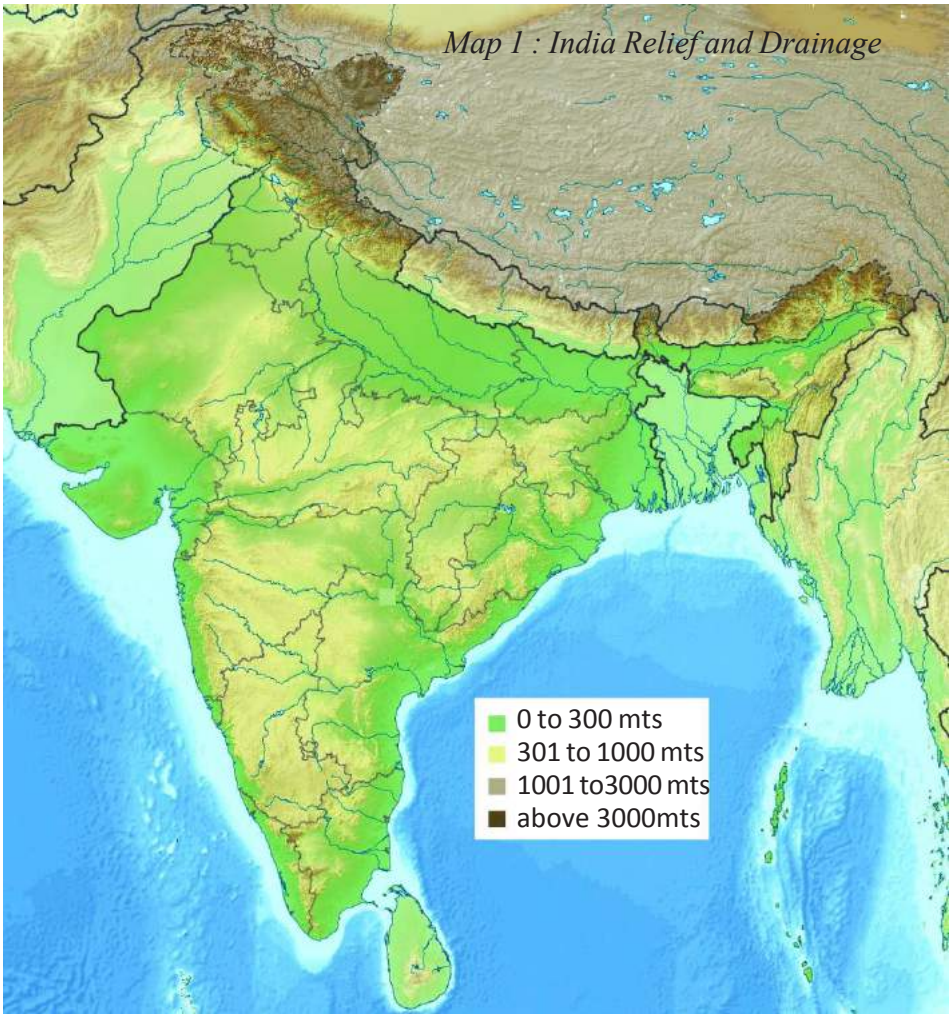
CHAPTER

5

Indian Rivers and Water Resources

- On a map of India identify and mark the Himalayas and the Western Ghats.
- Using the colour code, identify the height range in which some of the rivers originate. Using the atlas and the raised relief map follow the course of these rivers and locate the direction in which they are flowing.
- Discuss: About 5% of water is used for domestic purposes and yet a large section of the population does not have access to the water.
- 40 million hectares of land in India is flood-prone and an equally large part of the country is also drought prone. What are the causes of this?
- 70% of our surface water resources are polluted. Why?



Map 1 : India Relief and Drainage

The drainage of India has evolved and adjusted itself with the evolution of the three physiographic units: 1) the Himalayas 2) peninsular plateau and 3) the Indo-Gangetic plain. On the basis of its origin, the drainage system in India can be broadly divided into two categories: i) The Himalayan rivers and ii) The Peninsular rivers.

The Himalayan Rivers

The Himalayan Rivers belong to the three principal systems: the Indus, the Ganga and the Brahmaputra. These rivers originate from almost the same region within few kilometers of each other separated by water divides. They first flow parallel to the main axis of the mountains. Then they take a sudden bend towards the south cutting through the massive mountain chain to reach the north Indian plains. In the process they have carved out deep 'v' shaped valleys. This is well exhibited by Indus and the Brahmaputra rivers.

The Himalayan Rivers are perennial. This is because the rivers are supplied on rainfall as well as the melting snow.

The Indus System

The Indus originates in the northern slopes of the Kailash range in Tibet near Lake Manasarovar. It follows a north-westerly course through Tibet. It enters Indian Territory in Jammu and Kashmir. The main tributaries of the Indus in India are Jhelum, Chenab, Ravi, Beas and Sutlej. It covers Jammu and Kashmir, Punjab and Himachal Pradesh states of India.

- With the help of an atlas trace the course of Indus both in India and Pakistan.

The Ganga System

The Ganga has twin sources. The main one is the Gangotri glacier where it is called the Bhagirathi. The other is the Satopanth glacier north-west of Badrinath where it is called the Alakananda. The two join at Devprayag to form the Ganga that emerges from the hills of Haridwar. The Ganga is joined by a large number of tributaries. A majority of them originate in the Himalayan ranges but some of them have their sources in the peninsular plateau.

- Look at the map of river Ganga (5.2) and name the states which are drained by it.
- From the above map list out the north-flowing and south-flowing tributaries of the Ganga.

The Brahmaputra system

The Brahmaputra (known as the Tsangpo in Tibet) rises from the snout of the Chemayungdung glacier of the Kailas range near Manasarovar. It flows eastwards through southern Tibet. Near Lhotse Dzong, it opens out into a wide navigable channel for about 640 kms. Thereafter, the river breaks through a succession of

rapids. It enters in a great loop southwest through Arunachal Pradesh in India, first as the Siang and then as the Dihang. Emerging into the Assam valley it is joined by two tributaries-The Dibang and the Lohit. From here, the river is known as the Brahmaputra.

Map 2 : Ganga joining with Brahmaputra

The Peninsular Rivers

The Western Ghats are the water divide between the major peninsular rivers, discharging their water in the Bay of Bengal and as small rivulets joining the Arabian Sea. Most of the major Peninsular Rivers except Narmada and Tapati flow from west to east. The Chambal, Sind, Betwa, Ken, and Son, originating in the northern part of the peninsular belong to the Ganga river system. The other major river systems of the peninsular drainage are the Mahanadi, the Godavari, the Krishna and Cauveri. Peninsular rivers are characterised by fixed course, absence of meanders and largely non- perennial flow of water.

The Godavari is the largest peninsular river system. The source of this river is in the Triambak plateau near Nasik in Maharashtra and discharges its water into the Bay of Bengal.

- From the Map and using your atlas describe the following:

  The Godavari originates in ____and____

  The Krishna is the second largest east flowing peninsular river which rises near _____ .

  The Mahanadi rises near Sihawa in Chattishgarh and runs through____

  The Narmada originates near _____in Madhya Pradesh.

  The Tapati originates from ____and flows ____(fill in the direction of flow)

Water use

Water is a resource that becomes available to us as an annual flow i.e. we try to estimate how much we would be able to use during the year. In order to do this we need to recall the 'water-cycle' and estimate the inflows and outflows during the year. Outflows and inflows can be estimated at different levels - for small watershed or an entire river basin.

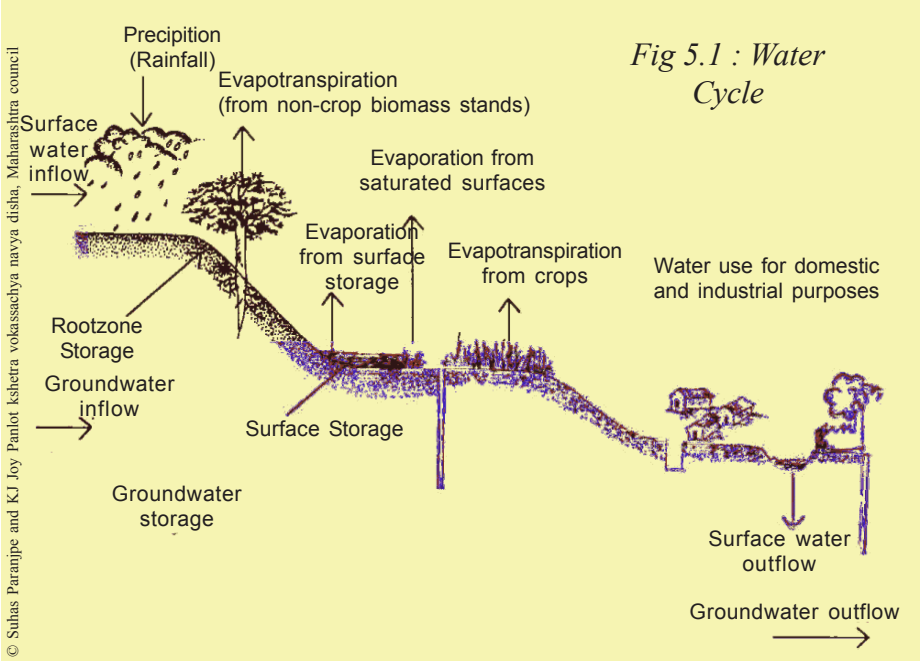


Fig 5.1 : Water Cycle

Now let us explore the idea of a 'water budget' as it would apply to a small or large region such as a village or a district.

Inflows

- Discuss the term "watershed".

For any area inflow = precipitation + surface flow + ground water flow. Surface flow includes rivers, streams, canals, and other flows on the surface. Ground water flow is difficult to estimate, but it can be done. Precipitation includes snow, dew, hail etc. To estimate the percipitation of an area we take an average over many years since percipitation varies from year to year.

Surface and ground water flows: For your area, whether a village or a town, list the surface water inflows from the river, or canals of irrigation projects.

- From the nearest Mandal office find out the total annual rainfall for your area over the past 5 years.

A small region such as a village may receive water through canals, pipelines etc- list all outside sources. This has to be added to the amount of rainfall to get an idea of the total inflow for the village. However it is more difficult to get an idea of ground water inflows but the general slope of the land helps one make a guess as to the possible direction of the flow.

Outflows

Evapotranspiration: Evaporation, the turning of water into vapour, takes place all the time in water bodies. It can happen to any exposed surface water such as lakes, rivers, seas etc. Living things also give off water into the atmosphere through their breathing process. This is called transpiration. The total amount of water added to the atmosphere from both evaporation and transpiration is called evapotranspiration.

- Recall from your science lessons what happens to the water that plants draw through their roots.

Water flowing out via surface flows and groundwater: Imagine a region such as a village. Some amount of water would flow out of the village as surface flows through streams. During monsoon months this surface flow would increase substantially. A portion of the rainfall percolates into the soil and travels to the underground strata and re-charges the aquifers. Some of it flows into and becomes available for use through wells and bore wells and a portion of it goes into very deep aquifers that do not become available. Some of the underground water becomes part of flows that eventually appear in streams or rivers.

Water for agriculture: Water reaches the root zone of crops either through rainfall or some process of irrigation. There's a capacity of the soil to store moisture. If there's excess water, such as a flood, and this isn't able to percolate below it would damage the roots. On the other hand, in a drought situation, if there isn't enough moisture in the root zone, the crops will wither/ wilt.

Water use for domestic purpose and for animals: Water used for drinking, cooking, washing, cleaning and for animals is vital. Planning for this component is needed to increase the availability so that a minimum amount is actually made available to all, irrespective of their income.

Water for industrial use: Water is required for manufacturing processes and this demand often competes with domestic and agricultural uses. This needs to be taken into account as this conflict is on the increase. The challenge areas facing industrial use are recycling of water and control of pollution.

What is available to a region or a village does not only depend on the inflows but also what is already available as 'stock' that we use. We often have to keep this distinction between stock and flow clear in our analysis. For example imagine a tank that is constantly being filled by an inlet pipe and water is also constantly used by an outlet pipe. We can measure the inflow as the amount of water liters/ minute and the outflow similarly as the water liters/ min that flows out. The amount of water in the tank keeps varying but at any one moment in time, say at 8.30 am, we can measure the amount in liters. This is the stock of water at that time.

A village may have tanks, ponds, lakes, these are all surface storages. Most villages in India draw water from wells and tube wells. They are dependent on ground water storage. These inflows and storage are connected. While some of the water flowing in is used directly, one part of this is recharging or replenishing the storage. Similarly, the use of tube wells draws water from storages and lowers the water available in them. Depending on comparative rates of inflow and outflow we can judge what is happening to the stock of water over many years. The question that we face today is the depletion of ground water storages and a tendency not to care about the availability for future generations.

The annual flows and stocks that recharge wells and tube wells is the water that is available for use. We should keep our needs in this range. When we dig into deeper aquifers - this is like mining water that has collected over thousands of

years. This is to be done only in extreme drought situations and replenished in good rainfall years. We will come back later to this question of 'sustainability'.

Water use in the Tungabhadra river basin

Tungabhadra, shared by the two southern states of Karnataka and Andhra Pradesh, is a tributary of the larger river system Krishna. It originates in the Western Ghats with a catchment area of 71,417 km^2, of which 57,671 km^2 are in Karnataka. The Tungabhadra basin has two parts: 1) the upper and middle catchment in Karnataka, and 2) the lower portion of the catchment in Andhra Pradesh.

According to official statistics, farmland is the main land cover in these states. Others such as trees, groves, fallow land, cultivable waste, permanent pastures, forests and natural vegetation cover the rest of the area. Some of the territory is used for storage by water harvesting systems called tanks. The lower portions of the basin, in Andhra Pradesh are characterised by lower rainfall and drought conditions. Some regions depend on rainfall and underground water (wells and tube wells). Other areas depend on surface flows by canals that carry water from dams built along Tungabhadra. There is a lot of difference in water availability between these two types of regions.

- On a map of India trace the course of Tungabhadra river.

Encroachment of public lands for cultivation is common. It results in more land being brought under cultivation at the expense of tree cover. Rampant felling of trees and mining activity is resulting in forest degradation, along with the destruction of the habitat of highly threatened flora and fauna. Inflows of groundwater depend on the tree cover in the catchment areas. Inadequate tree cover leads to water run-off as surface flow without getting a chance to recharge the underground system. Moreover this also causes flash floods. If we wish to be fair to both the rainfed and canal irrigated regions, we must adopt a different plan for water conservation and a system of sharing water.

Fig 5.2 : Tungabhadra Dam Construction - 1952

Tungabhadra dam has gradually lost its water storage capacity over the decades. About 50 years ago, the capacity of the reservoir was 3,766 million cubic meters, now with accumulation of silt due to mining, dust, soil erosion, debris, the

reservoir has lost its storage capacity by as much as 849 million cubic meters of water. As one study says, "No proper mining standards are followed in iron ore extraction. The mining of iron ore at Kudremukh and manganese in Sandur has seriously affected the stability of the catchments in the form of soil erosion and siltation of several small reservoirs, traditional tanks and Tungabhadra reservoir."

Conflicts between Karnataka and Andhra Pradesh are generally related to what is available for use. Water is a flow resource and its storage or use upstream affects what is available to people downstream. Water is shared based on agreements between state governments.

Access to water is a precondition in this farmland area where 80% of the population depending on agriculture for their livelihoods. Irrigation is provided through canal systems, while in rainfed regions farmers extract groundwater through bore wells. The major crops grown include paddy, jowar, sugarcane, cotton and finger millet.

Although the area is ideal for semi-arid crops, the major crops grown demand a lot of water (paddy and sugarcane). Cultivation of such crops throughout the basin has dramatically altered the water sharing balance. When all areas desire water for these crops, conflict becomes inevitable. Hence, there is a significant difference between those farmers with access to land and irrigated water, and those without access. For a fair use of water for all, a change in cropping pattern would have to be encouraged throughout the basin.

During the last two decades there has been an increasing trend in the number of small towns and industrial areas. This has made the competing demands for water more complex. While increased industrialisation and growth of urban areas have improved standards of living for some, the same activities have caused pollution especially by industrial units. There are 27 functioning large units and 2543 small units in this river basin. They consume a big amount of water per day. Industries were permitted to discharge effluents into the river but following public protests in 1984 regarding discharge of molasses that killed fish on a large scale, laws were enacted requiring industry to discharge only treated effluents. These laws are not implemented forcefully. Hence, severe pollution of the river system continues.

There has been a mismatch between keeping pace with development activities on various fronts and providing sanitation and drinking water supply for all sections of society, both in small towns and rural areas. Some say that drinking water and sanitation are basic needs and a minimum amount has to be provided irrespective of the ability to pay for these. When we experiment with metered water we have to allow that a certain section of society would not be able to afford the water that they must get as a basic requirement. A report for this river basin says, "…provision of drinking water to townships is not planned well, particularly the small towns have serious access and equity related issues, more so during summer."

- How would it help if there was a government river basin authority for overall planning of water use?
- What are the different conflicts in the use of water for Tungabhadra river basin?

Thus, the socio-economic aspects are of very important to water use management. Conflicts within communities in a region and across sectors such as use for agriculture, industry or drinking water are common. Apart from this, interstate disputes between Karnataka and Andhra Pradesh arise due to the trans-boundary nature of the river.

Rational and equitable Use of water - an example

We have read about the use of water and the need to look at all the inflows and outflows so that a judicious use and with fairness can be worked out. This could be for a river basin or a village. Such plans and implementation schemes are possible. Hiware Bazar village is an example.

Hiware Bazar was selected under the Adarsh Gram Yojana of Maharashtra government for watershed and all-round development of the village. Hiware Bazar is located in Ahmednagar district in Maharashtra. It is situated on the eastern (rainshadow) side of the Sahayadri mountain ranges that run north-south and separate Konkan, the coastal region, from the rest of Maharashtra. Ahmednagar district is drought prone with an average annual rainfall of about 400 mm.

The soil and water conservation works in Hiware Bazar were implemented on common lands and on private grasslands. Continuous contour trenches (CCTs) were dug on the hill slopes to arrest the erosion of soil, harvest water and encourage growth of grass. A number of water harvesting structures were also built in the village - check dams, percolation tanks, and loose boulder structures. Plantations on forest lands and roadsides were also part of the programme.

When Adarsh Gram Yojana was launched in Maharashtra, there were also some pre-conditions set for selection of villages. Most important were the four *bandis* (or bans) made famous by the Ralegaon Siddhi experience. The four *bandis* were *kurhad bandi* (ban on felling trees), *charai bandi* (ban of free grazing), *nasbandi* (family planning), and *nashabandi* (ban on liquor). People also had to agree to a certain amount of *shramdaan* (voluntary physical labour), except for the landless who were exempt from it.

The significance of these five ideals needs to be understood keeping in mind the situation in Hiware Bazar at that time, the late 1980s. Tree felling and open grazing was common amongst both rich and poor households. The surrounding hillocks, according to many local people, had a barren look, soil erosion was prominent and groundwater levels very low. In addition to this, fodder and fuel wood shortage were common in the village. Though there was a ban on free grazing people were allowed to cut grass and carry it to feed animals.

There are other bans in the village which were added later. Most significant was the ban on borewells for irrigation, growing sugarcane and banana and selling one's land to any outsider. These measures illustrate that issues of long-term sustainability (especially in terms of water use) were very much central to the strategy. The *bandis* were not mere proclamations but ways of community building aimed at people identifying with the common purpose. But it was not always a smooth affair.

The area irrigated for summer crops has increased from 7 ha to 72 ha. In a year of normal rainfall, there is enough water in the wells to irrigate not only the kharif bajra, but also the rabi jowar and some summer vegetable crops. Even in unirrigated land, the improvement in soil moisture level has helped to increase productivity. The range of crops is also considerably more diverse than in the past with people growing cash crops such as potatoes, onions, fruits (grapes and pomegranates) and flowers, and wheat. Perhaps the most significant development is that increased water availability has made a second crop possible and hence migration elsewhere has reduced. Although this has not meant that small and marginal farmers are able to eke out a living on their own lands only, it has made their lands much more productive. The conditions of wage employment have also improved with wage rates going up – though they remain on the low side.

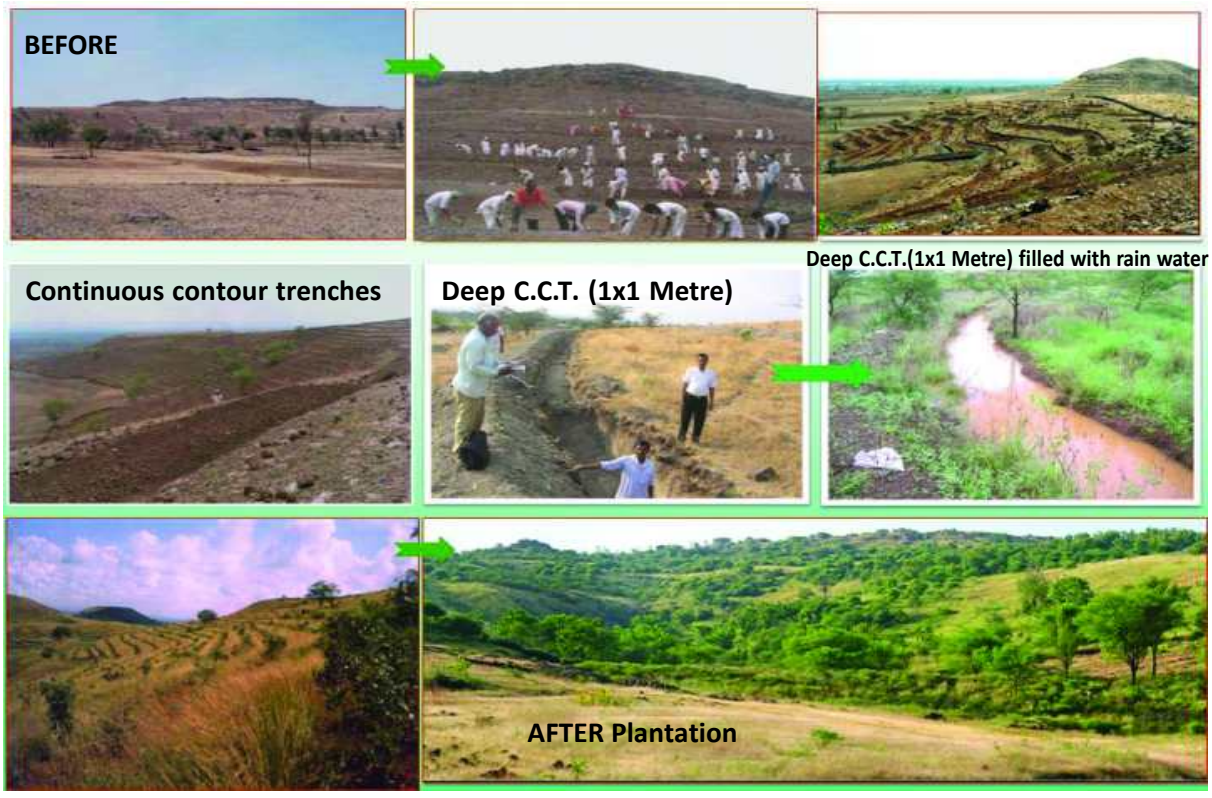


Fig 5.3 : Hiware Bazar - before and after soil and water conservation works

The main thing is the social control over ground water extraction and use – no borewells for irrigation (only for drinking water), no water- intensive crops like sugarcane. Water for irrigation should be taken only though dug wells. They also worked out certain thumb rule type of things like if they get good rainfall then they can take full rabi crop, if the rainfall is less then they bring down the area under rabi, etc. They keep rainfall data meticulously and use it for crop planning and water use prioritisation. Because of this even in years of continuous drought there was no drinking water shortage. This is mainly because they plan according to the water available.

The improvement of the livestock economy has also helped marginal and small farmers significantly. Concerted efforts have been made to promote Hiware Bazar's dairy industry as a means to improve the livelihood of all. Loans have been given to many small farmers. As a result, the number of milch animals in the village has increased. These developments are clearly linked to the fact that fodder availability has increased due to better productivity. Milk production in the village has also witnessed a more than 20 fold increase from 140 to 3,000 litres per day.

However one of the learnings has been that groundwater extraction cannot be controlled at a small unit or within a village boundary. Neighboring villages started going for deep borewells and started extracting groundwater over which Hiware Bazar had no control. Hence we need institutional norms and understanding at a much larger unit like sub-basin or river basin.

- Underline sentences that reflect efforts taken for water conservation in Hiware Bazar.
- What was the effort for planning agriculture according to the available water ?
- If you have access to internet, watch a documentary about Hiware Bazar at http://bit.ly/kothL1

Water as common pool resource

Over the past few decades groundwater has become the main source, especially for domestic use and agriculture. This tremendous increase in the use of groundwater has significant impact on water availability and access to it.

The current laws about groundwater in many states are both outdated and inappropriate. They were developed at a time when groundwater was a marginal source of water. Today shallow and deep tube wells have the potential to draw a lot of water. What should be the judicious way of using this water?

Current laws on ground water use are inappropriate because the basic link between access to groundwater and land ownership on which these rules are based are flawed. Since groundwater has to be extracted from the land above, a link was established between land ownership and control. The water drawn from the

underground system was assumed to be 'owned' by the landowner. This implies that groundwater is mostly controlled by individuals that own the land. Land owners were not restricted in the amount of water they can take out.

Why is the above understanding flawed? Underground water does not obey human land ownership boundaries that are made on the surface. Water is a flowing resource and what is extracted from an individual tube well or well depends on the underground rock formation, the recharge from rainfall or surface water. All these factors are happening over a large area. Hence the actions of others in the region will affect this particular well. For example, over-extraction from one tube well often dries up other tube wells around. Each one competes to go deeper than their neighbour and soon all tube wells up to a certain depth dry up, since these wells are interconnected by the underground structures in the region. It is therefore inappropriate to think of 'ownership' of a flowing resource such as water. Compare this to the air over the plot of land - it is always flowing and there's no way one can create boundaries. Similarly there are no boundaries in the flowing water underground.

Today this is the major source of water for people. When there is so much extraction it affects others in connected areas. It affects the stock of water that would be available for future generations. Therefore one can't allow individual landowners to extract as much water as they wish from their land. There should be some restrictions. These restrictions will be acceptable if we first delink the connection between ownership of land and water drawn from the underground system through tube wells on the land.

Where control over groundwater is linked to land rights, there are no pressures on individual landowners to use water in a fair manner. Nor is there any way to implement policies that take into account the welfare of a broader community and the environment. In what is, for all practical purposes, an unregulated system, there is, for instance, no authority that can determine how many wells, handpumps and other tubewells can be sunk in a given area. Some form of regulation that takes into account the broader aspects of groundwater use is necessary. Therefore water should be thought of as a collective pool resource that is meant for all people. Similar to roads, rivers, and parks, underground water is also 'public property', it belongs to all. While this is being recognised today, by some state governments, it has still not become widespread.

Regulation is not easy. This is also because for some resources like water, electricity, oil, natural gas etc consumption by one person or a sector affects what is available for others. In fact, in a number of states, the answer to falling water tables has been not to address the issue itself. State governments have thus often chosen to increase power subsidies to make extraction of ever deeper layers of groundwater possible. The limits of an approach that not only refuses to control access to groundwater but seeks to encourage it with specific subsidies have been

clearly understood. The political thinking has to change to make regulation work. This is the only way to stop the negative competition to finish off the common pool resource, since each person wants their share before someone else. This is the real contemporary challenge.

What is required are laws and rules to recognise that water is a common flowing resource. Drinking water is the first priority as well as a human right and that panchayati raj institutions must have control over the use of groundwater.

Let us see the dispute over water use between the Perumatty Grama Panchayat in Kerala and the Coca Cola Company. The Panchyat decided not to renew the license for extraction of water because of the lowering of the water table in neighbouring areas. There was also decreasing water quality to the extent that the local government primary health centre had concluded that the water was not fit for drinking. The issue was brought to the courts and is now pending in the Supreme Court, as on Janury 2014. The two decisions given by judges in Kerala gave two oppossing views of groundwater regulation. The first judge found that groundwater is a public resource meant for all, and that the state has a duty to protect it against excessive exploitation. Additionally the judge made the link that drinking water is a priority. The second judge took a completely different perspective and asserted the primacy of landowners' control over groundwater. These two contradictory decisions illustrate the confusion over our laws today.

In conclusion

In the first section, we looked at the river systems and the diverse physiographic conditions that we find in India. Water use for any region, whether small watershed or river basin, has to take into account all the inflows and the outflows. With this background we can understand the inefficient and unfair ways through which water is currently used. How we could be more judicious and fair is examined through the case study of Tungabhadra river basin. This is a complex exercise, but possible. Similarly, for a small region through careful planning and social initiative a more judicious use of water for all is feasible. We looked at the effort of the people of Hiware Bazar village and hope that people all over would be inspired towards creative action in their situation. Water resources require both collective action at the local level and appropriate laws and policies at the state and national level. Through the example of groundwater we can understand the shortcomings in our thinking today.

- Should groundwater regulation be primarily community-led, as in the case of Hiware Bazar?
- "The groundwater laws are both outdated and inappropriate." Explain.
- Should groundwater be considered a common pool resource? Explain your view.

Key words

Flow resoruces Groundwater Drainage Water Sharing Law
Watershed Catchment Area Drought Percolation

Improve your learning

1. Create a table to describe major river systems in India with the following items: direction of flow, countries or regions through which they pass through, and relief features of the areas.
2. Identify and list arguments that would support or oppose use of groundwater in various contexts, such as agriculture, industry etc.
3. What are the different inflow and outflow processes in the context of water resource?
4. Which of the inflow or outflow processes has most impact in the context of groundwater resources?
5. Make a list of challenges faced in the water resources in the Tungabhadra basin. Identify the solutions that have been discussed in the context of these problems either in this chapter or elsewhere in different classes.
6. There has been various ways in which changes occurred in the context of water resources. Describe the positive as well as negative social changes that got reflected in this chapter.
7. Which aspects of farming practices were regulated in the context of Hiware Bazar to improve the water conservation?
8. How significant are the laws, people's actions, in the context of water resources? Write a short note based on the ideas discussed in the last two sections of the chapter.
9. If you have access to internet, visit www.aponline.gov.in and learn more about Andhra Pradesh WALTA Act.
10. In what ways is water bought and sold in your area and for what purposes? Do you think there should be some checks and balances for this? Discuss.

Project

Think of plans for your village or locality, which if implemented would help everyone.