TECHNOLOGICAL AND INSTITUTIONAL APPROACH FOR ENHANCING WATER (LOGGED) PRODUCTIVITY IN AGRICULTURE: A CASE STUDY OF GANGA BASIN IN ALLAHABAD

Firdaus Fatima Rizvi*

Abstract

This paper deals with the case study of Allahabad that is rich in water resources and is one of the most fertile plains of the Ganges. Since the coming up of Sharda Sahayak Canal in the area, there has been a problem of waterlogging in the area for the past fourteen years. Surplus water from canal, rainwater, absence of effective drainage system and low capacity of river Varuna all add up to create high level of waterlogging in the fields. Land area of about 600 hectares in Phulpur block is waterlogged. The high water table has engulfed vast areas significantly affecting agricultural production.

This paper throws light on water availability in agriculture, extent, height and duration of waterlogging in crop fields and extent of crop loss because of waterlogging. It also includes landuse pattern of agricultural households and calculation of loss of production expected. It predicts future benefits in terms of agriculture production with certain estimated investments into the region. The paper lastly deals with technological and institutional approach for enhancing water productivity in agriculture. The study helps in the promotion of self-generating income activities on one hand and solving water related problems on the other at the village level.

1. INTRODUCTION

The progress of the economy in developing countries, largely depends on the performance of agriculture sector. Among the determinants for agricultural growth, the provision of irrigation is very important because rainfall is not evenly distributed over the year and is uncertain. The assured supply of irrigation water can increase crop yields even without any increase in inputs, and reduce the uncertainty of crop production (Reddy, 1997).

The failure to take the groundwater into account and inadequate attention to drainage and soil condition in the canal irrigation have led to emergence of conditions of waterlogging and salinity in many areas, resulting in valuable agricultural land going out of use (Dhawan, 1988). At times, waterlogging in agricultural fields forced farmers to go for single crop whereas other farmers go for multiple crops. The farmers have to wait for the water to subside before they can resume work.

Irrigation facility ensures security to agriculture crops during low rainfall but the rigidity in irrigation timings proves to be fatal (Hill and Dracup, 1975). The water distribution among the farmers is highly uneven, depending upon the location of the farm, resourcefulness of the farmer and on the water delivery system that is supply driven. The farmers who get water easily misuse it, thereby leading to very low irrigation efficiency. This has caused inadequate and unreliable water supply, and created a wide gap between created and utilised irrigation potential, temporal imbalance of water demands and supplies, excessive seepage and operational losses leading to waterlogging and soil salination (Paul and Sharma, 2001).

In irrigated agriculture, water supply is sufficient in upstream fields as compared to tail end fields. The demand for water by the tail end farmers is justified though this demand of water creates waterlogging situation in upstream farms because of their interdependence (Bromley, 1982). Each farmer must also be able to cut off supply when there is no need of water. Any excess water that has come into the fields has to be drained away (Singh, 1984).

* Associate Fellow, Council for Social Development, 53 Lodhi Estate, New Delhi.

2. CONCEPT OF WATERLOGGING

In agricultural terms, the soil should be considered as waterlogged when the water table is within such a distance from the surface of the ground that it reduces the crop production below its normal yield that would be expected from the soil type of that area (Department of Irrigation, Uttar Pradesh). In physical context, an area is said to be waterlogged when the water table rises to an extent that the soil pore in the root zone of a crop become saturated, resulting in restriction of the normal circulation of air and decline in the level of oxygen that further increases the level of carbon dioxide. The actual depth of water table, which is considered to be harmful, would depend upon the type of crop, the type of soil and the quality of water and the period for which the water table remains high. The actual depth of water table when it starts affecting the yield of the crop adversity may vary over wide range from zero for the paddy to about 1.5 m for the other crops. The crops, which otherwise, would have grown in the wheat season cannot be grown then due to high water table.

The yield of the following crops suffered when the water table depth is equal to or less than the depth indicated against each crop below (Department of Irrigation, Uttar Pradesh, 2001) -

1. Rice 0.6 m
2. Wheat 0.9 - 1.2 m
3. Sugarcane 0.9 m
4. Fodder 1 - 1.2 m
5. Cotton 1.5 - 1.8 m

Water is more valuable for a particular crop at crucial time called as “critical water” clearly mentioned in Table 1 depicting water requirement by various crops. If the water is not available at a specific time, then it becomes impossible to implant the crop. This usually happens when the rain fails to arrive on time and the canal water too is not available. Once the crop is planted, the marginal value of water decreases gradually and at certain time, it becomes zero, i.e., at the time of harvest. Thus, a situation occurs when plant require optimum water for its growth.

Table 1: Water Requirements by Various Crops

Crop	Growing Period (days)	Applied Water	Water per 100 days (cm)
Rice98	104	106	
Sunflower	110	87	79
Sugarcane	360	237	58
Cotton	200	105	53
Maize	100	44	44
Wheat	88	37	42
Linseed	88	32	36
Soyabean	110	37	34

3. STUDY AREA AND METHODOLOGY

Allahabad has a very good natural resource and is one of the most fertile plains of the Ganges, but villages selected for study in Phulpur block face severe problem of waterlogging. The study area is substantially rich in water resources and is one of the most fertile plains of the Ganges. But since the coming up of Sharda Sahayak Canal in the region, waterlogging has emerged as a problem for the past fourteen years. The surplus water from canal, rainwater during monsoon, the absence of effective drainage system and low capacity of river Varuna has all added up to contribute high level of waterlogging in the agricultural fields.

To find out the nature of the crisis, different blocks were visited and information collected on various aspects of water management. In Phulpur block, it was communicated by officials that certain villages in the block were in the grip of crisis not on account of scarcity of water but waterlogging. To make the study comprehensive and more effective, stratified random sampling technique was used to collect the primary data from the households.

In the initial stage, Phulpur block from Phulpur Tehsil was purposely selected for the case study. Three Nyaya Panchayats were selected from Phulpur block, and from each Nyaya Panchayat one-Gram Panchayat was selected. Then all revenue villages from each Gram Panchayats were selected to collect the required information with the help of a structured questionnaire. The cross sectional data was collected from all the revenue villages. The number of households were selected in proportion to the total number of households present in that particular revenue village, constituting more than 10% of the total households.

Further, secondary data was collected from district economics and statistical office, Department of Minor Irrigation, Department. of Sharda Sahayak canal system, soil conservation and soil profile office, block development office, DRDA and various officials working to facilitate the water supply in the area. The estimated investment cost of draining the river Varuna (projected by the engineers of Sharda Sahayak Khand, Phupur) was taken from the DRDA office. This study gives a technological approach in the form of the Benefit-Cost Analysis estimated on the basis of agriculture produce on one hand and investment cost of draining the river Varuna on the other. Apart from this, the study also provides an institutional approach in enhancing water productivity in agriculture. The study also suggests some self-generating activities for sustainance of livelihood.

4. PHULPUR BLOCK UNDER DIFFERENT DRAINAGE CLASS

Out of the total area 22794.3 ha, about 685.4 ha (3.0%) has been identified as the area under poorly drained class which remains submerged during monsoon period, 16993.5 ha (74.6%) area has been recognized as imperfectly drained and need proper drainage system for sustained cultivation. About 765.5 ha (3.4%) was moderately well drained and the remaining 2171.7 ha (9.5%) falls under well drained class and the rest 5% under miscellaneous use (Table 2).

Table 2: Area under different Drainage Classes

(Figures in bracket denote percentage)

Drainage Class	Area (in ha)
Poorly drained (D1)	685.4 (3.0)
Imperfectly drained (D2)	16,993.5 (74.6)
Moderately well drained (D4)	765.5 (3.4)
Well drained (D5)	2,171.7 (9.5)
Total	20,616.1 (90.5)
Miscellaneous	2,178.2 (9.5)
Grand Total	22,794.3 (100.0)

Source: Soil Survey Office, Allahabad, 2001

5. SOURCES OF IRRIGATION

The net irrigated area of district Allahabad and Phulpur block have increased with time (Table 3). Approximately 85% of the total area was net irrigated area in Phulpur block whereas, the district showed 71.31% net irrigated area for the year 2000-01.

Table 3: Irrigated Area by different Sources in Phulpur Block and Allahabad District

Sources	Phulpur Block			District Allahabad		
	1980-81	1990-91	2000-01	1980-81	1990-91	2000-01
Net irrigated area	67.06	75.14	84.86	42.83	57.47	71.31
Canal	6.56	41.19	7.26	37.96	48.70	54.93
Tubewells	80.28	53.25	85.79	52.15	45.73	42.69
Other wells	3.51	0.17	3.70	6.66	3.48	0.77
Tanks, lakes and ponds	9.65	5.36	3.26	2.44	1.07	0.87
Other sources	-	0.02	-	0.79	1.02	0.73
Total	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Source: District Statistical Reports, Allahabad

The source wise analysis of irrigation in Phulpur block showed that during 1980-81, only 6.56% area was irrigated by canal and 80.28% was irrigated by tubewells. Subsequently, with the coming up of Sharda Sahayak Canal, the canal irrigated area drastically increased to 41.19% of the total net irrigated area. During the same phase, waterlogging phenomenon has reached epic proportions, threatening the agricultural productivity. It is clear from Table 3 that farmers switched to an alternate source of irrigation practices in the year 2000-01 so the canal-irrigated area further decreased to 7.26% of the total net irrigated area in Phulpur block, 86% area was irrigated by tubewells and the rest of the irrigation was carried out by lifting water from lakes, ponds and rivers.

6. SHARDA SAHAYAK CANAL IRRIGATION

Sharda Sahayak Irrigation Project provides for the diversion of water from the river Ghagra and Sharda to 14 districts in Uttar Pradesh. Phulpur block has also been covered under this project. This canal was taken off from the river Sharda at Banbasa near the foothills to command the area between the rivers Ganga and Ghagra. Sharda Sahayak Canal passed through Phulpur block in the 1990s. The unlined canal has been constructed without considering the geography and watershed of the region and without taking into account the capacity of River Varuna where the canal ends.

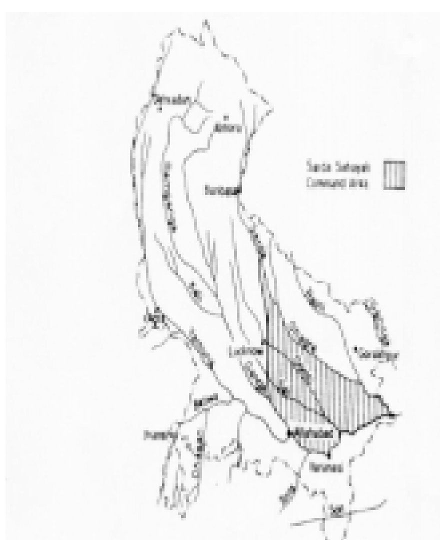


Figure 1: Sharda Sahayak Canal Command Area

The review work by Sharda Sahayak Khand 39 focuses on the major reasons behind vast water logging - Insufficient provision for drainage in the project estimate. No stress was given on construction of drains during the initial period. Drains were not dug to proper levels. Outfalls for drains were not available in Sharda Sahayak command area. No importance was given to drainage system. The drainage should have been completed from downstream to upstream. After the pressure on land increased the railway and bridges were constructed, that led to impeded drainage. Weed growth was very common in drains and needed to be eradicated from its roots. Because of continued rostering, no respite was available to crops through out Rabi from the water table rise.

7. LANDHOLDING PATTERN OF AGRICULTURAL HOUSEHOLDS

The landholding pattern also reflects the social and economic status of the society. Due to population pressure on land, average sizes of holdings have declined (Singh, 2001). Out of the total 150 households, 111 households were agricultural households. The land distribution pattern in the study area shows that approximately 29% of the agriculture households had less than 0.5 ha of land and 40% households had landholdings between 0.5 - 1.0 ha of land. This shows that around 69% landowners were marginal farmers. The small and semi-medium farmers consisted 21% and 10% respectively. The study also shows that there were no households where landholdings could be termed as large.

8. NATURE OF LAND USE IN AGRICULTURE HOUSEHOLDS

Out of the total land area (Table 4), inequitable distribution of irrigation had made almost 37% of the total agriculture fields waterlogged, getting water more than its optimum share (that includes 13% of the agriculture households which got completely submerged in water) and 2.65% was fallow land. Whereas 57.31% agricultural land was irrigated and receives optimum water for irrigation while only 3.18% land was unirrigated. The net operational area (both irrigated and non-irrigated land excluding waterlogged and fallow land accounted for 60% of the total cultivable land of the total agricultural households.

9. OCCURRENCE OF WATERLOGGING: ITS DURATION AND HEIGHT IN AGRICULTURAL FIELDS

The waterlogging in the sample area starts with the advent of the rainy season in the month of June and July. Of the total households, 80% agriculture households stated that waterlogging occurred in the month of August and September when there was high precipitation. Nevertheless, when the rostering of canal water takes place during this season for paddy cultivation, then the situation becomes worse.

The extent of waterlogging was quite high in agricultural fields where 13% agricultural households have crop fields’ completely submerged in water. As far as the duration of waterlogging was concerned, 36% of the respondent opined that water remained there for 4 - 5 months a year, and an equal number of households had problem of waterlogging for 6 - 7 months in continuation, whereas 10% had fields waterlogged for 8 - 11 months and about 2% had waterlogging for the whole year. Only 5.41% agricultural households had fields where no water accumulated

The height of water in the agricultural fields reflects the intensity of crop loss due to waterlogging and its impact on productivity of the land. Out of the total land, more than 44% and 32% agricultural households had crop fields where water stagnated to a height of 6 - 7ft and 4 - 5ft respectively. Only 1% faced waterlogging of 8ft. However, about 17% of the total households had agricultural lands with low waterlogging of 0 - 3ft above the ground and 5% households did not report waterlogging in their fields.

The canal and rainwater together spoil paddy crops, which grow up to a certain height. The water remained in the field for 5 - 6 months from July-August to December- January till the critical period for sowing of wheat crop also passes (see water requirements by various crops mentioned in Table 1). Thus, there was a proportionate change in loss for both the crops.

10. ESTIMATED LOSS OF AGRICULTURAL PRODUCE

In the study villages, according to field discussions and perceptions of the farmers and household respondents, there were namely 3 types of lands- good quality (Type A), medium (Type B) and low quality lands (Type C). The average yield of wheat was 6 qtl/bigah by taking an average of each quality of land (Type A: 7.5 qtl, Type B: 6 qtl, Type C: 4.5 qtl). The average yield of paddy was 8.83 qtl/bigah (Type A: 11 qtl, Type B: 9 qtl, Type C: 6.5 qtl).

The wheat and paddy production was assigned value of Rs. 623 /qtl and 616 /qtl respectively as per the prevailing market prices for the year 2001-02 (District Statistical Handbook, Allahabad, 2002). According to the data available from the block development office Phulpur, the total waterlogged area in the Phulpur Tehsil was 2400 bigah (600 ha). The expected crop loss for wheat was Rs. 8971200 (Rs. 89.71 lac) at an average yield of 6 qtl/bigah in the total waterlogged area.

The expected crop loss for paddy crop was calculated to be Rs. 13059200 (Rs. 130.59 lac) at an average yield of 8.83 qtl/bigah in the waterlogged area. It makes upto an annual loss of Rs. 22030400 (Rs. 220.30 lac) for both wheat and paddy crops excluding the loss of other cash crops that would have been sown had there been no incidence of waterlogging.

11. TECHNOLOGICAL APPROACH: DRAINING OF RIVER VARUNA

To make the study area free from waterlogging, it becomes utmost necessary to clean river Varuna so that has a larger carrying capacity till it reaches the Ganges in Varanasi. The draining of the Mahlahan lake and other adjourning small lakes should also be carried out simultaneously. According to Table 5, the total estimated investment cost (PVCt) 'With the Project' for the draining of the river Varuna 2001-02 was worked out to be Rs. 200.98 lac, projected by the engineers of Sharda Sahayak Khand, Phulpur (Source: Project economist, District Rural Development Office, Allahabad). The investment cost includes the cost of material as well as labour in mandays.

The agricultural study has been analysed for the year 2001-02 (within the waterlogged condition) which estimated the loss of agricultural production for paddy and wheat crops that represent the case of 'Without Project'. In the framework of social benefit cost analysis, the sample villages would be considered as a project area if the draining of river Varuna would be done in future, then would represent the case of 'With the Project'. The agricultural loss, which has been estimated earlier, would then turn into incoming future benefit. Thus, it can be said that if the government would spend Rs. 200.98 lac (PVCt -estimated investment cost) on draining of the river Varuna, the benefit will accrue in terms of crop production (Rabi and Kharif), a value that is estimated to be around Rs. 220.30 lac. So the Net Present Value of Benefit (NPVBt) (for the current year of analysis) will be-

NPVBt = NPVBt of paddy + NPVBt of wheat - PVCt

= Rs. 130.59 lac + Rs. 89.71 lac – Rs. 200.98 lac

= Rs. 220.30 lac – Rs. 200.98 lac

= Rs. 19.32 lac

The present value of benefit would be Rs. 19.32 lac just for paddy and wheat crops for the current year excluding all other crops that can be sown. It is also expected that the average agricultural yield in the defined area would also increase in future in addition with increase in quantity of livestock when the area is made free from waterlogging. The future benefit will also include all the intangible social and environmental benefits

Further, if draining of the river will not be required for the next 10 years as suggested by Sharda Sahayak engineers, then agriculture production of wheat and paddy including leguminous plants, oilseeds, cash and vegetable crops that are supposed to be sown in waterlogged area will turn into future benefit for the coming 10 years.

The intangible social costs like continuous reduction of fertility of land, the health cost, transportation and shelter problem, loss of livestock, migration, and other cost suffered would subsequently turn into intangible benefits in future. The environmental cost from declining productivity of natural resources like land, water, grassland (in the form of soil degradation, water pollution and other land resources linked with water, forest etc.) and actual cost for treatment of soil erosion, salinity and alkalinity etc., would also change into intangible future benefits (Reddy and Ratna, 2003).

12. INSTITUTIONAL APPROACH TO WATER RESOURCE MANAGEMENT

Recognition of the importance of ecological water demand is relatively recent. It has been highlighted at the Dublin Conference in 1992 (a preparatory meeting for UNCED, Rio 1992), which unanimously accepted that 'since water sustains all life, effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems (WMO, 1992).

The dimensions and components of a socially and ecologically responsible ways of governing water resources require a comprehensive elaboration. It is a necessity of using an integrated method for water resource management that takes the interaction among different sectors into consideration viz., the links among environment and food sectors, water and land interest, agriculture and non-agriculture sectors, upstream and downstream sectors and the like. Integrated Water Resource Management (IWRM) is a process that endorses the coordinated development of water, land and related resources.

One of the main issues is of designing the management of water among various uses and various users i.e the allocation of water among different sectors, and the allocation of water between different users of the same sector. The balance among different uses and users can be best addressed and dealt with under a political decision making mechanism that promotes participation, accountability and transparency (Adaman and Madra, 2003).

The issue of water governance should be addressed in an institutional set up and the corresponding legislation and enforcement mechanism are needed for an effective and sustainable policy (see Model- Institutional Approach in Water Resource Management). Thus, the participatory decision-making procedures and process, socially and environmentally embedded governance of water management should be enacted. The participatory approach for sustainable water management requires coordination among the governmental institutions and community institutions.

To ensure effectiveness, institutions are designed to support other existing institutions, human capabilities and available technologies. Innovation can create stronger institutions because of differences at local levels- differences ranging from social norms to environment and geography. Institutional reform is not just the preserve of a national government but also of the individual and communities, local entrepreneur, and multilateral organizations that can build institutions often in partnership with each other (WDR, 2002).

Coordination among institutions like block development functionaries, panchayati raj institutions, irrigation departments, agriculture development office, and district rural development agencies with the community Institutions is a necessity for rural development and water management. Government needs to involve user representatives in a system management and reduce its role in field level management by delegating a substantial part of the responsibility to user groups and creating incentives to induce them to assume this responsibility.

13. GOVERNMENT INSTITUTIONS AND THEIR ROLE IN WATER MANAGEMENT

13.1 Panchayati Raj Institution

According to the 73rd and 74th Constitutional Amendment Act, the panchayats, as a local self-government have been given full autonomy in deciding their priorities and also determining allocation to different programs (India Panchayati Raj Report, 2001). Gram panchayats have been assigned the responsibility to act as state tubewell and hand-pump functionaries. The gram panchayat and the kshetra panchayat have 6 subject committees, which include water management committee to execute all works. Item listed under the Eleventh

Schedule are minor irrigation, water management, watershed development, drinking water and sanitation. PRIs should utilise the fund in village-level development or make arrangements for water-related matters, which come under 6 subject committee.

Rural areas should be provided with a well developed, properly planned sewerage system, which should take care of both domestic and agricultural waste. It is proposed that a comprehensive sewerage and drainage programs be undertaken on an area wise basis after detailed study of the socio-economic conditions of the consumers site, existing land-use pattern and other incidental parameters

13.2 Agriculture and Irrigation Department

There should be water management committees at the district, block and panchayat levels involving district agriculture officer, block development officer, tehsildar, irrigation field functionaries, agriculture engineers, economists and farmers representatives. The committees will take decision on (a) Timing of canal closure for annual repair and maintenance (b) designing of suitable cropping pattern for each block within the irrigation command (c) delineating the waterlogged and high water table areas for rice and fish farming (d) avoiding mismatch between timing of water delivery and crop needs in canal command areas, and (e) laying out field channels and drains and making suitable provisions for their maintenance at the gram panchayat level.

13.2.1 Assessment of improvement in Agricultural Production as a measure of Irrigation Efficiency

The primary objective of irrigation system is to enhance agricultural production to a specified degree. However, the performance evaluation of a system is done only in terms of the area irrigated with no emphasis on quality of irrigation and its productivity. It is therefore necessary that besides the gross irrigated area, the quality of irrigation and productivity of the area is also recorded and used in the evaluation of the performance of irrigation systems.

The BDOs, agriculture department and related functionaries should be assigned the task to promote agricultural education through “Farmer Field School”. Farmers should be mobilised through these schools by transferring new agricultural technologies and providing help through documentation’s and field experiences. Promotion of “farmers interest groups” such as SHGs at the village level with a participatory approach would help in solving the water-related problems. New concept and technologies related to aquaculture, pisciculture, etc., and tolerant varieties of crops should be introduced in waterlogged areas. Irrigation projects should ensure better, timely and more equitable supply and economic use of water. Within area of operation, water users association or farmers organisation should be given powers that have so far been vested with the state irrigation departments so that the institutional base of village level associations can be strengthened.

All state irrigation acts needs to be amended to incorporate new provisions as per the formation of farmers’ bodies. Farmers must be encouraged to take responsibility for system operations, maintenance and water distribution. The District Planning Commission (DPCs) and the local governments, as required by provision of Constitution of India to plan for local areas, should work out the location specific watershed programs.

The agriculture department should install tube-wells in a waterlogged area to lower the water table and pass the pumped water to other non-waterlogged areas. Construction of private as well as state wells/tube-wells and cutting of canal supply and providing irrigation from groundwater pumped from well and tube-wells should also be undertaken further. The farmers should to be encouraged to grow water friendly plants such as water berry, sugarcane, bamboo, mushroom and eucalyptus in their fields. Cultivation of cash crops should also be encouraged.

The farm level has to be properly developed for irrigation through command area development. Open drains should be maintained and the slope of the field should be so formed, as to make the water gush quickly into the neighboring fields, and to other areas in between the fields. Small check dams and ponds should be constructed to collect excess water from the fields. The panchayats should also be made responsible to maintain the structures for water storage at village level.

Appropriate surface drainage technology needs to be evolved in integrating preventive and curative measures. Adequate research backup with appropriate cost-benefit assessment is required for the development of efficient drainage systems. These wet lands are part of our environment and suitable technological packages should be developed keeping the socio-economic condition in view.

13.3 Sharda Sahayak Canal Irrigation Department

Maintenance of irrigation systems requires periodic inspection of the facility to identify any deterioration (such as leakage in embankments, erosion, silting of canal beds, growth of weeds, malfunction of sluices etc) and execute the necessary repairs. Besides, the organisation also needs to be able to identifying major malfunctions as they rise and should have the capacity to correct them promptly.

The rostering of canal water should be done at times of need. The Sharda Sahayak Canal System should keep the records correctly pertaining to the time of sowing. When there is sufficient rainwater then supply of canal water should be stopped. Canal water needs not be supplied at the time of monsoons when the water is already available. A system should be developed to stop water so that unwanted water may be retained in the main canal itself.

Irrigation management is essentially a multi-disciplinary activity and requires multi dimensional attention. Effective and sustained linkages should be developed amongst the canal management authorities, command development authorities, agriculture extension services and the farmers. Unless there is active participation of farmers, no planning and implementation of on-farm development works would be successful. Before implementing any project, many predictions of soil behaviour under irrigation can be made. Among them more important are- Extent and location of areas suitable for irrigation; levelling of land in the command area according to geography and local topography so that each piece of land gets required water; adequate numbers of regulatory and controls structures including water measuring devices and canal escapes; crops that may be grown and yields that may be expected; uprooting of weeds as important measure for drainage improvement; addressing problems in drainage, addressing salinity and alkalinity that may arise; need for land reclamation; water delivery requirement under alternative cropping pattern and soil and water management.

Modernisation of the existing irrigation projects with selective lining in the canal distribution system and field channels should be undertaken to stop water seepage. It will also help in reducing the leakage of canal water due to which a high percentage of water is lost. The canal branches have abrupt open ends, which does not meet any natural drains. The canal escapes should be linked with big rivers and small check dams can be made in between the main branch of the canal and small branches to manipulate water according to need.

Waterlogging can be corrected by pumping and constructing adequate drainage in command area. 2 types of drains are required in the command are-

1. Open Drains- One to two meter deep open drains, which are useful in lowering the water table and in reducing sloughing of the side. These are the hollow fillings with mud.
2. Special underground drains are also useful for lowering the water table. They consist of field drains laid under the ground and are being extensively used in Egypt. These are expensive but highly efficient. Wherever the drains are constructed, the harvest gets nearly doubled (Rao, 1979).

Conjunctive use of two or more sources of irrigation in an area particularly those tapping surface and groundwater has often been recommended as a policy. This will not only augment water supply but will also lower water table. The complementary use of both surface and groundwater tends to offset each other, minimizing ecological externalities like waterlogging.

The technique of remote sensing should also be utilised as a remedial measure against waterlogging. If waterlogging is noticed at frequent intervals, it will alert irrigation and agriculture officers in charge of the project, to take suitable remedial actions in time or in advance. Thus, further deterioration due to waterlogging can be avoided or can be reduced. If the ground water wells are at shallow depth, then larger irrigation under well water should be planned.

In the canal system, for instance, it should be possible to construct small reservoirs in the command area to which water is supplied and the control over quantity and timing of water release to the users be left at the local level (Bharadwaj, 1990). The nodal centre at the Panchayat level should also have a link with the Sharda Sahayak Khand authorities so that the problem is tackled at village level.

14. WATER USER'S AGENCY THROUGH TRAINING AND APPROPRIATE LEGAL ACTS

Performance of the irrigation sector in increasing agricultural productivity in India is observed to be sub-optimal, inefficient and inequitable. It has been emphasized that the water users within a canal command at the tertiary level like minor/subminor should organise themselves and form Water Users Association (WUA), which should be formally registered. It is contemplated to delegate some responsibility to these WUAs, which include distribution of canal water among water users, operation and maintenance of the canal and collection of water rates. In accordance with the spirit of the National Water Policy (1987) of GoI, farmers should be made partners in management and distribution of water. This can be done by organising and registering farmers into "Water User Association".

The concept of system turnover to water users is grounded in laudable ideologies like democratisation, decentralisation. The farmers who are the end-users of irrigation water should participate in its management starting from planning, design and construction to operation and maintenance of the system. Farmers have sufficient knowledge about their local resources like land and water. Existing social capital, which includes local knowledge, skill, community network and kinship ties should be utilised in the management of irrigation systems. As the irrigation service is meant for the farmers and farm production, their views should be given due importance in the management of irrigation. The work responsibility ultimately goes to WUAs as it is difficult for irrigation agency to look after the individual problems of numerous farmers catering to their specific needs.

The benefit will accrue to the farmers and irrigation agencies by WUAs formation. It will lead to farmers' flexibility in the use of water and choice of the crops, optimal use of water in agriculture, ensuring equity in water allocation, resolving disputes in water distribution and more economic use of water and less wastage. On the other hand, irrigation efficiency will also increase, it will improve the relations with client farmers, the irrigation agency will face less obstructions and maintenance problems of outlets, better collection of water rates and saving on maintenance costs.

15. COMMUNITY INSTITUTIONS AND ITS ROLE IN WATER MANAGEMENT

It is said that if the common pool resources are smaller and more defined boundaries, the chance of success increases. Better the knowledge of sustainable yields, greater the chances of success. Secondly, smaller the numbers of users better the chance of success. If the users are bound by certain obligations and if the committee is homogeneous then there is greater chance of success (Wade, 1987).

State intervention and cooperative action are 2 ways of coordinating economic activity. Social cooperation plays a crucial role in process of development, by helping to translate economic prosperity into social opportunity as community activity helps in maintaining irrigation structures or civic initiatives (Dreze and Sen, ibid, 56). If environmental degradation is pervasive, the best solution is to leave the management of environmental resources to the local communities.

16. COLLECTIVE ACTIONS IN WATER MANAGEMENT

Collective action is action taken by more than one person and is directed towards the achievement of a common goal or the satisfaction of a common interest that is a goal or interest that cannot be obtained by an individual acting on his own. If the common goal or common interest is characterised by infinite benefits and non-exclusion, the achievement of that common goal or interest means that a collective good has been provided. Thus the collective action might be the formulation of a rule of restrained access to a common pool resource and observance of that rule.

Another strong movement is "Raising Voice" by the local users. Democracy should have a vital role if changes are to occur in India's environmental management, Through public discussions only the precariousness of the environmental situation can be recognized more fully. This could influence behavioral pattern and values in individuals and groups, government and local authorities. The instrumental role of democracy can determine the official policy at different levels of governance that can be influential in turning environmental concerns into an electoral issues and giving them a political significance (Dreze and Sen, 2002).

17. SELF-GENERATING ACTIVITIES FOR LIVELIHOOD SUSTENANCE

17.1 Rice Fish Farming

There is a good prospect of pisciculture and aquaculture activities in certain villages where vast land remains perennially waterlogged and village ponds are available. Training could be imparted to farmers for pisciculture and aquacultural activities. The rice-fish farming system could generate year round employment in the farm and ensure high productivity and profitability besides assuring conservation of the ecosystem. This needs to be improved through an integrated use of crop (staple rice) and fish culture technology.

17.2 Makhana-Fish Cultivation

Makhana (*Euryale Ferox Salisbury*) is known as "Gorgon Nut" or "Fox Nut" of the oldest aquatic cash crop of Muthilanchal (north Bihar). It is said that this crop has a greater potential to survive the waterlogging conditions, and also has a high nutritional value. It is easily and cheaply cultivated in suitable standing pools. The minimum level of water required is at least 2.5 - 2 m high during October-November and 0.6 - 1m during May-June for makhana cultivation. The time of sowing Makhana is usually November-December (Reddy, 2002). Air breathing fish like clarius batrachus (magur), chana punctatus (murrels), and anabus testrodinus (koi) could be combined for makhana fish cultivation for better monetary prospects.

17.3 Tree Cultivation

Remedial measures usually employed to remove waterlogging are canal lining and provision of subsoil drainage by construction of subsoil and surface drains. However, these are expensive measures. A more dynamic way of reclaiming such areas is to utilize the surplus water through afforestation by planting suitable tree samplings. If the area is planted by the trees then it is quite feasible and possible that the planted samplings would absorb the water, utilize part of it for their growth and transpire the rest in atmosphere. The trees adapted to the soil condition if planted in sufficient numbers are capable of minimising seepage in the end.

18. CREDIT MANAGEMENT FOR SELF GENERATING ACTIVITIES

The aforementioned self-generating activities in agriculture and other related fields as well as water-related problems require funds for development. This fund should be generated by the local self-governments, local institutions and users and need proper credit management. The funds generated can provide credit to the users for self generating activities like agriculture, pisciculture, aquaculture, etc on one hand and in solving water related problems on the other hand.

Strict rules and regulations should be framed to help in management decisions and monitoring use to ensure that individual users adhere to these rules. Credit provided to the users must have a legalized rate of interest and a specific time for returning the money fixed by the committee.

19. CONCLUSION

The state and local governments, irrigation and agriculture departments in coordination with the farmers and users association and self-help groups can come forward to tackle the problem of waterlogging, increase productivity and remove poverty from the region. Agriculture being the primary source of livelihood in these areas, the worst victims of this phenomenon is the landowners belonging to different categories and sharecroppers.

The cumulative population of such areas forms a good part of the total percentage. Therefore, innovative technologies to nullify the effect of waterlogging and salinity and other concomitant factors would be of significance in increasing the productivity of agriculture and contributing to decrease the effect that leads to poverty.

Private innovations, its practices and success eventually led the government to change the laws. Private innovation supported by formal institutional change may altogether strengthen institutions by directly supporting experiments, by allowing them to proceed and if tested successfully, by encouraging their growth. Openness in information sharing provides impetus to adopt and expand successful experiments. Policy makers can replicate successful innovation at other areas (WDR, 2002).

Water resource development leaders, planners and managers should be accountable to the people by working through transparent and consultative process. Water resource planning and development should be a multidisciplinary task rather than an engineering driven exercise. Successful response to water related disaster must be an activity of regular planning supported by accurate and timely information. Public debates, public hearings and water tribunals should be used to influence policies at different levels and to ensure the public accountability. Mass media and collective action should be used as a vehicle to get political commitment for integrated water resource management.

REFERENCE

Adaman, F and Y. Madra (2003), A participatory Framework for Poverty Eradication in I.H. Unver, Rajiv. K. Gupta and Aysegul Kebaroglu (Eds.), Water, Development and Poverty Reduction, Kluwer Academic Publishers, London.

Bharadwaj, K (1990), Irrigation in India: Alternative Perspective, Indian Council of Social Science Research, New Delhi.

Bromley, D.W. (1982), Improving Irrigated Agriculture, Institutional Reform and Small Farmers, World Bank Staff Working Papers N. 531.

GOUP (2001), Problems of Waterlogging in Irrigated Areas, Department of Irrigation Government of Uttar Pradesh (Unpublished Report)

Dhawan, B D. (1988); Development and Management of Water Resources in North Western India; Economic and Political Weekly, Vol. 24, No. 49.

District Statistical Handbook, Allahabad (2002), Economics and Statistics Department, State Planning Institute, Allahabad.

District Statistical Handbook, Allahabad (2003), Economics and Statistics Department, State Planning Institute, Allahabad.

Dreze, J and Sen, M (2002), India development and Participation, Oxford University Press, New Delhi.

Hill, W. A. and Dracup, J. A. (1975), Water Resource Systems Engineering, Tata McGraw Hill Publishing, New Delhi.

India Panchayati Raj Report, 2001, Devolution of Functions and Powers, National Institute of Rural Development, Hyderabad.

Paul, J. C and Sharma, S. D (2001), On Farm Water Management for Sustainable Agriculture and Improved Environment, *Yojana*, April, Vol 45.

Rao, K. L, (1979), India's Water Wealth, Orient Longman, New Delhi

Reddy, G.P (2002) Makhana-Fish Cultivation for Better Economics, *Yojana*, May, Vol 46.

Reddy, S (1997); Different Sources of Irrigation, Manak Publication, Delhi.

Reddy, V. Ratna (2003), Land Degradation in India, Extent, Cost and Determinants, *Economic and Political weekly*, Vol 38, No. 44, pp 4700.

Singh, S. (1984) Environmental Policy in India, Indian Institute of Public Administration, New Delhi.

Wade, R (1987), The Management of Common Property Resources, Collective Action as an alternative to Privatization of State Regulation, *Cambridge journal of Economics pp. 95-106.*

WMO (1992), International Conference on Water and the Environment, The Dublin Statement and Record of the Conference, Geneva.

World Bank (2002), World Development Report, Oxford University Press.

Table 4: Distribution of Agriculture Landholdings to Total Area (in Bigah)

Villages	Waterlogged Land (1)	Fallow Land (2)	Irrigated land (3)	Unirrigated Land (4)	Net operated area (5=3+4)	Total Area (1+2+5)
Rajepur	3.50 (5.19)	3.0 (4.44)	55.0 (81.48)	6.0 (8.89)	61.0 (90.37)	67.5 (100.0)
Rajepur Sarain Arjani	13.50 (27.55)	6.50 (13.27)	29.0 (59.18)	0.0 (0.0)	29.0 (59.18)	49.0 (100.0)
Mahlahan	31.05 (41.34)	0.00 (0.00)	44.05 (58.66)	0.05 (0.07)	44.10 (58.72)	75.1 (100.0)
Rasoolpur	2.0 (20.73)	0.0 (0.0)	7.35 (76.17)	0.30 (3.11)	7.65 (79.27)	9.65 (100.0)
Chitaha	19.0 (48.72)	0.0 (0.0)	19.50 (50.0)	0.50 (1.28)	20.0 (51.28)	39.0 (100.0)
Balkaranpur	23.40 (68.02)	0.0 (0.0)	9.50 (27.62)	1.50 (4.36)	11.0 (31.98)	34.4 (100.0)
Jalaalpur	21.0 (57.53)	0.40 (1.10)	15.10 (41.37)	0.0 (0.0)	15.10 (41.37)	36.5 (100.0)
Bahmai	24.10 (38.87)	0.0 (0.0)	34.35 (55.40)	3.50 (5.65)	37.85 (61.05)	62.0 (100.0)
Total	137.55 (36.86)	9.9 (2.65)	213.85 (57.31)	11.85 (3.17)	225.70 (60.49)	373.15 (100.0)

Source: Field Survey (Figures in bracket denote percentage)

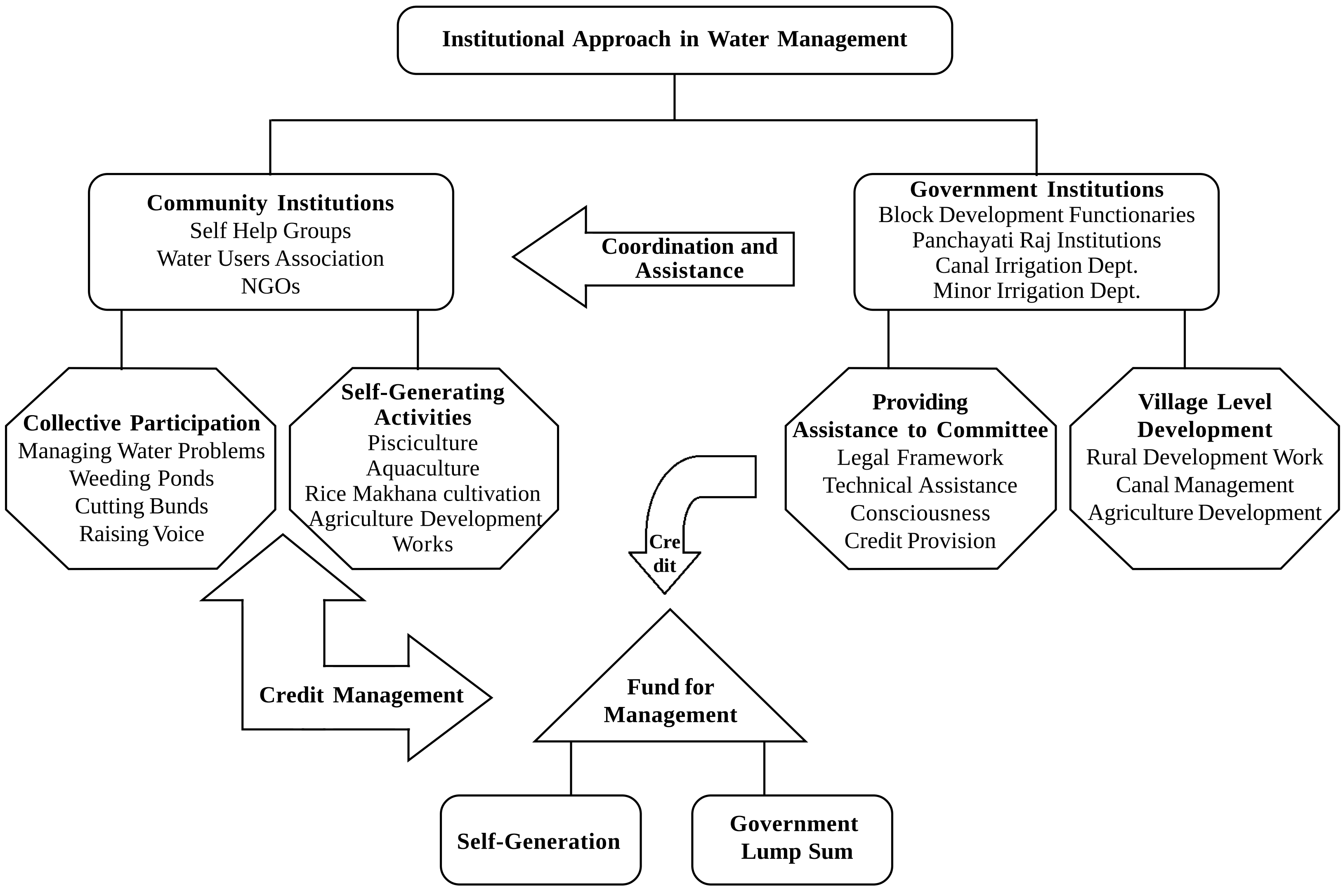
Note: 1ha = 4 Bigah

Net Operated Area = Total Area - Waterlogged Land - Fallow Land

Table 5: Estimated Investment Cost of Draining River Varuna for the year 2001-02

Total Length of the River	Work for Removing Silt		Masonry Work			Ratio of Material and Labour	Total Estimated Cost (in lac)	Total Estimated Mandays (in number)	Demand of Money for Year 2000-01 (in lac)
	length (in km)	Cost (in lac)	Cost of Material (in lac)	Labour Cost (in lac)	Total (in lac)				
196.0 to 189.0	7.0	22.61	1.60	0.710	2.31	10:90	24.92	16,500	24.92
189.0 to 178.0	11.0	24.24	0.48	0.26	0.74	40:60	24.98	20,000	24.88
178.0 to 169.0	9.0	22.73	0.65	0.45	1.1	40:60	23.83	20,000	23.83
169.0 to 165.0	4.0	20.34	-	-	-	40:60	20.34	1500	20.34
165.0 to 162.0	3.0	19.20	-	-	-	40:60	19.20	1400	19.20
162.0 to 160.50	1.50	13.60	-	-	-	40:60	13.60	1000	13.60
160.50 to 158.0	2.50	24.60	-	-	-	40:60	24.60	1700	19.49
158.0 to 155.50	2.50	24.78	-	-	-	40:60	24.78	1800	24.78
155.50 to 153.0	2.50	24.73	-	-	-	40:60	24.73	1750	24.73
196.0 to 153.0	43	196.83	2.73	1.42	4.15		200.98	65,650	195.77

Source: District Rural Development Office, Allahabad



Model- Institutional Approach in Water Resource Management