PAPER 2

SAWAS
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OVERVIEW OF WATER ALLOCATION PRACTICES IN UTTAR PRADESH AND UTTARAKHAND WITH A SPECIFIC REFERENCE TO FUTURE DEMANDS

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Nitin Kaushal and Madan Lal KansalAbstract

Ganga river basin is the lifeline of the whole of northern and central India. It feeds the requirements of the region in many ways, including irrigation, drinking, and industry etc. However, this river is also one of the ten most vulnerable rivers in the world. The key reason for its vulnerability includes over-abstraction and pollution. This paper explains various stresses and challenges the river faces, especially the ever-increasing population and changing water requirements thereby leading to ever-enhancing demand for water for fulfilment of various purposes. Further, this paper elaborates what is ideally and practically possible for saving this valuable natural resource. In addition to this, the paper also illustrates the situation 'as-is' in water sector and measures being considered and taken by various governmental agencies.

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INTRODUCTION

World oceans cover about three fourth of earth's surface. According to the UN estimates, the total amount of water on earth is about 1400 Million Cubic Kilometres which is enough to cover the earth with a layer of 3000 metres depth. However the fresh water constitutes a very small proportion of this enormous quantity. About 2.7 percent of the total water available on the earth is fresh water of which about 75.2 percent lies frozen in Polar Regions and another 22.6 percent is present as ground water. The rest is available in lakes, rivers, atmosphere, moisture, soil and vegetation. What is effectively available for consumption and other uses is a small proportion of the quantity available in rivers, lakes and ground water. The crisis in water resources development and management thus arises because most of the water is not available for use and secondly it is characterized by its highly uneven spatial distribution. Accordingly, the importance of water has been recognised and greater emphasis is being explored on its economic use and better management.

Further, with the increasing global water consumption, the situation in India is likely to aggravate colossally. A recently released study indicates that, in India, the water demand is growing annually by 2.8 percent to reach a whopping 1500 Billion Cubic Meters while supply is projected at 744 BCM, i.e. just half the demand. As a result, most of India's river basins could face severe deficits by 2030 with some of the most populous river basins facing the biggest absolute gap.

It's a well known fact that water is the basic need of mankind. From time immemorial, rivers have been considered as one of the main places for civilization throughout the world, this is chiefly due to the fact that rivers fulfil almost all requirements. However, this often leads to the degrading state of rivers. It is in this context, the paper will discuss current water allocation and future requirements for an ecologically healthy river, in this case, the Ganga. Further, an analysis of current water allocation practices in upper stretch of river Ganga vis-à-vis future water needs, the existing institutional arrangements and legal framework would also be beneficial for overall understanding of the problems.

Structure-wise, this paper discusses about water resources of River Ganga, its availability for various purposes, the water allocation scenario with specific reference to future demands. It also reviews concerned laws and policies to benefit from, and finally the recommendations to have positive gains in regard to water resources allocation and management.

Ganga river basin: Brief overview

The Ganga basin is a part of the composite Ganga-Brahmaputra-Meghna basin draining 1,086,000 square kilometers in China, Nepal, India and Bangladesh. To the north, the Himalaya or lower parallel ranges beyond form the Ganga-Brahmaputra divide. On the west the Ganga basin borders the Indus basin and then the Aravali ridge. Southern limits are the Vindhyas and Chota Nagpur Plateau. On the east, the Ganga merges with the Brahmaputra through a complex system of common distributaries into the Bay of Bengal. The Ganga river basin is the largest one in India in terms of catchment area constituting 26% of country's landmass (8,61,404 sq km) and supporting about 43% of its population (448.3 million as per 2001 census). The annual surface water potential of the basin has been assessed as 525 km^3 in India, out of which 250 km^3 is utilizable water. There is about 580,000 km^2 of arable land; 29.5% of the cultivable area of India. Its Catchment

lies in the states of Uttar Pradesh (294,364 km^2), Madhya Pradesh (198,962 km^2), Bihar (143,961 km^2), Rajasthan (112,490 km^2), West Bengal (71,485 km^2), Haryana (34,341 km^2), Himachal Pradesh (4,317 km^2) and Delhi (1,484 km^2), as well as the whole of Bangladesh, Nepal and Bhutan. Several tributaries rise inside Tibet before flowing south through Nepal.

The basin comprises of semi-arid valleys in the rain shadow north of the Himalaya, densely forested mountains south of the highest ranges, the scrubby Shivalik foothills and the fertile Gangetic plains. Central highlands south of the Gangetic Plain have plateaus, hills and mountains intersected by valleys and river plains. The important soil types found in the basin are sand, loam, clay and their combinations such as sandy loam and silty clay.

The river Ganga, originating in the Himalayas, is one of the world's major river systems with an iconic stature. The Ganga river basin is one of the most fertile basins in the world. The river runs for 2,525 kilometers from its source 'Gangotri' in the Himalayas to the Sunderbans Delta in Bangladesh. Glacier melt provides for a year round constant flow from the higher reaches, while the monsoon season brings peak flows from July to October. However it is the precipitation that is more significant flows in river Ganga.

Although the river as a whole is vulnerable to many threats, but the upper stretch (mainly from Gangotri to Varanasi) faces numerous challenges ranging from over-abstraction (for irrigation, domestic and industrial use) to sewage and industrial pollution. This stretch is often referred as 'critical stretch' and that is despite the fact that, this river has immense pertinence in terms of cultural and spiritual values. Infact this river is the lifeline for the people residing in its basin.

Web-note from Ministry of Water Resources website
A Report by McKinsey in collaboration with World Bank affiliate International Finance Corporation

The water availability in the upper Ganga river stretch is affected chiefly due to two aspects:

3. The scenario of water availability in upper Ganga stretch is overwhelming and this has led to creation of quite a few major irrigation systems. Infact the historical Upper Ganga Canal, constructed in 1870, which is considered to be an engineering marvel, takes off from this stretch of river Ganga. Further, other canals like Lower Ganga, Madhya Ganga, Parallel Upper Ganga and Eastern Ganga all takes off from this same stretch. While commissioning of these systems, it was envisaged that they will be meant primarily for subsistence agriculture, whereas in reality and in due course of time these systems are mainly used for water loving crops like – sugarcane and paddy as the water has been in abundance. The problem gets further aggravated by the fact that, the area under cultivation has increased tremendously and further put pressure on the canals for supplying additional water. Various canal systems on river Ganga in totality withdraw about 43000 cusec of water in kharif and 19000 cusec of water in Rabi. Most of the irrigation canals on this stretch of the river are run-of-the-river schemes, where large scale abstractions of water take place.

2. The geographical area of Uttar Pradesh is about 7% of the country's total area whereas it supports about 16% of country's population. If we compare population density of 1971 and 2001, it has increased by more than 100% i.e. from 300 to 689, whereas the average population density for India is 324. This has led to a sharp increase in water demand from the domestic and industrial sectors; it further puts pressure on available water resources. The upper stretch of the river provides drinking water to Delhi (200 cusecs) and many western and central Uttar Pradesh's cities like – Meerut, Ghaziabad, Kanpur, Varanasi etc. Further, these cities are also industrial towns, so industrial demand of water is largely met by the very same source. In addition to this, certain power plants like NTPC, Reliance Power Plant, Harduaganj Power Station also gets water (in tune to about 300 cusecs) from similar source, which further puts pressure on water availability.

Though these development has brought lot of wealth to the area, especially the western and western-central Uttar Pradesh, but this has also put pressure on water delivery from this river stretch and over a period of time, this stretch has become so water starved (especially during the lean season) that there is very less water available for the river itself, i.e. for maintaining its own ecology and health.

2.2 Water Rights on Ganga Water

The rights of Uttar Pradesh and Uttarakhand would be regulated by the rights of India on the Ganga. Crucial one among the treaties is the Ganga Water Treaty dated 12.12.96 between India and Bangladesh for sharing Ganga waters at Farakka Barrage. Article VIII of this treaty calls for cooperation in finding solutions to the long term problem of augmentation of flow in river Ganga. Further, clause II of Article II stresses that, efforts must be made by upper riparian (states/state) to protect the flows at Farakka.

The factors mentioned in the previous section pose a serious challenge to maintain the required flow in the river for the downstream station.

There is another angle to view this issue, although it has been reported that since Ganga River is largely fed by precipitation and less by snow and glaciers melt, so overall the quantum of water availability is likely to increase under a climate change scenario. On similar lines, as per an estimate by the Ministry of Environment and Forests, the annual rainfall in Ganga Basin would be 150 cm (2071-2100) as compared to current 134 cm (1960-1999) and similarly the annual flow would be 543 km^2 (2071-2100) as compared to current 482 km^2 (1960-1999). But during the summer months i.e. April-May-June, the pinch will be severely felt. So in wake of this assumption, treaties, like the Farakka ones will require to be renegotiated.

Web-note from Ministry of Water Resources website
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Since the upper stretch of River Ganga passes through two states namely Uttarakhand and Uttar Pradesh, so a description of both states will be beneficial to understand the situation 'as-is' at the ground with respect to water resources, its usage and the response of the respective governments. However it is to be noted that, it's the state of Uttar Pradesh which is more crucial for discussion at this juncture, as the demand and supply side is much more prominent in this state.

1. UTTARAKHAND

Agriculture is of critical importance in Uttarakhand for human sustenance, because it supports 75–80% of the population. Uttarakhand has a land area of 55845 km^2 of which 80% is hilly and the remaining 20% is plain land. Total cropped area accounts for around 23.5% of the total land area. The net area sown is around 14.5% and is under pressure to sustain a population of more than 50 million, almost 80% of which is rural. Only 11% of the total area is irrigated (in the hill areas), with the rest of the sown area being rain fed, where farmers often grow three crops in two years.

Traditional irrigation methods in the hill area have made use of the topography of the region – the steep slopes – and have relied on gravity for watering the fields. These irrigation canals dug along the contours of the fields to maintain the flow of water are locally called guls, whose length is 17,526 km as against 8,238 km length of 'Canals', showing the predominance of traditional irrigation systems. Unlike the hills, where agriculture is subsistence oriented, in the plains, it follows market economy, and has given impetus to ancillary industries depending on agro-products such as sugarcane mills and rice mills. The area irrigated by major and medium schemes amounts to a mere 6.97%. The area irrigated by Minor Irrigation amounts to about 93.02%.

2. UTTAR PRADESH

The state of Uttar Pradesh, most of whose area falls in the Ganga basin is endowed with bountiful water resources, but is now feeling the scarcity due to competing demands for various purposes. Tables 1 show a comparative sectoral allocation of water averages (in percentage) for the state. With relatively higher demands from other sectors; the availability of water for irrigation sector is likely to reduce progressively to about 70% to 75% in future.

Sectors	Uttar Pradesh	
	2001	**2050**
Irrigation	96	79
Domestic	3	12
Industry and Power	1	9
Others	-	-
Total	**100**	**100**

Table-1: Sectoral Allocation by Year (Source: SWaRA, UP)

2.1 Water Availability

The indo-gangetic plains are known to be resource rich, both in terms of water availability and the land fertility. The annual rainfall ranges from 39 cm to 200 cm with an average of 105 cm. About 80% of the rainfall occurs during the monsoon months, i.e. between July to September/October. Thus, there are wide fluctuations in the flow characteristics of the river because of these large scale temporal variations in the precipitation over the year. This puts pressure especially during the lean season, i.e. from December to June.

3. Executive Summary, Theme Paper on Efficiency of Water Resources System by India Water Resources Society 2004
4. SWaRA – State Water Resources Agency, Uttar Pradesh Irrigation Department, Government of Uttar Pradesh
5. Having Command Area above 20,000 Hectares
6. SOURCE: Inception Report, study on Problems and Prospects of Water and Energy Use Efficiency in Agriculture in Upper Ganga Basin

Upstream / Downstream Obligations and Allocations – the 'as is' scenario

A flowchart (Figure–1) illustrating inter-sectoral water allocation vis-à-vis demand supply mechanism is given below.

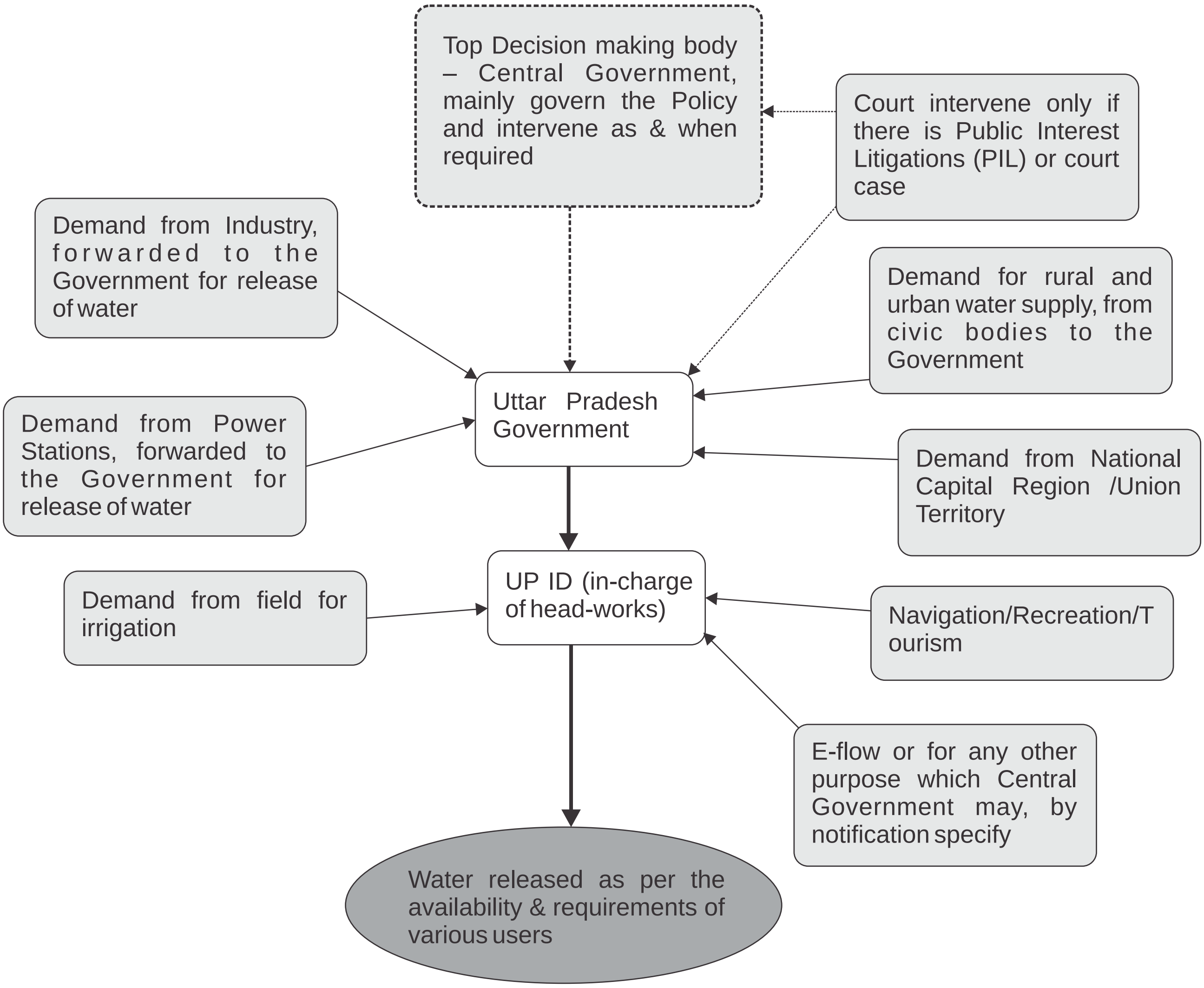

Figure-1: Flowchart illustrating Inter-sectoral water allocation practices vis-à-vis demand mechanism

By and large the allocations are made as per the chart illustrated above, however there are certain other drivers which locally influence water allocation within irrigation sector; this includes demand from local politicians and other powerful people for their particular area. The percentage of such practices is not high, however with a view to have ideal water allocation scenario, the same is required to be addressed, as they are key contributors for inequitable water distribution and quite often water abusage as well.

The current process of water allocation may not require too many modifications, except for due allocation for environmental purposes; however it's the quantum of sectoral water allocation that requires considerable renegotiations, given the fact that the water allocated for irrigation sector is above 60% of the total allocated water.

The information available on irrigation efficiency obtained in various major and medium projects is very scanty. Irrigation sector is the major consumer of water, so even a marginal improvement in the efficiency of water use in this sector will result in saving of substantial quantity of water, which can be utilized for maintaining Environmental Flows in rivers, especially in Ganga as major chunk of water from this river is diverted for irrigation. It is to be stressed that, the thrust should not be on providing more water for irrigation but it should be on improving the existing levels of efficiency in irrigation, so that the saved water can be used elsewhere, preferably for meeting the environmental requirements of the river. The efficiency obtained in this sector is generally in the order of 35-40% in surface water and 65-70% in ground water. These are considered to be very low and there is sufficient scope of improvement. So the need is to have higher water efficiencies for agricultural production, i.e. "More Crop Per Drop". The NCIWRDP, constituted by Government of India has in its report advocated that, it should be possible to achieve 50-60% efficiency in surface water irrigation and 70-75% efficiency in ground water irrigation by 2025 and 2050 respectively.

Current levels of water loss in irrigation are critical for the improvement of the overall scenario. At present, the canals are under performing and canal water use efficiency is as low as 30-40%. Improvement of about 10-20% is feasible and achievable with minor adjustments and focused sensitization of farmers. Even 10% improvement in canal and ground water efficiencies may yield substantial flow to the order of 2.7 BCM/year in the river Ganga.

On the other hand, in the times to come there is a likely possibility that additional water will be required for (i) drinking and domestic (to feed ever-growing population), (ii) industrial (to meet increasing industrial demand, an evidence of the same is a recent development that, the GoUP has come out with a Government Order which provides overriding water priority for industries against irrigation) and (iii) environmental needs (growing level of awareness related to river health issues and diminishing levels of water quality and quantity in the river). Since, the water available is almost finite, so the curbing could be chiefly from the allocation of irrigation sector.

The farm level irrigation efficiency is largely affected due to following aspects:

1. Absence or malfunctioning of control structures
2. Absence of metering
3. Lack of vigil on the canals and diversion structures
4. Lack of awareness (among farmers) in regard to quantum of water to be applied for the crop
5. Lack of extension services with regard to information dissemination about less-water requiring varieties, improved seeds, hybrid varieties etc.

Institutional Issues – *the 'as-is' scenario*

The present institutional arrangement in Uttar Pradesh, for the water resources sector is highly disintegrated, loosely coordinated and highly governmental and bureaucratic with very little effective participation of stake-holders other than the Irrigation Department. However the state has now initiated thinking towards broader water sector reforms in its own ways. These measures will help but not in a significant manner until there is absolute dedication and will to achieve the same.

The Major and Medium Irrigation Schemes and Flood Control works are with Irrigation Department (Civil) whereas Major, Medium and Minor Lift Pump Canals are being maintained by the Irrigation Department (Mechanical) and operation is with the civil engineering wing. The Irrigation Department currently employs about 5000 regular employees.

8. SOURCE: Inception Report of Study on "Problems and Prospects of Water and Energy Use Efficiency in Agriculture in Upper Ganga Basin"

Private minor irrigation schemes are looked after by the Minor Irrigation Department. Domestic water supply is dealt with by UP Jal Nigam, Jal Sansthan & local bodies. The Land Development and Water Resources Department undertakes soil and water conservation schemes and manages Command Area Development. The Ramganga and Sharda Sahayak Command Area Development Authority are supposed to take care of construction of the tertiary canal system, i.e. field channels (gul).

Under a recent development the state tube-wells have been transferred to the village Panchayats. The Uttar Pradesh Panchayati Raj Act, 1947 and as amended in 1963 empowers the State Government to require any Gaon (Village) Panchayat to construct, repair or maintain any small irrigation project and regulate the supply of water for irrigation purposes. The Act also provides that the Gaon Panchayat will have control over all waterways other than canals (as defined in the NICD Act, 1873) situated within their jurisdiction and not being under the control of State Government. However, their maintenance work is still being carried by the Irrigation Department (Mechanical). It is envisaged that, with this move the level of stakeholders participation will enhance.

Internal coordination amongst departments in Uttar Pradesh

State Water Board

A State Water Board has been constituted with a mandate to devise water policy for the state and to decide sectoral allocation priorities. It was constituted in 1996 under the chairmanship of the Chief Secretary with the Engineer-in-Chief, Irrigation Department as its member secretary. The State Water Board prepared the State Water Policy in 1999. However, the policy needs revision in the fast changing scenario of competing demands and hence the role of the State Water Board becomes more imperative for coordinating and implementing water allocation priorities.

State Water Resources Agency

The mandate of State Water Resources Agency (SWaRA) includes – allocation of water for various uses, preparation of river basin water plan, formulation of State Water Policy, preparation of water laws and implementation of SWP. The SWaRA was created in 2001 under the chairmanship of the Principal Secretary, Irrigation, GoUP
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State Water Resources Data and Analysis Centre

As a depository of data related to water and related statistics at state level, a data centre is created within SWaRA which stores raw data obtained from various state and central agencies and analyses them in a river basin context.

Uttar Pradesh Water Management and Regulatory Commission

With a view to ensure proper utilization and regulation of water resources of the State, the government has enacted the 'UP Water Management and Regulatory Commission Act 2008'; however the Rules and Regulations are being framed. It is envisaged that this Act will facilitate and ensure judicious, equitable and sustainable management, allocation and optimal utilization of water resources for environmentally and economically sustainable development of the state.

The Uttar Pradesh Water Management and Regulatory Commission (UPWMRC), which is an entity with constitutional authority was recently formed, and will have representation from associated fields, like irrigation, agriculture, finance, economics etc. Whereas the State Water Resources Agency (SWaRA), is a functional entity and does all the background work including – data collation, analysis and research for the commission and for the board.

At the moment there has been some teething troubles in the coordination and consensus building among these entities, however on a positive note it is hoped that in the times to come, both these entities will contribute towards larger water sector reforms in the state. Currently the UPWMRC is engaged in revising the water charges for the users, including irrigation, industry and others. The SWaRA is helping the commission with this task. The water charges have not been revised since 1998, so this is a crucial task being undertaken by the commission with the help of SWaRA.

Review of policies, legislations and IMO

The Government of India has drafted the National Water Policy (1987 and reviewed in 2002) under the aegis of the National Water Resources Council and the same has been accepted by the states and Union Territories. It stipulates optimization of efficiency of utilization in all the diverse uses of water and an awareness of water as a scarce resource. The policy further prioritize various water uses, which are -

i) Drinking
ii) Irrigation
iii) Hydro-Power
iv) Navigation
v) Industrial and other uses etc.

Within the above broad parameters, the state of Uttar Pradesh, while recognizing water as a State subject, has adopted these guidelines in the State Water Policy, 1999. The State Water Policy is not very clear, when it comes to priority for domestic use, sanitation, health & hygiene and environment & ecology. However, Policy recommends that the water allocations in an irrigation system should be done with due regard to equity and social justice. The policy also suggests for adoption of rotational water distribution system and supply of water on volumetric basis for removing disparities in the availability of water between head and tail reaches. In addition to this, the Policy further calls for ensuring of ecological and environmental balance while developing water resources and therefore stresses the need for a minimum flow in the natural streams, which fails to serve the very purpose. The policy accepts that, the present status has a substantial scope for qualitative improvement in this field. In this regard thrust needs to be given to:

i. Improvement of command areas (such as leveling of fields, improvement and maintenance of water courses etc.)
ii. Adoption of improved irrigation and agriculture practices using appropriate technology to ensure optimal use of water for agriculture production. This should also aim at adoption of appropriate cropping patterns

Though the water requirement of industries used to be very small compared to other sectoral demands in earlier years, the rapid industrialization is changing the scenario. As the industries are location specific, so the demand of water is also required to be location specific. Keeping this in view, the state government of Uttar Pradesh has amended their State Water Policy vide notification dated August 5th, 2004, to the extent that, it now has overriding priority over irrigation sector. Yet no effective mechanism is in place in UP to measure and monitors the quantity of water used by industries. In many ways this shows the changing attitude and priorities at the government levels.

While reviewing other relevant legal provisions as contained in the existing UP Irrigation Manual of Orders (IMO) and Northern India Canal and Drainage Act, 1873 being followed, it has been observed that the major Irrigation Acts which are now over a hundred years old, are based on social concepts so as to provide basic day-to-day necessities of life and do not consider farmer's involvement either important or desirable.

Irrigation administration was retained in the hands of technocratic bureaucracy which preferred to distance itself from the farmers and continues to do the same even today. The new enactments and statues in post independence India have followed the same tradition occasionally recognizing the importance of farmers but never giving them authority, power or resources to deal with irrigation administration in the ways farmers may deem fit.

Various irrigation related Acts, namely NICD Act (1873), Bengal Irrigation Act (1876) and the Bombay Irrigation Act (1879) do not provide for farmers' participation in irrigation management. These laws have guided State Irrigation Legislations in various states. The existing irrigation acts in most states, do not provide for the transfer of funds to water users for undertaking repairs. Nor do they encourage the mobilization of collective efforts and group initiatives in irrigation management. Farmers have everywhere remained dependent on State Government and the irrigation bureaucracy for supply and maintenance. All authority is vested in the department. A designated officer of the Irrigation Department is vested with large powers. Thus, decision-making rests with the irrigation bureaucracy and not with water users. Even in the matter of settlement of disputes, farmers have little say. Decisions affecting farmers are imposed rather than developed in consultation with them.

Department officers are not accountable to water users with regard to the supply of water, and the timings and the changes, are decided primarily by them. There is a lack of transparency in the management of the irrigation systems. Whether water will be released and when, correlation between water deliveries and farm requirements and, stoppages which affect water users are often not known to them. Decisions in these matters lie with the Irrigation Department and contrary to claims, farmers are usually not consulted. Non-existence of proper and strict Warabandi/Osrabandi at tertiary level is leading to inequitable distribution of water and loss of efficiency. Practically, this has led to widespread disagreement and disobedience among the farming communities and thus leaves with little hope for support from them.

Any move of future allocation of water resources is bound to be futile if it doesn't take into account field realities and local dynamics. For instance – if there is a thought that allocation for irrigation will be reduced then it will not succeed until the farming community is made aware about its necessity and also about various means of improving efficiency levels at the farm. This will also involve effective extension services. At the moment there is no such window of opportunity. On an optimistic note, such a move could be the UP PIM Act of 2009 which is currently being enacted in pilot areas in Uttar Pradesh and will be enacted throughout the state at a later stage. More about this will be discussed in last section of this paper.

Another one step forward in regard to water resources management is the move by the state government to come up with State Environment Policy 2006. The Section 6.2.4 of the policy calls for the adoption of integrated approaches by various authorities and departments for the management of water resources. Under this Section, which is on 'Strategy'; the historical, social, cultural, religious, drinking, irrigation and industrial value of rivers is recognized. It also recognizes necessity of due consideration for mitigating the impacts on the aquatic and terrestrial biodiversity and livelihood of individuals from the multipurpose river projects. The Policy also calls for the constitution of a river authority.

The word warabandi originated from two vernacular words, wara and bandi, meaning `turn' and `fixation' respectively. As such, warabandi literally means `fixation of turn' for supply of water to the farmers. Osrabandi is a synonym of warabandi. Under this system of management, the available water, whatever its volume, is equitably allocated to all farmers in the command irrespective of location of their holdings. The share of water is proportional to the holding area in the outlet command and allocated in terms of time interval as a fraction of the total hours of the week. Whereas the term warabandi is commonly used in Haryana, Punjab and Rajasthan, this system of water distribution is usually referred to as osrabandi in Uttar Pradesh.

Irrigation Distribution system and its inherent anomalies

Design and operation of the conveyance and distribution systems is in such a way that, inequity and indiscipline prevail in the command. The systems are designed to run either at full discharge or at partial discharge. The cross-regulators and head-regulators are so designed, that the off taking branch can draw full supply even when the flow in parent channel is in having partial supply. In the secondary system, this leads to various manipulations in the head reaches i.e. the head branches take larger share of the parent channel and much higher shortages are passed on to the lower branches. So the operation of the system is fundamentally dependent upon the two factors, i.e. method of water allocation and method of water distribution adopted for the system and water control within the distribution system.

In the north and north-western states of India i.e. Uttar Pradesh, Uttarakhand, Punjab and Haryana, the Supply Based System is generally followed. In this system, the available supplies are distributed amongst all stakeholders in proportion to the size of their land-holdings catering to the requirements of rotational cropping patterns with liberty of discretional use. They are even allowed to supplement their requirements from other sources like wells and tube-wells. For operation at secondary canal levels and for equitable distribution of water in proportion to the size of land holdings, each unit of culturable commanded area is allotted a fixed rate of flow of water known as 'Water Allowance'. It may be defined as the number of cusecs of outlet capacity authorized per thousand acre of culturable irrigable area. The 'Water Allowance' therefore not only defines the size of outlet for each outlet area, but also forms the basis for design of distributing channels in successive stages. Its value is often a compromise between demand and supply and is decided keeping in view factors like type of soil, normal crops that are to be grown in the area, rainfall, climate, intensity of irrigation desired to be achieved and availability of water in a normal year. The carrying capacity of distributaries and water courses is designed on the basis of the 'Water Allowance'. Outlets from the distributaries are ungated and are designed to take their authorized discharge in full supply conditions in the distributary, which usually operates as a unit either full or nil, which means that all outlets will draw their share simultaneously and automatically (being ungated) when the distributary runs full.

Competing demands for drinking, irrigation, industry and power generation necessitate rotational running of various canal systems during periods of lean flow. Whereas, it is easy to prepare an operational schedule for storage project where the quantum of available supplies is more or less known, the preparation of such an operation schedule on the run-off the river schemes is based on experience of the previous years. An operational schedule for storage projects inter-alia include supply of water for irrigation on a fortnightly basis with the provision that supplemental irrigation may become necessary depending on the rainfall in the catchment area. In this case, the schedule is prepared for Rabi (hot weather) supplies at the end of the monsoon (usually by the 15th of October), when approximate water available for the year is known. However, for run-of-the-river schemes like those on the river Ganga, irrigation withdrawals will depend on crop requirement and availability of water in the river. During the period of lean availability it may not be possible to run all the channels simultaneously even if there is keen demand on all of them. Under these circumstances, it becomes necessary to demarcate various channels of the system in a group or set of groups at a time and keep the remaining channels closed. This process of rotation is called 'Rostering'. In cases when supply matches demand all groups could run at full supply simultaneously. This Roster is prepared before the start of each season indicating weekly running of channels commencing from each Monday in the form of a Regulation Order. A register of actual running of channels is maintained and any variation from roster is clearly indicated with reasons. If due to some reason such as a breach the canal has not been able to run then it is made to run for the remaining days of the week so that each irrigator get his/her due share. Regulation Orders are prepared in such a way that each irrigator gets at least one irrigation in a month.

Discussion with the officers of UP Irrigation Department revealed that, although roasters are prepared on all systems of Ganga Canal, the operations in the field are not very meticulous, because of non-existence of any dependable system of operations at tertiary level i.e. at outlet level especially in the command of Lower Ganga Canal System.

The distribution system in other parts of North India, for instance in Punjab, Haryana and Western Uttar Pradesh where operation at tertiary level i.e. below outlet is managed by the cultivators through an equitable system of water distribution known as Osrabandi/Warabandi which is a system of water distribution according to a pre-determined schedule specifying the day, time and duration of supply to each irrigator in proportion to the size of his land holdings in the outlet command. Since timings of supply of water are fixed taking in account various factors like – land-type, standing crop and capacity of channel, the seepage losses in water courses and field channels, it enforces some rationing in the period of shortage. The system attempts to match available supply with demand and hence such system is working more or less satisfactorily. The UP Irrigation Department has designed the system of distribution on this very principle, keeping in view the following –

1. Within the minor canal command area, an unregulated free flow system will convey water to all the water course outlets which common chaks (about 30-60 ha CCA) with all outlets operated simultaneously during the weekly allocation period.

2. At the same time each farmer has been allowed to select his crops and cropping patterns supplementing his requirements with available private groundwater.

Although, the system is working more or less satisfactorily in the areas served by Upper Ganga Canal System in Western U.P, yet in spite of these specific provisions, it has not been implemented in the spirit is which it was envisaged, resulting in mismanagement, and wastage of water at various levels. Problem of head-enders taking excess water at the cost of tail-enders is more and more acute. This is partly because of weak motivation at various departmental levels coupled with the lack of political will in the area.

Cropping pattern

It is a well known fact that, water requirement for irrigation is a derived demand. The key determining variables include: requirement for food production, requirement for non-food production, efficiency of water use and production per unit of land.

Food sufficiency and to some extent export of food and non-food agricultural produce is essential for the country from both strategic and socio-economic considerations. Necessity for food self-sufficiency has always remained a key factor with authorities/commissions set-up from time to time. It rests mainly on four fundamental arguments –

1. unreliability of imported food grains for a large country like India
2. potential of augmenting food supply by improving existing low yields
3. foreign exchange constraints in case of large scale imports
4. income and employment considerations for the large workforce available in India, which is dependent on food production

The case of augmenting exports, particularly of the so-called commercial crops rests on comparative advantage this country has in production of several non-food agricultural commodities due to its diverse climate and land resources. Consideration in estimation of water requirement for irrigation is self sufficiency in food production at state/national level, where growing demand for better diet has increased the domestic demand for "thirsty" crops, namely – rice, wheat and sugarcane. About 66 – 71% of water usage goes for this purpose, thus tremendously increasing the absolute gap between demand and supply. Efforts to bridge this will mainly include (i) additional focus on water conservation and (ii) improving water use efficiency. Although water use efficiency is important, yet some losses are inevitable which in the upper reaches of river basin are returned to the system lower down as base-flow or recharge of ground water aquifers for further use.

On the Ganga system, three cropping zones can be distinguished, i.e. the sugarcane (western), the intermediate and the southern zone. Thought the cropping pattern varies significantly but it is seen from the statistics that the sugarcane crop is predominant in the head reaches of the system, whereas wheat and rice takes predominance in intermediate and southern zones. The historic reason for this pattern lies in the amount of irrigation water diverted in different areas.

The farmers with the introduction of irrigation have shifted from the traditional low value, low productivity and low irrigation water requirement crops to higher value high water requiring crops of proven stable productivity. Such typical shifts have resulted in skewed irrigation demand due to concentration of high water requiring crops in certain pockets, typical examples of this are – adoption of Cereal-Cereal; Rice-Wheat rotation in Northern India, especially in Punjab and Haryana and concentration of sugarcane in Western Uttar Pradesh. In addition, the farmers in order to take advantage of early market, cheap and early availability of labour, assured uninterrupted irrigation and subsidized/free electricity tends to advance the sowing of crops to high evaporative months escalating water demand further.

Way Forward

As has already been established, there is a wide gap between consumption and availability of water resources. Therefore additional efforts will be needed to bridge the gap. Concerted efforts are needed to use water more efficiently in three major areas of consumption i.e. agriculture, industry and municipal/domestic.
It is almost impossible that, irrigation sector will continue to enjoy the lion's share of water allocation in the future, so it has to mend its ways and means to ensure efficiency at all levels. The irrigation sector is the one with maximum scope of improvement; therefore key interventions are required for this specific aspect, which are as follows

1. *Legislations to facilitate Irrigation Management Transfer*

It is imperative that the Irrigation Acts and Rules must be amended to incorporate new social contract so as to legitimize a relationship of equals or a partnership between the Irrigation Bureaucracy and the Water Users. Provisions for the formation of farmers' bodies' i.e. WUAs or Farmer Organizations should be the hallmark of these laws so that the Participatory Irrigation Management (PIM) initiative becomes practicable.

From last 10–15 years, the government has recognized the vitality and necessity of farmers' involvement in operation and maintenance of canals and its associated systems. It is evident from the fact that, many Indian states including Andhra Pradesh, Madhya Pradesh, Orissa, Rajasthan, Maharashtra and Gujarat have come up with specific PIM legislations for their respective states. Further, some other states, including Karnataka has made necessary amendments in their prevailing Irrigation Acts. Despite all that, the development in this regard is not so impressive. However, it appears that in the times to come, the role of user's entities i.e. Water Users Associations will be fully recognized and they will be accordingly mainstreamed and strengthened. The farmers must be enabled to take the responsibility for system operations, maintenance and water distribution, be suitably empowered and given the financial resources and technical know-how relevant to their area of jurisdiction. This will help in improving the irrigation efficiency which in-turn may enable saving of supplies for Environmental Flows and for other developmental purposes.

The state of Uttar Pradesh has taken one step forward in that direction by enacting 'The Uttar Pradesh Participatory Irrigation Management Act, 2009'. For implementation of this Act, its Rules and Regulations have also been prepared. It is anticipated that, the Irrigation Department will be able to enforce this Act containing provisions of PIM in Sharda Sahayak Irrigation System of the state which falls under the project Area of World Bank funded Uttar Pradesh Water Sector Restructuring Project (UPWSRP) and complete Warabandi/Osrabandi accordingly.

This pilot project is expected to act as a model for further implementation in other canal command areas of Madhya Ganga and Lower Ganga Systems. This Act is required to be implemented in its true spirit, as it has been noted at many instances, the envisaged outcomes are difficult to achieve due to various reasons, including – department's reluctance and lack of support for its implementation, lack of awareness among the farmers about their rights and responsibilities. It looks like a moon-shot, but if at all it becomes effective then many issues are likely to get resolved.

2. *Conjunctive use of water*

Surface water and ground water are an integral part of available water resources. However, planning for their use has generally been in isolation resulting in sub-optimal utilization. Both the resources should therefore be developed in integrated and coordinated manner and be used conjunctively. The net output in the conjunctive mode is much more when compared to the net output when each source of water is used separately. Conjunctive use of both resources should be considered an alternative to tide over water scarcity during drought years. Large evaporation from carry over storage substantially reduces the effective availability. Ground water resources provide evaporation free carry over and can supplement the surface supplies whenever shortages are experienced.

The, development of eco-friendly strategies for conjunctive use of surface and ground water will optimize the use of water and also mitigate the problem of water logging to a large extent besides promoting sustainability of crop production in the given water endowments.

Discussions with Irrigation Department officers informed that, as an effort to ensure water adequacy, the concept of 'conjunctive use of surface and ground water' in a harmonious manner is being developed by SWaRA in a pilot project area, so that if found successful and workable, it could be adopted in command areas of other canal systems, where a large number of shallow irrigation tube-wells have been installed.

Under this initiative, the department is planning to come up with a Roster, which, in addition to usual canal running time-period (i.e. quantum of water availability through canals), will also have indicative water requirement from tube-wells (shallow ones). This will give farmers a clear idea about water availability through canal and required supplementing through the tube-wells. It is being contemplated that, administrative block-wise assessment of groundwater availability be made in the command of each distributary system and while preparing rosters, one or two rounds of watering will be exclusively done by groundwater depending upon field requirements. In this manner, groundwater utilization will get further impetus because during this period farmers may get assured and reliable supply of power in the irrigated areas. It will provide a range of possibilities viz.

- Availability of adequate water supplies when supplemented by groundwater at any point of time.
- To give late watering during lean flow periods for the maturity of crops.

3. *Crop diversification and integration of other practices*

The Green Revolution that made the country self-reliant in food and provided the food and nutritional security, has also ushered in second generation problems i.e. degradation of natural resources, decreasing total factor productivity and depleting of water resources apart from the salinisation of soils and nutrient deficiency in soil. This can be overcome by growing of different crops in a particular sequence in the same piece of land in a given period of time.

Diversification of crops, where the system of raising of crops plays a significant role, is therefore, one of the many challenges in the process of increasing the efficiency of water resources system. In the present scenario, agriculture in our country is at the threshold of diversification of crops and multi-cropping options. These broadly include crop rotation, mixed cropping, double-cropping etc. which will prove useful in the long run.

It is noteworthy that for sustainable agriculture integration of agriculture with pisciculture, poultry farming and animal husbandry in the same land will be useful because animal and poultry waste will act as organic manure on which microbes would work for decomposition and help in this integrating of crop residues thereby reducing the use of chemical fertilizers. Thus, the major advantage of these types of diversifications would be reduced erosion, improved soil fertility, increased yield, reduction in need of nitrogenous fertilizers in case of legumes and reduced risk of crop failure. These genetic diversifications and location specific varieties are essential for achieving sustainable production.

In response to the demand for commercialization of agriculture, there is a need to shift the focus from routine food grain system to newer cropping systems to meet the ever-increasing demand of pulses, oilseeds, fodder, fibre, fuels, spices, fruits and vegetables, medicinal and other commercial crops and make agriculture an attractive and profitable business.

Besides, care has to be taken for the problems being created on account of climate change due to Global Warming. Under climate change scenario, the impact of a rise in temperature would also enhance rate of Evapotranspiration (ET^o). Increase by 10C in temperature may cause the duration of wheat and rice reduced by a week. This in turn will reduce yield by 4 to 5 quintals per ha (M.S. Swaminathan, 1991). A recent study done at the Indian Agriculture Research Institute (IARI) on the impact of the global climate change on Indian agriculture indicates the possibility of loss of four to five million tonne in wheat production with every rise of 1^{o}C temperature throughout the growing period. According to another finding by Sinha and Swaminathan (1991) – showed that an increase of 2^{o}C in temperature could decrease the rice yield by about 0.75 ton/ha in the high yield areas; and a 0.5^{o}C increase in winter temperature would reduce wheat yield by 0.45 ton/ha. This will result in reclassification of currently favourable high potential wheat production area as heat stressed lower potential, short seasoned growing environment area in the years to come. Because for each ^{o}C rise of mean temperature, wheat yield losses are likely to be substantial thereby causing shortfall of food production.

To overcome the same, we may either have to increase cropping area (which is already reeling under stress) or switch to adaptable technologies which will mainly consist of initiatives like selection of varieties of wheat, rice, potato and other crops that are climate resilient. The second option appears to be more pragmatic. Considerable genetic variability exists in these crops for tolerance to high temperature besides the advantage of shorter growing period and high yield. Farmers will have to be educated about these crucial aspects.

4. Enhancing irrigation water use efficiency

It has been observed that irrigated agriculture, where the water delivery system is mostly supply-driven rather than demand-driven, results in over and under irrigation not matching with crop needs at different growth stages and hence results in sub-optimal efficiency. This is a severe deterrent to sustained agriculture which is a system of raising crops of greater human utility by utilization of existing resources with better efficiency without disturbing, imbalancing or polluting the environment. It is only possible through appropriate cropping and farming systems, using resources judiciously.

Since agriculture is the main concern for improving water use efficiency, there is a need to adopt a package of well known measures, such as drip and sprinkler irrigation, to control present flood irrigation wherever feasible, especially in water scarce areas having conditions are conducive to their application. Actual field studies indicated that, water saving to the extent of 25–33% and increased yield upto 35% can be achieved with sprinkler system in comparison with normal surface irrigation method. Similar savings are possible in drip system also. Low cost technology in drip system without pressure releases should also be encouraged. Even the system could be used in conjunction with canal systems.

10. Climate Change to Impact Indian Agriculture: IARI, The Financial Express dated 28th January 2008

Full utilization of created facilities and better design and proper operation and maintenance of the existing water distribution practices would considerably help in improving supply side efficiency. Increase in irrigation efficiencies is achievable by 20% as recommended by the NCIWRDP; this alone can generate deemed additional resource equivalent to present utilization by all other sectors.

This has become all the more important today in the light of national policy of economic liberalization. Thus, keeping all these aspects in view and as envisaged in the National Water Policy, allocation in any irrigation system should be done with due regard to equity, timeliness, efficiency and social justice.

1. *Other aspects*

Given the fact that, there are numerous industrial units along the bank of river Ganga, there is a need to factor in the incentives for those industrial units which undertakes concerted efforts for water saving and management (like–zero balance and positive balance) at their unit level. On the other hand, overriding priorities to industry (for water) over irrigation should be provided with extreme caution, so that there is no abusage of water at that level and tough punitive measures should be followed in such events.

Off-stream uses are mostly irrigated agriculture, withdrawals for industrial and domestic water supply and for Thermal and Nuclear power generation. On the other hand, the in-stream uses which relate to the water flowing through the natural stream to sustain in-stream water values at an acceptable level is equally important. Quantum of in-stream uses relate to sustenance requirements of fish and other aquatic life, outdoor recreation activities, navigation, hydroelectric power generation, water quality maintenance and eco-systems. In a situation of scarce availability, it becomes necessary to determine the priorities of allocation among various uses in a rational manner, so that they can co-exist and be addressed together.

Maintaining of ecology and overall health of river Ganga is equally important for biodiversity and socio-cultural requirements. The current water allocation practice has a reactive approach in this regard and the government machinery acts as per the eventuality or as per directives from the judiciary. This approach needs amendment in terms of adopting a proactive mechanism to address these expectations from the river, well in advance so as to protect collapse of any ecosystem associated with the river.

To sum up all this, it is essential to make refinements in water allocations, including explicit consideration of water quality & ecology related demands. Similarly, the share of Ganga River for meeting the downstream flow obligations also needs to be ensured.

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