CHAPTER - V

FACTORS THAT HAMPER IRRIGATION FACILITIES

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Irrigation facilities become a vital resource for economic growth and sustainable development. The various factors that hamper irrigation facilities such as political inability, because of that the Cauvery water dispute did not be solved till now. The existing laws are outdated and inadequate to deal with all aspects of water resources management, so there is lack of irrigation policy. Failure of monsoon has resulted in lack of rainfall due to deforestation. Deforestation has been made for the construction of river valley - projects, roads, industries etc. Water was polluted by stock breeding and fisheries. Sediment is the by-product of soil erosion. Soil erosion displaces and takes away the top soil. Sedimentation is the process of deposition of the sediment and it disturbs the flow of water. The natural calamities like flood caused damages to the life and property of the people. These factors are briefly analysed in this chapter.

Political inability

The people of India profess themselves to be citizens of a single nation. They are supposed to live together and resolve differences in accordance with the law of the land framed on the basis of equity and equality just like the people in any other democracy. But, the people of Tamil Nadu are afraid that they are given a discriminatory treatment in the settlement of the Cauvery waters dispute. There have been numerous inter-state river water disputes in the world over. They have been settled in

accordance with the settled law and procedure. But, in India, the state of Karnataka has been violating the sovereign agreements with impunity and the centre had remained partial.[1]

Correspondence between Karnataka and Tamil Nadu on the Cauvery waters took place in the mid-1950s, when work began on the Kabini project. A number of meetings were also held at the official level, although the first ministerial level meeting took place only in August 1968 under the chairmanship K. L. Rao, the Union Minister for Irrigation and Power; Veerendra Patil, the Chief Minister of Karnataka and M. Karunanidhi, the Minister for Public Works, Tamil Nadu participated. This was followed by five more meetings during 1970, in which Kerala was also included. At these meetings, details regarding the Kabini and the Hemavathy projects were discussed but Karnataka declined to give any assurance to adhere to the 1924 Agreement or to suspend work on these projects. Meanwhile in February 1970, Tamil Nadu requested the Government of India to refer the dispute to a tribunal under the Inter-State Water Disputes Act of 1956.[2] Since the Government of India did not comply with this request, Tamil Nadu moved the Supreme Court in August 1971 to direct the Government of India to refer the dispute to a tribunal and to direct Karnataka not to proceed with its new project.

In 1972, at the suggestion of Prime Minister Mrs. Indira Gandhi, the Chief Ministers of the basin states resumed their meetings. The meeting was attended by Chief Ministers Devaraj Urs, M. Karunanidhi and C. Achutha Menon, it was decided that a serious attempt should be made to resolve by

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[1] P. R. Kuppuswamy, *Cauvery - The role of the Centre and Karnataka and the apprehensions of the Tamils*, Karur, 2000. p. 2.

[2] *Ibid.*, p. 5.

negotiations, the Cauvery dispute between the states as early as possible. In the meanwhile, no state was allowed to take any step to make the solution of the problem more difficult either by impounding or by utilizing waters of the Cauvery beyond what it is at present.[3]

Then, the Government of India appointed a fact-finding committee. The committee was only to collect the data and was not to make any recommendations. The Cauvery Fact-Finding Committee (CFFC) was constituted in June 1972 and gave its first report in December 1972.[4] The committee consisted of P. R. Ahuja (Engineer), Jatindra Singh (Engineer), J. S. Patel (Retired Agricultural Commissioner) and B. D. Pal (Judge). Responding to requests made by the Chief Ministers in April 1973, the CFFC gave an additional report for a further verification of the data relating to area irrigated and utilization.

Meanwhile in June 1972, Tamil Nadu acting on advice from Prime Minister Mrs. Indira Gandhi to Chief Minister Mr. M. Karunanidhi withdrew its suit in the Supreme Court.[5] A series of meetings based on the CFFC's reports was held in 1973 and 1974 under the Chairmanship of successive Union Ministers for Irrigation (K. L. Rao, October 1973; K. C. Pant, June 1974; Jagajivan Ram, November 1974).

Hence various efforts were taken in the form of correspondence, exchange of proposals and a series of meetings at ministerial, official and technical levels to solve the Cauvery Water Dispute. But it cannot be solved till now. It shows the political inability of Tamil Nadu and Karnataka.

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[3] S. Guhan, *The Cauvery River Dispute towards Conciliation*, Madras, 1993, p. 24.

[4] *Ibid.*, p. 25.

[5] *Ibid.*, p. 26.

Lack of irrigation policy

There are Water Rights and Water Laws in the Indian Constitution, River Boards Act and Inter State Water Disputes Act of 1956, besides Irrigation Acts, Irrigation Commissions, Water Regulations, Offences and Penalties etc. But till now water disputes cannot be solved and there is no proper water resource management. The next chapter critically analyses about irrigation administration. Hence these laws are outdated and inadequate for the present situation.[6] So irrigation facilities are not properly utilized by the people.

Monsoon-wise Rainfall

Tamil Nadu has three distinct rainy seasons[7] viz. southwest monsoon during June to September, northeast monsoon during October to December and transitional season during January to May. The distribution of average annual rainfall during these three rainy season is given below.

Seasonwise rainfall in Tamil Nadu

Rainy seasons	Period	Rainfall (mm)	Percentage of total rainfall
Transitional period	Jan-May	178.7	19.3
Southwest monsoon	Jun-Sep	307.6	33.3
Northwest monsoon	Oct-Dec	438.7	47.4
Total		925.0	100.0

The maximum rainfall occurs during north-east monsoon.[8]

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6 *Report of the Expert Committee on Development and Management of Water Resources of Tamil Nadu*, Government of Tamil Nadu, Vol. I, Chennai, March, 2003, p. 70.

7 Schemes in Cauvery Basin in Tamil Nadu, Government of Tamil Nadu, PWD, Chennai, March 1991, p. 3.

8 *Ibid.*, p. 5.

The south-west monsoon which is normally expected to break at the southern tip of the west coast on the 1st June, gradually moves up and spreads over the head, reaches of the river Cauvery only by about the middle of June. There have been a few failures in the process, the notable being the year 1965-66.[9]

With a hope that the monsoon would be normal, the Mettur reservoir was opened on the normal date of 12th June with a starting storage of 21.2 TMC. But the monsoon proved to be very erratic and far below normal that year. Rainfall in Mercara in Coorg which is taken to be the yield indicator of the Cauvery basin recorded only 2054 mm of rainfall figures in the crucial months of July and August.[10] In 1965-66, the rainfall were 743 mm and 387 mm as against the normal rainfall of 1129 mm and 683 mm respectively. Consequently, the inflows into the Mettur reservoir in the months of July and August were 53.7 TMC and 55.1 TMC as against 93.5 TMC and 89.2 TMC respectively anticipated in these months. This resulted in the Mettur reservoir getting emptied early by the middle of September and there was an unprecedented crop failure in these years. Hence the rainfall distribution plays a vital role in deciding the cropping pattern and it leads to economic development. The rainfall and monsoon was affected due to deforestation.

Deforestation

A serious problem and a cause of inadequate forest area is the big reduction in the forest area through large-scale deforestation. It has been estimated that during the short span of 10-12 years from 1951-52 to 1972-73 there was deforestation to the extent of 34 lakhs hectares. This

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[9] A. Mohanakrishnan, *Selected Papers on Irrigation*, IMTI, Madurai, 1990, p. 188.
[10] *Ibid.*, p. 189.

indiscriminate felling of trees has occurred before independence also. Most of the forest in Tiruchirappalli district are tropical dry deciduous.[11] The important reasons for deforestation are used as fuel and industrial wood, extension of agriculture, i.e. crop cultivation in place of tree cultivation, construction of river-valley projects, roads, industries etc.[12] The progressive loss of forest cover both environmental and economic consequences. The environmental effects of deforestation are becoming too visible. Deforestation accelerates the flow of water in rainy season and thus affecting the perennial flow of rivers:

1. For instance it is the deterioration of land and water resources with expanding tree-less areas there often occur landslides during rains. These in turn silt up tanks and reservoir which in turn shorten the life span of irrigation projects. Again with small number of trees, there is large increase in the run off of water on the ground. This results in the lowering of the level of ground water.[13]
2. Shrinking forests during rains (through large surface flow of water, landslides etc.) increase the frequency and intensity of floods in plains causing untold misery to many and destruction of much property.[14]
3. The plant life as also the wild life are adversely affected. Many trees of many varieties are reduced in number and in certain areas are almost totally eliminated. Those which endure remain in a precarious

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[11] A. N. Agarwal, *Indian Agriculture*, New Delhi, 1980, p. 427.
[12] *Ibid.*, p. 428.
[13] *Ibid.*, p. 430.
[14] *Ibid.*, p. 430.

condition. No less damage is done to the wildlife, which finds their natural habit eroded. Quite a number of species die or get maimed.[15]

4. The people living near/around the forest areas are very badly affected. Forests for them are the sources of food, fuel, fodder and manure. They also get raw materials for their small or cottage industries. With deforestation their economic activities even their physical existence face destruction. In brief the natural environment of the Tiruchirappalli district, surrounding plains, soil, water, wild life etc. become very unfavourable affecting very adversely the entire life and the economy.[16]

Low production and productivity

An equally serious problem is the small output of the forest produce and small yield of the trees. As for production is concerned the low level is best indicated from its small contributions to domestic product. This has remained around one per cent of the domestic product. Over the years the rise in the production has been very small. In fact since the middle of seventies there has been a decline in the value of output.

To sum up, the problem of forests is three-fold of inadequate forest-area with the ongoing deforestation; of low production and low productivity. But this perception of the problem concentrates strictly on forests, namely tree growing. However, when one comes to the development of forests, the linkages of trees to agriculture, industries and the life in general, as also

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[15] Maimed - to render defective.

[16] Anita Roy Mukherjee, *Forest Resources Conservation and Regeneration*, New Delhi, 1995, p. 125.

wild life etc. Hence in the development of forest area, land trees, and their yields, one has to focus on all these inter-related aspects.[17]

In view of the many benefits of forests, it is essential that these are expanded fast, their production and productivity raised, and their utilization made to promote the economic well being of the people. For this, various measures are required to be adopted.

Recent attempts at afforestation

Destruction of forests thus ensured quick cash return but the process brings in its trial disastrous effect on the environment.[18] Afforestation scheme forms an important component and provide a viable alternative for growth and development in local situation. Though many other schemes have also been taken up for the restoration of environment, afforestation programme is probably the earliest scheme initiated by the state government. The programme of 'Van Mahotsava or planting trees' has been initiated since 1950 by the government to create awareness and enthusiasm in the minds of the local people for the preservation of forest and planting of new trees as 'trees means water, water means food and food is life'. But the programme is to fulfil its ideas.[19]

The afforestation programme has to take into consideration, the following hazards:

1. Fight against drought and erratic rainfall.
2. Ensure natural storage of underground water, including the revival of springs/streams.

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[17] *Ibid.*, p. 126.
[18] *Ibid.*, p. 127.
[19] *Ibid.*, p. 128.

3. Set up wind breakers by hedges thereby preventing erosion of soil by wind.
4. Making provisions of fruits, fodder fuel wood, house construction material, medicinal plants etc.
5. Working for purification of air by absorption of carbondioxide, aerosols and metallic compounds, and
6. to make home for wild life.

Hence due to deforestation, there is no rainfall. It directly affects irrigation and mainly agriculture.

Water pollution

Water pollution means contamination of water by any physical or chemical change, that can adversely affect organisms. The National Commission stated (1973) that water gets polluted if it has been not of sufficiently high quality to be suitable for the highest uses people wish to make of it at present or in the future.[20] In Tiruchirappalli district water was polluted by stock breeding and fisheries.

When cattle or horses are fed on a big pasture, there is little possibility of the livestock causing water pollution because their excreta are spread widely all over the pasture. However, when livestock is fed intensively in a limited area it causes a number of problems. In the case of the stockbreeding industry, the excreta and left over feed on livestock are the sources of water pollution.[21] Water pollution caused by stockbreeding has the following characteristics:

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[20] P. R. Trivedi and Gurdeep Raj, *Water Pollution,* India, 2000, p. 74.
[21] *Ibid.*, p. 15.

1. Degree of pollution varies largely depending on the location of the stockbreeding farm, system and scale of operation and the level of breeding technique.
2. Composition and quantity of excreta of livestock varies depending on the type, quantity and methods of feeding and watering.
3. Besides water pollution, the stock breeding industry also generates an offensive odour, flies, noise and so on.

In most instances, fisheries has been the victim of water pollution. But in recent years, as the number of fish farm increase, pollution of water areas surrounding fish farm caused by leftover feed and excreta of fish is becoming serious.

The waste water from stockbreeding and fisheries mix into the river. Because of this, water gets polluted and it affects irrigation as well as human beings and all living creatures.[22] Hence the river Cauvery is heavily polluted indifferent stretches due to heavy abstraction of water from the twelve dams on its course. In addition to river water pollution, ground water in Tiruchirappalli district is also polluted by waste water from industry, town drainage and chemical fertilizers. The ground water is polluted by paper mill industry in Pugalur village in Karur taluk, leather industry in Sempattu and wine industry in Ariyamangalam.

Soil erosion

Soil erosion which may be called the creeping death of the soil is a world wide problem. It affects the land from which soil is washed; damages the area downstream by floods and sediments and is detrimental to the economy because it lowers the overall income of the farm. In India, the

[22] *Ibid.*, p. 18.

problem of soil erosion assumed serious concern after the eleventh century with the destruction of forests by Mughals and to alarming proportions by the nineteenth century.[23]

The most fundamental ecological deficit that the world faces is the loss of soil through wind and water erosion. This loss of an invaluable natural capital asset and the associated loss of land productivity are spreading as pressure on the land intensifies. Soil erosion is not only widespread, but it is not reversible in any meaningful human time frame.

Once nutrient rich top soil is lost, the capacity of the land to store the nutrients and the water that plants need to sustain growth is greatly diminished. Soil scientists have assessed the risk of human induced desertification and the soil is losing productivity as a result of development activities.[24]

Soil erosion is not new and it has been happening for years. Soil could support the vegetation and the vegetation in turn reduces soil erosion and assists the formation of top form soil. New soil forms when the weathering of rock exceeds losses from erosion.[25]

World commission on dams, reports that the large dams affected 60% of the world's rivers often altering ecosystem irreversibly. The soil erosion in biodiversity affects soil microorganism, which is having a sponage effect on water flow.[26]

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[23] R. Ilangovan and M. Ibrahim bathusha, *Proceedings of one-day Workshop on role of citizens in water resource management coordinators*, Coimbatore, 2004, Jan 6, p. 32.

[24] *Ibid.*, p. 35.

[25] R. P. Tripathi and H. P. Singh, *Soil erosion and conservation*, New Delhi, 1990, p. 20.

[26] *Ibid.*, p. 23.

Sedimentation

Sedimentation is the process of deposition of the sediment and such depositions left undisturbed over time, hardens and even appears as sedimentary rocks in some places, while in some other places like the deltas of the river, sedimentation helps in reclaiming fertile soil from the sea. Mankind is thus doubly blessed by sedimentation and equally harmed as well.[27] There is river sedimentation and also reservoir sedimentation. River sedimentation attempts to change the very course of the river and causes morphological processes while reservoir sedimentation encroaches on the useful capacity of the reservoirs.

The problem of sedimentation actually started only when man started obstructing the natural flow of water for storage purposes, so that he could use such stored water when natural flow stops. Thus it is an evil born out of necessity. The extent or degree of silting depends upon the various factors described below:

i. Nature of the soil and the nature of vegetation in the catchment area,
ii. Extent and intensity of rainfall in the catchment,
iii. Bed slope in the drainage channels carrying the flood waters,
iv. Nature of soil in the drainage channels,
v. Size and shape of the storage work where the flow of water is obstructed.

The nature of soil in the catchment area is an important factor determining the degree of sedimentation. Hard soils, rocks and gravelly soils do not produce much of transportable silt. But this is a natural phenomenon and practically nothing could be done to change this characteristic. Only

[27] A. Mohanakrishnan, *Water resources development and management,* IMTI, Tiruchirappalli, 2004, p. 367.

while planning for a storage reservoir, one of the considerations could be preference for a location, where the catchment area is mostly of hard soil formation.[28]

Nature and intensity of vegetation is the second most important factor determining the degree of sedimentation. Bare soils are thinly covered forest lands. In this factor human effort can produce significant changes, like afforestation, terrace[29] cultivation etc.

The third factor is the extent and intensity of rainfall. Heavy rainfall with high intensity in brief periods produce more silt than moderate rainfall distributed over a longer period of time. But this again is a factor over which man has no control. The only option is to avoid construction of storage reservoirs in such locations.

The catchment drains, which have a steep, produce high velocities. They may carry sedimentation, but there will be no deposition of silt in the channels. If the soil of these channels is loose, they will scour the bed and take more silt. If the reservoir is large as in the case of Mettur Stanley Reservoir, it will not be significantly affected by sedimentation.[30]

Assessment of silt deposits

Small tanks: Silt deposits take place in all storages, big and small irrespective of size. In respect of irrigation tanks, which are only small reservoirs, the capacity calculation is done, only by taking the difference in level between the silt of the lowest sluice and the full tank level (FTL) and the area of water spread at the FTL. If the silt deposition takes place, below

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[28] *Ibid.*, p. 368.

[29] Terrace - a raised level bank of earth.

[30] C. S. Kuppuraj, *Poor people living in rich country*, Chennai, 2002, p. 72.

the silt of the lowest sluice, it is ignored because the loss is only in the dead storage and does not affect the performance of the tank. If the silt deposit is higher than the silt of the lowest sluice then the highest point in the silty bed is taken.[31] This is considered as sufficiently accurate for small irrigation tanks.

Major tanks and reservoirs: In case of major tanks and large reservoirs, block levels are taken on a grid basis and contours are drawn. The volume of capacity is estimated by taking the mean area between the contours and multiplying by the contour interval, in same way as the process for drawing the capacity. By comparing the original capacity, the volume of silt deposited at various contour intervals is worked out. Echo sounders are used for recording the bed levels. In Tiruchirappalli district, there are a large number of irrigation tanks, large and small, having ayacuts ranging from 7 hectares to 5000 hectares. Many of them are purely drained. Some of them have supply channels from rivers. These irrigation tanks are the greatest sufferers due to the bane[32] of sedimentation. In most of the cases, the entire catchment area or watershed area consists of cultivated lands, which means that the soil cover is not firm. Therefore when the rain water flows into the tank, they carry with them, a lot of silt which naturally gets deposited in the tank bed, thus reducing its storage capacity.

Sedimentation and Aquatic weeds

Aquatic weeds are as much as nuisance and evil predators to a water resources engineer as the other weeds are to a crop cultivator.[33] They are

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[31] *Ibid.*, p. 73.

[32] Bane - destruction.

[33] A. Mohanakrishnan, *Water Resources Development and Management*, IMTI, Tiruchirappalli, 2000, p. 370.

quit many in species and live happily with the rise and fall of the water surface in the storage transpiring large amounts of water and do not get eradicated easily. They obstruct the flow courses, encourage shoal formations and disrupt water deliveries besides causing heavy sedimentation in storages. They also multiply and spread profusely. This weed continues to be a menace and has proliferated much more now. Many attempts to eradicate the same lock stock and barrel have failed. Manual and mechanical uprooting, drying up and burning the same seem to be the only solution. Recently some biological control is being tried. Aquatic weeds hasten the deposition of suspended load in the water passing through the storages and increase sedimentation in the foreshore of the reservoirs.[34] They get well rooted in the sedimentation they catch and proliferate profusely.

Environment and Economic Aspects

In all the man made storages, whether small tanks or reservoirs, the level of the water held will be continuously changing overtime and the level will fluctuate between the minimum draw down level and the full reservoir level. During most part of the non-monsoon season the storage level may however be around the minimum draw down level and a good part of the water spread area would be exposed. This area would be slushy carrying the green sediment deposited, with the consequent growth of weeds and form a potential area for environmental degradation and pollution with encroachment by men and animal.[35] Over the years the water quality in the storage suffers. In a number of cases the industrial establishment are found in the foreshore of these reservoirs discharge their waste waters and effluents to flow into the storages, which discharges by their very nature

[34] *Ibid.*, p. 371.
[35] *Ibid.*, p. 373.

containing concentrated solutions and sediment which facilitate faster sediment depositions in the foreshore. These again eventually affect the storage capacity and contribute to the environmental degradation of the foreshore area. There is also the practice of the people encroaching on the water spread area as the water recedes and cultivating short term crop like vegetables. Utilising the residual soil moisture and this in turn loosens the soil and facilitates more of silt being pushed into the deeper reaches of the water spread during ensuing floods.[36] This practice is usually largely curbed and the area safeguarded in the case of reservoirs. But in small tanks controlling this activity is difficult. This of course eventually tells on the sedimentation and consequent reduction in storage space.

Pollutants released by industrial establishments and other foreshore uses as long as they are soluble and digestible may perhaps be diluted by the storage waters in the monsoon seasons. But if they are heavy harmful chemicals they turn into indigestible solid wastes lying all over in the water spread in small shoals[37] as potential environmental hazards.

Cases can be cited in Tamil Nadu where reservoir water pollution has reached intolerable and unbearable levels and court intervention had to be sought to get the industrial establishments committed to treat the effluents to safe levels or threatened to close down their business. These and other consequences explain the environmental hazards in reservoirs sedimentation.

As regards economic evaluation of reservoir sedimentation not much of direct research studies are available though the ill effects on the health and life of reservoir are evident. Cost of multipurpose reservoir projects is going up sharply in the recent years and the proportionate cost of the dead

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[36] *Ibid.*, p. 375.

[37] Shoals - Become shallow

storage with reference to the gross storage is itself an indicator of the economic loss due to sedimentation.[38] One consideration is that sedimentation is inevitable and the cost of water storage has to be borne as a part of the total cost.

But in cases where the volume of sediment deposited is found as brought out by reservoir sediment surveys exceeds the volume of water storage anticipated and provided, to conclude that the reservoir economics is going out of control and the sediment deposition is encroaching on the beneficial aspects of the reservoir project. To that extent it has to be agreed that the project is turning out to be uneconomical.[39]

Sedimentation of reservoirs is therefore seen from any angle a vital concern to water users be they irrigation engineers, water supply engineers, power generators, flood managers, pisciculturists or even recreators since it affects all these activities in some measure or other and hence requires to be minimized to the extent feasible.

Floods

Floods are among one of the most destructive acts of nature. World wide flood damages to agriculture, house and public utilities amount to enormous in addition to loss of precious human and cattle lives. In spite of human influence nature more and more in the present world, is still able to surprise mankind through these hazards. Floods mainly occur during the monsoon months, whenever the river flow exceeds its carrying capacity and overflows the banks causing the bank erosion and the extensive damages. World Meteorological Organisation (WMO) of 1974 defined flood as "a rise

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[38] C. S. Kuppuraj, *op. cit.*, p. 75.
[39] *Ibid.*, p. 77.

usually brief, in the water level in a river to a peak, from which the water level recedes at a slower rate".[40]

The Mettur Reservoir is the largest reservoir in the Cauvery basin, has moderated many floods during the four decades. The heaviest flood occurred in 1961 requires special mention. On 26th July 1961, the reservoir level rose up very fast in a matter of hours.[41] It touched the peak of 124.85 ft as against the full reservoir level of 120 ft. All attempts were made to maintain such higher levels as long as possible, thus giving respite for the downstream areas to recover from the ravages of flood already caused and to attempt breach closing. In spite of all these precautions and the effective flood routing in the reservoir, the Cauvery delta suffered heavy flood damages due to breaches in the conveyance system. At the Upper Anicut the Coleroon arm which is the flood carrier has a control structure. This structure was designed with the objective of regulating the floods entering the Coleroon and creating enough head to give the desired flows to the Cauvery arm meant essentially to take the irrigation supplies. The first breach occurred in the early hours of July 1961 between 18.6 and 19 miles in the common bank of the Cauvery and Coleroon and this was about a mile below the Grand Anicut at Koviladi. With the first cut in the common bank between Cauvery and Coleroon, more floods flowed into the Cauvery arm and the whole delta got disrupted badly. Then the Koviladi breach widened to 1000 ft and the velocity of the flood water gushing was very high. Finally the breach was closed on July 30th. Several suggestions for long term measures to manage future floods were made, of which one major item is the construction of a

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[40] P. K. Mohapatra and R. D. Singh, *Flood Management in India*, Journal of Natural Hazards, Vol. 28, New Delhi, 2003, pp 131-143.

[41] A. Mohanakrishnan, *Selected Papers on Irrigation,* IMTI, Madurai, 1990, p. 190.

barrage on the Cauvery arm at the Upper Anicut.[42] It gave a great facility to regulate the incoming floods in the desired proportion through Cauvery and Coleroon keeping the requirements and safety in mind. Since both the barrages have shutters with operating gears with provisions for both power operation and manual operation is possible to divert the required flows for irrigation in the Cauvery arm and the Coleroon arm.[43] The flood and the consequent submergence badly affected the cultivated crops and the several other losses to the community in the basin ran to several crores of rupees.

Impact of flood on human life

More than the loss of life and damage to property, the devastating effect of flood, the sense of insecurity and fear in the minds of people living in the flood plains are more telling. The after-effects of flood like the agony of survivors, spread of epidemic, non-availability of essential commodities and medicines, loss of the dwellings make floods most feared among the natural disasters being faced by human kind.[44]

Causes and condition of flooding

Flooding in a river basin generally occurs due to a number of basic causes of which the most frequent are climatological.[45] In general, the term flood mainly covers the situations as given below:

1. very heavy local rainfall,
2. heavy rainfall synchronizing with river spill,
3. cyclones,

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[42] *Ibid.*, p. 191.
[43] *Ibid.*, p. 192.
[44] *Ibid.*, p. 150.
[45] S. K. Agrawal, N. J. Singh and V. D. Roy, *Flood Management in India.*, New Delhi, 2004, p. 2.

4. swelling of water from streams due to low carrying capacity,
5. back water effect in tributaries when the main river carries heavy discharge,
6. landslides blocking in stream courses and ice jams resulting in the back water overflowing river banks,
7. flooding in coastal area due to high tides,
8. inadequate drainage / drainage congestion to carry away surface water with the desired quickness etc.
9. flooding due to the failure of flood control structures.[46]

Measures

Broadly, all measures taken up under the activity of 'modifying the flood' which are in the nature of physical measures are 'structural measures', while the others which are taken up as management tools without major construction activity are grouped as non-structural measures.

Structural measures

The main thrust of the flood protection programme undertaken in Tiruchirappalli district so far as has been in the nature of structural measures like: Embarkments, flood walls and chain tanks.

Embarkments played an important role in providing reasonable protection to affected areas. Realising the great potential of the reservoirs in impounding floods and regulating the flows downstream for flood moderation, flood control has been sought to be achieved as one of the objectives in multipurpose dams.[47] The floods generated may be heavy, fill

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[46] *Ibid.*, p. 3.
[47] *Ibid.*, p. 5.

in all the tanks in the chain one after the other surplussing down the line and finally join a natural drain. This incidentally reduces the risk of breaches.

Non-structural measures

Non-structural measures strive to keep the people away from flood waters, bearing in mind the stark reality that the flood plains in fact, belong to the river and that the flood perceived only as a curse, could be turned into a blessing in disguise in some ways.[48] It contemplates use of flood plains judiciously, simultaneously permitting and vacating of the same for use of the river whenever the situation calls for. This technique allows the use of flood plains reducing the disaster dimension, while retaining its beneficial effects.

In view of cost effectiveness of the non-structural measures and speedier implementation, and in recognition of the fact that as more and more human encroachments and activities are taking place in the flood plains in Tiruchirappalli district, the main thrust is now on the non-structural flood management measures.[49] The non-structural measures are broadly grouped as follows:

1. Flood forecasting and warning
2. Flood plain zoning
3. Flood proofing including disaster preparedness and response planning
4. Disaster relief
5. Flood fighting including public health measures

Hence frequent occurrence of floods are causing extensive damages to the life and properties. There is a need for carrying out the systematic study

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[48] *Ibid.*, p. 7.

[49] A. K. Lohani, R. D. Singh and K. D. Sharma, *Flood Problems and Management Practices in India*, New Delhi, 2004, p. 24.

to understand the flood phenomenon and their causes. It is required to investigate the various factors (natural as well as man made) which are responsible for generating the floods. There is a need for developing the decision support system to provide the knowledge and information about the areas to be submerged due to flood water in real time. It is helpful for the administrators in preparing the evacuation plans during the flood period to save the lives and properties of the people affected due to floods.[50] Nowadays inter-basin transfer is being considered by the Government of India. Such transfer would definitely help in reducing the flood to a certain extent. There is need to improve the cooperation and coordination between the scientific communities and appropriate local governments and civil defence agencies for developing the effective, workable plans to flood disasters.

Hence political stability, failure of monsoon, lack of rainfall, deforestation, water pollution, soil erosion, sedimentation and natural calamities like floods are the factors that hamper irrigation facilities. The Cauvery River Action Plan proposed works include treatment of sewage, low cost sanitation, crematoria, solid waste management, river front development and afforestation.

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[50] *Ibid.*, p. 25.