Environmental Impacts of Canal Irrigation in India

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Abstract

In today's scenario a major threat to human life is the environmental degradation and we ourselves are responsible for such degradation. Human effort since ancient times to increase agricultural production was wonderful. Various techniques of Irrigation for example tube wells, canal irrigation etc. have been introduced. It was considered a boon for the development of society, but due to human efforts to increase the agricultural production at any cost has become a curse for the society. Man always tries to over use the natural resources but in this process they forget that this over utilisation will adversely affect the society in many ways. It can even lead to serious environmental impacts on flora, fauna, human population etc.This paper deals with one such human effort to increase the agricultural production and it is the Canal Irrigation system. The construction of canals is in general beneficial for increasing the agricultural production but they are also responsible, if not properly handled, for some environmental hazards. On one hand financial input is sometimes more than the expected return and on another, if not properly handled and implemented, it causes ecological imbalances resulting in waterlogging, salinization, loss of forest area (due to extensive deforestation), grazing land, crop land etc, which leads to the displacement of human inhabitants and wildlife. Thus, overall this paper focuses on canal irrigation system of the state of Uttar Pradesh state in India.

1. Introduction

From time immemorial efforts are made to enhance the security of people by every means and one of the major among securities for the people is the agricultural development in the society either by introducing new irrigation techniques or by adding more land under cultivation. No doubt that the ancient techniques of irrigating fields were highly advanced of its period. It is always good to introduce certain new techniques to the existing one or to make certain modifications in the old ones but introducing altogether a new technique and replacing the old one is never advantageous. One has to forget that the arid and semi-arid regions covering for about 53.9% of the geographical area of country and about 40% of the total population represents a weak dependent socio-economy. Much before the British arrived in India and started the big canal system, rich culture and agriculture thrived in these dry areas. Sophisticated water management and evolved agriculture provided reasonable safety against soil water drought and ground water drought in these areas.

2. Demand of increased agricultural production

The root cause of maximum number of problems related to agriculture, soil, land, irrigation etc is the increasing population and their demand for food production. In comparing the 1941 and 1951 census of India, the increase in the population was over 40 million. Nearly 83% of the population live in rural areas and 70% depend on agriculture for livelihood. The gross land area is 729 million acres, out of this 528.3 million acres are classified (net area and the statistics have reference to it alone). The area "cultivable but not sown" includes 64 million acres of fallow and the area not cultivable includes some 54 million acres of forest. The actual area of food crops is like the sown land area, 236 million acres. This area is however constantly diminishing, in 1911 it had been 0.9 acres per head: since that date the area of cultivated land has somewhat increased but not enough to keep pace with the growth of the population. Meanwhile large areas of land are lost annually by erosion, waterlogging, salinity, and other causes. There is no evidence that yields per acres have increased. The rapid growth of population has not been accompanied by a corresponding increase in food production and in consequence the amount of cereals produced per head has fallen from nearly 15 oz. to 11 oz. daily in 1949/50, and the total calories per day from 2000 calories to 1600 calories only. This deterioration of dietary had apparently begun before the 1930s, there are number of observations and surveys suggest that in earlier days more food grains per head were available. A much more modest program was adopted in 1948 to

increase food production as much as possible by increased irrigation and by bringing into cultivation some of the land at present fallow or waste. The irrigation schemes are far by most important but these schemes have sometimes caused disaster. Like in Damodar valley region famine occurred and perished the life of million people. It is naturally a vicious river but it has been made worse by man. It was originally covered by forest but this has been badly overcut and overgrazed with the inevitable result of serious flooding and erosion. The problem of feeding India however will remain extraordinarily difficult if the population continues to increase at its present rate. Even to maintain present low standards of nutrition about 32 million acres of land would need to be added to the cultivated area in the next ten years. Government made certain effort to control the increasing population for example family planning etc which definitely helped in reducing birth rate but on the other side death rate showed still sharper fall, which led to the increase in population, thus increasing the demand of food production.

3. Irrigation

In order to cope up with this increased demand of food production, various irrigation techniques are introduced. Irrigation is an artificial application of water to the soil usually assisting in growing crops. Civilization has risen and fallen with the growth and decline of their irrigation systems. In crop production irrigation is mainly used to replace missing rainfall in periods of drought but also to protect plants against frost. Irrigation is typically applied in those arid (semi) areas where evaporation considerably exceeds rainfall, little natural leaching occurs and salts tends to accumulate. The groundwater in these zones is generally mineralised and the substrata may contain considerable geochemical salt deposits. The introduction of irrigation may leads to more deep percolation of both irrigation and rain water, recharging the ground water reservoir. As a result water table will rise until such levels at which discharge is again in equilibrium with recharge. Irrigation has two primary objectives first, to supply essential moisture for plant growth, this helps in transporting essential nutrients and secondly, to leach or dilute salts in soil.

Beside this irrigation provides number of side benefits such as cooling the soil and atmosphere to create more favourable environment for crop growth, it supplements the supply of water received from precipitation and other types of atmospheric water, flood water and ground water. Irrigation has acquired increasing importance in agriculture the world over. From just 8 million hectares in 1800 , irrigated area across the world increased fivefold to 40 million hectare in 1900 to 100 million hectare in 1950 and to just over 255 million hectare in 1995. With almost 1/5th of that area India has the highest irrigated land in the world today.

Historically civilizations have been dependent on development of irrigated agriculture to provide agrarian basis of a society to enhance the security of people. Close to 19th century canals irrigated 45%, wells 35%, tanks 15% and others 5%.

Due to Green revolution in India during 1970s there was a continuous expansion of formulated and dual cropping system on existing farmland occurred in the north west of country. This generated the need for more canal water for irrigation as rainfall in the area is not sufficient to satisfy crop water demands. Hence various irrigation techniques were introduced to meet the demand of increasing population, one such techniques that became highly prevalent was canal irrigation system. But besides being a bless canal irrigation has also brought the inherent attachments of several problems like salinity, waterlogging etc. Thus this paper is an attempt to study canal irrigation.

4. Canal Irrigation

Large scale canal irrigation, a trend introduced by British and continued in free India. It is an important means of irrigation and is more common in northern plains because Rivers are perennial, water is stored in reservoirs by building dams across rivers and then this water is distributed to the field by a method of canal. Canals can be an effective source of irrigation in areas of low level relief deep fertile soils, perennial source of water and extensive area. Therefore these are common in northern plains in the states of U.P., Punjab, Haryana, Rajasthan and Bihar which account for about half of canal irrigated areas of the country. It was during green revolution new crop varieties were introduced and it also leads to the increased use of inorganic fertiliser and pesticides and frequent irrigation.

No doubt it has its advantages that it brings down a lot of sediments from the river which makes the soil fertile, most of the canals provide perennial irrigation and supply water as and when needed, although initial cost is much higher, canal irrigation is quite cheap in the long run. But it do have its demerit also as canals are generally not deep and since they are open they may dry up. And the water soaks into the ground and leads to the problem of waterlogging, the marshy areas near the canals act as breeding grounds for mosquitoes, and the excessive flow of water brings the salt to

the surface making the soil infertile. Waterlogging and salinization are some of the major problems of Irrigation.

The intensive irrigation, need of green revolution agriculture has created a largely wasteful water requirement in the hope of increased food production in limited areas where irrigation has reached. On the other hand the ecological impact of intensive irrigation has been large scale waterlogging and development of wet deserts in fertile agricultural lands. Further this agriculture is so precariously dependent on irrigation that any delay in supply either due to actual water scarcity or due to mismanaged distribution will cause soil water droughts. On the whole this method of agriculture has increased its vulnerability to drought in many ways.

Canals account for 27.6% of the net irrigated area of the state most of which lies in the Ganga Yamuna doab, Ganga-Ghaghara doab and western part of Bundelkhand region. The total length of Canal is about 50,000Km which provides irrigation to about 70 lakh hectares of the cropped area.

5. Waterlogging

Waterlogging is one of the major drawbacks of Canal Irrigation. An agricultural land is said to be water logged when its productivity gets affected by high water table and productivity gets affected when root zone of plant gets flooded with water. More than 33% of the worlds irrigated land is affected by salinization and waterlogging. In India alone, 8.4 million hectare are affected by soil salinity and alkalinity, of which about 5.5 Million hectare are waterlogged.

Waterlogging is mainly the result of increased water table and it occurs due to excessive or intensive irrigation in poorly drained soil where water can't penetrate deeply and enters the soil faster than it drains away. It occurs even worse where there is compaction of subsoil layers, where water quickly enters the topsoil but is then blocked by water – resistant clay layer, which may occur naturally or may be induced through excessive use of agricultural machinery. There are many ways which increases the water table like water from canals may seep through beds and sides of canals reservoir etc or seepage of water from adjoining high lands into subsoil of affected land or because of inadequate drainage system soil having less permeable substratum below topsoil will not be able to drain water deep into ground causes high water table. In steep terrain water is drained quickly but in flat terrain drainage is poor which raises water table. When the water table rises it fills up the air spaces in the soil, plant roots in effect suffocate from the lack of Oxygen, limiting the plant growth in those areas. About 10% of all irrigated lands suffer from waterlogging. It occurs mostly on flat floodplain areas or gently sloping landforms with high rainfall and red duplex or heavy clay soils.

In Indo- Gangetic plain main reason for waterlogging is flood in the rivers. Rainfall in this region is very uncertain in quantity and distribution. More than 90% of the precipitation occurs in a short time span. This results in occurrence of flood. Rain water is stored in low lying areas and deteriorates soil in the long run. Waterlogging causes damage to the soil structure, suffocates plant roots, leads to the fall of productivity by about 20% in affected areas, pasture loss through drowning, fungal diseases, nitrogen deficiency, erosion in higher rainfall areas and soil structure decline, as soil is washed away. Farmers need to manage and plan their irrigation properly so that they do not over water the soil and suffer with this problem.

The problem of waterlogging started emerging on the large scale in the North West India during the last century with the growth of canal system. New areas have been affected by water logging in post-independence period when major irrigation projects were executed. Chambal in MP and Sarda Canal in UP etc are examples of this canal which leads to the problem of waterlogging and subsequent salinity through seepage as well as obstruction to the rain water run-off. The problems has been further aggravated by the process of new construction of roads railways, urban sites etc which have obstructed the natural flow of water. In other parts the problem of water logging is caused by the swelling of the rivers during monsoon which inundate large area. Areas suffering from bad surface drainage system and waterlogging in Punjab and Uttar Pradesh taken together amount to about 13.8 lakh hectares. National commission on Irrigation 1972 gives an estimate of waterlogged area of 8.10 lakh hectare for UP and 0.57 lakh hectare for MP. These figures were also accepted by national commission on agriculture, 1976.

6. Salinization

Ancient civilization flourished and then floundered when soil became saline due to poor irrigation practices and lack of drainage (example Mesopotamia civilization in the Tigris –Euphrates valley). There is a rudimentary relationship between irrigation and salinity. Salinization and waterlogging are the principal degradation processes on irrigated land. From various available data it is estimated that the world is losing at least three hectares of arable land every minute because of soil salinity .It is a serious problem of irrigated land. Of the 230 million hectares of irrigated land in the world 45 million

hectares is salt affected land to varying degrees by human induced processes. In contrast of almost 1500 million hectare of dry land agriculture, only 32 million hectare is salt affected soil. After a report survey waterlogging problem had developed in 2.46 million hectare, salinity in 3.06 million hectare and alkalinity in 0.24 million hectare. Affected areas are not completely out of production. But productivity reduces in such land .Salinity prone soils have been identified as being of three broad types (in relation to India).

i. The western part of India is a semi-arid to arid regions with hot climate and dry winter. In this climate evaporation is always greater than precipitation. Hence the soil profile development by eluviation is greatly retarded. The soil is marked by a concentration of salts saline and alkaline.
ii. The marked seasonality of rainfall affects salt release over a large part of the country. In south India and the Gangetic valley warm rainy climate is followed by a dry winter. During the rainy season precipitation is greater than evaporation which induces leaching of soluble salts down the profile. If the water table remains high, the soluble salts will remain in the profile. In North India the salts are transported in solution by the Himalayan Rivers, which later percolates in the subsoil of the plains and accumulated in the area of inefficient surface drainage. Thereafter during the dry season these salts are drawn upwards through the capillary spaces by evaporation from the surface. In many cases salts are deposited on the soil surface showing white or black patches of efflorescence on the soil surface.
iii. A large part of deltas and estuaries of rivers are affected by sea tide carrying salt laden deposits. Large parts of the seacoasts are subjected to periodic inundation by tidal water.

The quality of water in India is of high order. Canal water originating from the river or their reservoirs representing the Parent Rivers in quality unless contaminated. Proportion of salts are safe, usually less than 500 μs cm^{-1}. But even this small quantity of salt may play havoc if due care not taken. Minute quantities of salts are added to the soil with each irrigation crops removed much of the applied water from the soil to meet their evapo-transpiration demand but leave most of the salt behind. With each successive irrigation more and more salt is added. Hence a portion of the added salt must be leached from the root zone before the concentration affects the crop yield. Leaching is done by applying sufficient water so that a portion percolates through and below the entire root zone carrying with it a portion of the accumulated salts. After much successive irrigation the salt accumulation in the soil will approach some equilibrium concentration. A successful water management program keeps the equilibrium level within a certain limit that is best for crop growth. This equilibrium level is decided by three factors, important for good salinity management:

- The salinity of applied water
- Depth of water leached below the root zone
- Depth of water applied at the surface

7. Sarda canal of Uttar Pradesh

India being the second most populated country in the world face lot of problem in feeding its people. Same is the case with Uttar Pradesh (most populated state of the country). There are many reasons behind it but the one major reason which this paper is focussing is the mismanagement of canal irrigation system. Despite many failures of canal irrigation, badly managed irrigation projects are still developed for short term economic gains and political popularity. The Uttar Pradesh government in India has recently undertaken a canal project named Sarda canal at a total cost of 40 million rupees.

Sarda canal was built by British in 1928; it takes off from Sarda River at Banbasa (nainital). The length of the canal with its distributaries is 12,368 Km. It irrigates about 8 lakh hectare of land in district of Sahajahanpur, Barabanki, Pilibhit, Sitapur, Kheri, Hardoi, Lucknow, Unnao, Raebareli, Pratapgarh, Sultanpur and Allahabad district. Its main branches are Deva, Bisalpur, Nigohi, Kheri ,Sitapur, Lucknow and Hardoi. Another canal Sarda Sahayak takes off about Sarda sagar about 20 km below Sarda canal headworks near Indo-Nepal border and augments the supply in Sarda canal. It irrigates about 7.5 lakh hectare land in Jaunpur, Azamgarh, and Ballia district canal.

The construction of Sarda canal will result in the loss of 12500 ha of land, thus causing ecological imbalances, which is against the principal of soil conservation and it is a permanent loss that cannot be revived, constituted as follows:

1. Cultivated land 8000 ha
2. Forest land 1250 ha
3. Grazing land 3250 ha

The loss of the cultivated land is 8000 hectare. The average yield per hectare for all crops is supposed to be 21

quintals (2.1 tonnes) per annum. The total loss in production per annum will thus be 16800 tonnes. It is doubtful that this loss will be compensated by increased production. The total compensation paid to farmers for their land is in terms of seven million rupees. These huge investments may not yield expected returns. Besides several resources of minor irrigation have been or will have to be destroyed, because of their existence in the area or vicinity of the canal. The construction of this canal also leads to the displacement of human inhabitants and wildlife. The removal of trees during the canals construction will adversely affect the Motipur wildlife sanctuary which is rich in animal wildlife including Deer and Tiger. There is a great apprehension that the area might become devoid of Deer, which are the main animal wildlife inhabitants.

There are certain problems expected after coming into operation of its canal for example, Seepage – the texture of the soil in the canal command area is sandy loam or loam. The porosity being between 40.20% to 48.25%. The nature of the soil and the physical properties indicate that the rate of seepage will be moderate. The water table records show that during the summers and winters, the water table remains low, fluctuating in depth from 3.15 m to 4.25 metres respectively. It starts rising at the onset of monsoons, when a continuous rising of water table was recorded as the rainfall progressed until the water table rose to a depth of only 0.80 metre in 1983 and 0.70metre in 1984 during the month of September. The main branches of Sarda canal are 31 metres wide and 3- 4 metres deep. The discharge of the canal will be 360 cusecs and of the pump canal will be 77 cusecs .As the canal is unlined, the discharge will cause more seepage. The rate of seepage as experimentally determined by seepage metre is from 3.60 mm/ hr. to 6.0 mm/ hr. which is a moderate rate of seepage. But after the canals become operative this rate may increase by from 5 to 10 times.

Sarda Sahayak canal project commissioned in 1974. The operation of this canal has created serious problem of seepage started right from the beginning and at present it has created a situation which may be one of its type in the history of canal irrigation .The seepage of 1984 has damaged 385 villages, 13,677 houses and 2200 cattle's. Mature natural forest containing Sal trees have been killed by canal seepage over a vast tract. The canal seepage and high water table rendered vast tract waterlogged. Due to continuous waterlogging in the command area, the problems of malaria filarial skin disease and pest are very common.

Ultimately it can be said that that the above mentioned data's show that Sarda Canal operation will adversely affect the ecological balance of the state and as a consequence it will lead to the environmental changes such as management of land, water and forests for sustainable development.

8. Conclusion

The environmental problem such as waterlogging and salinization in the vicinity of irrigation canals are extremely widespread. It is also known that about half of the worlds irrigated area has already been damaged to some degree by waterlogging and salinization and that much of the additional land which is expected to be irrigated in the future is highly vulnerable to similar damage. This problem is not only widespread in India but in other countries like Pakistan, Iran, Iraq, USA, etc countries are also suffering with this problem.

Whenever a question arises that, "Why only canals among the indigenous techniques were adopted by modern engineers while others are not? Answer often comes out as: "Canal irrigation allows centralised management which goes well with bureaucratic control". But after reading the above details another question starts lurking in our mind that "Is it so?" Because the construction and operation of irrigation canals in India is in the hands of the state and the gap between the planners and operators on the one hand and beneficiaries on the other is even greater than in most other department of government.

But it is also important to consider that canal irrigation is successful at some places like in Italy, consorzi di bonificia involve farmers closely in the design and construction stage as well as in the operation and maintenance of irrigation canals. Thus it can be said that efficiency of canals can be substantially improved by forms of organisation which brings representation of the state into regular institutionalised connections with representatives of the affected farmer, both at the stage of construction and of operation and maintenance.

Secondly a large part of these problems are attributable to the poor drainage system. Inadequate drainage means that soil having less permeable substratum below pervious soil will not be able to drain water deep into ground causes high water table. If proper drainage is not provided then the storm water constantly percolates and level of water table rises. Providing intercepting drains along canals prevent seeping canal water from reaching the water logged areas. Improving natural drainage of area helps in reducing percolation of water so that water should not stand for longer period. To keep from salting out the soil, there must be proper drainage system. When the drainage is insufficient to counter this salt influx, the root zone becomes salinized. Thirdly lining of canals and water course reduces seepages of water.

Reducing the intensity of irrigation in area where there is possibility of water logging. Fourthly Crop rotation helps in avoiding high water table as there are certain crops which require more water and others require less water. Fifthly Optimum use of water for irrigation gives best results. Less than and more than that reduces yield. Overall it can be said that there are many ways to protect the land from such types of problems, and Canal Irrigation can be proved highly beneficial among different techniques of Irrigation.

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