

FLOOD CONTROL

By S. C. MAJUMDAR, I.S.E. (Retd.), Consulting Engineer to the Government of West Bengal, Calcutta

(Communicated by Dr. W. D. West, F.N.I.)

SUMMARY

The problem of flood is intimately connected with the problem of river conservation—conservation not only of the river channel proper but also of the rainfall within the catchment area. The method devised by nature for this purpose consists of absorption by the subsoil of a substantial portion of rainfall thereby reducing the run-off which not only reduces the intensity of floods and soil erosion but, being gradually released by percolation, maintains the river flow throughout the year. It is interference with this natural economy by destruction of forests and other harmful acts that is responsible for most of our river problems, particularly flood problems. A certain amount of interference is inevitable owing to pressure of population and to meet the growing needs of civilization, giving rise to a conflict between the needs of the river and those of man. This should be resolved with the aid of our advanced scientific knowledge and research.

Flood control measures can be broadly classified as (a) preventive and (b) remedial. The former aims at restoring the natural economy by efficient preservation of forests and other measures designed with the object of reducing the rate of run-off and preventing soil erosion and are more important as they deal with the flood problem at its source. Of the latter, flood-embankments are very common, but having regard to their evil effects fully discussed in the main paper, they cannot be recommended except for the protection of important vested interests. Among other remedial measures, the most important are flood moderating reservoirs. They are not, however, likely to be financially feasible unless the objective is widened and the reservoir is designed on a multi-purpose basis so as to develop and bring for the use of man potential river wealth in its various aspects, such as irrigation, navigation, power, etc. These objectives are not conflicting but complementary and are essential for raising the economic standard of the people.

For optimum development, our rivers should be treated as individual units irrespective of political boundaries. In the new constitution, power has been given to the Government of India to legislate in respect of inter-State rivers and a Bill will shortly be placed before Parliament. Some suggestions are offered in the main paper as to the organizational and legislative requirements for efficient conservation of our rivers and their optimum development on a multi-purpose basis so that necessary provision may be made accordingly in the proposed Bill.

Flood problem is intimately connected with the problem of river conservation—not only of the river channel proper but, what is perhaps more important, conservation of the rainfall within the catchment area. Nature's method for the conservation of rainfall as compensation against its erratic distribution is to have the precipitation partly in the form of snow if there is any catchment area at sufficiently high altitude, and what is more important, to absorb into the subsoil and store underground a substantial portion of rainfall which while reducing the run-off and the intensity of floods, maintains the river flow by percolation throughout the year when there is no rain and no surface flow to maintain it otherwise. The utility of a river to serve our various needs mainly depends on this compensating action provided by nature which, again, depends on the condition of the catchment, i.e. whether it has sufficient area under vegetation, particularly deep forest, which retards run-off thereby reducing the intensity of floods and their silt-content, and increases the portion of the rainfall which is absorbed and stored underground to maintain the river flow by subsoil percolation during the dry weather. It is interference with this natural economy by destruction of forests and by other harmful acts in the catchment areas and in the river channel that is responsible for most of our river problems, particularly the flood problem. To meet our growing needs, we want regular supply of water but by our action, we are making the distribution of river flow already faulty, still more irregular. This adversely affects all the fields of water uses and particularly aggravates the flood problem. Apparently, there is some conflict between the needs of the river and those of man as with the growth of population certain amount of interference with nature's economy is unavoidable. Room

has to be found for the growing population, while their needs from the land including the forests, now rapidly increasing with the progress of civilization, have to be met. This cannot be stopped but the process should be rationalized with the aid of our advanced scientific knowledge, by intensive study and research, so as to effect a reconciliation between these conflicting interests.

Flood control measures can be broadly classified under two categories: (a) preventive and (b) remedial. As prevention is better than cure the former are more important, such as efficient preservation of the existing forests, afforestation where possible, rational land management, contour trenching and bunding and terraced cultivation along hill slopes, all designed with the object of reducing the rate of run-off and preventing excessive soil erosion. They attack the flood problem at its source and help in reducing the intensity of flood, improving the dry weather flow and, at the same time, owing to less silt charge of the flood water, help in conserving the river channel by natural action. These measures, which do not involve much of capital expenditure but mainly require organizational effort including research and legislation, will, in my opinion, help considerably in reducing the depth of flooding to a safe level. This, while permitting the land building activity of the rivers to proceed, gradually raising the land and fertilizing it, will at the same time, maintain the drainage system in fairly efficient condition due to scour of the silt in the river beds by the clear water drained back from the land. In deltaic area, which is the region mainly affected by floods, this is how the rivers maintain themselves in nature and the aim of controlling measures should be to allow these beneficial activities of the rivers to function, subject to the depth of flooding being reduced to a safe level.

Remedial measures are measures designed with the object of controlling the flood after it has entered the river with a view to minimizing flood damages as far as possible. The most common is the construction of marginal flood embankment and as the deterioration, it causes to the river channel and the drainage system, in public health and productivity of the soil, takes years to manifest itself, it has hitherto been accepted as an effective protection against floods. If it were possible to imagine a river with non-erodible boundary and carrying no silt with the run-off from the catchment basin, embankments would certainly have been a permanent remedy against floods: but the problem is complicated by the all-important silt-factor, viz. the silt which the river brings from its catchment basin as also the silt which it picks up from its erodible boundary on the way. In the economy of nature this silt is intended to be carried with the flood spill so that it could raise and fertilize the land and reduce the silt content in the river-channel to what its velocity could transport. Confinement of the flood within the river by means of embankments disturbs this arrangement and a portion of the silt in excess of what the river can transport, deposits in its bed gradually reducing its carrying capacity. This causes higher and higher flood level to carry the same volume of flood necessitating higher and stronger embankment. So the deterioration of the river proceeds until a stage is reached when it is no longer possible to offer protection against floods by means of earthen embankments.

Embankment, therefore, offers no permanent solution to the flood-problem. At best, it is only a temporary expedient and puts off the evil day to future generations when owing to various vested interests created, and due to deterioration in the drainage system, in public health and productivity of the soil in consequence of the stoppage of beneficial flood spill from the land by embankments, problems are created which are almost insoluble. Even as a temporary expedient it can hardly be considered as a sufficiently effective protection as it is impossible to avoid breaches in earthen embankments and the destructive effect of concentrated discharge through breaches is more serious than gradual inundation, specially as the flood level relatively to the land gradually rises as a consequence of the embankments. It no doubt takes years before the evil effects of embankments are actually felt: this very fact makes

them rather risky expedients, as vested interests are created which stand in the way of any bold solution being adopted in future.

In Bengal, where the flood embankments were perhaps constructed the earliest in India, their evil effects are being felt rather seriously as in several parts, tracts formerly healthy and prosperous have now become hot-beds of malaria owing to the deterioration of the drainage system; land is lying fallow owing to the growing decrease in the productivity of the soil and population is declining. In the deltaic tracts of East Bengal, on the other hand, where there are no embankments and the land is annually inundated by the beneficial flood spill of the Ganga and the Brahmaputra-Jamuna rivers the people are healthy and prosperous. Not having any false sense of security, as would be given by the flood-embankments, they have their houses built on earthen mounds above flood-level and follow agricultural practices suitable to the flood conditions. In fact, this area is one of the richest agricultural tracts in India. Having regard to our experience in Bengal construction of flood-embankments cannot be recommended, except perhaps for the protection of important vested interests where there is no other alternative.

This has no doubt been written on the basis of my experience particularly in deltaic Bengal and there are also instances where beds of embanked rivers have already risen higher than the country level. It appears that the condition of embanked rivers in China is not better and perhaps worse in the case of the Yellow river of which the bed is reported to have risen about 4 metres above the adjacent countryside. Another important evidence as regards the evil effects of embankments that has recently come to my notice relates to the capital of Assam built several centuries ago in the Brahmaputra valley near Sibsagar by the late rulers (Ahom kings) of Assam. The area which was protected by flood embankments is now a big swamp several feet lower than the surrounding country level and it is impossible to drain it by gravity. This has undoubtedly been caused by the stoppage of land building activities of the river within the embanked area which, in consequence, has remained at the same level or has probably been lowered due to surface erosion caused by the local rainfall, while the surrounding land subjected to inundation by the silt-laden flood and the river-beds have been gradually raised.

Conditions obtaining in other countries are not definitely known. But in view of the simplicity of the design and construction of earthen embankments and the fact that their evil effects are not felt till after a long time, and consequently the people are tempted to take recourse to them for their immediate benefit, often reclaiming the land prematurely particularly in tidal areas, they are likely to be very common in deltaic areas. It is, however, possible that owing to the differences in climatic conditions and particularly differences in the silt charge of the flood water their evil effects have not been quite similar. Having regard to the seriousness of the position briefly referred to above organized effort on international level is urgently required so that experience gained from various countries can be compared and after critical study of the data collected necessary action can be taken, keeping in view not only the immediate benefit to be derived from these embankments but also their ultimate evil effects as regards health and productivity of the soil on which will depend the well-being of the future generations.

Other remedial measures that can be considered are:—

- (a) Provision of adequate openings in the railway and road embankments and removal of obstructions to the free flow of flood water;
- (b) Provision of flood escapes;
- (c) Improvement of spill and drainage channels; and
- (d) Construction of flood moderating reservoirs.

The aim of (a), (b) and (c) is to reduce the depth of flooding and its duration by efficient drainage. They permit land building activities of the rivers in the deltaic area to continue, which as explained before, being part of nature's economy, should be

allowed as far as possible. Combined with adequate preventive measures referred to previously, they might even provide adequate protection against flood-damages unless the deterioration of the river and soil erosion in its catchment basin have already reached an advanced stage necessitating recourse to (d) in addition. Having regard to the heavy cost of flood moderating reservoirs, however, prudent course would be to take timely action with regard to the preventive and other remedial measures so that their necessity may be avoided as far as possible.

The object of flood moderating reservoirs is to impound a portion of the flood temporarily and release it gradually, thereby reducing the intensity of the flood to what the river channel below can safely carry without causing any damage. Reservoirs constructed with such a limited objective cannot, however, be financially self-supporting, as mere protection of an area from flood can hardly be expected to yield any substantial revenue. If, however, the objectives are widened and the reservoirs are designed on a multi-purpose basis so as to include development of the potential wealth of the river in other respects as well, as far as practicable, such as navigation, irrigation and power, the revenue derived from the various sources might make these projects financially feasible, if not actually productive. For this reason, multi-purpose Reservoir Projects are now finding favour in India, particularly having regard to the immense benefits that are being derived from similar development of the Tennessee river in the United States of America under the direction of the T.V.A. Fortunately, these objectives are not conflicting but more or less complementary as the water impounded within the reservoir while relieving flood congestion lower down the river can be utilized for power generation, irrigation and navigation purposes. These latter objectives will no doubt require permanent storage: but as they are all revenue-producing the extra cost involved can more than be recouped. Besides, having regard to our economic backwardness in India which is attributable primarily to the long neglect in developing our natural resources, the development of our potential river wealth, which India undoubtedly possesses in plenty, is essential for raising the economic standard of the people.

But whatever may be the objective, whether it be flood-moderation alone or the other objectives are also combined, the first and essential requirement is efficient conservation of the river. Within the limitations imposed by nature in the matter of erratic distribution of rainfall over which we can have no control, we must try to stimulate the compensating action provided by nature by rational treatment of the catchment basin already explained, so as to equalize the river flow as much as possible. Secondly, where the possibility of utilization of this fluctuating daily river flow has already been exhausted as in India, to meet the ever-increasing demands for water uses, in the various fields, particularly in irrigation rapid expansion of which is urgently necessary to be able to feed the rapidly growing population, we must go in for storage schemes, i.e. impounding portions of the floods which now run to waste, often causing extensive damages and utilizing the same to supplement the river flow when it is otherwise inadequate to meet our various needs. The storage schemes being usually rather costly their revenue-producing potentialities in the various fields should be developed to the maximum extent possible so as to make them financially feasible, or in other words, they should be designed as comprehensive multi-purpose schemes embracing as many of the objectives of stream control as may be technically and economically feasible.

Technical feasibility of reservoirs, however, depends on the availability of suitable sites which are only found in the hilly portions of the river valleys where there may not be sufficient scope for utilization of the water and which may be beyond the jurisdiction of the political units where such utilization is not only possible technically and economically, but is also necessary to ensure sufficient revenue return against heavy financial commitment that has usually to be made in executing these schemes. This raises a number of complicated problems regarding loss of land to be submerged by the proposed reservoirs, water-rights and equitable apportionment

of the water which have to be solved to the satisfaction of all concerned before any progress can be made. Hitherto, this has been one of the major obstacles in the way of our proceeding with the river development projects as rapidly as could be desired and making the country self-sufficient as regards food. As most of our major rivers flow through more than one state many of our important development projects have been held up for years due to lack of agreement in the above respects among the different political units concerned.

A fundamental point that emerges from the above review is that both for general conservation as also for optimum utilization of their water, including flood-control, which are essential for raising the economic prosperity of the people, rivers should be treated as individual units irrespective of political boundaries so that comprehensive plans may be made for each major river basin, giving due consideration to the rights and needs of different political units, maximum possible development of the river potential and also their economic utilization. Hitherto, the Government of India had no constitutional power to ensure observance of this fundamental principle by legislation. This power has, however, been given in the new constitution and a comprehensive Waterways Bill will be placed before Parliament shortly. I should like to take this opportunity to express my views as to the organizational and legislative requirements for efficient conservation of our rivers and optimum utilization of their water on multi-purpose basis for due consideration in drafting the Bill.

As regards the organizational requirement, it does not seem to be desirable to entrust responsibility for river conservation solely to individual states who are directly benefited by its exploitation. In that case, having regard to the natural tendency to minimize and even ignore the adverse effect on the river so long as its exploitation brings in immediate benefit, nothing substantial will really be done. Though the ideal arrangement would appear to be to entrust this responsibility to the Centre it is not likely to work efficiently in practice as the task will be much too unwieldy for a single organization, having regard to the large number of rivers to be conserved in this sub-continent. Besides, co-operation of the states, particularly the local knowledge of their technical staff appear to be essential. It is therefore suggested that Inter-State Organizations consisting of representatives of interested states and of the Centre with adequate statutory powers and resources should be formed, ultimately one for each of the major river basins, to undertake responsibility for conservation and, as regards initiative, also of exploitation of rivers. In a large basin like that of the Ganga, it will also be necessary to create regional authorities for execution and maintenance of important inter-state schemes. The necessary co-ordination between the different regional authorities will have to be effected by the Main Basin Organization and as between contiguous Basin Organizations by the Centre. Necessary provision should be made in the proposed Bill to enable the Union Government to constitute these bodies with adequate powers and resources. With regard to the latter, it is suggested that a cess should be levied on the fruits of exploitation of rivers (irrigation, navigation and power) and placed at the disposal of the Basin Organization to finance the conservation measures.

Provision should be made in the proposed Bill for quick settlement of inter-state water disputes. The following principles are also suggested for consideration and inclusion in the Bill. The Union Government should have powers to authorize construction of schemes considered necessary in the interest of social welfare and general progress of the country even in spite of the opposition of recalcitrant minorities subject, of course, due regards being paid to the legitimate rights and obligations of the various riparian states concerned. These rights and obligations should be defined in the Bill in principle. For instance, apart from the right of prior appropriation which has to be conceded, right over the balance of water-resource available in any particular river-basin should be governed by the needs of the various riparian states and the obligations should include :—(a) rational treatment of the catchment

basin under the general control of, and, perhaps with a subsidy from the Main Basin Organization referred to above; (b) general control by this body, as regards broad outlines only, of schemes initiated by any state which involves extraction of substantial quantity of water from the river; and (c) finally as regards inter-state river development schemes, giving due facilities for their investigation, execution and maintenance.

To prevent sabotaging of promising schemes indirectly by any state, the proposed Bill should also lay down definite principles to regulate land compensation and rehabilitation. For this purpose, provision in the L.A. Act should form the basis of compensation subject to the right of appeal to the Supreme Court. Some concessions within reasonable limits seem justified for rehabilitating large numbers of displaced population in the case of reservoir schemes. In this connection, the Engineer also has an obligation to reduce the area of permanent submersion by the reservoir to the minimum extent possible, particularly as regards cultivated and culturable waste lands. Loss of food by permanent submersion of cultivated land in the interest of irrigation and flood control can certainly be justified as the loss will be recouped many times over by the project. But in view of the acute food shortage in the country, large additions to the submersion in the interests of power alone can hardly be justified. Production of hydel power is certainly necessary but in the interest of our food economy, loss of cultivated and culturable land should be avoided as much as possible, as making the country self-sufficient as regards food should be given the topmost priority in all our activities. Subject to the above remarks, the people who will have to be unavoidably displaced by the reservoirs should have the right to demand rehabilitation at the cost of the project in lieu of cash compensation. But subject to their present economic standard not being lowered which should be treated as the minimum, standard of rehabilitation should be so fixed that the cost may not materially exceed the money compensation as assessed under the L.A. Act. If any state wants a higher standard being fixed for rehabilitation as a part of general rural uplift, it should be prepared to bear the extra cost.

A further suggestion that occurs to me for reducing the extent of rehabilitation is that, provided the local condition is favourable the acquisition within the reservoir area may be limited to full supply level with perhaps a little margin, as the higher land which will be submerged only temporarily for a few hours at a time during the passage of floods is not likely to suffer any material damage but may even benefit by occasional flushing with silt-laden floods. The present agricultural practice in the latter area need not be interfered with though the homesteads will have to be shifted and houses re-erected on higher ground close by above the designed flood-level, at the cost of the project. This is all the more necessary as the modern tendency is enormously to increase the design flood. Though the probability of its occurrence is rather remote, having regard to the magnitude of the damage that would be caused by the failure of a dam, the engineer has to make necessary arrangement for its safe disposal. But this does not necessarily mean provision of costly flood-gates to be imported from foreign countries, apart from uncertainty of the delivery position during the present grave international situation. Nor would it be justified to incur heavy expenditure on river protection works below the dam as such a catastrophic flood, if it ever occurs, must necessarily be of very short duration. In my opinion, it should be sufficient if these works are designed to suit the highest recorded flood with some margin. For disposal of still higher floods all that seems necessary is to strengthen the dam profile so as to suit the design flood level and allow the flood to rise temporarily and gradually spill over the dam. In this process of rising, the flood absorption capacity of the reservoir will also be enormously increased which will reduce the peak rate of flood spilled over the dam and consequently its destructive capacity lower down considerably more than if it were attempted to work the reservoir to a fixed level at F.S.L. and dispose of the floods by controlled gates.