

UPSC CIVIL SERVICES · PRELIMS & MAINS GS PAPERS I & III

Agriculture for UPSC

Farming systems, soils, crops, irrigation, inputs, technology and allied sectors in one compact book, with data up to 2026, original diagrams and verified previous year questions.

Compiled by Arvind KrS

16

CHAPTERS

4

PARTS

171

PYQS 2011–2026

64

ORIGINAL DIAGRAMS

IN THIS BOOK

I Foundations of Agriculture**II** Crops of India and the World**III** Inputs, Technology and Sustainability**IV** Allied Sectors



Agriculture for UPSC

Notes for UPSC Prelims and Mains GS Papers I and III

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PART I

4 CHAPTERS

Foundations of Agriculture

Farming systems of the world, Indian land use and landholdings, agro-climatic zones, soils and plant nutrients, crop seasons and cropping systems.

CHAPTERS

01	Agriculture: Meaning, Types of Farming and World Agricultural Regions	5
02	Indian Agriculture: Land Use, Landholdings and Agro-climatic Zones	21
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TOPICS COVERED IN THIS PART

01 Agriculture: Meaning, Types of Farming and World Agricultural Regions

Agriculture: Meaning and Scope · Origins of Farming and the Spread of Crops · What Shapes a Farming System · Classifying the World's Farming Systems · Primitive Subsistence Farming · Intensive Subsistence Farming · Plantation Agriculture · Extensive Commercial Grain Farming · Mixed Farming and Dairy Farming · Mediterranean Agriculture and Market Gardening · Livestock Ranching · Co-operative and Collective Farming · Quick Revision

02 Indian Agriculture: Land Use, Landholdings and Agro-climatic Zones

Agriculture in India's Economy · The Nine-fold Land Use Classification · Land Use Trends, Net Sown Area and Cropping Intensity · Landholdings and the Agriculture Census · Small Farms: Problems and Responses · Agricultural Households and Women Farmers · Agro-climatic Regions of the Planning Commission · NARP Zones and Agro-ecological Regions · Production Records and Leading States · Who Runs Indian Agriculture: Ministries and ICAR

03 Soils, Soil Health and Plant Nutrients

Soil as a Farm Resource · Soils of India in Brief · Soil Fertility, Productivity and Nutrient Cycling · Soil Reaction (pH) and Acid Soils · Salt-affected and Waterlogged Soils · Essential Plant Nutrients · Nutrient Deficiencies: Symptoms and India's Status · Soil Organic Carbon and Soil Life · Soil Erosion and Conservation · Soil Testing and the Soil Health Card

04 Crop Seasons, Cropping Patterns and Cropping Systems

Crop Seasons of India · Classifying Crops · Cropping Pattern and Cropping System · Types of Cropping Systems · Crop Rotation · Allelopathy and Crop Interactions · Major Cropping Systems of India · Changes in India's Cropping Pattern · Crop Diversification · High-value Crops · Integrated Farming Systems

AGRICULTURE

PRELIMS · GS I & III

Agriculture: Meaning, Types of Farming and World Agricultural Regions

A Mongolian herder on the steppe, a Naga family burning a forest patch before the rains, a Punjab farmer running a combine through wheat and a Dutch grower flying tulips to Paris are all farming, yet they share almost nothing in method or purpose. Agriculture is the oldest way people have used land and still employs more people than any other activity on Earth. The United Nations has named 2026 both the **International Year of Rangelands and Pastoralists** and the **International Year of the Woman Farmer**, a reminder that the world's food comes from many very different farming systems.

SYLLABUS

PRELIMS

Indian and World Geography: Physical, Social, Economic Geography of India and the World

MAINS · GS PAPERS I & III

Distribution of key natural resources across the world (including South Asia and the Indian sub-continent); major crops and cropping patterns in various parts of the country

CONTENTS

01	Agriculture: Meaning and Scope	02	Origins of Farming and the Spread of Crops
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07	Plantation Agriculture	08	Extensive Commercial Grain Farming
09	Mixed Farming and Dairy Farming	10	Mediterranean Agriculture and Market Gardening
11	Livestock Ranching	12	Co-operative and Collective Farming
13	Quick Revision	14	Previous Year Questions

This chapter covers:

- the meaning and branches of agriculture, and the "-cultures" Prelims likes to test;
- where farming began and how crops crossed oceans in the Columbian Exchange;
- the physical, economic and institutional factors behind a farming system, including von Thünen's model;
- Whittlesey's classification and each major type, from shifting cultivation and nomadic herding to plantations, grain farming, dairying, Mediterranean farming and ranching;
- co-operative and collective farming, and new ways small farmers pool their operations.

Indian land use, landholdings and agro-climatic zones follow in Chapter 2; individual crops are covered in Part II.

01 Agriculture: Meaning and Scope

The word **agriculture** comes from the Latin *ager* (field) and *cultura* (cultivation). In its widest sense it is the science, art and business of **growing crops and rearing animals** for food, fibre, fuel, medicine and raw materials. It is a **primary activity**, because it draws directly on natural resources such as land, water, sunlight and soil, in the same group as fishing, forestry, mining and gathering.

Agriculture today covers far more than the cultivation of field crops. It includes horticulture, animal husbandry, dairying, poultry, fisheries, beekeeping, silk production and agroforestry, and it reaches forward into storage, processing and trade. Close to half of India's workforce still depends on farming and allied activities for a living, although the sector produces only about a sixth of the country's gross value added. This gap between people and output is the root of many issues discussed in this book: small farms, low incomes, disguised unemployment and pressure on land and water.

Branches of Agriculture

Each branch has its own name, usually ending in "-culture". These terms appear often in Prelims questions and in scheme names.

TERM	WHAT IT DEALS WITH	TERM	WHAT IT DEALS WITH
Agronomy	Field crops and soil management	Sericulture	Silkworms and silk
Horticulture	Fruits, vegetables, flowers, spices	Apiculture	Honeybees
Pomology	Fruit growing	Pisciculture	Fish farming
Olericulture	Vegetable growing	Mariculture	Farming of marine organisms
Floriculture	Flowers and ornamental plants	Silviculture	Raising forest trees
Viticulture	Grapes (vineyards)	Arboriculture	Individual trees and shrubs

TERM	WHAT IT DEALS WITH	TERM	WHAT IT DEALS WITH
Oleiculture	Olives	Agrostology	Grasses and fodder
Moriculture	Mulberry, the food of silkworms	Vermiculture	Earthworms for compost

Two newer terms are worth knowing. **Hydroponics** grows plants without soil, with roots in a nutrient solution; **aeroponics** suspends the roots in air and sprays them with a nutrient mist. Both are used for high-value vegetables in cities and in vertical farms.

02

Origins of Farming and the Spread of Crops

For most of human history people lived by **hunting and gathering**. Farming began only about **10,000–12,000** years ago, at the end of the last Ice Age, in what is called the **Neolithic Revolution**. It started independently in several places, each with its own crops and animals.

- **Fertile Crescent** (West Asia): wheat, barley, lentil, pea, chickpea; sheep, goats, cattle.
- **China**: rice in the Yangtze valley and millets in the Yellow River valley; pigs.
- **Mesoamerica**: maize, beans, squash, chilli. The **Andes**: potato, quinoa; llama and alpaca.
- **Africa**: sorghum, pearl millet, finger millet, coffee (Ethiopia), oil palm.
- **South Asia**: **Mehrgarh** in Balochistan shows wheat and barley farming and cattle herding from about **7000 BCE**; rice was being cultivated early in the Ganga plain. The Indian region gave the world cane sugar, rice of the *indica* group, pigeon pea, black and green gram, sesame, black pepper, mango, cucumber and tree cotton.

The Russian botanist **Nikolai Vavilov** mapped these "centres of origin" in the 1920s and 1930s, arguing that a crop shows its greatest genetic variety where it was first domesticated. His idea still guides gene banks, which collect wild relatives of crops from these centres.

The Columbian Exchange

Crops That Crossed the Oceans: The Columbian Exchange

After 1492, crops domesticated in the Americas spread to Asia, Africa and Europe, and Old World crops and animals reached the Americas.

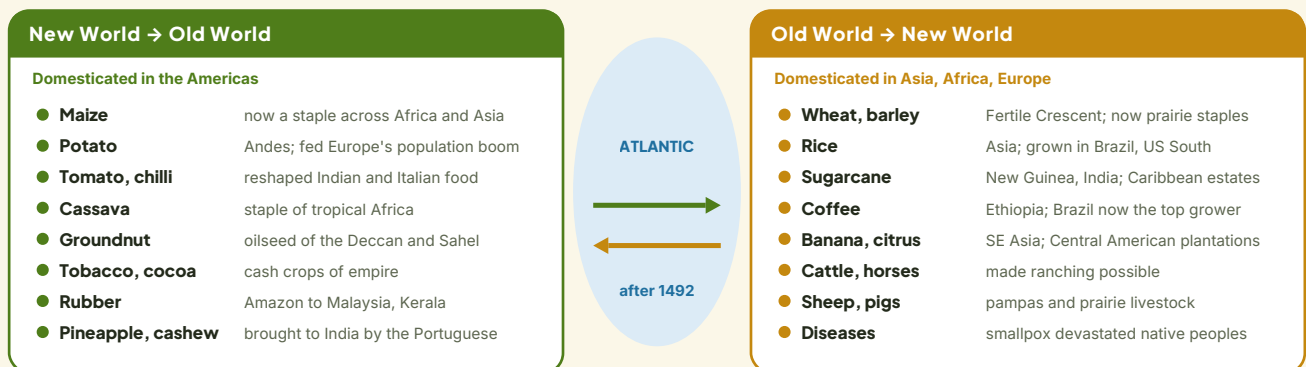


Fig. 1.1 The Columbian Exchange: crops of the New World (left) and the Old World (right) that crossed the Atlantic after 1492

After Columbus reached the Americas in **1492**, crops, animals and diseases moved across the Atlantic in both directions. This **Columbian Exchange** reshaped diets everywhere. Maize and cassava became staples in Africa; the potato fuelled Europe's population growth; and Indian cooking would be unrecognisable without the chilli, tomato and potato, all brought by the Portuguese.

A useful way to remember the direction: **tobacco, cocoa, rubber, maize, potato, groundnut and cashew** are New World plants, while **wheat, rice, sugarcane, coffee, banana and tea** began in the Old World. Rubber moved from the Amazon to Malaysia and Kerala only in the late 19th century, through seeds smuggled to Kew Gardens in London.

03 What Shapes a Farming System

Why does a farmer in Punjab grow wheat and rice, a farmer in Kerala coconut and rubber, and a herder in Ladakh keep yaks and pashmina goats? The answer lies in three groups of factors that work together.

Physical Factors

- **Temperature and growing season.** Each crop needs a minimum period free of frost and a certain amount of heat. Rice and sugarcane need long, hot seasons; wheat needs a cool growing season and a warm, dry spell at ripening.
- **Moisture.** Rainfall, its timing and its reliability decide whether a region grows rice, wheat, millets or nothing at all. Irrigation can override rainfall, as in Punjab or the Nile valley.
- **Relief and slope.** Level plains suit large fields and machines; steep slopes need terraces, as in the Himalaya and the Philippine Cordillera, or are left to forests and pasture.
- **Soil.** Alluvial soils support intensive cropping; black soils suit cotton; laterite suits plantation crops such as cashew and tea.

Economic Factors

Markets, transport, capital, labour and technology decide what is worth growing. Perishable goods such as milk, vegetables and flowers must be produced close to the market or moved quickly by road, rail or air. Capital pays for tractors, tubewells, greenhouses and cold stores; cheap labour favours hand-picked crops such as tea and cotton.

Institutional and Cultural Factors

Land tenure, the size of holdings, government policy and food habits all matter. Small, fragmented holdings limit mechanisation. Assured procurement of wheat and rice in north-west India has kept farmers in a rice–wheat cycle even where groundwater is falling. Religious and social customs shape livestock: pigs are reared in the North-East but rarely in much of the plains.

Von Thünen's Model

The German landowner **Johann Heinrich von Thünen** explained the economic logic of farm location in *The Isolated State* (**1826**). He imagined a flat, uniform plain with one market town and no roads, where transport

cost rises with distance. Each land use can pay a different "rent" after transport costs, so the use that earns most at each distance takes over that ring.

Von Thünen's Model of Agricultural Land Use (1826)

On a flat, uniform plain with one market town, land use is decided by how much rent each activity can pay after transport costs.

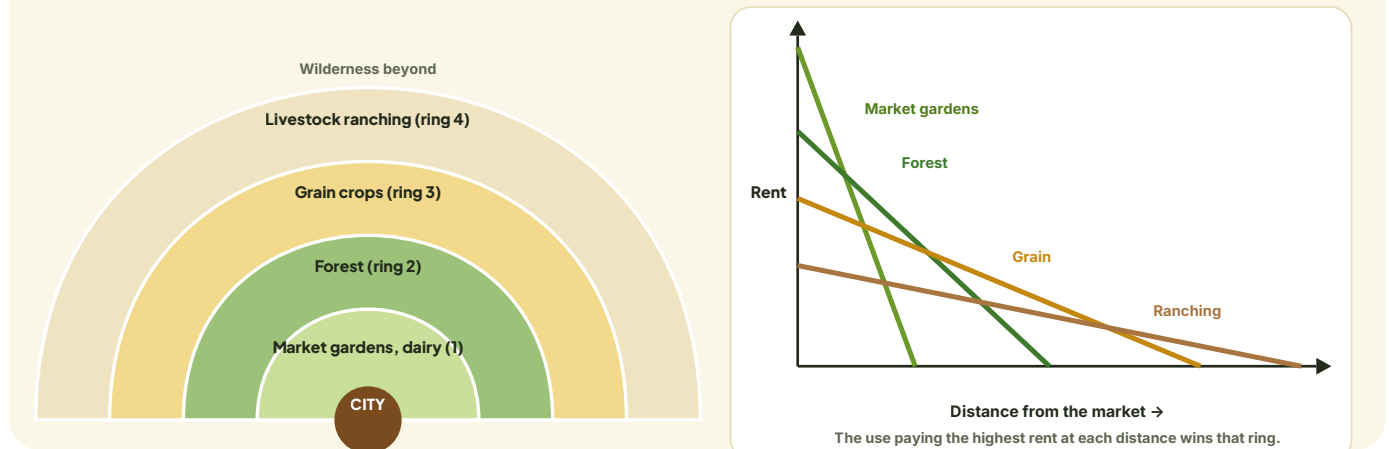


Fig. 1.2 Von Thünen's rings (left) and the bid-rent lines behind them (right). Perishable and bulky goods are produced close to the market; extensive uses such as grain and ranching are pushed outwards.

Perishable vegetables and milk crowd close to the town; firewood and timber, heavy and needed daily in his day, come next; then grain; and finally livestock, which can walk to market. Real landscapes are distorted by rivers, roads, soils and refrigeration, but the principle still holds:

dairies, poultry farms and vegetable belts ring every large Indian city, while grain and pasture lie further out.

04

Classifying the World's Farming Systems

Farming can be grouped in several ways, each bringing out a different contrast.

- **Subsistence or commercial.** In **subsistence farming** the farmer grows mainly to feed the household, selling only a small surplus. In **commercial farming** crops are grown for sale, often with heavy use of machines, fertilisers and hired labour.
- **Intensive or extensive.** **Intensive farming** applies much labour or capital to a small area and gets high output per hectare. **Extensive farming** uses large areas with few inputs per hectare, giving low yield per hectare but high output per worker.
- **Irrigated, rainfed or dry farming.** **Dry farming** is cropping in areas with less than about **75 cm** of rain using moisture-saving methods; **rainfed farming** depends on rainfall without irrigation.
- **Specialised, diversified or mixed.** A specialised farm grows one product; a diversified farm grows several crops; a mixed farm combines crops with livestock.

Whittlesey's Classification

The American geographer **Derwent Whittlesey** published the most widely used scheme in **1936**. He grouped farming using **five criteria**: the combination of crops and livestock; the intensity of land use; how produce is processed and marketed; the degree of mechanisation; and the types of farm buildings and structures. On

this basis he identified **13** agricultural regions of the world, which are usually condensed into the types shown below.

A Classification of World Farming Systems

Based on Whittlesey (1936): what is grown or reared, how intensively the land is used, and whether output is eaten at home or sold.

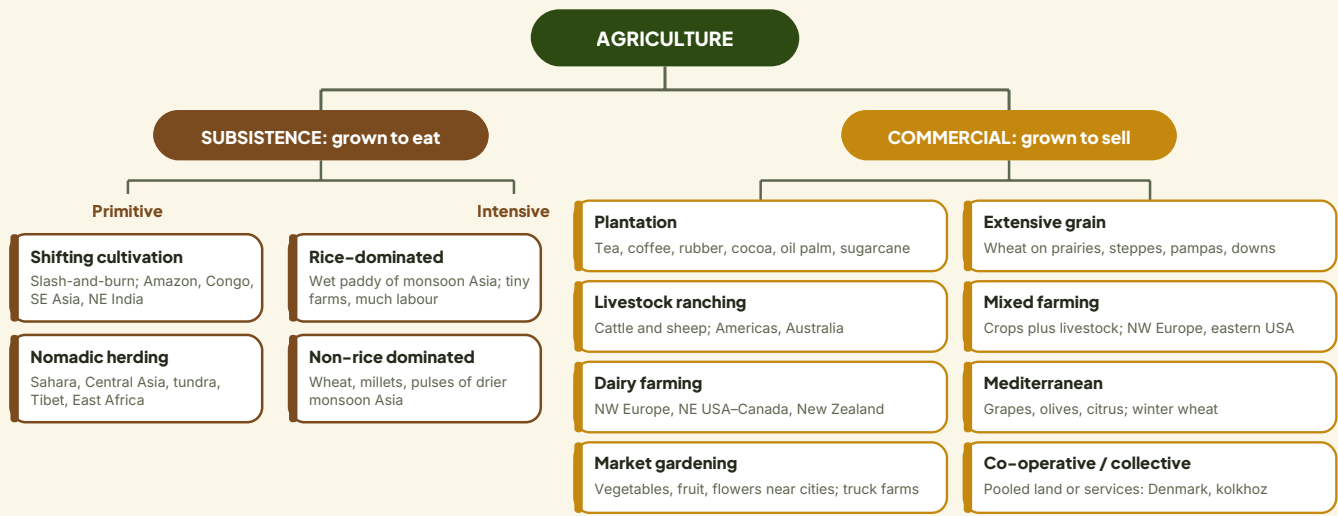


Fig. 1.3 The main farming types of the world, grouped as subsistence and commercial, with typical regions

05 Primitive Subsistence Farming

Two of the oldest systems still survive in forests, deserts, grasslands and mountains where other farming is difficult: shifting cultivation and nomadic herding.

Shifting Cultivation

Shifting cultivation, also called **slash-and-burn** farming, is practised in the tropical forests of the Amazon basin, Central and West Africa, South-East Asia and North-East India. A patch of forest is cut, the debris is dried and burnt, and crops are dibbled into the ash with simple tools such as the hoe and digging stick. The ash adds potash and other nutrients, and burning kills weeds and pests.

After two or three years, heavy rain washes out the nutrients, weeds return and yields fall. The farmer then moves to a new patch and leaves the old one to regrow. Fertility returns only if the **fallow period** is long enough. In North-East India the **jhum cycle** was once **20–30** years, but rising population has cut it to as little as **3–6** years in many areas, leading to soil erosion, loss of forest and falling yields.

The same practice goes by many local names, which are a Prelims favourite.



Fig. 1.4 A hillside freshly cleared and burnt for slash-and-burn cultivation

The Shifting Cultivation (Jhum) Cycle

A patch is farmed for a few years and then left to the forest; the farmer returns only after the soil has recovered.



Fig. 1.5 The shifting cultivation cycle. When the fallow period is shortened, the soil cannot recover between cycles.

REGION (WORLD)	LOCAL NAME	REGION (INDIA)	LOCAL NAME
Mexico, Central America	Milpa	North-East (Assam, Meghalaya, Mizoram, Nagaland)	Jhum, Jhumming
Venezuela	Conuco	Manipur	Pamlou
Brazil	Roca	Bastar (Chhattisgarh)	Dipa
Central Africa	Masole	Madhya Pradesh	Bewar, Dahiya
Indonesia, Malaysia	Ladang	Andhra Pradesh	Podu, Penda
Vietnam	Ray	Odisha	Pama Dabi, Koman, Bringa
Myanmar	Taungya	Western Ghats	Kumari
Sri Lanka	Chena	South-east Rajasthan	Valre, Waltre
Philippines	Caingin	Himalayan belt; Jharkhand	Khil; Kuruwa

INDIA: MAKING JHUM SUSTAINABLE

Jhum is tied to community land ownership, clan rules and food security in the hills, so outright bans have failed. The better approach has been to **improve** it: lengthening fallows, planting nitrogen-fixing alder trees on jhum land (a Naga tradition), growing fruit trees and bamboo on old plots, contour hedgerows, and settled terraces in valleys. Under the **Mission Organic Value Chain Development for**

North Eastern Region, hill farmers have been helped to shift towards certified organic ginger, turmeric, pineapple and large cardamom.

Nomadic Herding

Nomadic herding, or pastoral nomadism, is a subsistence system in which herders move with their animals in search of pasture and water along fixed, age-old routes. The animals supply milk, meat, wool, hides and transport. The main belts are:

- the dry belt from the **Atlantic coast of North Africa** across the Sahara and Arabia to **Central Asia and Mongolia**, with sheep, goats, camels and horses;
- the **tundra** of northern Eurasia, where the Sami and Nenets herd **reindeer**;
- the high plateaus of **Tibet** (yak) and the **Andes** (llama and alpaca);
- the savannas of East Africa (the Maasai, with cattle) and south-west Africa.



Nomadic herding, Mongolia



Gaddi shepherd, Himachal Pradesh

Fig. 1.6 Pastoralism on the steppe and transhumance in the Himalaya. Both move herds to follow seasonal pasture.

The Central Asian steppes, with their extreme continental climate and scanty rainfall, were the classic home of Kazakh and Kyrgyz herders. Nomadism is shrinking everywhere: national borders, settlement schemes, mining, fenced ranches and climate change have reduced the open range.

A related system is **transhumance**, the seasonal movement of herders and livestock between fixed summer and winter pastures, usually up and down mountains. In India the **Gujjars and Bakarwals** of Jammu and Kashmir, the **Gaddis** of Himachal Pradesh and the **Bhotias** of Uttarakhand take their flocks to high meadows (*bugyals* and *margs*) in summer and return to the foothills in winter. The **Raikas (Rebaris)** of Rajasthan move camels and sheep across the Thar.

COMMON CONFUSION: NOMADISM, TRANSHUMANCE AND RANCHING

Nomadic herding is subsistence-based and the whole community moves without a fixed home.

Transhumance involves a fixed home base and a regular seasonal move between two pastures.

Livestock ranching (Section 11) is commercial, with settled ranchers on large fenced holdings. Mixed

farming, by contrast, means crops and animals on the same farm; it is not the same as mixed cropping, which is growing two crops together in one field (Chapter 4).

06

Intensive Subsistence Farming

Intensive subsistence farming is typical of the densely populated **monsoon lands of South, South-East and East Asia**. Holdings are tiny, family labour is plentiful, and every scrap of land is used. Farmers apply large amounts of labour, manure and, increasingly, fertiliser to get very high output per hectare, but output per worker stays low. There are two types.

- **Dominated by wet paddy:** in the deltas and valleys of the Ganga, Brahmaputra, Irrawaddy, Chao Phraya, Mekong, Red River and Yangtze, and in southern China, Japan and Indonesia. Rice is transplanted into flooded fields, often with two or three crops a year, and hill slopes are terraced.
- **Dominated by crops other than paddy:** where rain is too low for rice, as in northern China, Manchuria, North Korea, northern Japan and the drier parts of India, farmers grow wheat, soybean, barley, sorghum, millets and pulses, using irrigation where possible.



Transplanting paddy in the monsoon



Batad rice terraces, Philippines

Fig. 1.7 Wet-rice farming: labour-intensive transplanting on the plains and terraced paddies on steep slopes

Why does this system feed more than half of humanity? The monsoon brings heavy rain in the hot season, exactly when rice needs standing water. Rivers lay down fertile alluvium every flood season. Rice gives more food energy per hectare than most grains, and the warm climate allows two or three crops a year. Cattle and buffalo provide draught power and manure, and fish are often raised in paddy fields. The weakness is **dependence on the monsoon**: a late or failed monsoon can cause severe hardship, which is why irrigation, flood control and drought-tolerant varieties are so important in this belt.

07

Plantation Agriculture

Plantation agriculture is a commercial system in which a single crop is grown on a large estate for sale, often for export. It was introduced by European colonists in the tropics. The **British** set up tea gardens in India and Sri Lanka, rubber in Malaysia, and sugarcane and bananas in the West Indies; the **French** grew cocoa and

coffee in West Africa; the **Dutch** grew sugarcane in Indonesia; and the **Spanish and Americans** developed coconut and sugarcane in the Philippines.

Typical features are:

- large estates with heavy **capital investment**, scientific management and technical know-how;
- **monoculture** of one crop such as tea, coffee, cocoa, rubber, oil palm, sugarcane, banana or pineapple;
- a large resident **labour force**, historically migrant or indentured;
- a processing unit on or near the estate, and good transport to ports.

Many plantations passed to national governments or local owners after independence; Malaysian oil palm and rubber, for instance, are now largely run by local companies and smallholders. In India, tea, coffee, rubber, cardamom and coconut are the main plantation crops. Tea in Assam, the Darjeeling hills and the Nilgiris, coffee in Karnataka, and rubber in Kerala are covered in Chapter 8.



Fig. 1.8 Plucking tea at a Darjeeling estate: plantations rely on large, skilled workforces

08

Extensive Commercial Grain Farming

Extensive commercial grain farming developed in the semi-arid interiors of the mid-latitude grasslands, settled by Europeans in the 19th century. **Wheat** is the main crop, with maize, barley, oats and rye. Farms are very large, from a few hundred to several thousand hectares, and almost every operation from ploughing to harvesting is mechanised. Yield per hectare is low, but output per worker is very high.

The main regions are the grasslands known by local names:

- **Prairies:** Canada and the USA
- **Steppes:** Russia, Ukraine, Kazakhstan
- **Pampas:** Argentina, Uruguay
- **Velds:** South Africa
- **Downs:** Australia
- **Canterbury Plains:** New Zealand

Sparse population, cheap land, level relief, fertile chernozem soils and railways to export ports made these the world's granaries. Because a single bad season can ruin a farmer, the system depends on crop insurance, storage elevators and futures markets.



Fig. 1.9 A combine harvester cuts and threshes wheat in one pass, allowing a few workers to manage a huge farm

Mixed Farming and Dairy Farming

Mixed Farming

Mixed farming combines the cultivation of crops with the rearing of animals on the same farm. It is found in the highly developed parts of the world: **north-western Europe**, eastern North America, parts of Eurasia and the temperate parts of the southern continents. Farms are medium-sized. Crops include wheat, barley, oats, rye and maize, plus fodder and root crops such as turnips and sugar beet, grown in a careful **rotation** that keeps the soil fertile. Cattle, sheep, pigs and poultry eat the fodder, and their manure goes back to the fields. Income is spread over several products, so risk is lower. The system needs high capital (machines, farm buildings, fertilisers) and skilled farmers.

Dairy Farming

Commercial dairy farming is the most advanced and efficient type of livestock rearing. It is **capital-intensive**, with cattle sheds, fodder storage, feeding and milking machines, and also **labour-intensive**, because animals must be fed and milked every day of the year. It is found close to urban and industrial markets, since milk is perishable, although refrigeration, pasteurisation and fast transport now let dairy regions lie further away.

The three main regions are **north-western Europe** (the largest), **Canada and the north-eastern USA**, and **south-eastern Australia, New Zealand and Tasmania**. New Zealand, with year-round grass, is the world's largest exporter of dairy products. India, the world's largest milk producer, follows a very different model: tens of millions of small producers with two or three animals each, linked to co-operatives (Chapter 14).



Fig. 1.10 Holstein-Friesian cows on a European pasture. Dairy is the most capital-intensive form of livestock farming

Mediterranean Agriculture and Market Gardening

Mediterranean Agriculture

Mediterranean agriculture is highly specialised commercial farming in regions with hot, dry summers and mild, rainy winters. It is found on both sides of the Mediterranean Sea (southern Europe and North Africa from Tunisia to the Atlantic coast), in southern California, central Chile, south-western South Africa and south and south-western Australia.

The region is an important supplier of **citrus fruits**. **Viticulture**, the growing of grapes, is its speciality: the best wines in the world come from high-quality grapes here, while inferior grapes are dried into raisins and currants. Olives and figs are also grown. Wheat and barley are sown in the rainy winter and harvested before the dry summer, and sheep and goats graze the hills. Summer irrigation supports vegetables and fruit for European markets.



Vineyards in Tuscany, Italy



Olive grove on Naxos, Greece

Fig. 1.11 Tree and vine crops survive the dry Mediterranean summer with deep roots and thick, waxy leaves

Market Gardening, Horticulture and Factory Farming

Market gardening and horticulture specialise in high-value crops such as vegetables, fruits and flowers, sold in nearby urban markets. Farms are small and lie close to cities with good transport. The system is labour- and capital-intensive, using irrigation, fertilisers, better seeds, greenhouses and, in cold areas, artificial heating. It is well developed in north-western Europe, the north-eastern USA and the Mediterranean. The **Netherlands** specialises in flowers, especially **tulips**, which are flown to cities across Europe.

Regions where farmers grow only vegetables are said to practise **truck farming**; the distance of a truck farm from the market is set by how far a truck can travel overnight. In **factory farming**, poultry and cattle are reared in stalls and pens and fed on manufactured feed, with strict control of disease. It is common in north-western Europe and North America and is growing around Indian cities for broilers and eggs.

11 Livestock Ranching

Commercial livestock ranching is the commercial counterpart of nomadic herding. Ranchers live in one place and keep large herds of **cattle or sheep** on vast, fenced holdings, moving them between parcels of pasture. It developed in areas where land was cheap and too dry for crops: the western USA and Canada, the **Pampas** of Argentina and Uruguay (where ranches are called *estancias*), southern Brazil, the interior of Australia (sheep and cattle "stations") and New Zealand, and South Africa.

Ranching is organised on scientific lines, with breeding, genetic improvement, disease control and veterinary care. The main products are meat, wool, hides and skins, which are processed, packed and exported. Refrigerated ships in the late 19th century allowed frozen meat to travel from Argentina and New Zealand to Europe, turning ranching into a global trade. Clearing forest for cattle pasture is now the biggest driver of deforestation in the Amazon.



Fig. 1.12 Longhorn cattle on a Texas ranch.
Ranching is commercial and needs large areas of grassland

12

Co-operative and Collective Farming

Farming systems differ not only in what is grown but also in how land and labour are organised.

Co-operative Farming

In **co-operative farming**, farmers voluntarily form a society and pool their resources for better farming while each keeps ownership of their own land. The co-operative buys seed, fertiliser and machinery in bulk, processes and markets the produce, and gives farmers better prices. It is most successful in **Denmark**, the Netherlands, Belgium, Sweden and Italy; in Denmark practically every farmer is a member. India's best-known example is the milk co-operative movement that began with the **Kaira District Co-operative Milk Producers' Union (Amul)** in Gujarat in **1946**.

Collective Farming

Collective farming rests on social ownership of the means of production and collective labour. It was introduced in the former Soviet Union from **1928** to raise output and feed the cities. Farmers pooled land, livestock and labour in a **kolkhoz** (collective farm) and kept only small plots for their own needs; the **sovkhoz** was a state farm run directly by the government with paid workers. Targets were set by the state and produce was sold to it at fixed prices. China followed with people's communes from **1958**. Both systems suffered from weak incentives and were dismantled or reformed from the late 1970s onwards. Israel's **kibbutz** (collective) and **moshav** (co-operative settlement) are smaller voluntary versions.

New Forms of Pooling: Small Farmer, Large Field

Most farms in Asia and Africa are small, and small farms struggle with high costs and weak bargaining power. Several models try to give small farmers the advantages of scale without taking their land:

- **Small Farmer Large Field:** many marginal farmers in an area organise themselves into groups and **synchronise and harmonise selected operations**, such as sowing the same variety on the same date, pest control and harvesting, so that the block behaves like one large field while each farmer keeps their land. The model spread from Vietnam's Mekong Delta.
- **Farmer Producer Organisations (FPOs):** companies or co-operatives owned by farmers that buy inputs and sell produce together. India's scheme for **10,000** new FPOs, launched in 2020, met its target in 2025.
- **Contract farming:** a company agrees in advance to buy a crop at a set price and often supplies seed and advice. This is different from Small Farmer Large Field, because the buyer, not the farmers, drives the arrangement.

13

Quick Revision

The table below sums up how the main farming types differ in scale, inputs and output. Note the contrast between output per hectare and output per worker, which is often tested.

TYPE	SCALE AND INPUTS	OUTPUT	TYPICAL REGIONS
Shifting cultivation	Small plots; hand tools; no fertiliser	Low per hectare and per worker	Amazon, Congo, SE Asia, NE India
Nomadic herding	Whole community moves with herds	Subsistence: milk, meat, wool	Sahara, Arabia, Central Asia, tundra
Intensive subsistence	Tiny holdings; much labour and manure	High per hectare, low per worker	Monsoon Asia
Plantation	Large estates; capital; hired labour	Single cash crop for export	Tropics: India, Sri Lanka, Malaysia, West Africa, Caribbean
Extensive grain	Huge farms; machines; few workers	Low per hectare, very high per worker	Prairies, steppes, Pampas, Downs
Mixed farming	Medium farms; rotation; machines	Crops plus livestock	NW Europe, eastern USA
Dairy	Capital- and labour-intensive	Milk, butter, cheese	NW Europe, NE USA, New Zealand
Mediterranean	Specialised; irrigation in summer	Grapes, olives, citrus, winter wheat	Mediterranean, California, Chile
Ranching	Vast fenced holdings; scientific breeding	Meat, wool, hides	Americas, Australia, New Zealand

Key Terms at a Glance

TERM	MEANING
Primary activity	Economic activity that uses natural resources directly: farming, fishing, forestry, mining
Neolithic Revolution	The shift from hunting and gathering to farming about 10,000–12,000 years ago
Centre of origin	Region where a crop was first domesticated and shows most genetic variety (Vavilov)
Columbian Exchange	Movement of crops, animals and diseases between the Americas and the Old World after 1492
Bid-rent	The rent a land use can pay at a given distance from the market (von Thünen)
Jhum cycle	The period after which a shifting cultivator returns to the same plot

TERM	MEANING
Transhumance	Seasonal movement of herders and animals between fixed summer and winter pastures

USING THIS CHAPTER IN MAINS

Questions on why monsoon Asia supports half of humanity, why plantation economies remain export-dependent, or why the temperate grasslands became world granaries all ask you to **link climate, soil and relief to the farming type and its economics**. Draw a simple sketch, such as von Thünen's rings or a world map of farming belts, name two or three real regions, and end with a present-day issue such as climate risk, deforestation or the decline of pastoralism.



Previous Year Questions



Prelims

2023

Which one of the following best describes the concept of 'Small Farmer Large Field'?

- a** Resettlement of a large number of people, uprooted from their countries due to war, by giving them a large cultivable land which they cultivate collectively and share the produce
- b** Many marginal farmers in an area organize themselves into groups and synchronize and harmonize selected agricultural operations
- c** Many marginal farmers in an area together make a contract with a corporate body and surrender their land to the corporate body for a fixed term for which the corporate body makes a payment of agreed amount to the farmers
- d** A company extends loans, technical knowledge and material inputs to a number of small farmers in an area so that they produce the agricultural commodity required by the company for its manufacturing process and commercial production.

Answer: (b). Small farmers group together and synchronise operations such as sowing and harvesting to gain scale, without giving up their land; (d) describes contract farming (Section 12).

2019

Which one of the following groups of plants were domesticated in the 'New World' and introduced into the 'Old World'?

- a** Tobacco, cocoa and rubber
- b** Tobacco, cotton and rubber
- c** Cotton, coffee and sugarcane
- d** Rubber, coffee and wheat

Answer: (a). Tobacco, cocoa and rubber come from the Americas; coffee, sugarcane and wheat are Old World crops, and cotton was domesticated in both (Section 02).

2013

"Climate is extreme, rainfall is scanty and the people used to be nomadic herders."
The above statement best describes which of the following regions?

☐ a African Savannah

☒ b Central Asian Steppe

☐ c North American Prairie

☐ d Siberian Tundra

Answer: (b). The Central Asian steppes have an extreme continental climate and scanty rainfall, and were the home of Kazakh and Kyrgyz herders (Section 05).

2012

Which of the following is the chief characteristic of 'mixed farming'?

☐ a Cultivation of both cash crops and food crops

☐ b Cultivation of two or more crops in the same field

☒ c Rearing of animals and cultivation of crops together

☐ d None of the above

Answer: (c). Mixed farming combines crops and livestock on the same farm; (b) describes mixed cropping (Section 09).

Mains

2017

GS I · 15 MARKS

What characteristics can be assigned to monsoon climate that succeeds in feeding more than 50 percent of the world population residing in Monsoon Asia?

Approach: Link monsoon traits (seasonal wind reversal, rain in the hot season, flood-borne alluvium) to wet-rice farming, multiple cropping and high carrying capacity; cite the Ganga, Mekong and Yangtze plains; note the risk of monsoon failure; end with irrigation and climate resilience (Section 06).

PART II

4 CHAPTERS

Crops of India and the World

Rice, wheat, millets, maize, pulses, oilseeds, sugarcane, fibres, plantation crops, spices and horticulture: conditions, regions and current trends.

CHAPTERS

05	Rice and Wheat	70
06	Millets, Maize and Pulses	84
07	Oilseeds, Sugarcane, Fibre and Other Cash Crops	99
08	Plantation Crops, Spices and Horticulture	116

TOPICS COVERED IN THIS PART

05 Rice and Wheat

Rice and Wheat in India's Food Basket · Rice: Origin, Types and Growing Conditions · Rice Seasons and Rice Ecosystems · Where Rice Is Grown: India and the World · Rice Varieties, Pests and New Technologies · Saving Water and Cutting Methane: SRI, DSR and AWD · Wheat: Types and Growing Conditions · Where Wheat Is Grown: India and the World · Wheat Varieties, Heat Stress and Diseases · The Rice-Wheat Cropping System

06 Millets, Maize and Pulses

Coarse Cereals and Pulses: An Overview · Millets: The Nutri-Cereals · Jowar, Bajra and Ragi · Small Millets and the Millet Revival · Maize: Growing Conditions and Regions · Maize Uses: Feed, Starch and Ethanol · Pulses: Legumes and Nitrogen Fixation · Major Pulses: Gram, Lentil and Peas · Major Pulses: Tur, Moong, Urad and Others · Pulses: Production, Imports and the Pulses Mission

07 Oilseeds, Sugarcane, Fibre and Other Cash Crops

Commercial Crops: An Overview · Groundnut, Mustard and Soybean · Castor, Sesame and Other Oilseeds · Edible Oil Imports and Oil Palm · Sugarcane: Growing Conditions and Regions · Sugarcane Technology and By-products · Sugarcane and Ethanol · Cotton: Growing Conditions and Regions · Bt Cotton and Pink Bollworm · Jute and Mesta · Tobacco, Guar and Other Cash Crops

08 Plantation Crops, Spices and Horticulture

Plantation Crops in India · Tea · Coffee · Natural Rubber · Coconut and Arecanut · Cashew and Cocoa · Spices: Pepper, Cardamom, Chillies and Others · Turmeric and Saffron · Fruits, Vegetables and Flowers · Horticulture Practices and Post-harvest Care · Horticulture Missions, Clean Plants and GI Tags

AGRICULTURE

PRELIMS · GS I & III

Rice and Wheat

In January 2026 the Union Agriculture Minister announced that India had overtaken China as the world's largest producer of rice, and the 2025-26 harvest went on to set new records for both rice and wheat. Yet the same fields that fill the country's granaries are also draining Punjab's aquifers, sending smoke over Delhi every November and releasing methane from flooded paddies. Rice and wheat together make up nearly three-quarters of India's foodgrain output, so their climate needs, geography, technology and problems sit at the very centre of Indian agriculture.

SYLLABUS

PRELIMS

Indian and World Geography: Physical, Social, Economic Geography of India and the World

MAINS · GS PAPERS I & III

Distribution of key natural resources across the world (including South Asia and the Indian sub-continent); major crops and cropping patterns in various parts of the country

CONTENTS

01	Rice and Wheat in India's Food Basket	02	Rice: Origin, Types and Growing Conditions
03	Rice Seasons and Rice Ecosystems	04	Where Rice Is Grown: India and the World
05	Rice Varieties, Pests and New Technologies	06	Saving Water and Cutting Methane: SRI, DSR and AWD
07	Wheat: Types and Growing Conditions	08	Where Wheat Is Grown: India and the World
09	Wheat Varieties, Heat Stress and Diseases	10	The Rice–Wheat Cropping System
11	Key Terms at a Glance	12	Previous Year Questions

This chapter covers:

- the growing conditions of rice and wheat, and the seasons and ecosystems in which rice is grown, from Aus–Aman–Boro to deepwater and saline coastal rice;
- the leading rice- and wheat-growing states and countries, with the latest production and trade figures;

- varieties and technologies: high-yielding and hybrid rice, basmati, biofortified and genome-edited rice, heat-tolerant wheat;
- water-saving and low-emission rice methods: SRI, direct seeding and alternate wetting and drying;
- wheat diseases and heat stress, and the success and strains of the rice–wheat cropping system.

Millets, maize and pulses follow in Chapter 6; irrigation in Chapter 9; seeds and gene editing in Chapter 10.

01 Rice and Wheat in India's Food Basket

Rice and wheat are **cereals**, members of the grass family (Poaceae) grown for their starchy grain. Together with maize they supply about half of all the food energy people eat worldwide. In India they divide the country between them: rice is the staple of the wet east, south and North-East, wheat of the drier north and north-west, and much of central India eats both.

The **third advance estimates for 2025-26** put India's foodgrain output at a record **376.6 million tonnes** (Mt). Of this, rice contributed **154.0 Mt** (about **41 per cent**) and wheat **120.7 Mt** (about **32 per cent**), both all-time highs. The long-run growth is striking: in **1950-51** India produced only about **20.6 Mt** of rice and **6.5 Mt** of wheat. Rice output has grown about seven-fold and wheat nearly nineteen-fold, mostly through higher yields rather than more land. Rice covers the largest area of any crop in the country, and wheat the second largest.

FEATURE	RICE	WHEAT
Season	Mainly kharif; also rabi and summer crops in the east and south	Rabi only
Temperature	Hot: about 22–32°C, ideally above 25°C	Cool growth (10–15°C); warm, dry ripening (21–26°C)
Rainfall	100–200 cm; irrigation where less	50–75 cm, or irrigation; heavy rain harmful
Soil	Clayey, water-holding alluvium; tolerates acidic and alkaline soils	Well-drained loams and clay loams; black soils of central India
Day length	Short-day plant (traditional varieties)	Long-day plant
Leading state	Uttar Pradesh, then Telangana and West Bengal (2025-26)	Uttar Pradesh, then Madhya Pradesh and Punjab (2024-25)
India's world rank	1st in production and exports	2nd in production, after China

02 Rice: Origin, Types and Growing Conditions

Asian rice, *Oryza sativa*, was domesticated from wild rice in the Yangtze valley of China around **9,000** years ago, and independently or soon after in the Ganga plain, where sites such as Lahuradewa in Uttar Pradesh

hold some of the oldest rice remains in South Asia. It has two main groups. **Indica** rice has long, slender, non-sticky grains and is grown across the tropical lowlands of South and South-East Asia. **Japonica** rice has short, round, sticky grains and suits the cooler climates of Japan, Korea and northern China. A separate species, **African rice** (*Oryza glaberrima*), was domesticated in the inland delta of the Niger; its crosses with Asian rice gave the hardy **NERICA** ("New Rice for Africa") varieties.

Climate and Soil

Rice is a crop of heat and water. It needs a mean temperature of about **22–32°C** through its growing period, high humidity and **100–200 cm** of rain; where rainfall is lower, as in Punjab and Haryana, canals and tubewells make up the shortfall. Traditional lowland rice is grown in **standing water** of **5–10 cm**, which suppresses weeds and keeps the soil soft. Bright sunshine during ripening improves the yield.

The best soils are **clayey and clay-loam alluvium** that hold water; the field is first **puddled** (ploughed while flooded) to create a hard layer that cuts seepage. Rice tolerates both acidic and alkaline soils better than most cereals, which is why it is often the first crop grown on reclaimed saline or sodic land. It grows from below sea level in Kerala's Kuttanad to about **2,000 m** in the Kashmir valley and the eastern Himalaya.

Most traditional varieties are **short-day plants**: they flower only when days shorten after September, which ties them to the kharif season. Modern high-yielding varieties are largely insensitive to day length, so they can be grown in any season where water and warmth allow.



Fig. 5.1 Transplanting paddy seedlings into a puddled field at the start of the monsoon

CONCEPT: WHY FLOODED PADDIES RELEASE METHANE

When a field stays under water for months, oxygen cannot reach the soil. Straw, roots and manure then rot through the action of **methanogenic archaea**, microbes that live only without oxygen and give off **methane**, a greenhouse gas many times more powerful than carbon dioxide over a few decades. Most of it escapes through the hollow stems of the rice plants. Paddies account for roughly a tenth of man-made methane worldwide. Anything that lets air back into the soil during the season, such as mid-season drainage, alternate wetting and drying or direct seeding, cuts these emissions (Section 06).

03

Rice Seasons and Rice Ecosystems

In most of India rice is a **kharif** crop, sown or transplanted with the south-west monsoon and harvested in October–December. In the warm east and south, however, where water is available, two or even three crops can be raised in one year. The crop calendar below shows how the rice seasons fit around the monsoon and around wheat.

In **West Bengal, Assam, Odisha and Bihar** the three seasons have their own names:

Crop Calendar of Rice and Wheat

Typical sowing, growing and harvest windows. Dates shift by a few weeks from state to state and year to year.

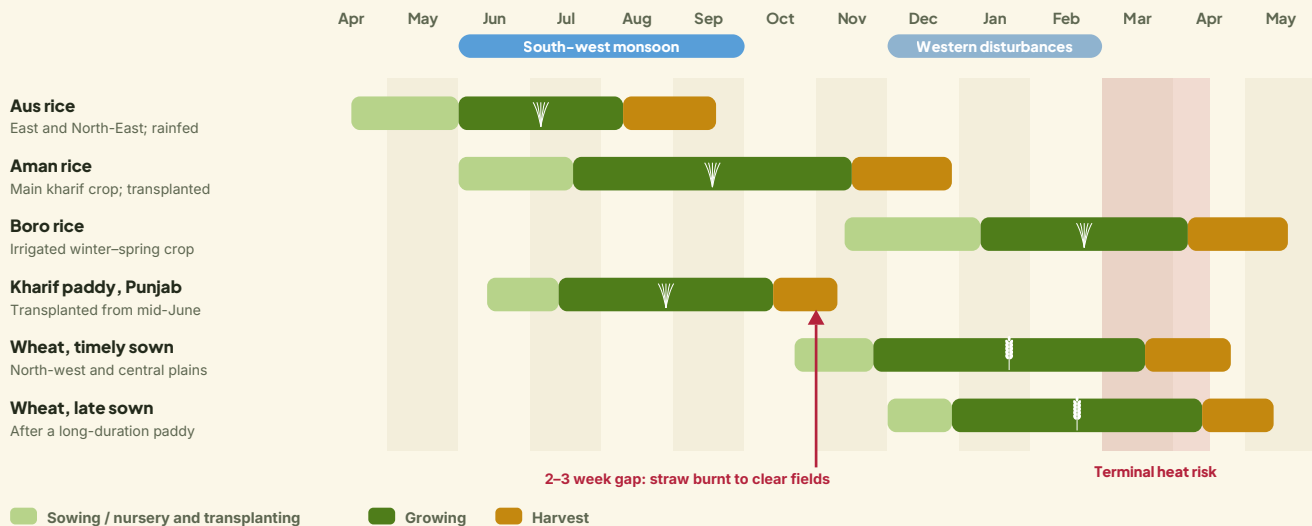


Fig. 5.2 Crop calendar of the three rice seasons of eastern India, kharif paddy in Punjab and timely and late-sown wheat. The short gap between paddy harvest and wheat sowing drives straw burning in the north-west.

- **Aus** (autumn rice): sown with the pre-monsoon showers of April–May and harvested in August–September; usually rainfed and short-duration.
- **Aman** (winter rice): the main crop, raised in nurseries in June–July, transplanted in the monsoon and harvested in November–December.
- **Boro** (spring or summer rice): nursery in November–December, transplanted in January–February with tubewell irrigation and harvested in April–May. Boro gives the highest yields because of clear skies, and it has spread rapidly in West Bengal and Bangladesh.

Other states have their own names. In the Cauvery delta of Tamil Nadu the seasons are **Kuruwai** (June–September), **Samba** (the long main crop, August–January) and **Thaladi** (October–February). Kerala's are **Virippu**, **Mundakan** and **Puncha**.

COMMON CONFUSION: AUS, AMAN AND BORO

Aus, Aman and Boro are **seasons** (crops grown at different times of year), **not varieties** of rice. Do not map them neatly onto kharif, rabi and zaid either: Aus and Aman are both kharif-season crops, while Boro straddles the rabi and summer months. In the same way, "Samba" is a season in Tamil Nadu, whereas "Samba Mahsuri" is a popular fine-grain variety from Andhra Pradesh.

Rice Ecosystems

Rice is grown in a wider range of water conditions than any other cereal. Scientists group India's rice land into five ecosystems.

ECOSYSTEM	CONDITIONS	WHERE IN INDIA
Irrigated	Assured water; two crops a year; highest yields	Punjab, Haryana, western UP, Godavari–Krishna–Cauvery deltas, Telangana
Rainfed lowland	Bunded fields fed by rain; risk of drought and flash floods	Eastern UP, Bihar, Odisha, West Bengal, Assam, Chhattisgarh
Rainfed upland	Unbunded slopes, direct-sown, no standing water	Plateau of Jharkhand, Odisha and Chhattisgarh; NE hills (jhum)
Deepwater and flood-prone	Water 50 cm to over 1 m; "floating" rice whose stems elongate with the flood	Lower Ganga and Brahmaputra plains, Assam, coastal Odisha
Coastal saline	Brackish water and salty soils	Sundarbans, Kerala's Pokkali and Kaipad fields, coastal Gujarat and Andhra

Two Kerala systems are worth knowing. **Pokkali** is a salt-tolerant rice grown in the coastal wetlands of Ernakulam in a rotation with prawn farming, and carries a GI tag. **Kuttanad**, where paddy is grown on reclaimed land up to about **2 m below sea level** behind dykes, is recognised by FAO as a **Globally Important Agricultural Heritage System**.

04

Where Rice Is Grown: India and the World

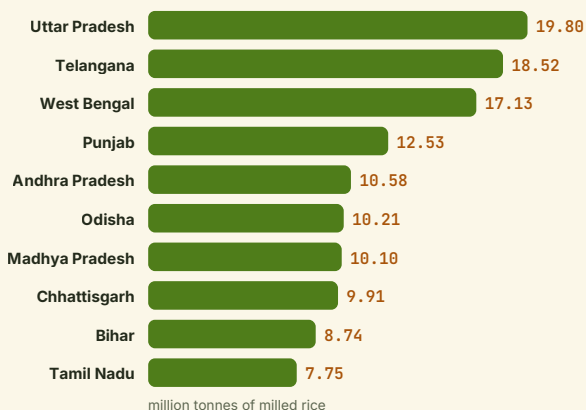
Rice is grown in every state, but production is concentrated in two kinds of region: the naturally wet **eastern and coastal lowlands** (the Ganga–Brahmaputra plains, the Mahanadi, Godavari, Krishna and Cauvery deltas and the west coast), and the **irrigated north-west**, where canals and tubewells turned Punjab and Haryana, areas of only **50–70 cm** of rain, into rice bowls after the Green Revolution.

Who Grows the Rice

Left: leading Indian states. Right: leading countries. India now tops the world on both FAO and USDA counts.

India: rice output by state

2025–26, third advance estimates (all-India 154 Mt)



World: paddy output by country

2024, FAO (world about 820 Mt of paddy)

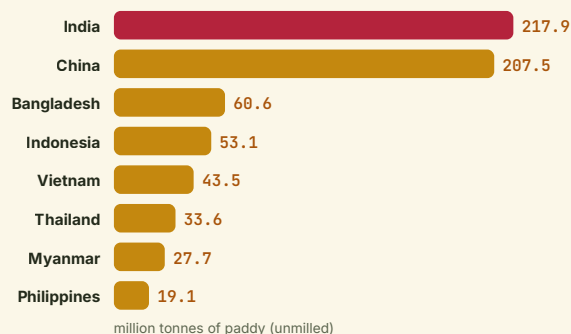


Fig. 5.3 Leading rice-producing states of India (2025–26, third advance estimates) and countries of the world (2024, FAO, paddy basis). India's share of world output is now just over a quarter.

The ranking of states has changed sharply in the past decade. **Uttar Pradesh** was the largest producer in 2025-26 with about **19.8 Mt**, followed by **Telangana (18.5 Mt)**, whose output has multiplied since the Kaleshwaram lift-irrigation project and assured procurement, and **West Bengal (17.1 Mt)**, long the traditional leader. Punjab, Andhra Pradesh, Odisha, Madhya Pradesh and Chhattisgarh follow. **Punjab has the highest yield** among major states, while yields remain low in the rainfed lowlands of Odisha, Chhattisgarh, Jharkhand and Assam, which is why "Bringing Green Revolution to Eastern India" targeted these states.

India in the World

Asia grows about **90 per cent** of the world's rice. On FAO data for **2024**, India produced about **218 Mt** of paddy against China's **208 Mt**, followed by Bangladesh, Indonesia, Vietnam and Thailand. The US Department of Agriculture's estimates for 2025-26 (milled rice) show the same order: India about **154 Mt** and China about **146 Mt**. India's yield per hectare, however, is still well below China's.

India has been the **world's largest rice exporter** since **2011-12**, ahead of Thailand, Vietnam, Pakistan and the USA. In 2024-25 it shipped a record **20.2 Mt** to more than **170** countries, nearly two-fifths of world rice trade. About **70 per cent** of the volume is non-basmati rice, mostly to West Africa and neighbouring countries, while **basmati**, about **30 per cent** of the volume, earns about half the value and goes mainly to Saudi Arabia, Iraq, Iran and the UAE.

Basmati is a long-grain aromatic rice whose GI (2016) covers the Indo-Gangetic plain of Punjab, Haryana, Himachal Pradesh, Delhi, Uttarakhand, western Uttar Pradesh and three districts of Jammu and Kashmir. Pakistan contests India's application for an exclusive basmati tag in the European Union. Many other traditional rices have their own GI tags, among them **Kalanamak** (UP), **Gobindobhog** (West Bengal), **Joha** (Assam), black **Chak-Hao** (Manipur), the medicinal **Navara** and the red **Palakkadan Matta** (Kerala).

INDIA: A RECORD HARVEST AND AN OVERFLOWING GRANARY

Bumper crops have created a new problem. The Food Corporation of India's rice stocks reached record levels in 2025, around three times the buffer norm. To ease the overhang the government lifted the 2022-23 curbs on rice exports in 2024, and between June 2025 and June 2026 sold about **6.35 Mt** of FCI rice to **ethanol distilleries** at well below its cost. Wheat, too, recovered: with output above **120 Mt**, the ban on wheat and flour exports imposed in May 2022 was lifted on **24 August 2026**. Surplus grain, however, sits beside falling water tables, which is why diversification away from paddy remains a policy goal (Section 10).

05

Rice Varieties, Pests and New Technologies

India's modern rice story began with **IR8**, the semi-dwarf "miracle rice" released by the International Rice Research Institute (IRRI) in the Philippines in **1966**. Its short, stiff straw could take heavy doses of fertiliser without falling over (lodging). Indian breeders soon produced their own high-yielding varieties such as **Jaya**, **IR36**, **Swarna** (MTU 7029) and **Samba Mahsuri** (BPT 5204), still among the most widely grown. Research is led by **ICAR-National Rice Research Institute**, Cuttack (founded **1946**) and **ICAR-Indian Institute of Rice Research**, Hyderabad; IRRI opened its South Asia Regional Centre at Varanasi in **2018**.

Hybrid, Stress-Tolerant and Basmati Varieties

- **Hybrid rice** was pioneered in China by **Yuan Longping** in the 1970s; hybrids yield 15–20 per cent more, but farmers must buy fresh seed each season. India released its first hybrids in **1994**.
- **Flood-tolerant Swarna-Sub1** carries the *Sub1* gene and survives up to about two weeks under water, a lifeline for flash-flood areas of the east. **Sahbhagi Dhan** tolerates drought, and the **CSR** series from Karnal tolerates saline and sodic soils.
- **Basmati**: the Pusa series from IARI, New Delhi (Pusa Basmati 1121, with its very long cooked grain, and 1509, 1692 and the blight-resistant 1718) dominates exports. In 2024 IARI released **Pusa Basmati 1979 and 1985**, non-GM varieties tolerant of a herbicide, which makes weed control in direct-seeded basmati easier.

Biofortified and Genome-Edited Rice

Biofortification means breeding more nutrients into the grain itself. Examples are **DRR Dhan 45** and **DRR Dhan 48** (high zinc) and **CR Dhan 310** (high protein) from ICAR. **Golden Rice**, genetically modified to make beta-carotene (the precursor of vitamin A), was approved for cultivation in the Philippines in 2021 but has since been held up in the courts.

In May **2025** ICAR released the world's first two **genome-edited rice varieties**, made with SDN-1 editing that adds no foreign DNA: **DRR Dhan 100 (Kamala)**, developed from Samba Mahsuri, which yields about a fifth more and matures some three weeks earlier, and **Pusa DST Rice 1**, developed from MTU 1010, which tolerates drought and salinity. How gene editing differs from GM is covered in Chapter 10. In January 2026 ICAR also released **184** new varieties of field crops, **122** of them cereals.

COMMON CONFUSION: BIOFORTIFIED AND FORTIFIED RICE

Biofortified rice is *bred* to contain more zinc or protein; the nutrient is inside the grain from the field.

Fortified rice is ordinary rice mixed after milling with about one per cent of artificial kernels made from rice flour, **iron, folic acid and vitamin B12**; it is supplied through government food schemes to fight anaemia. Neither is the same as **genome-edited** rice, whose own genes have been precisely altered.

Major Pests and Diseases

The most damaging rice diseases are **blast** (a fungus, *Magnaporthe oryzae*), **bacterial leaf blight** (*Xanthomonas oryzae*), **sheath blight** and the viral **tungro**, spread by the green leafhopper. Insect pests include the **brown planthopper**, whose attacks dry fields in circular patches ("hopperburn"), the **yellow stem borer** and the gall midge. A disorder rather than a disease, **khaira** is caused by **zinc deficiency**; it was first identified in the Tarai at Pantnagar in the 1960s and is common on intensively cropped alkaline soils.

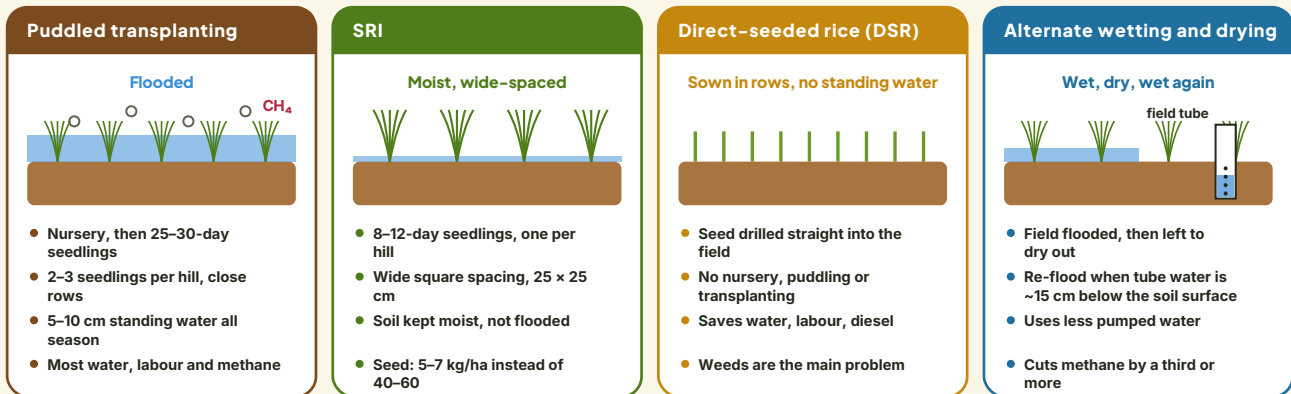
06

Saving Water and Cutting Methane: SRI, DSR and AWD

A kilogram of rice grown by flooding can take **3,000–5,000 litres** of water. With groundwater falling and climate targets tightening, three methods that use less water and emit less methane are being promoted across India.

Four Ways to Grow Rice: Water and Methane Compared

Keeping the field flooded all season wastes water and lets methane-forming microbes thrive; the newer methods let air back into the soil.



Approximate figures; savings vary with soil, season and variety.

Fig. 5.4 Conventional puddled transplanting compared with the System of Rice Intensification, direct seeding and alternate wetting and drying

System of Rice Intensification (SRI)

The **System of Rice Intensification** was developed in **Madagascar** in the 1980s by the French priest Henri de Laulanié, from practices of local farmers. Its principle is "more from less": healthier plants with bigger roots, rather than more inputs. Very young seedlings, **8–12 days** old, are transplanted singly at wide, square spacing; the soil is kept moist but not flooded, through **alternate wetting and drying**; weeds are churned back into the soil with a rotary or cono weeder, which also aerates it; and organic manure is preferred. The results are:

- **much less seed**: about **5–7 kg** per hectare instead of **40–60 kg**;
- **less water**, so **less electricity and diesel** for pumping;
- **less methane**, because the soil is aerated for much of the season;
- more tillers and usually higher yields, although SRI needs more careful labour at transplanting and weeding.

Tamil Nadu, Andhra Pradesh, Tripura, Odisha and Bihar have promoted SRI widely, and the same principles are now applied to wheat, finger millet and sugarcane (the Sustainable Sugarcane Initiative, Chapter 7).

Direct-Seeded Rice (DSR)

In **direct seeding** the seed is drilled straight into the field, usually dry, with a seed drill, as wheat is sown, so the nursery, puddling and transplanting are skipped. DSR saves water, labour and fuel, matures a week or more earlier, leaves the soil in better shape for the following wheat and emits less methane. Its weakness is **weeds**, because there is no standing water to suppress them; herbicide-tolerant varieties and timely spraying are the answer. Punjab and Haryana pay farmers a per-acre incentive to adopt DSR.

Alternate Wetting and Drying (AWD)

Under **alternate wetting and drying**, a field is flooded and then allowed to dry until the water in a perforated plastic tube sunk into the soil falls about **15 cm** below the surface; only then is it irrigated again. Developed by IRRI, AWD cuts irrigation by up to a quarter or more and methane by a third or more without lowering yield, and it is the basis of several rice carbon-credit projects. Irrigation methods are covered in Chapter 9.

Wheat: Types and Growing Conditions

Wheat was among the first crops domesticated, in the **Fertile Crescent** of West Asia about **10,000** years ago, and reached the Indus region early: Mehrgarh shows wheat farming from about **7000 BCE**. It is the most widely grown food crop in the world and the main source of vegetable protein in the human diet.

Three species are grown in India:

- **Bread wheat** (*Triticum aestivum*): about **95 per cent** of the area; used for chapati, bread and biscuits.
- **Durum or macaroni wheat** (*T. durum*): hard, amber grain for pasta and semolina; grown mainly in Madhya Pradesh, Rajasthan, Gujarat, Maharashtra and Karnataka, often under limited irrigation.
- **Emmer wheat** (*T. dicoccum*), locally **khapli**: about one per cent of the area, in Karnataka, Maharashtra, Tamil Nadu and Gujarat; valued for its fibre and low glycaemic index.



Fig. 5.5 A combine harvester cuts and threshes ripe wheat in one pass; most wheat in the north-west is now harvested by machine

Climate and Soil

Wheat is a crop of the **cool season**. It needs about **10–15°C** at sowing and during early growth, cool nights for tillering, and warm, sunny, dry weather of about **21–26°C** while the grain ripens. It needs **50–75 cm** of moisture spread through the season; in north-western India this comes from irrigation plus light winter rain from **western disturbances**. More than about **100 cm** of rain, high humidity and cloudy weather favour rusts and are unsuitable. Frost at flowering and hailstorms at maturity can ruin the crop.

The best soils are **well-drained loams and clay loams** of the northern alluvial plains and the moisture-holding **black soils** of the Malwa plateau and the northern Deccan. Wheat is a **long-day plant**, flowering as days lengthen in February and March. In India it is sown from late October to December and harvested from March in central India to April–May in the north-west and the hills.

Wheat Zones

For breeding and variety release, ICAR divides the country into **six wheat zones**: the **Northern Hills Zone**, the **North Western Plains Zone** (Punjab, Haryana, western UP, northern Rajasthan; the most productive), the **North Eastern Plains Zone** (eastern UP, Bihar, West Bengal, Assam), the **Central Zone** (Madhya Pradesh, Gujarat, southern Rajasthan), the **Peninsular Zone** (Maharashtra, Karnataka) and the small **Southern Hills Zone** (Nilgiris and Palanis). Yields fall from north-west to east and south as the cool winter grows shorter.

Where Wheat Is Grown: India and the World

Wheat is concentrated in the **north and centre** of India: the Ganga–Satluj plains and the black-soil plateau of Madhya Pradesh. South of the Narmada and east of Bihar the winter is too short and warm for good yields.

Uttar Pradesh is the largest producer, with about **35.7 Mt** in 2024–25, because of its sheer area. **Madhya Pradesh** (**24.5 Mt**) has risen fast on the back of irrigation from the Narmada and its tributaries, and is known

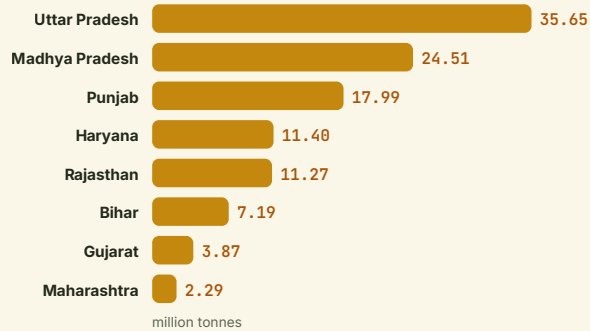
for golden, GI-tagged **Sharbati** wheat from Sehore. **Punjab (18.0 Mt)** has the **highest yield** in the country, about **5 tonnes** per hectare, followed by Haryana. Rajasthan, Bihar and Gujarat complete the list. For the country as a whole, 2025-26 output reached a record **120.7 Mt** (third advance estimates).

Who Grows the Wheat

Five states grow about 85 per cent of India's wheat; India is the world's second-largest producer after China.

India: wheat output by state

2024-25, final estimates (all-India 117.9 Mt)



World: wheat output by country

2024, FAO (world about 798 Mt)

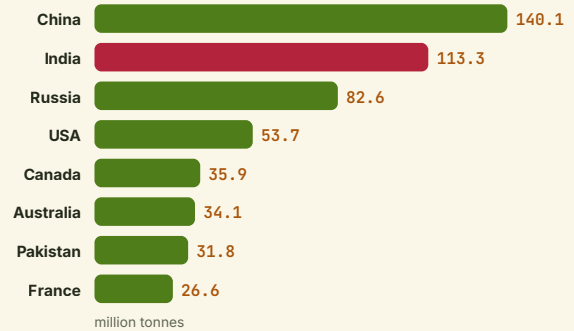


Fig. 5.6 Leading wheat-producing states of India (2024-25, final estimates) and countries of the world (2024, FAO)

India in the World

The world grew about **798 Mt** of wheat in **2024**. **China** was the largest producer (**140 Mt**), **India second (113 Mt)** on FAO's count), followed by Russia, the USA, Canada, Australia and Pakistan; the European Union as a bloc is also a major producer, led by France. Trade is dominated by the temperate grasslands (Chapter 1): **Russia** is the largest exporter, followed by the EU, Canada, Australia, the USA and Ukraine, while Egypt, Indonesia, Turkey and China are big importers. India consumes almost all its wheat at home, so its exports are small and swing with the harvest.

09

Wheat Varieties, Heat Stress and Diseases

The Green Revolution began with wheat. Semi-dwarf varieties bred by **Norman Borlaug** at CIMMYT in Mexico, carrying dwarfing genes from the Japanese variety Norin 10, were imported in **1965–66**. **Lerma Rojo 64** and **Sonora 64** were followed by the Indian selections **Kalyan Sona** and **Sonalika**, and wheat output doubled in about six years. **M. S. Swaminathan** led the effort at IARI. Today ICAR-Indian Institute of Wheat and Barley Research, Karnal, coordinates breeding; widely grown varieties include **HD 2967**, **HD 3086**, **DBW 187** and **DBW 303**.

Terminal Heat: Wheat's Biggest Climate Risk

Wheat fills its grain in March. If temperatures climb above about **30–32°C** in this window, the grain shrivels and yields drop; this is called **terminal heat stress**. The unusually hot March of **2022** cut India's harvest sharply and led to the export ban that year. Late sowing after a long-duration paddy crop makes the risk worse. The responses are:

- sowing earlier, using **zero-till drills** or the **Happy Seeder** directly into paddy stubble;

- **heat-tolerant and early-sown varieties**, such as IARI's **HD 3385**, bred to be sown in late October so that it ripens before the March heat;
- light irrigation during hot spells, and crop advisories based on weather forecasts.

Biofortified wheats such as **WB 02** and **HPBW 01** (rich in zinc and iron) and the durum **Pusa Tejas** (protein, iron and zinc) help fight hidden hunger.

Diseases and Weeds

The most important wheat diseases are the three **rusts**, caused by *Puccinia* fungi whose spores travel long distances on the wind.

Yellow (stripe) rust favours the cool, humid north-west and the hills; **brown (leaf) rust** is the most widespread; **black (stem) rust** is a threat in central and peninsular India. The **Ug99** race of stem rust, found in Uganda in **1999**, has spread through Africa and West Asia but has **not been reported in India**. **Karnal bunt**, a fungus first found at Karnal in **1931**, makes grain smell fishy and is a quarantine concern for exports. **Wheat blast**, a South American disease, reached Bangladesh in **2016**, its first appearance in Asia.

In the rice–wheat belt the worst weed is ***Phalaris minor*** (little seed canary grass, locally *gulli danda*), which looks like wheat in the seedling stage and has evolved resistance to several herbicides, beginning with isoproturon in the 1990s.



Fig. 5.7 Yellow (stripe) rust on a wheat leaf: lines of powdery orange-yellow spores

CROP	DISEASE OR PEST	CAUSE	KEY FACT
Rice	Blast	Fungus	Spindle-shaped leaf spots; neck blast breaks the panicle
Rice	Bacterial leaf blight	Bacterium	Pusa Basmati 1718 bred for resistance
Rice	Tungro	Virus	Spread by green leafhopper; yellow-orange stunting
Rice	Khaira	Zinc deficiency	Nutrient disorder; corrected with zinc sulphate
Wheat	Yellow, brown and black rusts	Fungi (<i>Puccinia</i>)	Wind-borne spores; resistant varieties are the main control
Wheat	Karnal bunt	Fungus	Quarantine pest; affects export markets
Wheat	<i>Phalaris minor</i>	Weed	Herbicide-resistant mimic of wheat

10 The Rice–Wheat Cropping System

A paddy crop in kharif followed by wheat in rabi on the same field is the **rice–wheat cropping system**. It covers about **10 million hectares** in India, mostly in the Indo-Gangetic plain from Punjab to Bihar, and more in

Pakistan, Nepal and Bangladesh. It supplies most of the grain that the government procures for the public distribution system.

Why It Succeeded

- **Technology:** semi-dwarf, fertiliser-responsive and photo-insensitive varieties of both crops, which fit one after the other in a single year.
- **Water:** the canal network of Punjab and Haryana, and later millions of tubewells powered by cheap or free electricity.
- **Assured markets:** minimum support prices and open-ended procurement of both crops, which removed price risk.
- **Inputs and institutions:** subsidised fertiliser, credit, agricultural universities such as Punjab Agricultural University, Ludhiana, and enterprising farmers who mechanised early.

How It Became a Bane

The same system now shows serious strain:

- **Groundwater depletion:** summer paddy in a semi-arid region is pumped from aquifers that recharge far more slowly than they are drawn down. Punjab's 2009 subsoil water law, which bars transplanting before mid-June, saved water but squeezed the time left before wheat.
- **Crop-residue burning:** with only two or three weeks between the paddy harvest and wheat sowing, farmers burn the straw, adding to winter smog over north India (Chapter 13).
- **Soil fatigue:** falling organic carbon, a hard plough pan from puddling, and spreading deficiencies of **zinc, sulphur, manganese and iron** because only nitrogen, and some phosphorus, is replaced.
- **Yield plateau:** rice and wheat yields in Punjab have grown only slowly since the late 1990s despite more fertiliser.
- **Pests, weeds and diversity:** herbicide-resistant *Phalaris minor*, more pests in a continuous cereal cycle, and the loss of pulses, oilseeds and millets from the rotation.
- **Emissions:** methane from paddies and nitrous oxide from heavy nitrogen use.



Fig. 5.8 Preparing a Punjab field for wheat without burning the paddy straw, the alternative now being promoted

Remedies

Solutions combine better practice with **crop diversification**. Replacing part of the paddy area with maize, cotton, pulses or oilseeds, or adding a summer moong or a green-manure crop such as *dhaincha* between wheat and rice, puts nitrogen and organic matter back into the soil, breaks pest and weed cycles and steadies yields. Haryana's **Mera Pani Meri Virasat** scheme pays farmers who shift land out of paddy. Within the system, **DSR, AWD, zero tillage** and the **Happy Seeder** or **Super Seeder** (which sow wheat into standing stubble), laser land levelling, balanced fertilisation guided by soil health cards and shorter-duration rice varieties (Chapter 4 on cropping systems) together form **conservation agriculture** for the Indo-Gangetic plain.

Key Terms at a Glance

TERM	MEANING
Puddling	Ploughing a flooded field to soften the soil and form a layer that stops water seeping away
Aus, Aman, Boro	Autumn, winter and spring–summer rice seasons of eastern India
Short-day plant	Plant that flowers when days shorten (traditional rice); wheat is a long-day plant
Lodging	Falling over of a tall crop under heavy grain or wind; semi-dwarf varieties resist it
Pokkali	Salt-tolerant GI rice of coastal Kerala, grown in rotation with prawns
SRI	System of Rice Intensification: young single seedlings, wide spacing, moist (not flooded) soil
DSR	Direct-seeded rice: seed drilled into the field without a nursery or puddling
AWD	Alternate wetting and drying: irrigating only after the field has partly dried
Terminal heat	High temperature during grain filling that shrivels wheat grain

USING THIS CHAPTER IN MAINS

Questions on the rice–wheat system ask you to **balance achievement against cost**. Open with the system's scale and its role in food security, explain the factors behind its success, then set out the strains: groundwater, residue burning, soil fatigue, yield plateau and emissions. Use the crop calendar to show why burning happens and a figure or two from this chapter for currency. End with practical remedies such as diversification, DSR, AWD, zero tillage and pulses in rotation, and link to climate resilience and water security.



Previous Year Questions



Prelims

2022

"System of Rice Intensification" of cultivation, in which alternate wetting and drying of rice fields is practised, results in:

1. Reduced seed requirement

2. Reduced methane production
3. Reduced electricity consumption

Select the correct answer using the code given below:

a 1 and 2 only

b 2 and 3 only

c 1 and 3 only

d 1, 2 and 3

Answer: (d). SRI uses a few very young seedlings (5–7 kg of seed per hectare), and its intermittent irrigation cuts both methane and the electricity spent on pumping (Section 06).

2019

Among the following, which one is the largest exporter of rice in the world in the last five years?

a China

b India

c Myanmar

d Vietnam

Answer: (b). India has been the world's largest rice exporter since 2011-12, ahead of Thailand and Vietnam, shipping both basmati and non-basmati rice (Section 04).

Mains

2020

GS III · 15 MARKS

What are the major factors responsible for making rice-wheat system a success? In spite of this success how has this system become bane in India?

Approach: Success factors: HYVs, assured canal and tube-well irrigation, fertilisers, price support and procurement, extension, mechanisation in Punjab-Haryana. Bane: groundwater depletion, soil and micronutrient decline, stubble burning, pests, yield plateau, lost crop diversity; suggest diversification, DSR, AWD, conservation tillage (Section 10).

2017

GS III · 15 MARKS

What are the major reasons for declining rice and wheat yield in the cropping system? How crop diversification is helpful to stabilize the yield of the crops in the system?

Approach: Reasons: falling soil organic carbon, nutrient imbalance, zinc and sulphur deficiency, falling water tables, late wheat sowing, terminal heat, pests, herbicide-resistant *Phalaris minor*. Then show how pulses, maize, oilseeds and green manure in rotation restore soil health and stabilise yields (Section 10).

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ORIGINAL DIAGRAMS

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PART II

Crops of India and the World

Chapters 05–08 · from p. 69

Rice and Wheat · Millets, Maize and Pulses · Oilseeds, Sugarcane, Fibre and Other Cash Crops · Plantation Crops, Spices and Horticulture

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