Floods Management and Drainage System in Haryana

Table of Contents

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1. Introduction

Haryana, a small state situated in northwest of India was carved out of the then joint Punjab on November 1, 1966 and covers about 4.4 million hectare land area, of which about 3.9 million hectare is arable. In the North, the state is bounded by the Shivalik range of mountains and in the East by the river Yamuna. Aravalli range running South of Delhi and the desert of Rajasthan form the boundary on the Southwest. In the Northwest, the Ghaggar River forms part of the boundary with Punjab. The elevations of the state vary from 400 m in the North to 210 m on Rohtak-Hisar axis, 310 m in South Narnaul, 190 m in the Southeast outfall point of River Yamuna and 190 m in Southwest outfall point in Ghaggar. This clearly indicates that there is sufficient scope for natural surface drainage provided the proper surface drainage network is there. This also negates the euphoria created about geographic shape of the state being saucer or bowl.

2. History of Major Floods in Haryana

Brief description of major floods experienced by Haryana from 1976 to till date is given below in chronological order.

2.1 Floods of 1976 & 1977

The state experienced very heavy floods during 1976 and 1977. In the southwest parts of Haryana 50/100 years return period floods were witnessed both during 1976 and 1977. The northern part of Haryana experienced such heavy floods during 1976, except Kaithal area, which experienced heavy flooding during 1977.

2.2 Flood of 1978

The floods during the year 1978 were the direct result of heavy rainfall in Haryana as well as in the catchment areas of river Yamuna in Himachal Pradesh. The discharge in Yamuna was more than 19,825 m^3/sec (700,000 cusecs) on 3rd September 1978. As a result of this high water level, the districts of Ambala, Karnal, Sonepat, Faridabad, Gurgaon and adjoining areas of Delhi were also affected.

2.3 Drainage Masterplan

After the devastation of the floods of 1978, the State prepared a masterplan costing Rs. 150 Crores and executed most of them for long-term mitigation measures of flood. The following schemes were part of the masterplan: –

- Construction of Ujhina Diversion Drain for Gurgaon and Faridabad districts.

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- Construction of KCB Drain for Rohtak district.
- Construction of Link Drains.
- Construction of Ring bunds around villages.
- Construction of River embankments and river protection works along river Yamuna.
- Remodelling of Drain No. 8, Diversion Drain No. 8, Main Drain No. 2 etc.
- Construction of Storage along canals and natural storages at Bhindawas, Bibipur, Massani Barrage on River Sahibi, Ottu Weir, Kotla lake etc.

2.4 Flood of 1983

Whereas the floods in the year 1978 were caused by rivers on account of heavy rainfall in their catchment areas (which lie outside the State), the floods in 1983 were caused by extremely intensive rainfall within the State. This caused flooding in the districts of Rohtak, Sonepat, Jind, Gurgaon, Hisar, Bhiwani, Faridabad, Kurukshetra, Karnal and Sirsa. The Rohtak district was worst affected where Drain No.8 was not able to carry the required discharge from Gohana areas for a number of days inundating the entire Gohana Sub-division. The situation in Rohtak town was also grim as about 1 m (3 to 4 ft) water remained standing in large parts of the town. Since Delhi had not completed the outfall drains in their areas, the floodwater submerged fields in Bahadurgarh, Jhajjar and most part of Rohtak district. Extensive damage to property, life, and cropped land was caused resulting in damage estimated at Rs. 500 million.

2.5 Flood of 1988

There were heavy rainfalls in Haryana during August 1988, which affected 615 villages in Ambala, Karnal, Kurukshetra, Jind, Sirsa, Hisar, Faridabad and Sonepat districts. The heavy rainfall in catchment areas of Himachal Pradesh resulted in very heavy discharge in river Ghaggar, which was 2,275 m^3/sec (80,398 cusecs) on 8th August 1988. Such a high discharge was last recorded in 1973. After the heavy rains of July and August, there were also incessant rains throughout the State in September which again caused flash floods in the Ambala, Karnal, Kurukshetra, Jind, Sonepat, Hisar, Sirsa and Faridabad districts resulting in losses of human lives and of cattle. Flood protection works, crops and infrastructure were badly damaged.

2.6 Flood of 1993

In 1993 high stages in the river Ghaggar, coinciding with heavy precipitation on the Ghaggar drainage tract inundated large areas in the districts of Ambala, Kurukshetra, Kaithal, Fatehabad and Sirsa. Similarly, large areas were inundated in the Karnal, Jind, Sonepat, and Rohtak districts of the Yamuna drainage tract and in the Bhiwani and Jhajjar districts of the Internal Central tract. There was continuous heavy rainfall for 76 hours from 9th July onwards which resulted in flooding of all rivers and drains. The total rainfall from 10th July to 12th July and again from 22nd July to 23rd July was of the order of more than 50% of the average annual rainfall in just five days. Heavy rainfall was also experienced in Punjab areas and as a result of this, a thick sheet of water flow entered Haryana through the SYL canal inundating a large number of villages. This inundation caused losses of human lives, of cattle, and destroyed large cropped areas and other property.

2.7 Flood of 1995

In 1995 high stages in the Ghaggar River coincided once more with high rainfall over much of the State causing inundations of large areas. The rainfall that led to the large inundations in 1995 was between 200 mm to 250 mm during September 2-4, following earlier heavy rains from 26th August to 30th August, which had already caused inundations. The districts of Rohtak, Bhiwani, Hisar, Jind, Kaithal, Ambala, Rewari and Sonepat were largely inundated and the situation was exacerbated by entry of floodwater from Punjab through the SYL canal. Floodwater also entered hundreds of villages in Rohtak, Bhiwani, Dadri, Gohana, Ambala Cantt., Ambala City, Panipat, Kaithal, Siwani, Pehowa, Tohana, Narwana, Hansi, and Barwala, Rewari and Ratia towns were also affected. All the cities and rural areas were under 0.6 to 3 m (2 to 10 ft) floodwater and the water remained stagnant for many days due to the non-availability of natural drainage system in Jind, Hisar, Rohtak and Bhiwani districts. All drains and canals overflowed and were not able to drain out the surface runoff. Road networks, Public Health installations including water works, electric installations etc. were submerged and badly damaged. The total cropped area affected by floods was 573,319 ha during this year and crop damages were assessed as Rs. 11,880 million.

2.8 Flood of 1998

In October 1998 very heavy precipitation, 1100 mm from 15th to 18th October, caused inundations of large areas, in the Kaithal district and Narwana-Tohana areas in Ghaggar Drainage Tract. Hansi areas (in the Hisar district), and areas in Jind, Rohtak, Jhajjar, Bhiwani and Rewari districts situated in the Internal drainage tract were also inundated for prolonged period. The Yamuna reached a peak discharge of 15,320 m^3/sec (5,41,000 cusecs) in October 1998 causing heavy damages to the existing river protection works. In its drainage tract there was flooding in some low lying areas in Sonepat and Karnal districts as well as in some areas of the Faridabad and Gurgaon districts near the river itself. Due to this unseasonal and incessant rains in combination with high flows in river Yamuna, 111,000 ha (2.75 Lac acres) area of the State were inundated.

2.9 Masterplan of 1998

Another masterplan for drainage costing Rs. 2200 Crores has been prepared in 1998 and following major schemes have been envisaged: -

- Development of a surface gravity drainage network for Ghaggar basin in Kaithal, Jind, Hisar, Fatehabad and Sirsa districts.
- Construction of Meham Lakhanmajra drain for Rohtak district.
- Construction of Darba Ghaggar Drain for Sirsa district.
- Construction of Kalwan Kinana Drain for Jind district.
- Construction of Numerous small link drains.

3. Flood Control Works

In general terms flood control and management can be divided into four, mutually non-exclusive, main categories of structural as well as non-structural measures that may all be implemented in a river basin. The four main categories referred to above may be summarized as follows:

1. Flood Protection Works on the river itself, aimed at containing flood flows within the river course. These works, of a structural nature, comprise construction of structures, or works on the river itself.
2. Flood mitigation works in the catchment. These works aim at reducing flood peaks by small storage dams, maintaining (or increasing) rainfall retention and reducing erosion in the catchment through soil conservation methods.
3. Damage reduction works in the flood plain. Works under this category include drainage systems, flood zoning, land-use restrictions, flood proofing; and
4. Flood warning, evacuation and emergency relief.

3.1 Protection Works

Flood Protection Works on the river itself, aimed at containing flood flows are carried out within the river course. These works are structural and comprise of construction of various structures, or works on the river itself. In Haryana number of flood protection works are carried out such as embankments, studs, drains etc and an infrastructure has been created for the same.

At district level 'Flood Control Committees' are constituted under the chairmanship of the Deputy Commissioner and consists of senior officers of Irrigation Department, Public Health Department, Building & Roads and Police Department. These committees carry out inspections of Flood Protection Works from time to time for planning the schemes for the coming flood season and recommend the same to the Government.

The schemes recommended by the Flood Control Committees are then technically scrutinized first by the concerned Superintending Engineers and further by Technical Appraisal Committee, the highest technical committee consisting of Chief Engineers and other senior officers of the Haryana Irrigation Department. After detailed technical scrutiny, the feasible schemes are recommended for evaluation and approval of the highest authority i.e. 'Flood Control Board', chaired by Hon'ble Chief Minister, Haryana and administrative secretaries of concerned departments. Thus a very elaborate and well-structured system has been put in place, which has been working effectively for flood control measures. Every year about 30 Crores Rupees are spent on flood protection works in the state.

Besides, high embankments called 'Ring Bunds' with proper approaches and ramps are also constructed around villages prone to flooding. The objective is to protect population from floods, which would otherwise maroon these villages and towns. This measure alone has saved a number of villages and towns from floods over the last many years.

3.2 Mitigation Works

Flood mitigation works in the catchment is the second important measure of flood protection. The aim of these works is to reduce flood peaks by small storage dams, maintaining (or increasing) rainfall retention and reducing erosion in the catchment through soil conservation methods. The catchment areas of the major rivers i.e. Yamuna and Ghaggar do not lie in Haryana. Still the State takes every possible step for all treatments for soil conservation in their catchment area. A large number of small bunds for storage and soil conservation are being constructed in hilly areas of the State under the Integrated Watershed Development Project, which is being executed by the Haryana Agriculture Department very successfully.

Haryana Irrigation Department has constructed such small storage cum soil conservation/cut off bunds in Aravalli range of hills in the districts of Gurgaon, Rewari and Mohindergarh. These bunds are effective in conserving soil, recharging of groundwater and create moisture in soil for Rabi crops.

3.3 Damage Reduction Works

Damage reduction works in the flood plain include drainage systems, flood zoning, land-use restrictions, flood proofing etc. The need of flood plain zoning has been recognized in India at various forums in the past. The Central Flood Control Board urged the State Governments in 1957 to take up flood plain zoning and if necessary, enact legislation for the purpose. The necessity of flood plain zoning was recommended by The Ministers Committee (1964) and Ministers Committee on Floods and Flood Relief (1972). It also endorsed that necessary legislation should be enacted in the states". In 1975, the Central Government circulated a model bill for flood plain zoning with the request the States may enact necessary legislation with suitable modifications. The Rashtriya Barh Ayog also endorsed the concept of 'flood plain management measures' in its report (1980). The GOI has issued guidelines for flood plain regulations based on the regulations issued by the Federal Emergency Management Unit (FEMA) of the US and other countries.

3.4 Flood Forecasting and warning

An essential and critical component in any flood plain is an effective flood forecasting system and an ancillary flood warning system. This is particularly so in India in general and in Haryana in particular, where population pressures have increased human encroachments into the flood plains with ever increasing damages both in terms of losses of human lives, losses of cattle and losses of crops. Similar to other countries, India also lays great stress on flood management by both structural and non-structural measures as expressed by India's National Commission on Floods in 1980. Flood forecasting and flood warning is recognised as an essential and highly cost-effective component of flood management regardless of the degree of flood protection provided. India's experience in FF and FW has generally been very good, FF has proven to be quite accurate and FW has proven to be a major factor in saving lives and reducing property losses.

4. The Surface Water Drainage System of Haryana

Haryana is covered by two main Drainage basins: The Yamuna basin of 16,330 km^2 or 37% of the area of the State, the Ghaggar basin (Part of Indus Basin) of 27882 km^2 or 63% of the area of the State. The drainage conditions in each of the two zones is as follows:

4.1 The Yamuna Basin

The eastern part of the State (the Yamuna Basin) has the most elaborate drainage network comprising about 350 main and tributary drains of a total length of 3,000 km. Yet the system is still not capable of draining accumulated surface water from all lands sufficiently fast and, following heavy rains during the monsoon season, there are many pockets of standing water, which can be attributed mainly to non construction of the field drains at micro level.
The main drains of this Zone are as follows:

(1) Main Drain No.2, running from the left bank of the Sirsa Branch Irrigation Canal to Panipat and draining the Chautang and the northern part of the basin discharging into the Yamuna near Panipat;
(2) Diversion Drain No.8, running from Gohana to Sonepat draining the central part of the basin and discharging into the Yamuna north of Delhi's northern border;
(3) Drain No.8 extending the Nai Nallah Drain from Gohana to Delhi, discharging into the Najafgarh drainage system at the Bhindawas Lake (also called Jahajgarh Lake);
(4) The Najafgarh Drain connecting the Najafgarh Lake and the Yamuna River;
(5) The Gaunchi Main Drain draining east and west Faridabad and discharging into the Yamuna along with the Ujjina Diversion Drain at Hassanpur.

In addition there are several small gravity drains and numerous permanent pumping stations with a total capacity of 1,240 cusecs in this basin, lifting accumulated water from depressed areas in Sonepat, Rohtak, Faridabad and Gurgaon districts into canals.

4.2 The Ghaggar Basin (Part of Indus Basin)

The Ghaggar basin covers an area of 27882 km^2 or 63 % of Haryana's area in the districts of Ambala, Kurukshetra (in part), Kaithal, Fatehabad, Sirsa, Jind, Hisar, Bhiwani, and Mahendragarh. The Ghaggar River runs along the boundary between Haryana and Punjab states, crossing it at several points. Though less severe than in the Yamuna Zone, flooding in this Zone is exacerbated by cross-Ghaggar inflows (from the Punjab) in the districts of Kaithal, Fatehabad and Sirsa. Constructed embankments along Ghaggar River and its tributaries have reduced the frequency of inundation but not eliminated it as heavy rainfall and inflows across the Ghaggar River, still persist.
The main drains of this Zone are as follows:

(1) Saraswati Drain taking discharge from Bibipur lake and running along Kurukshetra and Pehowa area and outfalling into River Ghaggar.
(2) Amin Drain
(3) Kaithal Drain.
(4) Pundri Drain No. 1 and 2.
(5) Kassan Drain.
(6) Rangoi Nallah
(7) Rangoi Diversion Drain
(8) Hisar Drain
(9) Hansi Drain
(10) Rori Ghaggar Drain.

Besides, there are a number of other tributary and link drains. Many drains, such as Pundri Drain No. 1 and 2, Kassan Drain and others, terminate along irrigation canals and drainage effluents are discharged by gravity or pump-lifted. In the Sirsa district the Rori-Ghaggar Drain has been constructed to drain frequently inundated areas in the district. At Kaithal an outfall into the Ghaggar has been provided at the terminal of the Kaithal Drain.
Therefore, the accumulated surface runoff needs collection, conveyance and disposal of the runoff into two out flowing rivers: the Yamuna and the Ghaggar through proper well designed drainage channels. The area serviced by River Yamuna has an elaborate efficient network but the area covered by Ghaggar basin needs a good main drain, which can be networked by service drains.

5. Brief on Design of Drains in Haryana

5.1 General

Surface drainage of agricultural land essentially constitutes removal and disposal of excess water from the land surface. The design capacity of drainage channels is determined in three steps: -

- Determination of design storms i.e. depth of rainfall of desired frequency of recurrence during a selected time interval. This is determined from rainfall intensity frequency analysis.
- Conversion of rainfall to actual run-off giving due consideration to soil characteristics, land cover, cropping conditions, land use and topography.
- Computation of necessary channel capacity giving due regard to the degree pf protection required and the tolerance of crops to flooding.

It is a normal practice to allow water to accumulate to shallow depths for certain duration of time that will not cause serious damage to the crops sown and will help in recharging groundwater. The drainage channel should have sufficient capacity to remove the volume of run-off during this crop tolerance period. Though flood routing methods provide precise analysis of complex run-off removal situations in normal cases. It is a usual practice to assume that the drainage channels run at full capacity during the entire period determined for run-off removal.

5.2 Design Capacity

The entire existing drainage system in Haryana was designed on the basis of an empirical formula viz. Boston Society Formula.

$$Q = C\sqrt{A}$$

Where Q = discharge in cusecs
A = catchment area in square miles
C = coefficient to account for catchment characteristics, rainfall (upto 500 mm) etc. and is taken as

(i) 200 for area having rainfall less than 20 inches or 500 mm;
(ii) 480 for area having rainfall 20 inches to 30 inches or 500 mm to 750 mm and
(iii) 2000 for sub-mountainous areas rainfall more than 30 inches or 750 mm.

In working out the drain capacity, a reduction factor was applied, which depended on catchment area. The reason was to effect economy and also that smaller sections gave a better hydraulic performance than those designed for peak discharge. This reduction factor was kept as: -

(i) 1/12 for drains of 100 square miles catchment area;
(ii) 1/8 for drains of 101 to 250 square miles catchment area and
(iii) 1/4 for drains of 250 square miles and above catchment area.

Banks of carrier drains wherever required and cross drainage works were designed for peak discharge as per the above formula.

5.3 Alignment of Drains

The drains are generally aligned along the lowest valley line. As far as possible, the alignment of the main or outfall drains is kept along the center of the area to be drained. The alignment of the drain is kept away from the depressions, ponds, marshes or villages so that its hydraulic performance is not adversely affected. In case the drain is to be taken across the valley either to reduce the length or for proper outfall conditions, the embankment should not be of excessive height so as to minimize the danger of flooding in the event of breach in embankment. Alignment of drains should avoid the depressions, which cannot be drained out by gravity. In case of unavoidable circumstances when the drain has to be passed through a depression, the embankment should be provided on both sides.

5.4 Drains Section

Normally the cut section is provided in drains, which is adequate for design discharges and no embankment is essential. But when an embankment is necessary in order to accommodate a portion of design discharge or where disposal of excavated soil is costly, it is kept of low height and gaps are provided in embankments so as to allow unrestricted inflows. In forced circumstances where embankment has to be provided for design discharge, inlets have been provided to allow water of the surrounding area to enter the drain. In incidences of floods higher than the channel capacity, water can spill over the area during high flood and return to the channel when flood recedes.

5.5 Cross Section and Side Slopes of Drains

A trapezoidal section is provided and side slope depends upon the nature of material excavated. In loamy soils of Haryana the slopes of 1:1 for cut sections and 1.5:1 for embankments have been provided. The side slope in sandy soils should be flatter.

5.6 Full Supply Level of Drains

The Full Supply Level in drains is never kept more than 0.3 m above the average ground level. Where a drain outfalls into a main drain or river, the FSL at outfall is kept higher than the HFL of the main drain or river so as to avoid flat slopes leading to recurring silting problems or need for high embankments.

5.7 Hydraulic Slope of Drains

The longitudinal slope depends upon the natural country slope. This has generally been restricted to a minimum of 0.10 m per Km so as to ensure minimum velocity required to avoid silting problem, which has resulted in rise in FSL above NSL by more than 0.3 m. For such reaches it is better to keep slope even less than 0.10 as silt free water reaches the drain.

5.8 Berm Width of Drains

Berm in drain is provided between the toe of embankment and the section of the drain. It should be equal to the depth of the drain subject to a minimum of 1m.

6. Conclusions

As is evident from the history, flood is a frequent event in the state. A large area in the flood plains of the Yamuna and Ghaggar rivers are inundated by either flood from the rivers, and/or by heavy precipitation. The following Measures are necessary for tackling the problems of perpetual flood.

- The storage dams across Yamuna River, outside the Haryana State need be constructed at priority.

- The small storage dams for water harvesting and soil conservation in the Shivalik foothills as taken up at higher pace as these dams would not only provide necessary irrigation water to farmers but would be a good treatment of soil in catchment area of the rivers. The catchment area should also be taken up so as to ensure soil conservation and avoid sudden flooding.

- Proper data acquisition and base needs to be improved, and maps need to be prepared for flooded areas based on the data and statistics of flooding events, flooding depth, duration and frequencies etc.

- Establishment of flood forecasting station is another priority for the state for which the Indian Metrological Department or Central Water Commission can be requested contacted.

- There is a Flood Warning (FW) system in the state but it needs to be revamped and designed for the needs of Haryana.