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Integrated Water Resources Management and Climate Change Adaptation Strategies

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Abstract

Water is one of the most important inputs for agriculture, human life, livestock, industries and all other living beings. But due to its spatial and temporal variation, its availability, accessibility and affordability poses a great challenge to water users and water managers/planners. The problem becomes more intense due to change in climate, which is being observed more severely now a days. Water can't be treated as a separate personal entity, rather it is an integral part of the ecosystem and it needs attention of every stakeholder keeping in view an integrated approach. For sustainable development and management of water resources it should be viewed from physical, economic, social, environmental, technical, scientific, professional, institutional, administrative, political and legal angles.

Proper strategy needs to be chalked out to combat climate change particularly extreme events like floods, droughts, cyclones, lack of water at critical crop growth stages or excess water in root zone of plant causing decaying of roots and plants. Climate change is not only a challenge for India, but it is challenge for whole world. Due to increasing awareness, all countries of the world are worried and working together to face climate change problem. To combat climate change, there is an urgent need of formulation and timely implementation of appropriate policies by Government to reduce risks of farmers, who not only suffer from complete loss of their crops and lose of food and water for their livestock, but also their livelihood options to satisfy their hunger.

This paper discusses the concept of integrated water resources management in order to improve water use efficiency and sustainable use of water resources. Also there is discussion about climate change, its adverse impact and possible implementable strategies to minimize adverse impact on resources.

Introduction

Water is an important and integral part of our ecological system. It is not only a vital source of life for human beings but it also supports agriculture, livestock, industries, and the environment. Declining per capita water availability, competing water demand for different uses and users, changing food habits and life styles, livelihoods and socio-economic scenarios climate change and environmental needs call for holistic management of water resources. The planning, designing, development and management of water resources depend on its spatial and temporal variation. While doing so it is also important to consider natural, social, physical, financial and human capital as well as cultural, historical and geographical situations available in the country. Integrated Water Resources Management (IWRM) is basically a process of utilization of water resources in such a manner so that combined and coordinated resources utilization creates many times better cumulative impact both in terms of quality and quantity without adverse impact on other resources, than single resource utilization and combining the impact of all the water resources afterwards. It varies from place to place and no single solution fitting to all the situations can be developed.

It is true that all the issues cannot be addressed at a time so prioritization of issues is important. Keeping in view the political interest and public support, current and urgent issues need to be addressed first. Flood and drought management, management of waterlogged areas, irrigation and drainage management and on-farm water management are the priority issues to be addressed. While addressing these issues UN Millennium Development Goals on reducing poverty and hunger, diseases and environmental degradation, including halving the proportion of people without access to basic drinking water and sanitation services, should also be kept in mind.

The process of addressing IWRM will differ in developing and developed countries. For example in developing countries improvement in livelihood through better agricultural production with limited water resources utilization and better accessibility to markets, controlling soil erosion/degradation through better soil conservation techniques and maintaining soil health, reduction in unemployment by engaging youth in agriculture and other services, creation of Self Help Groups/Activity based Interest Groups/Water Users Associations, creation of infrastructure for better water resources utilization, training and awareness campaigns about better use of water resources, developing communication products on floods, droughts, and other calamity control/management to minimize risk and increase reliability, involvement of women and their empowerment, may be major challenges needing immediate attention.

Mismanagement in Water Resources

In general Water Resources have been subjected to the following types of mismanagement

1. Excess withdrawal of water from rivers leading to reduced capacity for regeneration.
2. Excess groundwater withdrawal leading to depletion of water table and degradation of Groundwater quality, Seawater intrusion in coastal aquifers, Arsenic pollution etc.
3. Mismanaged irrigation systems resulting in waterlogging and salinity.
4. Disposal of untreated waste water into streams and aquifers and its application to crops, resulting in degradation of land and water, which causes health hazards.

Concept of IWRM

Integrated Water Resources Management is defined as skilled, equitable and coordinated handling and judicious use as well as regular development and management of water resources keeping in view the long term sustainability of land, water and other resources. It is done in such a manner so that resultant impact on resources is positive and many folds. It doesn't have negative impact on environment too. The concept is quite comprehensive and takes into account all the five capitals i.e., (i) natural, (ii) social, (iii) physical (iv) financial and (v) human. Upadhyaya [1-2] and Upadhyaya and Sikka [3] have discussed various water management technologies, challenges and opportunities and the concept of water, land and energy productivity. The role of participatory approach to understand IWRM and flow of information from top to bottom and bottom to top cannot be ignored for effective and successful implementation of IWRM strategies.

IWRM also offers an intelligent strategy for adaptation to climate change, involving both "hard" infrastructural and "soft" institutional interventions. The recent trends in participatory watershed management projects reflect an adaptation of the concept from a narrow focus on hydrological linkages to a wider recognition of the human element and interconnectedness of ecosystem. The links between scattered watershed initiatives and the larger basin needs to be realized for its integration at basin wise planning and management.

Integration of Water Resources with other Resources

Water is not a separate entity. It is related with everything or in other words everything depends on it. Water resources are limited in quantity but use of water resources is increasing day by day. Our ancient civilization started from river banks. Due to ever increasing population and realizing the responsibility of feeding the nutritious food, major share of water is required for agriculture. At the same time domestic, industrial, ecological and environmental requirements cannot be ignored. So, now-a-days importance of integrated water resources management is being realized all over the world. In any water resources management process, five steps, i.e., (i) planning, (ii) designing, (iii) implementation, (iv) monitoring, and (v) evaluation are required to be considered seriously, only then fruitful results and success can be expected. These all steps are closely linked to each other and need to be reviewed thoroughly at every stage. The purpose of timely review is to identify the weak link and make corrections/modifications/improvement immediately, so that timely desirable output is achieved. In the whole process creating awareness at different levels, adoption of participatory approach, seeking advice from all the concerned stakeholders including various experts from different departments at different stages cannot be ignored.

Some important issues to be addressed to attain IWRM are (i) Coordination among various stakeholders, (ii) Frequent dialogues, discussions and better linkages among various water resources managers and users, (iii) Efficient, judicious and equitable use and management of rain water, surface water, ground water and on-farm water resources, keeping in view availability, accessibility, adoptability and requirement, (iv) multiple uses of water to enhance water productivity, and (v) conjunctive use of rain, surface, ground water resources and any other stored water in ponds, lakes, rivers or any other water storage structure. An integrated approach to address physical, technological, social, economically, environmental, hydrologic, institutional, administrative, political, legal and financial issues to achieve higher water productivity should also be the part of Integrated Water Resources Management.

Climate Change Impact and Adaptation Strategies

Global warming is very important phenomenon, the impact of which is being realized by everyone in recent years. It is adversely influencing urban and agricultural water supplies, flora, fauna and aquatic systems, increasing more risk and uncertainties in floods and more challenges to manage these events and water resources as well as provide timely protection against these uncertain events. Temperatures are abruptly changing. At some locations, temperature trends are towards more cooling whereas at other locations trends are towards more warming. Temperature trends are also shifting from location to location i.e., sometimes early cooling and sometimes early warming. Due to changing temperature trends, snowpack melting trends are also changing, resulting in change in extent, duration, and frequencies of flood as well as rise in sea water levels. All these events create more complicated problem of water resources management.

In addition to this emission of different type of gases particularly carbon-di-oxide, methane, nitrous oxide, ozone, CFC and other halocarbons from decomposition of agricultural waste or livestock or non-agricultural waste is also a major source of environmental and water pollution. This is also one of the important issues and need to be addressed by joint efforts of concerned national and international organizations.

Drought or Deficit Water Supply Management Strategies

Now a days long past records of more than 30 years are not very relevant because in recent past (particularly within 10 years) climate (particularly temperature and precipitation) has changed at a very fast pace. The frequency of occurrence of drought, intensity, duration and distribution of drought has increased in recent years resulting in global warming and ultimately adversely influencing the natural, physical, human, livestock, agriculture and bio-diversity. Extended drought will further create more severe problems of water availability to agriculture, human and livestock resources. At some locations high intensity short duration rainfall events will result in higher runoff and less infiltration, resulting in more loss to property and other resources and less availability of water for agriculture human and livestock resources.

Keeping in view the spatial and temporal variation of climate particularly rainfall and temperature all over the world it is necessary to develop location or site specific solutions. These solutions should be socially acceptable, economically viable, environmental friendly and harmless, simple, sound, sustainable, easily and effectively implementable. Interventions/technologies/strategies/solutions should be implemented in participatory mode so that public is aware and there is full cooperation of public. In order to cope up with droughts, it

is necessary to effectively store water in surface water storage structures like ponds, doba, lakes, rivers, reservoirs or below the ground surface and efforts should be made to cut down evaporation/evapotranspiration as much as possible. At the same time initiatives should be taken to reduce the runoff by increasing small scale water storage facilities at many locations and to increase ground water recharge by natural or artificial means more efficiently and effectively. Water conveyance efficiency should be enhanced by reducing conveyance losses in transporting water from one place to another place. It can be done by lining of channels with different available materials like brick, cement, bitumen, plastic sheet Silpaulin 250 micron thick LDPE film. If it is joint and fixed properly with precaution with technically skilled person, water losses in conveyance will be reduced to a great extent. Water application efficiency can be enhanced by applying water directly at a place where it is required. It can be enhanced, if water is applied at the time when it is required and in the quantity in which it is required with the help of modified basin, check basin, furrow or raised bed furrow, pressurized irrigation systems like sprinkler, drip, low energy water application system, micro irrigation systems etc. The application of these systems depend on location, shape and size of field, slope, crop, source of water and energy its availability, accessibility and affordability by farmers etc. Water storage efficiency enhancement is also required, which depend on the maximum utilization by crop for its use and minimum wastage. So it is necessary to apply water in the crop root zone only and store it in the soil profile for use by the crop. Uniform application of water to crop is also very important so that each and every plant gets equal opportunity to use water for its development. In canals, water distribution efficiency is very poor and it has been observed that water is not being distributed uniformly among head, middle and tail reaches. Adequacy, equity and timeliness are the major issues to be addressed. In head reach, farmers use more water, followed by middle reach and least in tail reach. When water is available in abundance and head reach farmers water requirement is satisfied, maximum water is released in tail reach. As a result of excess water in tail reach, whole crop is destroyed. Release, allocation, distribution and utilization of canal water more efficiently and judiciously in the canal command can improve agricultural production even under water deficit condition. Similar, in case of ground water resources, proper selection and timely maintenance of pumps, motor suction and delivery pipes and other accessories not only improves the efficiency of the system but life of system also increases. So if water conveyance, application, storage, distribution, and uniformity issues are addressed properly, automatically water use efficiency will improve. Moisture conservation through mulching using locally available material such as use of cowpea, lantana, daincha, paddy husk, paddy straw, grass, black polythene etc., are some of the methods to cut down evaporation and store water in root zone to be utilized by plant only. In addition to this, farmers generally plant at ridge as well as furrows, this practice provide them security against drought as well as excess water and possibility of survival of at least one crop. When limited water is available farmers irrigate in alternate furrows or after leaving two furrows, so that lateral flow of water can at least meet out water requirement of crops without compromising much reduction in yield. Similarly in rice crop, alternate wetting and drying method and irrigation at critical crop growth stages do not reduce much yield of rice. During drought or water deficit situation, basic purpose is to improve water productivity, which can be improved by providing less water timely i.e., during critical crop growth stages and without allowing yield to be reduced much. Multiple uses of water, in which concept of water reuse and recycling as well as number of interventions like crop, livestock, fisheries, horticulture, vegetables, agroforestry, floriculture, apiculture are involved, may also be very effective technology to improve water productivity. Conjunctive use of rain, surface and ground water resources is another very important technology which can save crop from water starvation and overcome drought or drought like situation. In India, particularly in Bihar there is old traditional ahar (water storage structure) and pyne (water feeding to storage as well as irrigation channel) system, which was in fact well established system to fight against drought but now a days in the absence of regular maintenance, only few of them are functional. Ahar-Pyne system needs to be revived to utilize water efficiently under drought situation.

Water resources should be planned and managed on regional basis. It not only includes flood control and flood protection works but also includes whole system and hydrological cycle too. It takes into account catchment, rainfall in catchment, runoff, storage in reservoirs, reservoir operation and proportionate water distribution through canal network including (branch canal, distributaries, sub distributaries, minors, sub minors, outlets and field channels) and involvement of water users at all stages is very important. In case of Canal water, formation of Water Users Association at distributaries level and Federal of Water Users at Canal level, frequent dialogues among water users and water managers and timely communication can help in realizing the problems and chalking out amicable solutions. Similarly in Ground water resource management, due to small and fragmented land holdings, formation of ground water resource management committee and equitable sharing or selling of ground water at fixed rate can help in overcoming the yield loss due to drought. Rainfall though meager/scanty during drought is very important because whatever little rainfall occurs, it should be utilized properly and efforts should be made to enhance rainwater use efficiency To attain this, if dykes having height of 20-25 cm are created around rice fields, about 90-95% rainfall can be stored in rice fields and can be utilized for crop production. Erection of dykes will not only allow recharging of groundwater but it will also reduce runoff and soil loss from rice fields.

Now a days it is being stressed that expected climate change impacts should be considered in integrated water resources management and design of new projects, particularly water availability and water supply scenarios i.e., (whole hydrological cycle consisting of rainfall, runoff, evapotranspiration, storage, percolation etc.). Floods and droughts are basically stochastic phenomenon and not deterministic, so like rainfall, floods and droughts also vary with space and time. Accordingly, operation of water resources particularly release, allocation, distribution and utilization will be affected. The adverse impact of floods and droughts can be minimized by chalking out some strategies in advance like floods and drought protection works. While chalking out strategy/plan, views of local persons, their experiences to cope up with floods and droughts are very valuable and may be quite beneficial if considered positively.

When there is increase in risk and uncertainty, and availability of water is either limited or in plenty, both the situations lead to water conflicts among water users and water suppliers as well. But by frequent dialogues and discussions people get better mutual understanding. This helps in realizing the issues and reasons of conflicts and reduces these conflicts to great extent, ultimately leading to increase in water use efficiency.

Public has to realize that some water is essentially required maintaining ecosystem, birds, flora fauna, and minimum flows in

rivers. It should be taken into account while designing new water resources projects.

Plantation in between roads or by the side of roads helps to reduce the temperature in urban areas. When planted in upper watersheds, this process reduces runoff and soil erosion and increase ground water recharge.

Degraded waste land management can be done by planting medicinal and aromatic plants, which will increase land productivity. Similarly, land and water productivity of surface waterlogged areas, wet or marshy lands by the sides of canals or low lands can be enhanced by rearing fish or water loving or water tolerant hardy crops like rice, water chest nut, gorgon nut etc., depending on extent and duration of water logging. It is also necessary to rehabilitate the habitats including human beings and livestock of flood or drought affected areas.

Due to climate change, at some places temperature will rise and at other places temperature will fall and its frequency, intensity and duration will vary from location to location. This will result in untimely floods or droughts of different extent and duration. Because of unpreparedness to cope up with such situations, losses due to floods and droughts to human, livestock and natural resources will increase leading into waste generation and pollution.

In order to cope up with climate change and minimize its adverse impact on natural resources especially land and water resources as well as human and livestock resources, there is an urgent need to chalk out a strategic plan which should include the following points.

1. Develop Flood and Drought Insurance Policy and Emergency Advance Plan to protect people, livestock and other natural resources. It should essentially include cope up mechanism to repair and maintain degraded resources, rescue operations, awareness plans, management policy under adverse situations, in order to minimize the adverse impact of these events on whole ecosystem.
2. To cope up with droughts, many low lying areas of small size having dykes around should be identified in advance, so that excess runoff as a result of high intensity rainfall of less duration can be captured and stored for future use. Similarly during floods, first preference should be given to capture and store water in low lying areas having dykes around or ground water storage, where infiltration rate is high so that runoff is minimum. When runoff is essential, safe disposal of excess runoff through well connected drainage network into the river needs to be assured.
3. Information received from Early Warning System as well as crop water requirement in the command area should be effectively utilized in operation of reservoirs, barrages and whole network of canals.
4. Maintenance of reservoirs, barrage and canal network is a continuous process. It should be performed timely and there should not be any scarcity of funds for maintenance of whole irrigation system network. So monitoring of whole irrigation system network should not be neglected at any cost.
5. Participation of local public in whole process, their valuable experiences and suggestions should be considered because they deal with system and know better than anyone.
6. Water quality is another important issue, because climate change will influence amount, intensity, duration and distribution of precipitation, runoff, and temperature, leading to generation of sediments, pollutants, pathogens and pesticides etc. and sea level rise affecting ground water aquifers and more sea water intrusion ultimately resulting in availability and accessibility of less fresh water for drinking and domestic purpose. This issue needs special attention and should be effectively addressed.
7. Opportunities for reuse and recycling of water should be explored to the extent possible because this promotes multiple uses of water and improves water productivity. This is also effective in combating floods and droughts.
8. Conjunctive use of poor quality water with good quality water in different proportions reduces adverse impact on crop growth and production. Similarly, conjunctive use of rain, surface and ground water and application of water at different crop growth stages when it is essentially required is also very effective in increasing crop yield and reducing adverse impact of floods and droughts.

Conclusions

Water resources are very essential for economic, social and cultural growth of the society, but these resources are losing their capacity day by day to provide the services at desired level. The risk levels continue to increase, as due care to develop and use waters from different sources and various purposes, have not received due attention. Water is certainly needed for natural life as well as for human use. The indiscriminate, unscrupulous, unplanned development and irrational allocations appear to be more due to lack of appropriate and well planned policies rather than lack of technologies. As the water scarcity increases and demand for different other users of water goes up, it would be possible to maintain the ecosystem in good health, only by following the principles of integrated water resources management. In the changing climate scenarios it would be worth considering the sustainable management of water resources and formulating policy framework at all the levels i.e., field to river basin level and up scaling as well as out scaling strategies for implementation of policies.

Climate change adaptation is a very complex phenomenon and challenging too. To date, significant effort has been invested in developing tools to assess the links between climate and hydrology. These tools offer insights into how large-scale patterns of runoff might change in the future. Adaptation decisions are not made based on assessments of naturalized runoff but are instead derived from assessments of how human interactions with hydrology produce positive or negative outcomes for the economies and ecosystems upon which human communities depend. These aspects need to be better captured in the available analytical tools.

As the formulation phase of planning for water adaptation to climate change requires the use of a participatory and holistic process, efforts towards the adoption of the principles of IWRM should be encouraged. While IWRM does not explicitly integrate climate change considerations into the planning process, the underlying principles of good resource management can facilitate a process whereby information required for adaptation to climate change, including data and records, can be elicited from key actors.

As the impacts of individual water management actions can accumulate within a particular water system, basin planning, even if it covers multiple political jurisdictions, should be encouraged as adaptation to climate change is identified and implemented. When planning adaptation across boundaries, riparian countries should focus on preventing adverse impacts, sharing benefits and risks in an equitable and reasonable manner and cooperating on the basis of equality and reciprocity. This will assist in avoiding actions that might

be adaptive in one location and maladaptive elsewhere, potentially increasing the conflict over water management and allocation.

As the analytical approach that is likely to emerge for integrating climate change considerations into planning and decision-making is likely to differ from the currently established practice, educational programs for young water professionals should already be presenting alternative planning paradigms. Even if new standard procedures for integrating climate change into water management planning and decision making are not yet in place, young professionals should be aware of the challenges confronting the current approach so that they can engage in developing new approaches that they can bring with them as they begin their professional careers.

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