1. Details of Module and its structure

Module Detail	
Subject Name	Geography
Course Name	Geography 02 (Class XI, Semester - 2)
Module Name/Title	Drainage – Part 1
Module Id	kegy_20301
Pre-requisites	Knowledge about Drainage pattern
Objectives	After going through this lesson, the learners will be able to understand the following: • Drainage system, catchment area, watershed • Factors affecting Drainage patterns • River drainage patterns • River regimes. • River interlinking projects • Water pollution • Ganga action plan
Keywords	Drainage, Drainage System, Perennial, Catchment Area, Watershed, Drainage Basin

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You have observed water flowing through the rivers, *nalas* and even channels during rainy season which drain the excess water. Had these channels not been there, large-scale flooding would have occurred. Wherever channels are ill-defined or choked, flooding is a common phenomenon. The flow of water through well-defined channels is known as '**drainage'** and the network of such channels is called a**'drainage system'.**

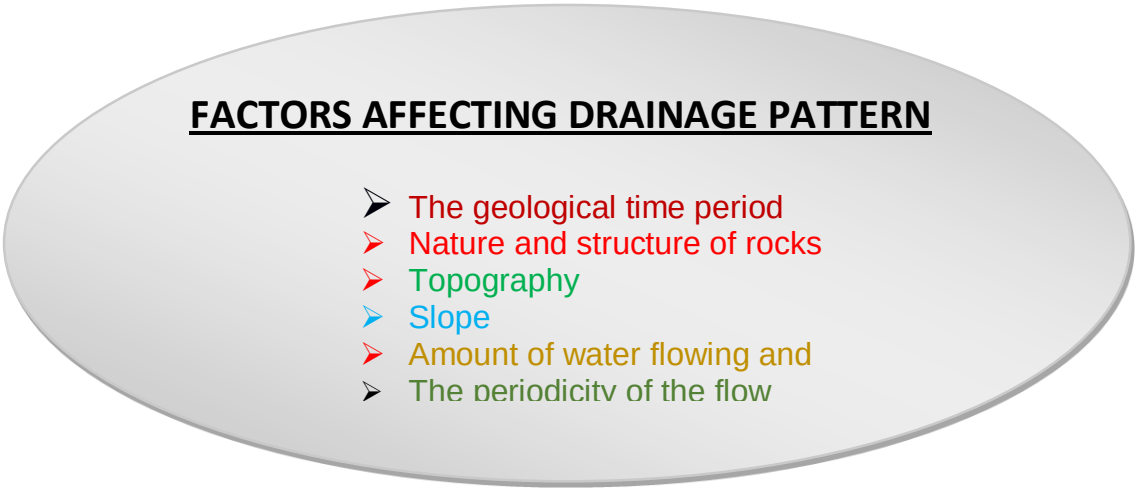

Fig 1. Factors Affecting Drainage System

Is river **perennial** (always with water) or **ephemeral** (water during rainy season, and dry, otherwise)? Do you know that rivers flow in the same direction? Can you explain the reason for water flowing from one direction to the other? Why do the rivers originating from the Himalayas in the northern India and the Western Ghats in the southern India flow towards the east and discharge their waters in the Bay of Bengal?

A river drains the water collected from a specific area, which is called its '**catchment area'**. It is an area which surface runoff is carried away by a single drainage system. The area of land bounded by watersheds draining into a river, basin or reservoir.

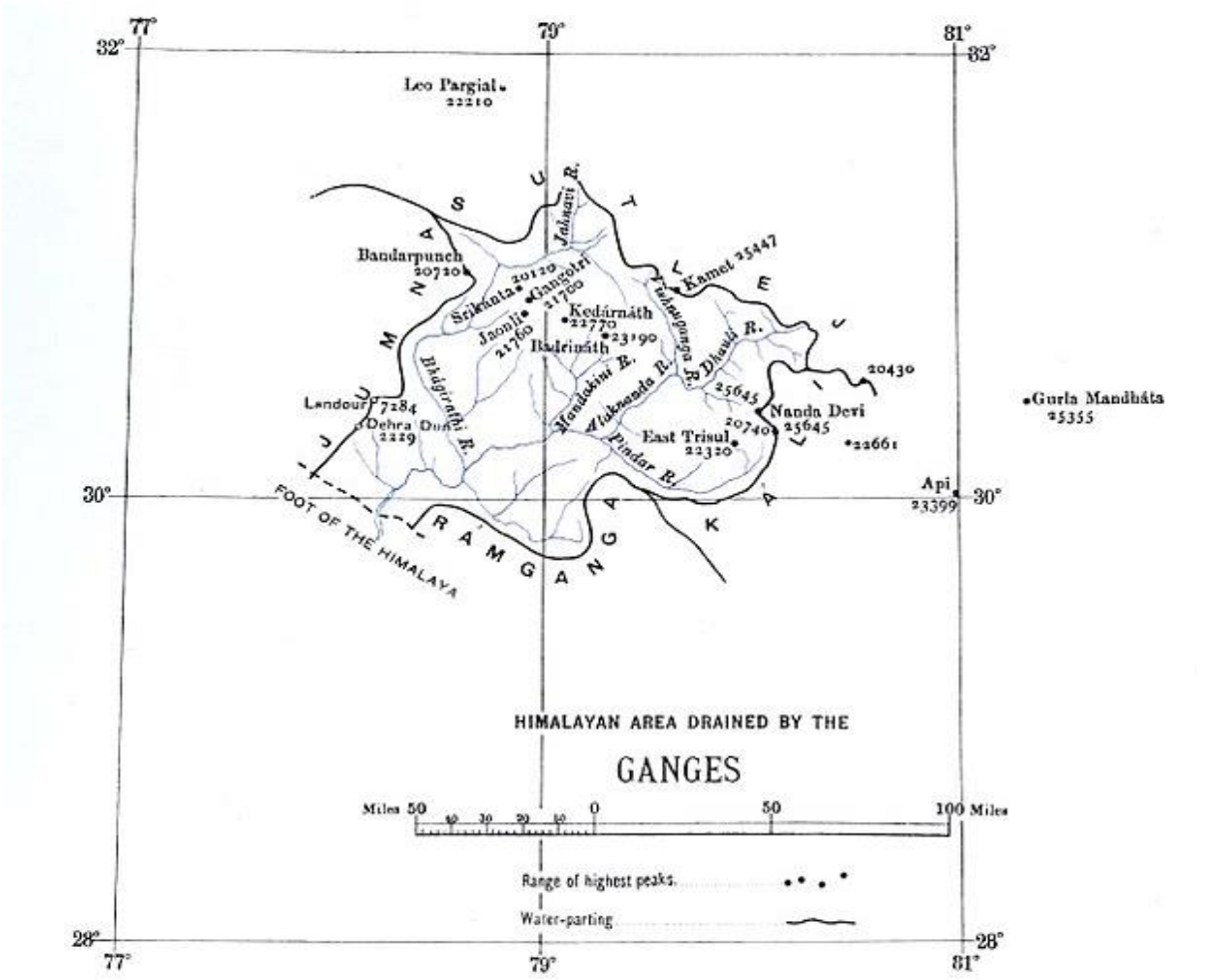

Fig 2.- Catchment Area of Ganga River

Source- https://en.wikipedia.org/wiki/File:Ganga_catchment.jpg

An area drained by a river and its tributaries is called a **drainage basin**. The boundary lines separating one drainage basin from the other is known as the **watershed**. The catchments of large rivers are called **river basins** while those of small rivulets and rills are often referred to as **watersheds**. A watershed is an area of land that drains or "sheds" water into a specific water body. All water bodies have a watershed. Watersheds drain rainfall and snowmelt into streams and rivers. These smaller bodies of water flow into streams and rivers. These smaller bodies of water flow into larger ones, including lakes, bays, and oceans. Gravity guides the path that water takes across the landscape. Not all rain or snow that falls on a watershed flows out in this way. Some seeps into the ground. It goes into underground reservoirs called aquifers.

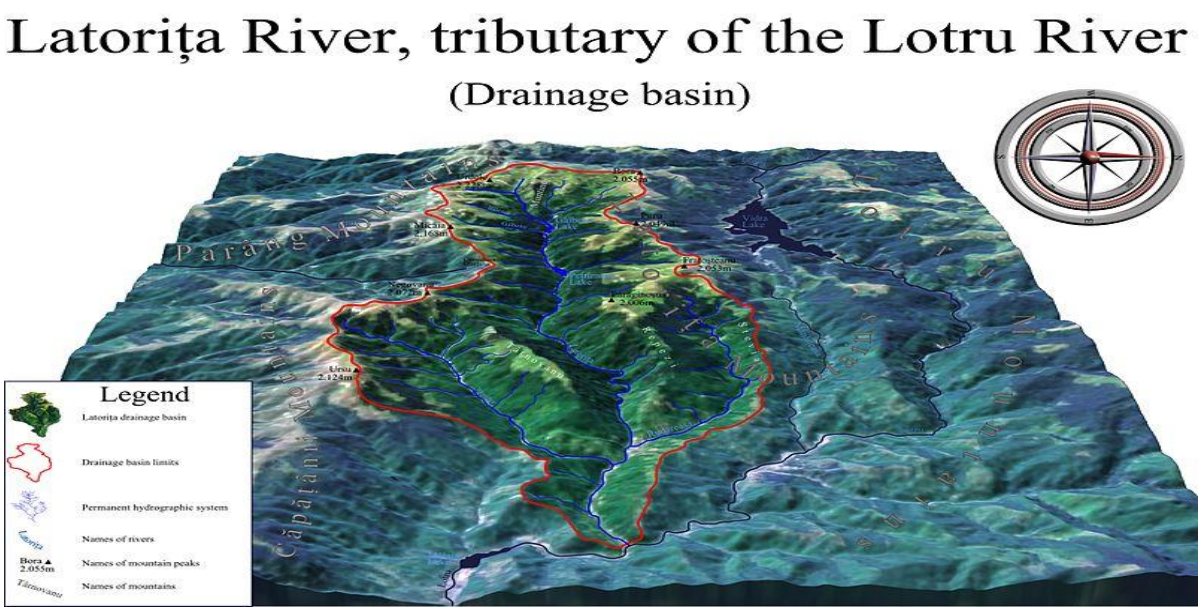

Fig. 3- Drainge Basin

Source- https://en.wikipedia.org/wiki/File:EN_Bazinul_hidrografic_al_Raului_Latorita,_Romania.jpg

There is, however, a slight difference between a **river basin** and **a watershed**. Watersheds are small in area while the basins cover larger areas. River basins and watersheds are marked by unity. What happens in one part of the basin or watershed directly affects the other parts and the unit as a whole. That is why, they are accepted as the most appropriate micro, meso or macro planning regions.

Indian drainage system may be divided on various bases. it may be grouped into:

1) On the basis of discharge of water (orientations to the sea),

2) On the basis of the size of the watershed

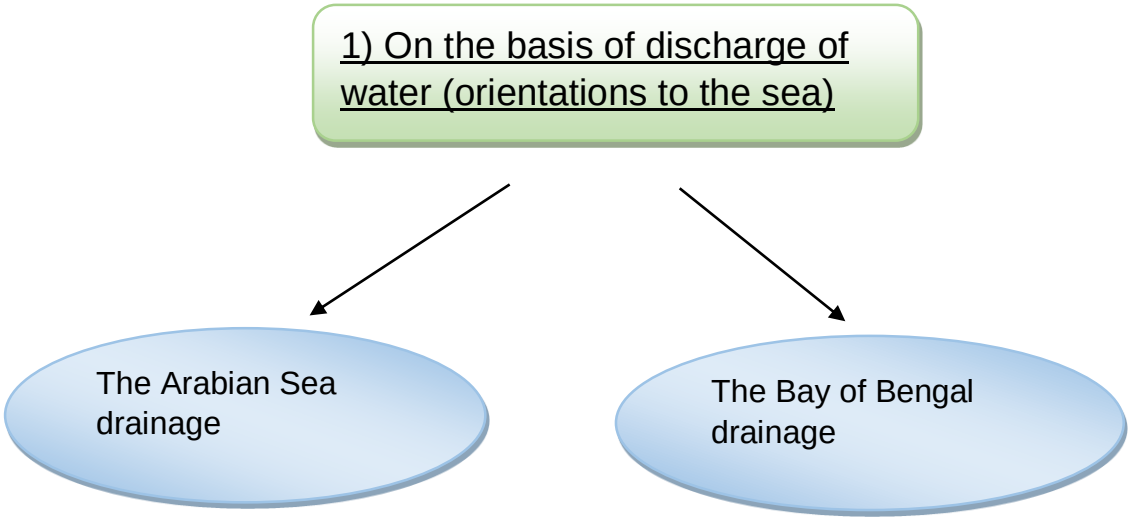

Fig4. Water orientation to the sea

They are separated from each other through the Delhi ridge, the Aravalis and the Sahyadris (water divide is shown by a line in Figure).

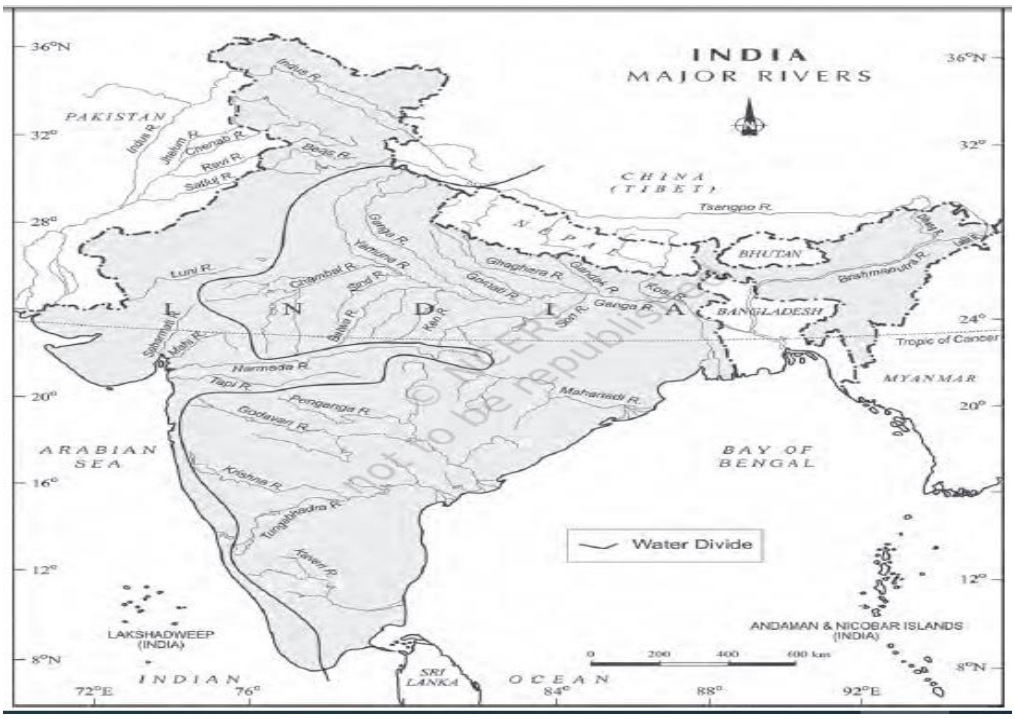

Fig 5- Water Divide

Nearly 77 per cent of the drainage area consisting of the Ganga, the Brahmaputra, the Mahanadi, the Krishna, etc. is oriented towards the Bay of Bengal while 23 per cent comprising the Indus, the Narmada, the Tapi, the Mahi and the Periyar systems discharge their waters in the Arabian Sea.

2) Classification on the basis of the size of the watershed,

(i) Major river basins with ***more than 20,000 sq. km of catchment area.***
It includes 14 drainage basins such as the Ganga, the Brahmaputra, the Krishna, the Tapi, the Narmada, the Mahi, the Pennar, the Sabarmati, the Barak, etc.

(ii) Medium river basins with ***catchment area between 2,000-20,000 sq. km*** incorporating44 river basins such as the Kalindi, the Periyar, the Meghna, etc.

(iii) Minor river basins with catchment area of ***less than 2,000 sq. km*** include fairly good number of rivers flowing in the area of low rainfall.
In addition
However, in addition to these the Watershed Atlas of India identifies the following watersheds;

- Micro Watershed
- Mini Watershed
- Mili watershed
- Nano Water shed

Many rivers have their sources in the Himalayas and **discharge** their waters either in the **Bay of Bengal or in the Arabian Sea**. Examples of large rivers flowing into the Bay of Bengal are the Ganges–Hooghly, the Padma, the Brahmaputra–Jamuna, the Barak–Surma–Meghna, the Irrawaddy, the Godavari, the Mahanadi, the Brahmani, the Baitarani, the Krishna and the Kaveri. Narmada, Tapi, Sabarmati, Purna are rivers flowing into Arabian sea.

On the basis of the mode of origin, nature and characteristics, the Indian drainage may also be classified into the Himalayan drainage and the Peninsular drainage. The major Himalayan rivers are the Indus, Jhelum, Chenab, Beas, Ravi, Saraswati, Sutlej, Ganga, Yamuna, and Brahmaputra. , The Godavari, the Mahanadi, the Brahmani, the Baitarani, the Krishna and the Kaveri are important peninsular rivers. Although it has the problem of including the Chambal, the Betwa, the Son, etc. which are much older in age and origin than other rivers that have their origin in the Himalayas.

Drainage pattern is the pattern formed by the streams, rivers and lakes in a particular drainage basin

Factors Affecting Drainage Patterns

A stream system achieves a particular drainage pattern to its network of stream channels and tributaries as a determined by local geologic factors. Drainage patterns or nets are classified on the basis of their form and texture.

- Their shape or pattern develops in response to the local topography and subsurface geology. Drainage channels develop where surface runoff is enhanced and earth materials provide the least resistance to erosion.
- The texture is governed by soil infiltration, and the volume of water available in a given period of time to enter the surface. If the soil has only a moderate infiltration capacity and a small amount of precipitation strikes the surface over a given period of time, the water will likely soak in rather than evaporate away. If a large amount of water strikes the surface, then more water will evaporate soaks into the surface or ponds on level ground. On sloping surfaces this excess water will runoff. Fewer drainage channels will develop where the surface is flat and the soil infiltration is high because the water will soak into the surface. The fewer number of channels, the coarser will be the drainage pattern

River Drainage Patterns

(i) The Dendritic drainage pattern -

- Resembles the branches of a tree is known as "dendritic" the examples of which are the rivers of northern plain and Godavari, Mahanadi, Kaveri, Krishna.
- It develops in regions underlain by homogeneous material. That is, the subsurface geology has a similar resistance to weathering so there is no apparent control over the direction the tributaries take.
- Tributaries joining larger streams at acute angle (less than 90 degrees). They develop where the river channel follows the slope of the terrain.
- Dendritic systems form in V-shaped valleys; as a result, the rock types must be impervious and non-porous.

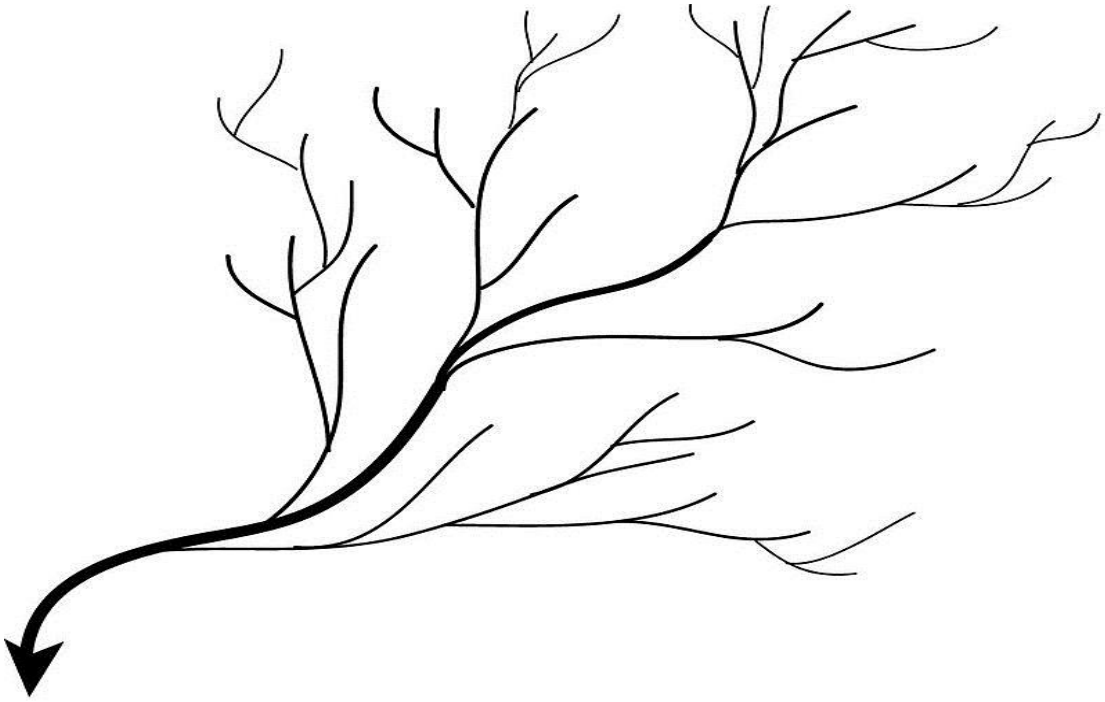

Figure 6- Dendritic Drainage Pattern

Source-
https://en.wikipedia.org/wiki/Drainage_system_(geomorphology)#/media/File:Dendritic_Drainage_pattern.jpg

(ii) Radial drainage pattern-

- When the rivers originate from a hill and flow in all directions, the drainage pattern is known as 'radial'.
- Usually this kind of pattern is seen in the flow of volcanoes as the lava emerges from one central point or crater.
- Laccoliths and domes also form radial patterns

- The rivers originating from the Amarkantak range present a good example of it. Rivers like Narmada, Son and Mahanadi originating from Amarkantak Hills flow in different directions and are good examples of radial pattern.
- Radial drainage patterns are also found/in the Girnar Hills (Kathiwar, Gujarat), and Mikir Hills of Assam.

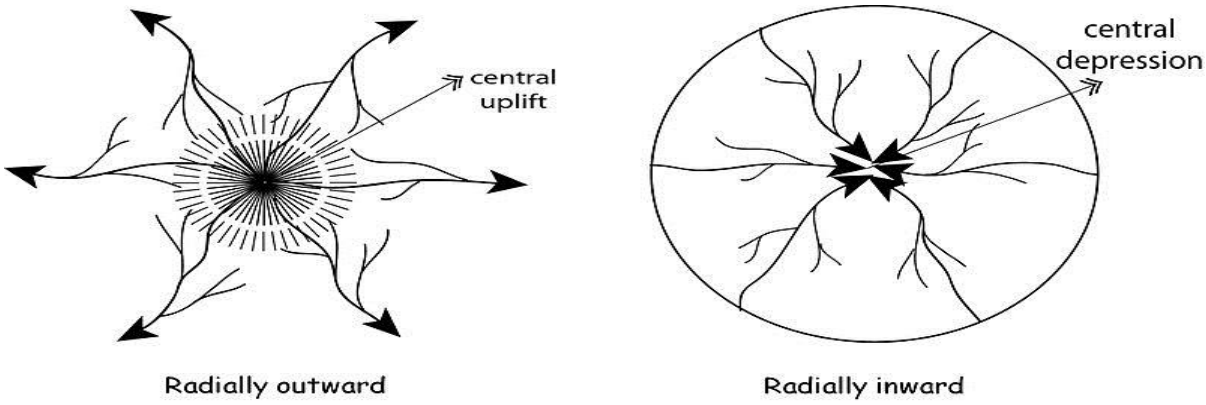

Fig. 7- Radial Pattern

Source- https://en.wikipedia.org/wiki/File:Radial_drainage_pattern.JPG

(iii) Trellis

- When the primary tributaries of rivers flow parallel to each other and secondary tributaries the pattern is known as 'trellis'. Tributaries join them at right angles, the pattern is known as 'trellis'. In this type of pattern the short subsequent streams meet the main stream at **right angles**, and differential erosion through soft rocks paves the way for tributaries.
- Examples: The old folded mountains of the **Singhbhum (Chotanagpur Plateau)**

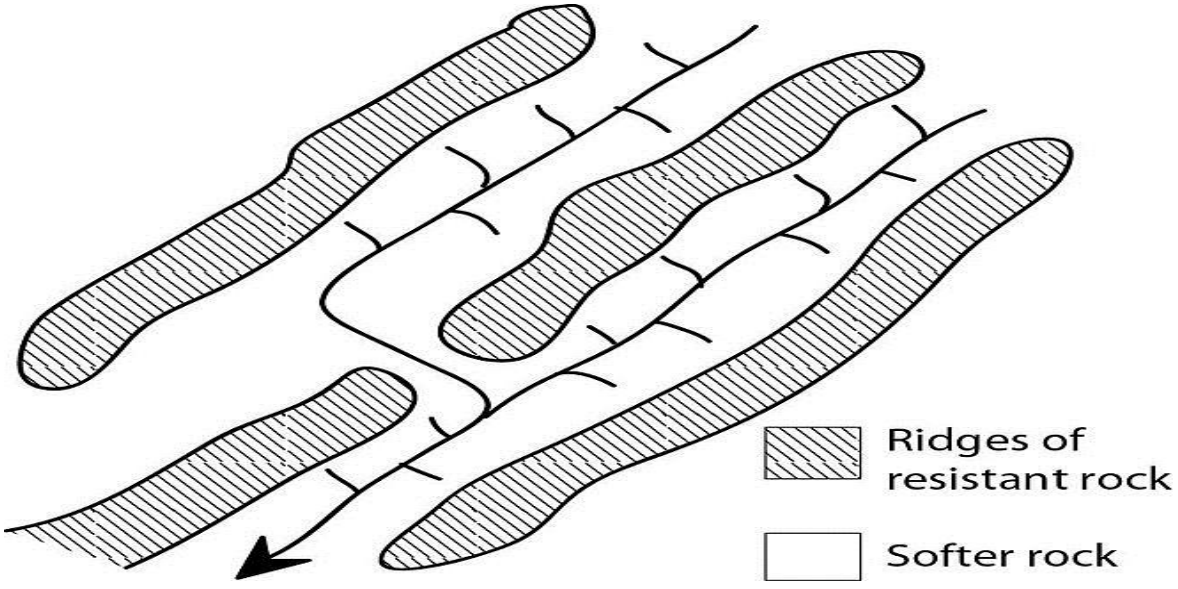

Fig 8-Trellis

Source-https://en.wikipedia.org/wiki/File:Trellis_drainage_pattern.JPG

(iv) Centripetal drainage pattern-

- When the rivers discharge their waters from all directions in a lake or depression, the pattern is known as 'centripetal'
- Examples: streams of Ladakh, Tibet, and the Baghmati and its tributaries in Nepal.

(v) Rectangular patterns- develop in areas that have very little topography and a system of bedding planes, fractures, or faults that form a rectangular network. Rectangular drainage develops on rocks that are of approximately uniform resistance to erosion, but which have two directions of joining at approximately right angles or 90 degrees. The joints are usually less resistant to erosion than the bulk rock so erosion tends to preferentially open the joints and streams eventually develop along the joints. The result is a stream system in which streams consist mainly of straight line segments with right angle bends and tributaries join larger streams at right angles.

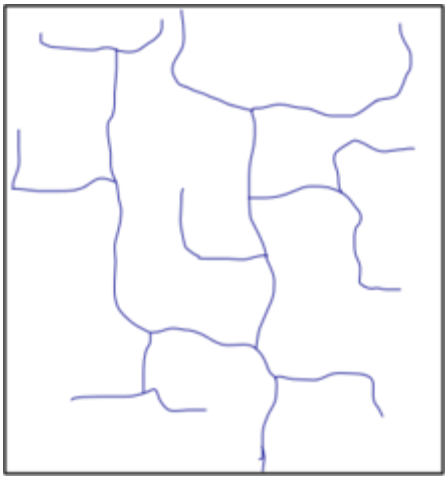

Fig. 8- Rectangular Pattern

Source- https://upload.wikimedia.org/wikipedia/commons/c/cb/Rectangular.png

(vi) Parallel drainage

System is a pattern of rivers caused by steep slopes with some relief. Due to steep slopes, the streams are swift and straight, with very few tributaries, and all flow in the same direction. Parallel drainage patterns form where there is slope to the surface. A parallel pattern also develops in regions of parallel, elongated landforms like outcropping resistant rock bands.

Tributary streams tend to stretch out in a parallel-like fashion following the slope of the surface. A parallel pattern sometimes indicates the presence of a major fault that cuts across an area of steeply folded bedrock.

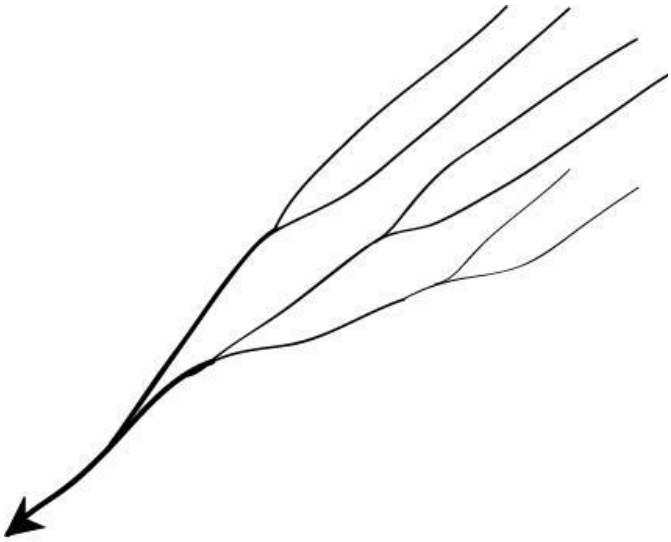

Fig. 9- Parallel Drainage

Source-
https://en.wikipedia.org/wiki/Drainage_system_(geomorphology)#/media/File:Parallel_drainage_pattern.jpg

(vii) Angular drainage patterns form where bedrock joints and faults intersect at more acute angles than rectangular drainage patterns. Angles are both more and less than 90 degrees.

River Regimes

Do you know that the quantity of water flowing in a river channel is not the same throughout the year? It varies from season to season. In which season do you expect the maximum flow in Ganga and Kaveri rivers?

The pattern of flow of water in a river channel over a year is known as its regime. The north Indian rivers originating from the Himalayas are perennial as they are fed by glaciers through snow melt and also receive rainfall water during rainy season. The rivers of South India do not originate from glaciers and their flow pattern witnesses fluctuations. The flow increases considerably during monsoon rains. Thus, the regime of the rivers of South India is controlled by rainfall which also varies from one part of the Peninsular plateau to the other.
The discharge is the volume of water flowing in a river measured over time. It is measured either in cusecs (cubic feet per second) or cumecs (cubic metres per second).

The Ganga has its minimum flow during the January-June period. The maximum flow is attained either in August or in September. After September, there is a steady fall in the flow.

The river, thus, has a monsoon regime during the rainy season. There are striking differences in the river regimes in the eastern and the western parts of the Ganga Basin. The Ganga maintains a sizeable flow in the early part of summer due to snow melt before the monsoon rains begin. The mean maximum discharge of the Ganga at Farakka is about 55,000 cusecs while the mean minimum is only 1,300 cusecs.

The two Peninsular rivers display interesting differences in their regimes compared to the Himalayan rivers. The Narmada has a very low volume of discharge from January to July but it suddenly rises in August when the maximum flow is attained. The fall in October is as spectacular as the rise in August. The flow of water in the Narmada, as recorded at Garudeshwar, shows that the maximum flow is of the order of 2,300 cusecs, while the minimum flow is only 15 cusecs. The Godavari has the minimum discharge in May, and the maximum in July-August. After August, there is a sharp fall in water flow although the volume of flow in October and November is higher than that in any of the months from January to May. The mean maximum discharge of the Godavari at Polavaram is 3,200 cusecs while the mean minimum flow is only 50 cusecs. These figures give an idea of the regime of the river.

Extent of Usability of River Water

The rivers of India carry huge volumes of water per year but it is unevenly distributed both in time and space. There are perennial rivers carrying water throughout the year while the non-perennial rivers have very little water during the dry season. During the rainy season, much of the water is wasted in floods and flows down to the sea. Similarly, when there is a flood in one part of the country, the other area suffers from drought. Why does this happen? Is it the problem of availability of water resource or that of its management? Can you suggest some measures to mitigate the problems of floods and droughts simultaneously occurring in different parts of the country?

Can these problems be solved or minimised by transferring the surplus water from one basin to the water deficit basins? Do we have some schemes of inter-basin linkage?

River Interlinking Projects

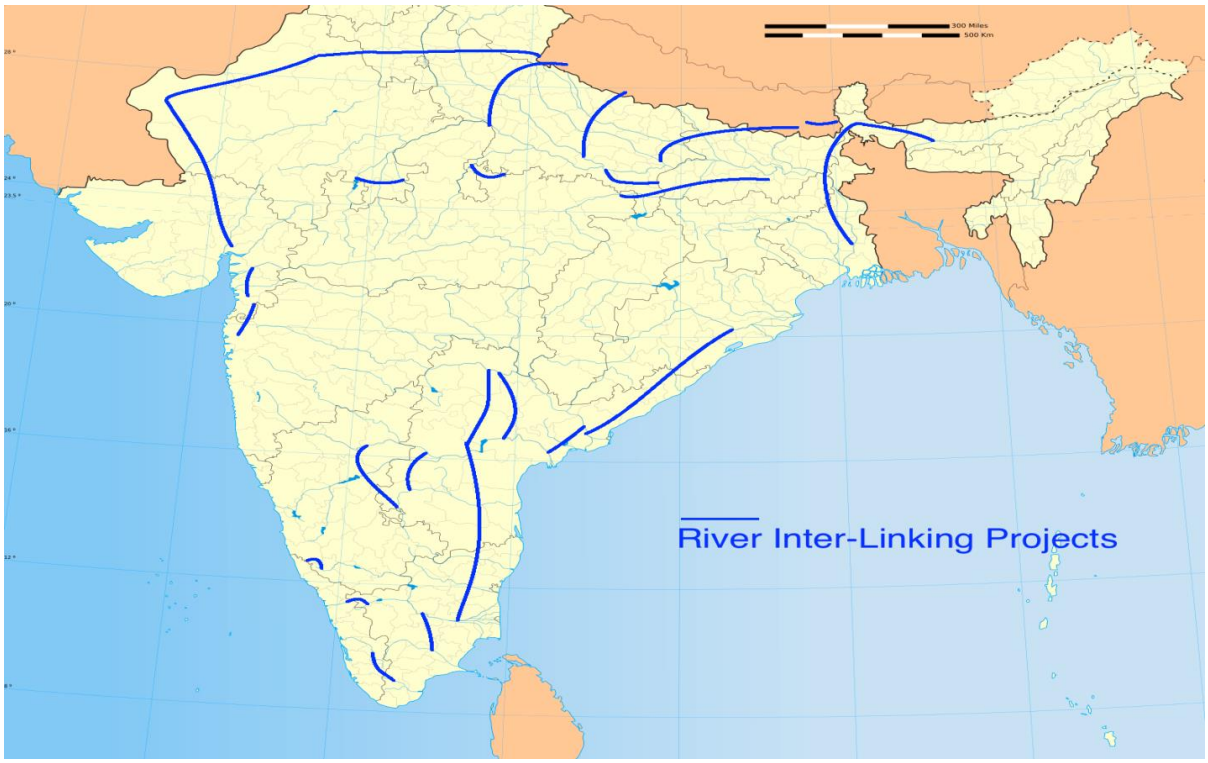

Fig 10-River inter linking projects

Source-
https://upload.wikimedia.org/wikipedia/commons/8/8b/1_NWDA_India_River_Inter-Linking_Project_Himalayan_and_Peninsular_Components.png

Periyar Diversion Scheme

The Periyar valley Irrigation scheme in Ernakulam district envisages the utilization of the tail race discharge from the completed Hydel scheme in the Muthirapuzha tributary of river Periyar together with the controlled release from Ennackal dam constructed by Kerala State Electricity Board under Hydel scheme across the Idamalayar tributary and the dependable run off from the uncontrolled catchment of Periyar river. It is intended for irrigating an area of 32800 Ha of land lying on the left bank of Periyar river through a network of canal system and controlling devices.

Advantages of Periyar Diversion Scheme

1. The scheme helps in stabilization of first and second crops in an area of 32800 Ha and raising an additional crop in an area of 20000 Ha of 3rd crop (Puncha)
2. Apart from Irrigation on left bank of Periyar, the scheme also enables in the right bank of Periyar, supply of water to FACT, supply of minimum quantity of water through the

river to check the intrusion of salinity at lower reaches as well as to meet the requirements of many lift Irrigation scheme of river Periyar.

3. Supply of water for drinking, industrial purposes etc is met by a portion of storage water by the barrage of Bhoothathankettu. The project was completed during the year 1992.

Indira Gandhi Canal Project

The **Indira Gandhi Canal** is the longest canal of India. It starts from the Harike Barrage. At Harike, a few kilometers below the confluence of the Satluj and Beas rivers in the Indian state of Punjab and terminates in irrigation facilities in the Thar Desert in the north west of Rajasthan state. Previously known as the Rajasthan Canal, it was renamed the Indira Gandhi Canal on 2 November 1984 following the assassination of Prime Minister Indira Gandhi.
The canal consists of the Rajasthan feeder canal with the first 167 kilometres (104 mi) in Punjab and Haryana state and a further 37 kilometres (23 mi) in Rajasthan followed by the 445 kilometres (277 mi) of the Rajasthan main canal, which is entirely within Rajasthan. The canal enters Haryana from Punjab near Lohgarh village then runs through the western part of the Sirsa district before entering Rajasthan near Kharakhera village in the Tibbi tehsil of the Hanumangarh district. The canal traverses seven districts of Rajasthan: Barmer, Bikaner, Churu, Hanumangarh, Jaisalmer, Jodhpur, and Sriganganagar.

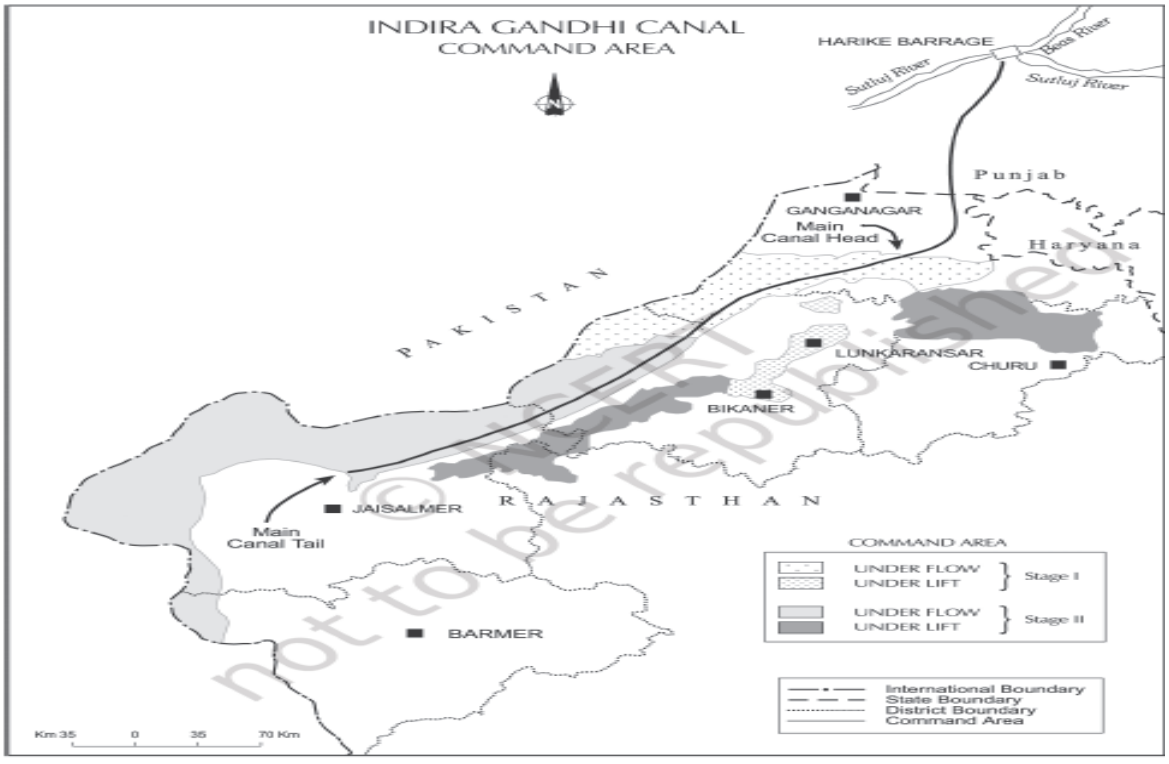

Fig 11-Indira Gandhi Canal

Advantages of Indira Gandhi Canal Project

1. After the construction of the Indira Gandhi Canal, irrigation facilities were available. The canal has transformed the barren deserts of this district into fertile and good fields. Crops of mustard, cotton, and wheat now grow in this semi-arid north-western region.
2. Besides providing water for agriculture, the canal will supply drinking water to hundreds of people in far-flung areas. It will enhance the living standards of the people of the state.
3. The Indira Gandhi Canal is a major step in reclaiming the Thar Desert and checking desertification of fertile areas. There is a planting programme for greening the desert in areas near the Indira Gandhi Canal which was started in 1965. This consists of the planting of shelter belts along roads and canals, blocks of plantations and sand dune stabilization.

Kurnool-Cuddapah Canal

Kurnool Cuddappah Canal popularly known as K.C. Canal is an irrigation canal located in Kurnool and Cuddapah districts in Andhra Pradesh, The K.C. Canal was constructed between 1863 and 1870 as an irrigation and navigation canal. This canal interconnects the rivers Penner and Tungabhadra. It starts from the Sunkesula barrage located on the Tungabhadra River near Kurnool.

Beas-Satluj Link Canal

Satluj Yamuna Link Canal or **SYL** as it is popularly known, is a proposed 214-kilometer (133 mi) long canal in India to connect the Sutlej and Yamuna rivers. It defines river water sharing between the states of Punjab and Haryana.

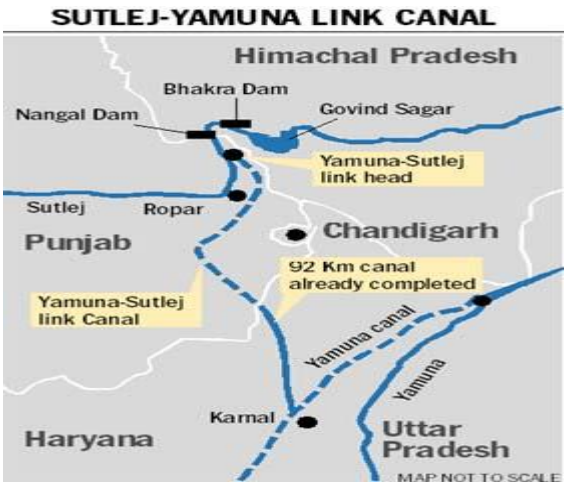

Fig 12-Sutlej Yamuna link canal

Source-
https://en.wikipedia.org/wiki/Sutlej_Yamuna_link_canal#/media/File:Sutlej_Yamuna_Canal_Link_dispute.jpg

Ganga- Kaveri Link Canal-

Features of Ganga-Kaveri Link Canal-

Annually 25 billion cubic meters of water are to be lifted from the Ganga river near Patna up to 460 meters to reservoirs on the Chotanagpur plateau. From these reservoirs on the Chotanagpur plateau . From these reservoirs the water coursing across the across the Deccan plateau through a 3300 km network of aqueducts, gravity canals, tunnels, natural water courses and reservoirs will flow into the southern and western rivers. This network consists of three main segments - linking the Ganga to Narmada, the Narmada to Godavari, and the Godavari to the river Kaveri. Through the Narmada river, water would be supplied to the existing and planned irrigational systems in Gujarat and Rajasthan. The canal network is expected to become a major navigational route for ferrying bulk cargo from south to the industrial and population centres of the north as well as to the major seaports of the country. The scheme is expected to minimise the impact of draughts by bringing under irrigation vast areas of culturable land. The objective is to double the presently irrigated area.

The interlinking project include three components: the northern Himalayan rivers interlinking component, the southern peninsular component and the intrastate river linking component canal is enough to transfer water from the Ganga basin to the Peninsular river? What is the major

.

Difficulties in interlinking of rivers are -

Is there enough water to transfer from the Ganga basin to the Peninsular river?

1. Difficulties posed by the unevenness of the terrain.
2. The water is to be lifted from the plain area to the plateau area.
3. The river interlinking project faced a barrage of criticism from activists and environmentalists on the ground that such an idea would be environmentally damaging.
4. Those states which had surplus water were not in a mood to share the precious resource with others.

There are following **problems in using river water**

(i) No availability in sufficient quantity

(ii) River water pollution

(iii) Load of silt in the river water

(iv) Uneven seasonal flow of water

(v) River water disputes between states

(vi) Shrinking of channels due to the extension of settlements.

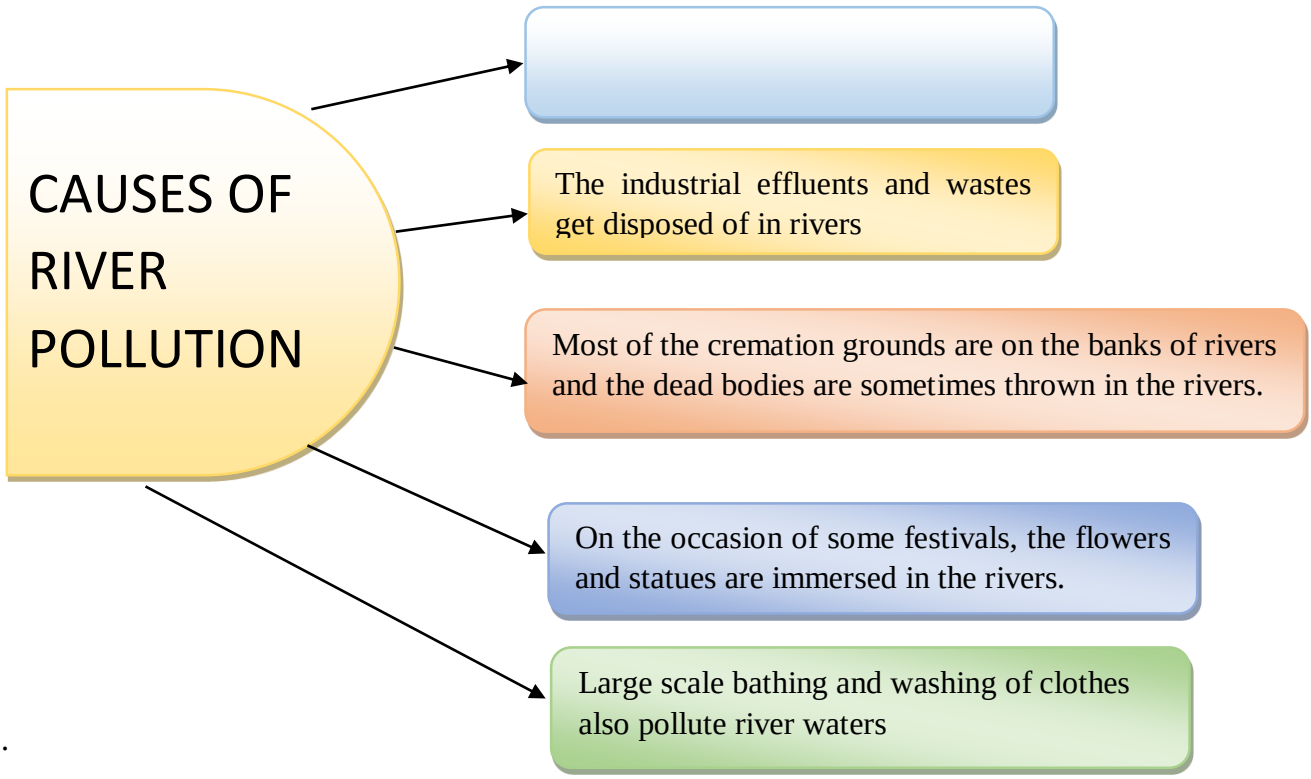

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Fig.13 Causes of River Pollution

Ganga Action Plan

The First River Action Plan i.e. the Ganga Action Plan was taken up by the Ministry of Environment & Forests in 1985. Since then its scope has increased to all the major rivers of the country and the programme was further extended to other major rivers of the country in 1995 under the National River Conservation Plan - NRCP.

Presently, the Centrally sponsored scheme of National River Conservation Plan - NRCP is under implementation in 160 towns along polluted stretches of 34 rivers spread over 20 States at an approved cost of Rs.4736 crore. The major rivers being Ganga, Yamuna, Gomti, Damodar, Satluj, Krishna, Cauveri, Godavari etc. among others. The objective of NRCP is to check pollution in rivers through implementation of the following pollution abatement schemes to bring the river to bathing quality standards:

1. Interception and diversion works to capture the raw sewage flowing into the river through open drains and divert them for treatment;
2. Sewage treatment plants for treating the diverted sewage;
3. Low cost sanitation works to prevent open defecation on river banks;
4. Electric and/or improved wood crematoria to conserve the use of wood and help in ensuring proper cremation of bodies brought to the burning ghat;
5. River front development works such as improvement of bathing Ghats, etc. and
6. Other miscellaneous works like afforestation, Public Participation etc.

All these works are done on the banks of rivers in the major towns and cities along identified polluted stretches of rivers across the country. Development and maintenance of a proper sewerage system in towns and cities is primarily the responsibility of the respective State Governments and Urban Local Bodies. The prevention and control of industrial pollution is being taken care of by the Pollution Control Boards.