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# UPSC – IAS

Civil Services Examinations

## Union Public Service Commission

## General Studies

### Paper 3 – Volume 1

Agriculture, Biodiversity, Disaster Management and Economic Development

SIERRA INNOVATIONS

# Index



## ENVIRONMENT & ECOLOGY

## Indian Economy

# 1. Irrigation in India

## Introduction

Irrigation in India Agriculture is the nerve of any country as it is needed for survival of living beings. For growing crops, irrigation is major process. Irrigation is described as the artificial application of water to the land or soil (whereas rain-fed farming is the natural application of water to the soil through direct rainfall.). It is the substitute or supplement of rainwater with another source of water. It is used in dry areas and during periods of insufficient rainfall. It is considered as basic infrastructure and vital input required for agricultural production.

## Sources of Irrigation

### 1. Canals (30%)

Canals are most important source of irrigation from the period of 1950s and 60s, but in the 1970s, they yielded first place to wells and tube wells and now constitute the second most important source of irrigation in India. Canals are most effective techniques of irrigation in areas of low-level relief, deep fertile soils, perennial source of water and extensive command area. Therefore, the main concentration of canal irrigation is in the northern plain of India, especially the areas comprising Uttar Pradesh, Haryana and Punjab. The canals in India are of two types:

**Inundation Canals**, which are drawn directly from the rivers without making any kind of barrage or dam at their head to regulate the flow of the river and the canal. Such canals are intended to use the excess water of rivers at the time of floods. When the flood subsides, the level of the rivers falls below the level of the canal heads and therefore, the canals dry up. The water supply of such canals is uncertain. They have, therefore, been converted into perennial canals.

**Perennial Canals** are those which are constructed by putting some form of barrage across the river which flows throughout the year and diverting its water by means of a canal to the agricultural fields, both far and near. Most of the canals in India are of this type.

Indira Gandhi Canal is the longest canal in India and the largest irrigation project in the world. It is 649 Km long and starts from the Harike Barrage at Harike, a few kilometers below the confluence of the Satluj and Beas rivers in the Indian state of Punjab and terminates in the Thar Desert in the north west of Rajasthan state by flowing through Haryana. The canal is one of the projects of Green Revolution in India and also runs through The Great Thar Desert.

**2. Wells**

Wells provide the most widely distributed source of irrigation in India. A well is a hole dug in the ground to obtain the subsoil water. An ordinary well is about 3-5 metres deep but deeper wells up to 15 metres are also dug. Well irrigation is more popular in those regions where ground water is in ample and where there are few canals for example eastern UP, Bihar etc. Some or the other type of lift is always required for using the well water for irrigation whereas old methods like mot are still practised widely in many areas, power driven pumps have become exceedingly popular in most parts.

**3. Tube wells**

Tube wells are common in areas where the water table is rather deep, say, over 15 metres. The sub-soil water is exploited through deep well pumping. Indo-Gangetic valley and in certain coastal deltaic areas tube well is common.

**4. Tanks (12% irrigation)**

A tank acts as an irrigation storage system which is developed by constructing a small bund of earth or stones built across a stream. The water impounded by the bund is used for irrigation and for other purposes. Some tanks are built partly as dugouts and partly by enclosing bunds. Tanks are of varying size but most of the tanks are of small size and are built by individual farmers or groups of farmers. Tank irrigation is more suitable in the peninsular plateau area such as Andhra Pradesh (Including Telangana) and Tamil Nadu. In these States tanks are formed through natural depression by building earthen embankments. There we have hard rocks and non-porous which hold water for long. Andhra Pradesh including Telangana is the largest state of tank irrigation which has about 29 per cent of tank irrigated area of India. Odisha and Karnataka also have some tank irrigation.

**Techniques of Irrigation**

1. **Surface/flood irrigation**

**Basin**

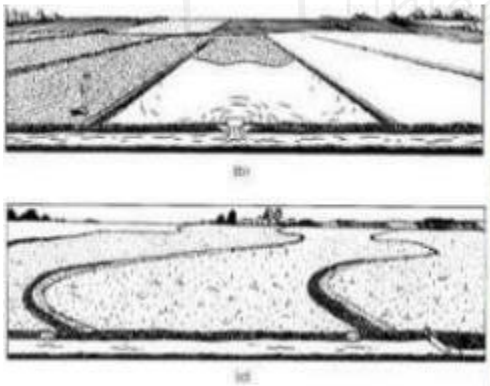
Basin irrigation is the most common form of surface irrigation, particularly in regions with layouts of small fields. If a field is level in all directions, is encompassed by a dyke/embankment to prevent runoff, and provides an undirected flow of water onto the field, it is herein called a basin. A basin is typically square in shape but exists in all sorts of irregular and rectangular configurations. It may be furrowed or corrugated, have raised beds for the benefit of certain crops, but as long as the inflow is undirected and uncontrolled into these field modifications, it remains a basin. It is suited for paddy, wheat crops.

**Furrow**

Furrow irrigation is conducted by creating small parallel channels along the field length in the direction of predominant slope. Water is applied to the top end of each furrow and flows down the field under the influence of gravity. Water may be supplied using gated pipe, siphon and head ditch. The speed of water movement is determined by many factors such as slope, surface roughness and furrow shape but most importantly by the inflow rate and soil infiltration rate. The spacing between adjacent furrows is governed by the crop species, common spacings typically range from 0.75 to 2 metres. The crop is planted on the ridge between furrows. It is suited for crops such as cotton, sugarcane and fruits such as tomatoes.

**Bay/border**

Border strip or bay irrigation could be considered as a hybrid of level basin and furrow irrigation. The field is divided into a number of bays or strips, each bay is separated by raised earth check banks (borders). The bays are typically longer and narrower compared to basin irrigation and are orientated to align lengthwise with the slope of the field. Typical bay dimensions are between 10-70m wide and 100-700m long. The water is applied to the top end of the bay, which is usually constructed to facilitate freeflowing conditions at the downstream end. One common use of this technique includes the irrigation of pasture for dairy production. One common use of this technique includes the irrigation of pasture for dairy production.



2. **Drip/Trickle/Micro/Localized**

Irrigation Drip irrigation involves dripping water onto the soil at very low rates (2-20 litres/hour) from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to plants so that only part of the soil in which the roots grow is wetted, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile. With drip irrigation water, applications are more frequent (usually every 1-3 days) than with other methods and this provides a very favourable high moisture level in the soil in which plants can flourish.

Drip irrigation is most suitable for row crops (vegetables, soft fruits like grapes), tree and vine crops where one or more emitters can be provided for each plant. Generally, only high value crops are considered because of the high capital costs of installing a drip system.

Drip irrigation is adaptable to any farmable slope. Normally the crop would be planted along contour lines and the water supply pipes (laterals) would be laid along the contour also. This is done to minimize changes in emitter discharge as a result of land elevation changes.

Drip irrigation is suitable for most soils. On clay soils water must be applied slowly to avoid surface water ponding and runoff. On sandy soils higher emitter discharge rates will be needed to ensure adequate lateral wetting of the soil.

**<u>Bamboo Irrigation (a kind of drip irrigation):</u>**

In Meghalaya and some north-eastern states, an ingenious system of tapping of stream and springwater by using bamboo pipes to irrigate plantations is widely prevalent. It is so perfected that about 18-20 litres of water entering the bamboo pipe system per minute gets transported over several hundred metres and finally gets reduced to 20-80 drops per minute at the site of the plant. The tribal farmers of Khasi and Jaintia hills use the 200- year-old system.

The bamboo drip irrigation system is normally used to irrigate the betel leaf or black pepper crops planted in arecanut orchards or in mixed orchards. Bamboo pipes are used to divert perennial springs on the hilltops to the lower reaches by gravity. The channel sections, made of bamboo, divert and convey water to the plot site where it is distributed without leakage into branches, again made and laid out with different forms of bamboo pipes. Manipulating the intake pipe positions also controls the flow of water into the lateral pipes. Reduced channel sections and diversion units are used at the last stage of water application. The last channel section enables the water to be dropped near the roots of the plant.

### 3. Sprinkler Irrigation

Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water. Sprinklers are buried in the ground along with their supporting plumbing, although above ground and moving sprinklers are also common

Sprinkler irrigation is often used when the land is uneven and thus, not suitable for surface irrigation. This method is better than surface irrigation in that less water is wasted and water is distributed more evenly. Pipes fitted with sprinklers are laid over or along the field. The sprinklers have rotating heads, which spray water over the crops.

Sprinklers are best suited to sandy soils with high infiltration rates although they are adaptable to most soils.

Sprinkler irrigation is suited for most row, field and tree crops and water can be sprayed over or under the crop canopy

## 2. Farming System and Cropping Pattern in India

Agriculture is an age-old economic activity in our country. Over these years, cultivation methods have changed significantly depending upon the characteristics of physical environment, technological know-how and socio-cultural practices. Farming varies from subsistence to commercial type. At present, in different parts of India, the following farming systems are practised.

**Primitive Subsistence**

Farming This type of farming is still practised in few pockets of India. Primitive subsistence agriculture is practised on small patches of land with the help of primitive tools like hoe, dao and digging sticks, and family/community labour. This type of farming depends upon monsoon, natural fertility of the soil and suitability of other environmental conditions to the crops grown. Farmers clear a patch of land and produce cereals and other food crops to sustain their family. When the soil fertility decreases, the farmers shift and clear a fresh patch of land for cultivation. This type of shifting allows Nature to replenish the fertility of the soil through natural processes; land productivity in this type of agriculture is low as the farmer does not use fertilisers or other modern inputs.

**Intensive Subsistence Farming**

This type of farming is practised in areas of high population pressure on land. It is labour intensive farming, where high doses of biochemical inputs and irrigation are used for obtaining higher production. Though the 'right of inheritance' leading to the division of land among successive generations has rendered land-holding size uneconomical, the farmers continue to take maximum output from the limited land in the absence of alternative source of livelihood. Thus, there is enormous pressure on agricultural land.

**Commercial Farming**

The main characteristic of this type of farming is the use of higher doses of modern inputs, e.g. high yielding variety (HYV) seeds, chemical fertilisers, insecticides and pesticides in order to obtain higher productivity. The degree of commercialisation of agriculture varies from one region to another. For example, rice is a commercial crop in Haryana and Punjab, but in Odisha, it is a subsistence crop.

Plantation is also a type of commercial farming. In this type of farming, a single crop is grown on a large area. The plantation has an interface of agriculture and industry. Plantations cover large tracts of land, using capital intensive inputs, with the help of migrant labourers. All the produce is used as raw material in respective industries. In India, tea, coffee, rubber, sugarcane, banana, etc. are important plantation crops. Since the production is mainly for market, a well-developed network of transport and communication connecting the plantation areas, processing industries and markets plays an important role in the development of plantations.

Cropping pattern is defined as how crops are distributed in time and space. India has three cropping seasons — Rabi, kharif and zaid (the summer months between rabi and kharif). Depending on the terrain, topography, slope, temperature, amount and reliability of rainfall, soils and availability of water for irrigation, the cropping patterns vary from region to region. The following are different types of cropping pattern followed in India:

- Monocropping or Monoculture: In this system, only one crop is grown on farm land year after year. Wheat, corn in areas where irrigation facility is not available.
- Multiple Cropping: The growing of more than one crop on the same land in one year.

❖ **Inter Cropping:**

Growing of two or more crops simultaneously in alternate rows or otherwise in the same area, where there is significant amount of inter crop competition. Pigeon pea planted with sorghum.

❖ **Sequential Cropping:**

Growing of two or more crops in quick succession on the same piece of land in a farming year. The swing of the succeeding crop and harvesting of the preceding crop may be done simultaneously or in a quick succession e.g. Just after the harvest of Maize Potato is sown and just after digging of potato. Chili is sown. Ricewheat in Norther India, Rice-Rice in Assam and West Bengal and coastal regions of Andhra, Tamil Nadu. Soya bean-wheat in Maharashtra, MP and Rajasthan. Rice-Pulses in Chhattisgarh, Odisha and Bihar.

❖ **Relay Cropping:**
Relay planting is inter-sowing of seeds/seedlings of the succeeding crop before harvesting the preceding/maturing crop. Generally, second crop is planted after the first crop has reach its reproductive stage of growth e.g. Potato is planted before the harvest of Maize and Radish is sown before harvesting of Potato.

❖ **Mixed Cropping:**
Cultivation of two or more than two crops simultaneously, on the same piece of land without any definite row pattern or fixed ratio. Wheat and mustard crops in northern India.

- Crop Rotation: Example Planting maize one year, and beans the next. Crop Rotation means changing the type of crops grown in the field each season or each year (or changing from crops to fallow).
- Ratooning: One of the important methods of intensive cropping, allowing the stubbles of the original crop to strike again after harvesting and to raise another crop.
- Mixed Farming: A system of farming on a particular farm which includes crop production, raising livestock, poultry, fisheries, bee keeping etc. to sustain and satisfy as many needs of the farmer as possible. The objective is subsistence while higher profitability without altering ecological balance is important in farming system.

# 3. Integrated Farming

System (IFS) Integrated Farming System (IFS) is an innovative approach wherein solo agriculture systems are integrated with livestock, aquaculture, forestry, or other inter-related set of enterprises to multiply gains and reduce input cost. Waste from one enterprise becomes an input for other, thus cost is reduced, production is increased and the ultimate income gets multiplied. The integration of various enterprises not only supplement the income of the farmers but also help in increasing the family labour employment and mitigating risk and is best suited for smallsized farms with limited resources.

Presently, the farmers concentrate mainly on crop production which is subjected to a high degree of uncertainty in income and inefficient resource utilization by the farmers. In this contest, it is imperative to evolve suitable strategy for augmenting the income of a farm by adopting integrated farming system. The following are the advantages of the IFS:

- Reduced production cost of components through input recycling from the by-products of allied enterprises and optimal utilization of resources. For example, poultry droppings are used as a feedstock for fish. Another example is, cattle dung mixed with crop residues and farm waste can be converted in to nutrient-rich vermi-compost.
- Sustainable soil fertility and productivity through organic waste recycling and is resilient and adaptive to climate variability.
- Integrated farming will help in environmental protection through effective recycling of waste from animal activities like piggery, poultry and pigeon rearing and will help in water conservation too.
- Integration of allied activities will result in the availability of nutritious food enriched with protein, carbohydrate, fat, minerals and vitamins
- Regular stable income through the products like egg, milk, mushroom, vegetables, honey and silkworm cocoons from the linked activities in integrated farming
- A judicious mix of agricultural enterprises like dairy, poultry, piggery, fishery, sericulture etc. suited to the given agro-climatic conditions and socio-economic status of the farmers would bring prosperity in the farming.
- The IFS approach has multiple objectives of sustainability, food security, farmer security and poverty reduction. And there can be different IFS models, depending on agroclimatic zones like rice-fish-poultry model, pig/poultry-fish-vegetable model, ricefish-vegetable model etc.

Due to the above advantages, the Ministry of Agriculture and Farmers' Welfare, Government of India has laid major emphasis on IFS while planning for doubling farmers' income by 2022.

IFS models with various combinations and permutations have been developed for different agro-climate zones and terrains for specific size of land holdings. Although these models are highly location specific, but choice of a model varies from place to place and even farmer to farmer in the same area. Net return from an IFS also varies depending on the selected model, characteristics of soil, input of resources etc. However, an extensive study in a district of Karnataka revealed that IFS can increase net farm income in the range of 25 percent to 150 percent depending on the local conditions. It can be further enhanced to 40 percent to 170 percent by adopting new technologies. In this context, the Indian Council of Agricultural Research (ICAR) has partnered with Central and State Agricultural Universities and has so far developed over 45 IFS models suitable to 23 States and one UT. These models are being disseminated to small and marginal farmers through the nation-wide chain of ICAR Krishi Vigyan Kendras (KVKs).

## 4. Agroecology

Agroecology is farming that centres on food production that makes the best use of nature's goods and services while not damaging these resources. Farming thrives when it works with local ecosystems, for example, improving soil and plant quality through available biomass and biodiversity, rather than battling nature with chemical inputs.

Agroecology is an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems. It seeks to optimize the interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system.

Worldwide, scientists, grassroots organizations, NGOs, consumers, universities, and public agencies are working with farmers to construct sustainable and nutritious food systems based in agroecology.

**Present system of agriculture not sustainable**

The present system of farming has resulted in the threat to food systems and bio-diversity. As a result of industrial farming, friendly insects are no longer part of the agricultural landscape, water pollution is rampant, depleted soils are commonplace and plunging groundwater tables have become the norm. The opportunity cost incurred from investing only in industrial methods of agriculture is one that has been borne largely by the farming community and the natural systems.

There are now unprecedented opportunities to advance agroecology globally as corporate food system has negative impacts on people's health, the environment, and the well-being of family farmers. Agroecology is recognized as both a mitigation and adaptation strategy for climate change. Consumers are increasingly demanding healthier food and a closer connection to food producers. Social movements around the globe – many with significant leadership by women's and indigenous organizations – are campaigning for a healthy food system built on an environmental and human rights ethos. The demand for agroecology is rising.

**What makes agroecology distinct?**

Agroecology is fundamentally different from other approaches to sustainable development. It is based on bottom-up and territorial processes, helping to deliver contextualised solutions to local problems. Agroecological innovations are based on the co-creation of knowledge, combining science with the traditional, practical and local knowledge of producers. By enhancing their autonomy and adaptive capacity, agroecology empowers producers and communities as key agents of change.

Rather than tweaking the practices of unsustainable agricultural systems, agroecology seeks to transform food and agricultural systems, addressing the root causes of problems in an integrated way and providing holistic and long-term solutions. This includes an explicit focus on social and economic dimensions of food systems. Agroecology places a strong focus on the rights of women, youth and indigenous peoples.

## 5. Conservation Agriculture

Conservation Agriculture (CA) is defined as a sustainable agriculture production system comprising a set of farming practices adapted to the requirements of crops and local conditions of each region, whose farming and soil management techniques protect the soil from erosion and degradation, improve its quality and biodiversity, and contribute to the preservation of the natural resources, water and air, while optimizing yields.

This novel resource conservation practice encompasses no or minimum soil disturbance, providing a vegetative soil cover through crop residues or other cover crops, and crop rotations for achieving higher productivity and reducing adverse environmental impacts. Conservation Agriculture is based on three core principles:

- Minimum soil disturbance (No tillage or reduced tillage).
- Maintenance of permanent soil covers.
- Cropping system diversity, crop rotations.

**Advantages of Conservation Agriculture:**

- CA based crop management practices not only enhance crop productivity but also reduces cost of production.
- Improvement of resource use efficiency through residue decomposition, increased recycling and availability of plant nutrients

- Protection of organic matter and soil and water conservation.
- Reduction in greenhouse gas emissions

**Challenges in adopting conservation agriculture:**

- Development, standardization and adoption of farm technology/machinery for seeding with minimum soil disturbance, developing crop harvesting and management systems.
- Lack of knowledge about the potential of CA to agricultural leaders, extension agents and farmers.
- CA has to be mainstreamed in relevant ministries, departments or institutions and supported by adequate provision of material, human and financial resources to ensure that farmers receive effective and timely support from well trained and motivated extension staff.

A paradigm shift has become a necessity in view of widespread problems of resource degradation, which accompanied the past strategies to enhance production with little concern for resource integrity. Integrating concerns of productivity, resource conservation and soil quality and the environment is now fundamental to sustained productivity growth for which conservation agriculture is the solution.

Some distinguishing features of conventional and conservation agriculture are as follows:

| **Conventional Agriculture** | **Conservation Agriculture** |
|---|---|
| Cultivating land using science and technology to dominate nature | Least interference with natural processes |
| Excessive mechanical tillage and soil erosion | No-till or drastically reduced tillage (biological tillage) |
| Residue burning or removal | Surface retention of residues (permanently covered) |
| Mono cropping, less efficient rotations | Diversified and more efficient rotations |

## 6. Protected Cultivation

Protected cultivation is the most contemporary approach to produce, mainly, horticulture crops qualitatively and quantitatively and has spread extensively the world over in the last few decades. It is also known as Controlled Environment Agriculture (CEA) and is highly productive, encourages water and land conservation as well as protects the environment. The technology involves cultivation of horticulture crops in a controlled environment wherein factors like the temperature, humidity, light, soil, water, fertilisers etc. are manipulated to attain the maximum produce as well as allow a regular supply of them even during off-season.

The main purpose of protected cultivation is to create a favourable environment for the sustained growth of crop, so as to realise its maximum potential even in adverse climatic conditions. Protected cultivation technology offers several advantages to produce vegetables, flowers hybrid seeds of high quality with minimum risks that arise due to uncertainty of weather while at the same time ensuring efficient use of resources. This becomes relevant to farmers having small land holdings who would be benefitted by a technology, which helps them to produce more crops each year from their land, particularly during off-season when the prices are higher. This kind of crop production system could be adopted as a profitable agroenterprise, especially in peri-urban areas. At present, there is a large gap between the demand and production of these crops to meet both quantitative and qualitative needs of domestic and export markets which are difficult to be bridged with traditional cultivation practices. Thus, protected high-value horticultural crops have great potential to enhance income especially of small farmers in India if appropriate technological interventions are made.

For protected cultivation, different types of structures can be created:

- Greenhouse: It is a framed structure covered with UV stabilized plastic films in which crops are grown under partially or controlled environment conditions.

- Plastic tunnel: These are miniature structures producing greenhouse like effect. Facilitates entrapment of carbon dioxide thereby enhancing the photosynthetic activity.

- Walk-in tunnels: These are covered with UV film, suitable for all types of crops; flowers and vegetables.

- Plastic mulching: Covering the soil around the plant with plastic film to conserve the soil moisture that prevents weed growth and regulate soil temperature.

**Advantages of protected cultivation:**

- Better quality of produce
- Higher productivity
- Efficient use of resources
- Better insect and disease control and reduced use of pesticides
- Off-season cultivation