Chapter 1
Introduction to Infrastructure

I consulted several things in my situation, which I found would be proper for me: first, health and fresh water I just now mentioned; secondly, shelter from the heat of the sun; thirdly, security from ravenous creatures, whether man or beast; fourthly, a view to the sea, that if God sent any ship in sight, I might not lose any advantage for my deliverance, of which I was not willing to banish all my expectation yet.

Daniel Defoe (Robinson Crusoe)

There is a tide in the affairs of men.
Which, taken at the flood, leads on to fortune;
Omitted, all the voyage of their life
Is bound in shallows and in miseries.

William Shakespeare (Julius Caesar Act 4, scene 3, 218–221)

A rising tide doesn't raise people who don't have a boat. We have to build the boat for them. We have to give them the basic infrastructure to rise with the tide.

Rahul Gandhi (former Prime Minister of India)

Water, water, everywhere,
Nor any drop to drink.

Samuel Taylor Coleridge (The Rime of the Ancient Mariner)

...infrastructure might not be a sexy word, but it’s on practically everyone’s lips...it’s not just a business issue; it’s a family issue. And it’s a political issue, a leadership issue, not just an engineering issue.

Rosabeth Moss Kanter (Move)

This chapter introduces infrastructure, its definition and its benefits. The importance of infrastructure arises not for its own sake, but rather for the services it provides directly to users, or to other infrastructure. For example, electricity is used by consumers and for transport. Thus, infrastructure needs providers, users and may be interconnected. They may also create externalities, such as pollution. Apart
technical infrastructure, as is currently understood, an exposition of other types of infrastructure – environmental, economical, social, just to name a few – are explained. Many people can manage without electricity, but nobody can live without water. This explains the notion of critical infrastructure, for which it is essential to consider better reliability and availability.

1.1 Infrastructure

1.1.1 Problems of Infrastructure

Robinson Crusoe’s problem was to find food and shelter, security and how to communicate – with his servant Friday and the outside world. In modern times, similar problems not only still exist, but have considerably increased. A small hamlet may accommodate a few people living close together, but the village has more problems calling for more solutions. How to communicate among each other in order to bring food, water from the source (or storage area, depot) to the end of the village. Other amenities are not different, for it would be equitable to make these accessible to one and all.

1.1.2 Definition of Infrastructure

A first appearance of the term infrastructure appears in the late 1880s in France, but was subsequently used in America in 1927 to designate the complex linkages of waterways, roadways, and communication networks assisting military organisation in the United States (Bowker 2018).

It is not very easy to give a definition to the word infrastructure. Structure comes from the latin word struere meaning assembly, whereas infra means below.

Structure could be defined as the organisation of the elements of a complex system into a coherent and permanent form. This expression is general enough to cater for the architectural, economical, philosophical and public works viewpoints.

Superstructure is anything that rests on a base. It is a word that is commonly used in marine terminology meaning the construction resting above the deck. From the philosophical point of view, it is the political system (State) and the ideological system (judicial, education, cultural, religious), resting on a given economic platform, or infrastructure.

This enables defining infrastructure as the means and forces of production which are necessary for social development. In more practical terms, all the works necessary for the development of a community would constitute infrastructure. However, the works – although necessary – are important, not because of their physical form or appearance, but because they provide or facilitate the provision of services to users and decision makers. This creates multiple and complex linkages of infrastructure to
the economy because there are externalities (spillover effects – both positive and negative) involving huge expenditure flows. The economic development of a country depends heavily on the availability of adequate infrastructure facilities. (An externality is the benefit or cost that results on a third party when someone else takes an action. More in Chaps. 2 and 17.)

For example, to attract tourists and provide them with a satisfying experience on which long-term, profitable business can be built, construction of suitable accommodation, restaurants and passenger transport terminals at the resorts is necessary. In addition, there must be a sufficiency of essential and basic services: roads, and transportation, water, electricity, sewerage disposal systems harbours, airports serving both the local residents and visitors.

As governments seem to be well aware of this, most of them have invested heavily in such sectors, apart from providing education and training, health and empowerment of disadvantaged groups.

Thus, the complex interaction and operation among human, economic, technical systems and the environment comprise the network of infrastructure services for which Hall et al. (2016) identify (a) suppliers (b) customers and (c) externalities. (a) suppliers comprise the public and private sectors which implement, and operate the physical facilities together with the relevant manpower.

(b) customers consist of individuals and households, who need these services for their welfare, government and businesses, which run their organisations with the support of these services.

(c) externalities to the supplier-customer connection are the various impacts (e.g. positive – shorter trips benefitting people and negative side-effects such as pollution of the environment) resulting from the implementation of such infrastructure services (more in Chaps. 2 and 17).

Between source and destination, there are many ways of providing infrastructure services – conversion or treatment, storage and conveyance. As there is no precise distinction between these categories (e.g. gas and water pipelines provide both storage and conveyance), Hall et al. (2016) gives following definition:

An infrastructure service operates physical facilities and ancillary human organisations to transform, store and convey (physical and virtual) resources so as to provide an option for an activity.

Among other things, the resources in the above definition include freight, passengers, water, waste products, various types of energy carriers, and information (data). But, much will depend on the relevant infrastructure service,

More will be explained later on the nature of “systems” in Chap. 6. For the time being, given the way infrastructure services and the associated processes for their provision, (mechanical, human, communications systems controlling the physical operation of actual infrastructure facilities), it is fitting to provide a definition of infrastructure systems:

An infrastructure system provides a particular infrastructure service through the assembly, interlinking, and coordinated operation of the relevant physical facilities and human systems required.
Of course, any country has a network of infrastructure services: electricity and water, to name just two of them. If each network form a “system”, then it should be easy to understand how any National Infrastructure is a *system of-systems* of infrastructures. These systems are integral to the proper functioning of modern economies, but also face a number of serious challenges. This is further developed in Chap. 6.

### 1.2 Examples of Infrastructure

By and large, infrastructure can be classified into several main categories (see Table 1.1) which are discussed below. Fig. 1.1 shows a pictorial view of infrastructure assets.

#### 1.2.1 Agriculture

Agriculture provides the means to produce food, as a basic requirement for life. Man has learnt to cultivate the necessary plants, with or without irrigation, depending on the circumstances. In many countries, it is not possible to cultivate crops successfully without irrigation. A **cash crop** or **profit crop** is grown for sale and is typically purchased by parties distinct from an or not owning farm.

Sometimes a fast-growing crop (**catch crop**) is planted between rows of a main crop. Thus, potatoes which take 70–120 days, tomatoes (75–90 days), beans (45–60 days), radishes (25–30 days), to mature, can be grown between rows of sugar cane and harvested before the main crop (sugar cane) matures. This practice allows more efficient use of land.

Without irrigation, the average yield per hectare can be very low, while irrigation facilities can considerably increase the yield per hectare. This can contribute significantly to the national economy and to the country’s food security. However, irrigation expansion can place a greater demand on surface and ground water resources, at the expense of other sectors such as the industrial and the domestic supply.

An important side issue might be to ask what if the irrigation system does not pay for itself by the extra yields obtained with irrigation.

Sometimes, subsidizing water and electricity for irrigation for political reasons, may lead to wasteful use, rather than more optimal practices. It is almost a truism that all planters (farmers) would like to get irrigation water for free. Most irrigation departments, have limited revenues and budgetary support, and therefore find it difficult to operate and maintain the efficiency of irrigation systems, thereby leading to further temporal deterioration of the ageing structures and systems.
| Category       | Details                                                                                                                                                                                                 |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Agriculture   | Different crops cultivated Irrigation systems                                                                                                                                                            |
| Buildings     | Materials                                                                                                                                                                                               |
|               | Public and private buildings (hospitals, fire stations, prisons, schools, government offices, police stations, car park structures)                                                                                                                                |
|               | Other buildings (public, residential, commercial, multipurpose complexes)                                                                                                                                 |
|               | Public and private housing facilities                                                                                                                                                                   |
|               | Industrial, manufacturing, warehousing and supply chain facilities                                                                                                                                         |
| Communication| Telecommunication networks (land telephone/optic fibre networks, telephone exchange stations, transmission towers)                                                                                      |
|               | Cable television networks                                                                                                                                                                                  |
|               | Wireless/satellite networks                                                                                                                                                                               |
|               | Information technology (IT) infrastructure networks: (cable distribution, computer networks, backup and recording mediums, cloud computing infrastructure).                                                    |
|               | Postal and Shipping                                                                                                                                                                                      |
| Education     | Primary and secondary schools, universities, other training institutions                                                                                                                                   |
| Energy        | Hydroelectric plants (turbines, penstock, surge tower)                                                                                                                                                     |
|               | Thermal plants (gas, oil, coal fuelled power generation), nuclear                                                                                                                                            |
|               | Gas pipelines (gas production at landfills, storage tanks)                                                                                                                                                 |
|               | Petroleum/oil distribution (pumping stations, truck/pipe transport, storage tanks)                                                                                                                                 |
|               | Renewable energy (infrastructure for solar power, wind power, biofuels)                                                                                                                                 |
|               | Electric power distribution grid networks                                                                                                                                                                |
| Health        | Public and private health facilities (hospitals, clinics)                                                                                                                                                 |
|               | Teaching and Research hospitals                                                                                                                                                                            |
|               | Private nursing homes                                                                                                                                                                                    |
| Housing       | Houses, apartments                                                                                                                                                                                       |
| Industry      | Factories, equipment, logistics                                                                                                                                                                           |
| Recreation    | Parks and playgrounds, recreational facilities, swimming pools, picnic areas                                                                                                                             |
|               | National monuments and Icons                                                                                                                                                                              |
|               | Lake and water sports, fishing facilities                                                                                                                                                                 |
|               | Theme parks, restaurants, security facilities, casinos                                                                                                                                                    |
| Tourism       | Hotels, transport and recreation facilities (fun parks, safari tours, ecotourism)                                                                                                                          |
| Transportation| Vehicles, bridges and tunnels, access roads, parking areas                                                                                                                                                 |
|               | Airports, helipads, air traffic control, ground facilities, Seaports, dry docks                                                                                                                           |
|               | Mass transit (monorail, trams, bus, platforms, stations)                                                                                                                                                  |
| Waste         | Solid waste (transport, landfills, transfer stations, recycling facilities)                                                                                                                                |
| Management    | Hazardous waste (transport, storage facilities, treatment plants, security)                                                                                                                                |
| Water         | Nuclear/radioactive waste (transport, storage facilities, security)                                                                                                                                       |
| Wastewater    | Water supply (pumping stations, treatment plants, service reservoirs, trunk mains, boreholes, mechanical/electrical equipment)                                                                         |
|               | Structures (weirs, dams, impounding reservoirs, tunnels, aqueducts)                                                                                                                                          |
|               | Irrigation water distribution (rivers, canals, weirs, gates)                                                                                                                                               |
|               | Sewerage (sewerage pipes, septic tanks, treatment plants)                                                                                                                                                  |
|               | Stormwater drains (roadside gutters and drains, canals)                                                                                                                                                   |

Adapted from Proag (2010)
Water supplies for irrigation can be obtained from three sources:

1. Directly from river flow by diversion canals.
2. Storage of flood-waters (rivers and rain water).
3. From water underground through boreholes.

The availability of supplies from these three sources varies in different parts of the country, according to physical presence and the cost of exploiting them.

However, two criteria need to be met before irrigation can be practised: (1) an adequately large availability of water of the proper quality; this requires the right (geology, water supply, topography, etc.) conditions an impounding reservoir, and (2) distributing the water economically through proper pipes and canals to the cultivated area.

Water passing through hydro turbines usually go back to the same river course from which it was abstracted – it is then sometimes possible for the same water to be used several times, depending on topography, for several generating stations to operate along the same river – or sometimes diverted to another river valley, at a level lower than the exiting tail race water. In other cases, suitable water works combinations provide that the exiting tail race water is used for say, irrigation or domestic water supply.

To summarise, the whole problem lies in proposing development schemes which can consider the following parameters:

(a) the extra production and yield obtainable from new crops and methods;
(b) how to market the extra production and yield;
(c) what extra capital, new equipment and other supplies, e.g. fertiliser, are now required with the new techniques;
(d) the new organisation logistics required;
(e) how to disseminate the new techniques and convincing farmers to change their old habits into new ones;
(f) the resulting modifications in social organisation and land tenure;
(g) how to adapt the plan to the different local area conditions, so that it becomes a network of inter-locking plans.

Of course, time is a very crucial factor in agriculture, in contrast to other economic sectors because of the following reasons:

1. the physical time needed for any improvement to manifest itself significantly.
2. the psychological time required for farmers to understand and practise a new technique.
3. the time required to bring in new materials, fertiliser, suitable seeds, etc.
4. the time taken by consumers to accept and purchase new products.
5. the time required to recruit staff members to engage in skilled research and dissemination. It is necessary for advisory staff not to be only to be familiar with the new techniques, but also be knowledgeable in teaching and winning the co-operation of the farmers. Otherwise, the whole plan may fail to achieve its aims.

The above indicate the introduction of a time lag between the concept and the implementation and/or the results.

1.2.2 Buildings

“Buildings, buildings, everywhere,
Nor any chair to sit down anywhere.”
is probably what Coleridge might say. It is a fact that buildings are needed for most uses, such as:

- Public buildings (government offices, hospitals, police stations, schools, fire stations, parking structures, prisons).
- Other buildings (public, residential, commercial, multipurpose complexes).
- Public and private housing facilities.
- Industrial, manufacturing, warehousing and supply chain facilities.

Even supplying water or electricity warrants buildings to house pumping plants or generators, among other needs. Different buildings may require different materials for their different properties or advantages with respect to the uses required of them.

The location of industrial areas may depend on the land area available, transport facilities, and certainly on the type of industries involved. This, in turn, affects the
type of buildings to be constructed, whose layout will affect other services such as roads, drainage, water and electricity supply.

Some administrative offices have to be frequented by numerous members of the public seeking to secure permits, to pay taxes etc. Other offices include public works planning, purchasing, educational organisation, higher law courts, etc. The buildings should therefore be properly located to allow easy access.

In a way, the town centre determines where residential housing will be conveniently located, as well as work places, some of which will probably be far from the town centre. If the land is organised into convenient school units, with roads and paths conveniently placed to collect children, at the different schools, primary and secondary. From a safety point of view, children commuting to school should not have to cross major roads unless they can do so safely, and conveniently. Thus, small land areas separated by a main road may not be suitable for residential buildings.

Furthermore, optimum school size and maximum walking distances, dictate the approximate catchment area for a single primary school and probably exert a more powerful influence on the layout than is the requirement for conveniently sited shops.

If construction of buildings near each other is indiscriminately allowed, the results can be

(i) dangerous,
(ii) unhealthy,
(iii) disagreeable, and
(iv) a cause of congested traffic.

Conversely, each individual site owner might feel that any necessary space should be taken care of the neighbour rather than by himself. As owners of small dwellings are often unaware of possible resulting bad conditions, the planning authority should enforce minimum rules about:

(a) setback (if required) from the street,
(b) loading and unloading facilities within the building’s boundary or compound,
(c) distance of the building from other buildings and from the boundary of its plot.

This last criterion may, of course, allow some possibility of building contiguity to enable continuous development of the street frontage. The distances prescribed will be affected by different considerations, such as fire prevention, fire-fighting and ventilation, etc.

Building height (see also Chap. 3) is important for different reasons:

1. it affects density, the number of people visiting the building and the volume of traffic connected to the building;
2. it influences the lighting (natural and artificial) of other buildings;
3. it influences the structural details, preventing collapse, of other buildings, as well;
4. it affects the fire-fighting problem.
Many local factors, such as climate, the type of construction to be used in each building, local habits etc., will influence the standards. The main point, however, is the specific purpose behind every regulation – which each relevant official can convincingly explain to members of the public, because he understands it.

These detailed regulations will be applicable either to all buildings or to buildings of certain categories, for example, to all houses or all shops. These regulations should, thus, be very clearly drafted and distributed freely to public members considering the planning or construction of a new building. Of course, the authorities should not prescribe such standards unless they do examine all plans for new buildings to check their compliance with the standards, and can inspect the buildings during construction to compare adherence to the approved plans.

1.2.3 Communication and Telecommunications

The postal system together with broadcasting services form part of the most extensive networks in the world. The postal system currently provides several services, *inter alia*:

(a) transportation (letters, parcels, postcards, newspapers),
(b) money order services (mandat poste, money orders etc.),
(c) banking services (deposits, withdrawals, life insurance),
(d) agency services (payment of several types of bills),
(e) courier services (fast delivery service of letters, parcels).

Tariffs for such services were formerly fixed using social considerations. In many countries, the public sector had, until recently, the monopoly of the telecommunications sector. Given the very often poor quality of services provided by public sector, and an associated high cost, the introduction of competition has gradually improved service quality, increased capacity, and allowed using new technology, such as IT (Information Technology). The result has been improved communications and a significant impact on the economy.

The last 25 years has brought an overall transformation in the telecommunications sector. The quality and range of services available have greatly improved through technological advances. New developments in information technology, such as data communication through e-mail and associated services through the internet, television broadcasting through satellites, cell phone and other communication possibilities have introduced new ways for people to conduct business and communicate.

Of course, a country can only benefit from the telecommunications network transformation if it keeps in touch with the technological development. However, being able to access or acquire data at will is one thing. Interpreting the information before integrating the data usefully into the country’s industrial structure is another: this depends on the thinking abilities of the individuals – to be addressed under education – accessing the data. In many industries (textile, garment, toy and
consumer electronics), countries have increased their competitiveness because they were able to obtain prompt information about demand trends or price movements, due to close and rapid links between the foreign markets and local production.

Service industries such as banking, trading, retailing, transportation, maintenance, and insurance can equally benefit when high speed information and real-time communication are available throughout the production process. Several countries have increased their competitiveness through a reduction of their service costs, thus entailing a higher efficiency of their financial markets and their economic system are reduced through shorter time.

As shown above, all activities (agriculture, industry, trade and commerce) become more productive. A few decades ago, communication between two persons A and B consisted in person A writing a letter to person B, who after receiving it 1 week later would reply to person A through the same postal service. Telephoning was expensive, if existent. Nowadays, information technology has enhanced human welfare by allowing cheap modes of communication (internet, live/video telephony) between families, friends and acquaintances. A rapid growth in this sector is probably essential for developing countries through a proper policy.

In most countries, a consumer can, using a telephone, fax machine, or personal computer linked to the Internet, place an order for goods with Amazon, etc., and have the articles delivered by DHL, and charge the purchase to a credit card. The same consumer may also contact (fax, phone, email) any number of financial institutions 24 hours a day, transfer money from anywhere to anywhere, in order to avoid the artificially low interest rates which may have been imposed by the government.

Twenty years ago this would have been unthinkable. For Nintendo kids, this will be a normal part of everyday life. Can a country afford to lag behind in the telecommunications sector?

However, the country needs to develop security of telecom infrastructure and cyber security, as this represents an important vulnerable link in the communication sector. in particular are escalating. Appropriate arrangements for co-ordination among several agencies may be required if they the new and emerging challenges are to be met.

**1.2.4 Education**

Poor countries cannot spend as much as rich countries for the education of children. Therefore, priorities both for quality and quantity have to be established.

In poor countries, the cost of education is higher because:

(1) with higher birth rates, there are more children in schools.
(2) educated people being relatively scarce, the ratio of a teacher’s salary to per capita national income is much higher in poor countries (Lewis 1966).
The strategy is to estimate the demand for skills, and to try to train at least as many people as are required to meet the demand for places with different levels of education.

However, even when there is a high proportion of high school and university graduates, there seems to be a lack of technically skilled people (workers, technicians, agricultural assistants, nurses, teachers, competent secretaries and supervisors) or professionals such as engineers, scientists, agronomists and doctors. Both apprenticeship facilities and in-service training are required.

Estimating the demand for skills is not easy; this will give a minimum number to be trained should production go on as expected. However, as soon as the market situation changes (often seasonally, or depending on overseas markets and fashion), some trained people might still find themselves unemployed, or there is a still further demand for such training in another field. One solution would be to train people to be multi-disciplinary or slightly versatile.

People go for courses where they expect higher salaries, but whatever expectations potential employees might have, the employers will try to use the lowest qualifications suitable for the job. It is also possible that employers would recruit secondary school graduates for jobs as sales clerks instead of primary school graduates, simply because the economy so dictates.

The tendency to go to higher qualifications for a particular job resides partly on the lack of thinking skills displayed by those coming out of the modern education system. Fifty years ago, the photocopying machine was barely available. There was no internet. Any student trying to write an essay would first consult encyclopedias, then take some notes (normally too lazy, or it is too tedious to copy verbatim) on the essay subject. With those notes in hand, the student would then sift through the ideas to write a presentable essay. This process, did force the student to think about the essay title, among providing other skills. Today, the internet – making information available at a mouse click – has killed such possibilities. Employers believe, rightly or wrongly, that those students with higher qualifications have better thinking skills.

It is therefore important to keep track of thinking skills or data interpretation as an important component of the education system, in particular if there is an emphasis towards ICT development in the country.

1.2.5 Energy and Power

In physics, it is learnt that energy is related to power through the time the latter is available. In the real world, these two topic subjects are so close that it is difficult to separate them. Most materials useable as fuel on a large scale are useable to produce power, while other forms of power such as electricity, are useable for heat production. Primitive fuels such as dung and brushwood are not plentiful enough to be used on a large scale. However, for national development, power is vital for both industry and transport. In industry, electricity dominates, while transport relies more on
petroleum products for power. Of course, other forms of heat and power are sometimes required by some industries require, but generally speaking, however, electricity is fast becoming the versatile source.

Power supply is influenced by the country’s physical endowments (gas, water, coal, oil, etc). If there is a shortage of power resources in one region, it may be possible to mitigate the lack thereof from other regions; however, if the country, itself, does not have such resources, importing resources (such as oil, gas, or coal) to produce power will definitely affect the country’s planning (both national and regional).

The planning, or more specifically the programming, of power development should take place before any development at all in other sectors, is considered. Industrial development can only take place after the necessary and relevant power supplies are made available. No firm or industry investor, whether private or public would be convinced by vague promises about power being made available. The business investor may consider investing in his own power source or generator (see also Chap. 9 on Reliability), because he cannot have an undue dependence on outside or national sources unless he is given a firm guarantee of what kind of infrastructure will be available and when.

The distance between the power source and the point of use influences the cost of power at that particular point. The cost of transmitting power was formerly so huge that the power source and the point of use needed to be practically identical. However, since electricity has been widely available, the equation has changed, given that electricity can be cheaply transmitted and the transmission costs are often negligible compared to other parameters.

As energy consumption depends on population growth and economic development, the energy policy of the country must consider the following issues:

1. Transport infrastructure depends on fuels for transport (petrol, diesel and electricity), which should be available at competitive prices.
2. Reasonable prices for electricity, and clean cooking fuels for households. Their needs for an affordable and adequate supply are growing. This will help avoiding indoor air pollution and collecting fuel wood.
3. The demand for fossil fuels, compared to import requirements of gas, crude oil, and petroleum products.
4. Adopting clean fuels and clean technologies will entail positive environmental impacts (indoor, urban and regional).
5. Social costs of different fuels as reflected by prices, subsidies, taxes and transportation costs of each.

Unfortunately, the above considerations are usually conflicting, thus requiring trade-offs. The different sectors: agriculture, business, households, industry, transport have increasing demands, which present a challenge to satisfy, solely, by cheap and clean electricity.

Some governments try to provide a convenient lifeline water supply to the poor, going to the extent of providing it for free. Is it possible to do the same thing for
energy on the basis that this is also critical for their welfare? Side question: is it a good practice to provide such free infrastructure services?

It is possible to improve energy efficiency in a country through different measures:

(a) auditing the large consumers,
(b) comparing with other users to find more efficient practices,
(c) using energy ratings and implementing their use for consumers’ equipment,
(d) encouraging high energy consumers to adopt higher efficiency practices,
(e) providing incentives for energy efficiency in buildings.

Procurement policies should work on two fronts:

- Encourage consumers to buy energy efficient products – with relevant labelling,
- Use life cycle costs, rather than initial costs only, to purchase equipment.

### 1.2.6 Health

Governments spend money on the health system because this is important in three ways:

1. the number of working man-hours is increased,
2. the quality of work gets improved with healthier employees,
3. when uninhabitable areas are cleared, natural resources which would not otherwise be used, may be harnessed.

Preventive public health policies or programmes can help more than curative medicine. The death rate has decreased drastically over the last centuries because the main killers have been wiped out at relatively small cost, using the services of only a handful of doctors, engineers either by improvements in the water supply – which have curbed cholera, typhoid and dysentery – or by environmental sanitation – which has materially reduced the incidence of malaria, yellow fever and tuberculosis – or by vaccination – which has nearly eliminated smallpox, diphtheria and poliomyelitis.

A country needs a minimum number of doctors to provide a good public health service. Beyond this number, extra doctors add to the comfort and convenience of patients, but do not add a great deal to health.

Most Governments realise the productivity of expenditure on public health. The debate, however, relates to the expenditure on curative medicine, especially on hospitals and on clinics. This part of the medical service is also the most visible to the public, who might want more of it. Unfortunately, it also costs most, and has a low productivity.

Although we might judge infrastructure (or its services) only in terms of productivity, people value health for its own sake, as they value consumer goods. Good health is valueless: people will often mortgage all they possess (e.g. go for expensive...
surgery) in search of better health; they buy medical attention even when it does not bring health, and so spend much money on the chronically ill, including those who will never again be able to work.

If a Government is trying to give people what they want, it seems wise to think that they want health more than they want anything else. In the light of the COVID-19 pandemic prevailing in 2020, how many people felt the lack of proper and adequate infrastructure?

### 1.2.7 Housing

Shelter is an essential component of human survival. Shortage of shelter is a universal phenomenon faced by majority of countries and particularly the developing nations. More often than not, however, it is perceived more as an urban problem. However, the magnitude of the housing shortage in rural areas is enormous.

As long back as 1948, the United Nations recognised housing as a basic human right. A roof over one’s head is an important personal asset which enhances one’s physical comfort and mental well-being. However, governments’ intended policies and achievements in this field provide cause for much frustration.

The cost of building houses probably is an important cause of the difficulty: how to build an acceptable house or apartment (wood, brick or cement) for urban working class family at a cost of less than Rs. 500,000, without the land. The annual cost of such a house is about Rs. 50,000. If a worker paid 10 per cent of his income in rent, he would need an income of Rs. 500,000 a year. Even if he paid 20 per cent he would need to earn Rs. 250,000 a year. And the percentage of workers who earn Rs. 250,000 a year in developing or third world countries is small.

Is it possible for the Government to build houses for the poor or should it encourage private persons to build houses, whether for owner-occupation or for rent? If the Government cannot subsidise houses, but insists that people live in expensive and unaffordable houses, then the housing problem becomes insoluble.

There should be more emphasis on the environment rather than on the house itself. Well-spaced houses, painted in different colours, can be very attractive. Governments should provide sites where workers can build their own houses cheaply; control the spacing of buildings; and look after lighting, water supplies and garbage disposal. Slums are not houses made of cheap material, but rather the over-crowding of sites and the absence of utilities. The provision of water supplies and waste disposal cannot be over-emphasised.

### 1.2.8 Industry

Although in towns, industry is only one of the employment sources, industrial activity starts becoming important as soon as the town grows beyond the minimum threshold when it served only as a simple commercial exchange centre. As society
develops, industry becomes part of the landscape and has to consider its rate of expansion, compatible with employment it has to provide to persons who cannot be employed in agriculture and who will be attracted to towns. In his novels, *Ruined City* and *A Town like Alice*, Neville Shute gives a good description how industrial activity can die down or start anew or why people might leave country life.

Industries, in different regions, crop up differently for various reasons (see also Chap. 2), depending on local available resources (materials, labour, power, etc), and the possible location of the factory with respect to these resources. Then things are simple. Often, however, few factories are set up because all these conditions are met and even when this is the case, probably not enough employment is created to absorb the local excess of labour.

Three factors often dominate the physical location of most modern industries:

(a) presence of some physical disadvantages, if any;
(b) availability of suitable or specialised labour in the vicinity;
(c) easy access to raw materials, marketing and distribution arrangements for the produce.

These three considerations entail that industries tend to favour flat land in the larger towns - which are likely to be the richer places already. Although commendable, it is not easy to start or develop industries in poor, mountainous areas, Furthermore, the money and time spent in developing industries in unsuitable or difficult areas might well result in a slower growth rate of industrial development. This may impact unfavourably on the general national development. It must not be forgotten that though workers like to earn much money, they also form part of the consumers who wish every product were cheap. Thus, these same workers would not be prepared to spend a lot, even to help their fellow workers who produce goods, which can be obtained more cheaply from other trade channels. This danger is very present with new industries competing against imported products, sometimes at dumping prices.

Given that power is almost synonymous to electricity, availability of power, although an important consideration, there is no constraint to power provision to most industrial centres, unless the quantity required is very large, where the price could also be significant. Whether there is a local tradition for industrial activity or organisation could also be another important parameter, in the sense that if a factory work tradition exists, skilled personnel (process workers, qualified technicians, managers, etc.) might be available or opportunities exist for local training in the various skills required. Proper commercial connections are certainly necessary as well as suitably experienced entrepreneurs with initiative capability to conceive and implement large projects.

Although the entrepreneur most often looks after a private enterprise, however a good manager must have entrepreneurial skills whether the company is privately owned or state-owned. Whether the government starts or nationalises a company, its foremost duty will be to get a manager with the necessary talent and skills to run the company. To be considered competent, this manager must possess qualities which differ significantly from those demonstrated by the usual state administrative official. Nowadays, more and more, industries use technology (sometimes highly sophisticated) to run their factories. Even if a simple, but devoted, manager can accomplish
much good work, even better progress will be achieved with the proper first class talent of the right kind. As industries develop further, this may become more acute.

An important public enterprise may act as a nucleus for a cluster of flourishing private companies, though it might not be easy to start at a moment’s notice. However, it certainly depends on the skills of the rare enterprising manager. In order to achieve economic development at an optimum rate, it is primordial to attract many types of economic investors with as many talented people as possible. As a means to attract investors and encourage exports, many countries have exploited the possibilities of the export processing zone (EPZ), a specialised industrial estate located physically and/or administratively outside the customs barrier, oriented to export production. It is not necessarily a specific zone (Likosky 2003), located near the port area. The buildings and services provided in the EPZs enable transforming imported raw materials and intermediate goods into manufactured finished goods, for export without incurring customs duty. If part (or all) the goods are sold locally, normal duty has to be paid.

Often, apart from custom duty exemption, EPZ firms are also exempted from legislation such as labour laws and domestic taxes. The export processing zone is thus an “enclave” within which firms, mainly foreign, enjoy special privileges which do not apply to the country as a whole. Other names include Special Economic Zones (SEZs) or Free Trade Zone (FTZ).

Mauritius used the EPZ approach to attract investors in the 1970s and 1980s to locate their labour-intensive activities in Mauritius, with several benefits and a package of fiscal concessions. (Zafar 2011, Bheenick and Schapiro 2006). Gradually, several reforms solved recurrent problems. Under certain basic conditions, the Mauritian EPZ model could be useful to other countries.

Technology, as well as machinery, encompasses organisation of production, knowledge, whether embodied in hardware or software, people, institutionalised practices.

It follows that technological capability is the ability to make effective use of technology. This includes the capability to choose technology, operate processes and produce goods or services. It also includes the capability to manage change in products and processes, and in the associated procedures and organisations.

Thus technological capability involves the following:

(i) the ability to search for available alternatives and to select appropriate technologies,
(ii) the ability to make selective use of technology in producing goods and/or services,
(iii) adapting technology to specific production conditions,
(iv) bringing minor innovation into the technology,
(v) research and development (R&D) facilities in institutions,
(vi) carrying out basic research.
1.2.9 Recreation

Tribe (2011) explains terms relating to both recreation and tourism. After considering time taken for sleep, domestic and personal chores, work, commuting, there is some leisure time available to be used freely. Activities, such as watching television or reading (indoors), or sports, cinema, tourism (outdoors), pursued during this leisure time are grouped into the term recreation. While someone regularly travels to his home or her place of work, a movement towards a place outside these destinations is called a visit. When the visit includes at least one night, this becomes tourism!

While at one time, most people barely had leisure time, except for rest, living conditions have changed considerably, so much so, that a whole leisure and tourism industry now exists, supplying goods and services for or influencing the use of leisure time. Other organisations, such as the IT sector, try to satisfy both leisure and non-leisure activities.

A few details are given in Table 1.2.

Many of these recreation activities do not require much personal outlay (e.g. watching TV, exercise, gardening, hobbies), but others might need basic infrastructure facilities, together with ancillaries for road access, parking areas etc., such as:

- Parks and playgrounds,
- National monuments and Icons,
- Lake, reservoir and water sports (picnic areas, fishing facilities),
- Theme parks/casinos (restaurants, security facilities).

Both public or private sector organisations may provide these leisure and recreation facilities.

Table 1.2 Recreation and tourism

| Recreation at home          | Recreation outside home          | Travel and tourism            |
|-----------------------------|----------------------------------|-------------------------------|
| watching TV and videos      | visiting attractions             | travelling to destination     |
| listening to the radio/music| eating and drinking              | accommodation at destination  |
| hobbies                     | hobbies                          | Recreation – may include activities from both previous columns |
| use of computers            | sports participation             |                               |
| exercise                    | betting and gaming               |                               |
| playing games               | watching entertainment           |                               |
| gardening                   | Bird watching                    |                               |
| DIY                         | reading                          |                               |
At local government level, leisure and tourism provision includes:

- public gardens and recreation facilities,
- libraries (reading rooms and borrowing facilities),
- leisure centres and swimming pools,
- arts centres,
- tourism support (free local maps, tourism advice bureau).

While some facilities (parks) are generally provided for free, others may be payable so as to meet operational costs (arts and leisure centres). Whether the municipality provides subsidised rates and public provision or lower local taxes and private-sector provision will depend much on the local political party in power.

In large countries, neighbouring towns may have different policies, while a single rule might apply in a small country, notwithstanding that political parties are influenced by:

- the national government,
- the local press,
- pressure groups,
- trade unions.

Private sector organizations (non-government-owned) can provide many of the services that can or are provided by the government organisations, except that the services are not free. These organizations can be divided into profit-making and nonprofit-making ones.

### 1.2.10 Tourism

The tourism industry basically considers people

1. moving from one region (where they live or work) of the world to another,
2. making visits of a few days to a few weeks,
3. with different modes of travel,
4. at the resorts or destinations catering to the needs of the visitors.

Thus, tourism involves a complex mixture of material factors (accommodation, transportation, the attractions and entertainments available) and psychological parameters (the wide spectrum of human attitudes and expectations based on recreational pleasure, culture and education, ethnology, and generally business, major events, adventure, sociology).

The multiplier effect spreads the benefits of tourism far beyond the resort. Broadly speaking, there are three categories of economic impact:

1. A *direct expenditure*: tourists spend money on accommodation, food, and on tourist facilities in the region.
(2) An indirect expenditure: activities above create business transactions (airfares, tour operators). Conversely, bird watching, or watching a football match in another town or country may also create impacts in the first category.

(3) The induced expenditure: local nationals (hotel employees, taxi drivers), having derived income from above, now spend their money on their needs, locally, or practice tourism elsewhere!

Tourism expenditures provide an increasing income to the area with a resultant social impact. Some other points need consideration:

(1) Should tourism be encouraged and expanded and will there be net benefits for the country or region?

(2) The main benefits are the provision of jobs, increased income and improved amenities for resident nationals.

(3) In many countries tourism is the major (e.g. Seychelles, Maldives), sometimes only, employer.

(4) Government revenue may also be increased through taxes (airport tax, environmental protection) and import duties on goods and services imported for tourism purposes. Sometimes, the tourism industry benefits from fiscal incentives because it is a job creator.

(5) Besides the development of hotels, tourism requires investment in airports, roads, public transport, telecommunications and public utilities. This improvement of the infrastructure and superstructure create long-term benefits for other parts of the economy.

However, too rapid development of tourism can contribute to inflation by causing land prices to rise, encouraging speculation on land and properties and destruction of agricultural land. It also puts excessive demand on construction and other industries that are suppliers to tourism. Next, this may add to the problems of pollution and danger to the ecology of the country, especially the flora and fauna. Historical, cultural and archaeological sites may also need protection through restrictive legislation. Then, since most tourism developments are irreversible, sudden changes in demand may lead to greater unemployment, substantial trading losses and increases social tensions. Facilities cannot often be converted to other uses and the creation of alternative employment takes time and substantial investment. Finally, social disadvantages may arise. The presence of a large number of tourists encourages consumption and behaviour patterns which are often inappropriate for local nationals.

**1.2.11 Transportation**

Transportation networks provide the backbone for the economy and without them much of our today civilisation could not exist. Transport is used by many people, who are able to observe and experience the defects (e.g. not enough seats, timetable not followed) of the transport facilities provided to them. Among other things, this
has also led to an intensive and widespread yearning to own a car, even just to drive only during the week end.

In fact, transport problems are not easy to analyse except at a very superficial level. Although calculating the savings in man-hours and tonne-kilometres that could result by reducing or decreasing certain road trips, is straightforward, these are only the obvious parameters and not the only ones. Thus, a scheme which might be subject to such easy analysis as above, may exhibit some complications when compared against others. Any scheme improving transport facilities will affect (significantly or less so) other land uses and thus impact on the traffic flow which initiated this transport improvement scheme being planned. This is quite an important parameter in urban areas, where significantly improving transport facilities entail major upheavals in land uses.

Although up to a threshold road traffic flows may be treated in isolation – a first diversion and re-channelling them, in canals or channels, so to say, just as water flows could be conveyed – this is a mistake of assuming that traffic flows are independent phenomena that can be individually processed. Unfortunately, traffic flows result from many other activities and unless this is recognised, it will be difficult to solve traffic problems. The morning traffic entering into a town most likely includes the following components:

(a) people going to work;
(b) business or pleasure trips;
(c) to be consumed in the town;
(d) transport of materials for manufacture or other processes in the town;
(e) people and goods travelling through the town towards some other place, etc.

At one time, the railway became an important means of transport, particularly for long distances, but often the last (or first) leg of the journey was by road. However, in the recent decades, road transport has achieved new peaks with new technology in road construction, motorways and with motorised vehicles.

Railways now show relative advantages under the following circumstances:

(i) transport of heavy goods over long distances, such as cars, petroleum and bulk cement which can be easily transhipped.
(ii) commuter traffic between the suburbs and big urban centres concentrations, with distances ranging between 20 to 60 km.
(iii) fast inter-urban traffic where the plane alternative might not happen to be convenient.

When the road network is comparatively undeveloped, the number of motor vehicles is usually small, but as the inhabitants (1) acquire more wealth and (2) experience the defects of available transport facilities, they will try to acquire a car. This may quickly increase the national vehicle fleet by several times, thereby increasing road traffic considerably.
1.2.11.1 Roads

A good road network (or a road in good condition) provides road access and connectivity to markets, schools, hospitals. Backward regions can use this basic infrastructure for trade and investment. (see Chap. 2 for the case of Budapest). Roads develop inter-modal transport networks by establishing connections with railway stations, harbours and airports. An efficient road network is a sine qua non for rapid growth.

Road transport connects the remote and hilly areas to the rest of the country, thereby enabling social integration and further economic development. Ease of access, operational flexibility, door-to-door service and reliability count as benefits of road transport over other transport modes. However, these also create road congestion as they increase both passenger and freight traffic. The complication is that any further investment to improve road transport leads to an increase in the number of users, thereby leading to further road congestion – a vicious circle indeed.

Thus, an associated problem of the road transportation is road congestion. Is there an alternative which minimises it? Part of the answer should lie with our spatial organisation. (see Chap. 3).

1.2.11.2 Water Transport

The specific features of water transport and its special merits can be observed under several distinct and distinguishing circumstances of use.

First, the ferry is usually used for short distance water trips. Although its slow speed, combined with embarking hassles, shows sharp contrast with the speed and ease of land travel, the ferry has not disappeared as a means of transport. Progress in bridge construction techniques and tunnelling, may have significantly reduced the number of ferries in operation. With the construction of the “Chunnel” – tunnel under the English Channel – it was believed that ferry service and the hovercraft would have significantly reduced. Surprisingly, both means of transport are still much in use, thereby having significantly impacted on the income expected to be generated by the operation of the “Chunnel”.

Secondly, canal and river navigation, though having been widely used in the past, has seen a reduced activity due to road transport improvements, in particular for perishable goods and small consignments. However, developments in barge design and propulsion have maintained this means of water transport, either for goods or for touristic travel. The vessels can be regularly seen on the large rivers, Thames, Seine or Danube or even smaller ones. Heavy goods suitable for bulk transportation are convenient to both railways and canals, where large volumes bring in economies of scale. However, here, railways have a speed advantage over canals.

Thirdly, transportation of sea freight long distances has a good market, again with economies of scale, with bigger and bigger cargo ships or tankers with a minimum of personnel aboard given the amount of technology now being inbuilt. Of course, air
cargo services might become an important competitor, but only for small or perishable goods, such as flowers or textiles where the products need to reach the consumer before the fashion period is over. For several purposes sea transport has no competitor. However, the growing technical evolution of ships requires the construction of probably fewer and bigger ports, where transhipment to smaller ships may be carried out.

The increasing ship tonnage entails that terminal size and ancillary equipment is now pertinent to sea traffic. Railways do not present a similar issue due to their technical limits restricting expansion in this direction, but as for sea transport, terminals with the proper equipment and the adequate personnel are required for efficient operation. Hence, the tendency, to focus on fewer terminals with more sophisticated equipment.

1.2.11.3 Ports – Utility and Capacity

Ports are useful to the country because they:

- provide a shelter to ships,
- allow ships to replenish resources (water, food, fuel, repair, safety, etc) for further navigation,
- enable cargo transfer between port and hinterland transport systems,
- provide quick, efficient, cost-effective cargo transfer and aggregation facilities.

Aggregation of individual berth capacity gives a port’s capacity. The individual berth capacity is influenced by the type of commodity it handles and is determined by

1. the berth’s size,
2. the length,
3. the size of vessel it can handle.

The berth capacity is measured by the deadweight tonnage of the vessel that can be serviced by the berth. Berth occupancy is used as a yardstick for berth use efficiency. The various parameters affecting a break-bulk berth’s efficiency include

1. the berth’s cargo-handling capacity,
2. the vessel’s cargo-handling capacity,
3. the cargo’s nature,
4. how the cargo is stored ashore,
5. how the cargo is transferred from the berth or storage facilities (by truck, train, etc.).

Thus a country which wants to increase potential volume of foreign trade should think about increasing and upgrading its port capacity.

A port’s productivity also largely relies on the productivity of the entire logistics chain of which the port forms part. Any interruption in the smooth functioning of any of these links (poor road/railway linkages, unsympathetic attitude of customs
personnel, and lack of adequate inland warehousing facilities) affects port productivity adversely. Apart from the efficiency of its own operations, the productivity of a port depends on the co-ordination of the operations of the various links in cargo movement such as stevedores, truckers, consignees, railway etc.

1.2.11.4 Airports

Transport at low prices is important, but other factors which should or are considered include simplicity, reliability and speed. In particular, air transport provides an excellent example. These factors have made road transport popular because the load owner obtains good facilities and, more or less, complete control over the journey from beginning to end. For example, over short and medium journeys, a farmer or merchant who wishes to use his truck has a certain control over his departure and arrival times, in contrast to his arrangements made through a third party such as the railway line, particularly if the required trips often change from day to day. Transhipment hassles are also usually avoided.

Air travel has developed quite a lot, and passenger planes now travel over short distances (100–200 km) as well as over longer trips (non-stop for some 12 hours (8–10,000 km). Local circumstances and new technology have greatly increased the role of air travel and its importance. In some countries, air cargo has made a spectacular development due to fast changing markets overseas.

The transport of high value and perishable goods, business travel, and access to difficult terrains have been improved, around the world, by air transport, given the speed and time saved. Furthermore, as in many countries, national carriers no longer have a monopoly and private air services are actively competing with other modes of transport because they have become affordable. However, for short-haul flights, the gain might be debatable because of time required between check-in and actual flight departure. Even on a 800 km journey, the home to destination travel time by a high speed train might be less than the air trip total time.

Far from being a mere mode of transportation for a selected few, air transport contributes significantly to the national economy and plays an important role in sustaining trade and tourism development. The civil aviation sector has perfectly managed to cope with the growth of domestic and international traffic through four categories of services, namely:

(1) regulatory,
(2) developmental,
(3) infrastructure, and
(4) operational.

1.2.11.5 The Relation of Transport to Other Activities

A region’s transport system determines its economic activity. Once this has been studied, it is then possible to attempt at providing social improvements. Thus, the
important areas sending goods to other places may be identified, together with a comparison of the various means of transport.

In many ways, towns are better cared for by governments than villages. However, it is difficult for towns to exist without transport, the more so when they become more specialised, with a need to send their products to distant markets. Nevertheless, governments probably do not spend enough on keeping the town traffic network up to date.

Rural roads manifest their value through the following principal purposes:

(a) connectivity: sending crops, fresh vegetables regularly to the market,
(b) education: transport of children from several villages to educational institutions,
(c) farmers’ education: sending trainers to the villagers for new agricultural knowledge,
(d) health services: transporting patients to and from clinics, and allowing free movement of doctors and nurses, etc.

1.2.12 Waste Management

In any country, managing solid waste means the monitoring and regulation of (1) waste collection, (2) its transport, (3) the different treatment processes and (4) its final disposal. Integrated solid waste management (ISWM) tries to encourage waste prevention, through the 3Rs, namely: (1) Reduce, (2) Reuse and (3) Recycle. Sometimes, when there is an additional step, e.g. biological processes such as composting, a fourth ‘R’ for Recovery, is added.

In order to make policies related to national composting and recycling more effective, it is useful to consider source separation to produce cleaner, improved quality waste components. Although source separation has been implemented in developed countries (Japan, South Korea, Switzerland, Sweden, and UK) with success, implementing such a practice in developing countries is still one of the difficult tasks to tackle sustainable waste management.

The behavior patterns of individuals when requested to carry out source separation of waste or asked about their willingness to cooperate depends on many factors. If these influence factors are properly assessed and understood, it will be easier to extract maximum cooperation for the implementation of such policies by applying the right nudging conditions and incentives.

Generally speaking, waste generation rate varies directly with the economic activity level of the country. Cities, developed countries, typically, produce a waste of about 1 kg/person/day. Developing countries are not always lagging behind.

Collection cost of waste depends on the following major factors:

- The method of collection;
- The vehicle type and its capacity;
- The number of personnel required;
Hauling distances to disposal sites, and
Collection frequency.

The collection frequency is influenced by several factors such as:
1. the characteristics and quantities of the wastes,
2. the climate and its effect on waste,
3. the types of storage available, and
4. the authorities’ degree of involvement.

Collection often varies between one to seven days per week, depending on the budget, urgency of collection, etc. In several areas, collection is even carried out at night, if possible after closure of business, to avoid proliferations of pests and rodents and/or to present a clean landscape early next morning.

Discharging municipal solid waste (MSW) into a landfill is also dependent on:
- Government objectives, targets and policies;
- Local environmental conditions;
- Nature of the wastes and potential reactions, and
- Feasibility of the treatment process (technical, financial, economical, etc.)

In practice, however, land availability for a landfill may be scarce, particularly if no proper infrastructural planning has been carried previously. Local residents or politicians who might be affected are important and, sometimes strong, stakeholders when a new landfill site is being identified. Common terms, such as NIMBY (Not In My Back Yard), NIMET (Not In My Election Term) or NIMTOO (Not In My Term Of Office) are often used by them. This, sometimes vociferous, opposition often results in the new landfill projects being thwarted.

However, one way of attenuating the NIMBY or NIMET/NIMTOO opposition is to reduce the design capacity (size) of the disposal facility. This, of course, requires an adequate treatment and processing at a suitable transfer station so that there are minimal wastes transferred to the landfill.

A radical mindset change may be obtained by planners (Carpintero 2015) shifting from the basic question

\textit{How do we get rid of our waste efficiently with minimum damage to public health and the environment?}

to the more appropriate

\textit{How do we handle our discarded resources in ways which do not deprive future generations of some, if not all, of their value?}

There are so many technologies available for the treatment and disposal of solid waste that there are multiple ways to formulate an integrated solid waste management (ISWM) system.
1.2.13 Water

Water is a natural resource which is essential for the survival of man and for his activities, especially his economic activities because it cannot be replaced in most of its uses. It is not only an essential element for life but also, in the twofold aspect of quality and quantity, a conditioning factor of economic growth and of social welfare.

Water supplies in small quantities for domestic use can be obtained from rivers by direct abstraction, without any storage impoundment, but this, of course, limits the water flow available to only a fraction of the dry weather river flow. In that case, impounding of rivers can become more frequent. In some cases, tapping underground sources may be necessary.

**Characteristics of Good Quality Water:** These can be listed as follows:

1. It must be pleasant to taste and appearance.
2. It must be free from pathogenic organisms.
3. It must be free from toxic substance.
4. It should not be corrosive in nature.
5. It should not contain excessive amount of solid substances which cause physiological effects on human beings and other consumers.
6. It should have sufficient quantity of dissolved oxygen.
7. It should be available in large quantities.

Should impoundment be implemented for some other purpose, such as hydro-generation, it might be possible to use the tail race water for domestic water supply or eventually, direct from the reservoir. Water needs for domestic purposes are usually quite small when compared to water requirements for irrigation and for generation of electricity.

Per capita water consumption depends on numerous social and economic factors, more particularly, the way the water is supplied. The daily basic consumption, for example, when water is supplied from public fountains, varies between 5 and 20 Litres/person, but for houses equipped with flush toilets, baths, sinks, lavatories and wash tubs the daily quantities of water used reach 120 Litres/person, and in certain places may reach average daily values of about 250 to 1000 Litres/person, for all domestic uses, irrespective of water being metered or not.

The requirements for industry differ from domestic water use in two ways:

1. **Quality:** water used for industrial need not always satisfy the same standards of purity. Thus, sometimes, the effluent from the municipal sewage purification works, though unsuitable for domestic consumption, may be used for washing, cleaning, cooling, etc. Sometimes, however, even water suitable for domestic use needs its iron contents to be removed before it can be used for dyeing textiles; otherwise, the textiles get reddish stains.

2. **Future water requirements:** For a given population, it is not difficult to forecast possible population growth, from which water requirements for domestic use in the future may be determined. This enables project planning schemes which can provide these future needs, for domestic purposes. However, industries depend
heavily on fashion and changing needs, which complicates the possibility of forecasting water requirements in this sector, over long periods. The only comfort is that there are only few industries requiring very large amounts of water. And, if the country does not have plentiful supplies, the industry will never be set up.

The guiding principle is that, given water supplies in a region are limited, nothing more can be provided, except at prohibitive prices (desalination, import, etc). However, ingenious schemes may be developed to use the water resources more fully than ever before, and eventually, used several times over (hydropower, domestic use, and then recycled for irrigation). Typically, hotels in tropical climates may use some 400 cubic metres daily for potable purposes; the effluents are treated and recycled for irrigation use (at night, to avoid any accidents).

1.2.14 Wastewater

Water is essential for development. Once the water has been used it is essential to have a good sewerage system to sustain the development.

A small coastal community might discharge untreated sewage directly into the sea without any ill effects, but if the same population were located besides a small stream, a high degree of treatment might be required, particularly during the low flow season. Improved standards of living, urbanisation, and industrial growth have increased the strength and quantity of municipal sewage in recent decades to the point that dilution alone is not enough to prevent the undesirable effects of pollution. The level of treatment required depends on the composition and strength of the sewage and the disposal facilities.

There are many different ways to treat sewage, while sometimes, more advanced treatment may be required. Water-quality control has become a new concept in the field of water-resources management. Recognising the economic value of water quality has introduced the need to maintain certain minimum flows in rivers.

Treatment processes are often classified as primary, secondary, or tertiary processes.

Primary treatment separates the suspended solids from the sewage, by screening and sedimentation in settling basins. The separated solids are then decomposed by bacterial action in a tank, and the liquid effluent is diluted before disposal or used for irrigation, although some care is needed. Considerable organic material remains in the liquid effluent resulting from primary treatment, and needs much oxygen to oxidise it. This is the BOD (Biochemical Oxygen Demand), which is used as an indicator of organic pollution in the water.

Secondary treatment goes further: effluent from a primary treatment process is oxidised, generally, through biological processes using filters, aeration, oxidation ponds, and other means. The ensuing effluent will usually have little oxygen demand and may even contain several milligrams per litre of dissolved oxygen.
Tertiary treatment is often accomplished by passing the effluent from secondary treatment through a fine sand filter.

Several factors, including the disposal facilities available will dictate the choice of treatment methods. In practice, the distinction between primary and secondary treatment is rather minor or arbitrary as many modern treatment methods include both sedimentation and oxidation in the same operation.

The Goreangab (Namibia) water treatment plant processes sewage from Windhoek’s 300,000 residents into potable water through a technology that partially mimics nature. Constructed in 1968, it was the first plant of its kind in the world. ([https://www.pri.org/stories/2016-12-15/recycling-sewage-drinking-water-no-big-deal-theyve-been-doing-it-namibia-50-years](https://www.pri.org/stories/2016-12-15/recycling-sewage-drinking-water-no-big-deal-theyve-been-doing-it-namibia-50-years)). Since its start, all the relevant standards have been fulfilled without difficulty. “People are always trying to catch us out so they can say that reusing water does not work. They have not succeeded.” (Pierre van Rensburg in *The Namibian*, 16th March 2016.).

Using recycled water means that this can be an addition to existing (waning) resources.

### 1.3 Services

The general public does not really know much how the commercial and financial services work or their usefulness. Nevertheless, these services are particularly important in the process of national development.

Firstly, apart from people employed in government administration, the commercial and financial services, as a sector, employs up to 30% of the active urban population.

Secondly, as the supply of capital where needed and proper marketing depends on these services, they ensure a smooth running of business because efficient marketing includes grading, transport, superior forms of storage and the necessary logistics to ensure that the right goods reach the right place where they are required at the right time. When these factors are absent, either in less developed countries, or even in highly industrialised countries (but lesser developed parts), the following defects may be found:

(a) Lack of organisation entailing a difficulty to quickly obtain a required service – the less common goods or specialist advice are not available locally, and quite some time elapses before these are delivered.

(b) If the service headquarters are located outside the region, their interests are probably also elsewhere.

(c) Banks do not have sufficient resources to satisfy all sound loan applications. If adequate capital is not available for commercial purposes, efficiency may be quite seriously affected, causing a scarcity of handling facilities and efficient storage. At the other extreme, what do banks do when they have excess liquidity with only a few loan applications?
(d) Lack of expertise may lead to inefficiency and a co-ordination failure. Sometimes as new needs emerge, there is an over-investment in new equipment due to many persons hoping to set a foothold in the market without referring to what others are doing. While there is often an excessive number of computer or smartphone shops, it also happens that many farmers will plant the same crop at the same time, with a resulting glut in the market.

It is probably worth stressing one or two special issues:

**Capital**, (loans or otherwise) is an important parameter in economic development. Although thought of as charging high commissions (see also Shute (2009)) financiers provide services needed by society. There is no short-cut to free money. As a small scale saver, households like to receive interest on their bank savings. If the bank lends this money to large scale investors, the bank will necessarily add the minimum rate preferred by the households to its own commission. The lower the rate the households accept, the lower can be the lending rate to business investors. This is what is often called the cost of money: at which rate can the investor borrow money?

Government may sometimes intervene by legislating on low interest rates for special purposes (as incentives to investors), but it would be a mistake to believe that this is the “correct” rate, because, in fact, the government is just subsidising the cost of money for a special purpose.

**Producers**, can only produce the right product at a convenient price if they understand and know the market conditions. Otherwise, they may end producing unwanted goods at no big value to them. For example, farmers should produce vegetables, at the right dates, of the right quality, preferably avoiding gluts, or low market prices will result. If they have to pay for commercial and financial services, they should enquire what they are obtaining in exchange. Getting a proper organisation is probably the most difficult issue because a first class co-operation and team work is required for efficient commercial work, the more so as economic development proceeds and the country’s economy becomes more complex.

1.4 Why Do We Need Infrastructure?

1.4.1 **Economic Infrastructure**

Economic development requires that measures capable of exerting favourable effects on the flow of income should be taken in public services. Generically, economic infrastructure has the following distinct components:

(a) energy (electricity, coal, petroleum and natural gas, renewable energy sources and atomic power for civil use),
(b) transport (roads, railways, shipping, ports and airports),
(c) telecommunications and information technology,
(d) special economic zones (SEZs),
(e) tapping water resources (hydro-generation, irrigation),
(f) rural infrastructure (water supply and sanitation, transport, housing, telephony), and
(g) urban infrastructure (water supply network, housing, sewerage, transport, slum clearance/development, and solid waste management).

Economists use the term social overhead capital to denote funds invested in such basic services, which are essential to the functioning of primary, secondary and tertiary productive activities (see Chap. 2).

1.4.2 Social Infrastructure

Social Infrastructure comprises the following:

(a) human development programmes and social security,
(b) health, poverty alleviation programmes, and family welfare,
(c) education, training and skill development,
(d) availability of labour, its employment and labour welfare,
(e) female empowerment, and
(f) raising the living standards of socially disadvantaged groups.

In order for development to occur, it is necessary to provide social overhead capital – and with it health care, and water supply facilities. Rather than being an end in itself, this is a basic investment, because this will supply the basic outlay required to uphold productive processes such as manufacturing.

Rather than concentrating on built infrastructure, this concept can easily be extended to other sectors which provide services. (see Fig. 1.2) These necessary services, which are also a sine qua non to a host of various economic and everyday activities, are generally provided by public agencies under some form of public regulation. These services may be provided for free or at rates determined by government. Neglect of such public utilities and facilities can, very easily and quickly, become a most serious drag on economic progress.

1.4.3 Critical Infrastructure

What would happen if tomorrow the transport system breaks down? How do people go to work? How are goods (including food) transported to other towns? What about a breakdown of the electricity network?

A little reflection shows that there are some sectors which cannot afford the luxury of a momentary outage! In fact, we say that these sectors form part of “critical infrastructure”. The European Union (European Commission 2020) defines
Critical infrastructures consist of those physical and information technology facilities, networks, services and assets which, if disrupted or destroyed, would have a serious impact on the health, safety, security or economic well-being of citizens or the effective functioning of governments in the Member States. Critical infrastructures extend across many sectors of the economy, including banking and finance, transport and distribution, energy, utilities, health, food supply and communications, as well as key government services. Some critical elements in these sectors are not strictly speaking ‘infrastructure’, but are in fact, networks or supply chains that support the delivery of an essential product or service. For example the supply of food or water to our major urban areas is dependent on some key facilities, but also a complex network of producers, processors, manufacturers, distributors and retailers.

(The URL provided is a hyperlink. Accessed 22 January 2020)

The UK government’s official definition of Critical National Infrastructure (CNI) is: “Those critical elements of infrastructure (namely assets, facilities, systems, networks or processes and the essential workers that operate and facilitate them), the loss or compromise of which could result in:

(a) Major detrimental impact on the availability, integrity or delivery of essential services – including those services whose integrity, if compromised, could result in significant loss of life or casualties – taking into account significant economic or social impacts; and/or

(b) Significant impact on national security, national defence, or the functioning of the state.”

(The URL provided is a hyperlink. Accessed 22 January 2020)
Following the terrorist attacks of September 11, 2001, the US Congress passed the USA PATRIOT Act of 2001 (P.L. 107–56) which defines “critical” infrastructure (CI) as “systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters (Sec. 1016(e)).”

The definitions above show that Governments are aware that infrastructure is not only important, but that some of them are so essential (the term used is “critical”) that without these critical links, the whole country, if not part only, practically stops functioning, (e.g. are there many countries which could still function properly if there was a general electricity power breakdown?). While UK defines 13 critical infrastructure sectors, USA considers some 16 sectors (updated in 2018) from a previous list of 18 in 2013.

The preceding section on social infrastructure, however, should have highlighted that there are many components in the range of infrastructure which could be critical to the smooth running of everyday life. Chapter 11 on resilience should certainly give a better opportunity to reflect on all these components and help us (or governments) decide on what we should call critical infrastructure sectors.

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