Trans. Inst. Indian Geographers
Vol. 22. No.2, July, 2000

FLOODS : AN ECOLOGICAL HAZARD OF THE SEMI-NATURAL DRAINAGE ECOSYSTEM OF THE INTER STATE CHANDIGARH REGION, INDIA

YADVINDER SINGH, Patiala

ABSTRACT : The Drainage System that was existing prior to the development of the city of Chandigarh has undergone a tremendous change in the last fifty years. The main factors that brought about this change are (i) The resultant 'badland' topography of the Siwalik hills in the northeast due to continuous deforestation and grazing resulting in increased run-off. (ii) Change in longitudinal profiles of ephemeral streams due to silt deposition giving a planar to convex profiles to stream beds. (iii) Eutrophication of streams due to sewage inflows in Attawa Choe, Kanthala Choe, Patiali Rao Choe and Sukhna Choe.

The result is that the rise in stream beds due to deposition of silt brought down the Siwaliks as well as eutrophication of stream beds due to discharge of sewage waters, flooding during rainy season is a normal feature year after year resulting in inundation of agricultural lands. During minor floods there is deposition of fertile alluvium in the fields making them more productive with increased soil fertility and moisture content. But large tracts of Inter-State Chandigarh Region (ISCR) lying in Punjab experienced two major floods in 1988 and 1993 causing greater damage. As much as 1,915.25 sq km area of Punjab and Haryana plains of ISCR was under water in 1993 in contrast to only 487.00 sq/km flood area in 1988.

The only remedy to check floods is (i) The gradual growth of thick forest cover in the Siwaliks thus checking siltation due to large scale run-off and (ii) by stopping the cutrophication of stream beds through treatment of discharged sewage waters from Chandigarh and its satellite towns.

INTRODUCTION

Development is an integral part of human progresss. In reality the term signifies exploitation of all biotic and abiotic resources available in natural environment for creation and growth of man-made environment. But developement, more often, is accompanied by environmental degradation. This is true of the modern city of Chandigarh in North West India where its fast development and expansion has cast some adverse effects on the ecology of Inter State Chandigarh Region (ISCR).

While the ecological effects of development in the Natural Hilly Ecosystem (NHE) of ISCR have earlier been studied and commented upon by Singh (1990, 1995 a, b) and Mehta and Singh (1995), in the present communication, effects of development on Semi-Natural Drainage Ecosystem (SNDE) or Waste-Assimilative Life Support Environment (WALSE) of the region have been analysed.

DEMARCATION OF DRAINAGE ECOSYSTEM

Co-ordination committee on Regional Planning as set up by the Government of India in 1975 originally demarcated ISCR with

Chandigarh as its core, sprawling over a landscape of 2, 513.5 sq km and extending from 30° 22' N- to 30° 57' N Lat. and 76° 25' E-to 77° 11' E Long. But, in order to include the areal spread of different operative ecosystems which cover the Chandigarh ecosphere, original ISCR was enlarged by the writer to cover tehsil as a functional unit for data base. This meant inclusion of adjoining areas of Punjab, Haryana and Himachal so as to cover an area of and 5, 391.50 sq km lying between 30°17' 31° 11' N. Lat. and 76° 16' to 77° 16' to 77°29' E. Long, with various functional ecological units often overlapping. Thus construed the ISCR is bounded by two great rivers of north India, the Yamuna on the east and Satluj on the west but within the ISCR there is no river except Ghaggar which is now a seasonal stream rising from the Siwaliks and drying up before entry into Rajsthan. Additionally, there are a number of seasonal streams draining ISCR. Here in ISCR, the SNDE covers only 197.75 sq km area and the NHE from where the SNDE originates, streches over an area of 684.758 sq. km. (Fig. 1).

FACTORS EFFECTING DRAINAGE ECOSYSTEM

The drainage system that was existing prior to the development of the city of Chandigarh has undergone a tremendous change over the last fifty years. The main factors that brought about this change are as follows :

(i) Badland topography of Siwalik Hills: In NHE of ISCR two ranges of Siwaliks lying in North East of ISCR are clearly demarcated, one on the east and the second on the west of river Ghaggar. These are respectively known as Morni and Kalesar Hills with 314 sq km area and Chandigarh Siwalik Hills with 370.75 sq km area. Writing under the title "Requiem for Siwalik Forests" and elsewhere Singh (1990, 1992, 1995a, 1996) pointed out that :

(i) During pre-Indepence period (1850-1947) the submontane zone of Chandigarh Siwalik Hills had plenty of sal forests ..... While at the foot of the hills in the savannah jungle there were abundant trees of *simbal*, *dhak*, *katha*, and *ber* together with *Katha-Tahli* forests in the riverain tracts abounded by grasses and seasonal patches of bamboos.

(ii) Now there is plenty of sal in Paunta Sahib - Nahan - Kalesar zone east of Chandigarh, a few patches of sal forest are found in Hoshiarpur Siwaliks at Bharwain (now in Himachal) on route Jawa Lamukhl and patches of sal occur in the Jammu Siwaliks

(iii) East of Pinjore the Morni forest in Haryana has plenty of chirpine and in Jammu Siwalik the chirpine is not scarce at all. In the intervening region there is plenty of chirpine on higher reaches of Pathankot Siwaliks.

(iv) Presently, there is no evidence of sal in Punjab Siwaliks and chirpine is found only near Pathankot.

(v) Because of large scale destruction of forest cover soil erosion become a major problem in Punjab Siwalik Hills by the turn of the last century.

(vi) Now in Siwaliks beyond Chandigarh there is hardly any closed forest area. The hills are characterised by highly degraded forests in which thorny species dominate and trees are very few in variety as well as in numbers.

(vii) When Chandigarh started comming up begining with 1950. the demand for bricks increased by leaps and bounds and to fire bricks forests were cut to the last tree.

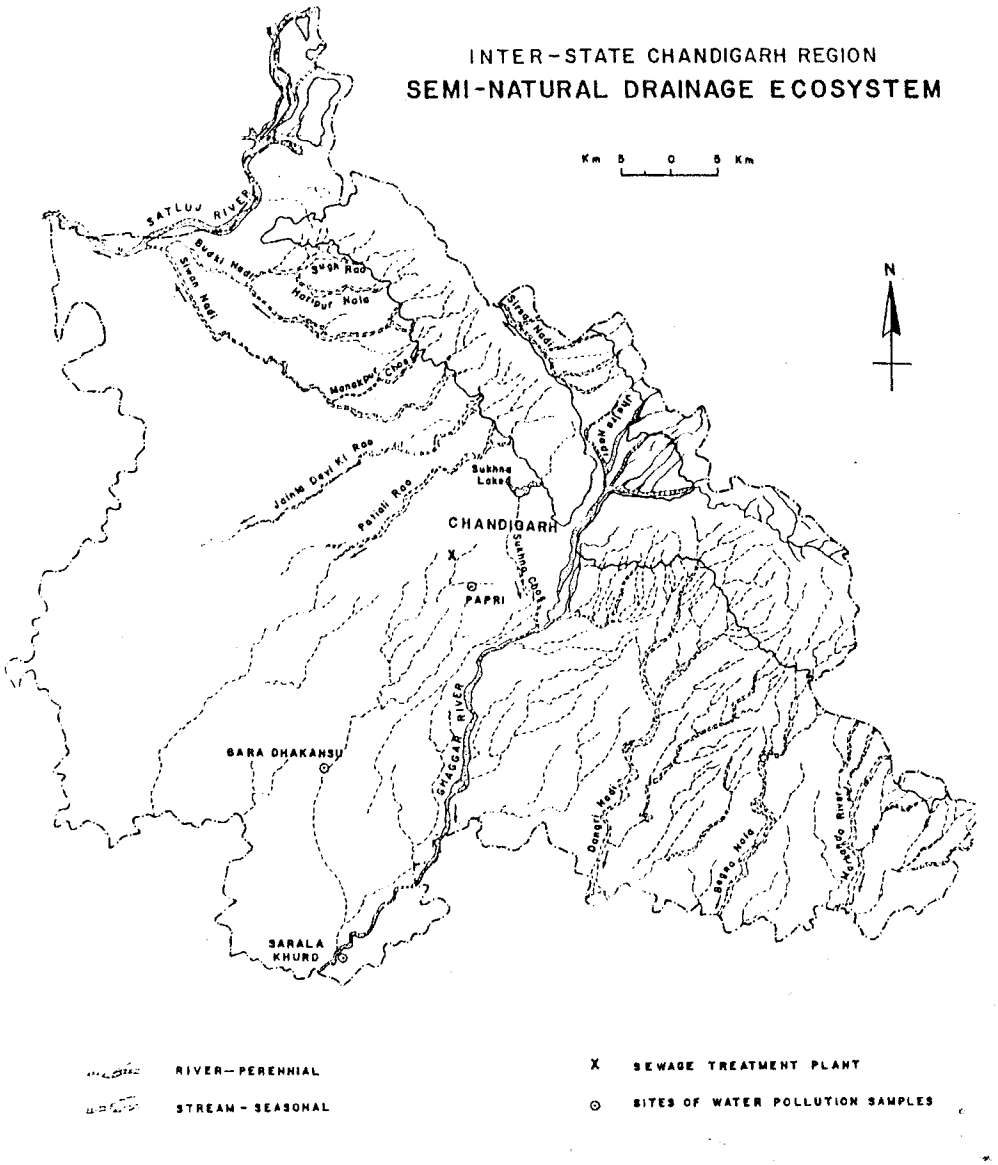

Fig. 1 : Inter-State Chandigarh Region - Semi-natural Drainage Ecosystem

Labourers also needed fuel to cook their food.

(viii) Choe terraces were converted into cultivable land.

(ix) Only scrub vegetation is left on the south-western side of the hills. Patiali Rao and Jaintia Devi Ki Rao catchment areas are now facing acute soil conservation problems.

(x) Landslips, gulleys and choes, large and small, are a common feature of these hills. Further, Singh (1995a) pointed out that in Chandigarh Siwalik hills changing vegetation pattern over the last five

decades or so has been mainly on vegetation side with the tree canopy all around being severly broken by human activities and at present 70-80% of the area of Chandigarh Siwalik Hills supports highly degraded tropical try deciduous scrub vegetation with abundance of thorny shrubs and scattered trees of low height and xerophyte predominating.

Mehta and Singh (1995) who analysed the environmental issues for Chandigarh Siwalik hills pointed out that

(i) Soil erosion in the hills of NHE has contributed to the problem of land degradation.

(ii) Changes in *NHE* have introduced or accelerated disorders in the availability of water, intensification of the rate of soil erosion and

(iii) Transformation of dense forests into scrubs. They also noted changes in ground water conditions with the result that the ground water recharge is weak. Their study also touched upon interaction aspects with other ecosystems. According to Singh (1995b) the story for the Morni and Kalesar Hills of ISCR between Ghaggar and Yamuna river is not different. There has been large scale deforestation and degradation of forests in these hills during 1966-1984 with over-all fall in forest area in Morni Hills by 12.35% during 1983-1986 and forests were mainly of Open and Scrub types (Singh, 1995 b) but with subequent afforestation efforts scrub forest area in 1991 decreased by 34.94% and Dense Forest area increased by 105.10% in Morni Hills. Even today, Chandigarh Siwaliks as well as Morni and Kalesar Hills present 'badland' topography of the highest order.

Because of deterioration in forest quality due to heavy biotic interference, unplanned timber extraction, road building and execution of developmental works, there are large water induced land slips / slides and gully formation in Morni and Kalesar Hills (Singh 1995 b).

Soil erosion in the hills of NHE has contributed to the problem of land degradation and the changes in the ecosystem have introduced or accelerated disorders in the availability of water, intensifications of rate of soil erosion and transformation of dense forests into scrubs (Mehta and Singh 1995). Over the years there have been marked variations in the quality and extent of forest cover in NHE. The earlier trend towards deterioration has of late been reversed to improvement side with afforestation efforts laking a big leap-forward. Sadly enough, along with this, during the last 100 years due to large scale forest destructions in Siwaliks of ISCR, one time valuable timbers of chirpine and sal have been totally extirpated from Chandigarh Siwaliks and in the Morni Hills. No doubt, some chirpine stands do exist but these forests have no extractable timber now. There has been a large scale destruction of plant wealth and a good amount of fauna has disappeared. The forests which are not only protective but also productive assets of the life support environment, on being over-burdened for biomass productivity by unscientific anthropogenic interference, have yielded place to ecologically vulnerable hilly region of ISCR experiencing high rate of soil erosion with reduction in forest area since Stable Forests cover only 36.5% area and 51. 34% area is in process of deforestation.

(ii) Sedimentation of seasonal streams in hill-foot plain :

Soil orosion in Punjab Siwaliks is an old problem (Grover, 1946) but with the development of Chandigarh the process has

been accentuated in the NHE of ISCR. Heavy siltation of the famous Sukhna Lake within a short span of its construction is a familiar example of heavy forest destruction in catchment zone and consequential heavy water run-off with soil loss. Like several other regions in India, the Siwalik hills experience severe soil erosion of more than 20 tons per hectare per year (Singh et al. 1990). According to Singh (1996) the rate and extent of soil erosion are governed by the quality and extent of vegetal cover, erosivity (rainfall), erodibility, topography, land management and socio-economic conditions of the people. Sedimentation of seasonal streams in SNDE of ISCR has brought about changes in their profiles. The present average soil loss of 367.5 t/ha/y from catchment area of certain Chandigarh Siwalik Hill streams is alarmingly high (Singh, 1996). The analysis of long profiles of streams, namely Manakpur choe, Sugh Rao, Jaintia Devi Ki Rao, Budhki and Siwan Nadis of the piedmont and hill-foot plains adjoining Chandigarh as studied by the writer (Singh, 1992) has indicated that the profiles lack the concavity which the graded streams attain to maintain competence and capacity to transport its load. When these main streams enter the hill-foot plain from Siwaliks and their tributaries too, which originate in the piedmont plain near the base of hills, these form very gently sloping, longitudinal profiles due to siltation. These streams have generally planar to some degree plano-convex curves (Singh, 1992). According to Mishra et al. (1978) in Siwalik areas untreated against erosion, on an average 50% of the total rain ends in run-off. Average annual rainfall for Chandigarh is 1,100.7mm. and nearly half of it goes unutilized down stream carrying huge amounts of silt alongwith it. So when heavy run-off comes from the badly denuded Siwalik Hills, with the raised stream beds, the water overflows the banks and causes floods.

(iii) Eutrophication of Streams :

Chandigarh has a very effective sewerage to collect into sewers both the domestic sewage and industrial effluents as well as the run-off from downpours. These are all drained out in the direction of natural slope towards south into seasonal streams. The city sewage system drains out in Attawa Choe (called Chila Choe down stream) and Kanthala Choe (as known as Choi Nala). The waste waters of SAS Nagar, Panchkula and some of the authorised and unauthorised colonies of the city drain out into Patiali Rao and Sukhna Choe. The industrial effluents flow into common sewer that joins the main sewage system carrying domestic sewage from urban areas to the Sewage Treatment Plant (*STP*). In 1982 only 24.50 mld of waste waters were treated at STP out of a total of 78 mld while in 1992 the total waste waters amounted to 163.80 mld (including 52.20 mld industrial effluent) out of which as much as 135 mld were treated (82. 12%). Although the quantity of pollutants (BOD, COD, TES, oil and grease) removed, has by and large, multiplied yet the treated sewage is still loaded with very high content.

Over the years, the quantity of waste waters of Chandigarh Agglomeration has increased more than 100% but the pollutant removal is only fractional. There does not seem to be any overall decline in the quantity of total wastes carried daily to the seasonal streams even after primary and secondary treatments. It may be noted that at STP removal of heavy metals is not done and use of sewage waters for irrigation is not free from heavy metal hazard.

Besides the waste water flowing into the streams of ISCR around Urban Aglomeration of Chandigarh after treatment from STP,

some sewage directly falls into Attawa choe from sector 23 and some industrial units pour out effluents heavily loaded with solid wastes directly into Patiali Rao and Sukhna choe from Industrial areas of *SAS* Nagar and Panchkula respectively. Thus the raw and the partially treated sewage contributed to the streams increase the pollution load down stream till they reach the outskirts of Chandigarh Conurbation. But as waste waters flow a long distance in these streams, the pollution as well as nutrient levels dediness with deposition of the sludge in the channel bed. With the progress of self purification process over distance in streams and with passage of time, the conditions change from polysaprobic to oligosaprobic. During succession the community structure changes and many less pollution tolerant forms appear in the later phase of succession (Walia, 1989).

According to Odum (1983) if organic material from sewage or industrial wastes can not be assimilated, the rapid accumulation of such material may destroy the system. The phrase cultural eutrophication is becoming widely used to denote organic pollution resulting from human activities. Thus at some time such combinations like accumulation of urban-industrial effluents, eutrophication, growth as well as death and decay of planktons (phyto- and zoo) aided by sedimentation in the stream channels result in speeding up the conversion of drainage basin towards nearly a terrestrial landscape. Therefore, in case of small water bodies like choes and streams there is net inflow of material (soil erosion and sewage solid waste sedimentation), more often outflow is obviously restricted and during heavy rains consequential heavy run-off from NHE and piedmont plain of Chandigarh, water in the water streams and choes over tops the banks causing floods.

FLOODING

With the rise in the stream beds due to deposition of silt brought down the Siwaliks over the centuries in piedmont and plain areas of the ISCR, flooding during rainy season is a normal feature year after year. Such inundation of agricultural lands along the margins of the streams is beneficial to agriculture because as a result of minor floods there is deposition of fertile alluvium in the fields which makes them more productive. Also moisture content of the soil is increased and in the non irrigated areas the prospects of raising good rabi crops become brighter.

However, human activity in drainage basin often aggravates flood hazards. Medlicott (vide Kayastha, 1992) had noted quite early that forest destruction was resulting in increased burden of detritus, obliterating the conditions of slope and resulting in accumulation of sand for which there was no water to carry further down. Excessive logging in the catchment areas of the streams leads not only to increased soil erosion but also to increased water run-off bringing in turn, flash floods in the choe valley lowlands and the flood plains. Since 1966 large tracts of the ISCR lying within Punjab experienced two major floods. This happened within just 6 years i.e. in 1988 and in 1993. The flood areas of 1988 and 1993 are shown in figures 2-3.

The flood fury was of Ear greater Intensity during 1993 as compared to 1988 as revealed in figures 3-4 and table 1. Also the damage caused was definitely greater.

As much as 1,747.50 sq km area was under water in 1993 in contrast to only 319.25 sq km in 1988. In 1988 Ropar tehsil had the maximum area (152 sq km) under water whereas in 1993 the maximum flooded area of 730.75 sq km was in Rajpura tehsil constituting more than

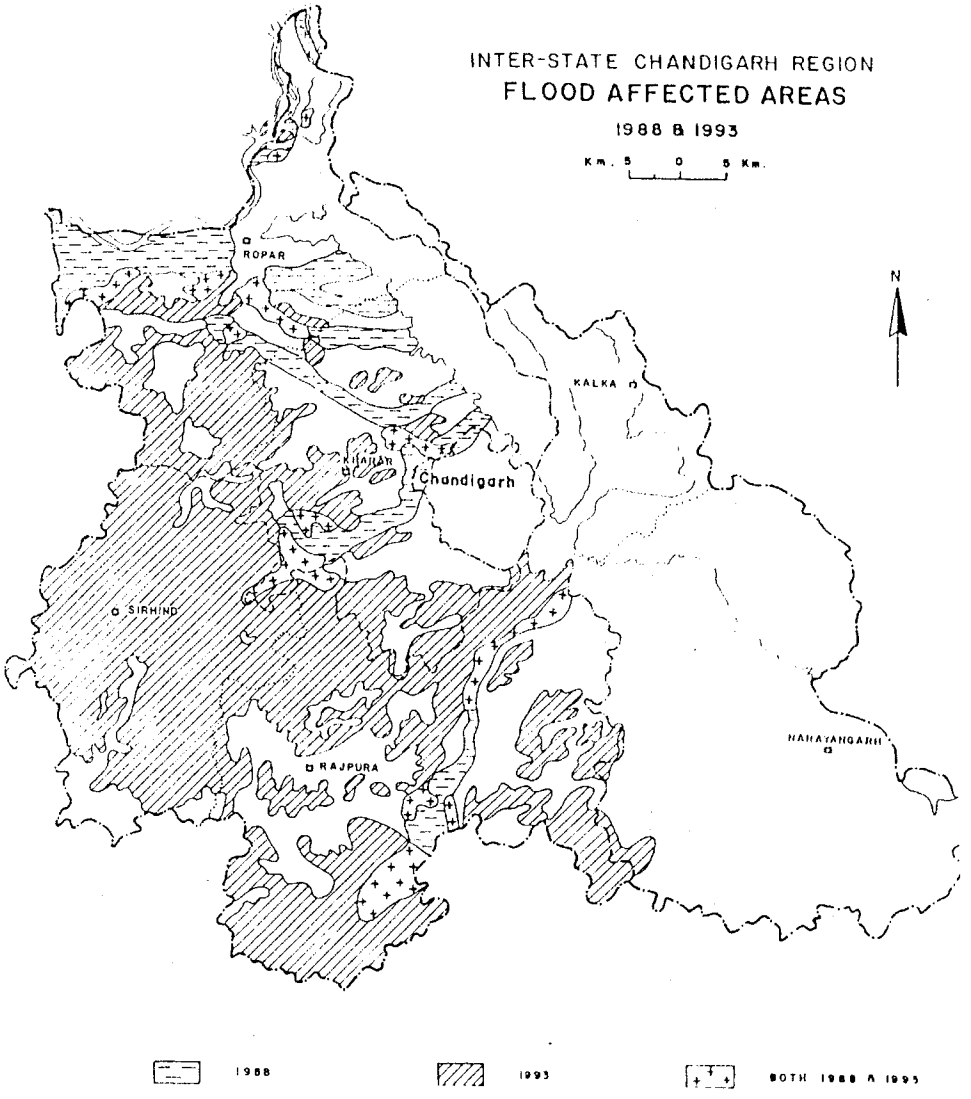

Fig. 2 : Inter-State Chandigarh Region - Flood affected areas

one third of the total area flooded. Union Territory of Chandigarh experienced no floods in 1993 but in 1988 only 7.50 sq km area was flooded. If we take the areas which experienced floods both in 1988 and 1993, then the lowest and highest figures are Kharar : 41.50 sq km and Rajpura : 77.75 sq km. Narayangarh tehsil, however, experienced no floods in 1988 while in 1993 the flooded area was just 17 sq km but very severely effected. Monitoring was also possible of flood intensities for 1993 in the flooded areas of the ISCR (Table 2) :

(a) Slightly flooded areas constituted only 10.63% of the total flooded area whereas

Table 1

ISCR : Flood Affected Areas, 1988 and 1993+ (sq km)

Year	Tehsils						Total ISCR
	Ropar	Kharar	Rajpura	Fatehgarh Sahib	Narayangarh	Chandigarh (U. T.)	
1988*	152.00 (47.61)	121.50 38.06)	38.25 (11.98)	– (2.35)	–	7.50	319.25
1993*	209.25 (11.97)	205.75 (11.77)	653.00 (37.37)	662.50 (37.37)	17.00 (37.91)	– (0.98)	1,747.50
1988 &1993**	48.50 (28.91)	41.50 (24.74)	77.75 (46.35)	–	–	–	167.75

\+ Figures within parantheses indicate per cent of the total ISCR flood affected area.
* Areas exclusive to each year.
** Flood affected areas common during the two years.

Source : PRSC 1993; Irrigarion Departments, Punjab and Haryana 1993.

the rest of about 90% was under severe or moderate intensity floods.

(b) Floods of severe intensity were experienced by more than half (52.84%) of total flooded area of 1,915.25 sq km.

(c) Rajpura Tehsil accounted for 38.16%, Fatehgarh Sahibn 34.59%, Ropar 13.46%, Kharar 12.90% and Narayangarh only 0.89% of the total flooded area.

(d) With the total flooded area of 662.50 sq km in Fatehgarh Sahib tehsil as much as 65.09% area experienced severe floods.

(e) Rajpura tehsil with maximum flood area of 730.75 sq km had 62.54% area reeling under severe floods.

(i) Damages :

According to Irrigation Department, Punjab and certain press reports significant infrastructural damages took place during 1993 floods. Narwana Branch of the Bhakra Main Line (BML) Canal breached at thirty odd places. A major 200 m breach in Satluj-Yamuna Link (SYL) Canal occured near Jansui (Rajpura-Chandigarh road) and four minor breaches developed downstream of this very canal. SYL Canal was also breached near Doomcheri village (near Morinda). Bridge over SYL Canal near Ropar was partly washed away and some culverts gave in under the pressure of stream flow. Near Ropar two breaches occured in BML Canal.

National Highway No. 1 was breached close to Sarai Banjara near Rajpura with 50m of road being completely washed away. Three kilometre road track was also damaged near Shambhu. A 500 m breach occured on National Highway No. 21. near Ropar. A sizeable portion of railway track on Sirhind-Rajpura section was washed away near Sadhugarh.

River Ghaggar changed its course along the right bank and floods destroyed the embankment near Lion Safari of Chhat Bir Zoological Park, damaging forest plantations. The thickly populated commercial area of

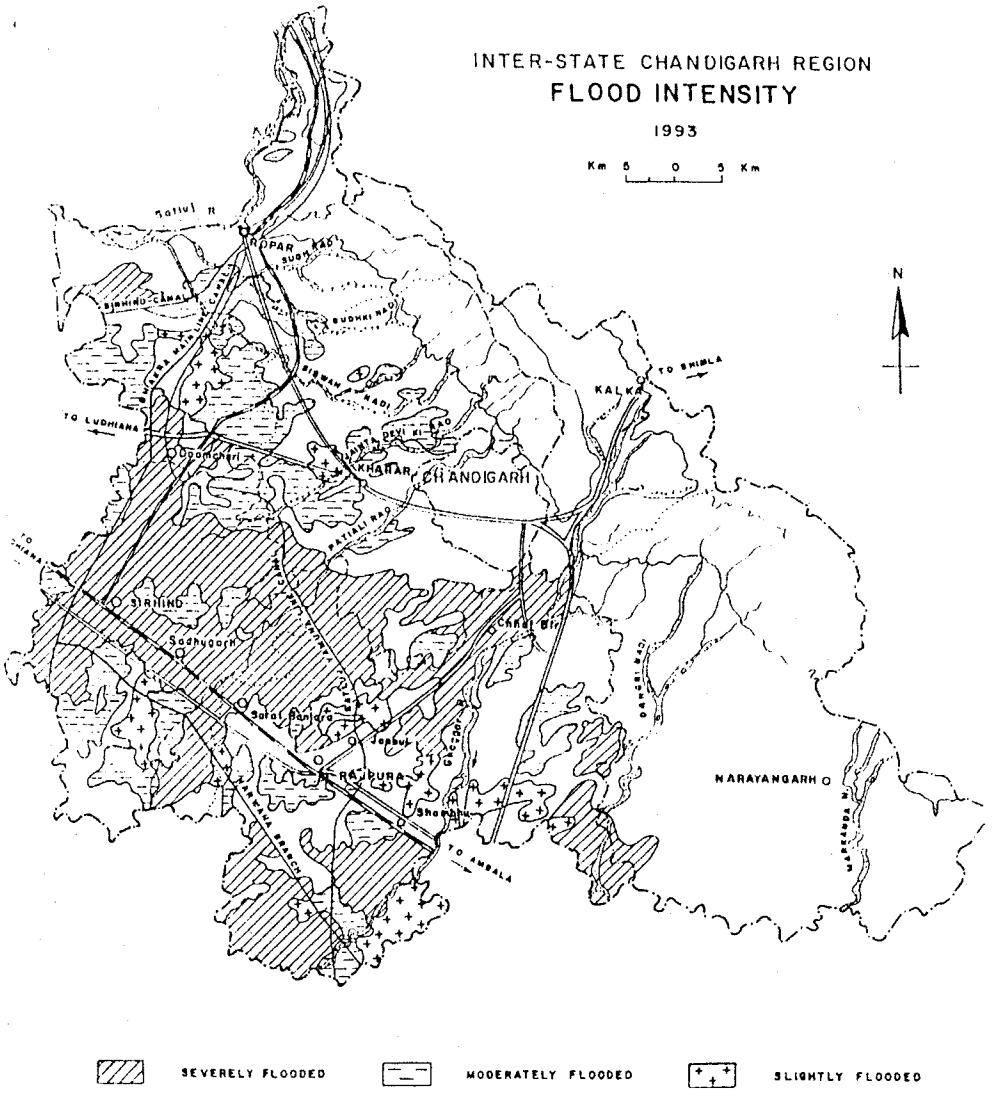

Fig. 3 : Inter-State Chandigarh Region - Flood Intensity

Ropar was ravaged by a 20 m wide and 10 m deep gorge that provided a link between the breached Budhki Nadi and Sirhind Canal. Sugh Rao, Budhki Nadi and Siswan Nadi embankments were breached and the streams had overtopped flow at numerous places.

A large number of village link roads in the choe velley lowlands and flood, plain were also damaged. Consequential to floods rail road, telecommunications and power supply were disrupted. In Ropar, Kharar and Rajpura tehsils over 8,000 hectares of land came under a thick carpet of sand which

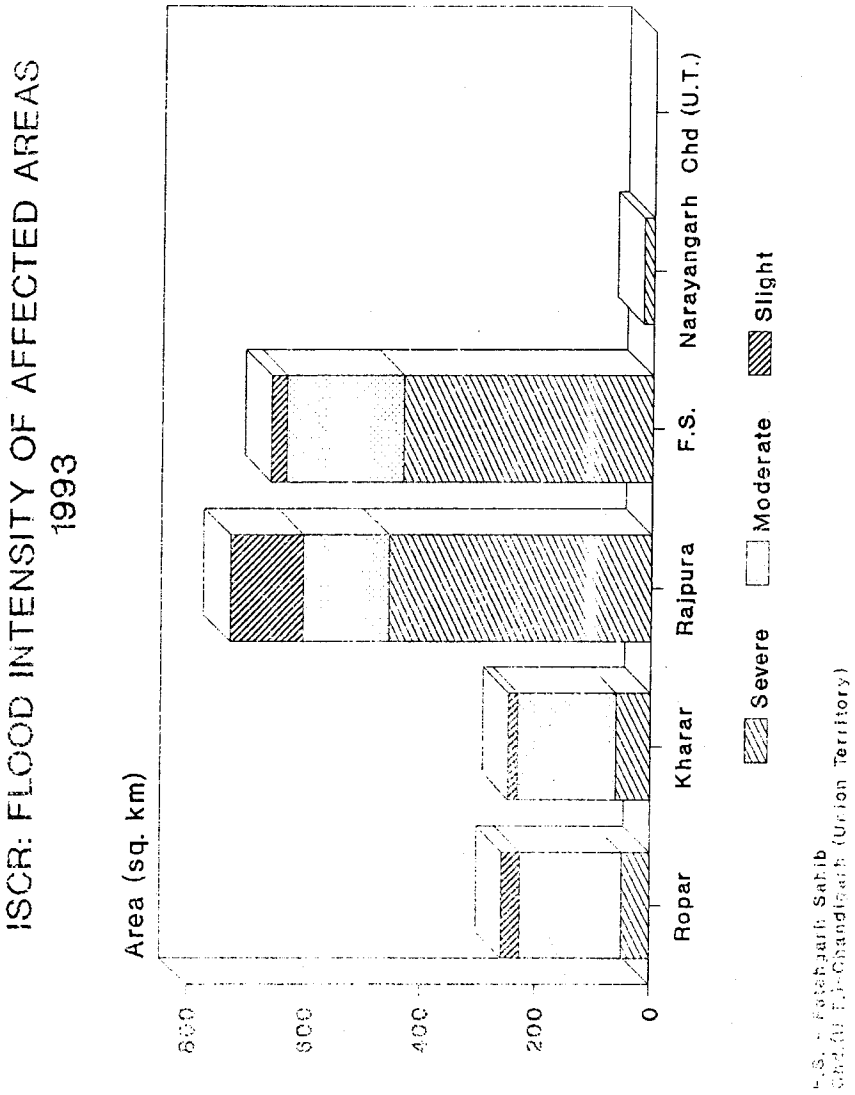

Fig. 4 : ISCR - Flood Intensity of affected areas - 1993

required a massive effort to reclaim. About 700 villages were thus affected. Large area of Kharif crops (oilseeds, paddy, sorghum etc.) had come under deluge. There was tremendous loss of human and cattle lives. Besides, epidemics like cholera and typhoid fever, diarrahoea, skin and respiratory diseases followed. Worst affected were urban slums and low lying areas where sewage got mixed with flood waters. Rural areas, in the vicinity of drainage lines from urban-industrial areas were most affected when streams carrying industrial effluents and sewage overflowed their banks and polluted agricultural lands.

(ii) Infrastructural Developments and other Man-Made Changes that Aggravated Floods

1. The incomplete SYL Canal became a man-made obstruction in the natural flow of water in the streams. The syphons, provided at different locations, on getting choked proved to be of little or no help. Consequently, the streams changed course as gushing waters moved to the southwest. Due to lack of proper syphons, underneath the SYL Canal, BML Canal and its Narwana Branch, clear natural channels downstream were obstructed by these canals.

2. Though stream embankments have been made in certain low lying areas to contain the flow of water, yet the rise in the level of stream beds as a result of high rate of sedimentation caused water to overflow the banks. The other contributory factors were the choking of streams by silt, weeds and flow of sewage from urban areas; obstruction of laminar flow due to urban encrochments; Eucalyptus, poplar and sugarcane cultivation on stream beds.

   Also, poorly maintained embankments could not withstand huge quantities of gushing waters and caved in at a number of places resulting in breaches.

3. Water rose in Ropar city and its surrounding countryside because the National Highway No. 21 intercepted the natural flow of Budhki Nadi and Sugh Rao. In the absence of any culvert, water started flowing towards the city.

4. The faulty design of the SYL Canal is also responsible for the floods in Ropar, Kharar and Rajpura tehsils. The flow of SYL Canal water was arrested in several low lying areas in Ropar and Patiala districts. As water continued to rise in such low lying areas, it ultimately breached the canal at different places.

5. Blocked sewers and inadequate arrangements for the disposal of sewage carried in sewer lines and failure to clear sewage disposal sites, created a grim situation during flooding by blocking the flow of water both in drains laid inside the urban areas and seminatural drainage lines in their vicinity.

(iii) Aftermath

It may be noted that the lands in the drainage area of the streams soon dry and the flooded streams return to normal flow within a short time after the rains subside. After some time when there are no rains, drought prevails as springs cease to exist because of vegetational degradation and xerophytic conditions prevail in the NHE.

(iv) Plus Point

However, at the time of floods, intercalation of subsurface water into cavities in the channels, loose soil, sand and gravel provide a seasonal reservoir for water supply to streams during period of drought.

CONCLUDING REMARKS

In ISCR the streams of SNDE pass through the hilly, urban and agricultural lands of their respective ecosystems. These have undergone effects of man-made changes on the forest ecosystem, total run-off, peak flow characteristics, hydrology of the area and quality of water,all consequential to development of Chandigarh and urbanization of its environs. The inferences that could be drawn from the present studies are :

1. The volume of run-off is governed primarily by infiltration characteristics and is related to slope, soil type and vegetative cover in the hilly and agroecosystems. It is therefore, also directly related to the percentage of impervious built up covered area of the urban land-use.

2. Total run off increases as a result of low permeability existing in the deforested hills, and bare urban landscape exposed during infrastructural development. As volume of run-off increases with high sediment yield during monsoon the flood peak also rises. Run off volume, thereby, also affects base flows because in any series of storms the larger the percentage of direct run off the smaller is the amount of water available for soil moisture replenishiment and for ground water storage.

3. Major effect on the water quality is of urban industrial land-use through the disposal of effluents from STP as well as the raw sewage into streams. It may be mentioned that not only raw sewage contains disolved minerals, solids and chemicals but even the treated effluents persistently retain toxins that are not extracted through treatment.

   Insecticidal and pesticidal percolation into streams from agro-ecosystem and chemical effluents from urban industrial waste water have net adverse effects on water quality and on stream plankton. Addition of mineral nutrients from both urban and agro-ecosystems enhances the growth of phytoplankton but in turn alters the balance of stream biota.

4. The amenity value of the hydrologic environment of the SNDE is primarily affected through the enlargement of the stream channels owing to increased floods which tend to have unstable banks and high turbidity of water resulting in sedi mentation of stream beds. The SNDE is also a waste assimilative life-support environment as a result of two factors namely 'solid waste accumulation' and the 'disruption of balance in the stream biota' that are detrmental to water quality. The gamut of urban and farm organic depositions in the channels changes a clear stream into one covered with slime having highly turbid water emitting foul smell.

Finally, it may be stressed that eutrophication of streams, loss of vegetal cover in the Siwaliks, high rate of soil erosion, deregulation of drainage basin resulting in heavy sedimentation of streambeds coupled with man-made infrastructural developments leading to obstruction in the natural water flow system, hav all greatly increased the flood prone areas on the ISCR.

The only, remedy to check floods is (i) The gradual growth of thick forest cover in the Siwaliks. (ii) stopping the eutrophication of stream beds through proper treatment of discharged sewage waters from Chandigarh and its satellite towns, (iii) Provision of proper passages to natural flow of rain waters, (iv) Stoppage of inhabitations or other construction works along banks of streams which should be provided with compact earthen, embankments after desiltation, (v) Lastly, enlightening public regarding benefits of allowing free flow of the waters in streams.

ACKNOWLEDGEMENTS

The writer is extremely thankful to Professor (Rs.) S. Mehta and Dr. (Mrs.) Dhian Kaur from Chandigarh for guidance, helpful criticism and moral support through out the conduct of the present work. Professors G. S.

Gosal and Jasbir Singh have been a great source of inspiration to me.

NOTES

1. Botanical equivalents of local names of trees : Simbal - *Bombax cieba* (*Salmalia malabarica*), sal - *Shorea robusta*, dhak - *Butea monosperma*, katha - *Acacia catechu*, ber - *Zizyphus numularia*, tahil - *Dalbergia sissoo*, Chirpine or Chilpine - *Pinus roxbuxghii*.
2. Attawa Choe, Kanthala Choe, Patiali Rao, Sukhna Choe, Jaintia Devi ki Rao, Sugh Rao, Manakpur Choe, Budki & Siswan Nadis names of seasonal stremas.
3. PRSC - Punjab Remote Sensing Centre, MBL - Bhakra Main Line, SYL - Sutle, Yumna Link.

REFERENCES

Berry, B. J. L. and Horton, E. E. 1974. *Urban environmental Management : Planning for Pollution Control.* New Jersey L Prentice Hall.

Glover, H., 1946. *Erosion in th Punjab : Its causes and cure - A Survey of Soil conservation*, Lahore : Feroze Print Works. pp. 1-x, 1-143.

Kayastha, S. L., 1992. Forests and Ecology in the Himalaya. In : Singh, R. B. (Ed.) *Dynamics of Mountain Geosystem.* Mew Delhi : Ashish Publishing House. pp. 26-39.

Mehta, S. and Singh, Y. 1995. Spatio-Temporal Changes in the Natural Hilly Ecosystem : A case study of the Chandigarh Siwalik Hills. *Trans. Inst. Ind. Geogr. 16* (2) : 135-146.

Mishra, P. R., Mittal, S. P. and Bansal, R. C. 1978. Manging landsand water resources of Siwaliks. Proc. Nat. Sym. on *"Land and Water Management in the Indus Basin (India)"*. Vol. 1. *Land and Water Resources*. Published by the Indian Ecological Soi. PAU, Ludhiana. pp. 215-220.

Odum, E. P. 1983. Basic Ecology. Philadephia : Saunders College Publ.

Singh, Y. 1990. Requiem for Shiwalik Forests. The Tribune : Spectrum dated August 9, 1990.

Singh, Y. 1992. Analysis of the Longitudinal Profiles of the Piedmont Plains of Northern Punjab. *Indian Geographical Journal 67* (2) : 56-61.

Singh, Y. 1995a. Saving Shiwalik Hills. The Tribune : Chandigarh dated July 1, 1995.

Singh, Y. 1995b. Landscape Changes in the Morni and Kalesar Hills, Northwest Siwaliks. XVII Indian Geography Gongress December 29-31, 1995. University of Jammu, Jammu. pp. 38-39. (Abstract).

Singh, Y. 1996. Corelative Degradational factors Operative in Chandigarh Siwalik Hills, NW India. Proc. 83rd Indian Sci. Congr. Patiala. Part-II (Y. S. Abstract). Section : Earth System Sciences.pp. 25-26.

Singh, G., Rambabu, N. P., Bhushan, L. S. and Abrol, I. P. 1990. Soil Erosion rates of India. Proc. Internal. Sym. on Water Erosion Sedimentation and Resource Conservation. Dehra Dun, India : CSWCRTI. pp. 32-38.

Walia, A. 1980. Pollution Biologyy of the Effluent Channels of Chandigarh Waste Waters, M. Phil (Zoology), Thesis Punjab Univ., Chandigarh.

ADDRESS OF THE AUTHOR

Dr. Yadvinder Singh
Department of Geography,
Punjabi University,
Patiala - 147 002 India.