Chapter 2
Fundamentals of Irrigation Development and Planning

Irrigation has historically been a major factor for increasing crop productivity. Irrigation raises the productivity of land directly by providing sufficient water supply to raise the yield per hectare per crop and by allowing a second crop to be grown during the dry season when yields are potentially higher. But the development of irrigation facility in itself (consequently the productivity and profitability) depends on several factors, which should be understood clearly and which are essential for the successful operation of an irrigation system. This chapter deals with these factors and synthesizes each factor. In addition, irrigation development in Asia and the Pacific region, the impact of irrigation on the environment and ecosystem, and the land classification system for irrigation are discussed.

2.1 Factors Affecting Farm Production

The upper limit of crop production is set by the genetic potential of the crop and the climatic conditions, provided water and nutrient availability are not limiting factors. Irrigation has historically been a major factor for increasing crop productivity. Irrigation raises the productivity of land directly by providing sufficient water supply to raise the yield per hectare per crop and by allowing a second crop to be grown during the dry season when yields are potentially higher. It also increases yields indirectly by raising the profitability of modern crop varieties with fertilizer use. But such increase in productivity or profitability depends on numerous other factors. The factors affecting farm productivity are described below.

2.1.1 Agro-Ecological Factor/Constraint

Climatic variability involving yearly variation in the onset and withdrawal of the rainy season, hailstorms, incidence of heavy rainfall, high humidity, cold or heat stress, cyclones and associated storm surges in the coastal areas.
2.1.2  **Soil Factor**

Deterioration of soil health due to continuous cropping, decline in productivity, steep slopes, shallow soils and soils poorly suited for terracing in hill areas, imbalanced/under-fertilized soils.

2.1.3  **Hydrological Factor**

Restricted opportunities for cultivation of rain-fed rice, seasonal droughts and floods, flash floods, impeded drainage/water-logged soils.

2.1.4  **Crop Factor**

Yield potentiality, crop duration, quality of seed, efficiency of nutrient/fertilizer use.

2.1.5  **Water Management**

Inefficient on-farm water management and inadequate drainage.

2.1.6  **Fertility Management**

Imbalance in the use of major and minor nutrients, absence of measures to correct the prevailing micro-nutrient deficiencies, nonintroduction of cropping system-based fertilizer use and management.

2.1.7  **Socio-Economic Factor/Constraint**

Lack of farmers’ access to production technology, lack of specialized physical and human factors, inadequate agricultural credit, unavailability of inputs at the proper time, market limitations (output side), adoption of risk aversion strategy, development and use of cost-effective and environment-friendly production technologies.
2.1.8 Other Management Factors

Nonpreparedness to meet the problems arising from environmental hazards; nonpreparedness to develop contingency plans and crop life-saving techniques; neglect in correcting the problems of soil such as salinity, sodicity, acidity, organic matter, etc.; nonarrangement for providing crop life-saving irrigation; nonadoption of proper control measures for insects and pests; nonestablishment of minimum desired level of plant population; and unconcern for timely agricultural operations.

2.2 Important Factors Affecting Irrigation Planning and Development

The major factors influencing development of irrigation facility are as follows:

- Soil
- Climate
- Topography
- Water source
- Crop(s) to be cultivated
- Energy
- Labor
- Capital
- Commodity/product market
- National policy and priority
- Institutional infrastructure
- Economic factor
- Environmental aspect
- Socio-cultural aspect

2.2.1 Soil

Suitability of a land for irrigated agriculture depends on soil characteristics, soil profile, geological deposits, and surface texture. Certain soil conditions are needed for profitable, diversified crop production under sustained irrigation. These include the following:

- Adequate moisture holding capacity for the proposed irrigation and cropping pattern
- Adequate infiltration rate to facilitate replenishment of soil-water lost through evapotranspiration, to minimize erosion, to prevent excessive deep percolation under the proposed method
Adequate internal drainage through the root zone for proper aeration, replenishment of soil-water reservoir, and leaching of salts

Sufficient depth of suitable soil profile to allow necessary development and provide adequate storage of moisture and plant nutrients

Suitable texture, structure, and consistency to permit necessary field operations in time

Absence of hazardous amount of acidity, sodicity, salinity, or any other toxic elements

2.2.2 Climate

Crops have their optimum climatic requirements for normal growth and development, and fruiting. Beyond the desired limit, crops cannot grow properly and produce flower. Some of the important climatic elements are maximum temperature, minimum temperature, night temperature, and day length. Atmospheric water demand or crop evapotranspiration should also be taken into account for irrigation planning.

2.2.3 Topography

Topography, vegetation, biological activity, and time give a soil its characteristics or soil profile. Suitability of a land for irrigated agriculture depends largely on its topography as it determines the choice of irrigation method. It can also affect labor requirement, irrigation efficiency, drainage, erosion, size and shape of fields, range of possible crops, and land development. Operational expenses increase with the surface feature, field size, stoniness or bush/tree cover, and surface drainage requirement.

2.2.4 Water Source

In planning and developing an irrigation project, source(s) of water should be identified so as to ensure continuous water supply. In water resource development, harmonization of the different demands for water, establishment of irrigation priority rights between upstream and downstream users, and consideration of the rights of the existing users of water from flood, which may be modified by dams, is essential. It requires a formal institutional approach based on local experience. If the project is based on groundwater resource, sustainability of the resource should be considered.
2.2.5 Crop(s) to be Cultivated

Depending on the crop type, the water requirement varies. Hence, water resources should be planned on the basis of the major crop(s) and cropping pattern. The factors influencing the choice of crop are the local/national demand (to ensure self sufficiency or to discourage import), profitability factor (to export, in response to foreign demand), ease of marketing and market demand, etc. The materialization of the planned cropping pattern is a must for protecting the soil (against salinity, alkalinity, aridity, etc.) and for feeding sufficient water to irrigation network areas.

2.2.6 Energy

If water is to be pumped from the source to the irrigated area/field, then the energy source for the pumping is a major consideration. If an electric transmission line is to be constructed, it will require an investment. If the pump is to operate with a diesel engine, it will certainly create an environmental problem.

2.2.7 Labor

For the implementation of irrigation projects, a huge amount of human labor will be required depending on whether the project will be human labor based, or a mechanized one. This point should be taken into account while planning for an irrigation project.

2.2.8 Capital

Establishment of a large scale irrigation facility requires large capital investment. Expenditure for irrigation consists of capital investments and recurrent expenditures for operation and maintenance. It should be checked whether the money is available from the local/central government, a public agency, or from a foreign donor. After ensuring that money is available, the project should be started.

2.2.9 Commodity/Product Market

An appropriate marketing system or facility of marketing the products to be produced from the irrigation project area should be considered for an economically sustainable production system. The producers are obliged to cultivate crops with relatively high profitability and market guarantees. Lack of viable product markets
and marketing institutions are major problems for sustaining production and effective irrigation development. Government organizations and other institutions should be developed to overcome marketing problems. The slow growth of markets for high-value crops sharply reduces the projected profitable crop mix that would warrant the frequently high costs of irrigation investments.

2.2.10 Economic Factor

A major problem affecting irrigation development projects is the high cost of construction yielding low benefits from agriculture. To achieve efficiency, irrigation investments must be fully recoverable, that is, the present value of public revenues to be generated from the project must be at least equal to the present value of cost. Who should pay for the cost (and in what proportion) depends on the distribution of benefits from irrigation. The beneficiary farmers must pay the cost in proportion to the benefits they receive.

Several factors affect the benefits from an irrigation project: low price of the crops, the prevailing low yields, and the high input costs are examples. All these factors are linked to the management level, and may vary from location to location, and region to region. Truly functioning credit systems for small-scale farmers or effective agricultural extension services may influence the prevailing situations.

2.2.11 Environmental Aspect

On the one hand, diversion of existing river-flow in the dry zone may affect downstream users in terms of quantity or quality or both. On the other hand, wet zone rivers may have large unutilized water resources flowing through heavily populated areas. In such a case, any large scale water resource development in these areas would involve displacement of people and property, which is socially and politically undesirable. These points should be taken into consideration and the regional or national benefits should be optimized.

Other environmental issues such as drainage effluents, siltation and sedimentation, water logging, development of salinity and acidity in soils, emission of methane gas from agricultural fields, distortion of natural habitat and bio-diversity, etc. should be considered while planning an irrigation project.

2.2.12 National Policy and Priority

Irrigation development or implementation of irrigation projects largely depends on the national/governmental policy and priority issues. The government may promote
irrigation development to increase and stabilize food production in the region. Despite a proposed irrigation development project being not economical (in terms of estimated net return and cost, and economic rates of return), the government can establish such a project considering regional/national food security, local employment opportunity, opportunity of establishment of local industry, and long-term savings in foreign currency.

2.2.13 Socio-Cultural Aspects

The implementation of irrigation projects will bring changes in land use pattern and intensity, land and labor productivity, household resource requirements, and tenure issues, which require management and institutional consideration. These socio-economic and institutional factors affect irrigation development.

2.2.14 Institutional Infrastructure

New construction or rehabilitation of existing irrigation systems requires operation and maintenance, and financing and cost recovery. An institutional framework and infrastructure is necessary for analyzing policy decisions with respect to project section, design and construction, operation and maintenance, cost recovery, and administration.

2.3 Irrigation Development in Asia and Pacific Region

The Asia-Pacific region comprises 54 countries. Because of the vastness and diversity in terms of geography, topography, climate, ecology, and other natural conditions, as well as differences in socio-cultural, economic, and political systems, the region is grouped into five subregions: Central Asia, Northeast Asia, South Asia, Southeast Asia, and South Pacific.

The Asian and Pacific region extends over a total area of about 27% of the world’s land area. With a concentration of nearly 60% of the world’s population and over 60% of the world’s irrigated land, the region is more densely populated and more intensively cultivated than any other region. Asia-Pacific is known for its highest potential renewable water resources in the world. But because of the large population, the region has the lowest water availability per capita.
2.3.1 Progressive Irrigation Development in Bangladesh

Up to the 1950s, Bangladesh (formerly East Pakistan, and even earlier, part of greater India) was dependent on traditional means of irrigation only, such as swing baskets, doans, etc. Modern tube-well irrigation technology was first introduced here in the early 1960s.

The dependence of Bangladesh’s agriculture on the south-west monsoon and its consequent vulnerability have been recognized from the earliest times. In Bangladesh, the strategy for economic development during the early 1950s was focused on large-scale public projects undertaken to stabilize water regimes associated with rainy season rice irrigations. Investments then took two main forms: improvement of flood control and drainage, and development of supplemental irrigation during the monsoon season. This approach was institutionalized in 1959 with the creation of the East Pakistan Water and Power Development Authority (now Bangladesh Water Development Board, BWDB) and the development of the nation’s first Water Resources Master Plan in 1964 (Satter 1999). Although the major emphasis was on flood control projects, small scale surface irrigation systems were tried out during the 1960s. About 4,000 low lift pumps (LLP) were installed by the East Pakistan Agricultural Development Corporation (now “Bangladesh Agricultural Development Corporation,” BADC) by 1967 (EPADC 1968). Programs to tap the subsurface water commenced in 1961 with the installation of about 400 deep tube-wells. Under the guidance of World Bank, an action plan focusing on food production, not flood protection, through small and quick yielding irrigation schemes was undertaken in 1972 (IBRD 1972). The new plan suggested a modest increase in large gravity projects, rapid growth in tube-well development, and constrained development of LLPs is limited. The expansion of LLPs was limited by the supply of dry-season surface water. Several large and small-scale development projects related to flood control, drainage, and

![Progressive expansion of irrigated area in Bangladesh](image-url)
irrigation were implemented by BWDD. The government’s main strategy for economic development during the second and third five-year plans was to undertake short-gestation, low capital, and quick yielding projects. This lead to a massive expansion in the tube-well programs, and by 1985, 17,000 DTW and
156,000 STW were in operation. The number increased to 24,059 DTWs and 348,875 STWs by the end of 1992–1993 (BBS 2001). This massive as well as rapid expansion of the tube-well program has led to overdraft of groundwater in some areas of the country (especially in the north-western, Rajshahi region). The number increased to 27,117 DTWs and 1,128,991 STWs in 2005 (BADC 2005) and 32,174 DTWs and 1,374,548 STWs in 2008 (BADC 2008).

Progressive expansion of irrigated area is shown in Fig. 2.1. A rapid increase during 1985–1986 occurred due to the corresponding increase in pumps and tube-wells. The trend of historic progress in acreage, yield, and productivity of wheat and rice is shown in Fig. 2.2. The availability of water (through pumping) increased the rice area over the years. The productivity of rice increased with the planting of high yielding varieties, fertilizer use, and improved management practices. The wheat area fluctuated and decreased to some extent. This is mainly because rice is the principal staple food grain of the people of Bangladesh.

### 2.3.2 Irrigation Development in China

About half of China’s territory is arid and semi-arid. In the north-western part of China, the annual rainfall is less than 250 mm and without irrigation there would be no agriculture. In the north-eastern and northern parts of China, the annual rainfall is 400–600 mm (Guangzhi et al. 2009), which substantially falls in summer and there is a spring drought almost every year. Irrigation is a necessary condition for agricultural development.

China has a long history of irrigation. About 2,000 years ago, their forefather had already built the world-famous Dujiangyan irrigation district in Sichuan Province. After several rehabilitation and modification many times, it is still being used. With an irrigation area of ten million mu (1 mu = 1/15 ha), it has become an economically developed region of the highest food production in Sichuan Province.

In 1949, the irrigated area of the whole country was 240 million mu accounting for only 16% of the country’s farmland. Since 1949, China has engaged in a vigorous water conservancy program, including the construction of 864,000 reservoirs of various sizes and numerous pumping stations with total installed capacity of 53,700 MW as well as two million tube-wells (Puli 1985). The irrigated area increased from 16 million hectares in 1949 to 46 million ha in 1983. By the end of 1998, irrigated area had attained 800 million mu, accounting for 40% of the farmland (Guangzhi et al. 2009).

In 1949, the water use for irrigation was approximately 100 billion m$^3$. On the one hand, with the increase of irrigation area, the use of water for irrigation gradually rose and reached 358 billion m$^3$ in 1980. After that, irrigation water use has been stabilized. On the other hand, industrial and municipal water uses have increased rapidly, thus leading to the dropping of the proportion of irrigation use in the whole water use of the country (Fig. 2.3).
2.3.3 Irrigation Development in Iran

Iran is located in the northern hemisphere between 25° and 40° longitude, and 43.5° and 64.5° latitude, having surface area of about 1.48 million Km². There are two mountain ranges, the Alborz and the Zagros, and to the south, down lands of Persian Gulf, Oman Sea, and Caspian Sea are found. Thus, Iran has a high differential elevation of about 5,000 m. About 73% of the land is arid and semiarid.

The development of water resources in Iran has always been hindered by serious problems. To begin with, the precipitation distribution within the country shows marked variations from one region to another. Precipitation mean varies from 50 mm in the central, southern, and eastern areas to 1,500 mm in northern and western parts. In 6% of the land, it is less than 50 mm, and in other parts it varies between 200 and 1,000 mm, only in 1% of the land it is more than 1,000 mm (Messdaghinia and Alavi 2010). The Caspian lowlands, representing 10% of the total area, has one-third of all the precipitation falling on Iran, while many parts of the central plateau receive scarcely any water at all.

Precipitation occurs over most of Iran between October and March, when temperature is low and agricultural activity is at a minimum. Fortunately, however, much of it in the upland regions falls as snow, and water is therefore stored in the solid form until snowmelt begins in the late spring and early summer. Rivers fed by melting snows have peak discharges during the months April, May, and June.
In Iran, water is a critical component for agriculture, industrial, and urban development. Because of insufficient rainfall, conservation and water management in Iran was a matter of great concern. Now it is becoming increasingly more and more important. The total incoming water to Iran is estimated to be $415 \times 10^9 \text{ m}^3$ of which 98% is from atmospheric precipitation (Mahmoud 1994). The total water exploited is $94 \times 10^9 \text{ m}^3$ with the agricultural sector being the largest consumer of water. The storage capacity of the existing dam is about $25 \times 10^9 \text{ m}^3$. Large increase in water demand with very little recharge have strained Iran’s groundwater resources resulting in serious decline in groundwater level and quality (Madaeni and Ghanei 2004). Water withdrawal from groundwater resources during the period 1972–2001 is shown in Fig. 2.4. Withdrawal has an increasing trend.

![Water withdrawal from groundwater resources in Iran during 1972–2001](after Mesdaghinia and Alavi 2010)

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### 2.4 Impact of Irrigation on Environment and Ecosystem

A fast growing population in the world requires a growth in agricultural output. Irrigation is often a condition for agricultural intensification in arid and semiarid regions. Current agricultural practices involve deliberately maintaining ecosystems in a highly simplified, disturbed, and nutrient-rich state. Intensification of agriculture to bridge the gap between food production and food needs in many countries have already transformed the environment and ecosystem. The recent intensification
of agriculture, and the prospects of future intensification, will have major detrimen-
tal impacts on the nonagricultural and aquatic ecosystems of the world.

Impact of irrigation development on social and environmental aspects may be
positive or negative.

2.4 Impact of Irrigation on Environment and Ecosystem

2.4.1 Positive Impacts

2.4.1.1 Health

Irrigation water use affect health by bringing water into close contact with people. This proximity can have positive health benefits by:

- Ensuring household food security and improving nutrition
- Providing with a reliable source of water for drinking and hygiene

2.4.1.2 Socio-Economic

Irrigation is generally considered as an effective way of increasing agricultural production (more land under crops, more crops per ha per year, more crop produc-
tion per ha per season). As production increases, per capita income increases; and
thus the socio-economic condition and livelihood improve. Thus the access to
irrigation or development of irrigation facility has a positive impact and profound
role to play on poverty reduction. The overall growth and technical change in
the agricultural sector has large implications on expanding the economic base
and poverty alleviation process in a region. Consequently, inequity of income is
reduced over time.

2.4.2 Negative Impacts

Water maintains a host of natural ecosystems. Withdrawal of water from upstream
can reduce the flow at downstream needed to sustain natural ecosystem. The off-
take and diversion structures often deprive downstream users of their water.

Negative impacts of irrigation may be through the following:

1. Water quality degradation
2. Groundwater abstraction
3. Water-logging and salinity
4. Health risk
5. Simplification and homogenization of the world’s ecosystem
2.4.3 Degradation of Water Quality

Agricultural intensification is often associated with cultural practices, which, when uncontrolled, can boost up the deterioration of water resource quality, mainly surface and ground waters. The doubling of agricultural food production during 1965–1999 years was associated with a 6.87-fold increase in nitrogen fertilizer and 3.48-fold increase in phosphorous fertilizer (Tilman 1999). A poor management of irrigation and drainage techniques, coupled with an inappropriate use of inputs (e.g., fertilizer, pesticides, herbicide, etc.), is one of the major causes of surface and ground water pollution within and around the irrigation schemes. This polluted water is often a source of pollution of rivers and water-tables nearby. The consequences of water pollution from agricultural sources may be diverse and sometimes disastrous. The main consequences are as follows:

- Human health consequences
- Ecosystem consequences
- Economical consequences

2.4.3.1 Human Health Consequences

The polluted water is one of the major sources of diseases across the world. According to the World Health Organization (WHO), about 4 million children die every year due to diarrheal infections (FAO, Irrigation and Drainage Paper, No. 55). The high level of nitrate concentration (NO₃–N) in groundwater (originated from Urea fertilizer, applied in agricultural field), which is a main drinking water source, is at a major risk. The nitrate causes cyanosis syndromes and has carcinogenic impacts when present in the stomach.

2.4.3.2 Ecosystem Consequences

Surface water pollution, and especially that polluted due to high nitrate and phosphate, is a serious ecological risk. This pollution causes destruction of live resources, and nonequilibrium of physical and biological environment, and aquatic ecosystem through the eutrophication phenomena. Drainage flows from irrigated fields can disturb the ecological balance by carrying excess chemical nutrients and pollutants into the ecosystem.

2.4.3.3 Economic Consequences

On the one hand, use of poor quality or contaminated water for drinking and other uses, and agricultural pollution have impact on economical aspects of other
activities such as industrial, tourism, fishery, etc. On the other hand, rectification of polluted water quality is expensive and requires long-term investments.

2.4.4 Groundwater Abstraction

Unplanned and excessive groundwater abstraction for irrigation can cause considerable damage to ecologies. Overdraft results in the decline of the initially shallow water-table, drying up the natural springs and ponds. Saline water intrusion from sea may occur in the coastal area.

2.4.5 Water-Logging and Salinity

Where shallow saline groundwater exists, irrigation may results in raise of shallow water-table, and thus salinity problem. In addition, seepage from canal may results in local water-logging problem. In the Indus Plains in Pakistan, water-logging and salinity is an acute problem.

2.4.6 Health Risk

Irrigation water can increase certain health risks by:
- Bringing people into contact with waterborne and water-washed diseases
- Providing a breeding ground for mosquitoes that carry malaria

2.4.7 Simplification and Homogenization of the World’s Ecosystem

The characteristics of the green revolution during the middle of last century are – control of crops and their genetics, of soil fertility via chemical fertilization and irrigation, and of pests via chemical pesticides. They have caused four once-rare plants (barley, maize, rice, wheat) to become the dominant plants on earth as human became the dominant animal. These four annual grasses now occupy 67, 140, 151, and 230 million hectares each, respectively, worldwide (Tilman 1999). These monocultures have replaced natural ecosystems that once contained hundreds to even thousands of plant species, thousands of insect species, and many species of
vertebrates. Thus, agriculture has caused a significant simplification and homogenization of the world’s ecosystem.

2.5 Land Classification for Irrigation

2.5.1 Concept of Land Classification

Land classification means grouping of land categories (soil and topography) that have the same relative degree of limitations (or hazards) for irrigation use at its present state for the same groups. Simply speaking, land class indicates the general capability of land for irrigation use. Land within a land class is alike or nearly alike in its potential to be developed and its response to a similar level of management.

2.5.2 Importance of Land Classification

In the context of irrigation development, the aim of land classification (sometimes referred as land evaluation) is to mapping an area to explore how well the land is suited to irrigation development, that is, to determine which class or classes of land should be so developed. The classification provides the following:

1. An inventory of land characteristics
2. The extent and degree of suitability of land for irrigation
3. Indicates relative capability for sustained production under irrigation
4. Identifies potential problems that may occur with irrigation
5. Facilitates making recommendations for appropriate management under irrigation
6. Facilitates optimal land resource utilization
7. Indirectly provides an economic assessment, that is, justify the expenditure on irrigating land

Land classification is used for various purposes. They are useful as source of information about soils for many kinds of general or broad area planning, and planning large-scale irrigation development projects. Land classification provides the means of making logical choices between alternative forms of development. In some countries and/or provinces, land classification is a mandatory requirement for irrigation activities.

2.5.3 Standards of Land Classification

The standards are used for the classification of lands for the formation of a new area/district, or for the reclassification of lands in a region.
2.5.3.1 Basis and Methods

Classification criteria may include both soil site characteristics and other criteria established at the time of mapping. The standards outline the minimum requirements with which any land must comply to be classified as “irrigable”, so they can be supplied with water. The standard for land classification for irrigation should include several criteria/factors:

- **Soil**
  - Permanent factors
  - Changeable factors
- **Topography**
- **Availability of water**
- **Climate**
- **Predicted response to irrigation**

Soil factors such as parent material, texture, effective soil depth, water holding capacity, and drainability are considered as the permanent land features.

Changeable factors include fertility, drainage, groundwater, salt content (salinity level), soil pH, and erodibility. Soil structure may be modified by physical and chemical processes. Relocation and chemical changes in soluble salts may occur as a result of irrigation. Micro-relief and characteristics of the soil profile can be altered by land forming, stone and brush removal, drainage, subsidence, or by increased erosion due to irrigation.

The elevation of the land in relation to the water surface elevation in the laterals may be important in some cases. Topographic features include size and shape of fields, relief, stoniness, earth moving requirement, bush/tree cover, surface drainage requirement. These features are important because they determine the irrigation method. Topographic features also affect irrigation efficiency, labor requirement, cost of land development, drainage, erosion, etc. Soil and topography ratings may be determined separately and combined into a land class that reflects the suitability of land for irrigation farming.

There is no justification for irrigation development in areas where rainfall does permit crop production.

Land classification for irrigation also involves predicting how land will respond after development and the application of irrigation water. The land classes must reflect the predicted land–water–crop interaction expected to predominate after irrigation development. This principle of prediction recognizes that irrigation shifts the natural balance, established over time, between water, land, vegetation, fauna, and humans. If land is to be irrigated, it should be permanently productive under the changes anticipated with irrigation.

2.5.3.2 Land Assessment Criteria

The classification system may include several classes of irrigable land and single or several classes of nonirrigable land (based on the limitations for irrigation).
The degree to which lands differ from the optimum state determines their suitability for sustained irrigated agriculture. In an ideal system, the best land would produce the highest yields of a wide range of variety of crops with the lowest inputs – Class I is better than Class II, Class II is better than Class III, etc. In a physical land classification survey, one can only make such a differential on the basis of judgment. Otherwise, detail soil survey is necessary.

2.5.4 Process of Land Classification

Land classification for irrigation is a multi-facet process. It begins with the systematic examination, description, and appraisal of land. The next step is to set criteria for classification based on different factors/characteristics, as mentioned earlier. The third, and the final step, is grouping of land according to the criteria.

2.5.5 USBR Land Classification System

In the 1920s and 1930s, the United States Bureau of Reclamation (USBR) introduced modern method of land classification for irrigated land. The USBR classification system is carried out in the context of a project plan and with respect to the land uses defined under the project plan. The system incorporates broad economic considerations from the beginning.

The USBR Reclamation Manual (1951) and subsequent Reclamation Instructions listed several principles of the USBR classification system:

**Prediction:** The classification should reflect future conditions as they will exist after the project is implemented. This recognizes that changes may occur in relationships between soils, water, and crops as a result of irrigation and land development, and that the classifier should use the classes to reflect whether these changes are likely to be favorable or unfavorable.

**Permanent and changeable factors:** The classifier should differentiate between permanent factors, such as soil texture, topography, soil depth, etc., and changeable factors, such as nutrient status, water table depth, salinity, pH, etc. Thus the survey and classification are directed to determine which inputs and improvements to changeable factors are cost effective.

**Economic correlation:** This assumes that a unique relationship can be established during a classification, between physical conditions of the land such as soils, topography and drainage, and an economic measure of the class ranges.

**Arability–irrigability:** Land that is physically and economically capable of providing a farmer with an adequate standard of living, where water should be available for irrigation, is first classified. Such land is called “arable.” Arable lands constitute areas that demand consideration for inclusion in a plan of development.
Lands that are selected for inclusion in the plan of irrigation development are called “irrigable” lands.
Land classification cannot provide the whole information on which development decisions are made. Other factors such as self-sufficiency in food, employment generation, development in business, national priority, etc. influence the decision-making process.

**Relevant Journals**

- Landscape and Ecological Engineering
- Applied Soil Ecology
- Geoderma
- Irrigation Science
- Agricultural Water Management
- Agronomy Journal
- European Journal of Agronomy

**Relevant FAO Papers/Bulletins**

- FAO Irrigation and Drainage Paper No. 51: Prospects for the Drainage of Clay Soils
- FAO Soils Bulletin 8: Soil Survey Interpretation and Its Use
- FAO Irrigation and Drainage Paper No. 53: Environmental Impact Assessment of Irrigation and Drainage Projects

**Questions**

1. What are the factors that influence farm production?
2. Discuss the factors affecting irrigation planning and development in an area.
3. Briefly narrate the irrigation development in Asian countries.
4. What are the positive and negative impacts of irrigation on environment and ecosystem?
5. What do you mean by land classification? What is the importance of land classification?
7. What are the processes of land classification? Mention the principle of USBR land classification system.

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