International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 4 Issue: 4 250 - 254

Drought in Thane District and the Scope of Conjunctive use of Surface Water and Sub-Surface Water

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***Abstract*—**This paper focusses on the main aspects and problems concerned with the planning, design, construction and management of conjunctive use of surface and sub-surface water resources along with its environmental impacts and constraints to sustainable development. Also the future action course for the planners and researchers are mentioned.

***Keywords*—** *conjunctive use, groundwater and surface water, sustainability*

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I. INTRODUCTION

Water is a prime natural resource, a basic human need and a precious national asset for any country, and which also belongs to a larger ecological system. No life on earth can exist without water, and the ceaseless flow of that water cannot exist without rain. The world's fresh water resources are unequally distributed both in time and space. The available water is dwindling due to various reasons such as scanty rainfall, population growth, increased per capita water use, ill-management of water supply and distribution, improper reservoir operation policies. To face this situation, a holistic approach is needed. This approach includes the integrated and conjunctive use of available surface and sub-surface water resources.The increasing demand for water in the district has brought forward the realisation that the underground reservoirs formed by the aquifers constitute invaluable water supply sources as well as natural water storage facilities. The planned augmentation of water storage in the ground water reservoirs by suitable recharge techniques is useful for reducing over-draft, conserving surface runoff and increasing available groundwater supplies

II. THEORY

The condition of Maharashtra gets rainstorm precipitation for a time of four months from June to September and the fading precipitation in the month of October and November. Circumstantially, the water request in this period is likewise less. This requires the need of putting away water in the water surplus season and using the same the same when the water interest is high (non-storm season). In the condition of Maharashtra, irregularity of downpours in consistently and brokenness of downpours make dry spell like circumstance. Water stockpiling in the state is 81% all things considered in enormous activities, 67% by and large in medium tasks, and 60% by and large in little ventures.

Maharashtra gets a normal precipitation of 1360 mm. to 650 mm, 85% of which will be chiefly gotten from southwest storm amid the period June to September. Notwithstanding, there is wide variety in the spatial dispersion of precipitation over the state. The whole geological region of Maharashtra is involved by 5 noteworthy waterway bowls to be specific Godavari, Krishna, Tapi, Narmada and west streaming waterways in Konkan seaside strip. Around 75% region of Maharashtra is depleted towards Eastern side, further joining with Bay of Bengal. The west streaming waterfront waterways join the Arabian Sea. Ground water has been the essential wellspring of water supply for residential, horticultural and mechanical utilizations in Maharashtra. It is the single biggest and most promptly accessible wellspring of watering system and more than half of the aggregate range under watering system relies on upon ground water sources. Almost 80% of rustic water supplies depend on ground water. Ground water advancement and in addition its wise administration is a noteworthy test confronted by the State.

Thane area is arranged between 18°42' N and 20°20' N and 72°45' E and 73°48' E. The range of the area is around 9558 km². The area is limited by Pune and Ahmednagar on the east, Nashik on the east and upper east, Valsad District of Gujarat state and Union domain of Dadra and Nagar Haveli on the north. The Arabian Sea frames the western limit, while it is limited by Mumbai city region and Mumbai rural locale on the southwest and Raigad region on the south. The area is secured in the middle of two westerly streaming waterway bowls, Vaitarna and Ulhas.

The Thane area includes 15 Talukas, to be specific Thane, Kalyan, Murbad, Bhiwandi, Shahapur, Vasai, Ulhasnagar, Ambarnath, Dahanu, Palghar, Talasari, Jawhar, Mokhada, Wada and Vikramgad. It is the main area in India which has

7 city enterprises. There are additionally proposition at present to bifurcate the area because of expanding populace size (Daily News Analysis, 2011).

The atmosphere of the region is particularly diverse on the beach front fields and on the eastern inclines. Being completely tropical, the beach front strip including Thane, Vasai, Palghar and Dahanutahsils is extremely moist and warm. Then again, the atmosphere on the eastern inclines and in the fields at the foot of the slants is nearly less moist. In any case, variety in temperature in the eastern locale is more than that on the waterfront strip. The most extreme temperature lies between 28.0 to 35.2 centigrade and the base temperature lies between 16.3 to 26.5 centigrade.
The region gets guaranteed precipitation of 2000 to 4000 mm. from the South-West rainstorm amid the months June to September. For the most part most astounding precipitation is recorded in the month of July. It is significantly more inland than on the coast. It is additionally less towards the North than towards the South.

As per World Health Organization's (WHO) rules of Right to Water, "Availability to water incorporates a constant supply of a base measure of water which is adequate for drinking, individual and residential cleanliness, at a moderate cost, inside a sensible separation". As indicated by WHO essential access can be characterized as the accessibility of no less than 20 liters of drinking water per individual every day inside a separation of not more than 1 km of the abode.

Manageable access to water has two parts:

a) Environmental maintainability

b) Functional maintainability.

Natural supportability alludes to ecological security through restricting extraction of water to a limit beneath what is really accessible. Practical supportability alludes to program maintainability regarding supply and administration. (WHO, 2010) manageability and Scaling-up Strategies.

The principle center of the undertaking ought to be on the maintainability of speculations. An exertion is to be made to make systems to include all areas of the groups in the determination of specialized choices which are moderate and ecologically and operationally maintainable. For this reason, the source manageability examination ought to be made part of the participatory evaluation at the group level. The attention would be on growing minimal effort specialized decisions, with specific accentuation on energize and protection of ground and surface water instead of on development of plans.

The alternative of putting away water might be development of dams (surface stockpiling) or the energize of groundwater (sub-surface stockpiling). Both the surface and the sub-surface water stockpiling techniques has its own particular favourable circumstances and dis-focal points to be considered while settling on the water stockpiling framework to be actualized. Coordinated water asset administration relies on upon co-operation and associations at all levels, from individual to legislative and non-legislative, national and global associations demonstrating a typical political, logical and moral duty to the requirement for water security and ideal water use arrangement.

Policy and Institutional Issues

1. **Conjunctive Management requires a basin perspective:**

Overall gains from conjunctive use can be enhanced by managing resources at the river basin level, but this cannot be done until the river basin becomes part of the water and land management unit.

2. **Reforms of Water Resources Management Institutions:**

A hindrance of greater dignity in conjunctive water management is the disconnected structure of governmental institutions entrusted with various water management responsibilities. Conventionally, the main system is managed by irrigation departments, groundwater by groundwater departments, and energy supply for groundwater pumping by electricity utility. Rarely a coordination among these departments is found. These operations should be coordinated for successful conjunctive water management.

3. **Monitoring and Information System:**

Emphasize should be laid on monitoring of sub-surface water behaviour and use pattern in the region under study. Geographic data bases and sub-surface water levels monitoring records should be maintained.

4. **Public-Private Partnership:**

In many surface irrigation systems, public tube-wells are used to stop water logging and secondary salinization due to surface irrigation. The problem is lack of coordination in private tube-well development. Since, surface systems are managed by government departments and tube-wells are operated by independent users, mutually gainful public-private partnership with better coordination and an appropriate policy framework should be encouraged.

Tools for sustainable development of water resources

To ensure sustainability, water resources systems need to be planned, designed and manged in such a way as to fully meet the social objectives of both present and future generations, while maintaining their ecological, environmental and hydrological integrity. Substantial increase in water demand for municipal, agricultural, and industrial uses, due to rapid population growth, makes the optimal conjunctive use of available surface water and sub-surface water supplies inevitable. Conjunctive use of surface water and sub-surface water can be developed on a short term or long term basis. The approaches in conjunctive surface water and sub-surface water use can be:

i. Storage of excess water in surface and sub-surface reservoirs from monsoon season for use in subsequent non-monsoon season.
ii. Diminution of endowed flood hazard in monsoon period with high peak stream flows by reservoir storage of surplus water.
iii. Use of sub-surface water reserves to supplement surface water shortages.
iv. Artificial recharge of excess surface water to sustain sub-surface water levels within a set in advanced range.

Non-integrated Conjunctive use applications

In this method, suitable optimization techniques are employed to solve the conjunctive use problem in a scientific and technically sound manner. The surface water and sub-surface water equations are solved numerically and the solution is passed on to the optimization model which gives the optimal solution for the decision variables consisting of surface water and sub-surface water allocations.

Integrated Conjunctive use applications:

In the integrated conjunctive use method, the numerical model for the solution of surface water and sub-surface water equations are integrated with the optimization model leading to a single mathematical model. The conjunctive use model is formulated as a non-linear programming problem with surface water and sub-surface water allocations from one or more sources as decision variables.

Components of Sustainable Water Resources Management

- Data Base Improvement
- Modelling Technology
- Sustainability Criteria
- Spatial Analysis Procedure
- Decision Support Systems

Data Base Improvement

Availability of reliable data on hydro-climatic patterns, water demands, spatial and temporal characteristics of surface water and sub-surface water bodies is essential for sustainable development of available water resources. Demand management and adaptation are essential components for improving project flexibility to mitigate with changing environmental conditions. Water use formulations should be based on the terrain data, available water resources, performance of existing water reservoirs and allied factors.

Modelling Technology

Modelling helps in establishing scientific understanding abd to integrate the various components and processes involved in the surface water and sub-surface water systems. Modelling helps in planning, design, management and operation of complex water resource systems. It acts as a bridge for knowledge transfer between researchers and the policy makers as a basis for testing different scenarios and to integrate planning and management strategies.

Sustainability Criteria

Sustainable water resources systems are those designed and managed to meet the present demand without posing a threat to the future water availability, while maintaining the ecological, environmental and hydrological integrity. Conjunctive use of surface water and sub-surface water consists of non-quantifiable factors such as environmental, economic and social factors. These factors are addressed under sustainable water resources systems. It consists of long term perspective for planning and integrated improvement and implementation policies. Although it is uncertain whether a water resource development project is sustainable or not, some parameters do help in assessing the sustainability factors. The sustainability factors to be considered consists of reversibility, risk and consensus, comparison with alternative methods, etc.

Spatial Analysis Procedure

Spatial analysis procedure involves Geostatistical methods, Remote Sensing and Geographic Information systems (GIS). Geo-statistics is a set of statistical estimation techniques which involves quantities varying over space and time. Uncertainty regarding the definition of standards for parameter and input identification for surface water and sub-surface water simulation models can be defined using geo-statistics. Geo-statistics also render flexibility for the creation, validation. Testing and evaluation of data sets that have distinct temporal and spatial components.

Remote sensing helps in landscape rendering, identifying landscape features and in some cases, measuring hydrologic state variables and processes.

Geographic information systems are computer systems capable of gathering, manipulating and displaying geographically referenced information. It is useful for multi-scale models within a complex and different characteristic territory. Using GIS, varied model parameters can be regionalised, represented in a digital map and referenced to the modelling grid.

Decision Support Systems

The repeated use of simulation models, linked with spatial analysis procedures, under different hypothesis, for system design, operation and management purpose is called Decision Support System (DSS). Decision support system models do not make decisions but merely provide information to the users. It provides means for assessing the different options for the design and management of complex water resources systems.Decision Support Systems are suitable for:

- Linking simulation and optimization models to determine the values of decision variables or system performance indicators.
- Combined use with GIS and other graphic procedures that permit statistical analysis and map displays of spatial data.
- Combined use with neural networks enable to reproduce results of complex physical and chemical processes.

Examples of conjunctive use

The surface water supplies can be taken from rivers, reservoirs, lakes, etc. and the sub-surface supplies withdrawn from deep aquifers or shallow wells.

Conjunctive use in Chennai, Tamil Nadu, India

Chennai in south India is a typical example where most of the water is supplied by surface reservoirs, but in addition there are deep tube wells and numerous shallow domestic wells. The various sources of supply and their approximate capacities and yields are as follows:

Main reservoirs

Poondi reservoir (capacity 75 mcm) Cholovaram tank (capacity 15 mcm) Red Hills Lake (capacity 30 mcm) These three reservoirs are inter-connected.

Major well fields

Alluvial aquifers 30-60 meter thick
Minjor well field (yield 45 Mld)
Panjetty well field (yield 34 Mld)
Tamoraipakkam well field (yield 21 Mld

These major well fields supply water mainly to industries. Agricultural wells are found throughout these alluvial aquifers, their yield approaches ten times that of the major well fields during the main irrigation season.

Conjunctive use in Uttar Pradesh, India

Foster et al (2010) have described the setting for conjunctive use in Uttar Pradesh State in India, categorised as humid and drought prone alluvial plain. River diversion systems often use lined canals to remove excess flood water during monsoon. However, simple modifications in the infrastructure use and the operating system can transform this waste into asset. Uttar Pradesh had a network of unused earthen surface drains constructed in the 1950's to control water logging and floods. After the 1950's, intensification of sub-surface water use created new opportunities for conjunctive management by building check structures at suitable intervals to promote groundwater recharge with monsoon floodwaters. In the course of a ten-year collaborative study, scientists from the International Water Management Institute (IWMI), University of Roorkee, the Water and Land Management Institute, and the Uttar Pradesh irrigation department found that using these modified drains for the monsoon flood irrigation produced the following benefits:

i. A 26 % increase in net farmer income.
ii. A decrease in average depth of groundwater from 12 metres in 1988 to 6.5 metres in 1998.
iii. Annual energy savings of 75 million kilowatts hours and pumping cost savings of RS. 180 million.
iv. A 15-fold increase in rice cultivation area.
v. A 50 % reduction in conveyance losses in canals.

Conjunctive use in Hyderabad, Telangana, India

Hyderabad in central India has plenty of surface reservoirs, but when the rainfall is below the annual average, the scarcity of water is pronounced to meet the water requirement. In this situation, the over-exploitation of the aquifers occurs. Existing shallow wells drilled n the weathered zone are exploited and gets recharged naturally at a very slow rate due to low permeability of the strata. A remedy to this situation is to drill the wells up to the fractured zone, which increases the well yield by ten times as compared to the shallow wells.

Proposed conjunctive use of river water and aquifers.

With reference to the examples of conjunctive use of surface water and sub-surface water resources in India, citied above, in a similar way emphasis should be laid to use extensive datasets and associated analysis to understand the hydro-geological, agronomic and socio-economic conditions. Strategies should include efforts to reduce irrigation canal losses, implementation of optimal surface reservoir operation policies, promotion of tube wells use in non-command and high water table areas, and investment into research and specialist extension in study of geo-technical investigation. Large wells with horizontal addits can be constructed in and near to the river bed. These wells can

collect water into the aquifers resulting in little flow in the river on the downstream side of the wells during the non-monsoon period. In addition to the induced recharge, artificial recharge of the aquifers can also be resorted to. A planned approach implementation at the regional scale aimed at effecting changes to the water supply/demand balance by considering the nature of the complete water cycle for the area and its spatial and temporal distribution should be implemented. A regional conjunctive use model with the existing rivers and near-real aquifer system with some reference to the geo-climatic conditions prevalent in the region can be developed.

III. CONCLUSION

Water being a scarce and valuable resource, it has to be developed, conserved and managed on an integrated and environmentally sound basis to ensure its availability and quality on a sustainable and long term basis. Ground water is currently perceived as an individual property and exploited inequitably and unsustainability in places and needs to be manged as a community resource, held by the state under public trust device to achieve food security, livelihood, and equitable and sustainable development for all. The conjunctive use of surface water and sub-surface water can enhance the reliability of water supplies. Surface water can fulfil most of the demand during the monsoon season but it is sensitive to hydrological variation. Sub-surface water is less sensitive to hydrological variations and can provide stable water supply during non-monsoon season. This necessitates the planning of peculiar reservoir capacity and well network on a regional basis. The following steps are proposed for the effective conjunctive use of surface water and sub-surface water:

- Planned conjunctive management through coordinated strategies at various levels from the river catchment area.
- Planned investments in hardware (system modernization and improved infrastructure), software (improved database), planning and management capabilities, and institutional reforms.
- Create incentives for conjunctive management among different stake holder groups.

These improvements are only possible with the proper institutional and organizational development, including investment in the capacities of local governments to lead on participatory surface water and sub-surface water management and integrated water resources management.

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