to maintain environmental flows and leverage decision support systems that enable optimum operations for a climate resilient and sustainable future.

To put it all into one nutshell, the way ahead is through understanding the vitality of geospatial technology for the current ecosystem, and accelerating its application readily given various industries, further taking a holistic approach to put the digital vision of the country in line with sustainable development goals. So with this integrated system we would like to showcase not only the visible use-cases, but also the broader picture that adds to water security by digitizing the diaspora of the entire water ecosystem to eliminate the gap of demand and supply as well as intervene in smart planning solutions for efficient operations and water resources management. In conclusion, we would like to cite-location intelligence empowers critical decisions and helps achieve sustainability goals by measuring, monitoring, and reporting which is a significant step towards transforming the country into a digital state with the Government interfacing citizens, businesses, and itself through the digital enablement of services and infrastructure further fostering sustainable developments with better water governance, which adds to socio-economic benefits for farmers, women and children.

S9:

Water for Environment and Livelihood

Salinization of water resources in Indian context: A long-standing problem of great concern

Aditi Tailor
Genetics and Tree Improvement Division
Arid Forest Research Institute
Jodhpur, Rajasthan-342005, India

Pooja Sharma
Centre for Development of Advanced Computing
Pune, India

Anjali Joshi
Centre for Development of Advanced Computing
Pune, India

Keywords

Salinization, Groundwater, Unsustainable Water Use, Saline Water, Desalinization

Synopsis

Salinization of water resources is a worldwide problem that also affects the soil resources adversely. Being residence to a large population, India has been facing tremendous pressure in terms of over-use of its natural water resources of the region, both above surface and under-surface, thus creating a chronic water scarcity. With climate change on the rise, this problem is expected to aggravate as it is likely to cause intrusion of salts in water resources along with anthropogenic factors, like groundwater pumping, irrigation, waste or wastewater disposal, etc. In many districts of the salinity-inflicted states of India, EC values, primary indicator of degree of salinity, of the groundwater are beyond permissible limits. Increasing salinity has not only made ground water non-potable for human consumption, it is also contributing to making lands more saline when this saline water is used for irrigation in agriculture, thus rendering land unfit for cultivation. In the past, this has driven area expansion under agriculture to meet the country's food requirements which, in turn, is caused rapid destruction of forests. Salinization has many other associated disadvantages, such as poor soil structures, losses ecosystems as well as socio-economy, leading further to problems like loss of livelihood, unemployment, migration and food insecurity. Groundwater depletion and salinization in India has arisen partly as result of promotion of agriculture growth supported by of water, energy, and food policies which have collectively lead to unsustainable use of water resources. Efficient implementation of management practices has been suggested to overcome the problem of salinity. Among them is the optimization of crop production systems so as to employ saline water for irrigation and at the same time prevent build-up of salinity in the root zone to levels that limit the productivity of soils. This can be achieved by taking into account factors such as rainfall, climate, and water table and water quality characteristics on soils and integrating appropriate crops while promoting practices like water table management (by managing abstraction, storage and recharge), rainwater conservation (by construction of engineered structures) and chemical amelioration. Furthermore, engineered techniques may be adopted to prevent movement of salt, to reduce water logging induced salinization, to reduce evaporation rates and to allow drainage. More recently, taking into consideration the limited availability of fresh water resources, desalinization of saline water (sea water) has emerged as a significant solution to addressing the problem of water availability. Phytodesalization using suitable plant species also serves as a favorable approach. As the problem of water scarcity, in its association with water salinization, is far from being resolved, there is an emergent need to assess the trends of salinization, to identify major contributors to this problem, to work out best strategies to reduce salinization as well as to realize the need to expedite desalination of saline water.

Enumeration of hydrological ecosystem service components in a Catchment

A. Sarangi
Principal Scientist
Water Technology Centre
ICAR-IARI, New Delhi-12, India

D.R. Sena
Principal Scientist
Division of Agricultural Engineering ICAR-IARI
New Delhi-12, India

C. G. Barakar
Management Trainee (Agril. Engg.)
NSCLtd, Central State Farm
Raichur, Karnataka

D.K. Singh
Professor, Division of Agricultural Engineering
ICAR-IARI
New Delhi-12, India

Keywords

Hydrologic ecosystem service (HES): InVEST model; Water Yield; Runoff and rainfall ratio; watershed

Synopsis

Ecosystem Services (ES) are benefits that people obtain from ecosystems viz. fresh water, food, fertile soils, health, economy and security. Moreover, benefits obtained from the hydrologic responses in form of runoff generation and its subsequent storage and ground water recharge are termed as hydrologic ecosystem services (HES). An attempt was made to enumerate different components Ecosystem Services (ES) using geospatial tools, SWAT and InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) model framework and to aggregate these metrics to identify hotspots of hydrological ecosystem services footprints (HESF) which can be used for making efficient water management decisions. In order to accomplish these objectives, the 3500 sq. km. Bhadra catchment in the Karnataka State was delineated with an elevation ranging from 477 to 1801m. The generated DEM was used in SWAT to delineate 64 sub basins and 754 Hydrologic response units (HRU) for quantification of surface runoff. Further, the spatio-temporal variability map of LULC, soil texture, hydrologic soil group etc. were prepared for identification of hydrologic ecosystem footprints in the Bhadra river basin. The spatio-temporal variability map of average annual precipitation of Bhadra basin indicated a variation of rainfall depth of 564mm to 4875mm. Generated actual evapotranspiration (AET) variability map ranged from 270mm to 1750mm in Bhadra river catchment. These variability maps were used in InVEST model to estimate the water yield of the catchment and the runoff and rainfall ratio (RRR) ranged from 0.25 to 0.65 for delineated 64 sub basins. The generated geospatial data and the estimated RRR can be used for enhancing water productivity in the catchment.

Water Quality Assessment of River Ganga at selected Ganga Front Towns

Hema Patel
Project Officer (Technical)
National Mission for Clean Ganga, India

D.P. Mathuria
Executive Director (Technical)
National Mission for Clean Ganga, India

Keywords

Water Quality, Ganga, Dissolved Oxygen, Physico-chemical, assessment

Synopsis

The water quality of river Ganga is monitored at various locations on main stem of river Ganga. In this study, the water quality assessment is carried out for the selected towns along river Ganga.

The River water quality is assessed for primary water quality criteria notified for outdoor bathing using physico-chemical and microbiological parameters such as pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Faecal Coliforms (FC) etc. The Data analysis was done using statistical parameters along with trend Analysis. The Dissolved Oxygen which is an indicator of river health has been found to be within acceptable limits and assessment of other parameters is also presented.

Fluoride & Fluorosis: A Socio-Economic Implication in Rajasthan

Dr Jakir Hussain
Specialist Environment
Upper Yamuna River Board, India

Dr Ikbal Husain,
Head Public Health Engineering Department (PHED)
Laboratory, Bhilwara (Rajasthan)

Keywords

Fluoride, Fluorosis, Dental, Skeletal Fluorosis

Synopsis

Fluoride plays a dual role in human health. Low fluoride concentration strengthens tooth enamel and prevents caries, tooth decay, tooth loss and cavities. Despite the fact excess intake (>1.5 mg/l) can cause dental and skeletal fluorosis (1.5–4.0 mg/l) moulting of teeth and other health problems such as low haemoglobin levels, gastrointestinal problems, bone resorption, skin rashes, urinary tract malfunctioning etc. Fluoride in groundwater is a global problem. More than 300 million people in 29 countries, including India, China, Pakistan, Saudi Arabia, the U.S., Uganda, Tanzania, Egypt, and Ethiopia, suffer from endemic fluorosis due to daily consumption of Fluoride contaminated drinking water/groundwater. In India, more than 66 million people are at risk of fluorosis due to consuming fluoride-enriched groundwater. This is alarming in 20 out of 29 states, from hard rock and alluvial aquifers in southern, central, and eastern states like Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Odisha, Jharkhand, Bihar, West Bengal, etc. to alluvial aquifers in north-western states like Punjab, Haryana, Rajasthan, Gujarat.

In Rajasthan the Central area is highly fluoride effected. Three centrally located districts viz Ajmer, Tonk and Nagore was studies for the presence of fluoride in groundwater. In the area the major problem is excessive fluoride as more than 50% of total habitations tested have excessive fluoride. Dental fluorosis is a hypomineralization of the enamel caused by excessive fluoride intake during odontogenesis. Fine white lines become discoloured enamel. Abnormalities in tooth colour and yellow to chocolate-brown stains damage young people's appearance. Due to tooth fluorosis and colour difficulties, smiling might produce insecurity and a poor look. Self-perception is a psychological trait of individuals that affects how they feel about their appearance and their happiness.

The study area covers part of the area referred to as “Banka Patti” by local people. Banka Patti literally meaning crooked stretch refers to the bent backs. The physical deformed condition of the people living in the area due to skeleton fluorosis. The social economical ramification of a population affected by fluorosis is tremendous. In an attempt to understand the nature of the fluorosis problem in Central Rajasthan.

Seasonal variation in water quality parameters of River Musi, at Damarcherla, Telengana

Karnakar kolipaka
Assistant Chemist
Central Ground Water Board

Dr Jakir Hussain
Specialist Environment
Upper Yamuna River Board, India

Keywords

Water Quality, River Musi, DO, BOD, pollution

Synopsis

Water is an important element of the physical environment and a valuable resource with numerous and varied uses. Rivers are the primary source of water for drinking, irrigation and other domestic purposes. The river shows strong seasonal dependence for various constituents and the water quality deteriorates sharply as municipal and Industrial wastes. River Musi is one of the tributaries of the Krishna River. Musi River is located at Vikarabad district and passes through the Hyderabad city with domestic and industrial discharge points on both sides, serves as an excellent disposal agent. The Objective of the study to investigate the seasonal variation in physico-chemical characterizes of Musi River at sampling station of damarcherla is located 6.3 km above from Musi–Krishna sangaman at Wazirabad, Telengana. The analysis of river water quality containing 9 parameters were analyzed and obtain results considered influences on water quality with significant seasonal changes during the all seasons of water year 2018-2019.The data has been compare with the norms of surface water of Bureau of Indian Standards(BIS:2296-1982). The obtained results revealed that increase of pollution load in winter season indicate the increase in organic matter in river water due to the anthropogenic interferences at the surrounding area of sampling point.

Assessment of Ground water Quality for Drinking and Irrigation use in Farrukhnagar block of Gurugram district, Haryana, India

Vijay Laxmi
Scientist B
Central Pollution Control Board. India

Dr Jakir Hussain
Specialist Environment
Upper Yamuna River Board, India

Keywords

Drinking and Irrigation water, SAR, % Na, Gurugram

Synopsis

Groundwater quality assessment is essential to ensure its long-term use in drinking, agricultural, and industrial activities. It is important to know the quality of water resources for drinking, domestic and irrigation in the rural and urban area. Because, in recent times, there has been increased demand for water due to population growth and intense agricultural activities, so, hydro-geochemical investigations come into prominence for the groundwater use. The purpose of this paper is to evaluate water quality of Farrukhnagar block of Gurugram district, Haryana, for both drinking and irrigation purposes.

In this study, total 37 different samples of groundwater were collected from Farruhknagar block of Gurugram district and analyzed for pH, electrical conductivity, hardness, total dissolved solids, major cations and anions. Analytical data was used to calculate irrigation parameters (SAR, percent Na, RSC, chloro-alkaline index, Base Exchange index, meteoric genesis index, and permeability index), magnesium hazard, and the Kelly index (KI). This study shows that Na and Ca are the most abundant cations, 59 and 22 percent respectively of total cations. Most groundwater samples are of the sodium sulphate or sodium chloride type based on the number of ions in water and their association type, according to the results of this study. EC categorization showed that 27% of samples are type III (high salt enrichment), 54% are type I (low salt enrichment), and only 19% are type II (medium enrichment of salts). 32% of samples showed TH levels above the BIS limit (600 mg/L), whereas 25% (68%) had levels below. Fluoride levels were found to be higher than the desirable limit (1.0 mg/L) in 57 percent of the samples. The EC of groundwater samples was associated with TDS, Na, K, Cl, and TH contents (r 0.7). The investigation showed that substantial linear positive association between the conductivity of groundwater samples (r=1.0), the conductivity of Na (r=0.81), the conductivity of TH (r=0.93), and the conductivity of Cl (r=0.93). That these ions generated spontaneously was shown by their correlation coefficient (r=0.81). TDS has a positive connection with Na (r=0.81) and Cl (r=0.93). According to Wilcox (1955), about 54% of investigated samples were very salty, and 38% were unsuitable for irrigation. Based on SAR values, 76% of samples are excellent, 21% are good, and 3% are doubtful. Wilcox's diagram showed that 22% are excellent to good, 30% are good to permissible, 11% are permissible to doubtful, 13% are doubtful to unsuitable, and 24% are unsuitable for irrigation. The USSL (1954) categorization of 35.13 percent of the study region's groundwater is C_3S_1.

Role of marginal fisherfolks in sustaining mangroves: Experiences from Point Calimere wetlands

Elamuhil S
Project Executive.
DHAN Foundation, India

Arsh Saluja
Project Executive.
DHAN Foundation, India

Madhan Mohan S P
Senior Team Leader
DHAN Foundation, India

Keywords

Ramsar Wetlands, fresh-seater interactions, Mangroves, marginal fisherfolks, conservation

Synopsis

Wetlands are one of the most productive ecosystems that have played a major role throughout human history by providing crucial services to dependent living beings. The Point Calimere wetland Complex, declared as a RAMSAR Wetland Site (No.1210), has a wide range of ecosystem habitats such as mudflats, swamps, mangroves, tidal creeks, lagoons, tropical dry evergreen forests, grasslands, coastal plains and sand dunes. The wetland complex has been engineered by the traditional communities by creating backwater canals along the intertidal zone to harvest the salt as well as the fish, well utilizing the diurnal tides. The fresh and brackish water interactions facilitated by the backwater canals favored the dense establishment of mangroves in this wetland complex, especially in the Muthupet Mangrove zone (11885.91 Ha). The backwater canals were well designed to drain the fresh water from the arteries of river Cauvery during the monsoons and allow the flow of the seawater during diurnal tides. As the freshwater supports the germination of the mangrove seeds in the intertidal zone, the seawater suffices the salinity of the intertidal zone favoring the growth of germinated mangroves. As these waters deposit silt and sludge in the backwater canals, the traditional fisherfolks who are fishing in these canals ensured the fresh and seawater interface by regularly desilting it.

The mangrove establishments are dense in the 5 km linear stretch from Athirampattinam to Muthupet as the intertidal zonal distance ranges from 2-5 kms, which is supported by these backwater fishing canals. Though the community reported that there were more than 250 such backwater fishing canals, currently 128 canals are in record and the local communities enjoy the usufruct rights over fishing in these backwater canals which are regulated by the State Forest Department. The mangroves in this wetland have posed serious threats from anthropogenic activities such as Salt pans, Shrimp culture, and also natural disasters such as Tsunami and cyclones. As the disaster rehabilitation investments encouraged the traditional fisherfolks towards sea fishing using subsidized FRP boats, the backwater fishing canals are left behind with the marginal fisherfolks.

The Gaja cyclone in 2018, severely devasted the mangroves both uprooting and shoot die back. Post the cyclone, the backwater canals remained dysfunctional due to severe sludge deposition and fallen wood debris. As the investment for desilting and debris removal were huge for marginal fisherfolk, they moved towards boat fishing as wage fisherfolk.

The poor fresh-seawater interactions favored the proliferation of halophytes such as Sueda to dominate the ecosystem suppressing the natural germination of Mangroves. Though the restoration investments on backwater canals were facilitated for the fisherfolk, less than 80 fisherfolks showed interest towards desilting the canals, specifically the older fisherfolks. As the backwater fishing is considered as a drudgery by the young fisherfolk, the future of backwater canals is uncertain. This would impose serious concern towards the mangrove survival and regeneration in the wetland complex, which is providing a wide range of ecosystem services both locally and globally. As the traditional backwater fishing canal serves as successful mangrove proliferation technique over the piloted grid or fish bone techniques, it is important for State led investments for restoration and maintenance of the back water canals in the perspectives of wetland conservation. The wetland management process shall be co-designed building on the rich indigenous knowledge of the backwater fisherfolks, enabling the marginals as the grassroot wetland conservators.

Agriculture Water Pollution in India - A Silent Alarm and Policy Action Needs

Praveen Kumar S
Project Executive
DHAN Foundation
Madurai India

Gurunathan A
Programme Leader
DHAN Foundation
Madurai, India

Keywords

Water Pollution, Agriculture, Non-Point Pollution, Organic Pollutants, National Environment Policy

Synopsis

India, the second most populous Asian Country with 0.4 billion (estimated), next to China is experiencing an alarmingly high rate of water pollution arising out of anthropogenic as well as agricultural activities, both emerging as non-point source from land mass and from farm gates. India extends over 3,287,260 Sq. Km, of which approximately 55% land is used for agriculture purpose. Water pollution poses a very serious sustainable development issue in the country. It is estimated that India's half of the morbidity problem arises out of poor water quality. Both surface and considerable quantum of groundwater in India amounting to approximately 70% is contaminated. This occurred mainly by unchecked as well as mismanaged disposal from industrial effluents, agricultural contaminants and household used and untreated water leading to sudden rise in the biological, toxic, organic and inorganic pollutants.

The Central Pollution Control Board (CPCB), the major regulator of water quality through their tests conducted over 1700 sites and have found both organic and in-organic contamination in water bodies are more than the permissible limit. Especially increasing level of ground water pollution which is out of sight compared with surface water pollution might pose a severe techno-managerial challenge to clean up and dissipate the pollutants.

Having only 2.4 percent of the world's land area, 4% of fresh water resources and over 17% global population, there prevails a great challenge to meet Water, Food and Nutrition Security of Indian Citizens. This Paper elicits the present Policy gaps and proposed policy measures to curtail agriculture water pollution and the paper was an outcome of South Asian Region Capacity Building Programme on Agricultural water pollution carried out by DHAN Foundation in India from October 2017 to December 2020.

Qualitative Profile of Biological Health Status of River Ganga

Ishaq Ahmad
Scientist-C
National Mission for Clean Ganga India

D.P. Mathuria
Executive Director (Technical)
National Mission for Clean Ganga India

Keywords

Bio-monitoring, Benthic Macro-invertebrates, River biological water quality, River health.

Synopsis

Biological monitoring, is one of the successful pragmatic approaches adopted in biological surveys to determine in-situ biological water quality of inland surface waters. Most of the biological water quality assessment surveys taken worldwide on lotic freshwater-ecosystems are based on monitoring of benthic macroinvertebrate fauna. To achieve the river rejuvenation goals through abatement of pollution under the Namami Gangae programme, National Mission for Clean Ganga (NMCG) put emphasis on ensuring regularity in monitoring (manual & real-time) the biological viz a viz microbiological and physico-chemical water quality characterization. Present study involves comparative assessment of spatio-temporal change in the river biological water quality based on biomonitoring programme undertaken by Central Pollution Control Board during 2014-2022. Community structure of the benthic macro-invertebrates of River Ganga and its tributaries reflects taxonomic richness with representative taxa distributed among the phyla Arthopoda (Crustacea; Insecta), Mollusca (Bivalvia; Gastropoda), Annelida (Hirudinia; Chaetopoda), Platyhelminthes. Amid the phase of various catchment interventions executed under the Namami Gangae programme for abatement of pollution, the results based on BMWP score clearly point towards improving tendency in biological water quality of River Ganga. It is envisaged to undertake further investigations with maximum scope for systematic understanding the spatio-temporal trends with respect to all abiotic-biotic characteristics of ecological significance to ascertain the accuracy of the findings for meeting the sustainable goals for wholesomeness and rejuvenation of River Ganga.

A review on Challenges and Solutions to Missing data in Hydrological Analysis

Karishma Bhatnagar Malhotra
Deputy Director
Central Water Commission
India

Keywords

Missing data, Imputation, Hydrological time series analysis, Artificial Neural Network, GMDH

Synopsis

Good quality of hydrological data is a prerequisite for a variety of purposes such as planning, designing, operating and maintaining multipurpose water resource projects, various modelling and statistical approaches for flood prediction and management, hydrological analysis, estimating and monitoring environmental flows, research and development etc. Hydrological data comprising of river Gauge (G), Discharge (D), Sediment (S) and Quality (Q) collected at daily, weekly, ten-daily or monthly frequencies using either manual entry procedures or automatic measurement systems at hydrological observations sites and are stored in databases that are made available to researchers, water managers etc. Missing data is a common problem in numerous hydrological databases that leads to inaccurate results, reducing statistical power and reliability of the data. Missing data also affects statistical analysis thereby reducing reliability and modelling conclusions drawn from using these incomplete datasets. There can be myriad reasons for missing data in hydrological observations such as incomplete data entry, natural calamity like floods, human error or equipment malfunctions, mismanagement, lost files, etc. In this paper a review of different techniques such as Artificial Neural Network (ANN), Group Method of Data Handling (GMDH) and other statistical models of handling and dealing with missing data is presented. The review shows that various researchers have tried to solve this ubiquitous problem of missing data in different fields of research using different approaches however, the hydrological community has paid less attention in dealing with these missing values especially in hydrological time series data.

Water Harvesting Through Step Wells Ancient Technology Survives In 21st Century Case Study Of Rejunuvation Program For Step Wells In Gujarat

ER. Kirit B. Trivedi
B.E.(Mech.), MBA (Marketing), CDM, M.I.E, F.I.V
D.E.E. (Mech.), Retired.
Government of Gujarat
Gandhinagar-Gujarat

Keywords

Step well, khandani khajana, rejunuvation, water harvesting, liquid assets

Synopsis

The source of all water is rain, a most beautiful gift of God. Natural supply of usable water for different purpose for all mankind and for all walks of life, hence we should preserve/conserve and harvest it by

adopting different traditional and contemporary methods and techniques which are available at our end at present for the betterment of mankind. Since time immemorial man has been trying to device more and more infallible methods for locating ground water. Water is a vital resource for agriculture, domestic use and industries. As per the WHO estimate only 0.007 % of all water on earth is readily available for human world consumption. The study made by IWMI-Global Water Scarcity study program, scenario of availability of water is not good and it reveals that by 2025 more than 1.8 billion people will live with absolute water scarcity.

There are various familiar water harvesting technologies which are very useful for various purposes, but these are not enough against the huge requirement of water in every field of life. Considering the facts and looking to the figures of rain fall in various districts of Gujarat, the technocrats, engineers, planners, administrators and politicians decided to implement new scheme and thus the development of rain water harvesting through the forgotten Step Well-Vaav-in the Gujarat state was taken-up. These ideas were developed and justified by the Government of Gujarat, and as such many Step Wells were searched, which were either completely blocked or partially blocked and restoration works for such Step Wells were taken-up.

Step Wells-"Jal-Mandir":-

The water is considered sacred from the time of Vedas and the steps to reach the water level in artificially construed reservoirs can be found in the sites of Indus Valley civilizations such as Dholavira and Mohenjo-Daro.Number of surviving step wells can be found across India, including in north Karnataka, Gujarat, Rajasthan, Delhi, M.P. and Maharashtra. Step wells, also called Kalyani or Pushkarni (Kannada), Bawdi (Hindi), Barav (Marathi), Vaav (Gujarati) are wells or ponds in which the water may be reached by descending a set of steps. With the passage of time old Step wells (Vaavs) were either filled or forgotten.In 2016 a collaborative mapping project, step well Atlas started to map GPS coordinates and collate information on step well. Over 2700 step wells have been mapped so far. Looking to the great value of ancient Step Wells in the field of water harvesting, National Water Mission has recently published one beautiful book on –**"Step well-Khandani-khajana-for the liquid assets of India".**

Restoration Work Of Step Wells For Water Harvesting:-

History reveals that lot of step wells may be in a damaged condition, so the state Government thought to conduct a research work to find out these historically important Vaavs and thus revive them in all respects. In view of this, Government of Gujarat started to find step wells in Gujarat and developed a data base of all the step wells and found many step wells which were forgotten in the history and they were found in some remote areas in many villages and forest areas. At present about 669 Step wells are there in Gujarat and out of this 518 are water filled and 73 are under the Archie logical Survey of India as a protected Monument. From 133 Partial blocked Step wells Government started restoration works of such step wells and rejunuvation work for about 40 step wells were done and the people residing nearby have been benefitted. Just like various historical sites are being revived throughout the world using latest technologies in the same way the glorious restoration work of Gujarat is also a real reflection of our engineering skills.

Step Wells Of Twenty First Century:-

Step wells were considered as the easiest way for rain water harvesting in old civilization and were helpful to the local population. The construction work was continued for a long time, up to about 1910, A.D. But one will be surprise to know that in recent time, in the year 2005, construction work of one step well was started and completed in the year 2009. This is Birkha-Baoli, at Jodhpur, Rajasthan and the main purpose is to conserve water for use by the city, and it is built in the style of traditional Indian step wells. The architect is Anu Mridul. This Step well is built of red sandstone, and is capable of holding 17.5 million litres of rain water. Now time is come, when one has to rethink about the rejunuvation of such ancient technology for water harvesting for the benefit of mankind by constructing more new step wells.

Benefits Of Water Harvesting Through Step Wells:-
As we are aware that we are living in such an era, where most of the countries are struggling for water and making various projects for rain water harvesting and trying to get some other solution to overcome the scanty of water. In such situation a small step to understand and look behind our old and ruined heritage constructions built for water harvesting and makes them available for water harvesting once again.

If the states which are rich in step wells can go through a detail survey of such forgotten structures and take an initiative to restore them to put in their original architectural design and make them a good source of rain water harvesting once again. I think this will be an extra ordinary tribute to those who took care of the people during that era. The reliable and informative details for the benefit of the people should make available through their official web site also.
In my full length paper, I shall be presenting a detailed information about the "khandani khajana-step wells" and its importance even in 21 century in the field of water harvesting for environment and livelihood. I Hope that the committee will find my inputs valuable and provide me an opportunity to present the same. Jai-Hind.

Environmental Flow for Existence of Ecosystems, People and Economies

Bhopal Singh
Director General
NWDA, New Delhi

N.N. Rai
Director
Central Water Commission
New Delhi

Akshat Jain
Dy Director
Central Water Commission
New Delhi

Payal Goyal
Dy Director
Central Water Commission
New Delhi

Keywords

Flow Regime; Riverine Ecology; Hydraulic Variables, Habitat Simulation

Synopsis

Water, energy and transport are the basic components for social prosperity and economic growth of any country. Historically, river valley projects have been planned and constructed to augment the supply in order to maximise the economic growth, without giving due attention to river health. This resulted in deterioration of river ecology. With growing understanding of importance of environment, ecology and habitat parameters, a need has been felt for restoration of rivers and their ecosystem through pollution control measures and release of adequate environment flows. Environmental flows (E-Flows) are required to maintain the river in desired environmental condition or predetermined state where there are competing water uses. However, taking steps to get water for environmental flows brings into focus the struggle over access to and ownership of water and water rights. In river basins where water is already apportioned, getting the water for environmental flow releases becomes a challenging task as this requires reapportionment of the water. In a developing economy like India as the economic growth and

social prosperity is advancing, the demand for water resources projects is also increasing. Consequently, rivers and their ecosystems are coming under immense pressure due to storage, diversion and abstraction of water for various consumptive and non-consumptive uses. Therefore, it is critical to balance the requirements of various human uses and ecological needs in a river system from a basin-wide perspective. The criteria for estimating environmental flows requirements should imitate the spatial and temporal flow patterns of river flow, which affect the structural and functional diversity of rivers, and which in turn influence the species diversity of the river. All components of the hydrological regime have certain ecological significance. High flows of different frequency are important for channel maintenance, bird breeding, wetland flooding and maintenance of riparian vegetation. Moderate flows are critical for cycling of organic matter from river banks and for fish migration, while low flows of different magnitudes are important for algae control, water quality maintenance and the use of the river by local people. Therefore the element of flow variability has to be maintained in a modified E-Flows regime. The present paper describes the importance of environmental flows, methodologies for environmental flow assessment and methodology adopted for the assessment of environmental flow for a reach of river Ganga between Haridwar to Unnao.

Strengthening Quality Infrastructure for Monitoring of the River Ganga in India

Franziska Wende
Project Coordinator
PTB, Germany

D. P. Mathuria
Executive Director (Technical)
National Mission for Clean Ganga, India

Dr. Anil Saxena
Technical Expert
PTB, Germany

Pallavi Bishnoi
National Consultant
PTB, Germany

Keywords

Ganga, Water Pollution, Monitoring, Quality Infrastructure, Laboratories

Synopsis

The project “Strengthening Quality Infrastructure for Water Monitoring of the Ganges River” was launched in 2019 as a part of the bilateral cooperation between the Government of India and the Federal Republic of Germany. It was commissioned by the Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, BMZ) in the frame project of the Development Programme 'Sustainable Urban Development (SUD) in India'. The project is implemented by the National Metrology Institute of Germany (Physikalisch-Technische Bundesanstalt, PTB) in cooperation with the National Mission for Clean Ganga (NMCG).

The project area is the Ganges River basin. After the launch of the Indian government's Namami Gange flagship programme in 2014 and the rejuvenation efforts undertaken through methodical interventions supported by the availability of surplus funds from various development agencies, the surface water quality of the river has been enhanced (NMCG citation). Although, the river still remains heavily polluted due to weakly monitored anthropogenic activities, presenting a great threat to people and the

environment as well as ecosystems and biodiversity in its catchment area . The lack of reliable (quality assured) water monitoring data has been recognised as one of the decisive bottlenecks for the development of specific, appropriate, and well targeted pollution-mitigation measures as well as policy instruments for the river basin. The project has been conceived to address this issue by strengthening the capacities of relevant actors to produce credible and standardised water quality monitoring data.

Situation in the intervention area: As India's holiest river, the Ganges has a high cultural and spiritual significance. Its catchment area is home to over 450 million people, more than 40 % of India's population. The river is heavily polluted, mainly due to the discharge of inadequately treated municipal and industrial wastewater and the disposal of solid waste. This represents a great threat to people and the environment as well as ecosystems and biodiversity. Vulnerable population groups such as women, people with disabilities and members of marginalised groups suffer particularly from environmental pollution and poor water quality, which affects food supply and health care. This threatens the human right to water and sanitation, as well as to an adequate standard of living for these groups. The respective State Pollution Control Boards are responsible for monitoring river Ganga and providing quality analytical data.

Situation in the sector: For rejuvenating the river Ganges, the Indian government initiated the flagship programme "Namami Gange" in June 2014 with a volume of about 2.4 billion EUR for a duration of 10 years, managed and implemented by the National Mission for Clean Ganga (NMCG). Furthermore, international development partners, as the German Development Bank (Kreditanstalt für Wiederaufbau (KfW)) and World Bank have allocated funds for infrastructure projects (mainly for municipal sewerage and industrial effluent management systems) in the Ganga basin. For the development of specific, appropriate, and well targeted measures for fighting pollution and sustaining the rejuvenation of the river, reliable (quality assured) water monitoring data are needed to map concrete pollution sources and determine the respective quality and quantity of pollutants. However, today the quality of the analytic data required for the assessment and the monitoring of the water quality of the river Ganges is insufficient. The main reasons are a) deficient coordination of the assessment and analysis of data by the environmental authorities on both state and central level, b) the lack of a water monitoring strategy and c) inadequate equipment and lack of trained personnel in the central and regional laboratories responsible for monitoring water quality in the Ganga states. This significant gap in the availability of reliable water quality data also poses a bottleneck for scientific analysis and policymaking.

Main Project Achievements: In the beginning, the project focussed on the small state of Uttarakhand (about 10 million inhabitants) at the source of the river. Soon, this approach was widened to the much bigger state of Uttar Pradesh (about 200 million inhabitants) in agreement with both the partners and BMZ. Most of the municipal and industries pollution originates in Uttar Pradesh. So, expert visits were conducted to assess laboratory capabilities of the State Pollution Control Board offices in both states. Based on the findings and the identified gaps, trainings and capacity-building activities were undertaken by PTB experts in Uttarakhand and Uttar Pradesh. Furthermore, a comprehensive summary of the assessments with a set of recommendations was handed over to NMCG and CPCB for further action. In the meantime, eight regional laboratories in Uttar Pradesh have now been accredited in accordance the standard ISO/IEC 17025:2017 during project implementation. During its activities, the project brought together expertise from India and Europe, and linked the water monitoring bodies with other relevant institutions.

This paper will especially discuss the current situation in six selected Water Monitoring laboratories in Uttar Pradesh at Kanpur, Prayagraj and Varanasi, and Dehradun, Roorkee and Kashipur in Uttarakhand, highlighting the significant developments during the ongoing project phase and the expert recommendations for steering the future efforts within the project purview.

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River rejuvenation by adopting Continuous Stream Storage approach in Mula basin using geospatial & simulation tools

Prajakta Gaware
Research Scholar
CoEP, Pune

Dr R K Suryawanshi
Emeritus Professor
CoEP, Pune

Keywords

River rejuvenation, Geospatial tools, Basin Simulation, Storage optimization

Synopsis

The riverine systems in India are currently under severe water stress and are unable to fulfill the current and rapidly increasing prospective water demands. The riverine system generally fills the existing storages during monsoon flood periods but gets dry during summer months or remains with stagnant polluted water. Such stretches are not only unpleasant sites but also potential health hazards to the local population. Also, the storage capacities of the reservoirs are inadequate to meet the peak irrigation and Public Water Supply (PWS) demands of the local population. To mitigate the effects of these issues, Continuous Steam Storages (CSS) can prove to be an effective measure. The approach adopts the creation of additional storage within the river/stream cross sections by constructing a series of small KT wear type storages at certain intervals along the length of the river/ streams. These small storages get filled during the monsoon period and increase the basin storage capacities. They meet the local irrigation and PWS demands, recharge ground, and remain filled from the environmental flows released from the upstream storages without any land submergence and other environmental issues.

This paper explains the case study of the Mula river basin in a drought-prone Nagar district of Maharashtra (India) which comes under the rain shadow region of the Sahyadri mountains and receives an annual rainfall of 550mm which is far less than the national average of 1200mm. The basin is having major storage at Mula dam having a capacity of 736.21 Mm3. However, a simulation study showed total deficits of 166.38 Mm3 in meeting irrigation and PWS demands. The main river, as well as tributaries, remain dry or polluted during the summer months. To mitigate these issues, the CSS approach is adopted in the basin. Using Bhuvan DEM, the basin is delineated, and by computing morphological parameters, additional ten stream storages are identified with a total storage capacity of 75.03 Mm3 downstream of the Mula dam with extensive use of ArcGIS and HEC-RAS. The basin simulation model is developed using RIBASIM to have the optimum allocation for PWS, irrigation, and environmental flows. After these additional stream storages filled with environmental flows are released from the Mula reservoir, simulation results indicate that water deficits are reduced to 91.35 Mm3. Thus, dry river rejuvenation is achieved by continuously releasing minimum environmental flows for filling CSS storages resulting in maintaining river ecosystem health and recharging the local groundwater storage without submergence of productive land.

Innovative framework for Water Quality Monitoring of Aquatic Resources

Rajendra Mohan Bhardwaj
Water Quality Expert
National Hydrology Project
Deptt. of Water Resources
Ministry of Jal Shakti

Kushagra Sharma
Senior Joint Commissioner
National Hydrology Project
Deptt. of Water Resources
Ministry of Jal Shakti

Dheeraj Kumar Fageria
Deputy Commissioner
National Hydrology Project
Deptt. of Water Resources
Ministry of Jal Shakti

Keywords

Water Quality Monitoring, Mobile Laboratory, Equipment, Parameter, Data, Real Time Water Quality Monitoring System (RTWQMS)

Synopsis

The water quality monitoring of aquatic resources is one of the pre-requisites to find out the utility of water for beneficial purposes. Water quality laboratories are an essential part of the water quality monitoring and thus National Hydrology Project has been mandated to strengthen and upgrade the existing laboratories of water resources departments. Besides the development of stationary water quality laboratories, mobile laboratory broadly deals with water bodies those are not monitored regularly and historical database on water quality is not available. The water resources departments of State of Gujarat and Tamil Nadu has taken the initiative and a set of mobile vans are commissioned. Mobile vans are equipped with instruments to measure the water quality parameters for level II stationary laboratories. Mobile Water Quality Laboratories are helpful to assess the fitness of water source for drinking, irrigation and industrial uses. The mobile vans are equipped with 8 equipment's comprising of the Pre-programmed UV visible Spectrophotometer, Digital Titrator, Portable Kit for Arsenic, Benchtop pH Meter, Benchtop Conductivity meter, Multiparameter Portable DO & ORP meter, Benchtop Turbidity Meter and Coliform Test kit to facilitate analyses of 23 water quality parameters. Each Mobile water quality van are equipped to perform water quality tests and analysis of the collected samples as per the prescribed norms and standards to meet BIS requirements including validation of data. The water quality data generation and dissemination through these mobile vans will be useful in chalking out policy-related measures in the catchment areas of the respective water bodies. The monitoring program will also help in creating awareness on water quality in rural and urban areas. The real time water quality monitoring system (RTWQMS) is also implemented under the project to resolve the issue of episodal pollution of canal systems in Rajasthan receiving water from the Sutlej and Beas River system of Punjab.

Assessment of Ground Water Quality in Durg district of Chhattisgarh State, India

Rakesh Dewangan
Central Ground Water Board
North Central Chhattisgarh Region
Raipur 492015 India

Anita Bind
Central Ground Water Board
North Central Chhattisgarh Region
Raipur 492015 India

Sidhanta Kumar Sahoo
Central Ground Water Board
North Central Chhattisgarh Region
Raipur 492015 India

Prabir Kumar Naik
Central Ground Water Board
North Central Chhattisgarh Region
Raipur 492015 India

Rajni Kant Sharma
Central Ground Water Board
North Central Chhattisgarh Region
Raipur 492015 India

Synopsis

Groundwater quality varies due to variation in climatic conditions, contact time of water with host rock and inputs from soil during percolation of water. The contaminations of the ground water by industrial effluent and domestic sewage sources are alarming in several parts of the country. The ground water as well as surface water is seriously deteriorated due to rapid industrialization and urbanization. The present study was conducted to assess the suitability of ground water and key contamination issues of the study area.

The present study was conducted during May 2021 with the collection of around 44 samples in the Durg-Bhilai area of the Chhattisgarh State. The collected water samples were analyzed for 16 basic parameters and 6 heavy metals as per the standard methods of analysis and results were compared with BIS drinking water standard 2012. The analytical result reveals that the most of the analyzed constituents are within the BIS prescribed limits and are fit for the drinking purpose. Majority of ground water of Bhilai-Durg twin city belongs to the calcium magnesium bicarbonate (Ca-Mg-HCO3) type and suitable for various uses like drinking, agriculture etc. However high content of nitrate, iron and manganese occurred in few of the ground water samples in the study which is discussed in this paper. Ground water is mostly neutral to mild alkaline in nature. Nitrate contamination in ground water is main problem observed in the Bhilai-Durg twin city. Exceptionally high fluoride, Iron and Manganese concentration is observed in few locations. Ground water mostly suitable for drinking and irrigation purpose in Bhilai- Durg twin city of the central India.

Groundwater Quality Assessment and Health Risks from Fluoride – A case study of Patna (Bihar)

Krishna Neeti
Department of Civil Engineering
National Institute of Technology Patna
Bihar - 800005 India

Reena Singh
Department of Civil Engineering
National Institute of Technology Patna
Bihar – 800005 India

Keywords

Water quality index, risk assessment, physicochemical parameters, correlation

Synopsis

This study focussed to determine fluoride concentration in drinking water and assess its health risks. A total of 12 physicochemical parameters were determined which includes fluoride, pH, EC, TDS, chloride, carbonate and bicarbonate (alkalinity), sulphate, nitrate, calcium and magnesium hardness. A correlation analysis method, WQI and HRA were used to determine whether the suitability of groundwater for drinking purpose in the study area. The results found in the study was: Correlation analysis showed that fluoride is negatively correlated with EC (-0.749), CO32- (-0.955) and positively correlated with Mg2+ (+0.659). All water samples exceeded the permissible fluoride limit when the results were compared to BIS (IS 10500:2012). The WQI for all the water samples was (>100), which indicates water is unfit for drinking. Health risk assessments are also performed to determine noncarcinogenic disease risks. Hazard Index was determined, and it was seen that HI was greater than 1. A hazard index (HI) ranges from 1.3 to 3.4for adult males, 1.4 to 4.0 for adult females, and 2.0 to 5.5for children. Fluoride concentrations in drinking water pose a greater health risk to children than adults. Fluoride levels in drinking water are an essential parameter that must be monitored as a corrective measure against dental and skeletal fluorosis.

Sustainable Agriculture and Water Management - Key to Economic Development

R.K. Agrawal
WAPCOS Limited

Amit Gupta
WAPCOS Limited

Keywords

Water Use Efficiency, Irrigation Technology, Socio-economic factors, Climate Change, Capacity Building

Synopsis

Water availability is detrimental to agricultural development and food production. The ever increasing population pressure leading to enhanced demand for food production mandates increase in irrigated area. However, menace of pollution and diversion of fresh water for other uses like industry has stressed the fresh water resources. Low irrigation efficiency, usually less than 65% of the applied water is actually used by the crops necessitates enhancement in sustainable use of irrigation water.

Figure 1. Objectives of Sustainable Agriculture

Efforts are being made by various stakeholders for better management and optimization of water consumption in agriculture. Better management usually refers to improvement in irrigation techniques and water use efficiency of crops. The former is closely related to the type of irrigation technology, environmental conditions and the scheduling of water application and latter involves Agricultural practices, such as soil management, fertilizer application and disease and pest control.

Socio-economic factors and climate change influence the pattern of agricultural water use. Sustainable Agriculture and water management is heavily dependent on social behavior of rural communities, economic constraints and legal & institutional framework that may favor the adoption of some measures over others.

Sustainable water management in agriculture, which has a multi-functional role, can be achieved by adopting improvements in irrigation application, soil and plant practices, water pricing, reuse of treated wastewater, farmers' participation in water management and capacity building. Equitable distribution and technological application of above initiatives is necessary for the most sought results.

This paper focuses on key factors which influences agriculture productivity and discusses State-of-Art technologies that are economically viable for sustainable agriculture. The adoption of these techniques can improve the agriculture output mitigating the adverse impact of climate change and constraints imposed by socio-economic factors.

Socio-economic development and sustainable growth with equity : with a special reference to River Basin

S. Vijaya Kumar
Executive Engineer
Irrigation and CAD Department, India

K Venkata Narayana
Deputy Executive Engineer
Irrigation and CAD Department, India

V. Mohan Kumar
Chief Engineer
Irrigation and CAD Department, India

N. Ravishankar
Deputy Executive Engineer
Irrigation and CAD Department, India

Keywords

River Basin, cooperative approach, early developers and late developers, reverse migration, Mission Bhagiratha

Synopsis

Water is a vital basic input for life and essential for all activities and a catalyst for development. Being a scarce natural resource, the stress is more pronounced with increasing population and priorities. Dependence of people for livelihood on agriculture and allied activities is more predominant in India.

As we stand today as a nation, looking back at our progress and contemplating the future, we may derive some satisfaction from the path traversed, particularly during the seventy-five years after Independence. There is the challenge of meeting the aspirations of people for socio-economic development in a way that development is sustainable and the growth processes do not destroy the delicately balanced environmental and ecological systems. At the core of all this is the challenge of meeting the water needs of the society equitably.

Exploitation of water resources increased phenomenally since the beginning of 20th century due to improved technology in building large dams and lift schemes. Consequentially, developed the reckless depletion of natural resource of water and industrial pollution of rivers and lakes. Diversion of wate hundreds of kilometres away from the river basin with no regard to the inside basin requirements of areas even adjacent to the river course. Further, these utilisations created cleavages between early developers and late developers. Accommodating democratic socio-economic aspirations of people of late developing states/regions and inside the river basin became a major challenge for the governments.

In India, especially in the peninsular and undulating terrain, large dams and small dams are increasingly accepted as complementary to each other rather than contradictory. Wherever possible, supplementation is needed from projects on main rivers which got good source of water to small dams where assured water is not available. For instance, supplementation from big reservoirs on main rivers which bring water from the western ghats to the tanks in drought prone areas in old Mahabubnagar district of Telangana state have changed the lives of people and as a result, reversal of migration of farmers and laboures is started.

There are increasing efforts, globally, towards cooperation among watercourse states for mutual benefit and protection of environment. United Nations Watercourses Convention, 1997 which entered into force in 2014, stipulated for general obligation of watercourse states to cooperate on the basis of sovereign equality, territorial integrity, mutual benefit and good faith in order to attain optimal utilization and adequate protection of an international watercourse. In India, interest in environmental issues began at the national level early in 1970s. Constitution of India mentioned 'environment' in the Directive Principles of state policy and Fundamental Duties, in 1976, a series of laws were enacted and policies and

programmes were initiated during the next ten years. Recently, Tribunals are allocating water for environmental flows also.

Report of the Commission on Centre-State Relations, 2010 recommended for a hierarchical but coordinated set of watershed agencies need to be set up by joint action of the Centre and States and participation of local bodies with inter-State basins as the focus. The overall responsibility for coordination would be that of the Inter-State River Basin Authority set up by the Central Government under River Boards Act, 1956. Disputes referred to a Tribunal (constituted on under the ISRWD Act, 1956, for making equitable allocations) should invariably be linked to constitution of Inter-State River Boards, charged with the responsibility for an integrated watershed approach towards inter-State rivers.

Nature fashioned the river basin as an ecological system or unit. A river basin is a topographic entity. While political boundaries may change from time to time and the governments which exercise control over a basin may change in number or in nature, the limits of the watershed of a river remain fixed for all time. In case of scarcity of water in relation to requirements, the watershed boundary provides a definite area within which to ration the waters; otherwise there would be no end to the claims that may be made on the scarce resource.

Since water is not uniformly distributed, transfers from basins with a surplus offer a solution to shortages in those with a deficit. Water transfers, however, create as many problems as they solve, no matter what the scale is. Even if the basin from which water is diverted have a surplus now, future requirements must always be taken into consideration. Whereas separate river basins correspond to organic units and have internal cohesion, units created through inter-basin diversion and long-distance transfer are artificial, and implicitly or explicitly, proclaim a preference for areas of need over areas of origin.

Instances of changing political boundaries within India occurred immediately after independence when most of the princely States acceded to India and during the states reorganization in 1956. Due to these changes, some regions were fortunate to get benefitted in utilization of inter-state rivers' water while some regions were unfortunate. Later on, there have been several minor adjustments in territorial boundaries by different Acts of Parliament and have their own consequences.

NCIWRD,1999 observed that almost half of the world's population suffers from diseases associated with insufficient or contaminated water. Safe water supplies and environmental sanitation are vital for health situation. Jal Jeevan Mission is envisioned to provide safe and adequate drinking water through individual household tap connections by 2024 to all households in rural India. Mission Bhagiratha taken up by Telangana government to provide safe drinking water to every house hold in Telangana state by drawing water from rivers has been a remarkable success story.

The challenge in water sector shall simultaneously take care of the needs of development and environmental health and thereby ensure the sustainability of development. The problems are not beyond the present state of knowledge and technology. Given the needed political will, societal awareness and cooperation, the nations will certainly overcome the challenges and achieve water-security for its people along with all-round development and sustainable growth with Equity.

Water Quality Comparison of Pre and Post Covid-19 Lockdown Period of Wainganga River Basin, India

Dr. Sandeep K Shukla
National River Water Quality Laboratory
Yamuna Basin Organisation
Central Water Commission
New Delhi, India

Keywords

Water Quality, Wainganga River, Pre-lockdown and Post-lockdown

Synopsis

Wainganga is one of the major river of Godavari river basin, which is the second largest basin after the Ganges basin. The two key tributaries of Wainganga River are Kanhan and Wardha. The Wainganga River originates from Seoni district of Madhya Pradesh, which situated at the foothills of Satpuda Mountains and flows till its confluence with Wardha River at Shivni Village in Chandrapur District of Maharashtra. The Wainganga river basin covers over three districts of Madhya Pradesh and five districts of Maharashtra and Kanhan originates in Satpura hills in Chhindwara district of Madhya Pradesh and flows through Chhindwara and Nagpur(MS) districts up to its confluence with Wainganga river in Bhandara district of Maharashtra.

The water quality data obtained after the analysis of sample received from June 2019 to March 2020 in pre lockdown period and compare with data received from month of June 2020 to May 2021 in post lockdown period to know the impact of lockdown on water quality of Wainganga river basin. The water quality parameters such as pH, Electrical Conductance (EC), Total Dissolved Solids (TDS), Turbidity (Turb), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Fluoride (F), Chloride (Cl), Ammonia (as N), Alkalinity (Alk), Total Hardness (TH), Boron (B), Sodium Absorption Ratio (SAR) and Total Coliform (TC) and the results compare with Designated Best Use Classification (BIS 2296-1982) and Drinking Water standard (BIS 10500:2012). The percent of water samples of during pre-lockdown period has been compared (June 2019 to March 2020) with post lockdown period (June 2020 to May 2021). It is observed from the study that overall BOD, TC, Turb, B were decreased, DO was increased and pH showing very slight change. Hence it can be concluded that the water quality was improved after lockdown period compare to pre-lockdown period. However, TDS, EC, COD, TH, F, Cl, Alk, NH3-N not decreases and no change observed with reference to SAR. Hence it can be concluded that the water quality was significantly improved with reference of BOD, TC, Turb, B and DO.

Role of Water Sensitive Cities for sustainable livelihood

Srishti Singh
Junior Research Fellow (JRF)
Maulana Azad National Institute of Technology (MANIT)
Bhopal, India

Keywords

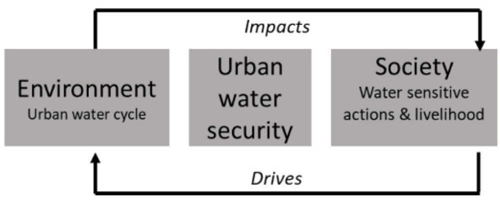
Water sensitive behaviour, socio-ecological approach, Ecological well-being, urban water cycle, conjunctive water management

Synopsis

A livelihood is sustainable when it does not deplete/disrupt ecosystems, can cope with and recover from stresses and maintain or enhance its capabilities both now and in the future (DFID 1999). The importance of water for human well-being and sustainable livelihoods cannot be overstated (CBD, 2016). This paper tries to understand the need of water sensitive behaviour of the society for developing livelihoods that are sustainable when it comes to water resources. Water has been identified as an important resource in India's governance more than three decades ago (Singh & Kaur, 2019). In 2012, the government of India adopted a fresh National Water Policy, which provided for significant change in our approach and action. Water is at the moment being used as a commodity – nearly 84% for agriculture, 4% for domestic, and rest for industrial use. In fulfilling these complex demands for water, we have overshadowed the larger socio-ecological needs. This is contrary to traditional usage – when a large percentage of water supported ecosystem recharges, conserve landscapes and forests; the significant benefits of which we have been reaping environmentally, socially and economically.

The stress on water resources is steadily increasing, because of population growth, urbanization, intensification of industries, agriculture and tourism, and rising economic welfare levels; and this stress is aggravated in recent years by the threats and impacts of climate change. Lack of water supply, sanitation and hygiene affects the health and well-being of people and ultimately affects the economic balance as well. a livelihood is sustainable "when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future" (DFID 1999).

The concept of the urban water cycle depicts the connectivity and interdependence of urban water resources and human activities, and the need for integrated management. It needs to be understood that these different forms of water are not isolated from each other, but rather they are closely linked in what is called the water cycle (UNESCO, 2020). Any approach to water resources management that takes the linkages within the water cycle systematically into account may be called 'Conjunctive Water Management'. In 2002, Wang Hao et al. developed the 'manual branch cycle' concept, which means human activities change the cycle path and performance of the natural water cycle. The well-being of present and future human populations depends on ecologically sustainable and socially equitable ways of living in the world (Neve, 2020). The urban water cycle is also a good concept for studying the water balance (also called the water budget) and conducting water inventories of urban areas. The paper will also try to link these ecological concepts with the Sustainable Livelihoods (SL) approach and come up with the discussions and conclusions on that basis.



Conjunctive Water Management is an approach to water resources management in which surface water, groundwater and other components of the water cycle are considered as one single resource, and therefore are managed in closest possible coordination, in order to maximize overall benefits from water at the short and at the long term (IW, 2022). The potential benefits of conjunctive water management are that there would be more water resources available for use and lower risk of water shortages, water resources sustainability, there are environmental, economic and social benefits and Sustainable Development Goals are achieved.

The relationship between the variations in the ecosystem and human well-being has both current and future prospects. The overexploitation of ecosystems may temporarily may disrupt the environment along with alleviating poverty and it may prove unsustainable. That is, the immediate response approach where just to solve today's pressing problems, we tend to deplete tomorrow's ecological resource base. The paper at the end will discuss the ways of bringing the change in behaviour/actions of the society for the societal and ecological well-being. Intelligent management of the water resources is required in order to cope with these growing challenges, and to achieve more resilience of the water systems and a higher level of water security at local and regional levels.

Acknowledgement
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Challenges in Managing the Environmental flows in the Interstate Rivers

Sudheer Padikkal
Consultant General Manager
KIIDC/Kerala WRD, India

Keywords

Environmental Flows, Ecohydrological Modelling, Interstate Rivers, Chalakkudipuzha Basin, PAP

Synopsis

Informed decision-making process of managing the environmental flows (E Flows) in any basin has several challenges. This is particularly more complicated in the case of interstate basins. Even a well-structured institutional arrangement in place to manage the basin, doesn't offer a promising E flows regime in most cases. In this paper, these constrains are examined in the context of an interstate river by taking a case study of Chalakkudipuzha basin in the southwest India. Recommended E flows in this basin, based on the ecohydrological model studies, are yet to be implemented due to several constraints. This paper suggests an operational framework to overcome these barriers and get the required E flows regime maintained.

Five distinct sections build this paper. In the Introduction section, the concept of E Flows and its importance in the context of ecohydrological modelling science is presented. Chalakkudipuzha River, the case study interstate basin is described in the second section together with the basin's linkages to Parambikulam Aliyar Project (PAP) Inter Basin Water Transfer (IBWT) network. The results of the

ecohydrological modelling studies conducted to assess the E Flows needs of Chalakkudipuzha basin is presented in the third section. The existing institutional arrangement to manage this basin and how this should be modified to manage the E Flows are discussed in the fourth section. Paper is concluded with some thoughts on the replicability of this framework and its standardisation.

Qualitative Review of Environmental Impact of Water Resources Projects

Ashok Kumar Kharya
Chief Engineer
Environment Management Organisation CWC

Alok Paul Kalsi
Director
Environment Management Directorate
CWC

Ashish Singh Kushwah
Deputy Director
Environment Management Directorate
CWC

Synopsis

The water resource projects have been implemented and operated since ancient times especially in Indian sub-continent. The prime example of water resource management works roots in the Indus valley civilization era. The water resource projects have immensely contributed to alleviating poverty and for growth and prosperity of the country by providing the irrigation and drinking water, flood control, navigation facilities etc. The water resource development was accelerated after the independence to meet the yearning needs of different sectors of society. However, as the magnitude of the water resource project development increased, their impact on the environment (including social) also increased substantially. To address this issue, the Government of India issued a notification in the year 1994 making Environmental Impact Assessment (EIA) mandatory for various activities (which included River Valley projects including hydel power, major Irrigation and their combination including flood control). Although some EIA Studies were carried out before 1994, it is only after EIA Notification 1994, EIA has become mandatory and comprehensive EIA studies were to be conducted before project implementation.

As many projects were completed and made operational before 1994, the Central Water Commission (CWC) considered to take up the Post Project Environmental (including social) Impact Assessment studies of such projects to investigate the environmental issues which still need to be taken care of. Accordingly, CWC has completed EIA studies of the 10 water resource projects, spread across various states of India, which were constructed prior to 1994. In the present paper, the aforementioned studies have been reviewed to understand the qualitative impact of the project on the environment and socio-economic life of the residents and affected families in the project area. The role of water resource projects implementation in the attainment of the various sustainable Development Goals is also discussed.

S10:

Reuse and Recycle of Waste Water for Water Resilience and Water Market

Reuse of treated wastewater and sludge from Faecal Sludge Treatment Plants (FSTPs) in Maharashtra, India: Existing and potential practices

Jigisha Jaiswal
Senior research associate
Center for Water and Sanitation
India

Upasana Yadav
Program Lead
Center for Water and Sanitation
India

Dhruv Bhavsar
Senior Program Lead
Center for Water and Sanitation,
India

Aasim Mansuri
Senior Program Lead
Center for Water and Sanitation
India

Dr. Meera Mehta
Center Head.
Center for Water and Sanitation
India.

Dr. Dinesh Mehta
Center Head
Center for Water and Sanitation
India

Keywords

Wastewater reuse, FSTP, reuse practices, resource recovery, scaling up

Synopsis

Globally over 80% of wastewater is discharged without treatment and the demand for freshwater is predicted to increase globally leaving most cities water stressed. With treated wastewater being an alternative resource of water, its reuse is one of the best answers to India's distress.

In this need of hour, our study focusses on the formulation and implementation of reuse of treated wastewater and the resource recovery plan. The research extends to understand the steps taken to implement the practice of wastewater reuse at the FSTPs across various cities of Maharashtra, India. It focuses on the factors that make reuse and resource recovery approach a success. The main objective of the research is to demonstrate the reuse practices adopted across various cities in Maharashtra, India and conclude significant potential reuse options for implementation for FSTPs treated wastewater and sludge.

The state of Maharashtra became Open Defaecation Free (ODF) in 2017, post that it issued a 7-point sustainability charter that included focus on ODF-Sustainability and ensuring effective collection and treatment of human faecal waste in all cities. Under this 200 plus FSTPs have become operational across various cities of Maharashtra. The state government has a policy focusing on reuse of treated wastewater.

Potential use of treated wastewater and sludge

The operational FSTPs produce treated wastewater and treated dried sludge. The FSTPs produce less quantity of treated wastewater in comparison to the Sewage Treatment Plant, so in most of the cities the treated wastewater is utilized in proximity of the FSTPs. The treated wastewater is used for landscaping and plantation around the FSTP campus. The treated sludge is also reused as a compost and is being given to farmers for their use. Mostly the reuse of dried sludge is carried out for non-food crops. Particularly in Sinnar, the treated wastewater is reused to build an urban forest. The FSTP at Sinnar has

been innovatively utilized for plantations and landscaping which not only enhances the aesthetics of the FSTP but also help in creating green spaces towards environment conservation. A landscaping plan which reuses the entire treated wastewater that is generated by the FSTP on-site has been implemented. The landscaped area is about 3530 sq.m and was designed by professional landscaping consultants. Along with this, as part of enhancing the FSTP facility, 3000 sq.m of barren land was developed as an urban forest. The plants used in the development were selected keeping in mind the hard-rock strata of the site as well as the climatic conditions of the city. Within months the plants were found to be flourishing. Based on this experience, an additional 1000sq.m of urban forest has been implemented. The treated wastewater from the FSTP is used for regularly watering these plants through drip irrigation system.

Scaling up Strategy:

The treatment plants in Wai and Sinnar have solar panels installed and have been connected to the grid. Now, both FSTPs are en-route to becoming "net energy positive". To ascertain the quality of the treated product, regular monitoring of the treated wastewater samples is being conducted in both the cities. Other cities also conduct quality tests to understand the treatment and quality of the end-products. Apart from the existing practice, the research has also delved upon various factors which can help a city to identify potential reuse options.

With 200 plus operational FSTPs in Maharashtra, many cities have taken up the practice of reusing treated wastewater and treated dried sludge. More than 15 cities in Maharashtra use the treated wastewater and dried sludge for landscaping and plantation purposes. 10 plus cities have started using the by-product in the form of compost and fertilizer for gardening purposes. The onsite aesthetic developments in the form of landscape and plantations have added great value to the FSTP infrastructure. The research identifies key dominant physical and financial factors which can guide the city to identify the best suitable reuse practice. With many FSTPs coming up in India and with the emerging experience of wastewater reuse implementation in few cities, there is a great potential of replicating the systematic approach wastewater reuse efforts in various cities in India.

Faecal Sludge Management at Madurai: Challenges in making a dignified water business

Lokesh S
Project Executive
DHAN Foundation, India

Virava Shankar G
Project Executive
DHAN Foundation, India

Elamuhil S
Project Executive
DHAN Foundation, India

Keywords

Faecal Sludge Management, Desludging operators, Dignified Business,

Synopsis

National Commission for Safai Karamchari quotes that a total of 928 sewer deaths have taken place in various States/UTs in the country from 1993 till 2020. In most urbanized areas in India, human excreta are disposed off to the centralised sewers but most of the time excreta flows on the housing plot itself. Some of them are septic tanks, dry latrines, bucket latrines, communal toilets, or other types, they all accumulate faecal sludge, which needs to be removed periodically. Generally, Faecal Sludge Management is a missing picture on the city master plan through it is a public sector responsibility but it is managed by the informal private sector operators.

This informal fecal sludge management is a great potential business when the mainstream is supported them with adequate de-sludging of sanitation facilities, safe handling and transport of sludge, treatment of sludge, and its safe disposal or reuse. Sewer deaths and the risk of toxic gases need to be handled professionally, In order to avoid the accidents, The argument of providing protective gear to mitigate the effects of manual scavenging falls short on many counts, mainly that it would not preserve human dignity in any form. On the other side WHO estimates 1.8 Billion People drinking water are contaminated by feces. In this background, The study was conducted in Madurai city which is located in the south of Tamil Nadu. It is spanned over an area of 148 sq. km. with a population of 14,70,821 where almost 30% are living in the slums. As per NCSK Report, 2019-20, (National Commission for Safai Karamcharis, 2020) the highest number of deaths related to manual scavenging were recorded in Tamil Nadu. In order to understand the potential business of handling Fecal sludge was estimated through the Participatory Learning Method (PALM) where exercise was done with a few desludging operators, which involved the use of exercises like, SWOT analysis, Stakeholder mapping, etc followed by Key Informant Interviews (KII). Almost 80 operators in Madurai City are unorganized where they get an average monthly income of 26 thousand INR. This creates the potential for INR 2.5 crores business market annually only in the Emptying and Transportation part of the value chain.

Trapping this unorganized business is having many challenges like n Madurai city, most of the septic tank's design and size are not as per standard. Awareness about the operation and maintenance of septic tanks is sub-optimal. The core city is suffocating with Space constraints for the containment, there is a lack of skilled manpower to create the containment and a lack of monitoring and enforcements by ULB. In concern to Emptying business, Lack of manuals(SOP) for Desludging, Absence of protective gears and protective equipment, Lack of information on health hazards and Safety of workers. In concern to transportation, there is no regulatory body for monitoring and completely depends on unorganized sector.

The overall efficiency of the existing STPs in Madurai City are having only 14.3% (Source: Operative Guidelines of Septage management-GoTN,2014) which results in 55% of overall faecal sludge to unsafe management. The effective solutions emerged out this study are to regularize the faecal Sludge Management, a city-level Steering committee to be formed. In order to ensure safe discharge, Public Social Private Partnership with Tech-driven approach like using GIS and GPS needs to be encouraged. The general public needs to be sensitized on drinking water contamination due to faecal matters to be established. The whole picture of the study in pointed on organizing the desludging workers makes the whole process effective for making a dignified water business.

Greywater recycling solutions using nature based filters, challenges for bulk producers in Urban areas & Impact of greywater recycle and reuse on Water Resilience

Prashant Sharma
Founder
Positive Action for Child and Earth Foundation, India

Keywords

Greywater, water resilience, save water, reuse water, water security

Synopsis

Regions and Cities across the world are facing growing water security risks, more frequent or intense flooding, or increasing stress on eco-hydrological systems, such as rivers, wetlands, or groundwater. Consider the case of Bengaluru city in India, which experienced the worst flooding in its history, in September 2022, due to excessive rains. Current spate of environmental catastrophes like droughts and floods have brought the importance of water resilience to the forefront. Resilience is commonly understood as the ability of systems to withstand or cope with stressors while continuing to maintain key functions or structures (Folke 2016). water-resilient cities are able to manage floods and water scarcity through a combination of measures to reduce exposure and vulnerability to those hazards, and to embrace multifunctional use of land or integrated upstream and downstream water management (White 2010).

One of the most potent and sustainable strategy for building water resilience is to recycle and reuse greywater and to sell/trade surplus water on the water market. The water market can even be an informal one - If a residential colony is recycling greywater in excess of what it is actually using, the excess recycled water can be traded/sold to quench local demand. Similar to how, many residential complexes sell/trade the excess compost they produce from their wet waste.

Recycling greywater and reusing it for non-potable purposes poses a fantastic opportunity to scale up water resilience and work towards a socially inclusive and equitable governance of water distribution. When people are water literate and water is available in abundance, it will be more adequately available to everyone irrespective of social status. Waste water recycling and reuse contributes to achieving at least 6 UN SDG's, specifically SDG6 because when waste water is recycled and reused for non-potable purposes like toilet flush water, gardening, cleaning etc., it frees up freshwater/ground water for use as drinking water.

Following this, the goal of this paper is twofold: (1) to explore and compare nature based greywater recycling solutions for bulk producers of greywater in urban areas. (2) How waste water recycling and reuse is most likely to make water systems more resilient to increasing risks and uncertainties posed by nature. I will also touch upon innovative ways with which recycled water can enter the water market.

Methods - For this I researched and read hundreds of published academic literature available in the public domain. I studied numerous PhD papers, studies, pilot projects, reports on greywater management, and recycling & reuse of greywater submitted by scientists, water experts as part of their PhD, research work or for completion of their masters in science or engineering degrees. This research was self-funded. In addition, I also conducted greywater assessment survey of a dozen sites of bulk greywater producers to understand challenges around greywater recycling and reuse. In addition, I also discussed with them the highest rated recycling solution.

Results – In the times we live in, conventional water resource management paradigms are not sufficiently equipped to respond to unexpected or uncertainty in the hydrologic cycle. Water resilience is one of the most important outcomes expected from any water resource management strategy but old strategies no longer work because we live in highly unpredictable times.

The site assessment consisted of public places and public institutions mainly and it was found that constructed wetlands are the most suitable technology for recycling greywater. Several challenges to greywater recycling were discovered during the assessment exercise and it was also observed that water literacy and greywater awareness needs to be increased via effective Information, education and communication campaigns.

The paper further sheds light on the rather limited information and knowledge we have of the benefits of recycling and reusing greywater. It is well understood and admitted that current water management systems do not enhance water resilience in the face of current and emerging scenarios. The paper echoes the conclusions of the UN World Water Development Report that most water systems around the world are not resilient to increasing risks (UN World Water 2015). Interestingly, all participating public institutions stated that water reuse and recycle as a very important aspect to build water resilience.

Nature-Based Hybrid Solution for Wastewater Treatment

Sagar Suryakant Kolekar
Student
IIT Bombay

Keywords

Nature based wastewater treatment, constructed wetland, agriculture, reuse

Synopsis

Water is important for life; however there is a water scarcity problem worldwide. Many regions in India face acute water stress problems. The advancements in agriculture, industry, and urban activities around water resources have e ected badly on aquatic ecosystems and river downstream ecological conditions. The generation of wastewater due to population increase has become a concern for India. The untreated wastewater pollutes freshwater resources. The reuse and recycle of treated wastewater for crop irrigation will reduce stress on irrigation freshwater and also provides nutrients. Moreover, it is also an environmentally friendly option, avoids pollution, and eliminates potential health hazards. There are different technologies available for the wastewater treatment. The Anaerobic System (AnSys) and Constructed Wetland (CW) is a nature based wastewater treatment which is a combination of both natural (e.g. wetland) and technological wastewater treatment methods (e.g. filters). The Canna Indica and Phragmites Karka are planted over the wetlands which absorbs the toxic from the wastewater. The Dual Medial Filter (DMF) and Ultra Violet (UV) system is also added as tertiary treatment for disinfection purpose. Wastewater will pass through the primary settler, anaerobic baffled reactor, and anaerobic filter of AnSys. The effluent would flow under gravity from the outlet chamber of AnSys to horizontal CW1 and CW2 and then to the collection tank. Then it will be pumped from to the Dual Media Filter (DMF) followed by Ultra Violet (UV) system. To check the efficiency of the design of the system, wastewater quality (e.g. pH, total suspended solids, total dissolved solids, total solids, total nitrogen, total phosphate, BOD, COD and conductivity) testing were done. Results indicated that BOD/COD ratio is more than 0.3 and wastewater is alkaline as pH is more than 7. The average values of orthophosphate, total solids, and conductivity are 6.09 mg/lit, 379 mg/lit, and 1.02 μs/cm respectively. The capacity of this system is 50 KLD and the treated wastewater will be reused for short rotation crops.

PANEL DISCUSSION

PD1:
Strategies for Demand and Supply Side Management

Optimization of Groundwater Monitoring Network: Essentials to Sustainable Management of Groundwater Resources

Dhirenkumar Chavda
Groundwater Management & Modelling Expert, TAMC
National Hydrology Project
MoJal Shakti, Govt of India

D. Gnanasunder
Senior Joint Commissioner, NPMU
National Hydrology Project
MoJal Shakti, Govt of India

Lalatendu Behera
Assistant Director, NPMU
National Hydrology Project
MoJal Shakti, Govt of India

Keywords

Groundwater monitoring, optimisation, criteria

Synopsis

Groundwater is the most preferred source all over the world as available on demand with good quality. India is the highest consumer of the groundwater in the world. Total annual ground water extraction for the year 2020 has been estimated as 244.92 BCM out of annual Extractable Ground Water Resources 397.62 BCM. States have diversity in development and extraction of groundwater depends on population, geomorphology, agroclimatic zones, intensity of agriculture, type and yield of aquifers and availability of surface water sources for various usages. These diversities generate demand of intensive monitoring of groundwater resources for water resource management to ensure future availability of water for all needs when required. Groundwater monitoring required network of monitoring stations with specific criteria and objectives. Current groundwater monitoring network focused to serve administrative requirement rather than based on technical criteria. Most of existing monitoring stations includes dug wells and bore wells of shallow depth to monitor unconfined aquifer at shallow depth and it represents density per geographical area according to land use pattern and used for estimation of dynamic fresh groundwater resources. The current system does not allow to monitor actual groundwater extraction and consumption from deeper semi-confined and confined aquifers from decades. The document intended to suggest additional criteria for optimisation of existing monitoring network for groundwater management considering recharge and discharge areas, multiple aquifers system, population and abstraction density etc.

Conglomerative Measures toward Enhancing Water Use Efficiency of an Irrigation Projects

Dilip G Durbude
Professor and Head
IWDM faculty WALMI
Aurangabad (India)

Keywords

Water Use Efficiency, Irrigation Projects, National Water Mission, NAPCC, WALMI

Synopsis

Even though having globally fourth ranks in term of number of dams, India will have the largest gap between water resources availability and demand in future due to the impact of climate change. Therefore, to bridge the gap between water availability and demand, Water Use Efficiency (WUE) in various sectors of water demand is becoming one of the key issues in the country. Among various water demanding sector, the irrigation sectors is the biggest consumer of fresh water as about 80% of water from developed surface water resource projects is being utilised for irrigation purpose. But, the irrigation water usage across the country is inefficient, which is in an average of 36% as per figures released by the Union Government. Keeping in view, the future challenges in water sector, National Water Mission (NWM) under National Action Plan on Climate Change (NAPCC) identifies five major goals. One of the most important goals is to improve the efficiency of water use at least by 20%. This can be achieved by ensuring improved efficiency both on the demand side as well as the supply side. The research in the area of increasing WUE in agriculture is one of the important strategies to achieve this goal. Under these strategies, Water and Land Management Institutes (WALMI) and Irrigation Management and Training Institutes (IMTI) functioning in various states of India carried out various studies for enhancing WUE of an irrigation projects in various part of country. It is revealed from the study that the overall WUE of various major and medium irrigation projects is found in the range of 13 to 62%. Hence, it is recommended that the overall efficiency of an irrigation project could be improve upto 60% with the help of systematic approach by using appropriate technique for optimizing water use efficiency, scientific water management and measures for minimizing water losses. This improvement could be possible by improving each components of overall efficiency of the irrigation project such as dam/reservoir filling efficiency, Conveyance Efficiency, On Farm Application Efficiency (OFAE), and Drainage Efficiency. The dam/reservoir filling efficiency could be practically achievable between 95% to 98%, while conveyance efficiency of the main canal and distributaries could be enhance up to 95% by well maintaining the canal lining. OFAE due to the method of irrigation could be possible to achieve up to 85%-90% by adopting the micro-irrigation technology. Therefore, in the present study, the various conglomerative measures for enhancing the overall WUE of major and medium irrigation project were recommended and various policy levels as well as administrative and institutional level measures were also discussed.

Domestic Water Supply Evaluation on the basis of Water Demand Management and Dublin Principles: A Case Study of Ludhiana City of Punjab

Dr. Jasdeep Kaur
Assistant Professor in Economics
Khalsa College for Women
Sidhwan Khurd

Keywords

Water Leakage, Tariff Structures, Water Metering, Illegal Water Connections, Commercialization of Water

Synopsis

Water, the basic need of life, is likely to surpass the scarcity of many other commodities during the twenty first century. It will be a great challenge to meet increased demand for water due to increasing population, economic growth and technological changes. The opportunities to enhance the supply of potable water are becoming limited (Marothia, 2003). The supply is shrinking year by year due to ever increasing demand, over exploitation, pollution and inefficient water use methods and policies.
This is more so in the developing countries due to unchecked population growth, interest groups competition and conflict (Ballabh, 2003), expansion of economic activities (Biswas, 1993; Narayanamoorthy, 2003) along with lack of institutional framework and policies for water management. By 2025, half of the world's population will be living in water-stressed areas (WHO, 2017).

The domestic water supply in Ludhiana city is being evaluated on Water Demand Management and Dublin Principles. The principles on which domestic water supply is being evaluated are as: Use efficiency, allocative efficiency and environmental sustainability.

Objective of the Study:
To evaluate the domestic water supply in Ludhiana city on the basis of various theoretical principles.

Review of the Literature:
Arlosorof (2007) in his paper on, "Water demand management – A strategy to deal with water scarcity in Israel: A case study", found that to combat water scarcities in The Middle East, a condition which might accompany the Middle East socio-economic policies for many years to come is 'Water Demand Management', and/or 'Water Conservation' as well as the 'Increase of Water Use Efficiency'.

Emoabino and Alayande (2007) in their paper on, "Water demand management, problems and prospects of implementations in Nigeria", pointed out that water supply in Nigeria was facing serious challenges and supply-oriented indefinite expansion of water supply infrastructures was stressing the available budgetary allocations to the sector to the limit.

Hoffmann et. al., (2006) in their paper on, "Urban water demand with fixed volumetric charging in a large municipality: The case of Brisbane, Australia", asserted that residential consumption is charged using a fixed annual service fee with no water entitlement followed by a fixed volumetric charge per kilolitre.
Sharma and Vairavamoorthy (2009) in their paper on, "Urban water demand management: prospects and challenges for the developing countries", examined that as the traditional supply-driven urban water management is not sustainable, water utilities should embrace water demand management (WDM) measures to meet increasing water demand.

Worthington and Hoffman (2007) in their working paper on, "A state of the art review of residential water demand modeling" reported that a synoptic survey of empirical residential water demand analysis conducted in the last twenty-five years. Both model specification and estimation and the outcomes of the analysis are discussed.

Evaluation of the Domestic Water Supply:

Water Demand Management (WDM) has cropped up as a complementary arrangement to the traditional supply side management. Demand management has some objectives to manage the scarce water resources of the world (Hamdy and Lacirignola, 1999; Araral, 2010; Arlosoroff, 2007; Emoabino and Alayande, 2007; Gidey, 2006; Kayaga and Smout, 2007 and Naik et. al., 2006). Some of the objectives are:

- Conserve peculiar natural resources.
- Minimizing the cost of providing water to the end users.
- Minimizing non-renewable water use.
- Use water efficiently.
- Safeguarding the environment from degradation.
- Reducing the disputes over water use.

Some of the water demand management measures are like:

- **Water conservation measures.**
- **Water pricing measures**
- **Information and Educational Measures**
- **Legal measures**
- **Ecological Measures**
- **Institutional Measures**

In nutshell, the evaluation of Ludhiana city on the basis of water demand management and Dublin principles showed that if water resources are used efficiently, the wastage of water can be considerably reduced. The prevalence of large number of illegal water connections in the city makes the situation rather more worse.

Using the WEB.BM mathematical optimization model to improve future reservoir operating rules -- a case study of the Bargi Reservoir in Narmada River Basin

Nesa Ilich
TAMC NHP Project
Ministry of Jal Shakti

Synopsis

Narmada Control Authority approached the National Hydrology Project office in 2019 with a request for assistance to select a basin management model that would be used to conduct water accounting and all other functions expected from modern modelling tools. One of the requirements was the ability to use mathematical optimization to derive the best reservoir operation. This paper explains the benefits of mathematical optimization and how it should be used to improve analyses and creation of better reservoir operating rules as well as the related deficit sharing policies. As an example, the impacts of varying e-flow target releases were assessed against the ultimate irrigation demands on Bargi reservoir along with the impacts on the generated hydro power. The paper demonstrates a methodology to develop future reservoir operating rules and water demand management policies based on statistical analyses of optimal solutions obtained for all simulated years.

Restoring Community Water Swaraj - Experience of DHAN in Gundar And Vaippar Basins

Rajkumar K N
Programme Leader
DHAN Foundation, India

Vellaiappan U
Senior Team Leader
DHAN Foundation, India

Keywords

Community, Water-Governance, Traditional Water Bodies, Livelihood and Environment

Synopsis

All over the planet, people are confronted with extremely degraded land, not caused by natural events, but rather by their own actions. The resulting climate change and shifting weather patterns only intensify this crisis. Gundar Basin of Tamil Nadu, South India, one of the drought-stricken regions on the planet. The extreme weather conditions challenge the life and livelihoods of the local communities. Combating or reversing the climatic conditions requires collective and intensive efforts.

While the impact of Climate Change is loud-spoken across the world, the Gundar and Vaippar basins already started feeling the heat of the climate change. In the year 2016, the basin experienced lowest rainfall after 140 years. The farming sector came to a standstill position. Many parts of the basin experienced drought for the next three years until 2018. In the next two years they received better rainfall. Often farmers have started saying "we are unable to predict the monsoon and plan the agriculture activities".

Challenges often come or create new opportunities. The Gundar basin has a presence of 2276 water bodies in the basin and is known for decentralized water resources conservation. Though the communities experience drought, it is not new to them. Being part of a rain shadow region, the ancient communities have constructed a large number of small water bodies across the slope to harvest, store and utilize the water for multiple needs. They are "Climate Smart Structures" that require no energy for irrigation. They are man-made yet support the environment and biodiversity. Most of these structures are centuries old and represent the wisdom of the ancient communities. Changes in the monsoon necessitated the communities to construct such water bodies in the drought prone areas.

DHAN Foundation has been working on community-led and invested conservation and development of traditional water bodies in India for the past 25 years. The field implementation has brought immense learning and the approach evolved over a period of time. Though the approach started with renovating individual tanks, understanding hydrological condition took a shift towards, chain of tanks, sub-basin and basin approach. In the Gundar and Vaippar basin, DHAN has been working for the past 25 years. In the year 2011, DHAN Foundation launched large scale conservation works with the support of HUL in Gundar Basin. About 250 water bodies were renovated (PHASE I) with the support of donor and community investment.
While many organizations consider the community as beneficiary or receiver of benefit, DHAN considers them as partners. They are involved right from planning to the post project sustainability. In fact, the project is used as a tool to reach and start the development project. Community-led and invested development is the process innovation and USP of this project. Considering the success in terms of economic, social and environmental, a project titled IMPACT was implemented for a period of four years with an extended period of two years (Sustainability Period). More than 390 water bodies were covered through supply side management and water demand management.

In a period of six years 250 irrigation tanks were renovated by the associations promoted by DHAN with the funding support, along with their own investment. Besides renovating the identified water bodies, the water bodies renovated during the period 2011 – 2015 were also maintained by the village level associations. In six years, about 79 billion liters of water was saved by these associations, which were assured by India's top auditors like Deloitte and E&Y. The water saving was professionally calculated after considering the soil type, rainfall, evaporation, infiltration, antecedent soil moisture to arrive at dry, damp, wet conditions of the soil to calculate yield, dimensions of structure, slope for calculation of water harvested by a particular structure.

While focusing on renovation, DHAN has given importance to promote water demand management in the command area of the irrigation tank. Since water is a finite resource, efficient management is critical for successful crop. The IPCC reports and other sector experts communicate that; there will be increased demand for water for irrigation in future. In order to promote water use efficiently, DHAN has implemented a range of activities that suits the activity. The intervention includes, SRI method of cultivation, land levelling, Soil Mulching, Composting, Green Manuring, Tank Silt Application, Micro Irrigation, Water Conveyance Equipment, Crop Diversification etc., Select farmers cultivating on the command area of 144 water bodies were identified and supported to work on water demand management.

All these interventions resulted in water saving of 39 billion liters. More importantly, farmers have learned such improved agriculture practices. Realizing the impact and suitability to the context, communities have started scaling the interventions in the command area of other irrigation tanks with the credit support and with their own investment. The initial investment made by DHAN in terms of training and demonstration made this happen.

As a whole…

1.The project has ensured community governance on 650 water bodies in the Gundar and Vaippar basins by organising stakeholder into association.

2.At village level these associations have platforms to work collectively and discuss on conservation and development.

3.Communities have implemented the conservation works and they have gained confidence and rich experience in implementing such renovation works.

1.About 119 billion liters of water was saved through renovation of water bodies and water demand management.

2.An additional yield of over 50884 tons was reported in a period of six years.

3.The project has created over 1.7 million person days of employment.

4.The associations are working mainstream to access services and continuous support

The organic connectivity between the water bodies and the local community was restored.

Way Forward

India is home to 9.45 lakhs water bodies. Performance of water bodies is critical for life and livelihoods. Building people institutions around water bodies results in better maintenance and local management of water resources. All the six hundred water either renovated or covered through water demand management are managed by the community and this can serve as a spark to enlighten the farmers across the nation.

Efficient Water Management for Irrigation Supply to Command Area in Narmada River Basin Using Optimization Model

T.R. Nayak
Member (Civil)
Narmada Control Authority
India

Nishi Choudhary
JRF
Narmada Control Authority
India

Aditya Sharma
Executive Member
Narmada Control Authority
India

Keywords

Reservoir operation, optimization, linear programming, Narmada River Basin.

Synopsis

Introduction:
In integrated water resources management (IWRM), reservoirs are recognized as one of the most efficient infrastructure components [1]. Reservoirs are constructed across the river to store the excess amount of water in the monsoon season and to use this stored water in subsequent dry spells/non-monsoon seasons [2]. Reservoirs act as important sources to provide resilience against hydrologic variability and achieve sustainable water management within basin boundaries with some conservation practices. Therefore, to mitigate the adverse effects of drought, available water from the reservoir should be used optimally along with specific operating policies. At present, with the ongoing advancement of the social economy and requirement for water, the water resources shortage problem has worsened, and the operation of reservoirs, in terms of consumption of runoff water, has become remarkably important. To achieve optimal reservoir operating policies, a considerable number of optimization and simulation models have been introduced in the course of recent years.
Statement of problem:
Due to the distinctive characteristics of India's monsoon season, about 80% of the river flows occur in the four monsoon months of the year (mid-June to mid-October). During this period only limited water needs to be made available for irrigation direct from the river flow because the farming area does not require much extra water having received it directly from the rain. It is in the post-monsoon period that the agricultural water demand is highest. Hence storing the water available in the monsoon season, for use in the subsequent months of the year, is an inescapable part of the development process.
In India, the Narmada Basin has a sub-tropical climate. Rainfall over the basin is monsoon-driven, i.e., a vast majority of annual rainfall over the basin is contributed by the southwest monsoon season, prevailing from mid-June to mid-October [3]. The population of the basin is mostly dependent on agriculture and considering the agricultural importance of the basin, a substantial rainfall deficit during the monsoon season may result in severe repercussions. On the other hand, the rainfall in other seasons is scanty and thus, has very little to negligible impacts on drought occurrences. The problem is encountered when the utilizable water available at SSP is accounted less than the normal year. According to NWDT share policy, the deficit also has to be shared in the same proportionate among the party States, which results in comparatively less allocation to Gujarat and Rajasthan that causes low releases through the canal.

Objectives:
The objective of the present work is to allocate water to the command area of the Narmada Main Canal (NMC) in Gujarat and Rajasthan during the drought year by hedging hydropower generation. As per the Water Policy of India, irrigation demand has a higher priority than hydropower demand. An optimization model has been developed for integrated reservoir operation of the multi-purpose Sardar Sarovar Project (SSP) to allocate water optimally among various demands based on water availability.
The aims of optimization include:
1. To minimize deficits in domestic, irrigation, industrial, hydropower, and environmental flow demands.
2. To avoid unnecessary water loss as spills.
3. Meeting to the extent feasible targeted carry-over storage in the reservoirs for usage in the next year to tide over uncertainty in the onset of monsoon in the coming year.

Research methodology:
In the present study, the Linear Programming technique is used to develop an operation policy for major reservoirs in Narmada River Basin (NRB), India especially in a drought year. The purpose of the model is to suggest reservoir operation in such a manner to allocate water for irrigation so that the production of agricultural goods may not be much affected and a considerable amount of water can be conserved by reducing releases for hydropower generation and spills and satisfy policies under given constraints.

The decision variables are inflows and releases for domestic, irrigation, hydropower generation, and environmental flow requirements. Constraints bound for reservoir release were stage capacity curve, initial storage, and target storage that need to be maintained at a certain period.
The results derived by using the Linear Programming Optimization model show that the downstream irrigation demands were satisfied and also a considerable amount of water was conserved by reducing the hydropower generation and avoiding spillway releases.

Expected outcome:
For sustainable development in and around a river basin, it is necessary to transfer water from the regions having surplus water to regions having less water due to spatial and temporal variations in available water resources. Using this model, stakeholders can estimate the quantity of water released to fulfill various demands from the reservoirs according to their priorities. This model also illustrates how much volume can be released for satisfying the specific demands optimally because the model is simulated for the ultimate demand.

PD2:

Role of Water in Achieving Sustainable Development Goals

The interdependence of water and forest ecosystem in the scenario of changing climate

Pooja Sharma
Arid Forest Research Institute
Jodhpur, Rajasthan, India

Anjali Joshi
Arid Forest Research Institute
Jodhpur, Rajasthan, India

Aditi Tailor
Arid Forest Research Institute
Jodhpur, Rajasthan, India

Tanmaya Kumar Bhoi
Arid Forest Research Institute
Jodhpur, Rajasthan, India

Randhir Kumar Choudhary
Ministry of Jal Shakti
Government of India

Keywords

Climate Change, Forest, Water, Conservation

Synopsis

Climate change attributes to suffer billions of people due to inadequate availability of water and can exacerbate water shortages and threaten to sustainability of life. Moreover, climate change is affecting the forests and altering its role in regulating water flows and influencing the availability of water resources. Therefore, the relationship between forests and water is a crucial issue that must be high priority to consider. Forested catchments supply a high proportion of the water for different purposes i.e. domestic, agricultural, industrial and ecological needs in both upstream and downstream areas. The maintenance of healthy forests is a necessary pre-condition of this globally preferential state and important roles of forests in producing and regulating the world's temperatures and fresh water flows. Well recognized for storage of carbon, forests also play equally important role in respect of carbon sequestration for climate change. Indeed, carbon sequestration can be viewed as one co-benefit of reforestation strategies designed to protect and intensify the hydrologic cycle and associated cooling for high temperature climate. In the past, forest and water policies were often relies on the fact that under any hydrological and ecological circumstance, forest is the best land cover that maximize water yield, regulate seasonal flows to downstream and ensure high quality of water. Following this assumption, conserving (or extending) forest cover in upstream watersheds was deemed the most effective measure to enhance water availability for agriculture, industrial and domestic uses, as well as for preventing floods in downstream areas. A key challenge faced by land, forest and water managers is to maximize the wide range of multisectoral forest benefits without detriment to water resources and ecosystem function. To address this challenge, there is an urgent need for a better understanding of the interactions between forests/trees and water, for awareness raising and capacity building in forest hydrology, and for embedding this knowledge and the research findings in policies. Strategies for reduced deforestation, forest landscape restoration and forest preservation offer essential ingredients for adaptation, mitigation and sustainable development.

PD3:

Water Education, Public Awareness and Role of Media

Public awareness and media usage to promote water literacy in the Kukadi Command Area

Dr. H. T. Dhumal
Chief Engineer
Water Resources Department
India

P. P. Kaduskar
Executive Engineer
Water Resources Department
India

S. U. Dumbre
Executive Engineer
Water Resources Department
India

Keywords

Public awareness, water education, conflict, social pragrams

Synopsis

The Kukadi irrigation project, which consists of a network of 5 reservoirs and 8 canals, is situated in the Krishna Basin in Maharashtra. It is eventually located in a tropical area where rains only fall annually from June to October during the monsoon season. The project provides water for industry, drinking, and primarily for agriculture in drought-prone areas of Pune, Ahmednagar, and Solapur Districts of Maharashtra. Total water utilization of Kukadi Project is 1101.45 Mcum. Due to population expansion, per capita water demand, and urbanization, water will become increasingly limited as a result of development, structural work, and infrastructure improvements. But regrettably, the amount of water available does not grow or remain stable over time. Therefore, it becomes necessary to raise their level of awareness of water users through media and other social activities. This element should be taken into consideration by government organizations like the Water Resources Department. Water demand and supply problems are major issues for the Kukadi irrigation project, especially during the rabbi and hot weather seasons. As a result, water users and government officials are frequently in conflict like agitation. The water resources department has accomplished a lot in terms of water education, raising public awareness, and using the media to increase the literacy of water consumers. The team has organized numerous camps, seminars, conferences, and open Melawas throughout the command area. A number of successful social programs have been put into place, including "Maza Kalwa Mazi Jababdari" (My Canal, My Responsibility), "Kalwa Shiwar Pahani" (Canal Area Inspection), "Pani Parishad" (Water Conference), on-site pre-rotation meetings, etc. It raised awareness of the fact that water users own and are responsible for this infrastructure's ownership of the water supply. Additionally, TV appearances and the passionate engagement of elected officials like MLAs and municipal water agencies have produced positive symbols for other regions. As a result, this study can be used as a pilot project for all irrigation projects in the State.

PD4:
Decentralized Solutions for Water Management

Benefits of Decentralised Treatment System over Centralised System for Communities with Lack of Water Infrastructure

Saurabh P Deshpande
Process Engineer
Black and Veatch Corporation

Synopsis

The world has been facing water supply challenges due to increasing demand, drought, depletion and contamination of groundwater, and dependence on single sources of supply for a long time. Water demand is usually met through freshwater sources like rivers and underground aquifers. The water from these sources is treated before providing it to the users. Designing water and wastewater treatment systems involve the evaluation of various criteria such as technical, social, economic, environmental, and also includes multiple stakeholders. For example, Building a central water treatment plant requires a massive amount of capital, footprint, and time compared to building a decentralized water treatment plant network. Due to the increase in demand, it has become imperative for treatment plants to handle larger flows than the rated plant capacity. Many places around the world have started developing decentralized plants for small communities that lack the infrastructure or to reduce the stress and provide an alternative to natural water sources. For example in Chennai, the water table has been too low in recent years due to which many areas within the city had to be without adequate amounts of water for a few days. A few apartment complexes installed their own treatment plants within the society. They could use the treated water for non-potable reuse to help reduce the pressure on the local sources of water and to have an alternative source of water.

Out of total water supplied for domestic use around 70–80% gets generated as wastewater. Most of this wastewater is either treated in a large centralized plant or is released untreated into a water body due to the inability to develop infrastructure in that area. Many recent studies have also concluded that this supply if totally captured, can help to meet the severity of water crises, and industrial and agricultural water demand. This can be achieved by developing small decentralized treatment systems in small clusters where building large centralized treatment systems is impossible.

It has been seen that in Surabaya, the second biggest city in Indonesia around 3 million inhabitants are released directly into water resources due to a lack of water infrastructure (Maria Prihandrijanti, 2008). Through this paper, it can be inferred that small communities can be helped to treat and potentially reuse the water using a decentralized system. In this paper, the comparison is conducted to show how developing a decentralized network of water and wastewater treatment systems could help each small community develop potable and nonpotable alternatives and help reduce the increasing pressure on natural water sources.

It has been seen that for a household cluster of around 320 houses, it is environmentally preferable to have a decentralized system. The paper leans more towards the conclusion that a decentralized approach to water wastewater management for communities without proper infrastructure is environmentally preferable to the common centralized system. A detailed definition of a decentralized system is still debated and further research is required. Through this paper both water and wastewater decentralized and centralized treatment systems have been compared on multiple factors involving capital investment, construction time frame, footprint requirement, adaptability to change, ability to handle upsets, and toxic outbursts.

Decentralized Wastewater Treatment – Need of the hour

Lalit Bajare
Chief Technology Officer,
Innivative Water Technologies Pvt Ltd, India

Keywords

FBTec®, Innovative Technology, Jal Shakti ministry empanelled

Synopsis

The world is not running out of water. The real challenge is to provide enough clean water to a rapidly growing global population (and the attendant demands that come with growth: more energy, more food, more industry, and more consumption). Increasingly irregular weather patterns and natural disasters only exacerbate the situation.

According to a report published in "The Guardian" on 4th March 2014 (www.theguardian.com 4th March 2014), 1.2 billion people call India home, 377.1 million of whom live in cities. In the next 40 years, India's population is expected to grow by nearly half a billion. In the next two decades alone, 225 million more people will be living in Indian cities. The water required to serve this population today is 740 bn cubic meters per year (compared to 102 bn cubic meters per year for the UK). By 2030, this number is expected to grow by approximately 200%, to nearly 1.5 tn cubic meters per year.

According to the UN Water reports; The world generates 359 billion m3 of wastewater every year. Globally, 80% of wastewater flows back into the ecosystem without being treated or reused, contributing to a situation where around 1.8 billion people use a source of drinking water contaminated with faeces, putting them at risk of contracting cholera, dysentery, typhoid and polio.

A new study by scientists at Utrecht University and the United Nations University published on 8th February 2021 concludes that about half of global wastewater is treated, rather than the previous estimate of 20%. Still a lot of work needs to be done in this area and the world needs to put-in efforts to make "every drop count". We need to look at wastewater as a source of water by recycling and reusing it at source.

Need of the hour: "Decentralized Wastewater Treatment Systems":
The best way to look at wastewater as a source of water is to recycle and reuse it at source by putting up small, decentralized wastewater treatment plants which needs lesser space, lesser and manageable funds at one go, lesser power and most importantly no sewerage network. We must not carry sewage from one place to another and then treat it...rather we must treat and reuse it at source. (Images will be included in the next stage)

Appreciable actions taken by the Jal-Shakti Ministry; government of India:
The Jal-Shakti ministry has correctly taken action in the same direction by identifying some innovative technologies. The Swachh Bharat Mission Grameen is now putting on more focus on the rural or Grameen areas. Indian technologies like "FBTec®" have been empaneled (https://pib.gov.in/pressreleaseIframePage.aspx?PRID=1674888). Installations on public toilet to recycle and reuse each drop of water were appreciated. We can have a look at it at https://youtu.be/7qJPt-z4U6Q (Photos to be included in next submission)

Brief on the Emerging / Innovative Technology:
"FBTec®" is a proprietary technology (patent applied for) with following features:
1.It uses a fixed media which doesn't need any replacement.
2.The different zones are designed in such a way that the media doesn't move an inch even when the entire plant is moved to another place.
3.The design the modular where-in capacity can be enhanced or reduced with ease.
4.The units are movable and can be shifted from one place to another with ease.
5.Most significantly, it caters to the range of capacities 1 KLD (1000 lit/day) to 2 MLD (20,00,000 Lit/day) of sewage treatment where very few options are available and especially, in government listed rates, this range is not covered at all.
6.Least footprint, Minimum site work, least maintenance needs, low power consumption are the other features.
7.Low investment needs.

Addressing the need in an innovative way:
The pace of urbanization is rapid and the infrastructure development is falling behind. The innovation (FBTec®) helps the local body governments following ways:
1.Centralized plant need large spaces / lands, capital investments and sewage networks which are generally not available.
2.The National Green Tribunal (NGT) penalizes the local governments frequently for water pollution.
3.Conserving clean water is a challenge.

Treating, recycling and reusing the wastewater at source is achieved with "FBTec®" installations eliminating all the above infrastructure, land and fund needs and hence, it has been recognized as an innovation by the ministry. The smaller plant capacities are useful in towns and villages which is a neglected area for years.

Actions needed for the future:
The action plan should focus on taking the initiative forward and install such units at every private, semi-government and government entities or establishments like schools, colleges, government offices, bus stands, railway stations, public toilets and even at the religious places like temples, mosques and ashrams.

Government bodies like gram panchayats, nagar parishads, Zilla Parishads, municipal corporations etc must allocate some budget to install these units in each and every village to every city.

PD5:
Role of Civil Society in Efficient Water Management

Jal Jeevan Mission provides an effective and participatory policy framework towards source sustainability- Examples from UP, a part of Gangetic Plain

Asad Umar
Director-WASH
Aga Khan Foundation, India

Jairam Pathak
State-WASH Lead
Aga Khan Foundation, India

Nyati Tripathi
Programme Officer -WASH
Aga Ohan Foundation, India

Keywords

Groundwater, Aquifer, grey water, source sustainability, Jal Jeevan Mission

Synopsis

The state of Uttar Pradesh is blessed with a very rich river system, which is divided into nine agro-climatic regions, eight major river basins, and diversified hydro-geological setup primarily dominated by vast groundwater resources potential stored in multi-layered alluvial aquifers. However, over-exploitation of groundwater, erratic & decreasing trend of rainfall pattern, increased water contamination and reduced ecological flows have put the State into a critical and challenging situation. Over the last decade or so, incidences of water shortages, flooding, groundwater depletion, polluted water bodies have become alarmingly more frequent and intense. The threat of climate change is likely to affect the State's water security. As evident, UP is largely depending on ground water to meet its 80% drinking, 70% agricultural and 85% Industrial needs. Growing dependency on ground water resources can be assessed by the fact that the rate of ground water development/ exploitation assessed as 54.31 percent in the year 2000, has increased to 72.16 percent in the year 2009. The Central Groundwater Board's estimates show the groundwater table has been declining every year and if the groundwater continues to decline unabated, meeting the agricultural and drinking water requirements will become a big challenge. The NITI Aayog report on 'Composite Water Management Index (2018)' underlines that even state like Uttar Pradesh, which is part of Indi-Gangetic plain, traditionally known for good rainfall and large-scale ground water potential are also facing continued trend of declining water table and there are 138 blocks falling under semi-critical, critical, and overexploited category and this is quite alarming specially to ensure the sustained access of water.

However, it is encouraging to note that the State Government is working on both policy and regulation side of water sector. Recently, Uttar Pradesh has been ranked as the best state in water conservation efforts for 2020. It will have a lasting impact towards sustainability of drinking water sources. The state has signaled its intent by launching several notable initiatives that address water security - Jal Jeevan Mission, Jal Shakti Abhiyaan, National Mission for Clean Ganga, are among others. Hence, a very favourable enabling environment has already been created at the highest level. It is now important to leverage on this to make a difference on the ground. The JJM and JSA, are aimed at improving water accessibility in rural areas as well as promoting water conservation in water-stressed regions.

In alignment with Jal Jeevan Mission, Aga Khan Foundation supported by HDFC Bank is implementing a rural water supply programme across 40 villages of Sidhauli and Bakshi ka Talab block of Sitapur and Lucknow district of Uttar Pradesh, this initiative is aligned with Jal Jeevan Mission . The pre-monsoon water level data of 2020 from hydrograph stations revealed that the depth to water level ranges between 9.0-14 mbgl. Long term water table trend of 10 years (2011-2020) from Bakshi ka Talab the indicates an overall declining trend is 0.21 m/year . Stage of ground water development is around 69% that means area is moving towards semi critical stage.

However, the Jal Jeevan Mission presents a unique opportunity to ensure source sustainability by prioritizing appropriate recharge measures specially through rainwater harvesting and grey water management. The state of Uttar Pradesh which generates approximately 9727 MLD wastewater, highest in the country and accounts for almost 25% of the total wastewater generated, can significantly contributes towards minimizing the water stress through its reuse for non-potable purposes and for ground water recharge. Though grey water could be a source of contamination and health concerns but given India's growing need for water, its efficient management could be an opportunity to minimize stress on freshwater resources. With the implementation of Jal-Jeevan mission, a village with 1000 population, on an average generates 38000 litre grey water per day which could be a potential source of ground water recharge. Looking at the possibilities of contamination, Central Ground Water Board (CGWB) recommends the use of treated wastewater as a source of artificial ground water recharge once it meets the standards.

Under ongoing intervention, Aga Khan Foundation is prioritizing the primary treatment of Grey water and this has already been demonstrated at village Mirzapur Mafi of Sidhauli Block of Sitapur district. Here Panchayat is reviving the village pond using nature based solution phytoremediation measures where floating wetland has been introduced. To ensure high reduction of BOD and low sludge production, an anaerobic baffle reactor is also planned to be installed on this site. With 25KLD capacity the anaerobic baffled reactor would help to ensure flow of treated water to the pond and hence not only helping the natural ecosystem of the pond but in ground water recharging .

Gram Panchayats, as part of their GPDP plans are also prioritizing revival of surface water bodies through plantation, desilting of existing ponds, construction of new one and through water conservation activities. In villages, Bahargain, Lalpur and Shivpuri of Bakshi ka Talab Block and in Ganera, Mukeempur and Bibipur villages of Sidhauli block, above activities have been prioritized to desilt the water bodies not only to improve the water storage capacities in the village but to also recharge the ground water and ensure the sustainability of newly build water supply schemes.

Under Jal Jeevan Mission the key priorities are not only to improve the water access through decentralized community-based management of rural water supply schemes but to ensure functional convergence at program level and promoting the efficient utilization of MGNREGA and JJM resources for source sustainability and water safety. In the districts of Sitapur and Lucknow a set of 40 villages has been identified where piped water supply schemes are supported by source strengthening measures, a network of observation wells has also been setup where impact of recharge measure and groundwater abstraction will be monitored. Going forward, paradigm shift towards a participative, multidisciplinary approach for water supply programmes, with a focus on water security measures, and modern data management systems will help to sustain the rural water supply services as envisaged under Jal Jeevan Mission.

Investing in the rejuvenation of urban water commons: Experiences from Madurai city

Ahila Devi S
Programme Leader
DHAN Foundation, India

Elamuhil S
Project Executive
DHAN Foundation, India

Vasimalai M P
Executive Director
DHAN Foundation, India

Keywords

Traditional surface water bodies, urban water commons, land use conversions, community-led rejuvenation, cultural commons

Synopsis

The landscape of Madurai urban, the temple city of Tamil Nadu, has been hydrologically embedded with hundreds of traditional surface water bodies well connected as cascades with the existing drainage network as well as the rivers. The meteorological characteristics of the Indian Monsoon and the geological characteristics of the Deccan Plateau necessitated the creation of these surface water bodies to store rainwater during the monsoon and utilize the same at a later date. The layout, structure and construction of these small water bodies bring out the ingenuity of the community that has adopted a style quite fitting to the gradual fall of the contours and the system of decentralized village administration. The 'Self-revenue generative' nature and direct dependency of rural living on the revenue, were the key factors behind the existence of these water bodies over the millennium. Each village in this region has a minimum of three distinct water harvesting and storage structures – the Irrigation tanks known as 'Eri', 'Kanmoi' or 'Kulam', the drinking water storages known as 'ooranis' and the 'holy' temple tanks. Villages in Madurai are named after the water bodies that sustained their living and livelihood, signifying their reliance on these surface water bodies. The city of Pandiyas, post-Independence expanded as the 'Thoonganagaram' (Sleepless city), a hub of administration, tourism, heritage, agro-market and centre for the service sector. It opened up greater and wider opportunities, pulling non-natives, and accelerating land-use conversions, converting water bodies and their agricultural land into development zones. The built-up area of Madurai city has increased five times (from 13.5 sq.km. to 67.5 sq.km.) in just four decades. These conversions have resulted in the deterioration of urban water bodies and waterways. The shift in socio-cultural consumption of these waterbodies from being a 'commons' to a 'free ride commodity' led to encroachment, and disposal of solid and liquid wastes in waterbodies and waterways. The characteristics of the free ride depend on the nature of the demography i.e. individual, collective, and marginals. Despite the urban pressures, the city has 55 irrigation tanks, 44 ooranis/ponds, and 12 temple tanks, still serving the urban. Increased water stress, fall of groundwater reserve, floods and prolonged failure of monsoon showers in the last decade pushed the urbanites towards conservation of these water bodies. Among various efforts, the rejuvenation of these water commons is more effective than just restorations, especially when the rejuvenation is community-led and community-invested. Redesigning the water commons for future functionalities to connect the local communities with the water commons, stakeholders' acceptance for the redesign without affecting the hydrological balance remains vital in the urban context. Though the commons are 'Open Access' in nature, enriching the 'openness' of the rejuvenated urban waterbodies is a greater challenge as most of it pushes the marginal communities away from the rejuvenated water commons, considered polluters. The spirit of the water commons lies not in the 'exclusion or exploitation' but in the 'collective sense of ecological' practices and its vernacular openness'. DHAN Foundation in collaboration with key stakeholders, enabled the urban communities in rejuvenating 16

urban water bodies, by introducing functional components such as recreation, rejuvenating some of the traditional practices, and evolving combating mechanisms against urban pressures. The urban rejuvenation experiences consolidate that building a new framework of trusteeship and developing the cultural commons around the water bodies sustains the urban waterbodies as the urban commons. This paper highlights various expressions of the community rejuvenation processes that would help in better investment in urban bodies for marching towards 'sustainable cities and communities' (SDG -11).

Sustainable water management through spirituality and religion

R.K.Khanna
Former Chief Engineer
Central Water Commission
New Delhi, India

Keywords

Spiritual, Religious, Social, Water Management

Synopsis

Water is a basic necessity of life. According to our religion and culture, it is one of the Panchmahabhutas viz earth, sky, fire, air, and water. The quest for water must have started along with the evolution of human life. Life starts with water, with the child being given a bath, and it similarly ends with water. So, water accompanies us through the journey of life.

Earlier, there was enough water for everybody, say, up to the middle of last century. Then the water shortage started, and now it has assumed alarming proportions, with people talking of water wars and what not. This concern for water quantity and quality led to a lot of brainstorming. One of the points that emerged was that due importance should be given to water management.

Interestingly, many religions lay stress on this aspect. The central point of Jainism is non-violence (Ahimsa). Jainism strongly believes that there is life in water. Quoting the famous scientist Dr J C Bose, Jain scriptures say that one drop of water contains 39450 bacteria. It, therefore, preaches limited use of water for the survival of humans viz for drinking, cooking, bathing etc. Some Jain saints (munis) take bath with just around 650 grams (56 Tolas) of water, by immersing a piece of cloth in water and rubbing the body with it.

In Hinduism, one of the holiest and most revered books, the Bhagwadgita preaches self-control (Sanyam) which means restraint in our thoughts and actions. This obviously includes limited use of resources, including water.

In Islam water has been given a lot of importance as some ecological hadith, relate to the obligation to assist the thirsty ones, whether humans or animals and to prevent wastage of water during performing of wudhu (ablution); the water structures called as hauz (pond) were built to protect the wastage of water.

Various other religions also give a lot of importance to water.

Social aspects of water are equally important. Some water source is commonly provided in temples, mosques and gurudwaras such as a pond, well or hand pump.

Beyond religion, there are the spiritual aspects of water use and management. Spirituality means leading a simple life of austerity and simplicity beyond the glare of materialism. The lifestyle of a spiritual person will reflect self-restraint so that his needs are limited. In fact, he leads a life of fulfilling his needs and not any of his greed's, as indicated by Mahatma Gandhi. He abhors exhibitionism, thus conserving all natural resources, including water.
The paper describes the importance given to water use its and management in various religious and social practices in the country. It also discusses the spiritual aspects of water use leading to the prevention of its wastage and subsequent management.

Roof water harvesting: A Sustainable solution for drinking water in needy places

Rajapandian R
Chief Executive Officer,
Sustainable Healthcare Advancement
(SUHAM) Trust,
DHAN Foundation

Saravanakumar B
Senior Project Executive,
Sustainable Healthcare Advancement
(SUHAM) Trust,
DHAN Foundation

Synopsis

About 85% of rural population in India is solely depended on groundwater, which is depleting at a fast rate. In the urban areas though about 60% of the population is depended on surface water sources, the availability and quality are questionable. By 2025, it is expected that 3.4 billion people will be living in countries defined as water scarce. Pollution wise in developing countries, more than 90 per cent of sewage and 70 per cent of industrial waste water is dumped untreated into surface water which makes the water resources non potable. Groundwater levels are declining across India because of erratic rainfall. Rainfall is the important element of Indian economy. Although the monsoons affect most part of India, the amount of rainfall varies from heavy to scanty on different parts. There is a great regional and temporal variation in the distribution of rainfall. Over 80% of the annual rainfall is received in the four rainy months of June to September of the South West Monsoon. The average annual rainfall is about 125 cm but has its spatial variations. This leads to the scarcity of safe drinking water for the human being and creatures.
Water is a fundamental human need. Safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purposes. Improved water supply and sanitation, and better management of water resources, can boost countries' economic growth and can contribute greatly to poverty reduction. Water is vital for life and livelihood and it is precious but becoming a rare commodity because water cannot be manufactured unlike other commodities. So available water resources need to be improved and developed in a sustainable way with proper management of the resources to derive optimal benefits which should be conserved and preserved as a valuable and scarce one in the present world for preventing the water depletion. Despite, roughly 66% of the earth's surface is covered in water only 2.5% of the Earth's water is fresh water and out of 25% only a small fraction is available for human use.

Since water is a costly commodity and scarce material, there is a need for saving the available water for now and future. There are technologies to preserve, save, maintain water resources for various purposes. Roof water harvesting is the simplest technique through which rain water is captured from the roof catchments and stored in reservoirs for drinking purpose. Roof water harvesting is the accumulation and deposition of rainwater for reuse on-site rather than allowing is to run off. Rain water harvesting can also

be defined as direct collection and storage of rain water as well as other activities aimed at harvesting and conserving surface and groundwater, prevention of loss through evaporation and seepage and other hydrological studies and engineering interventions aiming at most efficient utilization of Rain Water towards the best use of humanity. The major emphasis is to harvest rain water because of the depletion of ground water table which is at high risk with erratic rainfall and delayed onset of monsoons. So there is a need to harvest rain water through the roof water harvesting structures which is cost effective technique for tiled and concrete roofs. Through which rain water can be diverted to surface or sub surface tank through a delivery system installing a filtering unit in between to filter the microorganisms, debris and chemical substances which attributes to the contamination of water. The stored water can be used for drinking and cooking purposes which is free from the contaminants which lead to a health life.

The roof water harvesting is being demonstrated to the community and institutions where the ground water table is low and poor rainfall. The cost effective model is built at community residences to conserve the water during rainfall and use it during summer. The SHGs promoted by DHAN facilitates technical support for cost effective models and financial support. There are significant models using concrete structure, brick walls, Plastic tanks which can be suited for the context and financial capacity of people. It is being sensitized among the community for drinking water and ground water recharge. The same model at bigger level is showcased for institutions where the catchment area is big like office buildings, apartments, schools, hospitals etc. The storage capacity could be in thousands to lakh litres where it can be provided drinking water support to the entire scarcity period. It was observed that the quality of water is outstanding and the cost of investment for water cans has been significantly reduced. The maintenance cost also significantly very less.

DHAN has facilitated to construct hundreds of Roof water harvesting structures for poor community in a cost effective way at various places of the country. Roof water harvesting in schools is one of the significant model developed by DHAN brings substantial change in safe drinking practices among school children in Madurai and Chennai. This initiative provide solution for the children to access safe drinking water and to avoid morbidity during the seasons. The roof water harvesting in schools is a demonstration for the parents, teachers and students to replicate the same at household level to save, harvest and consume the safest water in the world. The behavior and practice change is envisaged among the community for the effective use of natural resources through this intervention.

Safe water at the doorsteps
Pride and Dignity towards Women Empowerment

Rajapandian R,
Chief Executive Officer,
Sustainable Healthcare Advancement (SUHAM) Trust,
DHAN Foundation

Ayyappan S,
Programme Leader,
DHAN Foundation

Synopsis

Close to 42 per cent rural households and 19.3 per cent urban households travel every day to fetch drinking water from various sources. The 76th round of National Sample Survey shows that the households by distance they cover ranges from less than 0.2 km to over 1.5 km one way. Event it is fetched with struggle and challenge, there is no assurance for quality. It is a heavy drudgery for women and girls to spend their significant amount of time for loading and unloading of water for the family. The society derived that it is a duty of women, especially in rural and tribal. Women faces physical and mental problems due to inaccessible and insufficient water. Safe water impacting on the reduction of number of waterborne diseases to save out of pocket expenditure and increased workman-days. The women and girls could save at least 1-2 hours per day in their restless schedule. The adolescent girls who affected much due to inaccessible where they miss the schools and colleges significantly. It requires sustainable solution where women can participate along with the stakeholders. Access to safe water at household level is an empowerment and dignity of women.

DHAN Foundation, a development organisation joined hands with water.org, USA to promote replicable and sustainable model by involving Jal Jeevan Mission and Gram Panchayats to ensure safe water accessibility. The Jal Jeevan Mission is a flagship program initiated by the Government of India to ensure at least 55 litres of water per capita per day by 2024. It is an add-on product of Swachh Bharat Mission where Jal Jeevan Mission ensures the usage of toilets and regular handwashing by providing water supply to the households. The household connections ensure the hygiene, ownership, access and saves time rather comparing street taps. It is known fact that high conflict evolves while fetching water in street taps and more over unhygienic condition around street taps also matters high. The partnership brings access to safe water through 'SCALE UP Program' through Kalanjiam women SHGs and Vayalagam Farmers' groups promoted by DHAN across 14 states. DHAN plays enabling role where SHGs are being activated to play the role of demand stream. DHAN and SHGs negotiate with Panchayats and Jal Jeevan Mission to provide water tap connections to the household level. DHAN work with banks to steer SHG-Bank linkage and facilitate technical support for poor and vulnerable people. The MoUs were made with Gram Panchayats to provide water connections to all households from SHGs promoted by DHAN. The SHGs will provide lending support to pay the deposits/ fees to the panchayats and purchase accessories for household water connections. The Civil Engineers and Health Coordinators from DHAN ensure the technical support for the connection and effective use of water.

In the last five years, 4.5 lakh families were facilitated to get water tap connections at household level. Especially 80,797 families received financial support of Rs.116.12 Crore from through SHGs under commercial bank linkage in 260 SHG Federations across 14 states. A special loan product was developed at SHG level under highly affordable lending. A population of 3,87,825 were benefited under this lending support towards enjoying the access to safe water. The sustainable behavioural change communication leads to get aware of situation and behaviour & practice of households in effective way of using water. This brought significant change in rural sanitation system also, leading to open defecation free status in every village. The women supported entire family in bringing access to finance, safe water and sanitation to the entire family. Always women are heading the health of the family. The purifiers are introduced among 50,000 families for further purity and safety of drinking water at household level. Now thousands of Gram panchayats are being enabled by the women in the villages and SHGs are evolved like a strong demand system. They can fulfil their entire needs by governing and working with mainstream institutions. It is really a prideful moment of every woman in the family. It is a great achievement by the women towards expressing their pride, dignity and empowerment. In another five years, entire 2.5 million families in DHAN will be reached with safe water and sanitation facilities towards achieving health, water & sanitation security.

Vayalagam way of Social capital with nested federations for effective Governance of small scale water bodies

Venkatesan N
Programme Leader
DHAN Foundation
India

Mohan J
Programme Leader
DHAN Foundation
India

Sundar D
Project Executive
DHAN Foundation
India

Keywords

Tank, Cascade, People-Institution, Sustainability, Governance

Synopsis

DHAN Foundation's water theme was initiated as a pilot focusing on community owned tank rehabilitation project by collaborating with mainstream institution at Madurai way back in 1992. This pilot Project of "Tank Rehabilitation" with an aim to enhance livelihoods of poor and marginal farmers evolved into "Vayalagam Tank fed Agriculture Programme" during 1998. The major focus of sustaining tankfed agriculture of small, marginal and underprivileged farming community by creating access to water, crop production technology and institutional governance become inevitable. In new millennium, the programme integrated micro finance, insurance, extension (through Plant Clinics) and tank based watersheds reached over 4302 Villages in 7 States and promoted 6465 Vayalagams, 30 registereds federations and 40 unregistered federations by end March 2022. The primary institution viz. vayalagam (tank association) promoted at hamlet/around small fresh water resources such as tanks, village ponds, community wells and the like. Due to ensure better water sharing on hydrologic basis, these Vayalagams are integrated at cascade/Watershed level and then at block level as Federations.

The UNDP defines the water Governance as the broad range of political, social, economic and administrative systems that are in place to regulate the development and management of water resources and provision of water services at different levels of the society (UNDP, 2005). Water governance requires law and institutions. The water governance seeks a balance of these four dimensions as shared above.

Based on the definition referred above, the DVTF has promoted the nested people institution model with primary institution for each water body and then cascade association at cascade and then federations at block or district level. Then all the federations in the sub basin and basin level will be pooled together and promoted as sub basin and basin associations.

Different dimensions of water governance through nested people institution:

- The social dimension refers to the equitable use of water and other natural resources through the institutions promoted above.
- The economic dimension informs on efficient use of water and other resources and role of water and other resources in overall economic growth in the area where we promote the federations.
- The political empowerment dimension points to granting water stakeholders and citizens at large equal democratic opportunities to influence and monitor political process and outcomes.
- The environment sustainability dimension shows that improved governance allows for more sustainable use of water resources and ecosystem integrity.

Principles of effective governance:

Transparency: through the nested people institutions promoted, members of the federations at different level are facilitated to access the information and their understanding of decision making mechanism on various issues faced related to local management of the water dies and related development of the farming community. Transparency, integrity and accountability of the members and leaders in the institution are fundamental to the creation of a peaceful and secure management structure for its implementation of different interventions at different levels.

Accountability: Good governance and sound institutions play a huge role in promotion of accountability. Accountability is about being answerable for one's actions. It requires the ability of the institutions to scrutinize leaders, public and institutions and governments and hold them accountable for their actions.

Participation: The people institutions like federations are successful if all stakeholders, including marginalized and resource poor groups can become meaningfully involved in all water management and other interventions envisaged through the federations at different levels. Federations should support and encourage all stakeholders to participate in the development.

Access to Justice: Effective governance that promotes principles of governance should provide frame work where everybody has access to all kinds of resources and particularly the water which can be materialized through justice. In practical terms, this means that legal frame works need to provide solutions that enable all users to demand their rights from duty bearers. This requires not only effective legal frame work, but also well-functioning institutions.

Responsiveness: responsiveness refers to how well leaders and federations take the needs of the member Vayalagams and cascades in to account and are able to uphold their rights. The federations' agenda addressing responsiveness could include Human rights, gender rights, pro poor policies, anticorruption, integrity and regulatory equality.

Growth path of the federations: These institutions undergoes four generation concept for graduation of sustainability from one level to another level with time frame and significant transformative institutional processes and interventions. In its two decades of growth, vayalagams nested institutions evolved context specific development agenda with community governance through continued empowerment as narrated below.

This paper will capture the DHAN Foundation's 30 years of experience on people led governance for effective and efficient management of small scale water resources at grassroots with the following leads as way forward.

1. The Vayalagam model of nested people institution with community governance is the effective mechanism for ensuring the local management of the small scale water bodies in our country on long term basis for sustainable development.
2. The transparency as one of the principle of community governance for effective information sharing and decision making will be ensured across all the nested institutions such as Vayalagams, cascades and Federations for all policy decisions of the federations for poverty reduction and water resource management.
3. The accountability as another principle of governance will be effectively demonstrated at Vayalagams, cascades and federations for their commitment to the members for poverty reduction and effective management of the water resources for sustainable development.

4. The participation is the important principle of the governance will be ensured at all levels of nested people institutions for evolving the policies and decision making related to sustainable development.
5. All federations and their member institutions with effective governance need to work together through Vayalagam Mutual Movement for achieving the joint vision of equitable, sustainable and effective management and services to the members at grassroots level.
6. The Self-regulation is the effective mechanism for ensuring the good governance system at all levels of the federations and their member institutions.

Sustainable development of Tank ecosystem through Community lead water conservation works in Rural context: Achievements and Action Leads

Venkatesan V
Programme Leader
DHAN Foundation

Keywords

Sustainable development, tank ecosystem in rural context, water and heritage, community lead water conservation, equality in water sharing, holistic growth, collective ownership on water bodies

Synopsis

Tank ecosystem is the lifeline for rural communities. It serves as base for biodiversity, livelihoods, water security in rural context. The traditional water bodies like tanks, Ooranis (Drinking water ponds), etc are the indispensable components in the lives of community. The thirty years of DHAN Foundation's contributions in enabling the community towards water conservation works has established a new social order. The community lead water conservation is the key for sustainable development of tank ecosystem which is highly possible through structured enabling mechanisms.
Promoting people institutions at different levels like village, cascade, block, and basin gets top primacy in community lead water conservation works. The institutions promoted at different levels by DHAN Foundation demonstrates the democracy across all its endeavors. The structured mechanisms preserved across the institutions ensures the governance at higher order along with community ownership. The nested institutional structure brings multiple elements like peer pressure, mutuality, leadership development, stakeholders collaboration, etc which are very vital for holistic development. Village Vayalagam (Tank Associations) is the base unit promoted at village level which pays platform for the grassroots people to emerge as water leaders.

Steady and longstanding partnership sustains water security. DHAN Foundation believes in an enabling journey with the community which sustains their vibrancy towards water conservation works. The enabling is ensured across the key components like conflict resolution, governance building, localizing the standards, and community monitoring during the implementation. The implementation of water conservation projects at village level never commences unless the consent of entire members is ensured. Generally, it consumes reasonable duration, at times a year to bring the community for a common consent and enrolling them as membership with Village Vayalagam. However, such longstanding journey with the community brings organic association between DHAN Foundation and community which brings vibrancy and ownership among them.

Community lead water conservation model calls for contribution from each family towards common property management. Three decades of DHAN Foundation's water works has enabled the community to revive around 6000 water bodies to an amount of Rs.210 crores. Out of the total amount spent, nearly Rs.40 crores has been contributed by the member families as cash and kind. Such contributions from the individual families ensures their stake and ownership on the respective water bodies for continued maintenance. It has multiplier effect in enhancing the quality of implementation, generating surplus, developing additional components, and generating action leads for sustainable management of respective water bodies.

Indeed, water deepens the democracy, governance and enlarges the partnership. The Village Vayalagam has strengthened the demand system and established platform to join hand with various mainstream institutions. Such collaborative avenues have generated reasonable quantum of resources and expertise towards water conservation works in the respective context. Negotiation with the supply system is strongly exercised which has paved way for channelizing the resources. The MGNREGA works has witnessed greater participation by the Vayalagam families. The Village Vayalagam in association with the respective Panchayat are channelizing the MGNREGA towards water conservation in individual's land for which the provision is already declared by the Central government.

Basin approach binds the community beyond borders. Ensuring equality in water sharing and water distribution across the villages is one of the key objectives of the Vayalagam Associations. The leaders from the Village Vayalagam gets converged with the Basin level deliberations and debates on the revival of basin through collective endeavors. The primary objective of the basin level deliberations is to generate implementation strategies for saturating the water conservation across the entire water bodies in the respective basin. The member families belong to the respective basin get involved in the future search processes to visualize the prospective growth.

Water and heritage are highly interconnected. Our ancestors have treated the water bodies as a noble platform which had prominent connectivity with their life style. Moreover, the practices in the social system also paved way for protecting the water bodies. One such practice was the Neerkatti (water regulators) system. There were few dedicated families who were appointed as water regulators and their role was to manage water distribution across the members. The community lead water conservation models aim at protecting such practices. Series of conventions and action research are done to understand the status of Neerkatti system and also to revive it across the Vayalagam villages.
Community lead water conservation models also calls for holistic development of community. It brings water in a multi facet approach like water and sanitation, water and health, water and livelihoods, water and gender, etc. This establishes a greater opportunity for the families to avail entitlements as well as to get incorporated in various welfare actions. The Vayalagam federations promoted at block level acts as mother federations and around which thematic federation are promoted like mutual federations for insurance, SUHAM federations for health, Jeevidam federations for livelihoods, etc. In addition, these federations together contribute for sustainable development of the mother institutions.

Sustainable development of Tank ecosystem through community lead water conservation works done through DHAN Foundation has reached nearly 4 lakhs poor families belongs to 17 basins at national level. This has emerged as a Vayalagam Movement wherein the community benefitted are volunteering to contribute for the prosperity of the fellow families. The water leaders emerged from the grassroots are becoming lifetime workers to move around the Vayalagam villages and seeding the concept of community lead water conservation models. Moreover, endowment funds are created at each Village Vayalagam and kept in fixed deposit. The interest amount earned out of fixed deposit are being used for the permanent maintenance of tank structures. Besides this, the Agriculture Finance Groups (AFGs) are promoted wherein the entire members of the Village Vayalagam are taking part in savings and credit activities. The AFGs are getting linked with local banks and receives credit support to meet the financial requirements of agriculture activities. The Vayalagam model of community lead water conservation works has proved to be a noble model in shaping the lives of farming families at large.

Peoples' Participation – Panacea to Prevent Pollution of Rivers in India

Deepika Sharma
Assistant Director
National Water Development Agency India

K.K. Rao
Assistant Director
National Water Development Agency India

Keywords

Human Awareness, Water Conservation, Public Participation, Environment, Natural Resources

Synopsis

Water is vital for all forms of life and the centrepiece of existence and its management, conservation and prevention is in evitable. Human behaviour, understanding and activities directly affect the quality of water. Human beings, need to understand without clean water resources, our survival will be endangered. Prevention of pollution of rivers in India can be achieved by two level mechanism i.e. Government to make rules and regulations which is incomprehensible without the second level i.e. Public participation and awareness to achieve the goal of providing clean and pollution free water to every individual of the nation. If we ignore the prevention of water pollution, this ignorance will bring many punishments for human survival itself. Aspect of water pollution can not be ignored in present environmental conditions where protection Environment and its resources is inevitable to save mankind and to have sustainable future. Use of latest tools and technologies along with awareness need to be adopted at individual level and Governmental level to achieve success in prevention of our natural resources.

PD6:
Challenges in Urban Water Planning and Management

Urban Water Planning and Management: Evaluation of Indian Context

Dr Harinarayan Tiwari
Managing Director
Floodkon Consultants LLP
India

Meesha Tandon
VP Suap Foundation

Keywords

Urban Hydrology, Flooding, Risk, Social Development, Economic

Synopsis

The rate of urbanisation has increased all around the world. Today, metropolitan regions are home to more than half of the world's population. By 2050, 2.5 billion more people are expected to live in cities due to ongoing urbanisation and population increase, bringing the global share of people living in urban areas to 66%. A significant portion of the increase—nearly 90%—will also occur in Asia and Africa. As a result, rapid and unplanned urban growth threatens sustainable development when the necessary infrastructure is not developed or when policies are not implemented to ensure that environment conservation is given top priority.

A common example is the flood disaster, which has largely affected metropolitan areas rather than being a rural phenomenon. Urbanization has been shown to speed up peak flow and reduce its arrival time. Therefore, it is ironic that urban expansion, which is meant to improve their quality of life, puts city people at a larger risk for flooding.

Urbanization has many distinct effects on the health of aquatic ecosystems in addition to increasing the risk of flooding. New methods of thinking and new strategies are required to address the many issues brought on by urbanisation and link it to the three pillars of sustainable development—economic development, social development, and environmental protection.

Nevertheless, the question "urbanization for what?" has been insufficiently addressed and inadequately explored. In this paper, author will explore the major challenges and possible solutions for Urban Water Planning and Management.

Integrated Water Resource Management: Mandakini River in Bundelkhand

Synopsis

Mandakini river originates as a seasonal river in Satna district, MP at an elevation of 156m above M.S.L. and flows downstream towards Uttar Pradesh (northwards) where it meets Yamuna River near Rajapur village. Watershed of Mandakini River is spread over more than 1600sqkm and the river becomes a perineal river downstream of the Vindhyan catchment due to the presence of several small and large springs, originating from neighboring hillocks. The river, likely to be significantly governed by subsurface flow, faces several pressures: urbanization, several check dams along the length, wastewater nallahs contaminating the river, lack of floodplain demarcation, lack of riparian buffer zone, water scarcity issues in the catchment and many others. More than 2 lakh people are dependent on the river for drinking water and agriculture.
The river can broadly be divided into 3 stretches: the catchment stretch, the urban stretch and the

agricultural stretch. The river is also susceptible to flooding and also drought like situation in the catchment. This paper looks at the status of groundwater and surface streams at the catchment level, identifies issues impacting the river across the 3 stretches and also grades the river based on existing status (mostly based on observations as data is not available). The paper also looks at how a comprehensive water cycle approach can be adopted to improve sustainability of the river through measures across the 3 stretches under the overarching umbrella of Integrated Water Resource Management.

Water Planning and Management Issues in Urban Areas

Rajendra Kumar Agrawal
BE(Civil), MIE, MA(Socio)
Chartered Engineer
Advisor
Sahayata Samajik Sanstha
Bhilai Chhattisgarh

Keywords

Sustainability, resilience, circular economy

Synopsis

As per WB report, 2 Billion People lack access to safely managed drinking water services, 3.6 Billion people lack access to safely managed sanitation 1.65 Billion have been affected by floods in last two decades and ¼ of all health care facilities have no basic water services.

Urban areas are growing very fast globally and irrespective of political divides within the country, everybody is of the opinion that Urban Areas must be Green, Resilient and Inclusive.

Since water is at the heart of every development and without water nothing can be planned it is of utmost importance that development is made Water Proof by Realistic and Sustainable planning and management of water.

Due to climate change and unpredictable growth water planning is needs to be done to absorb wide range of shocks and stresses. It must be based on resource sustainability, availability and economical use.

Water Management side in urban areas are sensitive and tricky issue. The management side needs to be based on best practises. Optimum storage and use of storm water is a key issue presently being tried by the various ground water recharging techniques. The second most important is management of sewage generated in huge quantity in urban areas daily that is to be recycled and reused for enhancement of water availability for different uses in urban areas. Most important part in the management is Understanding and Valuing water, Citizen Engagement and technical acts of urban local bodies.

The paper touches all the above key issues in Water Planning and Management in Urban Areas through simple and scientific methods.

PD7:

Converging towards National Perspective – IBWT

Using modern technologies for implementation of Interlinking of Rivers in India

K.K. Rao
Assistant Director
National Water Development Agency India

Deepika Sharma
Assistant Director
National Water Development Agency India

Keywords

Interlinking, Perspective, KBLP, Technologies, Component

Synopsis

Interlinking of Rivers (ILR) is an old age concept, in India as well as abroad, of diversion of water from surplus river/basin to water deficit river/basin using engineering structures for equitable distribution of water among regions/areas so that water is available for domestic, industrial & irrigation purposes, mitigation of drought conditions, infrastructure & Socio-economic development etc. This is also done to divert flood waters to other needy areas so that the flood water flowing into sea is utilised for the overall development. The ILR project is a variant of River Valley Project which comprises dam, barrage, reservoir, canal system, power house etc. ILR Projects will supplement ever growing food and energy demand in the country. Using Modern technologies during planning, execution and monitoring of ILR Projects in India is the need of the hour for the development of nation as a whole so that the benefits envisaged by the planners, who have designed the National Perspective Plan (NPP) way back in 1980s, to reach nook and corner of the country. These technologies would definitely give thrust for better results in all phases of these projects and reduce the time required for preparing and fine tuning the requisite reports; completing preparatory works of project; executing the civil, mechanical, electrical, environmental and other works of projects and monitoring of project during execution as well as post completion.

Linking Rivers Project: A Renewed Push for Water Security

Dr R N Sankhua
Chief Engineer (South)
NWDA, Ministry of Jal Shakti, Govt of India

Keywords

Water Security, ILR

Synopsis

In spite of the glaring environmental concerns, the benefits of the project for the region are hard to ignore. The inter-linking of the rivers is expected to address the chronic drought in the region and ensure availability of water to dry areas though the ILR sometimes puts some State Governments in a delicate dilemma, wherein it has to choose between environmental conservation and social welfare. Since the river-linking projects involve clearing of forest land and endangering animals, besides relocating the local population, a robust custom made multi-pronged environment strategy that is for each of the project region to minimise the ecological impact should be put in place. River water distribution is an extremely successful method of ensuring balanced distribution of precious water resources, and if executed well, the benefits can be reaped by many generations. The Ken-Betwa, Damanganga-Pinjal, Par-Tapi-Narmada river-linking projects are progressive step forward, provided the ecological impacts are more than adequately compensated for. The National River Linking Project (NRLP) water transfers envisage easing the water shortages in Western and Southern India, while mitigating the impacts of

recurrent floods in Eastern India. The NRLP when completed, will increase India's utilizable water resources by 25%, and reduce the inequality of water resource endowments in different regions. The increased capacity will address the issue of increasing India's per capita storage. It currently stands at a mere 200 m3/person, as against 5960, 4717 and 2486 m3 /person for the USA, Australia and China, respectively.

The satisfaction of the domestic water must receive the highest priority in our water policy in the face of erratic spatio-temporal variations in the precipitation. Further, protection of rain-fed farmlands from variations in the climate, especially long spells of droughts, should be an equally important and high priority objective in India's water policy. The logic behind the interlinking project is based on the view that there is 'surplus' water in some rivers, which, if transferred to the other 'deficit' rivers, would provide a permanent solution to the problem of human sufferings from droughts and water scarcity.

Prophesy Of Problems in the Construction of ILR Projects

Dr R N Sankhua
Chief Engineer (South)
NWDA, Ministry of Jal Shakti, Govt of India

Keywords

ILR Projects, Prophesy of problems in construction,

Synopsis

With contrived polarization, this article rationalizes rationally abrogating transformation of the water management ideas through execution of structural entities of river inter linking projects into sustainable and gainful social reforms at the behest of water development because of the cogent reasons. The notion of endangering National River Linking Project (NRLP) sans detailed scientific insight is an undeniable setback to the efforts being made by the present proactive Government to arrive at a consensus among the participating basin States for the ILR projects implementation with emphasis on groundwater recharge and may get jeopardized in view of suggested anti-developmental & anti storage approach. Each State to enshrine the Right to Water, beyond written solutions through DPRs prepared by NWDA, it is essential that practical measures are put in place to make this right a reality. The riparian states' relations may fall apart at the seams, sans transparent execution of water sharing on bilateral and multilateral agreements. Against the backdrop of the urgency of water issues, the NRLP may come as a cropper without direct access to emblematic water facts and relevant, synthetic and in-depth information about planning of the resource. Abduction is closely associated with the philosophy of pragmatism and is sometimes understood as switching back and forth between inductive and deductive logics to develop novel insights and hypotheses before the construction of highly complex structures of ILR. The would-be-structures are signs of the upsurge of irrigation, domestic and industrial water supply, whose fortunes have risen as the cost-benefit ratio of ILR projects and have become clear over the years hastening this shift. But that didn't stop grassroots movements from organizing and growing to fight for their rights and livelihoods. The present article offers inputs from my professional's perspective and is an attempt to focus on the constructional and socio-environmental problems of the apt executions through agreeable hydro-diplomacy, project management across the riparian regions for a concerted, coordinated and unperversed fulfilment of the connecting flows of rivers in India.

ILR-Need for Institutional Reforms

Bhopal Singh
Director General
National Water Development Agency
Ministry of Jal Shakti
Govt of India

Synopsis

Water is one of the key drivers of the socio-economic development of any region. Looking at the large variation in precipitation and available water resources in India, the inter-basin water transfers from surplus basins to water deficit basins/areas is imperative to address the imbalance in water availability across the country and water security in the country. A National Perspective Plan has been prepared for inter-basin water transfer from surplus basins to deficit basins/areas. However, there are many challenges in the implementation of inter-basin water transfer (IBWT) projects in the country like interstate and international issues, environmental and R&R concerns etc. As stressed from time to time, there is need for constituting an autonomous body for planning, investigation and implementation of ILR projects in national interest.

In this regard, a proposal for constitution of National Interlinking of Rivers Authority (NIRA) is under active consideration by Govt. of India to further the ILR programme in the country. NIRA is proposed to be constituted with restructuring and strengthening of National Water Development Agency (NWDA). The restructuring of NWDA into NIRA with enhanced mandate would help in transforming a planning and investigation agency to an implementing body and promoting ILR programme as a national programme for the benefit of the nation as a whole. NIRA is proposed to be constituted with a three tier structure i.e. Governing Council, Governing body and Executive Body. However, even after the constitution of NIRA, the present approach of consultation and evolving consensus amongst various stakeholders would still be the driving principle for implementation of ILR programme in coming years.

Critical Analysis of Public Acceptability of River Linking Projects

Rajesh Kumar Jain
Research Scholar
Lingaya Vidyapeeth,Faridabad

Rajesh Goyal
Dean
NiCMAR Pune, India

Professor Dr Dulal Golder
Junior Research Fellow
Lingaya Vidyapeeth., Faridabad
India

Bhupesh
Expert Jain Philosophy

Aprajita Jain
Expert Jain Philosophy

Keywords

Public, Acceptability, River linking, water scarcity

Synopsis

The human life has been subjected to natural factors for existence since the age of stone. Availability of water has been major factor governing place of habitant. In vedas also need of rain God and Jain philosophy need of sustenance through Karma mechanism is advocated. We have herd need of wells, canals Tanks and storage structures in ancient and medieval times. The study has been done to critically analysis need of River Linking Projects. The success and acceptability of any system depends upon human behavior, its deeds or Karma, behavior with others, needs of others, concentration on own situation, preserving at the confrontation with obstacles and ultimately meeting targets.

With these background authors has attempted to articulate lifesaving aspects of those villagers who will be subjected to River Linking Projects.The human tendency to accept or go with change depends upon human behavior as well their awareness about latest technology. Monitory benefits, sustainability after change. One of important factor was introduction to latest crops and transformation of farmers to adopt. The pressurized irrigation as a substitute to rainfed irrigation with uncertainty was also important. Also weightage given in analysis to apprise farmers baseline and post project condition.

The factors were converted in to sutra or formulated to assess acceptability of Linking. The study was done in 8 districts of country concerning Ken-Betwa,Par-Tapi-Narmada, Chambal River Linking of Rajasthan and Barakar-Damodar-Subarnalekha in Jharkhand. The success rate was found very convincing.

The Mahoba district of Uttar Pradesh 88%,Girdih District of Jharkhand 905,Chhatarpur District of Madhya Pradesh 88%, districts in Maharashtra 80% surveyed found supporting on various parameters. The overall acceptability is found 90% against 10% against it. So study confirms the acceptability.

Study of Sustainability Aspects of Chambal River Linking System Using Reservoir Simulation Techniques

Rajesh Kumar Jain
Research Scholar, Lingaya Vidyapeeth,
Faridabad, India

Rajesh Goyal
Dean and Professor, NICMAR
Delhi NCR Campus, Bahadurgarh, India

Dulal Goldar
Feculty of Civil Enginerring, Lingaya
Vidyapeeth, Faridabad, India

Keywords

Reservoir, Sustainability,Mohanpura,Kundaliya,Gandhi Sagar,Rana Pratap Sagar

Synopsis

Abstract: In the present analysis, computer based multi reservoir simulation model of four reservoirs viz. Gandhi Sagar, Rana Pratap Sagar, Mohanpura and Kundaliya in Chambal basin has been done while they are in isolation or iner connected with success rate of 75% for irrigation,100% for drinking water and 90% for Hydro power in term of volume and time reliability .Three scenarios Case I : When these reservoirs are operated in isolation with their performance and efficiency and reliability in term of time and volume as well as targeted hydro power generation .The analysis established availability of water for diversion with the success rate needed and spills at Mohanpura and Kundaliya are available for interlinking. Case II when water is diverted from Mohanpura to Kundaliya and then Gandhi Sagar CaseIII Kundaliya to Rana Pratap Sagar These further done for three sub cases. 1st when designed parameters of all 4 reservoirs kept intact. 2nd only water use targets modified and 3rd optimization of reservoir capacities.

The case II established either increase in target diversionII(1 &2) or reduction in reservoir capacityII(3)and the success rate of Mohanpura and Kundaliya reservoirs more than in case I and also improves irrigation and power for Gandhi Sagar The case III established that either diversion can be increased or hydro power can be increased, the success rate for Mohanpura and Kundaliya remains same as in case II,No change in success rate of Gandhi Sagar over case I and increase in power generation in case III(1,2&3) up to 94%.Thus the simulation studies confirm the sustainability of Chambal river system by River Linking System using multi reservoir simulation technique.

PD8:
Agriculture Sustainability under Unforseen Circumstances

Agriculture Sustainability under unforeseen circumstances

Dinesh Kumar Chauhan
Vice President-New Initiatives
Green Agrevolution Private Limited

Synopsis

Agriculture has significant challenges due to the world's chronically high rates of hunger and malnutrition (793 million people were chronically hungry in the globe in 2015) and unsustainable human activities on the planet's carrying capacity. Agriculture would need to produce 60 percent more food globally in the same period in order to fulfil the rising food demand of the nearly nine billion people who will be on the planet by 2050 as well as the anticipated dietary changes. In addition, some 1.3 billion tonnes of food are lost or discarded annually along the supply chain, resulting in significant economic and environmental implications.

Major challenges

At a time when there is a rising demand for food, feed, fibre, and commodities and services from agriculture (including crops, livestock, forestry, fisheries, and aquaculture), there is also a rising scarcity of natural resources and a rapid deterioration of those resources. In regions that depend heavily on agriculture and currently have significant levels of food insecurity, some of the fastest population increase is anticipated. Additional, closely related aspects make matters more difficult:

Due to its detrimental effects on the environment and natural resources, the current trajectory of agricultural production expansion is unsustainable. The genetic variety of crops has decreased by up to 75%, one-third of farmland is damaged, and 22% of animal breeds are endangered. In the past ten years, almost 13 million hectares of forest per year have been converted to other land uses, and more than half of fish sources are fully utilised.

Way Forward

The challenges mentioned above lead up to four fundamental values that should direct the strategic creation of fresh ideas and the move toward sustainability:

- The key to sustainable agriculture is increasing resource utilisation efficiency.
- Sustainability necessitates taking immediate action to preserve, protect, and improve natural resources.
- Agriculture cannot be sustained if it does not safeguard and enhance rural livelihoods and social welfare.
- Sustainable agriculture must increase environmental, community, and human resilience, particularly against climate change and market instability;

Sustainability must be viewed as a process rather than a clearly defined goal that must be attained if we are to keep up with the quick rate of change in unforeseen circumstances. In turn, this necessitates the creation of technological, policy, governance, and financial frameworks that aid resource managers and agricultural producers who are actively engaged in a dynamic innovation process.

PD9:
Role of Hydropower for Energy Security

PD10:

Aligning with Nature while Ensuring Water Security Challenges and Opportunity

Identifying water poverty hotspots in the state of Maharashtra, India

Aishwarya Dhawan
PhD Scholar
Department of Humanities and Social Sciences,
Indian Institute of Technology Bombay, India

Haripriya Gundimeda
Professor
Department of Humanities and Social Sciences,
Indian Institute of Technology Bombay, India

Keywords

Water Poverty Index, Principal Component Analysis, Maharashtra, Spatial Mapping, Moran's I

Synopsis

The emerging global consensus that water shortage is attributed to lack of means rather than merely resource availability highlights the unequal access and distribution of water. The fundamental in discussing water scarcity is its availability i.e., the scarcity of readily available water. This issue arises due to spatial and temporal fluctuations in water supply and demand. Different regions have a relative abundance or shortage of freshwater at varying time periods. Hence, water scarcity is essentially a local or regional problem. Inadequate water availability induces loss of human capital (through adverse impact on human health and morbidities) and natural capital (through pollution). Preventing effective utilization of available livelihood resources can lead to poverty. Like other natural resources, water acts as a factor of production, and poverty can be reduced by the efficient allocation of water (Sullivan & Meigh, 2003). Thus, improved water resource management and access to safe water and sanitation are essential for eradicating poverty and building peaceful and prosperous societies (UN World Water Development Report, 2019). India faces an ongoing water scarcity situation, affecting millions of people every year. Since the last decade, the condition has worsened unprecedentedly in various states, including Maharashtra, the wealthiest Indian state. Almost half of the state endures water crisis, particularly during the summers. The looming water crisis along with emphasis on the role of water in fighting poverty has put water issues as the central agenda at various national and international platforms. Thus, estimating comprehensive water poverty appears a critical policy tool for efficient water management. Water poverty, an evolving concept examines the link between socioeconomic aspects affecting accessibility to safe water and its physical availability. Water Poverty Index (WPI) generates result in a single number for better management of water management and poverty alleviation.

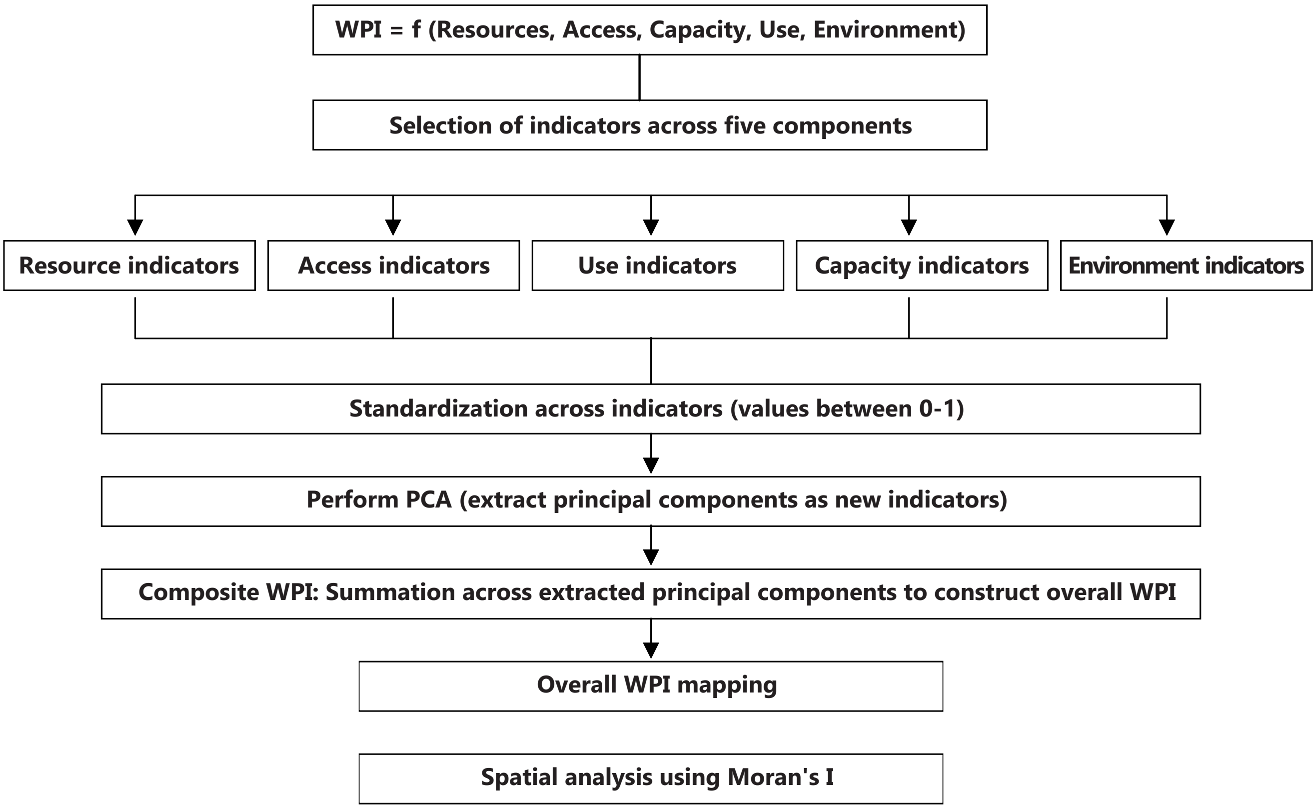
The objective of this paper is to estimate the degree of water scarcity in the state of Maharashtra, India using WPI. Different components of WPI can be aggregated into a composite index using principal component analysis and combining this information with Geographic Information System (GIS) to illustrate water poverty across the districts of the state. Using secondary data for the five components of WPI, namely, resources, access, use, capacity and environment, the generated index would substantially reflect the link among the hydro-climatic, environmental, and socio-economic aspects affecting accessibility to safe water and poverty alleviation Further, addressing the water poverty-related policy concerns, proper scale implications in available studies are not comprehensive and conclusive. For example, it is important to ask how multitier governments would address the district level water poverty given water is a state subject. In an attempt to fill this research void, this study proposes assessing the district level water poverty of Maharashtra, India, and mapping the spatial heterogeneity.

1. Research Strategy: material and methods

1.1 Water poverty index construction and mapping

The conceptual framework followed for the construction of WPI is illustrated in Figure 1. The paper constructs WPI by aggregating several relevant individual indicators, upon selection of indicators, the linear relationship among indicators in each component has been established. For those indicators which are correlated, a Principal Component Analysis (PCA) has been performed to extract principal components and use them as new variables. Among various methods of normalization, we have used Z-score standardization for individual indictors and a rescaling (min-max) approach to normalize the final composite WPI. Using ArcMap 10.3 version, we illustrate the spatial distribution of water poverty across the state. Initiating with the demonstration of variation in all extracted principal component scores and then mapping the overall water poverty.

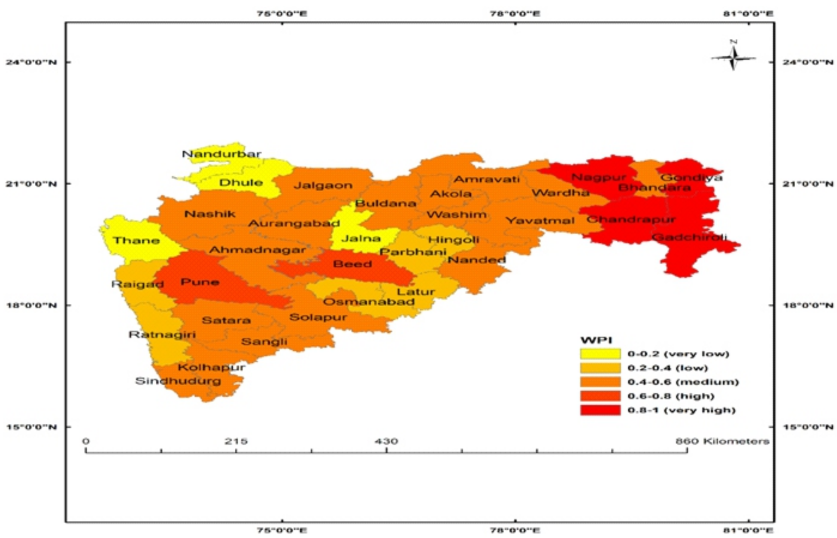
Figure 1: Research Design for WPI



2. Results and Discussion

PCA has been performed using SPSS software (version 22). We aggregated the values of extracted principal components to generate overall WPI between 0 and 1. Districts with high WPI scores have a higher degree of water-related poverty and vice versa. Also, a spatial clustering pattern is found for the local spatial analysis with Moran's I value of 0.305.

Figure 2: District wise spatial variation of water poverty index across Maharashtra



Clearly there is a great disparity regarding water poverty across the districts. Overall WPI score for the state of Maharashtra is 0.47, which signifies that the state has performed poorly across all five components of the composite index. Our result shows that WPI is mainly influenced by access and capacity components of WPI. Out of thirty-three districts selected for our analysis, twenty-one falls into medium to very high categories. This reveals the severity of the water poverty situation in this state. There is an extensive economic, social and climatic spatial variation across the state, which has a distinct intrastate impact. This is now an overdue task to investigate new ways of water availability which must incorporate the massive spatial and temporal variations in the distribution of water resources in India considering its access as well.

3. Summary and Conclusion

The present study uses the concept of WPI to understand water stress in the state of Maharashtra, India. Using secondary data, this is a study assessing water poverty across the districts of the state facing crucial water management issues. The emerging water stress in this region indicates substantial use of this resource, affecting resource sustainability with rising possibilities of conflicts. Effective water management requires linkage between water availability, its accessibility as well as capacity to manage safe water from improved sources to meet water demand. Nonetheless, one of the major constraints of this study is the inability to create this composite index for any one particular year along with unavailability of data for few components. However, using the available data will be helpful in assessing the existing disparity. Such assessment would provide critical information on how some regions are considerably more affected.

Spatio-Temporal Assessment of yield in a river basin for equitable distribution of water amongst the deserving party states

Vijay Kumar Dwivedi
Assessor, Mahanadi Water Dispute Tribunal
Ministry of Jal Shakti, Govt. of India
Janpath Bhavan, Janpath, New Delhi

Synopsis

Since time immoral, a river basin has been a focal region for human settlement as well as for all living beings including flora and fona because the river basin provides potable water to all. The human settlement usually took place at the outlet of the basin due to easy availability of water. With time, as the development starting taking place, not only requirement of water increased exponentially but also the demand for available space followed the same trend. The civilization started going up opposite to the direction of flow and utilizing the water available up the settlement point in the basin, thus depriving the already settled civilization at the mouth of the basin. With explosion in population and availability of developed tools, the same basin area was divided into different autonomous regions, here-in called States, who claim to have absolute right over the water available in any form in the particular State to satiate all the present and presumed (forecast) need of water in the State. These anthropological shifts have given rise to dispute amongst the Party States in the river basin. These disputes are only due to lack of equitable distribution of water amongst the Party States. For equitable distribution, what is imperative is the real time spatio-temporal assessment of yield water in all forms in the basin so that the concerned Party States can be made to utilize certain percentage of the estimated yield by designing the demand as per the available yield. In this paper, real-time spatio-temporal yield of the basin of River Mahanadi has been estimated by considering the geography of the river basin, because geography of the basin presents the realistic situation.

Nature-based Solutions: Scientific protocol for restoration of ecological function of environmentally degraded river basins

Yogendra Babu Sharma
CGWB, MoJS, Govt. of India

Synopsis

Human activity in recent years has left a major footprint on our environment. Biotic resources such as flora and fauna, together with abiotic resources like land and water, have been greatly altered by human activities. In the process of human development, we have cleared forests, dammed rivers, drained wetlands, established new vegetation communities and released a variety of chemicals into ecosystems. Consequently, many ecosystem services that provide important functions have been compromised. Human intelligence, mostly developed in the last century, has provided us scientific basis to analyse the potentially dangerous consequences of these human impacts. And, we are now attempting to reverse the degradation process by restoring these important ecosystems through better environmental policies and awareness.

As environmental quality is now expected to be a driving force for all civilizations on the earth, environmental protection is seen as an opportunity to examine sustainability and economical viability of any developmental project. Additionally, climate change has been identified as another major challenge where we have to deal with rising temperature, sea level rise, extreme weather events, and subsequent reduction in our greenhouse emissions. Therefore, all future development of mankind to meet high quality life standards would merely depend on holistic and sound environment policy. Disparity in current environmental policies of various countries is considered as business opportunity for many sectors including housing, infrastructure, and manufacturing industries. The consistent progress in environmental legislation, particularly in developing countries, has already shown positive results. However, there is still enormous potential for improvement in both policy making and capacity building for betterment of all abiotic and biotic environments of various degraded ecosystems.

Degraded ecosystems are essentially the outcomes of either human induced or anthropogenic changes in their physical, chemical, and biological environments. The potentially dangerous consequences of these impacts have triggered the attempts to reverse this degradation process by restoring the impaired ecosystems. Consequently, restoration has emerged as an activity that eventually assists the return of an environmentally degraded ecosystem to its earlier undisturbed state. In other words, ecological restoration attempts to promote recovery of ecosystems damaged by human impacts and the overall objective of restoration is to restore the structure and function of an impaired ecosystem to a pre-existing state. However, historically restoration has focussed more on re-establishment of ecosystem structure because of measuring and restoring ecological function is a complex and time consuming task. Although restoration ecology has scientifically developed and served as boon for many altered ecosystems in recent years, restoration still remains an 'acid test' in ecology.

For example, in water limited ecosystems, a change in hydrology is a main cause of land degradation. As water availability is reduced, the soil surface becomes increasingly barren and loss in vegetation cover intensifies the desertification process through splash and sheet erosion. Further, smoothing and sealing of the soil surface decelerate the water infiltration and accelerate runoff and gully erosion. Owing to the effects on both water availability and plant function, the cumulative effects of land degradation results in a further loss of vegetation cover. This phenomenon is quite common in arid and semi-arid ecosystems where restoration of soil properties and hydrological conditions seems to be primary concern. A systematic restoration in these cases requires rehydration of soil surface through reinstatement of pristine hydrological conditions followed by reestablishment of vegetation cover to a known baseline conditions. However, estimation of undisturbed baseline conditions requires a reconstruction of past environment at different temporal scales.

Therefore, a methodical restoration primarily depends on a scientific assessment of pristine conditions. For this purpose, reconstruction of past environment using sedimentary records provides unique perspective on patterns, causes, and rate of ecological and hydrological changes. As they also provide information about the drivers of changes that caused degradation, these long-term proxies have a much greater influence than simply documenting environmental trends of an ecosystem. Furthermore, they are capable of providing specific information on pre-disturbance baseline levels and chronological variability in their physical, chemical, and biological parameters for a scientific restoration of damaged ecosystems.

As the human population continues to expand, prime natural resources, such as fresh water, arable soils, and forests are increasingly damaged and depleted by human activities. Several plants and animals species are disappearing at unprecedented rates; these losses endanger human life too and indeed its very existence. Manifestly, conservation of resources is desirable; however, these efforts are not sufficient for sustenance of crucial ecosystem services. There is nevertheless good news that the degradation of ecosystems is often reversible, and evidently restoration can be effective in reinstating such ecosystems to a desired state which seems to be a new hope to counter the human impacts. However, the success or failure of a restoration effort entirely depends on comprehensive assessment of an ecosystem that can provide the scientific basis for restoration.

On one hand, contemporary restoration efforts are merely based on ecological parameters like populations and communities. On the other hand, some restorations are utterly driven by proliferation of hydrological variations in aridity and precipitation. To date, there has been little research on the integration of hydrological and ecological theories that can offer the greatest insights in understanding of human impacts in various environmentally degraded regions on the earth. My research work on "ecological consequences of human impacts in the Mahi river basin of western India" provides a scientific approach to identify the environmental damages caused by human activities at different temporal scales in the Mahi river basin. This research work is consistent with 'INTERNATIONAL AGENDA & INTEREST' on the key issue of river basin management, environment, and climate change. At the end, the findings of this research work provide a systematic scientific protocol to restore the ecological function of many environmentally degraded river basins in the world.

Solving the Water crisis through Indian Vaidic Science

Madhukar Swayabhu
Head Research
Vaidic Srijan LLP

Synopsis

We all understand that the world is going through a global water crisis and everyone in his / her own capacity is trying to deal with it, because water is essential for life. We know that water is the very fundamental basic need for life, that's why all the space agencies in quest to find life on other planets and moons are primarily searching for water there. Because the very basic hope for life starts from water. On our blue planet too, the first living cell was born in water and propagated to land and then to air.

There is a huge drinking water crisis across the globe and it is worsening day by day. It is envisaged that in coming years the situation will get even more grave. Though we know that from United Nations to governments to local bodies to corporations – everyone has been working towards conservation,

restoration, extraction and what not, but if we look at the world in the last fifty years, has the situation improved or has it worsened? The fact of the matter is, in spite of all efforts being put by all the organisations and individuals – the situation is turning grimmer each day. More and more people, plants and animals are parched today. There's a rapid desertification happening, that too in spite of the efforts to restore.

The approach we have been taking about Water is – that it is a chemical molecule or a substance that is made up of two atoms of Hydrogen (H) and a single atom of Oxygen (O2), so a single molecule of water is H2O and that's a dead chemical like any other chemical compound, nothing else.

But if this approach is correct, there are many questions left unanswered and unexplained. Like, why is this single compound so important for life? Why can't we make it in laboratories? Why is there so much of hue and cry about this single chemical compound? Why did life begin in water and not H2SO4 or NaCl or CaCO3, if any compound is the same as water?

And now some bigger questions defying our understanding further more:

·All substances on Earth get condensed when frozen to sub-zero temperature and expand when heated, while water expands when frozen. That's why ice is lighter and water and floats above instead of sinking.

·All substances follow the laws of physics including gravity, while water has a force of its own working against gravity called buoyancy.

·Unlike most of the substances, water exists in all three states as solid, liquid and gas.

That leads to an obvious conclusion – are we understanding Water rightly or we are trying to solve the Water crisis, without even understanding the subject holistically?

This is where Vaidic Science comes to our rescue, when it says "Water is not a dead substance, but a living ecology, which is capable of self-healing, like any other living ecosystem". This changes approach is the key sustainable solution.

SE 7:
Special Session for Young Professionals

Dissipating water resource: An analysis of the depleting potable water and groundwater and its management in Delhi-NCR region

Nischal Gaur
Student, B.A(Hons.) Geography (Class of 2022)
IP College for Women
University of Delhi, India

Keywords

Potable water, groundwater, urbanisation, Yamuna reservoir, water scarcity

Synopsis

The water resource problem is construed by the quality of drinking water, domestic water, industrial water, groundwater and availability of space. Water issues are experienced in Delhi-NCR pertaining to management and shortage of space. Delhi-NCR region is one of the fastest growing regions of India. The blistering industrialization and urbanisation of the region is likely to have its impact on the groundwater resources. It is facing increasing environmental issues due to numerous reasons such as rapid population growth and continuously increasing commercial and industrial activities and other anthropogenic activities. This rapid growth and urbanisation has resulted in a scarcity of water resources in the region, and to compensate for this shortage, groundwater is being utilised to such an extent that the resource is getting depleted rapidly. The region is mainly dependent upon the Yamuna reservoir, but this source has become a waste water reservoir due to the disposal of municipal and industrial waste into the river. Majority of the water treatment plants are either not working or are overloaded against their respective capacities.

The present study is an attempt to analyse the drinking water and the groundwater quality in the Delhi-NCR region for the time period 2011-2021 and to map the areas that are worst hit by water scarcity in the region. The data obtained from secondary sources is evaluated and the changes in the quality and quantity of potable and groundwater resources is analysed. Based on this evaluation, mapping of the region is done on the basis of quality of water and the supply. After analysing the results, efficient and sustainable alternatives are suggested to combat the problem of water scarcity and to improve the quality of the resource in the region. Special emphasis is given to improve the condition of the Yamuna watershed.

Parched spaces in the Detroit of India: An Analysis of the Dying Water bodies in Chennai, and its Implications to the City

Pallavi Singh
B.A (Hons.) Geography(class of 2022),
Indraprastha College for Women,
University of Delhi,India

Keywords

Lakes, drainage, urbanization, climate, infrastructure

Synopsis

Water is the lifeblood of man and of life on Earth. India is enriched with diverse and distinctive traditional water reservoirs whose water quality and quantity have declined and many of them have disappeared, due to poor monitoring.Such is the case of one of its metropolitan cities,Chennai which is not a city with low rainfall, despite several warnings over the past few years, this state has faced an unprecedented water crisis.The groundwater level is decreasing and the surface water of the lake is too polluted for domestic use.

This paper dwells deep into understanding the Lakes which were once a source of water cannot even afford to be a helping hand. A lack of rainfall has threatened to drying up and deterioration of several lakes on the fringes of Chennai inclusive of Poondi, Cholavaram, Redhills and Chembarambakkam, which supply the city with drinking water which leads to the accumulation of contaminated water and makes it unsuitable for drinking.Groundwater in and around Chennai is supplied by Puzhal and other lakes - Sholavaram, Kaliveli, Pulicat and Maduranthakam;All are located within a radius of 60km around the city. However, encroachment of these waters,a longstanding problem, has greatly reduced each lake's capacity to hold water and replenish groundwater levels.

The major cause for this devastation/shrinking groundwater levels is not only environmental factors(unpredictable weather patterns and brought on by climate change) but also anthropogenic problems (like rapid urbanization, improper maintenance and mismanagement of existing water bodies).This Research reflects that achieving the sustainable development goals addresses the complexities of climate change, requires a holistic approach that integrates cross-cutting solutions to address the interdependence and interplay of social, economic and environmental aspects.The study will also highlight the "zero day" incident in Chennai that can be called a man-made water crisis. Chennai's water problems, be it flooding or drought, cannot be addressed until water is at the heart of the city's urban planning. And as humans, on a global scale, we must rethink how we deal with our relationship with land and water before it's too late.

Study of Losses Due to Floods for year 1980-2020 to Understand Effectiveness of Flood Management Activities in India

Parmod Kumar
Deputy Director
Central Water Commission
India.

Sharad Chandra
Director
Central Water Commission
India

Keywords

Floods, Damages, Forecasts

Synopsis

Floods is the most recurrent natural disaster around the world. In India, around 40 MHa of the geographical area is flood prone. Damages due to floods consists of loss of lives, property, livestock, infrastructure etc.

As per the data reported by States, the average annual flood damage for period 1953 to 2020 is around 5200 Crore. Analysis of the flood damage data provides useful insights into the pattern of damage and how effective has been flood management strategies. There can be many other factors that may have resulted in change in flood damage pattern, however, in the present study expansion of CWC flood forecasting activities is studied vis-a-vis the change in flood damage data. The flood forecasting network has expanded from 1 station in 1950s to 331 stations in 2021. Depending on the availability of data for different parameters, data of 1980-2020 has been used for the present analysis. It is observed that despite manifold increase in population the number of people affected has not increased considerable and loss of lives per capita has reduced over the period of 1980 to 2020. Further, decadal damages due to floods has a decreasing trend except for 4 years which included unprecedented events like Uttrakhand floods of 2013.

This analysis provides useful insights into the effectiveness of the flood management activities with limitations that it can be extended to study similar pattern locally to improve the understanding. Such analysis can provide very useful information for decision making in relation to flood management in the country.

Spatial Distribution and Temporal Trends of Rainfall Parameters and Occurrence of Flood events in Krishna-Bhima Basin, India

Dr. Resmi S R
Engineer-Water Resources
FAMS Design Solution Private Limited
India

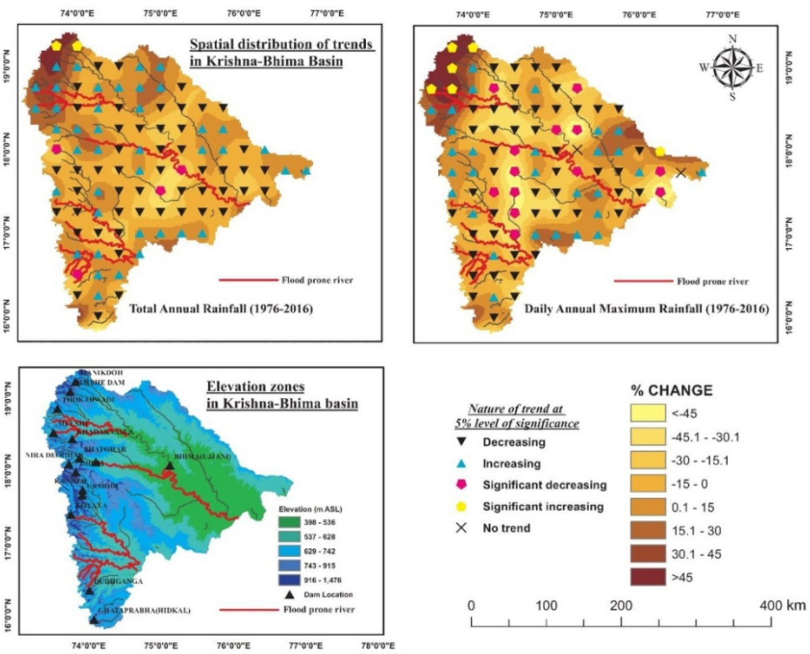
Dr. Viraj Loliyana
CEOFAMS Design Solution
Private Limited, India

Keywords

Rainfall variability, Krishna-Bhima basin, Reservoir storage, Flood, Non-uniformity

Synopsis

The present study is carried out to have a better understanding of rainfall variability and annual trend at a basin scale during the past 40 years in the flood-prone Krishna-Bhima basin. The spatial distribution of annual rainfall and 1-day maximum rainfall shows significantly increasing trend in the northern part of the basin that abodes the Western Ghat ridge line. Some of the major dams that fall in this cluster are Dimbhe Dam, Manikdoh Dam, Thokarwardi Dam, Mulshi Dam, Khadakwasla Dam and Koyana Dam. To evaluate the possible aftereffects of the observed trends in view of the flooding situation in the basin, the changes in available Reservoir storage data are mapped during the period of 2000-2021. Results show significantly increasing trend in the reservoir storages of Khadakwasla Dam & Koyana Dam and an increasing trend in the reservoir storage of Manikdoh Dam. The combined effect of these can be attributed as the major cause of recurring flood events in the downstream inhabited towns like Pandharpur, Satara, Sangli, Kolhapur and Ichhalkarji. In contrary to the above observation, the central and eastern part of the basin is found to exhibit an overall decreasing trend in the rainfall parameters, with significant decrease in 1-day maximum rainfall throughout the area that constitutes the Deccan Plateau. This may adversely affect the water availability in the region, which is predominantly occupied by agricultural lands. This demarcation in the spatial distribution of rainfall implies the non-uniformity in the Indian Summer Monsoonal Rainfall, which is the major source of rain in the Krishna-Bhima basin and calls for the detailed analysis of the same on a finer spatio-temporal frame. There is an urgent need to take suitable major considering the climate adaption measures.



Rainfall Variability over Krishna Bhima Basin

Application of MCDM Techniques in Identification of Best-Suited Satellite Precipitation Products to Complement the Hydrological Research in achieving Regional Water Security

Dr. Deepak Singh Bisht
Scientist 'B'
National Institute of Hydrology Western Himalayan Regional Centre Jammu – 180 003

Dr. Soban Singh Rawat
Scientist 'E'
Hydrological Investigation Division
National Institute of Hydrology Roorkee – 247 667

Dr. Jose George Pottakkal
Scientist 'E'
National Institute of Hydrology
Western Himalayan Regional Centre
Jammu – 180 003

Keywords

Western Himalayan Region, Satellite Precipitation, Multi Criteria Decision Making, Group Decision Making

Synopsis

Precipitation is one of the most important meteorological variables in hydrological studies which has maximum influence on the overall outcome. In Western Himalayan Region (WHR), owing to the complex terrain and rugged topography, it is difficult to find dense meteorological observatory network. Moreover, even if a sufficiently dense network can be ensured in future, the problem of past record will still persist. In hydrological modelling or climatology, past records are extremely important as they help in analysing the change in local hydrological regime. Taking the changing climate and exacerbating weather conditions into account, it is imperative to have seamless information of precipitation in time and space to make informed decision to keep stock of precious water resources to not only meet the water demand in times of scarcity but also to mitigate the risk posed by climate extremes. With the advent of numerous Satellite Precipitation Products (SPP) in the recent decades, dependability of hydrologists has lessened on station data as satellite precipitation products can be readily availed and utilized. Since the accuracy or skills of SPPs may differ from region to region, it is vital to analyse their ability in resolving the regional precipitation climatology using appropriate statistical methods. Therefore, in this study, a total of five SPPs, viz., APHRODITE, PERSIANN-CDR, CHIRPS, CMORPH, and IMERG were evaluated for their ability in resolving regional precipitation climatology of WHR with respect to gridded precipitation product of India Meteorological Department (IMD). Different performance indicators i.e., Probability of Detection (POD), False Alarm Ratio (FAR), Normalised Root Mean Sqaure Deviation (NRMSD), Pearson Correlation Coefficient (CC) and Skill Score (SS) were used for evaluating the SPPs.

Multicriterion Decision Making (MCDM) approaches i.e., Compromise Programming (CP), Cooperative Game Theory (CGT), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Weighted Average Technique (WAT), and Fuzzy TOPSIS were used for ranking the SPPs across different grids in WHR. Entropy based weight assignment to NRMSD, CC, and SS were performed while applying them in MCDM methods. Group Decision Making (GDM) approach utilizing Spearman Correlation Coefficient and Additive Ranking Rule was employed to obtain the final ranking of SPPs from multiple rankings assigned through different MCDM methods. The SPPs were ranked for daily precipitation, monthly

precipitation, and monthwise daily precipitation across all the grids. Overall, APHRODITE is found to perform better than other SPPs in majority of the grids whereas CHIRPS and CMORPH were found to be least favourable products among the selected five SPPs in the study. The study demonstrates the application of MCDM techniques in identifying the best-suited product for a region through a comprehensive investigation in WHR. The methodology can be extended to any other region to compensate the lack of ground based observation with region specific best-suited SPPs to develop policies and research studies for ensuring water security and sustainable development through efficient water management.

Insights on comprehensive qualitative and quantitative approaches for diverse microbial community analyses, wastewater characterization, and biochemical process performance of full-scale SBR plant in Roorkee, India

Ghazal Srivastava
Environmental Engineering Group,
Civil Engineering Department,
Indian Institute of Technology Roorkee,
Uttarakhand-247667, India

Absar Ahmad Kazmi
ivil Engineering Department
Indian Institute of Technology Roorkee
Uttarakhand-247667, India

Keywords

Bio-selectors; Polyhydroxybutyrates; Readily biodegradable chemical oxygen demand; Sequencing; Sequencing batch reactors

Synopsis

This study was dedicated to a detailed analysis of the 3-MLD capacity full-scale SBR treatment plant installed at IIT- Roorkee to investigate the activated sludge communities and the insights into the processes that govern their presence and growth. This is one of the original comprehensive long-term investigations of the microbial community in the full-scale wastewater treatment plant in India, where conventional identification, molecular identification by quantitative 16SrRNA Ilumina-based metagenomic sequencing of anoxic selector compartments and aeration tank, and extensive process information related to treatment plant design and process performance have been compiled. Additionally to many other well-established factors, local conditions are elementary conditions of sharp change studied in wastewater characteristics from place to place. Pre-anoxic selector-equipped sequencing batch reactors (SBR) perform efficiently in removing different water quality parameters and Fecal Coliforms. The supervision of 3-MLD Full-scale SBR established at IIT, Roorkee, drew interest to the processes concerning simultaneous nitrification and denitrification (SND) and biological phosphorous removal (BPR) undergoing with the deviations in influent wastewater, particularly the readily biodegradable COD (rbCOD), and their effects on the microbiota. Customary examining of all the SBR units for a period of two years disclosed that on the whole average removal efficiencies were >94% COD, >95% BOD5, >95% TSS, >96% NH4+-N (0.7 ± 0.5 mg/L in effluent), >86% TKN, >69% TN (9.7 ± 3.0 mg/L in effluent), >42% Ortho-PO4-P (1.6 ± 0.5 mg/L in effluent) and >46% TP and achieved <50 MPN/ 100 mL fecal coliform in the final effluent after disinfection. Anoxic tri-sectional selector and an aeration tank constituted one SBR followed by the other availed 76 ± 9% SND at rbCOD/ TCOD ratio of 0.12 ± 0.04 (R^2= 0.8 and $p<0.001$), rbCOD/ sCOD of 0.33 ± 0.10, sCOD/ TCOD of 0.35 ± 0.10, and COD/TN of ~12.8.

The sludge volume index (SVI) of the aeration sludge was <50 mL/g. The qualitative optical microscopic experiments showed intracellular polymers (polyhydroxy butyrates (PHB) and polyphosphates), protozoa, floc morphology, and few types of filamentous bacteria (Microthrix parvicella, thiothrix, and Nostocoida limicola) in the sludge of the plant. Advanced three months' study by lowering SRT to 10days reduced the TPeffluent to 1.7 mg/L. The microbial community dynamics after 16SrRNA analysis of the biomass revealed the presence of ammonia oxidizers (22%), nitrite reducers (5%) and denitrifiers (10%), sulfate-reducing bacteria (2%), and potentially resembling polyphosphate accumulating organisms (16%). Organic compounds oxidizers, i.e., Alphaproteobacteria, include the species of nitrifiers (Nitrosomonas, Nitrospira, and Nitrospirillum), and the species of Pseudomonas, Rhodococcus, Flavobacterium, and Beta proteobacteria class were liable for the denitrification process. The major genera responsible for P-removal were observed as Acinetobacter, bifidobacterium, and Paracoccus. Both the anoxic-aerobic sequential phases have benefitted the plant for higher treatment quality and proper growth of functional microorganisms; moreover, the influence of wastewater characteristics played a significant role. The study clarifies the degree of variations in wastewater and the composition of microbes are the key factors for laying out an optimized treatment system for COD, Nitrogen, and Phosphorus removal for the decentralized systems in the Indian scenario.

Removal of Nutrients from Dairy Wastewater using Sequencing Batch Reactor

Anurag Tomar
Department of Civil Engineering Indian Institute of Technology Roorkee

Ankur Rajpal
Department of Civil Engineering Indian Institute of Technology Roorkee

A.A Kazmi
Department of Civil Engineering
Indian Institute of Technology Roorkee

Vinay Kumar Tyagi
Environmental Hydrology Division
National Institute of Hydrology
Roorkee

Keywords

Partial Nitrification-Denitrification, Sequencing Batch Reactor, Nutrient Removal, Industry Dairy Wastewater Treatment

Synopsis

As the dairy industry has emerged as one of the most rapidly developing industries on both small as well as large scales, the volume of effluent generated also increased significantly. Effluents produced by the dairy milk industry contain a high amount of nutrients, organic and inorganic content. If dairy wastewater is discharged without treatment, then it pollutes the water bodies and disturbs the ecosystem. For effluent discharge, the Indian government has imposed very strict rules and regulations to protect the environment. Dairy wastewater contains high ammonia concentration and therefore, partial nitrification-denitrification is reported to be technically feasible and economically favorable. Ammonia oxidizing bacteria (AOB) and nitrite-oxidizing bacteria (NOB) are involved in nitrification. By inhibiting NOB, partial nitrification-denitrification can be maintained. Inhibition of NOB can be done by managing dissolved oxygen (DO) concentration, pH, temperature, and solids retention time (SRT).

The main focus of the present study was to establish partial nitrification-denitrification in a laboratory-scale SBR for removal of nitrogen via nitrite pathway and comparing its performance with other SBR involving conventional nitrification-denitrification at 16h, 12h, and 8h cycle time, respectively while treating dairy wastewater. In the present study, two laboratory-scale sequencing batch reactors (SBRs) were used. Partial nitrification-denitrification was allowed to establish in SBR-1 and conventional nitrification-denitrification was allowed to take place in SBR-2. Dairy wastewater was collected from Vita Milk Plant Kurukshetra, Sirsala, Haryana for the study. In SBR-1, 70.24-82.25 % and 81.05-81.92% nitrite accumulation was achieved and maintained during Phase-1 and Phase-2. Various parameters like air supply rate and temperature were varied to get the optimum nitrite accumulation in Phase-1. In the present study, the performance of SBR-1 and SBR-2 were evaluated for 16h, 12h, and 8h cycle time in Phase 2. The maximum nutrients removal efficiency was observed for 16h cycle time. It was observed that nutrients removal efficiencies were reduced with a decrease in cycle time. Total nitrogen removal efficiency for 16h cycle time for SBR-1 and SBR-2 were 62.745% and 74.253%, respectively. The total phosphorous removal efficiency for 16h cycle time for SBR-1 and SBR-2 were 40.036% and 46.697%, respectively. The BOD removal efficiency for 16h cycle time for SBR-1 and SBR-2 were 70.462% and 79.834%, respectively. The COD removal efficiency for 16h cycle time for SBR-1 and SBR-2 were 76.974% and 86.506%, respectively. The TS removal efficiency for 16h cycle time for SBR-1 and SBR-2 were 90.697% and 94.942%, respectively. The TSS removal efficiency for 16h cycle time for SBR-1 and SBR-2 were 83.374% and 90.317%, respectively. In the present study, the overall performance of SBR-2 involving conventional-denitrification was better than the SBR-1 involving partial nitrification-denitrification.

Perspectives on Vermifiltration technology as an efficient decentralized wastewater treatment system in achieving sustainable development goals (SDGs) with equity

Sudipti Arora
Research Scientist
Dr. B. Lal Institute of Biotechnology 6E,
Malviya Industrial Area
Jaipur- 302017

A.A. Kazmi
Professor
Department of Civil Engineering,
Indian Institute of Technology Roorkee
Roorkee- 247667, India

Keywords

Vermifiltration, wastewater treatment, SDGs, Earthworms, sustainability

Synopsis

The world is currently striving to achieve the globally adopted sustainable development goals (SDGs). Exploring the role of technology in achieving the SDGs is critical for the decision-makers and will allow them to overcome any possible trade-off. Essentially, urbanization, industrialization, and an increase in population and socio-economic growth have led to global water crises and the problem is affecting millions of lives, especially those who are dependent on water for agricultural activities & food production, in developing countries. With limited resources and a maximum consumption rate, today the world is facing the acute problem of water pollution as well. The conventional technologies for wastewater treatment are not technically & economically feasible due to heavy 'sludge' formation as the product, associated with increased capital cost, and operation & maintenance costs. Therefore, there grew huge interest in nature-based sanitation solutions which pave a greener way towards environmental sustainability & provide an innovative solution to the problems of water scarcity as well as water pollution. The present work emphasizes the role of nature-based wastewater management systems in achieving the SDGs. The present review focuses on an alternative, highly efficient, and innovative technology i.e. vermifiltration technology which utilizes the use of earthworms to process water pollutants more efficiently. Besides, a wide diversity of microflora is also present inside the earthworm's gut which is responsible for the treatment of organics & other contaminants present in the wastewater. The review summarizes the importance of vermifiltration technology, being highly efficient in the removal of BOD, COD as well as suspended solids and gives an insight into the design, mechanisms & applications. Also, the recent advancement in vermifiltration technology becomes the focal point for most researchers and environment-based industries. This technology in combination with constructed wetlands, hydroponics, macrophytes, etc. certainly enhances the productivity and treatment efficiency of this filtration unit. Thus, vermifiltration technology is a great combination of a microbial-geological system which is a green technology and is easy to construct, operate, and maintain in developing countries as well. Truly, vermifiltration is regarded as a self-promoted, self-regulated, self-improved, self-driven, self-powered, and self-enhanced technology that is based upon exceptionally low energy consumption.

The perspectives of vermifiltration technology as an efficient decentralized wastewater treatment could contribute to achieving 11 out of 17 SDGs. The major contribution came from its ability to increase water availability (SDG 2: zero hunger and SDG 6: clean water and sanitation), enhance human health worldwide (SDG 3: Good health and well-being), provide a new source of income for smallholders (SDG 1: no poverty and SDG 8: decent work and economic growth), SDG 9: industry, innovation, and infrastructure) and reducing the environmental impact of wastewater (SDG 11: sustainable cities and communities, SDG 12: responsible consumption and production, SDG 13: climate action, SDG 14: life

below water, and SDG 15: life above land). A set of indicators (guidelines) are proposed to improve the contribution of the wastewater treatment facility to the United Nations' SDGs and targets worldwide with equity. This review aims to bring the attention of prospective researchers to study every aspect related to the vermifiltration technology so that it may be adopted as a reliable technology for the remediation of wastewater treatment meeting the concept of "Zero discharge".

Integrated Management of Groundwater pollution caused by Landfill Leachate emanating from Gazipur Landfill, New Delhi, India, through source apportionment and Remediation Strategies

Anjali Bhagwat
Scientist B
Hydrological Investigation Division
National Institute of Hydrology
Roorkee-247667, Uttarakhand, India

Keywords

Groundwater, Landfill leachate, Plume Movement, Chemical Charaterization, Isotopic Characterization, Source Apportionment and Remediations.

Synopsis

The population in the National Capital Region (NCR) has increased significantly during the past few decades and is still growing. Therefore, assessment of groundwater quality and quantity is essential for the sustainable management of groundwater resources. The increasing demand for water due to the growing population and infrastructure development in the region has led to the overexploitation of groundwater. The depleting groundwater levels in the region have increased the vulnerability of groundwater to contaminant pollution. The disposal of waste in non-engineered landfill sites increases the risk of groundwater pollution through the percolation of liquids which have high concentrations of hazardous chemicals. But the extent to which waste dumping is responsible for groundwater deterioration is very difficult to quantify and predict. Thus, studies done so far rely on the chemical characteristics of Landfill leachate and the surrounding groundwater to ascertain the extent of groundwater pollution. But these studies fail to establish its reliability when the contaminant contributions are coming from sources, other than the Landfill. Thus, the present study attempts to understand the groundwater pollution caused by the Gazipur Landfill site, Delhi by chemical and isotopic characterization of : (i) emanating landfill leachate, (ii) surface water sources and (iii) 108 groundwater samples taken from 100 Km2 area surrounding the landfill. The result showed that more than 90% of the groundwater wells, which were examined are contaminated and had a high heavy metal concentration. Further, the carcinogenic effect of consumption of groundwater is ascertained with Chronic Daily Intake and Cancer Risk values. Results indicate that cadmium has a high carcinogenic risk factor of 1.02×10-4 as compared to other heavy metals. When the movement of the leachate plume ascertained based on chemical characteristics was validated with isotopic data, the leachate plume registered a much larger migration than reflected in the previous studies. The discrepancies observed are because of the recharge contribution coming from other surface water sources present in the study area. The study also attempted various physio-chemical and Phytoremediation strategies to reduce groundwater toxicity caused by landfill leachate. Coagulation with FeCl3 was found to remove 99% of Organic carbon and reduce the operation cost by 71.9%. Whereas, Phytoremediation with Marigold proves to be efficient, as it reduces the amount of leachate formation, and is highly economical with a refund value of more than

5.71. The study is useful for policymakers for achieving sustainable development goal 6 i.e. to ensure clean water and sanitation.

Study of the Changes in Time of Concentration (TC) by Different Methods and its Relationship with Relevant Morphometric Indicators

D. Sahu
Research Scholar,
Indira Gandhi Krishi Vishwavidyalaya,
Raipur

M.L. Gaur
College of Agricultural Engineering
and Technology,
Godhra AAU Anand

Synopsis

Time of concentration (Tc) is a crucial parameter for hydrologists to use in rainfall-runoff simulation in order to forecast how a watershed will response to a certain rain event. An important consideration when designing hydrological projects for watersheds is the time of concentration (Tc). The time from the hydraulically farthest point to the watershed outlet is referred to as the time of concentration. The Tc can be calculated using a variety of techniques. In this work, variability of Tc values over 9 watersheds, as computed by 6 different approaches were accessed via simpler and dimensional comparisons across watersheds. These 9 distinct watersheds with area ranging from 313 to 3236 km2 of different districts located of middle Gujarat region was estimated using GIS and RS. Efforts were made to establish regionally quantified morphometric indicators in respective of 9 watersheds, which included different indices to cover physiographic and morphometric features of watersheds. There have been many proposed equations for calculating the time of concentration, here the study included California culvert practise, Ventura, Passini, Johnstone-Cross, Kirpich and Williams approaches. Outcomes demonstrated that all the Tc computations by methods of 'Passini' and 'Ventura' gave relatively higher dispersions i.e. heterogeneities from watershed to watershed. Other four methods gave Tc values almost in a confined band width being more or less equal and homogeneous. The findings showed that Tc values produced using the Kirpich approach are more reliable than those derived using other formulas and more accurately reflect the hydrologic state of the watershed. Average variability of Tc across watersheds was ranging between 12.3–50.2 hours, which was derived from Kirpich approach. The Kirpich based Tc values were finally adopted for its advanced evaluations/relationships with watershed-based parameters. Major parameters which gave significant and acceptable correlations were watersheds area (km2), watershed perimeter (km), watershed length (km), length of all streams (all orders) in watershed, Shape Factor of Watersheds, Compactness Coefficient, Texture Ratio of Watersheds, Drainage Texture of Watersheds. These regionally established ranges could be of multiple utilities for coming R & D work on ungauged watershed monitoring in middle Gujarat region.

Comparative Assessment of Drought Events Using Gridded and Point Datasets for Krishna River Basin

Ajay Gupta **Rajendra P. Pandey**

Manoj K. Jain

Keywords

Gridded-data, Point-data, Precipitation, Temperature, SPI, SPEI

Synopsis

Assessment of drought is important for the management of water resources due to extreme climatic conditions. Gridded data are usually used for analysis of drought due to the unavailability of the point data over a longer time duration. In the present study, gridded data and station data are compared at ten locations using precipitation, maximum and minimum temperature data. Two drought indices i.e., Standardized Precipitation Index (SPI), and the Standardized Precipitation Evapotranspiration Index (SPEI) were used over the semi-arid Krishna river basin of India for the period of forty years from 1980-2019. Firstly, the two drought indices, SPI and SPEI were estimated from both the datasets at 3-month timescales and the drought characteristics were identified. Further, the performance of both gridded and point data were checked in drought characterization in terms of average annual rainfall and the number of severe drought events using the statistical parameters at seasonal (south-west and north-east monsoon) and annual scale. The gridded and point data for the corresponding duration have correlation coefficient (R2) value in the order of about 0.86. The mean value of the precipitation for the gridded data at the annual scale varied from 499 mm to 1129 mm, whereas it varied from 489 mm to 1400 mm for the point data. Also, the number of severe drought events for gridded data varied from 9 to 19, whereas for point data, it varied from 7 to 24. It was observed that the average annual rainfall of most of the gridded dataset is relatively higher than that of point data. Also, the analysis results indicated that the gridded data could not capture all the severe and extreme drought events during the study period. The reason may be simply because the gridded rainfall has been estimated using interpolation of observed rainfall in the stations in the vicinity of the given grid. On the other hand, the observed point data captures most of the severe and extreme drought events more realistically. Thus, it is important to note that the point rainfall data yield a more realistic assessment of drought events. Therefore, the points data should be preferred over gridded data for better accuracy of drought forecasting and early warning systems.

Coupled steam explosion with biomethanation to produce Class A Sludge in Municipal wastewater treatment plants in India

Gowtham Balasundaram
Department of Civil Engineering Indian Institute of Technology
Roorkee-247667, India

Pallavi Gahlot
Department of Civil Engineering Indian Institute of Technology Roorkee-247667, India

Vinay Kumar Tyagi
Environmental Hydrology Division,
National Institute of Hydrology,
Roorkee, India, 247667

A.A. Kazmi
Department of Civil Engineering
Indian Institute of Technology
Roorkee-247667, India

Keywords

Anaerobic digestion, Thermal hydrolysis, Solubilsation, Class A biosolids, sustainability

Synopsis

Water Industry is facing unforeseen economic and environmental constraints not just because of the stringent regulations but also because of the large amount of sewage sludge generated. Sewage Sludge management involves around 40% of the total operational cost of the waste water treatment plant (WWTP) and hence increased attention has been paid to sludge treatment and disposal in the recent decade. Sludge also contains a myriad of toxic substances that includes pathogens, organic contaminants, heavy metals etc. Anaerobic digestion has gained interest because of its increased organic matter stabilisation, pathogen reduction, methane generation that could be used to generate electricity which can in turn be used to run WWTPs. During anaerobic digestion, hydrolysis is the rate-limiting step in which the biological decomposition of organic polymers to monomers/dimers and particulate matter solubilization occurs slowly. Hence, to destroy the sludge integrations and to release the intracellular and extracellular matter there's a need for sludge pre-treatment.

In the current study, dewatered sewage sludge was collected from a 68 MLD SBR-based wastewater treatment plant located in Haridwar, India. The total solids (TS) content of the sludge was adjusted to 14% before feeding it to a thermal hydrolysis pilot plant. The pilot consisted of a steam generator, reactor, and a flash tank. Through vapor injection, sewage sludge was hydrolyzed at 160℃ (6bar) for 30minutes followed by a steam explosion in the flash tank. . Batch anaerobic digestion studies were performed using 500 mL glass bottles with polybutylene terephthalate (PBT) screw caps of 34 mm aperture bore and silicone rubber seals (DURAN, Germany). Biogas generation was observed every day by pressure measurement using a manometer (HHP351-G, Omega, USA). The pressure was converted to volume using the formula: $V=P*Ta*Vr/Pa*Tr$
Where, V = daily biogas volume (mL), P = reactor pressure (kPa), Ta = Ambient temperature (K), Vr = volume of headspace (mL), Pa = ambient pressure (kPa), Tr = reactor temperature (K).

Results revealed that the highest sludge solubilization (SDCOD) of 37% was obtained at a pretreatment temperature of 160oC for 30min. Mesophilic and thermophilic batch studies revealed that the highest cumulative methane yield was shown by the thermally hydrolyzed sludge (390 mL/gVS) followed by thermophilic digestion (165mL/gVS) and then control (100mL/gVS).

It should be noted that the concentration of fecal coliforms reduced to below 1000 MPN/g dry solids and the helminth worms were almost negligible in the THP effluent meeting class A quality biosolids. It can be concluded that thermal hydrolysis alters the physico-chemical properties of sludge effectively thereby allowing improved biodegradability, biogas yield, and pathogen annihilation meeting class A biosolids quality. Nevertheless, these techniques will be a great success upon the economic and technical feasibility, marketing facets, and public acceptance.

Scenario of Hydrochemistry, Health risk, and Solute Source in Groundwater of Bathinda District, Punjab

Kaptan Singh
Madan Mohan Malaviya University of Technology
Gorakhpur, U.P., India

Rajesh Singh
Environmental Hydrology Divisions
National Institute of Hydrology
Roorkee, U.K., India

Govind Pandey
Madan Mohan Malaviya University of Technology
Gorakhpur, U.P., India

Sandeep Singh
Environmental Hydrology Divisions
National Institute of Hydrology
Roorkee, U.K., India

Sandeep K Malyan
Dyal Singh College
University of Delhi
Delhi, India

Keywords

Hydrochemistry, Water quality index, Solute sources, Health risk

Synopsis

Bathinda is one of the cancer-prone districts of Punjab and recent research has indicated that drinking water is one of the factors responsible for cancer in the residents. Most of the residents depend on groundwater for drinking and other domestic needs. Therefore, a comprehensive study was undertaken to understand the current scenario of the contaminants, hydrochemistry, water quality index, health risk assessment, and solute sources. The groundwater was observed to be more deteriorated in post-monsoon as compared to pre-monsoon. The observed solute such as major cations (Ca, Mg, Na, K), anions (SO4, NO3, Cl, F), and toxic metals (As, Pb, Hg, Ni, Cr, and U) influenced the hydrochemistry and human health in the district. The Principle Component Analysis indicated the source of most of the solutes (Ca, Mg, Na, K, SO4, Cl, F, As, Pb, Hg, Ni, Cr, and U) is geogenic and NO3 is from agro-chemical and fertilizers. The health risk assessment study indicated U, As, Ni, F, and NO3 pose a high risk to human health (HQ>1). Children have the highest average cumulative risk posed by the contaminants in drinking followed by males and females. Overall the contaminants, U, As, Ni, F, and NO3 majorly pose risk to the health of residents in the study area.

Integrated GEE-MODFLOW Model for Groundwater Recharge Assessment

Nitesh Patidar
National Institute of Hydrology
Roorkee

Gopal Krishan
National Institute of Hydrology
Roorkee

Anupma Sharma
National Institute of Hydrology
Roorkee

Synopsis

Diffused groundwater recharge plays a significant role in replenishing aquifers. Increasing groundwater extractions and natural and anthropogenic alternations in surface and sub-surface hydrological regimes has necessitated frequent assessment of recharge. Integrated hydrological models provide comprehensive assessment of recharge by considering surface and subsurface processes, however, are often data-hungry and need exhaustive data pre- and post-processing. The, Integrated Google Earth Engine (GEE) - MODFLOW model, developed at NIH, provides a framework that enables quick data preparation for integrated modelling, post-processing of model outputs and visualization of results. The developed system includes a combination of three models, namely Root Zone Flow (RZF), Unsaturated Zone Flow (UZF) and Groundwater Flow (GWF), to simulate processes in root zone, vadose zone and groundwater zone. It also encompasses Google Earth Engine (GEE) to get various remote sensing data, such as precipitation, Leaf Area Index (LAI), vegetation fraction, impervious surface fraction, elevation, land cover, etc., and is powered by various Python-based APIs and libraries for data processing and visualization. The integrated model is evaluated to simulated surface and subsurface components in two basins, namely upper Mahanadi (upstream of Hirakund dam) and Hindon river basin. The performance in simulating streamflow is found satisfactory with Nash-Sutcliffe Efficiency (NSE) of 0.6 in upper Mahanadi Basin. The model's capability to simulate groundwater recharge and head is evaluated in Hindon river basin. Model simulates the recharge and groundwater head with reasonable accuracy ($R2>0.8$). In Hindon basin, the ever-increasing groundwater abstractions to cater the agricultural needs have led to depleted groundwater levels. These depletions have led to decreased groundwater availability and have made the groundwater more susceptible to pollution and have reduced the baseflow contribution to the streams. In the basin, the rainfall recharge varies between 70 to 350 mm/year. The spatial variation in recharge is also considerable and is mainly governed by land cover and precipitation, for example the areas with high imperviousness (urban areas) exhibits lower recharge than the agricultural areas. The GEE-MODFLOW also supports dissemination of model outputs through a web-based portal. A basin dashboard is developed for Hindon basin utilizing the developed frame work.

Assessment of Greenhouse gas emissions from a Horizontal Subsurface Flow Constructed wetland in Roorkee, India

Dr. Sandeep K Malyan
Ph.D. (Environmental Sciences)
ARO-Fellow Israel, ICAR-Jawaharlal Nehru Award Reception

Rajesh Singh
Environmental Hydrology Division,
National Institute of Hydrology,
Roorkee-247667, India

Sandeep Singh
Environmental Hydrology Division,
National Institute of Hydrology,
Roorkee-247667, India

Arti Bhatia
Division of Environmental Sciences,
Indian Agricultural Research Institute,
New Delhi-110012

Keywords

Wastewater; Constructed Wetland; Greenhouse gases; Methane; Carbon dioxide

Synopsis

The wastewater problem is one of the rising global problems and population explosion along with industrialization are the main culprits. The composition of wastewater is highly variable with sources and its management is essential for achieving the goal of sustainable development. Wastewater can be treated with physical, chemical, biological, or a combination of biological/physical/chemical treatment approaches. Generally, biological treatment approach such as Constructed Wetlands is considered economically feasible and sustainable. Wastewater has a high carbon and nitrogen-based compounds and may contribute to greenhouse gas emissions to the atmosphere. In this study investigation of greenhouse gas emission from inlet and outlet cells of horizontal subsurface flow constructed wetland in India was conducted using the static closed chamber technique. The fluxes of CH4, CO2 and N2O from inlet cell ranged from 42.5-670 µg m-2 day-1, 20.8-42.5 µg m-2 day-1, and 0.167-1.17 mg m-2 day-1 respectively. The lower fluxes of CH4, CO2, and N2O from outlet cell was observed in the range 20.8-128 µg m-2 day-1, and 0.798-5.25 mg m-2 day-1 respectively. The higher biochemical oxygen demand (Inlet Cell) of wastewater leads to significantly higher CH4 emissions as over lower biochemical oxygen demand (Outlet Cell). The total substrate surface area of the constructed wetlands was 52.5 m2 and it reduced CH4 emission by 79.1% which indicate that the wastewater treatment with constructed wetland significantly reduced gaseous pollutant emission to the atmosphere. Methanogens consumed the organic carbon and released CH4 as a byproduct through a complex process known as methanogenesis. The process of methanogenesis is inversely related to the dissolved oxygen and redox potential. The vascular plant Phragmites australis and Canna indica in constructed wetlands enhanced the dissolved oxygen in a rhizospheric zone in the substrate of the constructed wetlands which halt the methanogenesis process and result in lower CH4 flux. Our finding indicates that nature-based wastewater treatment through constructed wetlands must be considered for reducing greenhouse gaseous pollutants as well as for improving water quality.

Evaluation of Metals, Pesticides, PAHs and PCBs in groundwater of Malwa Region of Punjab, India

Sandeep Singh
Environmental Hydrology Division
National Institute of Hydrology
Roorkee – 247 667, Uttarakhand

Sandeep K Malyan
Dyal Singh College,
University of Delhi 110003

Kaptan Singh
Madan Mohan Malaviya University of Technology,
Gorakhpur 273010

Rajesh Singh
Environmental Hydrology Division,
National Institute of Hydrology,
Roorkee 247667

Keywords

Heavy Metals, Pesticides, Drinking Water, Health Risk Assessment.

Synopsis

Malwa region Population is now exceeding 10 million and there is no respite for the people from heavy toll that the highly contaminated water in the area is taking their health, children's growth, soil fertility and food production. Inappropriate and intensive use of pesticides often involved in agriculture, results in contamination of groundwater resources. This is a first assessment of the groundwater of Malwa, Punjab (India), a region characterized by intensive rice and wheat production, for metals, pesticides, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyl (PCBs). A monitoring network was developed based on the cancer patients' data in these districts. The results of pre and post-monsoon sampling revealed the presence of metals, pesticides, PAHs, and PCBs in the groundwater of all the districts of the study area at a significant concentration. The common pesticides detected were Alachlor, Atrazine, Butachlor, Chlorpyriphos, DDT, Ethion, Isoproturon, Lindane, Phorate, Naphthalene, Pyrene, and Anthracene, all commonly used in agricultural practices. Statistical and spatial analysis shows a significant impact of sampling season and well depth on the concentration of these metals, pesticides, PAHs, and PCBs. The results of this study indicate the presence of heavy metals at a concentration hazardous to human health (96% in pre and 88% in Post Monsoon) and pesticides, PAHs, and PCBs at a concentration posing no risk to human health. The concentration of arsenic, nickel, chromium, lead, uranium, and radon in most of the groundwater samples were sufficient to put the consumers at carcinogenic risk.

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- Shri Nagesh Mahajan, Consultant Level-3 (Technical), IWW Secretariat, New Delhi

NOTE

ORGANISER

Director General
National Water Development Agency

IWW Secretariat, 212-Palika Bhawan
R K Puram, New Delhi- 110066, INDIA

Phone : 91-11-24121759 & 91-11-24122379

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