16

Farming and food supply

'But of all the occupations by which gain is secured, none is better than agriculture, none more profitable, none more delightful, none more becoming to a free man.'

Cicero, *De Officiis*, 1.51

'Behold, there shall come seven years of great plenty throughout all the land of Egypt: and there shall arise after them seven years of famine; and all the plenty shall be forgotten in the land of Egypt; and the famine shall consume the land …'

The Bible, Genesis 41: 29, 30

'He who slaughters his cows today shall thirst for milk tomorrow.'

Muslim proverb

The location of different types of agriculture at all scales depends on the interaction of physical, cultural and economic factors (Figure 16.25). Where individual farmers in a market economy (capitalist system) or the state in a centrally planned economy have a knowledge, or understanding, of these three influences, then decisions may be made. How these decisions are reached involves a fourth factor: the behavioural element.

Environmental factors affecting farming

Although there has been a movement away from the view that agriculture is controlled solely by physical conditions, it must be accepted that environmental factors do exert a major influence in determining the type of farming practised in any particular area. Increasingly, the environment is seen to be an input converted into monetary terms, e.g. yields and slopes.

In 1966 McCarty and Lindberg produced their optima and limits model, an adaptation of which appears in Figure 16.1. They suggested that there was an optimum or ideal location for each specific type of farming based on climate, soils, slopes and altitude. The optimum is defined as where the total cost of production per unit output (TCP) is minimised for that crop or livestock. As distance increases from this optimum, conditions become less than ideal, i.e. too wet or dry; too steep or high; too hot or cold; or a less suitable soil. Consequently, the profitability of producing the crop or rearing animals is reduced, and the **law of diminishing returns** operates when either the output decreases or the cost of maintaining high yields becomes prohibitive. Eventually a point is reached where physical conditions are too extreme to permit production on an economically viable scale, and later at even a subsistence level (page 477). McCarty and Lindberg applied their model to the cotton belt of the USA (Figure 16.2), but it can equally be adapted to account for the growth of spring wheat on the Canadian Prairies (Figure 16.3).

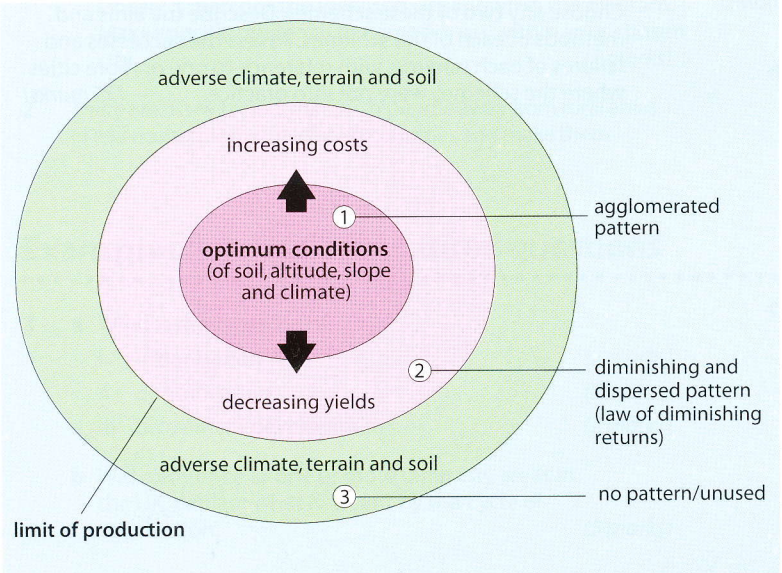


Figure 16.1
The optima and limits model (*after* McCarty and Lindberg)

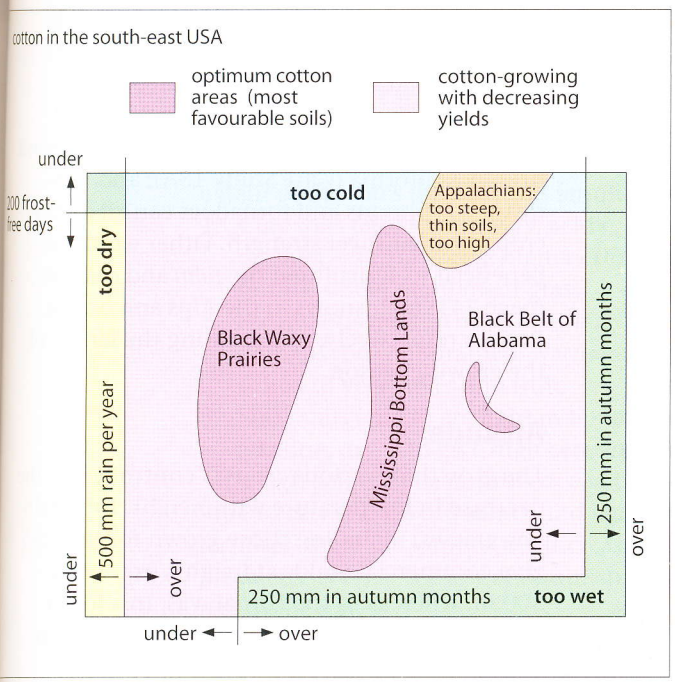


Figure 16.2

Optima and limits model applied to the former cotton belt in south-eastern USA

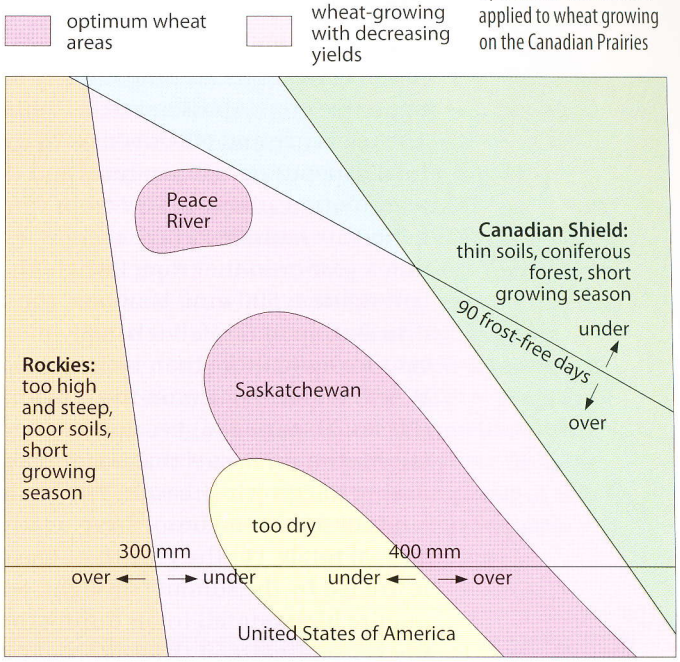


Figure 16.3

Optima and limits model applied to wheat growing on the Canadian Prairies

Temperature

This is critical for plant growth because each plant or crop type requires a minimum growing temperature and a minimum growing season. In temperate latitudes, the critical temperature is 6°C. Below this figure, members of the grass family, which include most cereals, cannot grow – an exception is rye, a hardy cereal, which may be grown in more northerly latitudes.

In Britain, wheat, barley and grass begin to grow only when the average temperature rises above 6°C, which coincides with the beginning of the growing season. The growing season is defined as the number of days between the last severe frost of spring and the first of autumn. It is therefore synonymous with the number of frost-free days that are required for plant growth. Figures 16.2 and 16.3 show that cotton needs a minimum of 200, and spring wheat 90. Barley can be grown further north in Britain than wheat, and oats further north than barley because wheat requires the longest growing season of the three and oats the shortest. Frost is more likely to occur in hollows and valleys. It has beneficial effects as it breaks up the soil and kills pests in winter, but it may also damage plants and destroy fruit blossom in spring.

Within the tropics there is a continuous growing season, provided moisture is available. As well as decreasing with distance from the Equator, both temperatures and the length of the growing season decrease with height above sea-level. This produces a succession of natural vegetation types according to altitude, although many have been modified for farming purposes (Figure 16.4).

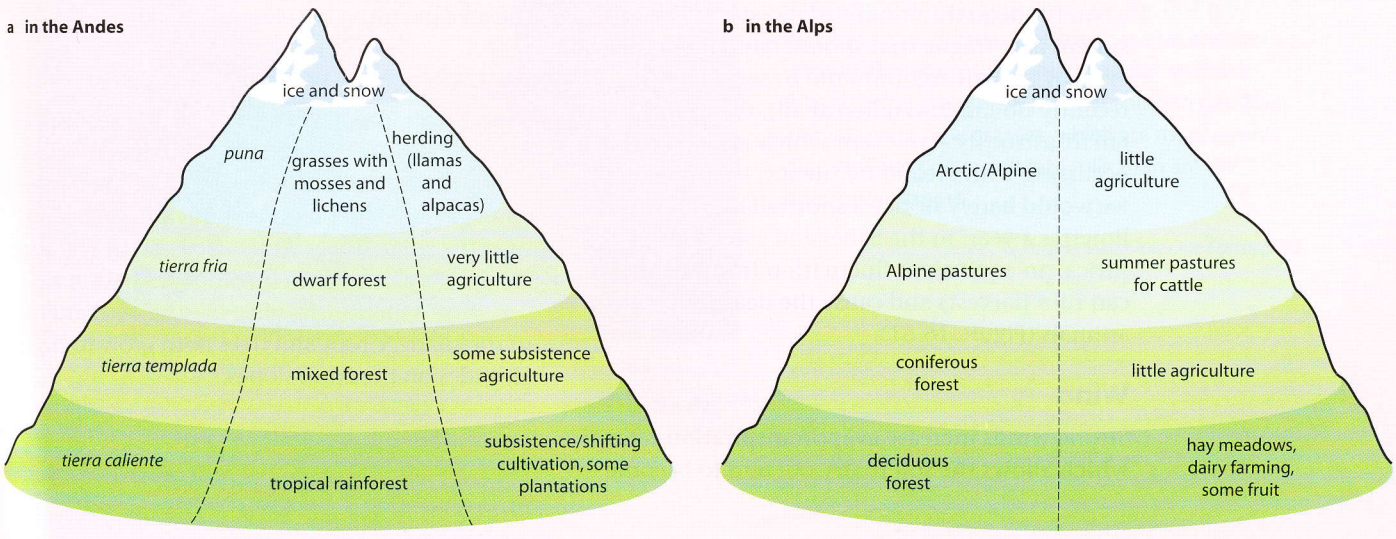


Figure 16.4

The effect of altitude on farming and vegetation

Precipitation and water supply

The mean annual rainfall for an area determines whether its farming is likely to be based upon tree crops, grass or cereals, or irrigation. The relevance and effectiveness of this annual total depends on temperatures and the rate of evapotranspiration. Few crops can grow in temperate latitudes where there is less than 250 mm a year or in the tropics where the equivalent figure is 500 mm. However, the seasonal distribution of rainfall is usually more significant for agriculture than is the annual total. Wheat is able to grow on the Canadian Prairies (Places 70, page 486) because the summer rainfall maximum means that water is available during the growing season. The Mediterranean lands of southern Europe have relatively high annual totals, yet the growth of grasses is restricted by the summer drought. Some crops require high rainfall totals during their ripening period (maize in the American corn belt), whereas for others a dry period before and during harvesting is vital (coffee).

The type of precipitation is also important (page 62). Long, steady periods of rain allow the water to infiltrate into the soil, making moisture available for plant use. Short, heavy downpours can lead to surface runoff and soil erosion and so are less effective for plants. Hail, falling during heavy convectional storms in summer in places such as the Canadian Prairies, can destroy crops. Snow, in comparison, can be beneficial as it insulates the ground from extreme cold in winter and provides moisture on melting in spring. In Britain we tend to take rain for granted, forgetting that in many parts of the world amounts and occurrence are very unreliable (Figure 9.28). India depends upon the monsoon; if this fails, there is drought and a risk of famine (page 502). Even in the best of years, the Sahel countries receive a barely adequate amount of moisture. The ecosystem is so fragile that should rainfall decrease even by a small amount (and in several years recently no rain has fallen at all), then crops fail disastrously – an event which appears to be occurring with greater frequency. In Britain, we would barely notice a shortfall of a few millimetres a year: in the Sahel and sub-Saharan Africa, an equivalent fluctuation from the mean can ruin harvests and cause the deaths of many animals (Figure 16.61).

Wind

Strong winds increase evapotranspiration rates which allows the soil to dry out and to become vulnerable to erosion. Several localised winds have harmful effects on farming: the *mistral* brings cold air to the south of France (Figure 12.22); the *khamsin* is a dry, dust-laden wind found in Egypt; Santa Ana winds can cause brush fires in California (Case Study 15A); and hurricanes, typhoons and tornadoes can all destroy crops by their sheer strength. Other winds are beneficial to agriculture: the *föhn* and *chinook* (page 241) melt snows in the Alps and on the Prairies respectively, so increasing the length of the growing season.

Altitude

The growth of various crops is controlled by the decrease in temperature with height. In Britain few grasses, including those grown for hay, can give commercial yields at heights exceeding 300 m, whereas in the Himalayas, in a lower (warmer) latitude, wheat can ripen at 3000 m. As height increases, so too does exposure to wind and the amounts of cloud, snow and rain, while the length of the growing season decreases. Soils take longer to develop as there are fewer mixing agents; humus takes longer to break down and leaching is more likely to occur. Those high-altitude areas where soils have developed are prone to erosion (Case Study 10).

Angle of slope (gradient)

Slope (see catena, page 276) affects the depth of soil, its moisture content and its pH (acidity, page 269), and therefore the type of crop that can be grown on it. It influences erosion and is a limitation on the use of machinery. Until recently, a 5° slope was the maximum for mechanised ploughing but technological improvements have increased this to 11°. Many steep slopes in South-east Asia have been terraced to overcome some of the problems of a steep gradient and to increase the area of cultivation (Figure 16.29).

Aspect

Aspect is an important part of the microclimate. **Adret** slopes are those in the northern hemisphere that face south (Places 28, page 213). They have appreciably higher temperatures and drier soils than the **ubac** slopes which face north. The adret receives the maximum incoming radiation and sunshine, whereas the ubac may be permanently in the shade. Crops and trees both grow to higher altitudes on the adret slopes.

Soils (edaphic factors)

Farming depends upon the depth, stoniness, water-retention capacity, aeration, texture, structure, pH, leaching and mineral content of the soil (Chapter 10). Three examples help to show the extent of the soil's influence on farming:

1 Clay soils tend to be heavy, acidic, poorly drained, cold, and give higher economic returns under permanent grass.
2 Sandy soils tend to be lighter, less acidic, perhaps too well-drained, warmer and more suited to vegetables and fruit.
3 Lime soils (chalk) are light in texture, alkaline, dry, and give high cereal yields.

Although soils can be improved, e.g. by adding lime to clay and clay to sands, and by applying fertiliser, there is a limit to the increase in their productivity – i.e. the law of diminishing returns operates.

Global warming

Despite uncertainty as to the exact effects of global warming, scientists agree that the greenhouse effect will not only lead to an increase in temperature but also to changes in rainfall patterns. The global increase in temperature will allow many parts of the world to grow crops which at present are too cold for them: wheat will grow in more northerly latitudes in Canada and Russia, while maize, vines, oranges and peaches may flourish in southern England (Case Study 9B). Of greater significance will be the changes in precipitation, with some places becoming wetter and more stormy (Australia and South-east Asia) while others are likely to become drier (the wheat-growing areas of the American Prairies and the Russian Steppes).

Places 61 Northern Kenya: precipitation and water supply

The Rendille tribe live on a flat, rocky plain in northern Kenya where the only obvious vegetation is a few small trees and thorn bushes. Their traditional way of life has been to herd sheep, goats and camels, moving about constantly in search of water. (See Places 65, page 479 and Figure 16.5.)

'On the government map of Kenya, the realities of the Rendille's land are summarised in a few words: "Koroli Desert", it says, and just above this is the warning "Liable to Flood". There are two rainy seasons here: the long rains in April and May and the short rains in November. But the word "season" suggests that the rains are much more predictable and steady than they are in reality. Add together rainfall from the long and the short rains and you arrive at only 150 mm on the Rendille's central plains in an average year. But the word average means nothing here, because "normal variation" from that average can bring only 35 mm of rain one year and 450 mm the next. Variation from place to place is even more erratic than variation from year to year. Rains can be heavy when they do come, and water often rushes off the baked ground in flash floods; thus the apparent contradiction of a flood-prone desert.

It may suddenly rain in a valley for the first time in ten years; and it may not rain there for another decade. Therefore, the Rendille do not so much follow the rains as chase them, rushing to get their animals on to new grasses, which are more easily digested and converted into milk than are the drier, older shoots.'

L. Timberlake, *Only One Earth*, p. 92

Figure 16.5
Rendille herders at a shallow hand-dug well

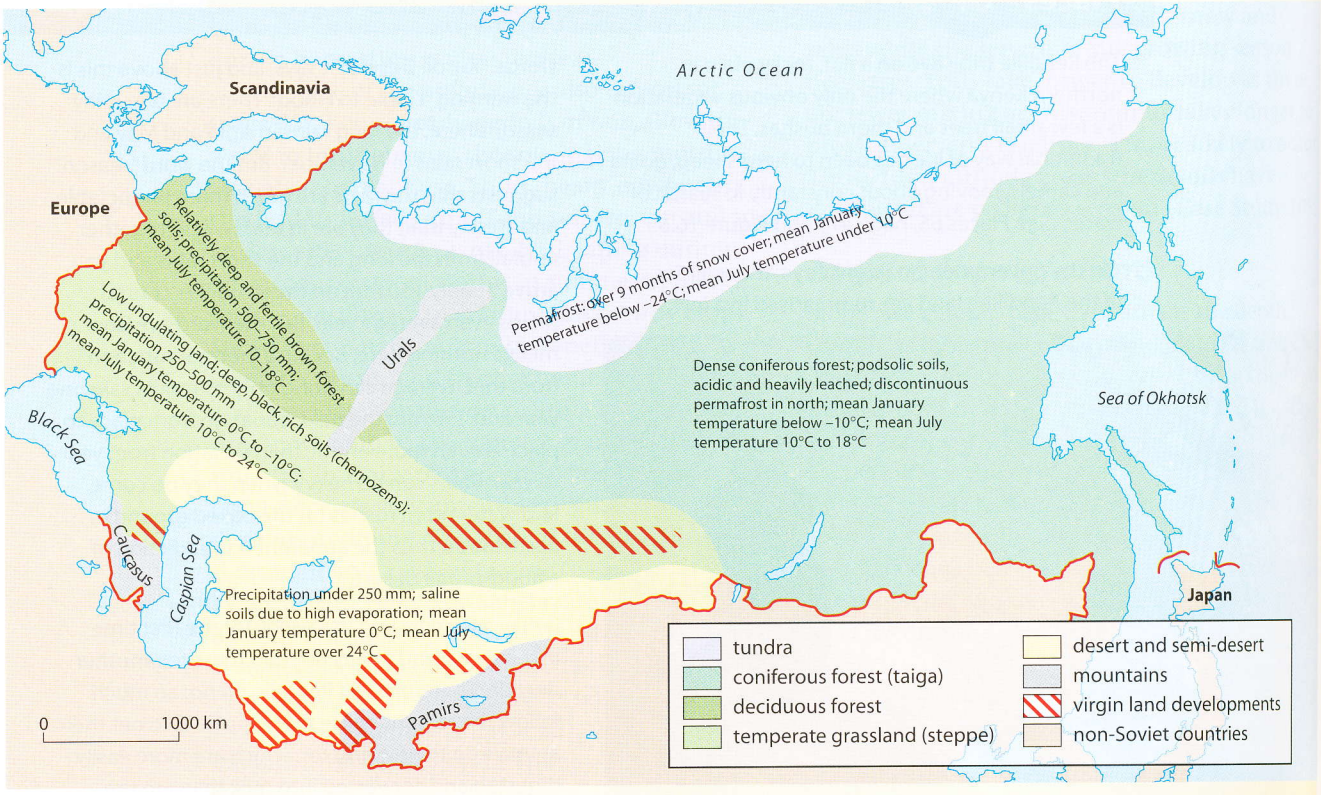
Places 62 The former Soviet Union: physical controls on farming

Although the former Soviet Union is the largest country in the world, physical controls of climate, relief and soils have restricted farming to relatively small parts of the country. Of the land area of 22.27 million km^2, only 27 per cent was farmed in 1989 (10 per cent arable and 17 per cent pastoral), mainly in the deciduous forest belt, where the land had been cleared, and on the Steppes. The remaining 73 per cent (non-farmed) consisted of forest (42 per cent), tundra, desert and semi-desert (Figure 16.6).

After the Second World War, farmers were offered incentives to exceed their production targets. This task was most difficult for those farmers who were 'encouraged' by state directives rather than by financial incentives to develop the 'virgin lands' (Figure 16.6), in such states as Kazakhstan, by ploughing up the natural grassland in order to grow wheat and other cereals. Unfortunately, the unreliable rainfall, with totals often less than 500 mm a year, did not guarantee reliable crop yields. Later, to help cereal production, irrigation schemes were begun. These have since been extended into semi-desert areas where cotton is now grown. This necessitated the Soviets constructing large-scale transfer schemes by which water from rivers in the wetter parts of the country was diverted to areas suffering a deficiency.

Future water-transfer schemes are even more ambitious and may never reach fruition, as they involve diverting water from the northward-flowing Pechora, Ob and Yenisei rivers towards the south. Apart from the cost, environmentalists fear that this could result in the saline Arctic Ocean receiving less cold river water and then being warmed up sufficiently to cause the pack ice to melt and sea-levels to rise.

Figure 16.6
Physical controls on farming in the former Soviet Union



Cultural (human) factors affecting farming

Land tenure

Farmers may be owner-occupiers, tenants, landless labourers or state employees on the land which they farm. The **latifundia** system is still common to most Latin American countries. The land here is organised into large, centrally managed estates worked by peasants who are semi-serfs. Even in the mid-1980s it was estimated that in Brazil 70 per cent of the land belonged to 3 per cent of the landowners. Land is worked by the landless labourers among the peasantry who sell their labour, when conditions permit, for substandard wages on the large estates or commercial plantations.

Other peasant farmers in Latin America have some land of their own held under insecure tenure arrangements. This land may be owned by the farmer, but it is more likely to have been rented from a local landowner or pawned to a moneylender. This latter type of tenancy takes two forms: cash-tenancy and share-cropping. **Cash-tenancy** is when farmers have to give as much as 80 per cent of their income or a fixed pre-arranged rent to the landowner. If the farmer has a short-term lease, he tends to overcrop the area and cannot afford to use fertiliser or to maintain farm buildings. If the lease is long-term, the farmer may try to invest but this often leads to serious debt. **Share-cropping** is when farmers have to pay, as a form of 'rent-in-kind' for occupying the land, part of their crop or animal produce to the landowner. As this fraction is usually a large one, the farmer works hard with little incentive and remains poor. This system operated in the cotton belt of the USA following the abolition of slavery and still persists in places. Both forms of tenancy, together with that of latifundia, resemble feudal systems found in earlier times in western Europe. The **plantation** is a variant form of the large estate system in that it is usually operated commercially, producing crops for the world market rather than for local use as in latifundia. On some plantations (oil palm in Malaysia – Places 68, page 483), the labourers are landless but are given a fixed wage; on others (sugar in Fiji), they are smallholders as well as receiving a payment.

In economically more developed, capitalist countries, many farmers are owner-occupiers, i.e. they own, or have a mortgage on, the farm where they live and work. Such a system should, in theory, provide maximum incentives for the farmer to become more efficient and to improve his land and buildings. Tenant farmers have been and still are, albeit in reduced numbers, an important part of land tenure in developed countries as well as in developing countries.

In sharp contrast to the neo-feudalist (latifundia, cash-tenancy and share-cropping) and capitalist systems of land tenure is the socialist system. In the former USSR, the individual farmer and the company-run estates were replaced by the ***kolkhoz*** (collective farm) and ***sovkhoz*** (state farm) system of organisation and management. Other forms of socialist tenure include the **commune** system which operated during the early years of communism in China (Places 63) and the ***kibbutz***, which is a form of communal farming in Israel.

Inheritance laws and the fragmentation of holdings

In several countries, inheritance laws have meant that on the death of a farmer the land is divided equally between all his sons (rarely between daughters). Also, dowry customs may include the giving of land with a daughter on marriage. Such traditions have led to the sub-division of farms into numerous scattered and small fields. In Britain, fragmentation of land parcels may also result from the legacy of the open-field system (Places 51, page 400) or, more recently, from farmers buying up individual fields as they come onto the market. Fragmentation results in much time being wasted in moving from one distant field to another, and may cause problems of access. It may, however, be of benefit as it can enable a wider range of crops to be grown on land of different qualities.

Farm size

Inheritance laws, as described above, tend to reduce the size of individual farms so that, often, they can operate only at subsistence level or below. In most of the EU and North America, the trend is for farm sizes to increase as competitive market capitalism leads to the demise of small farms, and their land being purchased for enlargement by larger and more efficient, economically successful farms (page 493). Capital-intensive farms use much machinery, fertiliser, etc. and have a wide choice in types of production.

In South-east Asia and parts of Latin America and Africa, the rapid expansion of population is having the reverse effect. Farms, already inadequate in size, are being further divided and fragmented, making them too small for mechanisation (even if the farmers could afford machines). They are increasingly limited in the types of production possible, and output in certain areas, such as sub-Saharan Africa, is falling. Although farms of only 1 ha can support families in parts of South-east Asia where intensive rice production occurs and several croppings a year are possible, the average plot size in many parts of Taiwan, Nepal and South Korea has fallen to under 0.5 ha (about the size of a football pitch). In comparison, farms of several hundred hectares are needed to support a single family in those parts of the world where farming is marginal (upland sheep farming in Britain, cattle ranching in northern Australia).

Places 63 China: land tenure

Pre-1949

Before the establishment of the People's Republic in 1949, farming in China was typical of South-east Asia, i.e. it was mostly intensive subsistence (page 481). Farms were extremely small and fragmented, with the many tenants having to pay up to half of their limited produce to rich, often absentee landlords. Cultivation was manual or using oxen. Despite long hours of intensive work, the output per worker was very low. The need for food meant that most farmland was arable, with livestock restricted to those kept for working purposes or which could live on farm waste (chickens and pigs).

People's communes, 1958

After taking power in 1949, the communists confiscated land from the large landowners and divided it amongst the peasants. However, most plots proved too small to support individual farmers. After several interim experiments, the government created the 'people's communes'. The communes, which were meant to become self-sufficient units, were organised into a three-tier hierarchy with communist officials directing all aspects of life and work (Figure 16.7). Members of the commune elected a people's council, who elected a subcommittee to ensure that production targets, set by the Central Planning Committee (the government) in a series of Five Year Plans, were met. The committee was also responsible for providing an adequate food supply to make the unit self-supporting (crops, livestock, fruit and fish), for providing small-scale industry (mainly food processing and making farm implements), organising housing and services (hospital, schools) and for flood control and irrigation systems. Most communes had a research centre which trained workers to use new forms of machinery, fertiliser and strains of seed correctly (Green Revolution, page 504). By pooling their resources, farmers were able to increase yields per hectare.

50 families	= 1 production team	(300 people, 20 ha)	Responsible for own finances and payment of taxes for welfare services
10 production teams	= 1 brigade	(3000 people, 200 ha)	Responsible for overall planning, although they left the details to the production team
5 brigades	= 1 commune	(15 000 people, 1000 ha)	Responsible for ensuring that production targets set by the state were met

Figure 16.7
The structure of a former Chinese commune

Responsibility system, 1979

The introduction in 1979 of this more flexible approach, which encouraged farming families to become more 'responsible', preceded the abolition of the commune system in 1982. Under it, individual farmers were given rent-free land in their own village or district. They then had to take out contracts with the government, initially for 3 years but now extended to 30, to deliver a fixed amount of produce. To help meet their quota, individual farmers were given tools and seed. Once farmers had fulfilled their quotas, they could sell the remainder of their produce on the open market for their own profit. The immediate effect, due to farmers working much harder, was an increase in yields by an average of 6 per cent per year throughout the 1980s. Rural markets thrived and some farmers have become quite wealthy. Profits were used to buy better seed and machinery and to create village industry. Although most farmers have improved their standard of living, admittedly from an extremely low base, those living near to large cities (large nearby market) and in the south of the country (climatic advantages) have benefited the most.

1999

Hua Long (Case Study 14B) was one of several villages where the residents claimed that both their standard of living and quality of life had improved considerably over the last 20 years (Figure 16.8). Even the more rural villages were showing signs of an improvement in services and amenities (Figures 14.47 and 14.48), while the more efficient and prosperous farmers were able to save money and to invest it in new homes (Figure 14.49) and machinery. Farmers were now able to sublet land, hire labour, own machinery and make agricultural decisions.

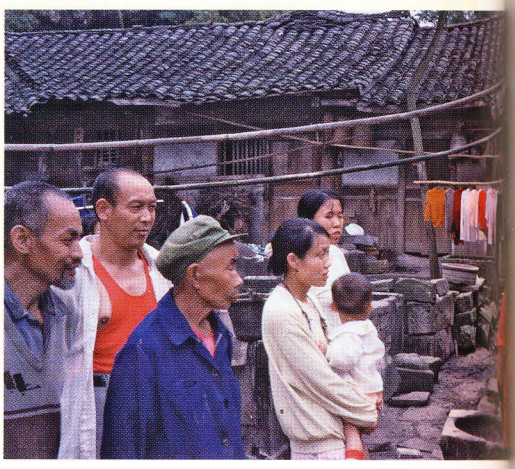


Figure 16.8
Group 4 Team 1 in Hua Long village

Large farms are often	extensive on more marginal land	commercial in the EU and North America	animal grazing (sheep, cattle ranching); plantations; and temperate cereals (wheat)	further from large cities	areas of low population density and/or under-populated	increasing in size and efficiency due to amalgamation and mechanisation
Small farms are often	intensive on flat, fertile land	subsistence in Asia, Latin America and Africa	tropical crops (rice); and market gardening	nearer large cities	areas of high population density and/or overpopulated	decreasing in size and efficiency due to fragmention and hand labour

Figure 16.9
Reasons for spatial variations in farm size

Bearing in mind the dangers of making generalisations (Framework 11, page 347), Figure 16.9 gives some of the spatial variations, and reasons for these variations, between large and small farms. Differences in farm size also affect other types of land use and the landscape.

Economic factors affecting farming

However favourable the physical environment may be, it is of limited value until human resources are added to it. Economic man – a term used by von Thünen (page 471) – applies resources to maximise profits. Yet these resources are often available only in developed countries or where farming is carried out on a commercial scale.

Transport

This includes the types of transport available, the time taken and the cost of moving raw materials to the farm and produce to the market. For perishable commodities, like milk and fresh fruit, the need for speedy transport to the market demands an efficient transport network, while for bulky goods, like potatoes, transport costs must be lower for output to be profitable. In both cases, the items should ideally be grown as near to their market as possible.

Markets

The role of markets is closely linked with transport (perishable and bulky goods). Market demand depends upon the size and affluence of the market population, its religious and cultural beliefs (fish consumed in Catholic countries, abstinence from pork by Jews), its preferred diet, changes in taste and fashion over time (vegetarianism) and health scares (BSE and GM foods).

Capital

Most economically developed countries, with their supporting banking systems, private investment and government subsidies, have large reserves of readily available finance, which over time have been used to build up **capital-intensive** types of farming (Figure 16.24) such as dairying, market gardening and mechanised cereal growing. Capital is often obtained at relatively low interest rates but remains subject to the law of diminishing returns. In other words, the increase in input ceases to give a corresponding increase in output, whether that output is measured in fertiliser, capital investment in machinery, or hours of work expended.

Farmers in developing countries, often lacking support from financial institutions and having limited capital resources of their own, have to resort to **labour-intensive** methods of farming (Figure 16.24). A farmer wishing to borrow money may have to pay exorbitant interest rates and may easily become caught up in a spiral of debt. The purchase of a tractor or harvester can prove a liability rather than a safe investment in areas of uncertain environmental, economic and political conditions.

Technology

Technological developments such as new strains of seed, cross-breeding of animals, improved machinery and irrigation may extend the area of optimal conditions and the limits of production (Green Revolution, page 504). Lacking in capital and expertise, developing countries are rarely able to take advantage of these advances and so the gap between them and the economically developed world continues to increase.

The state

We have already seen that in centrally planned economies it is the state, not the individual, that makes the major farming decisions (Places 62 and 63). In the UK, farmers have been helped by government subsidies. Initially, organisations such as the Milk and Egg Marketing Boards ensured that British farmers got a guaranteed price for their products. Today, most decisions affecting British farmers are made by the EU. Sometimes EU policy benefits British farmers (support grants to hill farmers) and sometimes it reduces their income (reduction in milk quotas). Certainly countries in the EU have improved yields, evident by their food surpluses (pages 487 and 493), and have adapted farming types to suit demand. Increasingly farmers in the UK are being pressurised by the demands of supermarkets and in developing countries by those of transnational companies.

Places 64 China: farming

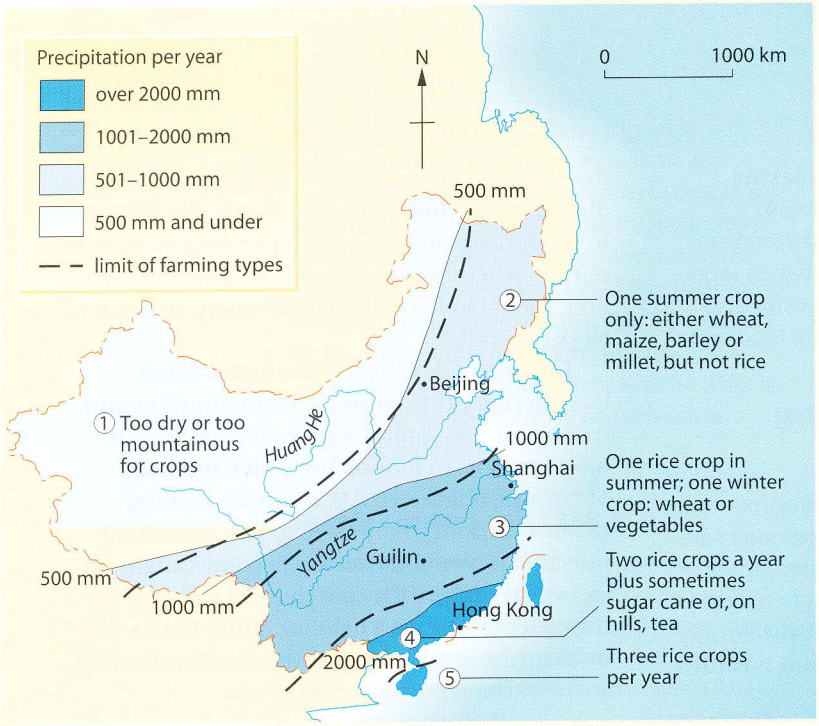


Figure 16.10
Farming in China: the relationship between precipitation and farming type

Figure 16.11
Intensive farming: planting rice near Kunming

Figure 16.12
Extensive farming: wheat and oilseed rape near Xi'an

It is very difficult to generalise (Framework 11, page 347) about farming in a country that is the world's third largest in terms of area (40 times that of the UK) and largest in population. An atlas will show more accurately that, in general, the height of the land decreases, while temperatures and rainfall together with the length of the growing and rainy season (the monsoon, page 239), increase from the deserts and mountains of north and west China to the subtropics of the south-east. The type of farming – i.e. the type of crop grown and the number of croppings per year – shows a close correlation with such physical factors as the length of the growing season and the amount and distribution of annual rainfall (Figure 16.10).

Although there has been a population movement towards the towns, increasingly since 1979, especially to those near to the coast, and an increase in employment in the manufacturing and service sectors, 56 per cent of Chinese still live in rural areas and 44 per cent are farmers. Despite many improvements both in farming and in rural settlements (Case Study 14B), most farmers still have a very hard life and live at, or only a little above, subsistence level (page 477). Many work in their fields from daylight to dusk and have to rely upon hand labour (Figure 16.11). Although machinery is increasingly being used on the larger, flatter fields and the bigger farms of north-east China (Figure 16.12), animals such as the water buffalo are better suited to the smaller fields and farms found towards the south of the country where every conceivable piece of land is intensively used (Figure 16.13). Pastoral farming is practised in the higher, drier lands to the north and west (Figure 16.14).

Most farmers are still short of capital, although since the introduction of the responsibility system (Places 63) they now have the freedom to grow those crops or rear the animals they choose, together with the incentive to produce more and to diversify, as they can now sell any surplus. (The creation of wealth was not allowed during the first 30 years of the People's Republic, which coincided with a time when food shortages caused the deaths of millions of people.) As a result farmers across the country now claim that their standard of living, their quality of life and the country's food supply are better than they have been in living memory (Case Study 14B).

Figure 16.13
Use of animals: water buffalo near Dazu

Figure 16.14
Pastoral farming: northern China

Von Thünen's model of rural land use

Heinrich von Thünen, who lived during the early 19th century, owned a large estate near to the town of Rostock (on the Baltic coast of present-day Germany). He became interested in how and why agricultural land use varied with distance from a market, and published his ideas in a book entitled *The Isolated State* (1826).

To simplify his ideas, he produced a model in which he recognised that the patterns of land use around a market resulted from competition with other land uses. Like other models, von Thünen's makes several simplifying assumptions. These include:

- The existence of an isolated state, cut off from the rest of the world (transport was poorly developed in the early 19th century).
- In this state, one large urban market (or central place) was dominant. All farmers received the same price for a particular product at any one time.
- The state occupied a broad, flat, featureless plain which was uniform in soil fertility and climate and over which transport was equally easy in all directions.
- There was only one form of transport available. (In 1826 this was the horse and cart.)
- The cost of transport was directly proportional to distance.
- The farmers acted as 'economic men' wishing to maximise their profits and all having equal knowledge of the needs of the market.

In his model, von Thünen tried to show that with increasing distance from the market:

a the intensity of production decreased, and
b the type of land use varied.

Both concepts were based upon **locational rent** (*LR*) which von Thünen referred to as **economic rent**. Locational rent is the difference between the revenue received by a farmer for a crop grown on a particular piece of land and the total cost of producing and transporting that crop. Locational rent is therefore the profit from a unit of land, and should not be confused with **actual rent**, which is that paid by a tenant to a landlord.

Since von Thünen assumed that all farmers got the same price (revenue) for their crops and that costs of production were equal for all farmers, the only variable was the cost of transport, which increased proportionately with distance from the market. Locational rent can be expressed by the formula:

$$LR = Y(m - c - td)$$

where:

LR = locational rent
Y = yield per unit of land (hectares)
m = market price per unit of commodity
c = production cost per unit of land (ha)
t = transport cost per unit of commodity
d = distance from the market.

Since Y, m, c and t are constants, it is possible to work out by how much the LR for a commodity decreases as the distance from the market increases. Figure 16.15 shows that LR (profit) will be at its maximum at **M** (the market), where there are no transport costs. LR decreases from **M** to **X** with diminishing returns, until at **X** (the **margin of cultivation**) the farmer ceases production because revenue and costs are the same – i.e. there is no profit.

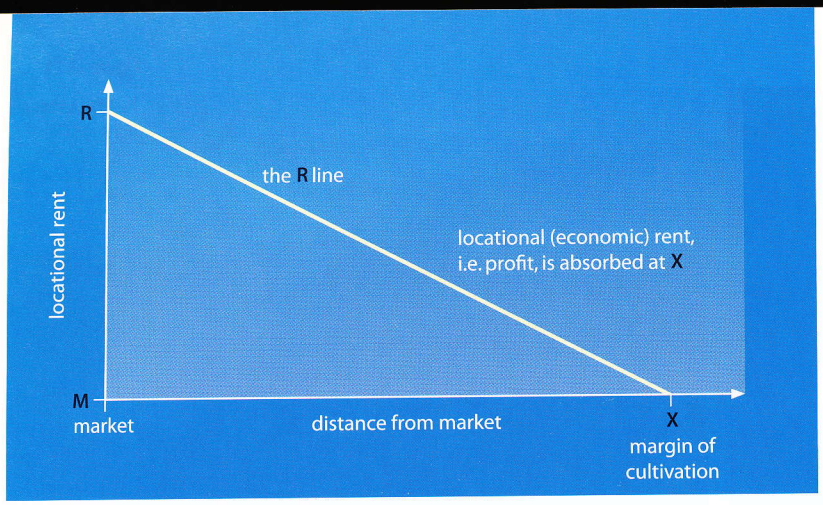


Figure 16.15
The relationship between locational (economic) rent and distance from the market

Details of von Thünen's theory

Von Thünen tried to account for the location of several crops in relation to the market. He suggested that:

a bulky crops, such as potatoes, should be grown close to the market as their extra weight would increase transport costs

b perishable goods, such as vegetables and dairy produce, should also be produced as near as possible to the market (he wrote before refrigeration had been introduced)

c intensive crops should be grown nearer to the market than extensive crops (Figure 16.16).

Consequently, bulky, perishable and intensive crops (or commodities) will have steep *R* lines (Figures 16.15, 16.16 and 16.17).

Figure 16.16 shows the result of two crops, potatoes and wheat, grown in competition. The two *R* lines, showing the locational rent or profit for each crop, intersect at Y. If a perpendicular is drawn from Y to Z, locational rent can be translated into land use. Potatoes, an intensive, bulky crop, are grown near to the market (between M and Z) as their transport costs are high. Wheat, a more extensively farmed and less bulky crop, is grown further away (between Z and X) because it incurs lower transport costs.

Figure 16.16
Locational rents for two crops grown in competition

Farm product	Market price per unit of commodity	Production costs per unit of land (ha)	Transport costs per unit of commodity	Profit if grown at market
Potatoes	100	30	10	70
Wheat	65	20	3	45

What happens if three crops are grown in competition? This is the combination of von Thünen's two concepts: variation of intensity and type of land use, with distance from market. Let us suppose that wool is produced in addition to potatoes and wheat (Figure 16.17).

Potatoes give the greatest profit if grown at the market, and wool the least. However, as potatoes cost £10 to transport every kilometre, after 7 km their profit will have been absorbed in these costs (£70 profit – £70 transport = £0). This has been plotted in Figure 16.18a which is a **net profit graph**. Wheat costs £3/km to transport and so can be moved 15 km before it becomes unprofitable (£45 profit – £45 transport = £0). Wool, costing only £1/km to transport, can be taken 30 km before it, too, becomes unprofitable. Figure 16.18 also shows that although potatoes can be grown profitably for up to 7 km from the market, at point A, only 3.5 km from the market, wheat farming becomes equally profitable and that, beyond that point, wheat farming is more lucrative. Similarly, wheat can be grown up to 15 km from the market, but beyond 7.5 km it is less profitable than, and is therefore replaced by, wool. The point at which one type of land use is replaced by another is called the **margin of transference**.

The types of land use can now be plotted spatially. Figure 16.18b shows three concentric circles, with the market as the common central point. As on the graph, potatoes will be grown within 3.5 km of the market. This is because competition for land, and consequently land values, are greatest here so only the most intensive farming is likely to make a profit. The plan also shows that wheat is grown between 3.5 and 7.5 km from the market, while between 7.5 and 30 km, where the land is cheaper, farming is extensive and wool becomes the main product. Von Thünen's land use model is therefore based on a series of concentric circles around a central market.

The formula for locational rent (page 471) assumed that market prices (m), production costs (c) and transport costs (t) were all constant. What would happen to a crop's area of production if each of these in turn were to alter?

If the market price falls or the cost of production increases, there is a decrease in both the

Figure 16.17
Locational rents for three commodities in competition

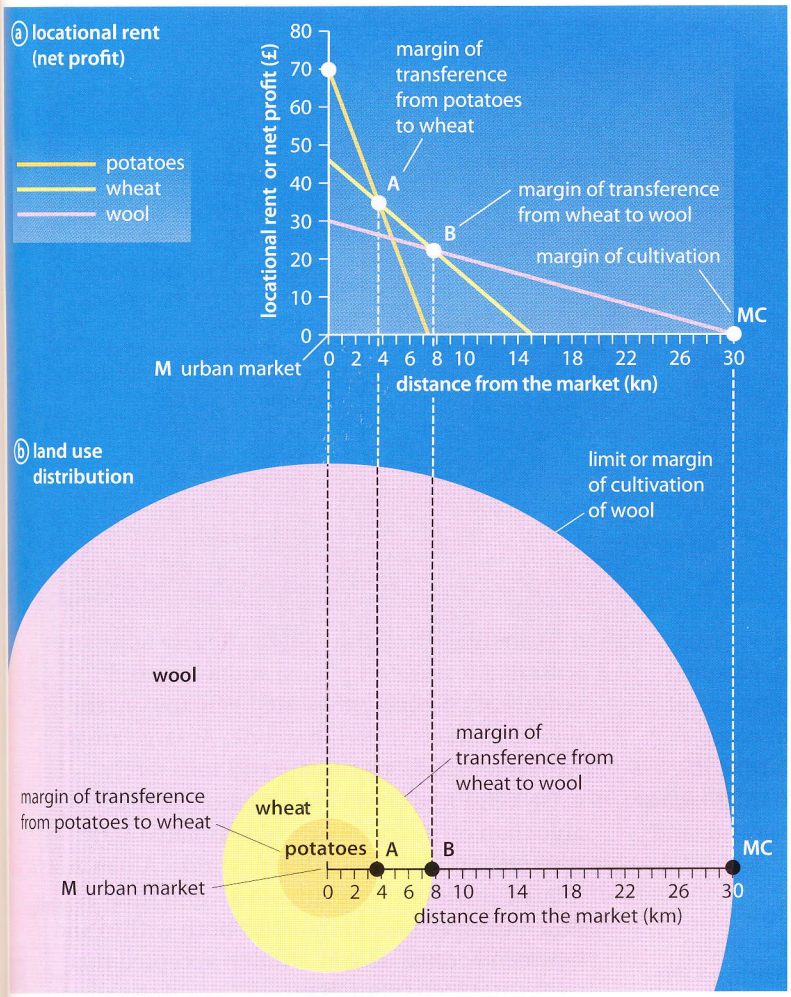


Figure 16.18

Locational rent (net profit) and land use of three commodities produced in competition

profit and the margin of cultivation of that crop (Figure 16.19a and b). Conversely, if the market price rises or the costs of production decrease, profits would rise, leading to an extension in the margin of cultivation. Changes in transport costs will not affect any farm at the market (Figure 16.19c) but an increase in transport costs reduces profits for distant farms, causing a decrease in the margin of cultivation. Conversely, a fall in transport costs makes those distant farms more profitable and enables them to extend their margin of cultivation.

Von Thünen's land use model

Von Thünen combined his conclusions on how the intensity of production decreased and the type of land use varied with distance from the market, to create his model (Figure 16.20a). He suggested six types of land use which were located by concentric circles.

1 Market gardening (horticulture) and dairying were practised nearest to the city, due to the perishability of the produce. Cattle were kept indoors for most of the year and provided manure for the fields.
2 Wood was a bulky product much in demand as a source of fuel and as a building material within the town (there was no electricity when von Thünen was writing). It was also expensive to transport.
3 An area with a 6-year crop rotation was based on the intensive cultivation of crops (rye, potatoes, clover, rye, barley and vetch) with no fallow period.
4 Cereal farming was less intensive as the 7-year rotation system relied increasingly on animal grazing (pasture, rye, pasture, barley, pasture, oats and fallow).

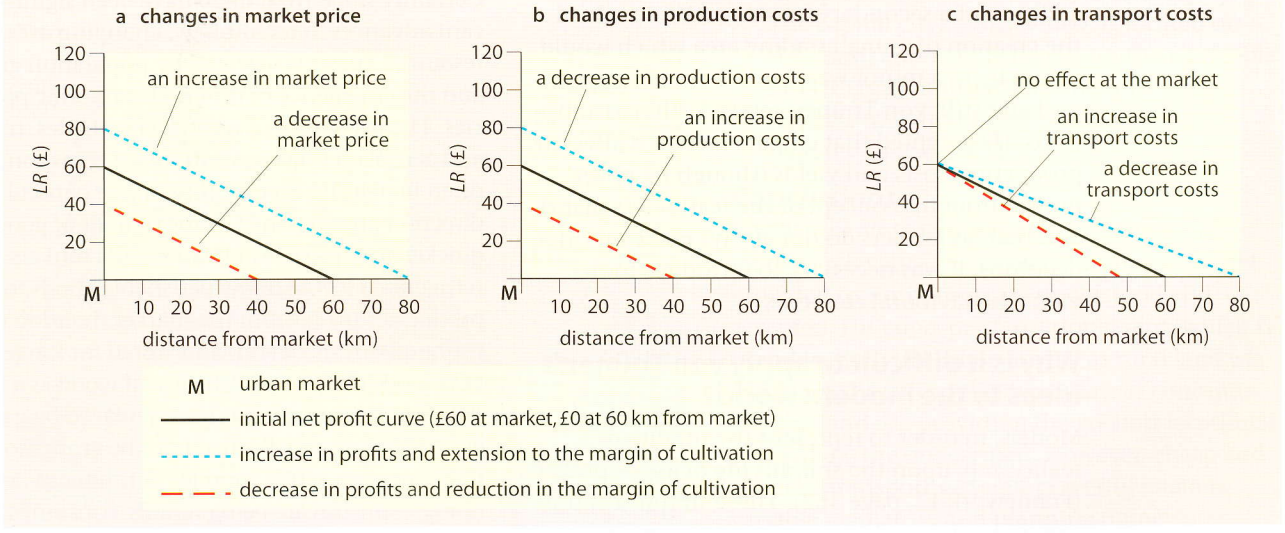


Figure 16.19

Some causes of variation in locational rent

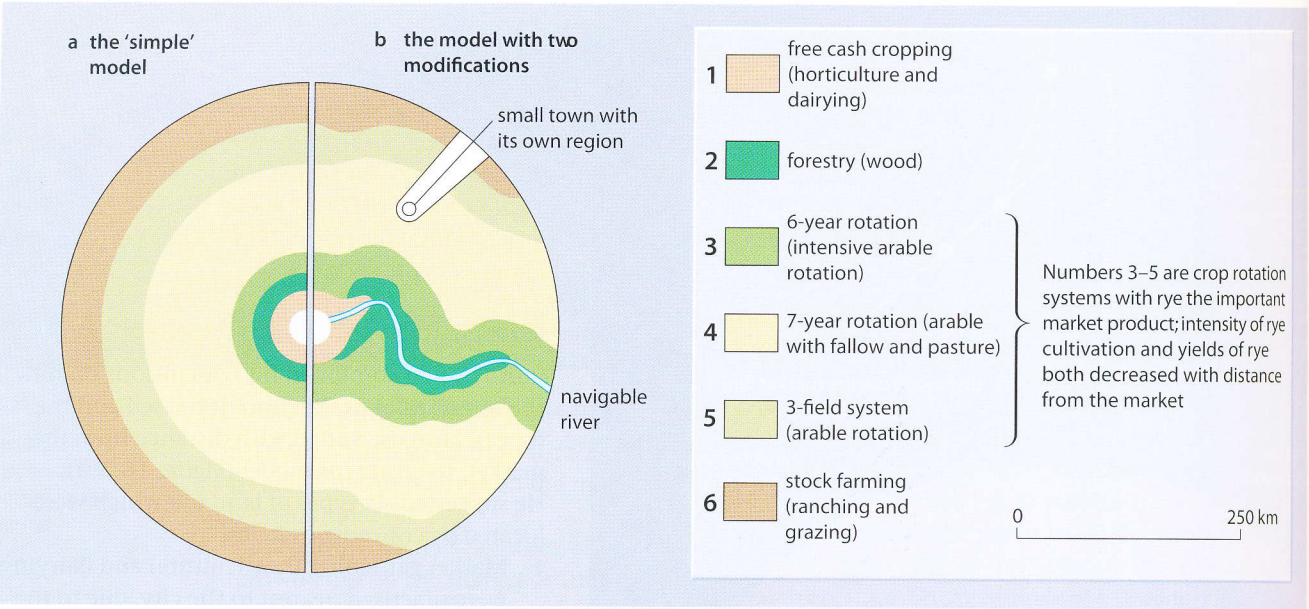


Figure 16.20
The von Thünen land use model

5 Extensive farming based on a 3-field crop rotation (rye, pasture and fallow). Products were less bulky and perishable to transport and could bear the high transport costs.
6 Ranching with some rye for on-farm consumption. This zone extended to the margins of cultivation, beyond which was wasteland.

Modifications to the model

Later, von Thünen added two modifications in an attempt to make the model more realistic (Figure 16.20b). This immediately distorted the land use pattern and made it more complex. The inclusion of a navigable river allowed an alternative, cheaper and faster form of transport than his original horse and cart. The result was a linear, rather than a circular, pattern and an extension of the margin of cultivation. The addition of a secondary urban market involved the creation of a small trading area which would compete, in a minor way, with the main city.

Later still, von Thünen relaxed other assumptions. He accepted that climate and soils affected production costs and yields (though he never moved from his concept of the featureless plain) and that, as farmers do not always make rational decisions, it was necessary to introduce individual behavioural elements.

Why is it difficult to apply von Thünen's ideas to the modern world?

Models, in order to represent the totality of reality, rely upon the simplifying of assumptions (Framework 12, page 352). These simplifications can, in turn, be subject to criticisms which in the case of von Thünen's model can be grouped under four headings:

a Oversimplification There are very few places with flat, featureless plains, and where such landscapes do occur they are likely to contain several markets rather than one. As large areas with homogeneous climate and soils rarely exist, certain locations will be more favourable than others. Similarly, the 'isolated state' is rarely found in the modern world – Albania may be nearest to this situation – and there is much competition for markets both within and between countries. Von Thünen accepted that while his model simplified real-world situations, the addition of two variables immediately made it more complex (Figure 16.20b).

b Outdatedness As the model was produced 170 years ago, critics claim it is out-dated and of limited value in modern farming economics. Certainly since 1826 there have been significant advances in technology, changing uses of resources, pressures created by population growth, and the emergence of different economic policies. The invention of motorised vehicles, trains and aeroplanes has revolutionised transport, often increasing accessibility in one particular direction and making the movement of goods quicker and relatively cheaper. Milk tankers and refrigerated lorries allow perishable goods to be produced further from the market (London uses fresh milk from Devon) and stored for longer (the EU's food mountains). The use of wood as a fuel in developed countries has been replaced by gas and electricity and so trees need not be grown so near to the market, while supplies of timber in developing countries are being rapidly consumed and not always replaced. Improved farming techniques using fertilisers and irrigation have improved yields and extended the margins of cultivation.

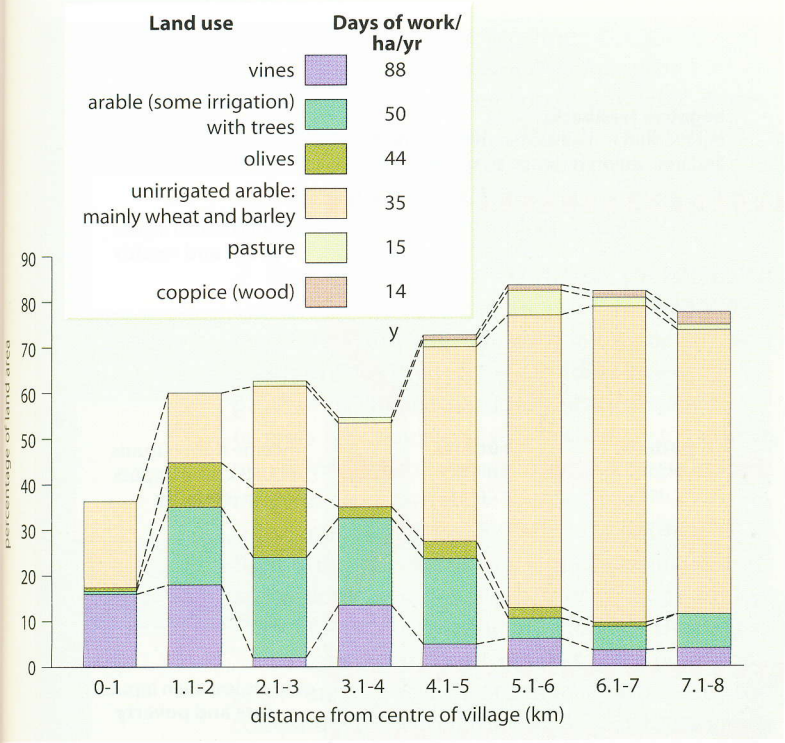


Figure 16.21

Land use and labour requirements around a hilltop village in southern Europe

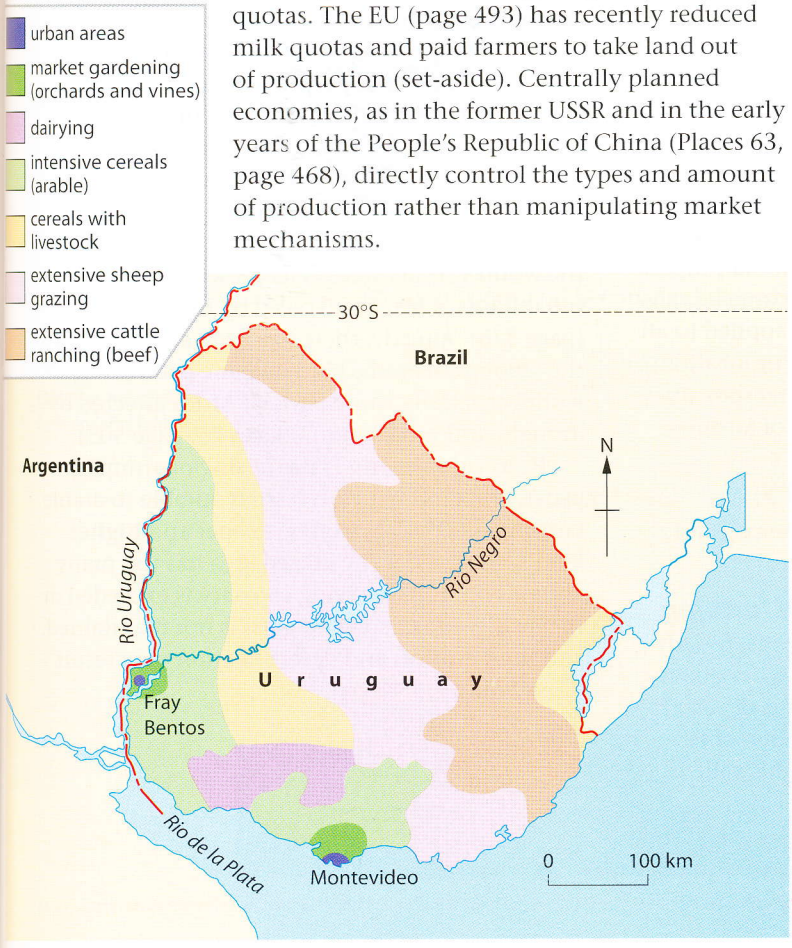
Elsewhere, farmland has been taken over by urban growth or used by competitors who obtain higher economic rents.

c Failure to recognise the role of government

Governments can alter land use by granting/reducing subsidies and imposing/removing quotas. The EU (page 493) has recently reduced milk quotas and paid farmers to take land out of production (set-aside). Centrally planned economies, as in the former USSR and in the early years of the People's Republic of China (Places 63, page 468), directly control the types and amount of production rather than manipulating market mechanisms.

ure 16.22

d use patterns in Uruguay



d Failure to include behavioural factors

Von Thünen has been criticised for assuming that farmers are 'rational economic men'. Farmers do not possess full knowledge, may not always make rational or consistent decisions, may prefer to enjoy increased leisure time rather than seeking to maximise profits and may be reluctant to adopt new methods. Farmers, as human beings, may have different levels of ability, ambition, capital and experience and none can predict changes in the weather, government policies or demand for their product.

How relevant is von Thünen's theory to the modern world?

It is pointed out on pages 411 and 557 that although theories are difficult to observe in the real world, they *are* useful because reality can be measured and compared against them. In the case of von Thünen's model:

a Figure 16.21 takes, at a **local** level, a relatively remote, present-day hill village in the Mediterranean lands of Europe. Many villages in southern Italy, Spain and Greece have hilltop sites (in contrast to von Thünen's featureless plain) where, usually, transport links are poor, affluence is limited and the village provides the main – perhaps the only – market (Figure 14.7). As the distance from the village increases, the amount of farmland used, and the yields from it, decrease. Two critical local factors are the distance which farmers are prepared to travel to their fields and the amount of time, or intensity of attention, needed to cultivate each crop.

b Figure 16.22 shows, at the **national** level, the spatial pattern of land use in Uruguay. The capital city, Montevideo, is located on the coast, and Fray Bentos is on the navigable Rio Uruguay: a situation similar in some respects to von Thünen's modified model (Figures 16.20b and 16.35).

Conclusions

Von Thünen's land use model still has some modern relevance, particularly at the local level, provided its limitations are understood and accepted. His concept of locational rent, which is useful in studying urban as well as rural land use (page 425), is still applicable today, as conceptually the land use providing the greatest locational rent will be the one farmed. However, cheap and efficient transport systems, powerful retailers, variable regulatory and planning frameworks, and uneven patterns of wealth now severely limit the model's application in the modern world.

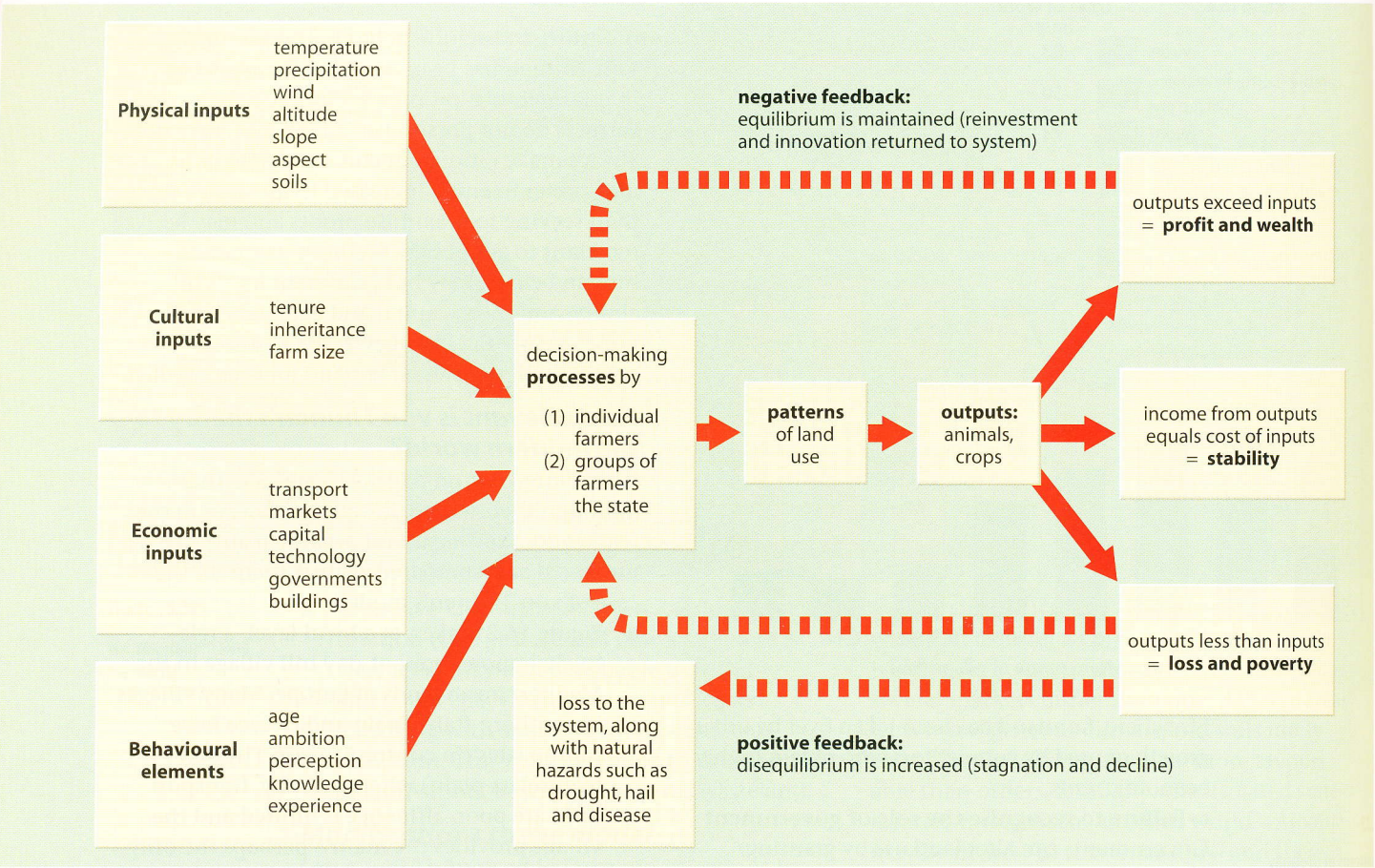


Figure 16.23
The farming system

The farming system

Farming is another example of a system, and one which you may have studied already (Framework 3, page 45). The system diagram (Figure 16.23) shows how physical, cultural, economic and behavioural factors form the inputs. In areas where farming is less developed, physical factors are usually more important but as human inputs increase, these physical controls become less significant. This system model can be applied to all types of farming, regardless of scale or location. It is the variations in inputs that are responsible for the different types and patterns of farming.

Types of agricultural economy

The simplest classifications show the contrasts between different types of farming.

1 Arable, pastoral and mixed farming

Arable farming is the growing of crops, usually on flatter land where soils are of a higher quality. It was the development of new strains of cereals which led to the first permanent settlements in the Tigris–Euphrates, Nile and Indus valleys (Figure 14.1). Much later, in the mid-19th century, the building of the railways across the Prairies, Pampas and parts of Australia led to a rapid increase in the global area 'under the plough' (page 485). Today, there are few areas left with a potential for arable farming. This fact, coupled with the rapid increase in global population, has led to continued concern over the world's ability to feed its present and future inhabitants, a fear first voiced by Malthus (page 378). Already, there has been a decrease in the amount of arable land in some parts of the world, especially those parts of Africa affected by drought and soil erosion (Places 75, page 503).

Pastoral farming is the raising of animals, usually on land which is less favourable to arable farming (i.e. colder, wetter, steeper and higher land). However, if the grazed area has too many animals on it, its carrying capacity is exceeded or the quality of the soil and grass is not maintained, and then erosion and desertification may result (Case Study 7).

Mixed farming is the growing of crops and the rearing of animals together. It is practised on a commercial scale in developed countries, where it reduces the financial risks of relying upon a single crop or animal (monoculture), and at a subsistence level in developing countries, where it reduces the risks of food shortage.

2 Subsistence and commercial farming

Subsistence farming is the provision of food by farmers only for their own family or the local community – there is no surplus (Places 67, page 481). The main priority of subsistence farmers is self-survival which they try to achieve, whenever possible, by growing/rearing a wide range of crops/animals. The fact that subsistence farmers are rarely able to improve their output is due to a lack of capital, land and technology, and not to a lack of effort or ability. They are the most vulnerable to food shortages.

Commercial farming takes place on a large, profit-making scale. Commercial farmers, or the companies for whom they work, seek to maximise yields per hectare. This is often achieved – especially within the tropics – by growing a single crop or rearing one type of animal (Places 68, page 483). Cash-cropping operates successfully where transport is well developed, domestic markets are large and expanding, and there are opportunities for international trade (Places 69 page 484, and 70 page 486).

3 Shifting and sedentary farming

Many of the earliest farmers moved to new land every few years, due to a reduction in yields and also reduced success in hunting and gathering supplementary foods. **Shifting cultivation** is now limited to a few places where there are low population densities and a limited demand for food; where soils are poor and become exhausted after three or four years of cultivation (Places 66, page 480); or where there is a seasonal movement of animals in search of pasture (Places 65, page 479). However, farming over most of the world is now **sedentary**, i.e. farmers remain in one place to look after their crops or to rear their animals.

4 Extensive and intensive cultivation

These terms have already been used in describing von Thünen's model (Figure 16.16). **Extensive farming** is carried out on a large scale, whereas **intensive farming** is usually relatively small-scale. Farming is extensive or intensive depending on the relationship between three factors of production: labour, capital and land (Figure 16.24). Extensive farming occurs when:

- Amounts of labour and capital are small in relation to the area being farmed. In the Amazon Basin (Places 66, page 480), for example, the yields per hectare and the output per farmer are both low (Figure 16.24a).
- The amount of labour is still limited but the input of capital may be high. In the Canadian Prairies (Places 70, page 486), for example, the yields per hectare are often low but the output per farmer is high (Figure 16.24b).

Intensive farming occurs when:

- The amount of labour is high, even if the input of capital is low in relation to the area farmed. In the Ganges valley (Places 67, page 481), for example, the yields per hectare may be high although the output per farmer is often low (Figure 16.24c).
- The amount of capital is high, but the input of labour is low. In the Netherlands (Places 71, page 487), for example, both the yields per hectare and the output per farmer are high (Figure 16.24d).

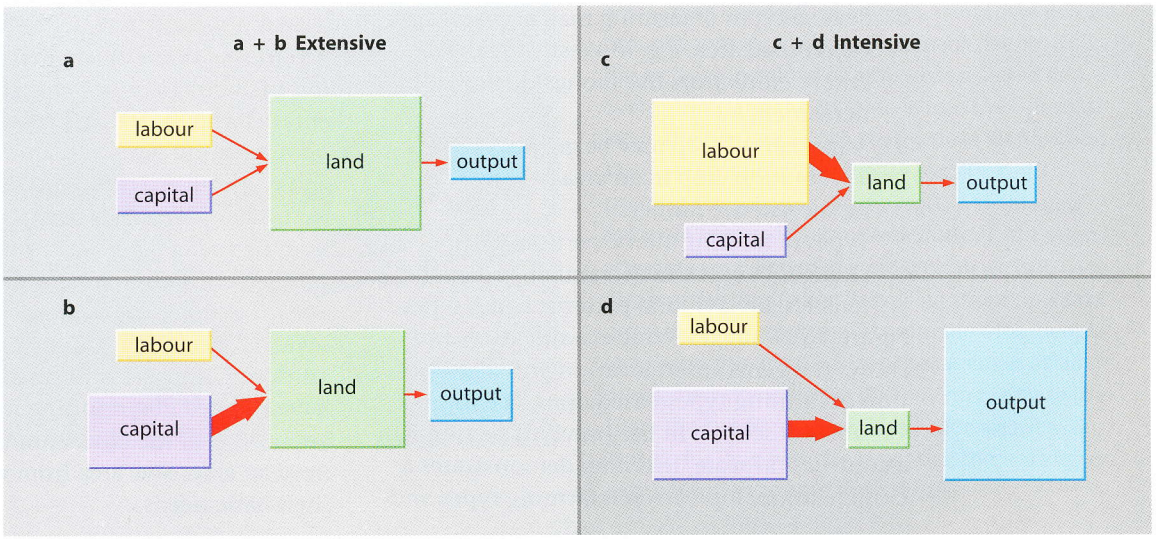


Figure 16.24
Extensive and intensive farming (*after* Briggs)

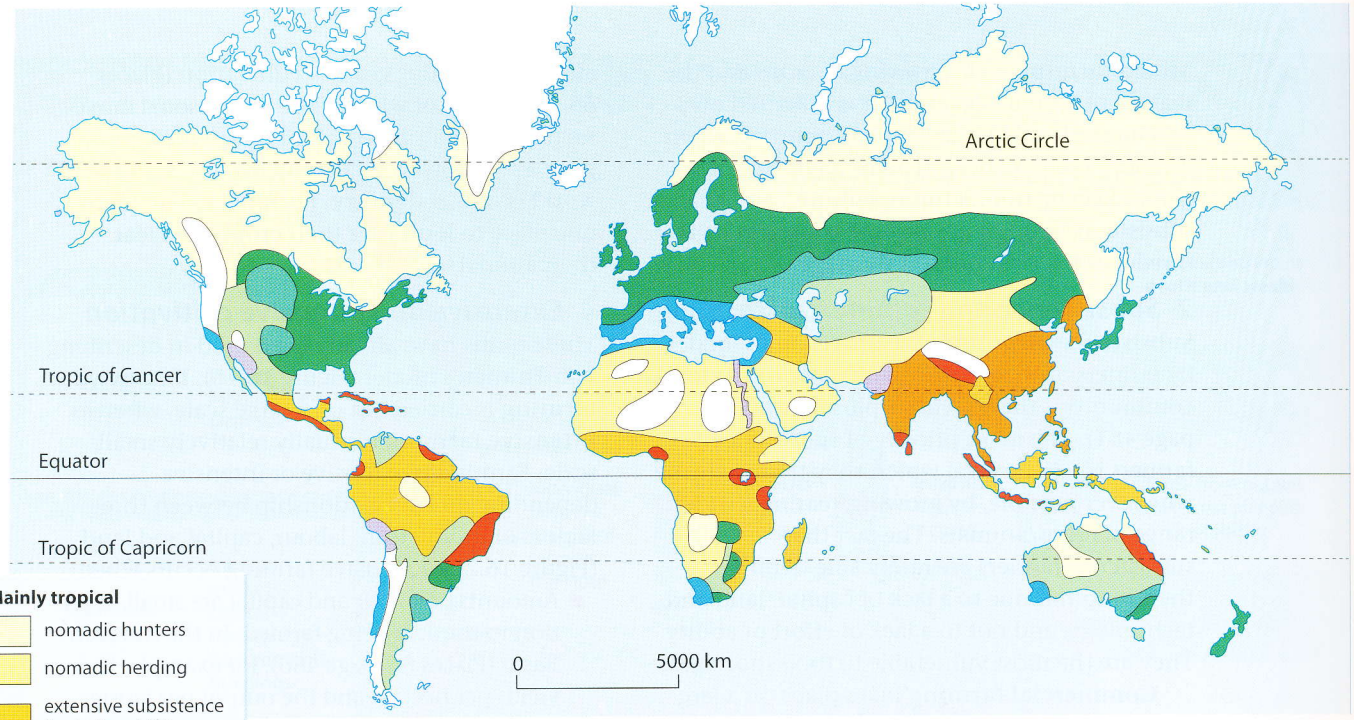


Figure 16.25
Location of the world's major farming types

World distribution of farming types

There is no widely accepted consensus as to how the major types of world farming should be classified or recognised (Framework 7, page 167). There is disagreement over the basis used in attempting a classification (intensity, land use, tropical or temperate, level of human input, the degree of commercialisation); the actual number and nomenclature of farming types; and the exact distribution and location of the major types.

You should be aware that:

1 Boundaries between farming types, as drawn on a map, are usually very arbitrary.
2 One type of farming merges gradually with a neighbouring type; there are few rigid boundaries.
3 Several types of farming may occur within each broad area, e.g. in West Africa, sedentary cultivators live alongside nomadic herdsmen.
4 A specialised crop may be grown locally, e.g. a plantation crop in an area otherwise used by subsistence farmers.
5 Types of farming alter over time with changes in economies, rainfall, soil characteristics, behavioural patterns and politics.

Figure 16.25 suggests one classification and shows the generalised location and distribution of farming types based upon the four variables described in the previous section. On a continental scale, this map demonstrates a close relationship between farming types and the physical environment/pattern of biomes (page 306). It disguises, however, the important human–economic factors that operate at a more local level.

The following section describes the main characteristics of each of these categories of farming together with the conditions favouring their development. A specific example is used in each case (which should be supplemented by wider reading) together with an account of recent changes or problems within that agricultural economy.

1 Hunters and gatherers

Some classifications ignore this group on the grounds that it is considered to be a relict way of life, with the original lifestyle now largely, or totally, destroyed by contact with the outside world. Others feel that even if it did exist then it does not constitute a 'true' farming type, as no crops or domesticated animals are involved. It is included here as, before the advent of sedentary farming, all early societies had to rely upon hunting birds and animals, catching fish, and collecting berries, nuts and fruit in order to survive ... which is surely why we rely upon farming today. There are now very few hunter-gatherer societies remaining – the Bushman of the Kalahari, the Pygmies of central Africa, several Amerindian tribes in the Brazilian rainforest, and the Australian Aborigines. All have a varied diet resulting from their intimate knowledge of the environment, but each group need an extensive area from which to obtain their basic needs.

2 Nomadic herding

In areas where the climate is too extreme to support permanent settled agriculture, farmers become **nomadic pastoralists**. They live in inhospitable environments where vegetation is sparse and the climate is arid or cold. The movement of most present-day nomads is determined by the seasonal nature of rainfall and the need to find new sources of grass for their animals, e.g. the Bedouin and Tuareg in the Sahara and the Rendille and Maasai in Kenya (Places 65 and Case Study 12A). The indigenous Sami of northern Scandinavia have to move when their pastures become snow-covered in winter, while the Fulani in West Africa may migrate to avoid the tsetse fly.

There are two forms of nomadism. **Total nomadism** is where the nomad has no permanent home, while **semi-nomads** may live seasonally in a village. There is no ownership of land and the nomads may travel extensive distances, even across national frontiers, in search of fresh pasture. There may be no clear migratory pattern, but migration routes increase in size under adverse conditions, e.g. during droughts in the Sahel. The animals are the source of life. Depending upon the area, they may provide milk, meat and blood as food for the tribe; wool and skins for family shelter and clothing; dung for fuel; mounts and pack animals for transport; and products for barter. Just as sedentary farmers will not sell their land unless they are in dire economic difficulty, similarly pastoralists will not part with their animals, retaining them to regenerate the herd when conditions improve.

Places 65 Northern Kenya: nomadic herders

Rainfall is too low and unreliable in northern Kenya to support settled agriculture (Places 61, page 465). Over the years, the Rendille have learned how to survive in an extreme environment (Figure 16.26). All they need are their animals (camels, goats and a few cattle): all their animals need is water and grass. The tribe are constantly on the lookout for rain, which usually comes in the form of heavy, localised downpours. Once the rain has been observed or reported, the tribe pack their limited possessions onto camels (a job organised by the women) and head off, perhaps on a journey of several days, to an area of new grass growth. In the past, this movement prevented overgrazing, as grazed areas were given time to recover. Camels, and to a much lesser extent goats, can survive long periods without water by storing it within their bodies or by absorbing it from edible plants – food supply is as important as water. Humans, who can go longer than animals without food but much less long without water, rely upon the camels for milk and blood, and the goats for milk and occasional meat. Indeed, the main diet of blood and milk avoids the necessity of cooking and the need to find firewood.

Figure 16.26
Rendille camels and goats at a waterhole

But the Rendille way of life is changing. Land is becoming overpopulated and resources overstretched as the numbers of people and animals increase and as water supplies and vegetation become scarcer. Consequently, as the droughts of recent years continue, pastoralists are forced to move to small towns, such as Korr. Here there is a school, health centre, better housing, jobs, a food supply and a permanent supply of water from a deep well (Figure 16.26). The deep well waters hundreds of animals, many of which are brought considerable distances each day. However, the increase in animal numbers has resulted in overgrazing, and the increase in townspeople has led to the clearance of all nearby trees for firewood. This has resulted in an increase in soil erosion, creating a desert area extending 150 km around the town (desertification, Case Study 7). Although attempts are being made to dig more wells to disperse the population, travelling shops now take provisions to the pastoralists, and the tribespeople have been shown how to sell their animals at fairer prices, many Rendille are still moving to Korr to live. There the children, having been educated, remain, looking for jobs, with the result that there are fewer pastoralists left to herd the animals.

3 Shifting cultivation (extensive subsistence agriculture)

Subsistence farming was the traditional type of agriculture in most tropical countries before the arrival of Europeans, and remains so in many of the less economically developed countries and in more isolated regions. The inputs to this system are extremely limited. Relatively few labourers are needed (although they may have to work intensively), technology is limited (possibly to axes), and capital is not involved. Over a period of years, extensive areas of land may be used as the tribes have to move on to new sites. Outputs are also very low with, often, only sufficient being grown for the immediate needs of the family, tribe or local community.

The most extensive form of subsistence farming is shifting cultivation which is still practised in the tropical rainforests (the *milpa* of Latin America and *ladang* of South-east Asia) and, occasionally, in the wooded savannas (the *chitimene* of central Africa). The areas covered are becoming smaller, due to forest clearances, and are mainly limited to less accessible places within the Amazon Basin (Places 66), Central America, Congo and parts of Indonesia. Shifting cultivation, where it still exists, is the most energy-efficient of all farming systems as well as operating in close harmony with its environment.

Places 66 Amazon Basin: shifting cultivation

With the help of stone axes and machetes, the Amerindians clear a small area of about 1 ha in the forest (Figures 16.27 and 16.28). Sometimes the largest trees are left standing to protect young crops from the sun's heat and the heavy rain; so also are those which provide food, such as the banana and kola nut. After being allowed to dry, the felled trees and undergrowth are burnt – hence the alternative name of 'slash and burn' cultivation. While burning has the advantage of removing weeds and providing ash for use as a fertiliser, it has the disadvantage of destroying useful organic material and bacteria. The main crop, manioc, is planted along with yams (which need a richer soil), pumpkins, beans, tobacco and coca. The Amerindian diet is supplemented by hunting, mainly for tapirs and monkeys, fishing and collecting fruit.

Figure 16.27 'Slash and burn': a shifting cultivator clearing the rainforest

The productivity of the rainforest depends on the rapid and unbroken recycling of nutrients (Figure 12.7). Once the forest has been cleared, this cycle is broken (Figure 12.8). The heavy, afternoon, convectional rainstorms hit the unprotected earth causing erosion and leaching. With the source of humus removed, the loss of nutrients within the harvested crop, and in the absence of fertiliser and animal manure, the soil rapidly loses its fertility. Within four or five years, the decline in crop yields and the re-infestation of the area by weeds force the tribe to shift to another part of the forest. Although shifting cultivation appears to be a wasteful use of land, it has no long-term adverse effect upon the environment as, in most places, nutrients and organic matter can build up sufficiently to allow the land to be re-used, often within 25 years.

Figure 16.28 Crops gown in *chagras* (fields) around the *maloca* (communal house)

The traditional Amerindian way of life is being threatened by the destruction of the rainforest. As land is being cleared for highways, cattle ranches, commercial timber, hydro-electric schemes, reservoirs and mineral exploitation, the Amerindians are pushed further into the forest or forced to live on reservations. Recent government policy of encouraging the in-migration of landless farmers from other parts of the country, together with the development of extensive commercial cattle ranching, has meant that sedentary farming is rapidly replacing shifting cultivation. After just a few years, as should have been foreseen, large tracts of some cattle ranches and many individual farms have already been abandoned as their soils have become infertile and eroded.

4 Intensive subsistence farming

This involves the maximum use of the land with neither fallow nor any wasted space. Yields, especially in South-east Asia, are high enough to support a high population density – up to 2000 per km^2 in parts of Java and Bangladesh. The highest-yielding crop is rice which is grown chiefly on river floodplains (the Ganges and Figure 16.30) and in river deltas (the Mekong and Irrawaddy). In both cases, the peak river flow, which follows the monsoon rains, is trapped behind bunds, or walls (Places 67). Where flat land is limited, rice is grown on terraces cut into steep hillsides, especially those where soils have formed from weathered volcanic rock as in Indonesia and the Philippines (Figure 16.29). Upland rice, or dry padi, is easier to grow but, as it gives lower yields, it can support fewer people. Rice requires a growing season of only 100 days, which means that the constant high temperatures of South-east Asia enable two, and sometimes even three, croppings a year (Figure 16.10).

The high population density, rapid population growth and large family size in many South-east Asian countries mean that, despite the high yields, there is little surplus rice for sale. The farms, due to population pressure and inheritance laws (page 467), are often as small as 1 hectare. Many farmers are tenants and have to pay a proportion of their crops to a landlord. Labour is intensive and it has been estimated that it takes 2000 hours per year to farm each 1 hectare plot. Most tasks, due to a lack of capital, have to be done by hand or with the help of water buffalo. The buffalo are often overworked and their manure is frequently used as a fuel rather than being returned to the land as fertiliser. Poor transport systems hinder the marketing of any surplus crops after a good harvest and can delay food relief during the times of food shortage which may result from the extremes of the monsoon climate: drought and flood.

Figure 16.29
Rice cultivation on terraced hillsides, Bali

Places 67 The Ganges valley: intensive subsistence agriculture

Rice, with its high nutritional value, can form up to 90 per cent of the total diet in some parts of the flat Ganges valley in northern India and western Bangladesh. Padi, or wet rice, needs a rich soil and is grown in silt which is deposited annually by the river during the time of the monsoon floods. The monsoon climate (page 239) has an all-year growing season but, although 'winters' are warm enough for an extra crop of rice to be grown, water supply is often a problem. During the rainy season from July to October, the *kharif* crops of rice, millet and maize are grown. Rice is planted as soon as the monsoon rains have flooded the padi fields and is harvested in October when the rains have stopped and the land has dried out. During the dry season from November to April, the *rabi* crops of wheat, barley and peas are grown and harvested. Where water is available for longer periods, a second rice crop may be grown.

Figure 16.30
Rice harvesting on the floodplain of the River Ganges

Rice growing is labour intensive with much manual effort needed to construct the bunds (embankments); to build irrigation channels; to prepare the fields; and to plant, weed and harvest the crop (Figure 16.30). The bunds between the fields are stabilised by tree crops. The tall coconut palm is not only a source of food, drink and sugar, but also acts as a cover crop protecting the smaller banana and other trees which have been planted on the bunds. The flooded padi fields may be stocked with fish which add protein to the human diet and fertiliser to the soil.

In 1964, many Indian farmers and their families were short of food, lacked a balanced diet and had an extremely low standard of living. The government, with limited resources, made a conscious decision to try to improve farm technology and crop yields by implementing Western-type farming techniques and introducing new hybrid varieties of rice and wheat – the so-called Green Revolution (page 504). Although yields have increased and food shortages have been lessened, the 'Green Revolution' is not considered to be, in this part of the world, a social, environmental or political success (Figure 16.63).

5 Tropical commercial (plantation) agriculture

Plantations were developed in tropical areas, usually where rainfall was sufficient for trees to be the natural vegetation, by European and North American merchants in the 18th and 19th centuries. Large areas of forest were cleared and a single bush or tree crop was planted in rows (Figure 16.31 and 16.32) – hence the term monoculture (page 280). This so-called **cash crop** was grown for export and was not used or consumed locally (Places 68).

Figure 16.31
A rubber plantation in Malaysia

Plantations needed a high capital input to clear, drain and irrigate the land; to build estate roads, schools, hospitals and houses; and to bridge the several years before the crop could be harvested. Although plantations were often located in areas of low population density, they needed much manual labour. The owners and managers were invariably white. Black and Asian workers, obtained locally or brought in as slaves or indentured labour from other countries, were engaged as they were prepared, or forced, to work for minimum wages. They were also capable of working in the hot, humid climate. Today, many plantations, producing most of the world's rubber, coffee, tea, cocoa, palm oil, bananas, sugar cane and tobacco, are owned and operated by large transnational companies (Figure 16.32).

Plantations, large estates and even small farmers are being increasingly drawn into making commercial contracts to supply fruit and vegetables to consumers in the developed world. Although such contracts may help some developing countries to provide jobs and to pay off their international debts, it also means they have to import greater volumes of staple foods to make up for the land switched from staples to export crops (page 501).

Figure 16.32
The advantages and disadvantages of plantation agriculture

Advantages	Disadvantages
Higher standards of living for the local workforce	Exploitation of local workforce, minimal wages
Capital for machines, fertiliser and transport provided initially by colonial power, now the transnational corporations	Cash crops grown instead of food crops: local population have to import foodstuffs
Use of fertilisers and pesticides improves output	Most produce is sent overseas to the parent country
Increases local employment	Most profit returns to Europe and North America
Housing, schools, health service and transport provided, also often electricity and a water supply	Dangers of relying on monoculture: fluctuations in world prices and demand
	Overuse of land has led, in places, to soil exhaustion and erosion

Places 68 Malaysia: tropical commercial (plantation) agriculture

A plantation is defined in Malaysia as an estate exceeding 40 ha in size. Many extend over several thousand hectares. The first plantations were of coffee, but these were replaced at the end of the 19th century by rubber. Rubber is indigenous to the Amazon Basin, but some seeds were smuggled out of Brazil in 1877, brought to Kew Gardens in London to germinate and then sent out to what is now Malaysia. The trees thrive in a hot, wet climate, growing best on the gentle lower slopes of the mountains forming the spine of the Malay peninsula. Rubber tends not to be grown on the coasts where the land is swampy, but near to the relatively few railway lines and the main ports. The 'cheap' labour needed to clear the forest, work in the nurseries, plant new trees and tap the mature trees was provided by the poorer Malays and immigrants from India (Figure 16.31).

The Malaysian government has now taken over all the large estates, formerly run by such trans-nationals as Dunlop and Guthries, having seen them as a relict of colonialism. In the early 1970s, the Federal Land Development Authority (FELDA) was set up. Initially its job was to clear areas of forest, divide the land into 5 ha plots and to plant young rubber trees. After four years, smallholders were put in charge of the trees but FELDA still provided fertiliser and pesticide and, later, bought and marketed the crop.

The world demand for rubber steadily declined after the 1950s, mainly due to competition from synthetic rubber – apart from the years immediately after the first AIDS scare (page 622) which saw an increased demand for contraceptives. By 2000, the income of one-quarter of smallholders was said to be below the poverty line. Official figures suggested that half the country's smallholders, each with an average of four dependants, were totally reliant on rubber which, by 2001, hit a low price of RM1 per kg (RM = Malaysian ringgit, the local currency). Since then it has risen sharply, reaching over RM7 in 2006, which was high enough even for trees felled by storms to be tapped. However, the high price is predicted to be a short-term trend.

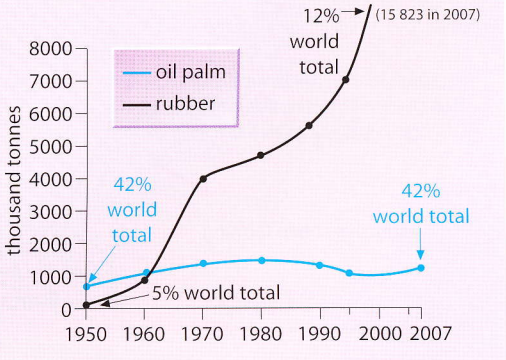
Figure 16.33 Oil palm

The Malaysian plantation industry is now heavily dependent on just one crop, oil palm (Figure 16.33). Oil palm, which covers over 80 per cent of the country's plantations, has many advantages over rubber including higher yields, higher prices, lower production costs and a less intensive use of labour (Figure 16.34). It is also more versatile because, apart from providing an edible oil and being used in a wide range of foodstuffs, it is also used in the oleochemical industry in the manufacture of soap, cosmetics and paint. Since 2000, further large areas have been converted into oil palm plantations where the crop is grown as a source of biofuel, mainly in the EU (page 543). Palm oil currently accounts for 6 per cent of Malaysia's GDP.

Although oil palm fruits have still to be harvested manually (the fronds get in the way of machines) and the fruits have to be harvested within a short period of time (otherwise the oil is lost), the spraying of herbicides, the application of fertiliser and transportation have all been mechanised.

Figure 16.34 The changing importance of rubber and oil palm

		Rubber	Oil palm
Production	1950 (thousand tonnes)	722	49
	1995 (thousand tonnes)	1089	7810
	2007 (thousand tonnes)	1200	15 823
	Tonnes per ha	2	24–26
	Years for trees to mature	6–7	4–5
	Labour intensive	Higher	Lower
	Price	1990s very low; since 2003 rising	Higher, rising



6 Extensive commercial pastoralism (livestock ranching)

Livestock ranching returns the lowest net profit per hectare of any commercial type of farming. It is practised in more remote areas where other forms of land use are limited and where there are extensive areas of cheaper land with sufficient grass to support large numbers of animals. It is found mainly in areas with a low population density and aims to give the maximum output from minimum inputs – i.e. there is a relatively small capital investment in comparison with the size of the farm or ranch, but output per farm-worker is high. This type of farming includes commercial sheep farming (in central Australia, Canterbury Plains in New Zealand, Patagonia, upland Britain) and commercial cattle ranching (Places 69), mainly for beef (in the Pampas, American Midwest, northern Australia and, more recently, Amazonia and Central America). It corresponds, therefore, to the outer land use zone of von Thünen's model (Figure 16.20) and does not include commercial dairying which, being more intensive, is found nearer to the urban market (Places 71, page 487).

The raising of beef cattle is causing considerable environmental concern. It is a cause of deforestation (uses 40 per cent of the cleared forest in Amazonia), desertification and soil erosion (overgrazing) and global warming (release of methane). It also takes more water and feed to produce 1 kg of beef than the equivalent amount of any other food or animal product.

Places 69 The Pampas, South America: extensive commercial pastoralism

The Pampas covers Uruguay and northern Argentina. The area receives 500–1200 mm of rainfall a year – enough to support a temperate grassland vegetation. During the warmer summer months the water supply has to be supplemented from underground sources, while in the cooler, drier winter much of the grass dies down. Temperatures are never too high to dry up the grass in summer, nor low enough to prevent its growth in winter. The relief is flat and soils are often of deep, rich alluvium, deposited by rivers such as the Parana which cross the plain (Figure 16.35). The grasses help to maintain fertility by providing humus when they die back (Figure 11.29b).

Many ranches, or estancias, exceed 100 km^2 and keep over 20 000 head of cattle. Most are owned by businessmen or large companies based in the larger cities, and are run by a manager with the help of cowboys or gauchos. Several economic improvements have been added to the natural physical advantages. Alfalfa, a leguminous, moisture-retaining crop, is grown to feed the

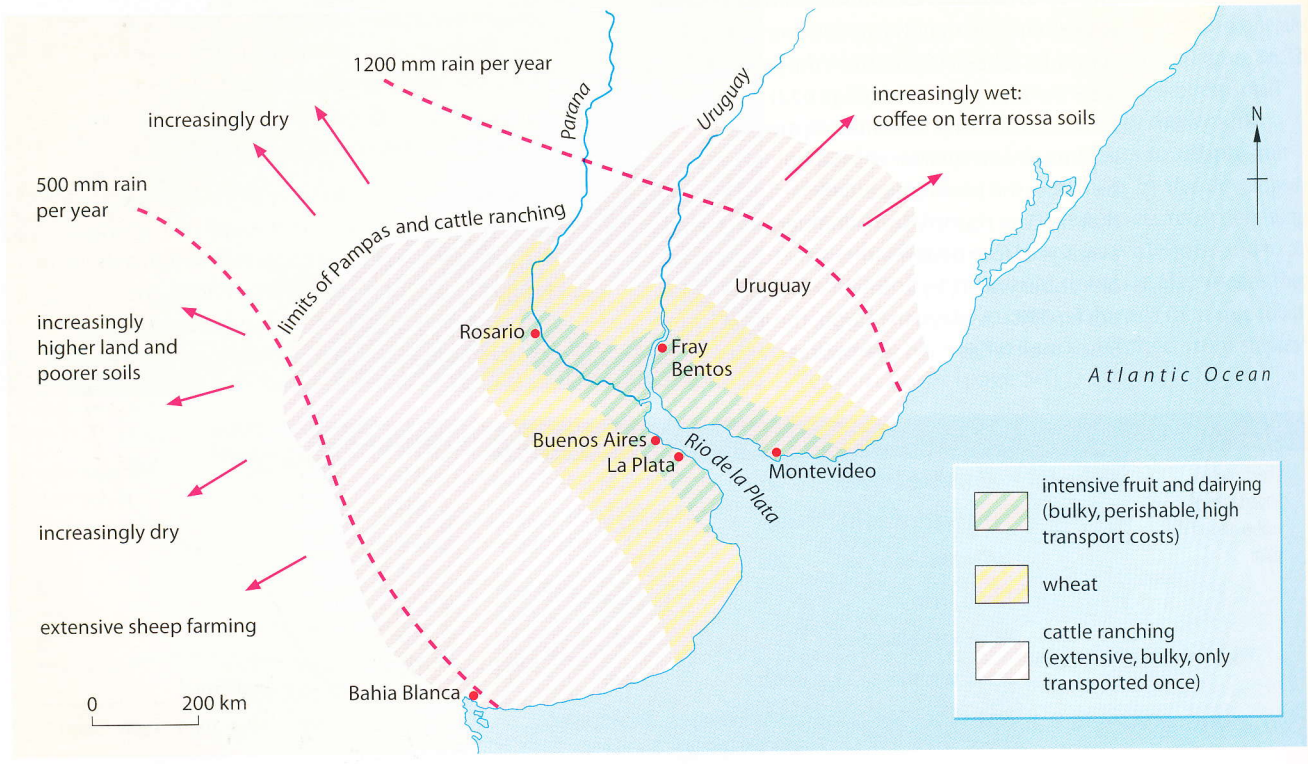


Figure 16.35
Land use on the South American Pampas, an area with a zonation similar to that suggested by von Thünen

cattle when the natural grasses die down in winter. Barbed wire, for field boundaries, was essential where rainfall was insufficient for the growth of hedges. Pedigree bulls were brought from Europe to improve the local breeds and later British Hereford cattle were crossed with Asian Brahmin bulls to give a beef cow capable of living in warm and drier conditions. Initially, due to distances from world markets, cattle were reared for their hides. It was only after the construction of a railway network, linking places on the Pampas to the stockyards (*frigorificos*) at the chief ports of Rosario, Buenos Aires, La Plata and Montevideo on the Rio de la Plata (Figure 16.35), that canned products such as corned beef became important. Later still, the introduction of refrigerated wagons and ships meant that frozen beef could be exported to the more industrialised countries.

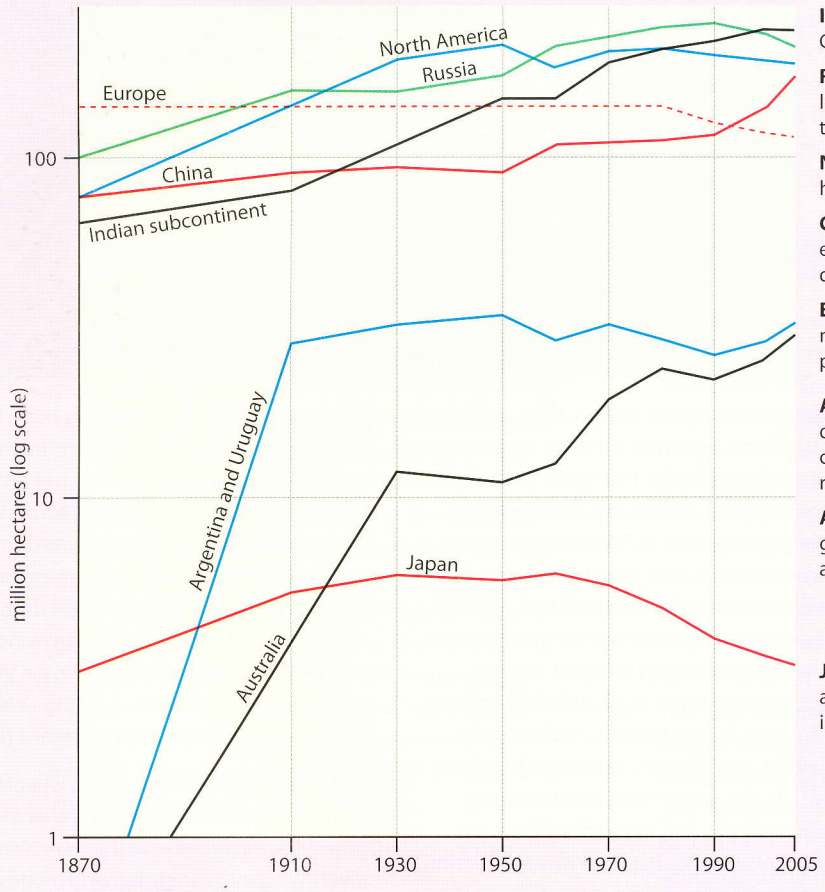
7 Extensive commercial grain farming

As shown on the map of the Pampas (Figure 16.35) and in the von Thünen model (Figure 16.20), cereals utilise the land use zone closer to the urban market than commercial ranching. Grain is grown commercially on the American Prairies (Places 70), the Russian Steppes (Figure 16.6) and parts of Australia, Argentina and north-west Europe (Figure 16.25). In most of these areas, productivity per hectare is low but per farmworker it is high.

It was the introduction and cultivation of new strains of cereals that led to the first permanent settlements (Figure 14.1) and, later, it was a reliance upon these cereals to provide a staple diet which allowed steady population growth in Europe, Russia and South-east Asia (Figure 16.36). A demand for increased cereal production came, in the mid-19th century, from those countries experiencing rapid industrialisation and urban growth. This demand was met following the building of railways in Argentina, Australia and across North America (Figure 16.36). More recent demands have, so far, been met by the Green Revolution in South-east Asia (page 504) and increases in irrigation and mechanisation.

Figure 16.36

Changes in the world's arable areas, 1870–2005



Indian subcontinent: growth due to Green Revolution; now stable

Russia: more mechanised, cultivating new lands, irrigation, 5-year plans; recently land taken out of production

North America: overproduction, bad harvests about 1960

China: increase in late 1950s due to expansion of communes and since 1990s due to a rise in standard of living

Europe: most land used in 19th century, now a decline due to urbanisation and EU policies

Argentina and Uruguay: rapid increase due to railways; decline due to increasing costs of transport to overseas markets; recent demand from China

Australia: rapid increase due to railways, growing population (recently), irrigation and world demand

Japan: only a limited amount of land available (competition from housing and industry); rice provides a higher yield

Places 70 The Canadian Prairies: extensive commercial arable farming

The Prairies have already been referred to in the optima and limits model (Figure 16.3). Although this area has many favourable physical characteristics, it also has disadvantages (Case Study 12B). Wheat, the major crop, ripens well during the long, sunny, summer days, while the winter frosts help to break up the soil. However, the growing season is short and in the north falls below the minimum requirement of 90 days. Precipitation is low, about 500 mm, but though most of this falls during the growing season there is a danger of hail ruining the crop, and droughts occur periodically. The winter snows may come as blizzards but they do insulate the ground from severe cold and provide moisture on melting in spring. The chinook wind (page 241) melts the snow in spring and helps to extend the growing season, but tornadoes in summer can damage the crop. The relief is gently undulating, which aids machinery and transport. The grassland vegetation has decayed over the centuries to give a black (chernozem – page 327) or very dark brown (prairie) soil (page 328). However, if the natural vegetation is totally removed, the soil becomes vulnerable to erosion by wind and convectional rainstorms.

Figure 16.37 Extensive commercial cereal farming on the Canadian Prairies

When European settlers first arrived, they drove out the local Indians, who had survived by hunting bison, and introduced cattle. The world price for cereals increased in the 1860s and demand from the industrialised countries in Western Europe rose. The trans-American railways were built in response to the increased demand (and profits to be made) and vast areas of land were ploughed up and given over to wheat. The flat terrain enabled straight, fast lines of communication to be built (essential as most of the crop had to be exported) and the land was divided into sections measuring 1 square mile (1.6 km^2). In the wetter east, each farm was allocated a quarter or a half section; while in the drier west, farmers received at least one full section.

The input of capital has always been high in the Prairies as farming is highly mechanised (Figure 16.37). Mechanisation has reduced the need for labour although a migrant force, with combine harvesters, now travels northwards in late summer as the cereals ripen. Seed varieties have been improved, and have been made disease-resistant, drought-resistant and faster-growing. Fertilisers and pesticides are used to increase yields and the harvested wheat is stored in huge elevators while awaiting transport via the adjacent railway.

In the last three decades, spring wheat has become less of a dominant crop and the area on which it is grown has decreased considerably, with many farms diversifying into canola (second biggest crop), barley, sugar beet, dairy produce and beef (Case Study 12B).

8 Intensive commercial (mixed) agriculture

This corresponds with von Thünen's inner zone where dairying, market gardening (horticulture) and fruit all compete for land closest to the market. All three have high transport costs, are perishable, bulky, and are in daily demand by the urban population. Similarly, all three require frequent attention, particularly dairy cows which need milking twice daily, and market gardening. Although this type of land use is most common in the eastern USA and north-west Europe (Places 71), it can also be found around every large city in the world. Intensive commercial farming needs considerable amounts of capital to invest in high technology, and numerous workers: it is labour intensive. The average farm size used to be under 10 ha but recently this has been found to be uneconomic and amalgamations have been encouraged by the American government and the EU in order to maximise profits. This type of farming gives the highest output per hectare and the highest productivity per farmworker.

Food surpluses

As farming in the more developed countries of North America and the EU continued to become more efficient, output increased. Farmers were paid subsidies, or a guaranteed minimum price, for their produce. The result was the overproduction of certain commodities for the American and European markets. Although food surpluses are needed for trade to take place, the issue is the unit cost at which the surpuses are produced. The problem arises when surpluses are produced at costs and subsidised prices that are above world market prices. This means that the commodities can only be sold on at a further subsidised price which then either distorts world markets or makes them inaccessible to developing countries. During the 1980s and 1990s, the EU introduced a variety of measures to try to limit the production of surplus products. These included fixed quotas on milk production, with penalties for overshoots; limits on the area of crops or number of animals for which the farmer could claim subsidies; and – voluntary at first but later compulsory – set-aside, which obliged farmers to leave a proportion of their land uncultivated (page 493). Since 2000, the EU has also encouraged farmers to restructure their farms, to diversify and to improve their product marketing. Farmers are, therefore, no longer paid just to produce food. Today's CAP is demand driven and takes into account consumers' and taxpayers' concerns while still giving farmers the freedom to produce what the market needs but not to receive subsidies on products that are overproduced. In addition, farmers have to respect environmental (page 496), food safety and animal welfare standards. These initiatives have meant that over time the EU has managed to reduce its use of export subsidies while managing to maintain, and in some cases even increase, its agricultural exports. Even so the EU remains a net importer of farm products.

Places 71 The western Netherlands: intensive commercial farming

Most of the western Netherlands, stretching from Rotterdam to beyond Amsterdam, lies 2–6 m below sea-level. Reclaimed several centuries ago from the sea, peat lakes or areas regularly flooded by rivers, this land is referred to as the **old polders**. Today, they form a flat area drained by canals which run above the general level of the land. Excess water from the fields is pumped (originally by windmills) by diesel and electric pumps into the canals. With 469 persons per km^2 in 1998 (compared with only 360 in 1975), the Netherlands has the highest population density in Europe. Consequently, with farmland at a premium, the cost of reclamation so high and the proximity of a large domestic urban market, intensive demands are made on the use of the land (Figure 16.38).

There are three major types of farming on the old polders.

- Dairying is most intensive to the north of Amsterdam, in the 'Green Heart' and in the south-west of Friesland. It is favoured by mild winters, which allow grass to grow for most of the year; the evenly distributed rainfall, which provides lush grass; the flat land; and the proximity of the Randstad conurbation. Most of the cattle are Friesians. Some of the milk is used fresh but most is turned into cheeses (the well-known Gouda and Edam) and butter. Most farms have installed computer systems to control animal feeding.
- The land between The Hague and Rotterdam (Figure 16.38) is a mass of glasshouses where **horticulture** is practised on individual holdings averaging only 1 ha. The cost of production is exceptionally high. Oil and natural gas-fired central heating maintain high temperatures and

sprinklers provide water. Heating, moisture and ventilation are all controlled by computerised systems. Machinery is used for weeding and removing dead flowers, and the soils are heavily fertilised and manured. Sometimes plants are grown through a black plastic mulch (heat-absorbing) which has the effect of advancing their growth and thus extending the cropping season to meet market demand for fresh produce. Several crops a year can be grown in the glasshouses, i.e. cut flowers in spring, tomatoes and cucumbers in summer, and lettuce in autumn and winter.

- The sandier soils between Leiden and Haarlem are used to grow **bulbs**. Tulips, hyacinths and daffodils, protected from the prevailing winds by the coastal sand dunes, are grown on farms averaging 8 ha (Figure 16.39). The flowers form a tourist attraction, especially in spring, and bulbs are exported all over Europe from nearby Schipol Airport.

Figure 16.38
Agricultural land use in the western Netherlands

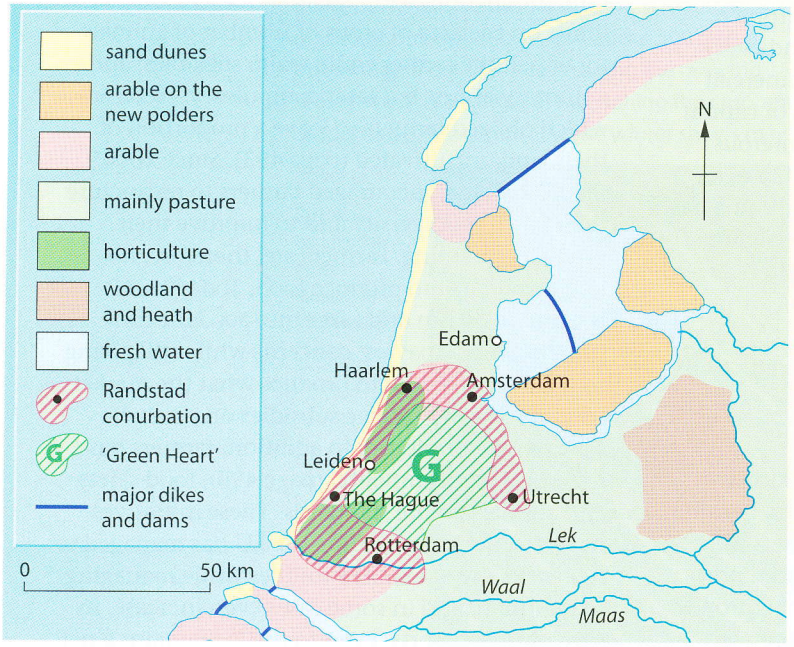


Figure 16.39
Intensive farming on reclaimed polder land in the western Netherlands

9 Mediterranean agriculture

A distinctive type of farming has developed in areas surrounding the Mediterranean Sea. Winters are mild and wet, allowing the growth of cereals and the production of early spring vegetables or *primeurs*. Summers are hot, enabling fruit to ripen, but tend to be too dry for the growth of cereals and grass. As rainfall amounts decrease and the length of the dry season increases from west to east and from north to south, irrigation becomes more important. River valleys and their deltas (the Po, Rhône and Guadalquivir) provide rich alluvium, but many parts of the Mediterranean are mountainous with steep slopes and thin rendzina soils (page 274). Due to earlier deforestation, many of these slopes have suffered from soil erosion. Frosts are rare at lower levels, though the cold mistral and bora winds may damage crops (Figure 12.22).

Farming tends to be labour intensive but with limited capital. There are still many absentee landlords (latifundia, page 466) and outputs per hectare and per farmworker are usually low. Most farms tend to be small in size.

Land use (Figure 16.21) shows the importance of tree crops such as olives, citrus and nuts, while land use frequently illustrates that crops which need most attention are grown nearest to the farmhouse or village, and that land use is more closely linked to the physical environment than controlled by human inputs (Places 72). Many village gardens and surrounding fields are devoted to citrus fruits, such as oranges, lemons and grapefruit, as these have thick waxy skins to protect the seeds and to reduce moisture loss. These fruits are also grown commercially where water supply is more reliable, e.g. oranges in Spain around Seville and on *huertas* (irrigated farms) near Valencia, lemons in Sicily and grapefruit in Israel. Recently there has been a rapid increase in the use of polythene, especially in south-east Spain, where the area around Almeria has become known as the 'Costa del Polythene', and in Israel. The polythene, which is stretched across 3 m high poles, creates a hothouse environment suitable for the growth of tomatoes and other crops such as melons, green beans, peppers and courgettes. The crops are harvested twice yearly, usually when they are out of season in more northerly parts of Europe.

Vines, another labour-intensive crop, and olives, the 'yardstick' of the Mediterranean climate, are both adapted to the physical conditions. They tolerate thin, poor, dry soils and hot, dry summers by having long roots and protective bark. Wheat may be grown in the wetter winter period in fields further from the village as it needs less attention, while sheep and goats are reared on the scrub and poorer-quality grass of the steeper hillsides. Grass becomes too dry in summer to support cattle and so milk and beef are scarce in the local diet.

Apart from central Chile, other areas experiencing a Mediterranean climate have developed a more commercialised type of farming based upon irrigation and mechanisation. Central California supports agribusiness based on a large, affluent, domestic market which is, in terms of scale, organisation and productivity, the ultimate in the capitalist system. Southern Australia produces dried fruit to overcome the problem of distance from world markets. All Mediterranean areas have now become important wine producers.

Places 72 The Peloponnese, Greece: Mediterranean farming

Figure 16.40 is a transect, typical of the Peloponnese and many other Mediterranean areas, showing how relief, soils and climate affect land use and farming types. The area next to the coast, unless taken over by tourism, is farmed intensively and commercially (Figure 16.41). As distance from the coast increases, farming becomes more extensive and eventually, before the limit of cultivation, at a subsistence level (Figure 16.42).

Figure 16.40
Land use and farming types in the Peloponnese (not to scale)

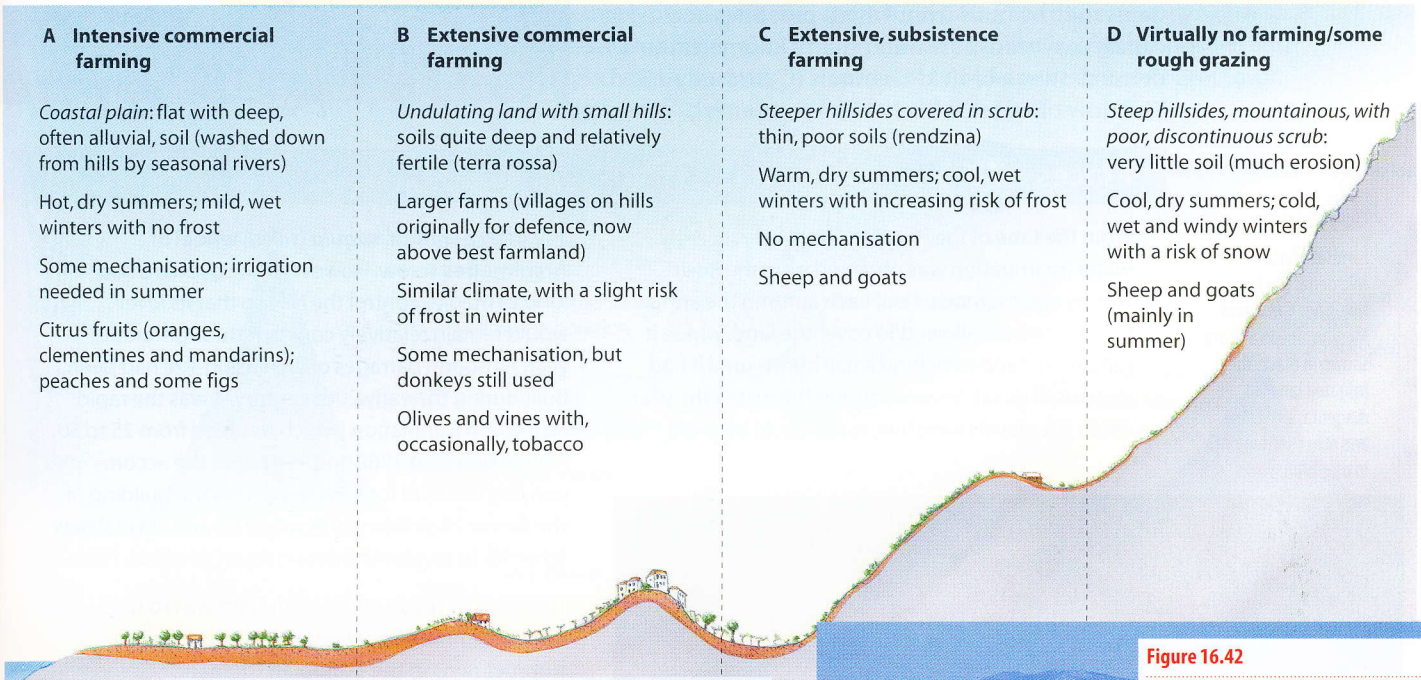


Figure 16.41
Intensive fruit, mainly oranges, next to the coast, settlement on higher, less fertile land in mid-distance, and deforested hills in the background: near Navplion in the Peloponnese

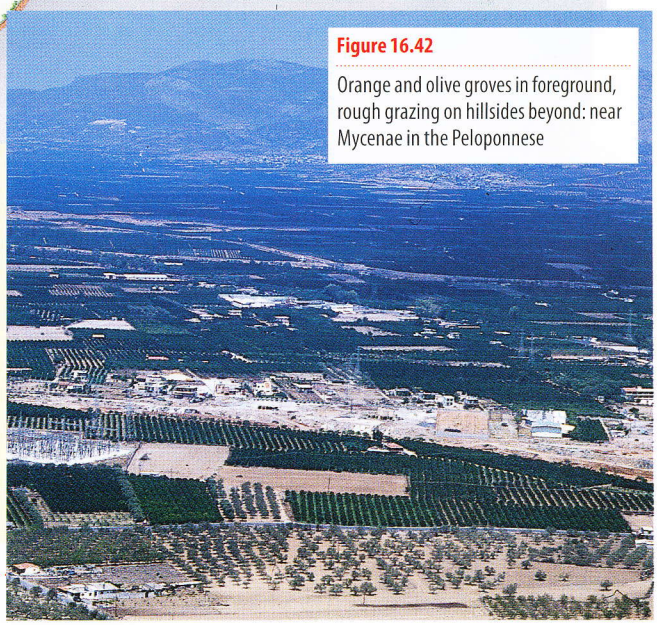


Figure 16.42
Orange and olive groves in foreground, rough grazing on hillsides beyond: near Mycenae in the Peloponnese

10 Irrigation

Irrigation is the provision of a supply of water from a river, lake or underground source to enable an area of land to be cultivated (Figure 16.43). It may be needed where:

1 rainfall is limited and where evapotranspiration exceeds precipitation, i.e. in semi-arid and arid lands such as the Atacama Desert in Peru (Places 24, page 180) and the Nile valley (Places 73)
2 there is a seasonal water shortage due to drought, as in southern California with its Mediterranean climate (Case Study 15A)
3 amounts of rainfall are unreliable, as in the Sahel countries (Figure 9.28)
4 farming is intensive, either subsistence or commercial, despite high annual rainfall totals, e.g. the rice-growing areas of South-east Asia.

In economically more developed countries, large dams may be built from which pipelines and canals may transport water many kilometres to a dense network of field channels (Case Study 17). The flow of water is likely to be computer-controlled. Unfortunately, it is the economically less developed countries, lacking in capital and technology, that suffer most severely from water deficiencies. Unless they can obtain funds from overseas, most of their schemes are extremely labour intensive as they have to be constructed and operated by hand.

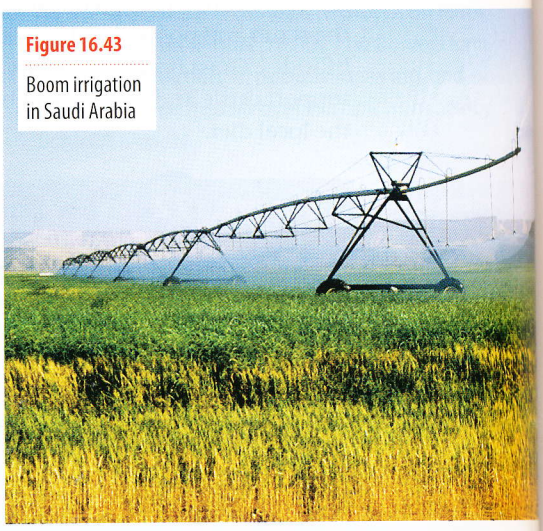


Figure 16.43 Boom irrigation in Saudi Arabia

Places 73 The Nile valley: irrigation

From the time of the Pharaohs until very recently, water for irrigation was obtained from the River Nile by two methods. First, each autumn the annual floodwater was allowed to cover the land, where it remained trapped behind small bunds until it had deposited its silt. Second, during the rest of the year when river levels were low, water could be lifted 1–2 m by a ***shaduf***, ***saquia*** (*sakia*) **wheel** or **Archimedes screw**. However, the Egyptians had long wished to control the Nile so that its level would remain relatively constant throughout the year. Although barrages of increasing size had been built during the early 20th century, it was the rapid increase in population (which doubled from 25 to 50 million between 1960 and 1987) and the accompanying demand for food that led to the building of the Aswan High Dam (opened 1971) and several new schemes to irrigate the desert near Cairo (late 1980s).

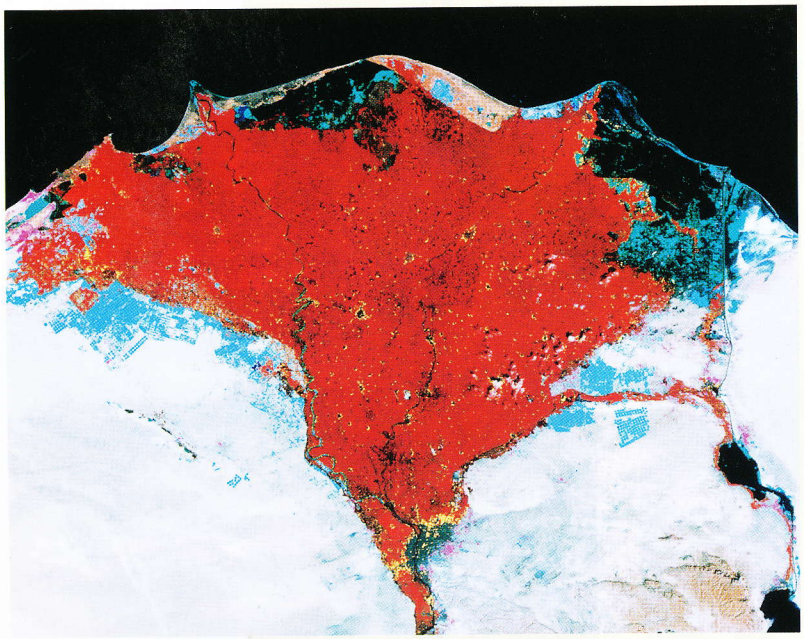


Figure 16.44 Landsat photo of the Nile delta: the River Nile, Suez Canal and Mediterranean Sea are shown in black, the irrigated lands in magenta, and Cairo and other settlements in pale blue

The main purpose of the High Dam was to hold back the annual floodwaters generated by the summer rains in the Ethiopian Highlands. Some water is released throughout the year, allowing an extra crop to be grown, while any surplus is saved as an insurance against a failure of the rains. The river regime below Aswan is now more constant, allowing trade and cruise ships to travel on it at all times. Two and sometimes three crops can now be grown annually in the lower Nile valley (Figure 16.44). Yields have increased and extra income is gained from cash crops of cotton, maize, sugar cane, potatoes and citrus fruits. The dam incorporates a hydro-electric power station which provides Egypt with almost a third of its energy needs for domestic and industrial purposes. Lake Nasser is important for fishing and tourism.

Following the construction of the Aswan High Dam (Figure 16.45), Egypt has modernised its methods of irrigation. Electricity is now used to power pumps which, by raising water to higher levels, allow a strip of land up to 12 km wide on both sides of the Nile to be irrigated. **Drip irrigation** utilises plastic pipes in which small holes have been made; these are laid over the ground and water drips onto the plants in a much less wasteful manner, as less evaporates or drains away. Between the Nile and the Suez Canal, **boom irrigation** has been introduced (Figure 16.43 shows this method in use in Saudi Arabia), creating fields several hectares in diameter. However, the Dam has created several problems.

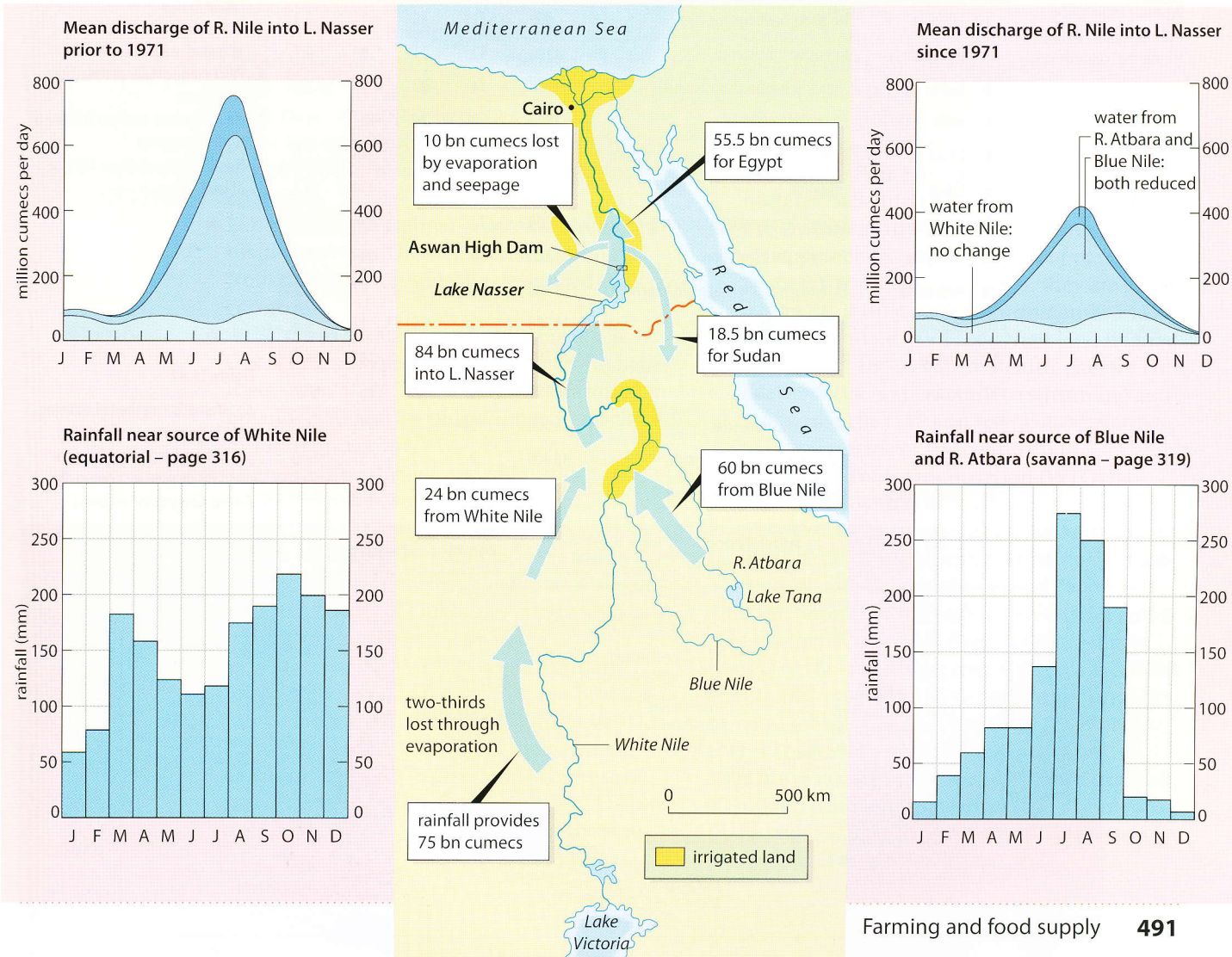
Environmental

The cessation of the summer Nile flood has also meant the ending of the annual deposition of fertile silt on the fields, which in turn means that fertiliser now has to be added. Without its supply of sediment, which included silt and sand, the delta has begun to retreat, causing a loss of tourist beaches, the threat of saltwater contaminating existing irrigation schemes and – not envisaged when the Dam was originally built – less protection against the rising sea-level of the Mediterranean which is resulting from global warming. The number of bilharzia snails has also risen due to the greater number of irrigation channels, while moisture in the air, caused by evaporation over Lake Nasser, is affecting ancient buildings.

Economic and social

Farmers have been encouraged to grow cash crops for export instead of providing a better diet for themselves, and their costs have increased due to the need to buy fertiliser. The area of land under irrigation has actually decreased since the Dam was built due to the increased effects of salinisation (page 273 and Figure 16.53) and clay is less easy to find for making sun-baked bricks in the traditional manner. More recently, great concern has been raised over rising damp and the deposition of salt (salt crystallisation, page 40), resulting from the constantly higher river level, in the foundations of temples and other buildings dating from the time of Ancient Egypt.

Figure 16.45
The Nile: sources and uses of water



Farming types and economic development

Throughout the section on types of farming, several fundamental assumptions have been made. These include the generalisations that: 'the poorest countries are those which, because they have the lowest inputs of capital and technology, have the lowest outputs'; and 'the wealthier countries are those which can afford the highest inputs, giving them the maximum yield, or profit, per person'. Is it really possible to make a simple correlation between wealth (the standard of living) and the type of agriculture?

Figure 16.46 shows 15 countries selected (not chosen randomly) as representing the main types of farming and used as examples in the previous section. Using the five variables A–E, it is possible to postulate four hypotheses:

1 The less developed a country (i.e. the lower its GDP/GNP per capita – see pages 604 and 606), the greater the percentage of its population involved in agriculture.
2 The less developed a country, the greater the percentage of its GDP/GNP is made up from agriculture.
3 The less developed a country, the less fertiliser it will use.
4 The less developed a country, the less mechanised will be its farming (fewer tractors per head of population, for example).

Figure 16.47 shows schematically possible links between farming and economic development. As with all data, there are considerations which you should remember when drawing conclusions from Figure 16.46.

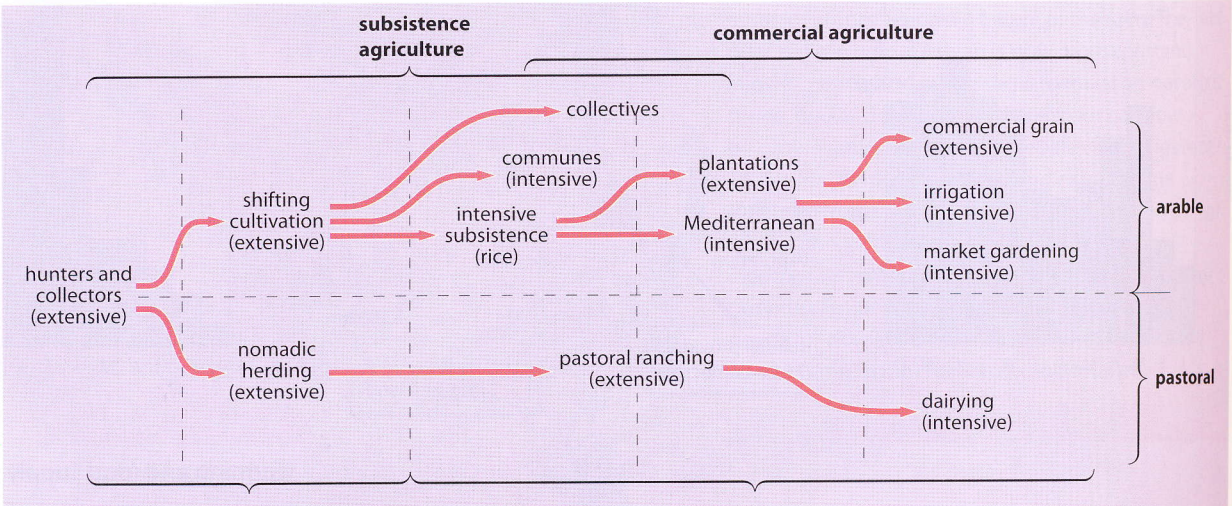
- The countries were selected with some bias in order to cover all the main types of farming.
- GDP/GNP is not the only indicator of wealth or development (pages 607–608).
- GDP/GNP figures are not necessarily accurate and may be derived from different criteria (page 606).
- There may be several different types of farming in each country.

Figure 16.46
Types of farming, GDP and agricultural data for selected countries

	Country	Major farming type	A	B	C	D	E
1	Ethiopia	Nomadic herding	800	81	46	12	0.3
2	Bangladesh	Intensive subsistence	1300	52	21	88	0.7
3	Kenya	Nomadic herding/subsistence	1700	74	27	31	2.8
4	India	Intensive subsistence	2700	58	20	101	15.7
5	China	Intensive subsistence/centrally planned	5300	54	16	278	7.0
6	Egypt	Irrigation	5500	31	15	434	30.7
7	Uruguay	Extensive commercial ranching	1600	12	11	94	24.2
8	Malaysia	Commercial plantation	13 300	16	9	683	24.1
9	Argentina	Extensive commercial grain/ranching	13 500	9	10	27	10.7
10	Russia	Centrally planned	14 700	9	5	12	4.8
11	Greece	Mediterranean	29 700	15	7	149	94.5
12	Spain	Mediterranean	30 100	6	4	157	68.7
13	UK	Intensive commercial	35 100	2	1	311	88.3
14	Canada	Extensive commercial/grain	38 400	2	2	57	16.0
15	Netherlands	Intensive commercial/mixed	38 500	3	2	478	163.9

A Gross domestic product (GDP) per capita in US$
B Percentage of population engaged in agriculture
C Percentage of GDP derived from agriculture
D Kg of fertiliser used per hectare of agricultural land
E Number of tractors per 1000 ha of land

Figure 16.47
An alternative method of showing links between types of farming and levels of economic development (as devised by a group of A-level Geography students)



The EU – an example of a supra-national agricultural policy

Member countries of the EU are meant to implement the Common Agricultural Policy (CAP) by which most major decisions affecting farming are made in Brussels and not by individual countries or by individual farmers. The five basic aims of the CAP were to:

1 increase agricultural productivity and to improve self-sufficiency
2 maintain jobs on the land, preferably on family farms
3 improve the standard of living (income) of farmers and farmworkers
4 stabilise markets
5 keep consumer food prices stable and reasonable.

Although many of these aims had been fulfilled by the early 1990s, there was increasing concern over both the running and the effects of the CAP.

- 70 per cent of the EC's (as it was then) budget was spent supporting farming when agriculture only provided 5 per cent of the EC's total income.
- As farmers were encouraged, and were helped by improved technology, to produce as much as possible, large surpluses were created (page 487).
- Imports were subject to duties to make them less competitive with EC prices. This handicapped the economically less developed countries.
- EC farmers were granted generous subsidies to maintain prices. This helped restrict imports from non-EC economically developed countries.
- As EC farms became larger and more efficient, it was the more prosperous farmers who benefited, often at the expense of those farming in upland areas and on the periphery, especially in southern Europe.
- There was insufficient regard for the environment.

Since 1992 the CAP has undergone a series of reforms in order to solve some of these problems and has introduced policies aimed at encouraging the de-intensification of farming and the protection of the environment.

- **Subsidies** guaranteed farmers a minimum price and an assured market for their produce. Farmers tended, therefore, to overproduce (hence the EU surpluses), and the payment of subsidies became a drain on EU finances. Since the 1990s, steps have been taken to limit the production of surplus products either by reducing subsidies for them or, in some cases, imposing penalties (page 487). In the early 1990s, the EU began a programme of progressive reductions of subsidies in cereal, beef and other commodities which has led, over time, to the elimination of the so-called 'mountains and lakes' surpluses of agricultural products. Even so, in 2006 the CAP still accounted for 45 per cent of the EU's total budget.
- **Quotas** were introduced in 1984 to reduce milk output. These, like subsidies, have been gradually phased out and, as announced in 2006, will end by 2015. To try to reduce the impact on dairy farmers (Figure 16.48), the EU has proposed five annual quota increases between 2008 and 2013.
- **Set-aside** was initially introduced on a voluntary basis, but later enforced, to try to reduce overproduction of arable crops. Farmers who took 20 per cent of their cultivated land out of production (pasture and fallow were not included) were given £20 a hectare, provided that the land was either left fallow, turned into woodland (under the Farm Woodland Management Scheme) or diversified into other non-agricultural land uses such as golf courses, nature trails, wildlife habitats and caravan parks. By the early 2000s, there was little surplus production and so when 2007–08 saw a rapid global increase in food prices, the EU fixed the set-aside rate at zero. This meant that British farmers could bring up to 5 million hectares back into production.
- **Environmentally friendly farming** is a new EU approach by which, instead of paying farmers to produce more food, they are given payments if they meet environmental and animal standards and keep their land in good condition – the so-called '**health check**'. This health check is an attempt to streamline and modernise the CAP and to encourage farmers to be 'guardians of the countryside'.
- The **World Trade Organisation (WTO)** has been trying, with minimum success (pages 627–629), to encourage the EU, and other well-off trade blocs, to reduce tariffs, quotas and subsidies so as to help the developing countries.

The CAP reforms of the early 2000s did not anticipate the increased global needs to fight climate change (page 256), to improve water management and supply (page 610), to satisfy the growing demand for biocrops as a source for renewable energy (page 543), or the rise in food prices. In 2008 it was claimed that even within the EU itself, 43 million people were at risk of food poverty – that is, they had less than one meal in two days that included meat, chicken or fish.

Figure 16.48
Problems for dairy farmers, 2008

UK dairy farmers on brink of collapse

UK dairy farmers lose an average of 4.7p on every pint of milk they produce, giving the average dairy farm an annual loss of £37,600, new figures show.

The figures from First Milk, a farmer-owned dairy business that supplies more than 1.8 bn litres of milk a year, lay bare the desperate plight of the UK dairy industry.

According to a report out today, the average price paid to a farmer for a litre of milk over the year to March 31 2007 was 17.5p. However, the cost of producing this milk was 22p. This 4.7p loss multiplied by the 800,000 litres that the average farm produces each year equates to £37,600.

The UK dairy industry has been shrinking rapidly since 2000. Around 11pc of the national herd has disappeared in the past five years, while farmer numbers are reducing at the rate of 6.5pc a year.

First Milk is calling for the introduction of a new formula to calculate a 'consistently fair price' for milk. The formula should take into account rising production costs, labour costs on the farm and should include a profit margin so that farmers can reinvest in their businesses.

It says that farmers should be paid 29.6p a litre for their milk this year.

The report – called *The Real Price of Milk* – details the rising costs that have been absorbed by farmers in recent years, including animal feed, fertiliser and fuel. These rising costs were equivalent to an extra £36,000 a year since 2006.

Daily Telegraph, 3 March 2008

Figure 16.49
A rural landscape with trees and hedges, Dorset

Farming and the environment

Numerous pressure groups are claiming that the traditional British countryside is being spoilt, yet the countryside of today is not 'traditional' – it has always been changing. The primeval forests, regarded as Britain's climatic climax vegetation (page 286), were largely cleared, initially for sheep farming and later for the cultivation of cereals. Although there is evidence that hedges were used as field boundaries by the Anglo-Saxons, it was much later that land was 'enclosed' by planting hedges and building dry-stone walls (page 397). It is this 18th- and 19th-century landscape which has become looked upon, incorrectly, as the traditional or natural environment (Figure 16.49). However, the rate of change has never been faster than in recent years. Estimates by the Nature Conservancy Council suggest that, between 1949 and 1990, 40 per cent of the remaining ancient broadleaved woodlands, 25 per cent of hedgerows, 30 per cent of heaths, 60 per cent of wetlands and 30 per cent of moors have 'disappeared'. While most accusing fingers point to the intensification of agriculture, together with afforestation and building programmes, as the major causes, it should be remembered that farmland too is under threat from rival land users (Figure 17.4).

Farming as a threat to the environment

a The use of chemicals

Fertiliser, slurry and pesticides all contribute to the pollution of the environmental system. Fertiliser, in the form of mineral compounds which contain elements essential for plant growth, is widely used to produce a healthy crop and increase yields. If too much nitrogenous fertiliser or animal waste (manure) is added to the soil, some remains unabsorbed by the plants and may be leached to contaminate underground water supplies and rivers. Where chemical fertiliser accumulates in lakes and rivers, the water becomes enriched with nutrients (eutrophication) and the ecosystem is upset (Figure 16.50). In parts of north-west Europe, levels of nitrates in groundwater are above EU safety limits and over 80 per cent of lowland areas in the UK are said to be affected.

In Britain, the Water Authorities claim that slurry (farmyard effluent) is now the major pollutant of, and killer of life in, rivers. After several decades in which the quality of river water had improved, the last few years have seen levels of pollution again increasing, especially in farming areas.

Figure 16.50
How eutrophication can upset the ecosystem

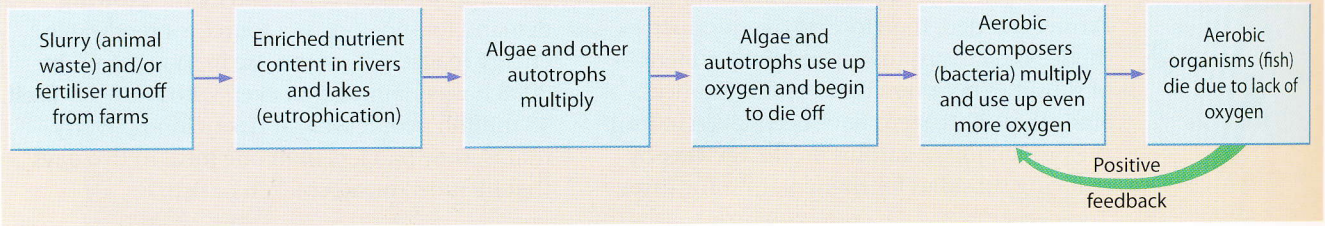


Figure 16.51

The case for and against hedgerows and ponds in a rural area

For	Against
Hedgerows	
Form part of the attractive, traditional British landscape	Are not traditional and were initially planted by farmers
Form a habitat for wildlife: birds, insects and plants (Large Blue butterfly is extinct, 10 other species are endangered)	Harbour pests and weeds
Act as windbreaks (and snowbreaks)	Costly and time-consuming to maintain
Roots bind soil together, reducing erosion by water and wind	Take up space which could be used for crops
	Limit size of field machinery (combine harvesters need an 8 m turning circle)
Ponds	
Form a habitat for wildlife: birds, fish and plants	Take up land that could be used more profitably
Add to the attractiveness of the natural environment	Stagnant water may harbour disease
i.e. Concern is environmental	**i.e. Concern is economic**

Pesticides and herbicides are applied to crops to control pests, diseases and weeds. Estimates suggest that, without pesticides, cereal yields would be reduced by 25 per cent after one year and 45 per cent after three. The Friends of the Earth claim that pesticides are injurious to health and, although there have been no human fatalities reported in Britain in the last 15 years, there are many incidents in developing countries resulting from a lack of instruction, fewer safety regulations and faulty equipment. A UN report claims that 25 million agricultural workers in developing countries (3 per cent of the total workforce) experience pesticide poisoning each year. Pesticides are blamed for the rapid decrease in Britain's bee and butterfly populations, and an up to 80 per cent reduction in 800 species of fauna in the Paris basin. Pesticides can dissipate in the air as vapour, in water as runoff, or in soil by leaching to the groundwater.

Figure 16.52

An agricultural landscape without trees or hedges, Cambridgeshire

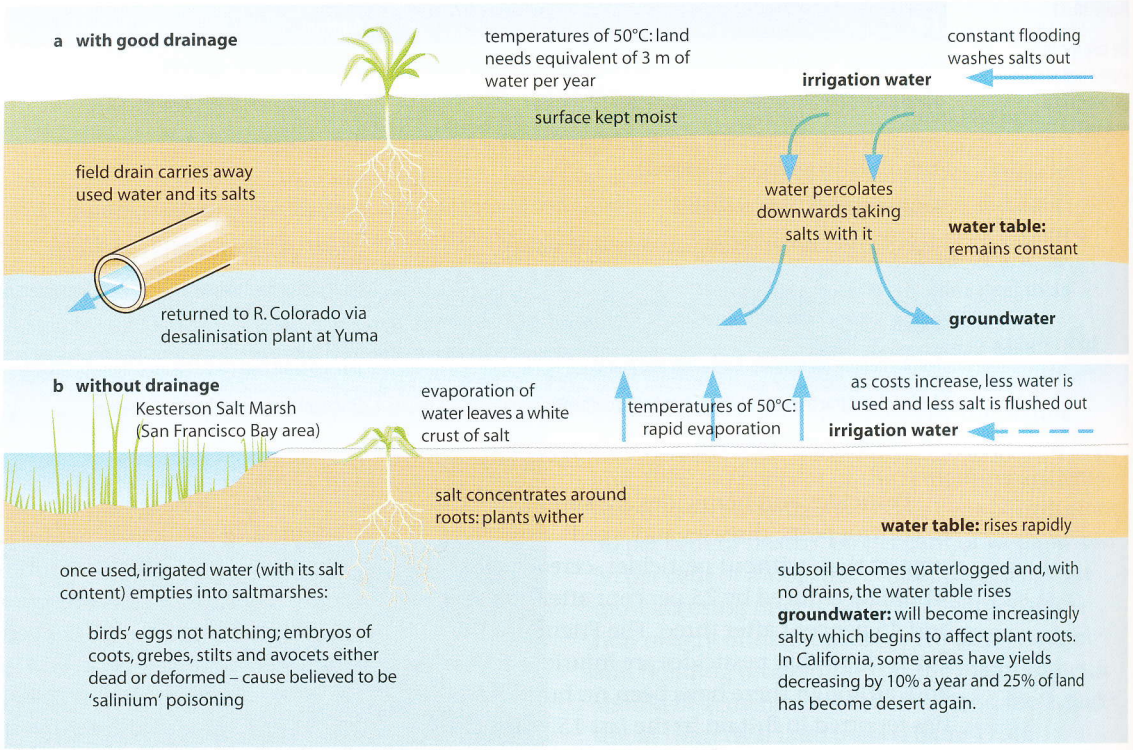
b The loss of natural habitats

The most emotive outcries against farmers have been at their clearances of hedges, ponds and wetlands. These clearances mean a loss of habitat for wildlife and a destruction of ecosystems, some of which may have taken centuries to develop and, being fragile, may never recover or be replaced. As stated earlier, over 25 per cent of British hedgerows were removed between 1949 and 1990 – in Norfolk, the figure was over 40 per cent. Figure 16.51 lists some of the arguments for and against the removal of hedgerows and the drainage of ponds/wetlands. Figures 16.49 and 16.52 show the contrast between a landscape with trees and hedges, and one where they have been removed.

Farming can increase soil erosion. The rate of erosion is determined by climate, topography, soil type and vegetation cover (Case Study 10), but it is accelerated by poor farming practices (overcropping and overgrazing) and deforestation. In Britain, wind erosion (Figures 7.8 and 10.34) tends to be restricted to parts of East Anglia and the Fens where the natural vegetation cover, including hedges, has been removed and where soils are light or peaty. Water erosion (page 62) is most likely to occur after periods of prolonged and heavy rainfall, on soils with less than 35 per cent clay content, in large and steeply sloping fields and where deep ploughing has exposed the soil.

Arable farming, especially when ploughing is done in the autumn, removes the protective vegetation cover, increasing surface runoff. The intensification of farming, and overcropping, in areas of highly erodible soils in the USA have led to a decrease in yields and an estimated loss of one-third of the country's topsoil – much of it from the Dust Bowl during the 1930s. Deforestation in tropical rainforests, mountainous and semi-arid areas – Brazil, Nepal and the Sahel, respectively – also accelerates soil erosion.

Figure 16.53
Salinisation in California



Irrigation (Places 73, page 490) also needs the surplus water to be drained away. Without this careful, and often expensive, management, the soil can become increasingly saline and waterlogged (Figure 16.53). As the water table rises it brings, through capillary action (page 261), dissolved salts into the topsoil. These affect the roots of crops, which are intolerant of salt, so that over a period of time they die. Where water is brought to the surface and then evaporates, a crust of salt is left on the surface and the area may revert to desert. To date, only rough estimates have been made of the amount of irrigated land now affected by salinisation, but figures suggest that it may be as high as 40 per cent in Pakistan and Egypt, and 30 per cent in California.

Attempts by farming to improve the environment

a Environmental improvement schemes

The EU and the British government introduced several schemes in which financial incentives were offered to farmers who tried to improve their environment, e.g. set-aside, woodland management and Environmentally Sensitive Area (ESA) schemes (page 493).

Many parts of Britain benefited from set-aside because, when this was in operation, soils that were left under either permanent or rotational fallow with its protective vegetation cover were given the time to improve their humus content, while other areas saw the restoration of ponds, wetlands and other wildlife habitats. The woodland management scheme increased the number of trees and small woods, while the Countryside Commission and the Nature Conservancy Council looked at areas where it was considered that farming landscapes were under threat from changing farming practices. These two parties originally looked at 46 'search' areas which targeted chalk and limestone grasslands, lowland heath, river valleys, coasts, uplands and historic landscapes. From these, 22 were eventually to be designated, at four different stages, as Environmentally Sensitive Areas (ESAs) because of 'their high landscape, wildlife or historic value' (Figure 16.54). Farmers living in ESAs were then invited to join the scheme at one of two levels: a lower level paid on condition that they maintained the existing landscape; and a higher level if they made environmental improvements such as replanting hedges or restoring ponds and traditional farm buildings. This, the Countryside Stewardship Scheme (CSS), was superseded in 2005 by the Environmental Stewardship Scheme (ESS).

Environmental Stewardship is a joint farming-environmental initiative that builds on the success of the former ESAs and Countryside Stewardship schemes. Its primary objectives are to:

- conserve wildlife (biodiversity)
- maintain and enhance landscape quality and character
- protect the historic environment and natural resources

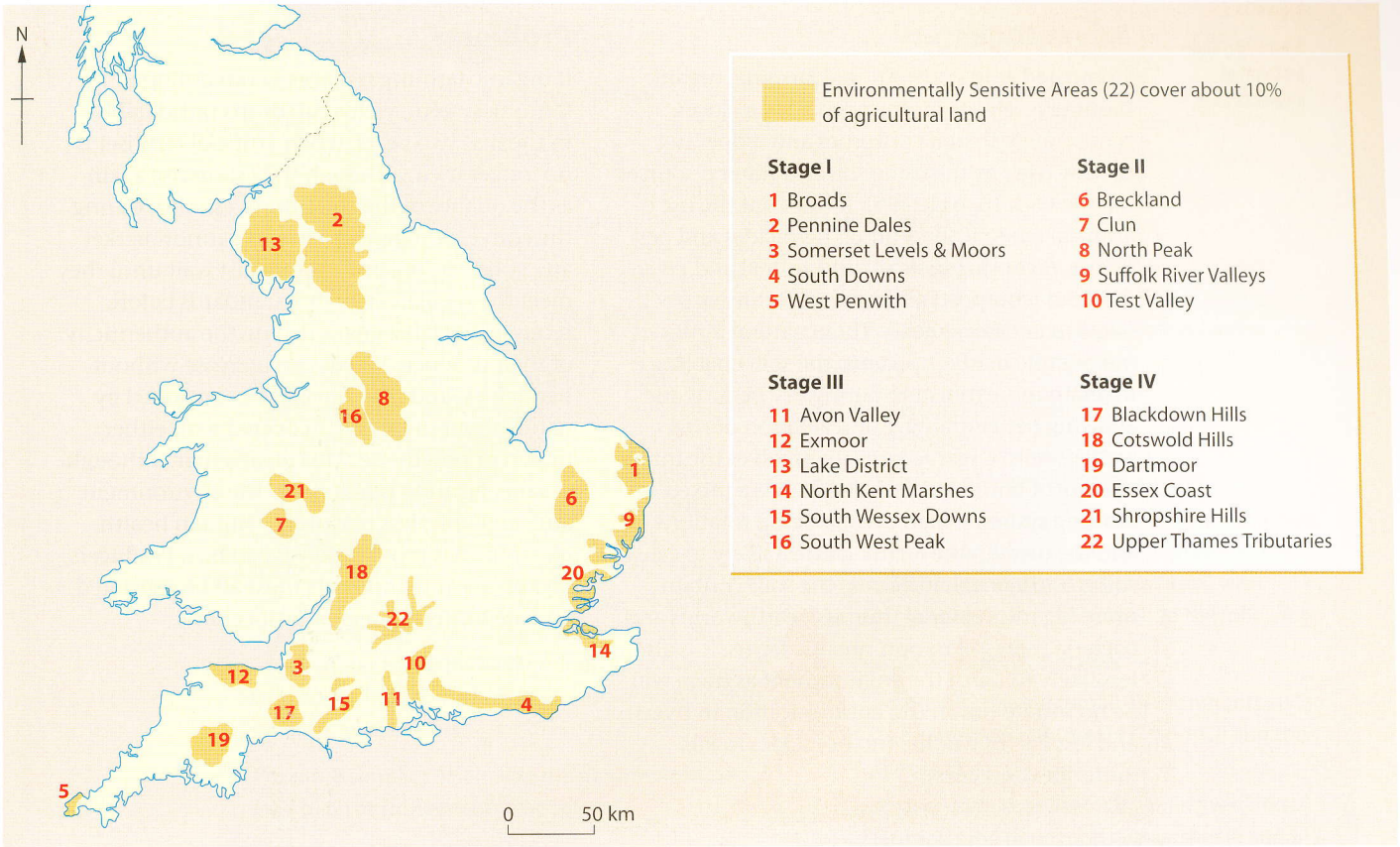


Figure 16.54
Environmentally Sensitive Areas (ESAs) in England and Wales

- promote public access and understanding of the countryside.

Within these primary objectives were the secondary aims of:

- genetic conservation and
- flood management.

There are three levels of stewardship:

- Entry Level Stewardship (ELS) is open to all farmers and landowners and provides a straightforward approach to land management for which payment is £30 per hectare.
- Organic Entry Level Stewardship (OELS) is similar but is geared to organic farming with payments of £60 per hectare (Case Study 16B).
- Higher Level Stewardship (HLS) is designed to build on the first two in that it aims to achieve a wide range of environmental benefits across the farm. As it also concentrates on more complex types of management where landowners need advice and support and where agreements need to be tailored to suit local circumstances, then payments are less rigid.

b Organic farming

Since the mid-1980s there has been a small but increasing number of farmers in Britain and elsewhere who have turned to organic farming (Case Study 16B). Organic farming aims to produce food of high nutrient quality by using management practices that avoid the use of agrochemical inputs and which minimise damage to the environment and to wildlife. As such, it is both self-supporting and an example of sustainable development (Framework 16, page 499). For any food to qualify for the organic label it must adhere to a strict set of rules enforced by a regulatory body, such as the Soil Association.

Figure 16.55 describes both the advantages of organic farming and some of its problems. In the last few years, more British shoppers have been prepared to pay the higher prices asked for organic produce, believing it to be healthier than conventionally produced food. This, together with a greater range of organic brands, has persuaded the giant supermarkets that it is worth their while to stock organic products. However, it will be interesting to see if these shoppers continue to buy 'organic' at a time of rising global food prices and during the 'credit crunch'.

Figure 16.55
Advantages and problems of organic farming

Advantages

Compared with conventional farming, organic farming is self-sustaining in that it produces more energy than it consumes and it does not destroy itself by misusing soil and water resources (Framework 16, page 499). It rules out the use of artificial (chemical) fertiliser, herbicides and pesticides, favouring instead only animal and green manures (compost) and mineral fertilisers (rock salt, fish and bonemeal). These natural fertilisers put organic matter back into the soil, enabling it to retain more moisture during dry periods and allowing better drainage and aeration during wetter spells. Organic farming involves the intensive use of both land and labour. It is a mixed farming system which involves crop rotations and the use of fallow land. It is less likely to cause soil erosion or exhaustion as the soils contain more organic material (humus), earthworms and bacteria than soil in non-organic farms. It is also less likely to harm the environment as there will be no nitrate runoff (no eutrophication in rivers) and less loss of wildlife (no pesticides to kill butterflies and bees).

Problems

If organic farming replaces a conventional farming system, yields can drop considerably in the first two years, when artificial fertiliser is no longer used, although they soon rise again as the quality of the soil improves. Also, during the conversion period, farmers cannot market any goods as 'organic': they must wait until they meet the regulatory body's standards before receiving its label guaranteeing the authenticity of their produce. Weeds can increase without herbicides, and may have to be controlled by hand labour or by being covered with either mulch or polythene. This means that, although organic farming is helpful to the environment and, arguably, less harmful to human health, its produce is more expensive to buy. Producers, processors and importers must all be registered and are subject to regular inspections.

GM crops

The growing of genetically modified (GM) crops is an issue of global concern that has led to the extreme polarisation of opinions held by those in favour and those against. GM crops are a result of a deliberate attempt, using biotechnology, to alter the genetic make-up of a plant with the intention of increasing yields by making it resistant to either disease, pests or a climatic extreme such as drought. At present, nearly all the world's GM crops being grown are in the USA, Argentina, Canada and China (where the world's first GM crop was planted in 1992). In the USA, around 70 per cent of all packaged foods already contain GM material. Of about 40 million hectares of GM crops at present being grown worldwide, most are soya and maize (corn):

	1998	2007 (million ha)
Soya	14	20
Maize	8	12
Oilseed rape	3	4
Sugar beet	1	2
Potatoes	>1	1

The production of GM crops is dominated by several large transnational corporations. They claim that GM crops are essential in order to feed the world's growing population and to combat the rise in global food prices which, with the effects of climate change, they believe is the main cause of the increasing food shortages, especially in sub-Saharan Africa (Places 74 and 75). The TNCs claim that after 30 years of growing GM soya and maize in the USA, there appear to be no ill-effects either to people's health or to the environment, although recent reports suggest that, instead of improving yields of those crops, output has actually fallen by up to 10 per cent. The TNCs also suggest that, apart from reducing hunger, GM crops will reduce the use of weedkillers and insecticides and will provide both cheaper and higher-nutrient food.

But the production of GM crops is opposed by virtually all the main environmental groups, which claim that the crops remain untested and that such crops are not a solution to food shortages as, so far, being grown intensively in developed countries, they seem inappropriate to the needs and demands of up to 400 million subsistence smallholders in many of the world's poorest countries. The environmental groups claim that governments, including that of Britain, are being misled if they believe GM crops will end food shortages, as they neither increase yields nor tackle the fundamental problem of poverty. They also fear that pollen from GM crops is adversely affecting insect wildlife, especially bees and butterflies. This debate is far from over, with DEFRA claiming (2008) that 'while tests in Britain are continuing, no GM crop will be released if there is any doubt about its impact'.

Framework 16 Sustainable development

The concept of sustainable development dominated the environmental agenda during the 1990s and, following the 1992 Earth Summit at Rio de Janeiro, has been embraced by governments at all levels of development. The term is not, however, easy to explain; Dobson, in 1996, claimed that there were over 300 different definitions and interpretations. Of these, the most widely used is that taken from the Brundtland Report (The World Commission on Environment and Development, 1987) which claims that sustainable development 'meets the needs of the present without compromising the ability of future generations to meet their own needs'. This definition, according to Munton and Collins (*Geography*, 1998), 'highlights the socio-economic rather than the environmental basis of sustainable development and, unlike earlier understandings of the term "environmental sustainability", it gives absolute primacy to improving human conditions and not to environmental limits'.

Put more simply, sustainable development should lead to an improvement in people's:

- quality of life, allowing them to become more content with their way of life and the environment in which they live
- standard of living, enabling them, and future generations, to become better off economically.

This may be achieved in a variety of ways:

- by encouraging economic development at a pace that a country can both afford and manage so as to avoid that country falling into debt
- by developing technology that is appropriate to the skills, wealth and needs of local people irrespective of the country's level of development, and developing local skills so that they may be handed down to future generations
- by using natural resources without spoiling the environment, developing materials that will use fewer resources, and using materials that will last for longer – ideally, once a resource is used, it should either be renewed, recycled or replaced.

Sustainable development needs careful planning and, increasingly as it involves a commitment to conservation, the co-operation of groups of countries and, under extreme conditions, global agreement.

Sustainable development is a theme that keeps re-appearing throughout this book. It is a concept that, from a geographer's point of view, can be studied:

- through a selection of physical and human environments
- at a variety of levels of development

in the context of people and food supply, resources, and natural and human created/adapted environments. Examples referred to in this book, with chapter numbers in brackets, include the following:

- **People and environments**
  - world biomes and fragile environments such as the tropical rainforest (11 and 12) and the tundra (5)
  - smaller-scale ecosystems including wetlands (16) and sand dunes and saltmarshes (6 and 11)
  - effects of economic development on scenic areas and the wildlife of coastal and mountainous areas (6, 17 and 20)
- **People and resources**
  - finite resources of fossil fuels (18) and minerals (17)
  - renewable resources, providing that they are carefully managed, including soils (10); fresh and reliable water supply (3 and 21); forests (11 and 17); crops and food supply (16); energy (18); recycled materials (19); and the atmosphere (9)
  - ecological footprint (13) and carbon credits (21)
- **Socio-economic**
  - population growth and family planning (13)
  - urban growth/loss of countryside (15)
  - housing materials (15 and 19)
  - development of skills and levels of education (21).

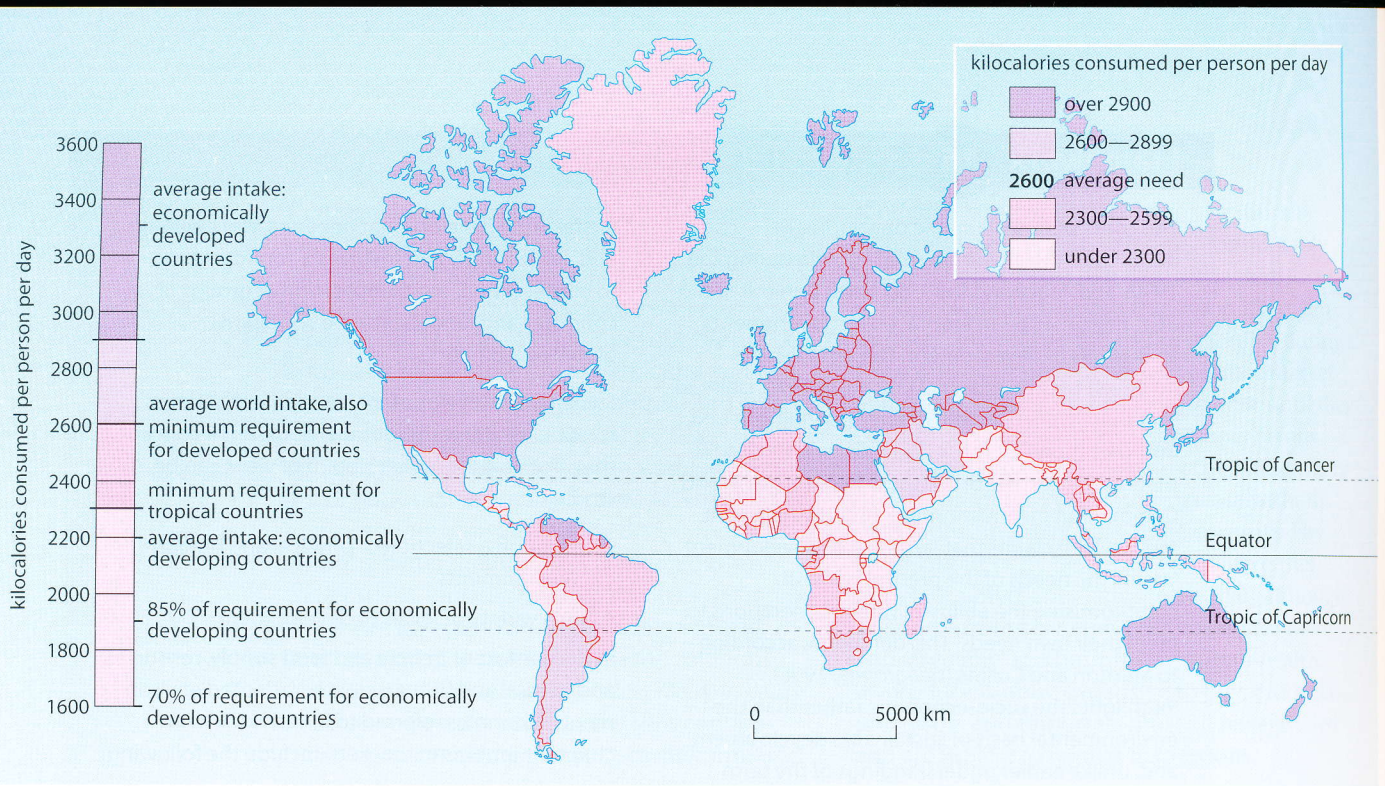


Figure 16.56

World food supply in 2008: average kilocalorie consumption per person per day, by country

Food supplies

Diet and health

It is over 200 years since Malthus expressed his fears that world population would outstrip food supply (page 378). Today, despite assurances from various international bodies such as the Food and Agriculture Organisation (FAO) that there is still sufficient food for everyone, it is estimated that three-quarters of the world's population is inadequately fed, and that the majority of these live in less economically developed countries. The problem is, therefore, the unevenness in the distribution of food supplies: surpluses still exist in North America and the EU; and there are shortages in many developing countries.

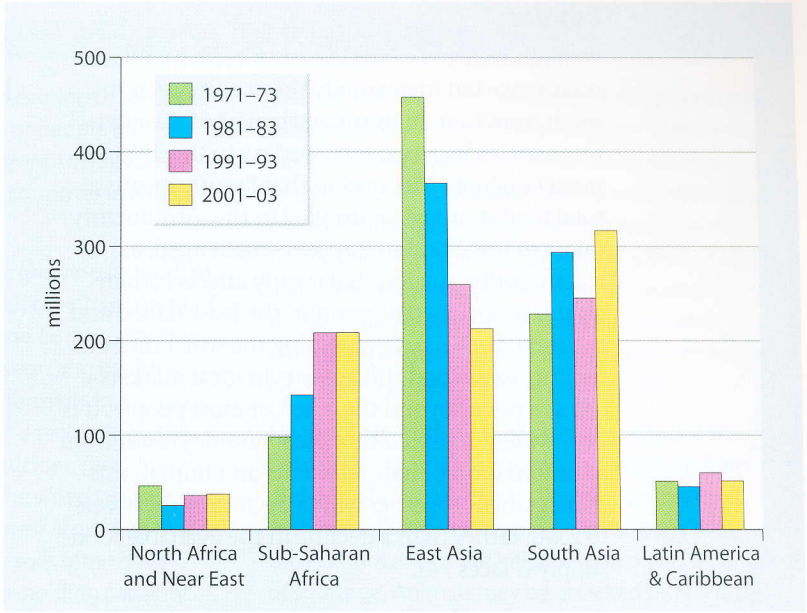
This uneven distribution is reflected in Figure 16.56 which shows variations in kilocalorie intake throughout the world. Dieticians calculate that the average adult in temperate latitudes requires 2600 kilocalories a day, compared with 2300 kilocalories for someone living within the tropics. The FAO reports that the actual average intake for the economically more developed world is 3300 kilocalories, but only 2200 kilocalories in less developed countries. However, the quantity of food consumed is not always as important as the quality and balance of the diet. A good diet should contain different types of food to build and maintain the body, and to provide energy to allow the body to work. A balanced diet should contain:

- **proteins**, such as meat, eggs and milk, to build and renew body tissues
- **carbohydrates**, which include cereals, sugar, fats, meat and potatoes, to provide energy, and
- **vitamins** and **minerals**, as found in dairy produce, fruit, fish and vegetables, which prevent many diseases.

Malnutrition and undernutrition, often caused by poverty, affect many people including even a surprisingly high number in developed countries. Malnutrition may not be a primary cause of death, but by reducing the ability of the body to function properly, it reduces the capacity to work and means that people, and especially children, become less resistant to disease and more likely to fall ill. Nutritional diseases, which include rickets (vitamin D deficiency), beri-beri (vitamin B1 deficiency and common in rice-dependent China), kwashiorkor (protein deficiency) and marasmus (shortage of protein and calories), can reduce resistance to intestinal parasitic diseases, malaria and typhoid. In contrast, people in developed countries are at risk from over-eating and from an unbalanced diet which often contains too many animal fats which can cause heart disease. Malnutrition, a Millennium Development Goal (page 609), is believed to be the underlying cause for almost half of all child deaths worldwide. Figure 16.57 shows the proportion of children aged under 5 who are underweight. More than one-quarter of all under 5s living in the developing countries are underweight, about 143 million in total, with the highest levels in South Asia and sub-Saharan Africa. In these countries children living in rural areas are twice as likely to be underweight as those living in urban areas. There is no gender difference.

Figure 16.58

Number of persons chronically undernourished in developing countries



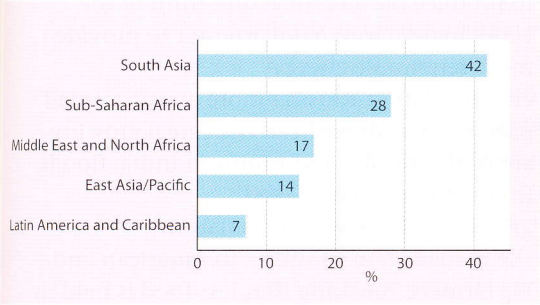


Figure 16.57

Percentage of children under 5 who are underweight

Trends in food supply

Since the early 1950s world food output has usually increased more rapidly than has world population. This increase has been more rapid in the developing countries, albeit from a very low base, than in developed countries and, during the 1960s and 1970s, was attributed mainly to the 'Green Revolution' (page 504). There were, however, exceptions to still this trend. The main exception was sub-Saharan Africa where, in several countries, food output per person actually fell and has continued to fall. A second exception was short-term periodic declines in either global or, more often, regional rainfall. During the late 1980s, for example, many places received below average totals which resulted in an estimated fall in the world's food reserves from 101 days to 54 days, and when up to 35 per cent of the world's total population was left living at or below starvation level. At that time there was much pessimism about future food prospects, and Malthus's gloomy predictions were, for a time, revived (page 378).

However, food production did once again begin to exceed the rate of population growth, this time in the 1990s, although there were disparities on a continental scale. While there was 5 kg of food per person for North America, 3.5 kg for Oceania and 2 kg for Western Europe, there was only 1 kg for Latin America and South-east Asia and less than 0.5 kg for Africa. Even so, at the beginning of the 21st century the WHO was able to report that 'new farming techniques are improving output, nutrition seems to be improving, life expectancy is increasing due to a better diet and global food supplies are in a relatively good shape with surpluses in certain areas'. However, the WHO report did highlight several areas of considerable concern.

- There was a continued decline of food production in Africa (Places 75) and an inability of several of the countries located there to afford to buy sufficient to satisfy their shortages and, therefore, they were forced to rely increasingly on food aid (page 632).
- Although production was increasing in most regions, there had been a global decline in the yields of the three staple food crops of wheat, rice and maize.
- Throughout history, whenever extra food was needed, people simply cleared more land for crops. Today, most high-quality land is already in use, or, increasingly, has been built upon. Much of the remaining areas have soils that are less productive and more fragile, i.e. less sustainable (Framework 16, page 499).
- There is a lack of **food security** – a term used by the WHO which means a lack of nutritious food needed to keep people alive and healthy. Although numbers have dropped, some 20 per cent of the world's population are still thought to experience chronic undernutrition (Figure 16.58).
- There is increasing globalisation of food production, with transnational corporations and large supermarkets in developed countries sourcing more of their food from developing countries. Smallholders in less well-off countries are being drawn into contracts to supply fruit and vegetables to markets in the developed world which is resulting in a decline in the growth of staple foods for their own domestic consumption.

Famine

Famines were once considered to be an inevitable occurrence but increasingly they can be seen to result from human mismanagement of the environment, or localised wars leading to the displacement of people. The notion that famine means a total food shortage (as implied in the introductory quote to this chapter) has been challenged, as recent studies suggest that it only affects certain groups in society (the poorest, the least skilled and the rural dwellers). Even during the worst times of famine, some food still appears in local markets – but at a price beyond the reach of most people. It is now widely accepted that most famines result from a combination of natural events and human mismanagement together with a decline in the access to food, rather than a decline in the available food supply (Places 74).

Rising food prices

The year 2008 saw an unprecedented rise in global food prices which resulted from a combination of factors (e.g. wheat £70 per tonne in 2006, £180 per tonne in 2008). These factors included:

- a change in diet, especially in India and China where greater affluence has led to a rising demand for meat products which in turn means more grain is needed to feed the extra number of reared animals
- more land and more cereal crops being used to produce biofuels (e.g. one-third of the USA's maize crop) in an attempt to provide more renewable energy
- climate change causing more erratic rainfall patterns, e.g. drought in the cereal growing areas of Australia and northern India, floods in the American mid-west
- growth in the world's population
- the reduction of subsidies to American and EU farmers, meaning that less food is held in storage
- encouragement of developing countries to grow cash crops rather than cereal crops.

Places 74 Niger: famine

In 2005, Niger was on the brink of a famine with over 3 million of its inhabitants (one in every three) suffering from severe hunger. To many people living in remote rural areas – which is the majority of the population – the only food available until that year's crop was ready was a watery-looking porridge look-alike. The often quoted causes of famine and food shortages are poverty and overpopulation, but this is too simplistic an answer. While it was true that many people were, at that time, unable to afford what food was available from within the country, and Niger itself was too poor to buy much from other countries, especially at a time when global food prices were beginning to rise, the real cause of the threatened famine was a combination of environmental, economic, social, cultural and political factors.

Niger had experienced two natural disasters in 2004: drought (it is a Sahel country – Case Study 7 and page 280), and a locust infestation. These were exacerbated by social causes that included a growing population that needed to be fed and, within that population, a considerable unevenness in the distribution of wealth. The country's limited development is shown by a lack of technology in farming, in which most of the population is engaged. Also, there is a limited amount of land suitable for agriculture, and what there is lies on the fringes of the Sahara Desert and so is 'marginal' (zone 3 on Figure 16.1, and Figure 16.59), with nutrient-deficient soils and a lack of water (rain or irrigation).

The lack of development (notice its position at the foot of the HDI table on page 607) is partly due to a lack of resources (other than uranium), which means that with little to export, Niger has a balance of trade deficit (page 624) which places it on the wrong side of the development gap (page 605). With limited money for investment and a legacy of colonialism, the country lacks a basic infrastructure. This includes a poorly developed transport network, which makes it difficult to distribute food internally at times of shortage and limits links with the outside world (the only long-haul flight is to Paris); it also has a poorly developed banking system.

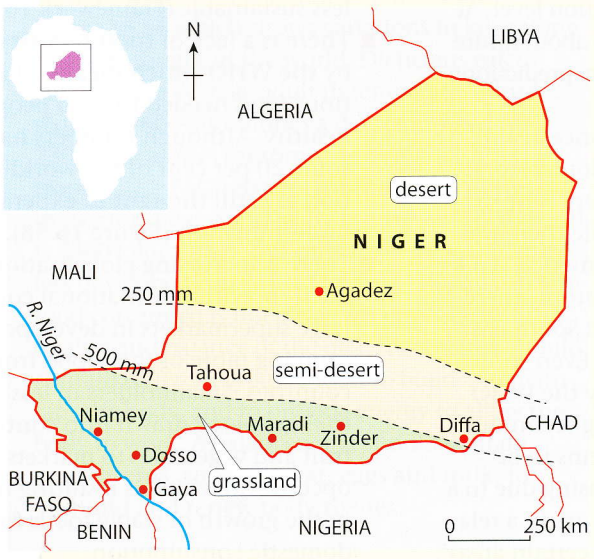


Figure 16.59
Niger

Places 75 Sub-Saharan Africa: food shortages

Severe drought, civil strife and economic security have displaced large numbers of people and disrupted food production (Figure 16.60). Food shortages at present affect 26 countries in sub-Saharan Africa (Figure 16.61).

The population of this region is growing faster than anywhere else in the world. With over 70 per cent of its labour force in agriculture and 66 per cent living in rural areas, the income, nutrition and health of most Africans is closely tied to farming. In an area where, due to limited capital and technology, the use of new seeds, fertiliser, pesticides, machinery and irrigation is the lowest in the world, agriculture is almost totally reliant upon an environment that is not naturally favourable. The soils often have fertility constraints, a low water-holding capacity and limited nutrients, making them vulnerable to erosion. High evapotranspiration rates harm crops while the unreliable rains which may cause flooding one year may then fail for several that follow. Periods of drought are getting longer and more frequent with experts arguing as to whether this is part of a natural climatic cycle, less moisture in the air due to deforestation, or the effects of global warming.

With increases in population, fallow periods have been reduced and the land has been overgrazed or overcropped which, together with destruction of trees for fuelwood, has accelerated soil erosion and desertification (Case Studies 7 and 10). The region has limited money for investment in agriculture and when overseas aid has been given it has often been channelled into unsuitable projects such as promoting monoculture, growing crops for export instead of domestic consumption, increasing the size of animal herds on marginal land and ploughing fragile soils that would have been better left under a protective vegetation cover.

Financial aid from overseas can also increase the debt of the recipient country (page 632). People's diet often lacks sufficient calories or protein and, with many living in extreme poverty (page 609), they cannot afford the inflated food prices at times of shortage. Animals may be attacked by tsetse fly, crops in the field by locusts, and crops in storage by rats and fungi. To add to these difficulties, several countries are, or have been recently, torn by civil strife resulting in the problem of internally displaced persons and refugees. This, together with administrative corruption, interrupts farming and the distribution of relief supplies. Last, but by no means least, is the effect of the HIV/AIDS pandemic which, even when not fatal to individual farmers, considerably reduces their ability to work (Places 100, page 623).

Figure 16.60

Children awaiting food aid: Somalia

Figure 16.61

Countries with exceptional shortfalls in food production supplies

Country	Reasons
Burundi–Rwanda–Uganda	Civil strife, IDPs
Central African and Congo Reps	IDPs
Chad	Civil strife, refugees
Congo Democratic Republic	Civil strife, refugees, IDPs
Eritrea–Somalia	Civil strife, drought, IDPs
Ethiopia	Drought, IDPs
Ghana	Flood and drought
Guinea	Civil strife, refugees
Kenya	Civil strife, drought, pests
Lesotho–Swaziland	Drought, HIV/AIDs
Liberia–Sierra Leone	Civil strife, refugees, IDPs
Malawi–Zambia	Drought, HIV/AIDs
Mali–Niger–Burkina Faso	Drought, locusts
Mauritania	Drought, locusts
Mozambique	Floods, drought, HIV/AIDs
Sudan	Civil strife, IDPs, drought
Zimbabwe	Economic crisis, HIV/AIDs

IDPs = internally displaced persons

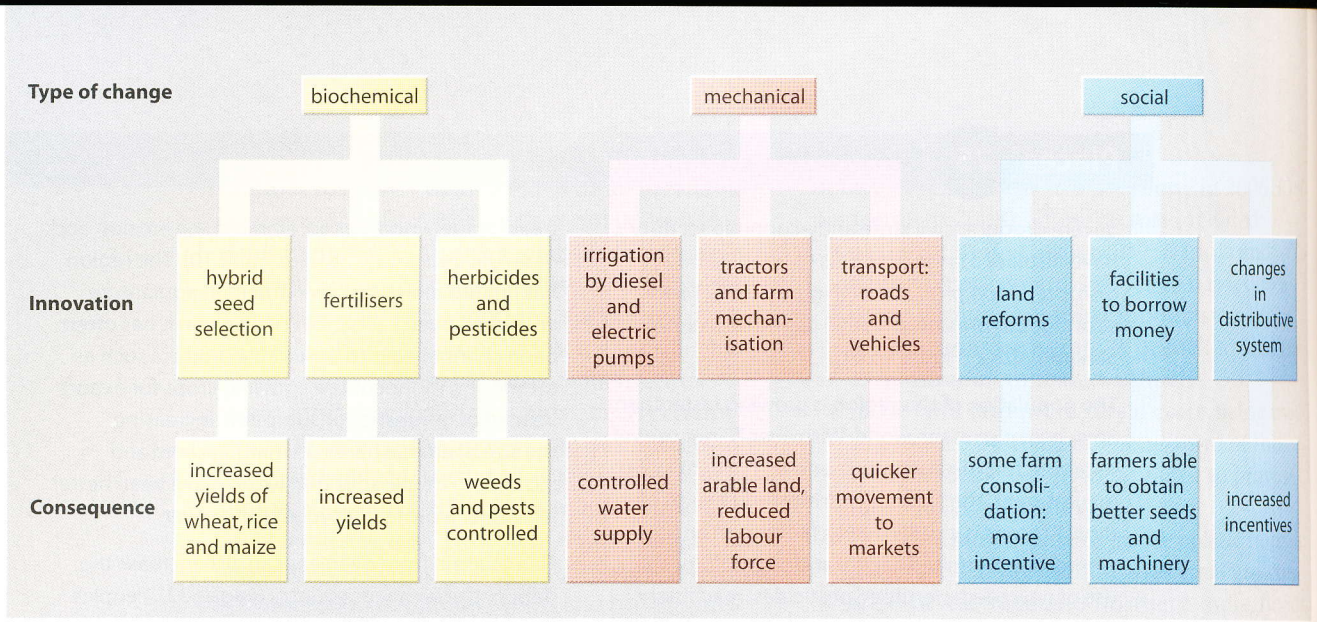


Figure 16.62
The Green Revolution

What might be done to improve food supplies in developing countries?

As most areas with an average or high agricultural potential have already been used, future extension of cropland can only take place on marginal land where the threats of soil erosion and desertification are greatest. The solution is not, therefore, to extend the cultivated area but to make better use of those areas already farmed.

Land reform can help to overcome some inefficiencies in the use of land and labour. The redistribution of land has been tackled by such methods as the expropriation of large estates and plantations and distributing the land to individual farmers, landless labourers or communal groups; the consolidation of small, fragmented farms; increasing security of tenure; attempting new land colonisation projects; and state ownership. The success of these schemes has been mixed. Not all have increased food production, although many farms in China have seen an increase in yields since the transference of farming decisions to individual farmers under the responsibility system (Places 63, page 468; Places 64, page 470).

The **Green Revolution** refers to the application of modern, Western-type farming techniques to developing countries. Its beginnings were in Mexico when, in the two decades after the Second World War, new varieties or hybrids of wheat and maize were developed in an attempt to solve the country's domestic food problem. The new strains of wheat produced dwarf plants capable of withstanding strong winds, heavy rain and diseases (especially the 'rusts' which had attacked large areas). Yields of wheat and maize tripled and doubled respectively, and the new seeds were taken to the Indian subcontinent. Later, new varieties of improved rice were developed in the Philippines. The most famous, the IR-8 variety, increased yields sixfold at its first harvest. Another 'super rice' increased yields by a further 25 per cent (1994). Further improvements have shortened the growing season required, allowing an extra rice crop to be grown, and new strains have been developed that are tolerant of a less than optimum climate.

In 1964 many farmers in India were short of food, lacked a balanced diet and had an extremely low standard of living. The government, with limited resources, was faced with the choice (Figure 16.62) of attempting a land reform programme (redistributing land to landless farmers) or trying to improve farm technology. It opted for the latter. Some 18 000 tonnes of Mexican HYV (high-yielding varieties) wheat seeds and large amounts of fertiliser were imported. Tractors were introduced in the hope that they would replace water buffalo; communications were improved; and there was some land consolidation. The successes and failures of the Green Revolution in India are summarised in Figure 16.63. In general, it has improved food supplies in many parts of the country, but it has also created adverse social, environmental and political conditions. The question now being asked in India is: 'How green was the Green Revolution?' For the first time in four decades, population growth is outstripping food production. This is due to high birth rates, longer life expectancy, more land being devoted to commercial crops and a mass rural–urban migration caused by India's rapidly emerging economy. At the same time there are growing health concerns with fertiliser and pesticides, leached into water supplies, blamed for a rapid increase in cancers, birth defects and other illnesses. A small but growing number of farmers are turning away from a reliance on chemicals to a more organic-type of farming.

Successes	Failures
Wheat and rice yields have doubled	HYV seeds need heavy application of fertiliser and pesticides, which has increased costs, encouraged weed growth and polluted water supplies
Often an extra crop per year	Extra irrigation is not always possible; it can cause salinisation and a falling water table
Rice, wheat and maize have varied the diet	HYVs not suited to waterlogged soils
Dwarf plants can withstand heavy rain and wind and photosynthesise more easily	Farmers unable to afford tractors, seed and fertiliser have become relatively poorer
Farmers able to afford tractors, seed and fertiliser now have a higher standard of living	Farmers with less than 1 ha of land have usually become poorer
Farmers with more than 1 ha of land have usually become more wealthy	Farmers who have to borrow are likely to get into debt
The need for fertiliser has created new industries and local jobs	Still only a few tractors, partly due to cost and shortage of fuel
Some road improvements	Mechanisation has increased rural unemployment
Area under irrigation has increased	Some HYV crops are less palatable to eat
Some land consolidation	Fertiliser and pesticides have contaminated water supplies causing health problems
Conclusions	
A production and economic success which has lessened but not eliminated the threat of food shortages	Social, environmental and political failure: bigger gap between rich and poor

Figure 16.63

An appraisal of the Green Revolution in the Indian sub-continent

Appropriate technology (Case Study 18) is needed to replace the many, often well-intentioned schemes that involved importing capital and technology from the more developed countries. Appropriate technology, often funded by non-governmental organisations such as the British-based Practical Action (Places 90, page 577), seeks to develop small-scale, sustainable projects which are appropriate to the local climate and environment, and the wealth, skills and needs of local people. This means:

- *Not* large dams and irrigation schemes, but more wells so that people do not migrate to the few existing ones, drip irrigation as this wastes less water, stone lines (Figures 10.40 and 16.64) and check-dams (Figure 10.43). For stone lines, stones are laid down, following the contours, even on gentle slopes in Burkina Faso, while small dams built of loess are constructed across gulleys in northern China. In both cases, surface runoff is trapped giving water time to infiltrate into the soil and allowing silt to be deposited behind the barriers. These simple methods, taking up only 5 per cent of farmland, have increased crop yields by over 50 per cent.
- *Not* chemical fertiliser, but cheaper organic fertiliser from local animals (which can also provide meat and milk in the diet). Unfortunately, in many parts of Africa dung is needed as fuel instead of being returned to the fields.
- *Not* tractors, but simple, reliable, agricultural tools made, and maintained, locally.
- *Not* cash crops (often monoculture) on large estates, but smallholdings where both cash crops (income) and subsistence crops (food supply) can be grown. Mixed farming and crop rotation are less likely to cause soil erosion and exhaustion. Intercropping can protect crops and increase yields (smaller plants protected by tree crops).

Figure 16.64

Stone lines in Burkina Faso

A Farming in western Normandy

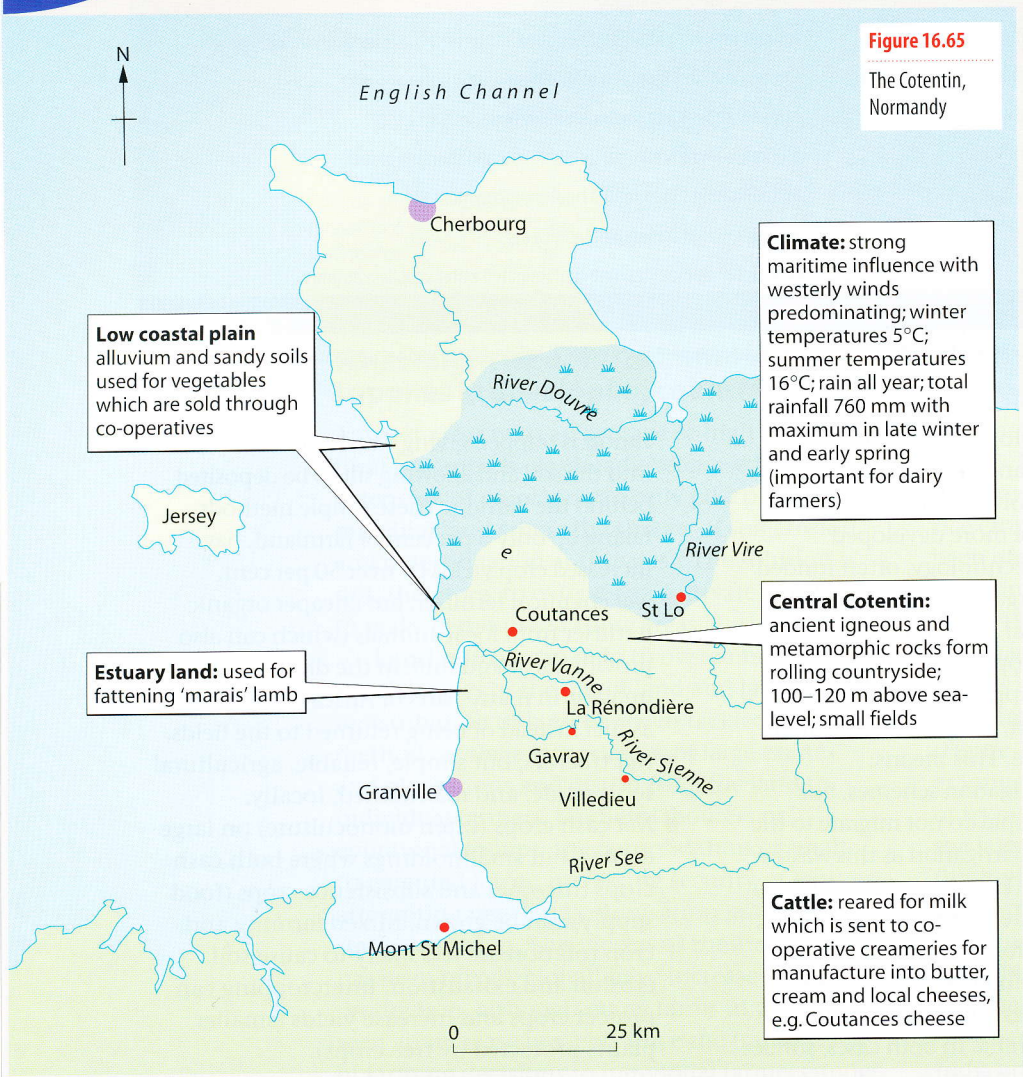


Figure 16.65 The Cotentin, Normandy

The Cotentin lies between the Vire estuary and Mont St Michel Bay (Figure16.65). It is mainly an agricultural region, although tourism is also important. The maritime climate, with rain (760 mm per year) occurring at all seasons and reaching a maximum in the late winter and spring months, is important for the farming. The maximum occurs just as temperatures are rising and the grass is starting to grow. This has been the basis of the successful dairy farming industry. Cattle are reared for their milk from which Normandy butter is made in addition to many local cheeses and cream. Most farms also produce fodder for their cattle, either in the form of silage in the late spring or as crops of corn in the late summer.

La Rénondière is a typical Cotentin dairy farm (Figure 16.66). It lies at 71 m above sea-level in a small valley whose stream flows into the River Vanne 0.75 km to the north. The land slopes very gently; fields are small and bounded by dense hedges; and most of the farm can be ploughed except for a small area in the valley bottom which becomes very wet. The Normandy-style farmhouse of grey stone covered in creeper, with white shutters, faces south. It is sheltered from the westerly winds, as are most of the buildings grouped around it.

The farm is 44 ha in area. This is large for Normandy, where the average size is between 15 and 24 ha. Cattle are kept on 4 ha close to the farm; the rest of the land is used for producing fodder for the animals. The present herd consists of 52 cattle – mainly Friesian, with some traditional Normandy cows. The black-and-white Friesians have high milk yields, but the Normandy cows have better-quality milk with a high cream content. They are kept outdoors all year round, with some protection in the winter. The cattle in milk are brought to the dairy twice a day and they produce on average 116 litres per cow per day (Figure 16.67). The small milking parlour is similar to many in the region. It holds eight cows at a time, and is simpler than large dairies in the English Midlands or on dairy farms close to Paris. The milk is kept under refrigeration on the farm until it is collected by the creamery lorry – each day in summer, but every two days at other times of the year (Figure 16.68).

The cows are artificially inseminated and produce one calf a year. Bull calves are sold in Gavray market for veal, and female calves are sold or used to replenish the herd. They are carefully checked for yield and as this drops off they are replaced. They are kept as long as possible, as the return from cull cows is not high.

The present farmer has been on the farm for over 20 years, but it was farmed earlier by his parents and grandparents. All the work is done by the farmer, his wife (she is in charge of the dairy) and his father. Neighbours help during silage making. There is a strong tradition of dairy farming in the region.

On the western side of the Cotentin, there is a low-lying plain approximately 15–60 m above sea-level. It contains areas of sandy soils which are important for producing vegetables, including carrots, leeks, sweet corn, lettuce and tomatoes. These vegetables are marketed through co-operatives in the larger towns of the region, as well as in Paris and the UK.

The lowlands along the estuary of the Sienne and the Vanne are used as grazing land for the 'marais lamb'; large flocks of sheep are fattened on the marshes, providing yet another income for the farmers of the region.

As income from farming declines, farmers across the EU are having to diversify. In

Figure 16.66
A typical Normandy farmhouse

Figure 16.67
A small milking parlour

Figure 16.68
A co-operative creamery in Normandy

addition to their regular enterprises, many Normandy farmers breed and train trotting ponies – making regular visits to the long open sandy beaches to train them at low tide. As in Britain, bed and breakfast accommodation during the short tourist season from June to the end of August provides an additional source of income.

A major issue facing farmers in this part of France is the steady loss of people from the land. Many small farmers are going out of business, leaving houses empty. As in other peripheral regions of Europe, young people are moving to the cities. There is evidence that one or two wealthier large farmers are buying up vacant land. Some of the villages contain summer homes, owned by Parisians, with a number of British residents both in holiday and permanent homes. Prices for some houses without land have been low, encouraging overseas buyers. Villages still contain their bakery and shop, often with a butcher, but children are being forced to travel increasing distances to school. These features of rural life are common to many remoter areas within the EU.

The impact of EU regulations can be seen. Milk quotas in line with EU rulings have been set by the government (page 493). They are generally higher than in the UK, perhaps due to the political strength of the farmers, and are an established part of the farm economy. However, they are generally unpopular with local farmers. Perhaps they will not be too disappointed when milk quotas are phased out by 2015 (page 493).

Subsidies for lamb encourage the producer to maintain flocks. Demand for lamb is high, as is shown by the high prices in the supermarkets.

From 1988, EU farmers were paid subsidies if they left parts of their land uncropped. Payments for this set-aside land ended in 2008 when the rise in global food prices forced the EU to encourage farmers to bring back into production former crop-growing areas and to introduce new policies by which farmers will only get subsidies if they keep their land in good condition – the so-called 'health check' (page 493).

Figure 16.69
The Nafferton Ecological Farming Group's plan

	Conventional management	Organic management
Crops	Cereal-dominated rotation (typical of lowland Northumberland) – almost a monoculture. An 8-year rotation would be 2 years silage, 2 years winter wheat, 1 year barley, 1 year industrial rape, 1 year winter wheat, 1 year barley	Rotation includes legumes and prohibits mowing. An 8-year rotation would be 3 years red clover/grass cultivation, 1 year spring wheat, 1 year potatoes, 1 year spring beans, 1 year vegetables, 1 year spring barley
	Can use from a range of 220 herbicides, 186 pesticides and 43 fungicides	No synthetic herbicides or pesticides but S, Si and Cu can be used as nutrients
	Significant use of soluble fertiliser	No soluble fertiliser such as N and Cl (Figure 10.13)
Animals	90 dairy cows fed on silage, grazing or purchased feed (37% diet from grazing)	80 dairy cows fed on home-grown cereals, beans or forage (80% diet from grazing)
	Young stock and calves reared for beef	Young stock rearing
	Maximum efficiency and production	Animal welfare/sustainability paramount
	Animals often kept indoors	Access to outside (including chickens)
	Higher stock density	Lower stock density
	Greater medical protection	No growth promoters
	Seasonal withdrawal period	Longer withdrawal permitted

Figure 16.70
How the land is farmed

B Organic farming in Northumberland

The Nafferton Ecological Farming Group at Newcastle University is located at Nafferton Farm adjacent to the A69 between Newcastle and Carlisle. The farm, including its buildings, covers 293 ha. In 2000 it was divided into two equal 140 ha parts, with the land to the west to be farmed conventionally and that to the east organically (Figure 16.69). As well as being the same size, both sections were to have the same number of animals and – the ideal for the experimental comparison – exactly the same climate, soil and relief. The differences in crops and animal rearing between the conventionally managed and the organically managed areas are shown in Figure 16.70. The money for organic funding and for research comes from the EU, which sets legally binding standards to which the UK must adhere; the UK can add further regulations but cannot delete any.

The Ecological Farming Group researches the effects of soil, crop and livestock management on food quality and safety, environmental impact, soil health and biological activity, biodiversity, and the economic viability of the two types of farming system. It has confirmed that the organic management area:

- by using less fertiliser, produces less CO_2 and has a smaller ecological footprint (page 379)
- by using less nitrogen, reduces eutrophication (page 494)
- by using compost to bind the soil together, reduces soil erosion (page 495)
- has a greater biological activity (e.g. earthworms)
- despite not adding fertiliser, which increases crop yields, has outputs similar to those of conventional methods of the 1980s
- produces milk that is both better in quality and healthier than that produced conventionally (Figure 16.71).

Being a commercial venture, what the research centre actually grows can be influenced by market demand – so long as this demand fits into the rotation system. For example, if the market price for wheat increases, then more wheat might be planted that year. The centre does sell some of its own produce but cereals are sent to a grain merchant for processing before being sent to shops and supermarkets.

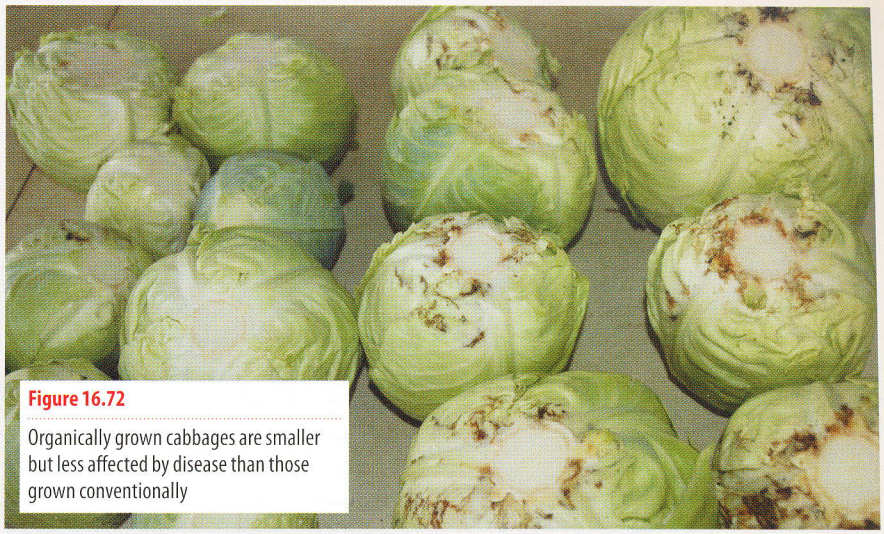


Figure 16.72
Organically grown cabbages are smaller but less affected by disease than those grown conventionally

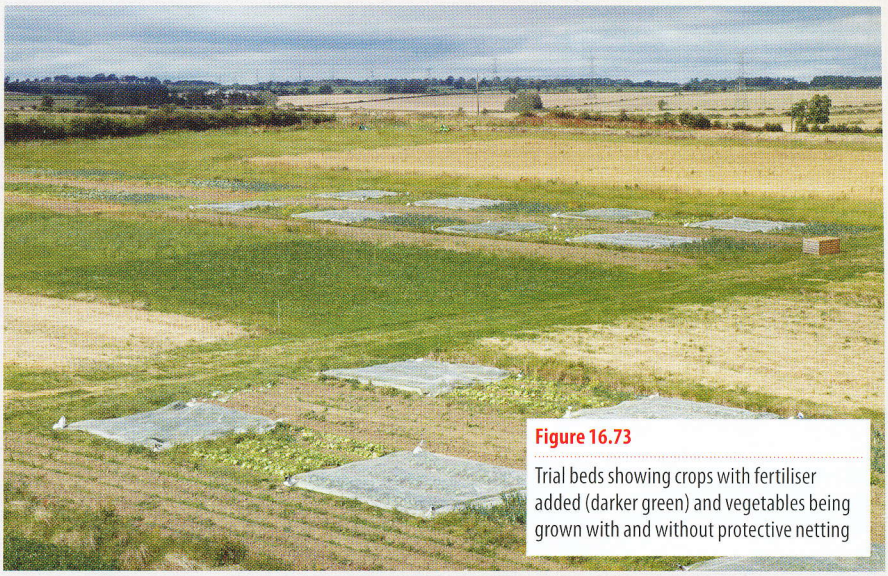


Figure 16.73
Trial beds showing crops with fertiliser added (darker green) and vegetables being grown with and without protective netting

Organic milk has more healthy benefits

A study of organic milk, conducted by Professor Carlo Leifert of Newcastle University, has shown that drinking organic milk has greater health benefits than drinking normal milk. The study showed that organic milk contained 67 per cent more antioxidants and vitamins than ordinary milk and 60 per cent more of a healthy fatty acid called conjugated linoleic acid (CLA9) which tests have shown can shrink tumours. Similar levels of vaccenic acid, which has been shown to cut the risk of heart disease, diabetes and obesity, were also found as was an extra 39 per cent of the fatty acid Omega-3 which has also been shown to cut the risk of heart disease.

Gillian Butler, the livestock project manager, pointed out the health benefits even if consumers did not switch completely to organic milk. She pointed out that organic milk is more expensive to produce, as you get less milk per unit of land, and to buy, but because it is higher in all these beneficial compounds you do not need to buy as much to get health benefits.

Adapted from *Daily Telegraph*, 28 May 2008

Figure 16.71
Findings on organic milk

C Banana cultivation in South and Central America

Bananas are the main fruit in international trade and the most edible in the world. In terms of volume they are the first export fruit while in value they rank second after citrus fruits. The banana industry is a very important source of income, employment and export earnings for several major exporting countries, mainly in Latin America and the Caribbean as well as in Asia and Africa.

Countries a World producers	% total
India	23
Brazil	9
Ecuador	9
China	8
Philippines	8
Rest of world	43
Countries b World exporters	**% total**
Ecuador	29
Costa Rica	14
Philippines	12
Colombia	10
Guatemala	6
Rest of world	29

Figure 16.74

World producers and exporters of bananas

Over half the world's bananas are grown in just five countries (Figure 16.74a) and 98 per cent in developing countries. Despite this, only one in five bananas enters the export market and of these 70 per cent come from five countries (Figure 16.74b). Although they are the major export of Ecuador and Costa Rica, the highest levels of dependence can be found in the Windward Islands of St Lucia (50 per cent of its exports), St Vincent and the Grenadines, Dominica and Grenada.

World trade in bananas is dominated by two groups of producers, the ACP (Africa, Caribbean and Pacific) producers and the 'dollar producers' of the Central American republics Colombia and Ecuador (controlled by large American transnationals). Over 80 per cent of bananas entering the EU come from the Caribbean where they are grown on small family-owned farms by people who are almost totally reliant on this single crop as a source of income (Figure 16.75). Bananas are grown on plantations in the Ivory Coast and Cameroon which are also members of ACP. Each country is given a quota based on the amount it exports. In 1998, bananas were at the centre of a major trade dispute between the EU and the USA.

Bananas are cultivated under tropical conditions where the temperatures are high and rainfall exceeds 120 mm per month. In some tropical plantation conditions where evapotranspiration is high, irrigation may be used. Drip irrigation is more effective and produces a better bunch weight of bananas than basin irrigation. In order to meet the demands of the marketing companies, the bunches (or hands) of bananas must be over 270 g in weight. Bananas grown for local consumption are mainly cultivated on small landholdings, whilst those produced for export are grown on large plantations (Figure 16.74a). In most Caribbean countries, bananas are grown on small family-run plots. The crop requires a high labour input, which in the Caribbean islands is mainly provided by the smallholder's family. Suckers taken from a mother plant are rooted and grow well in the deep volcanic soils. Weeds growing between the plants need to be kept down until the plant is tall enough to outgrow them. It is common to see plants being supported by props so that the weight of the bunch does not pull the plant over. Fruit has to be protected from bruising and scarring. Each bunch may be covered by a large plastic bag until it is ready for harvest. This takes place about 10 months after the plant is established. The fruit is cut when it is still green and hard, and then it is taken to the processing plant. Here it is packed and refrigerated before being sold or shipped overseas (Figure 16.74b).

On the Caribbean islands marketing is done through transnationals such as Fyffes. The small farmers rely on the banana industry to provide their basic needs of food, shelter and education.

These small-scale farmers are also the ones who suffer most from hurricane damage as in 1998 when Hurricane Mitch destroyed much of the plantation area of Nicaragua and Honduras, and in 2005 when Grenada's crop was devastated (Figure 16.75).

Country	Production (tonnes)	Export (tonnes)	% total exported	Export (value £'000s)
Belize	76 000	64 891	85	21 353
Colombia	1 764 501	1 621 746	92	464 959
Costa Rica	1 875 000	1 775 519	95	483 492
Dominica	16 000	12 732	80	6 800
Dominican Republic	547 433	163 510	29	44 640
Ecuador	6 118 425	4 764 193	78	1 068 659
Grenada*	0	0	0	0
Guatemala	1 150 200	1 129 477	98	238 100
Honduras	887 072	545 527	61	134 698
Jamaica	125 000	11 713	93	4 693
Mexico	2 250 041	70 166	31	25 342
Nicaragua	49 915	45 532	91	11 579
Panama	439 228	352 480	80	96 517
St Lucia	45 000	30 630	68	15 542
St Vincent & Grenadines	50 000	24 470	55	12 815
Trinidad & Tobago	7000	39	6	23
World total	69 644 923	15 946 146	23	5 651 321

* Grenada lost all its crop in 2005 through hurricane damage

Figure 16.75

Banana production in the Caribbean and Central America, 2005

The influence of the large transnational companies is strong in the Central American countries where the bananas are grown on the rich alluvial soils found on the coastal lowlands, providing high yields per hectare for large plantations owned by transnationals. Labour is hired and often low-paid. Land is carefully cultivated and more mechanisation is used than on smaller farms. There is intensive use of fertiliser and pesticides which is having cumulative environmental effects. One of the most serious of these is the damage to the coral reefs off the Costa Rican coast, where 90 per cent are now dead as a result of pesticide runoff from banana plantations.

Bananas were to become one of the first products to be traded internationally under the Fairtrade label (Figure 21.44) and also, in places, to be grown organically. Under Fairtrade, farmers in South and Central America are getting a fairer price for their produce, enabling them to improve their standard of living (Figures 16.77b and 21.45).

Following years of expansion because of increased demand for the fruit, there is now a problem of oversupply. Economies such as those of St Vincent and St Lucia depend on the crop for survival. There is a need to diversify into food crops and other cash crops to reduce the dependency on one major export.

Figure 16.76
The banana producers

Figure 16.77
The banana industry:
a Bananas on the tree
b Preparing Fairtrade bananas for export

Further reference

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UN World Food Programme (WFP): www.wfp.org/english/

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World Resources Institute: Feeding the World: www.igc.org/wri/wri/wri/wr-98-99/feeding.htm

Questions & Activities

Activities

1 Study the map in Figure 16.78. It shows the general pattern of intensity of farming in Europe.

a i Describe the location of the areas where average intensity of farming is 75 per cent of the average, or lower. *(2 marks)*

ii Choose a named location within the area described in **i** and explain why physical geography makes farming difficult in that area. *(3 marks)*

b i Describe the location of the area with average intensity 50 per cent or more above average. *(2 marks)*

ii Explain how market forces have affected the development of the area of intensive farming you have described in **i**. *(4 marks)*

c Name **one** area of intensive farming that is found within the peripheral area of Europe.

i Describe the type of farming.

ii Explain why this area of intensive farming has developed there. *(7 marks)*

d Name **one** area of low-intensity farming found within the farming core.

i Describe the type of farming.

ii Explain why this area of low-intensity farming has developed, despite the favourable market conditions. *(7 marks)*

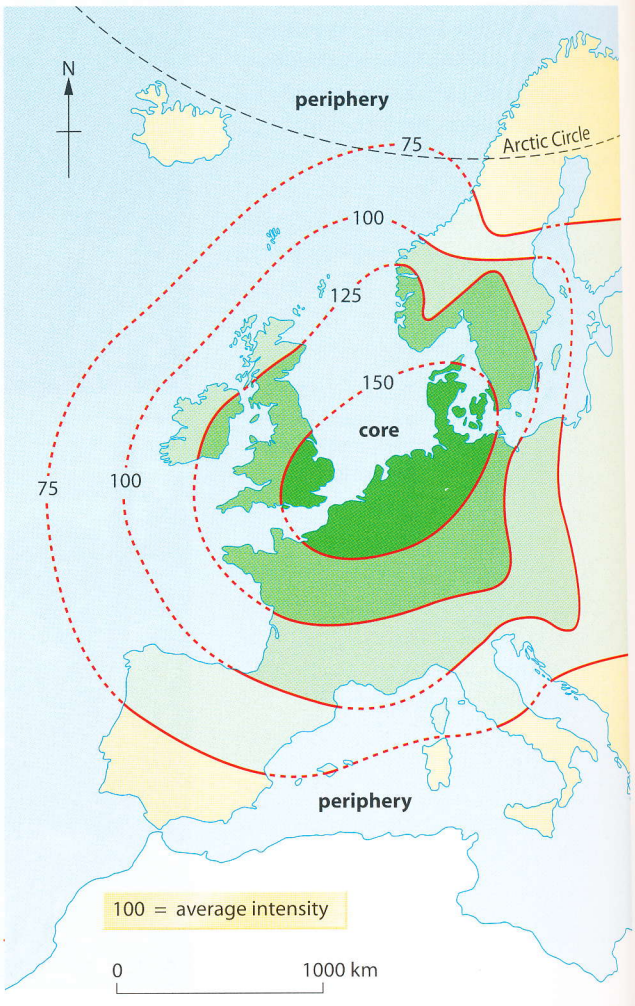


Figure 16.78
Intensity of agriculture in Europe (*after* van Valkenburg and Held, 1952)

2 Study Figure 16.79.

a Complete a copy of the table below. *(4 marks)*

b Moorland and woodland both produce low returns for farmers.

i Using information from your table, suggest what is the main physical type of land in this sample that is left as:

- moorland
- woodland. *(2 marks)*

ii Suggest why each of these types of land is not used for a type of farming that produces better returns. *(6 marks)*

	Altitude in metres	Angle of slope in degrees
Arable	0–20	0–3
Improved pasture		
Rough pasture		
Woodland		
Moorland		

c **i** What do the following terms mean:

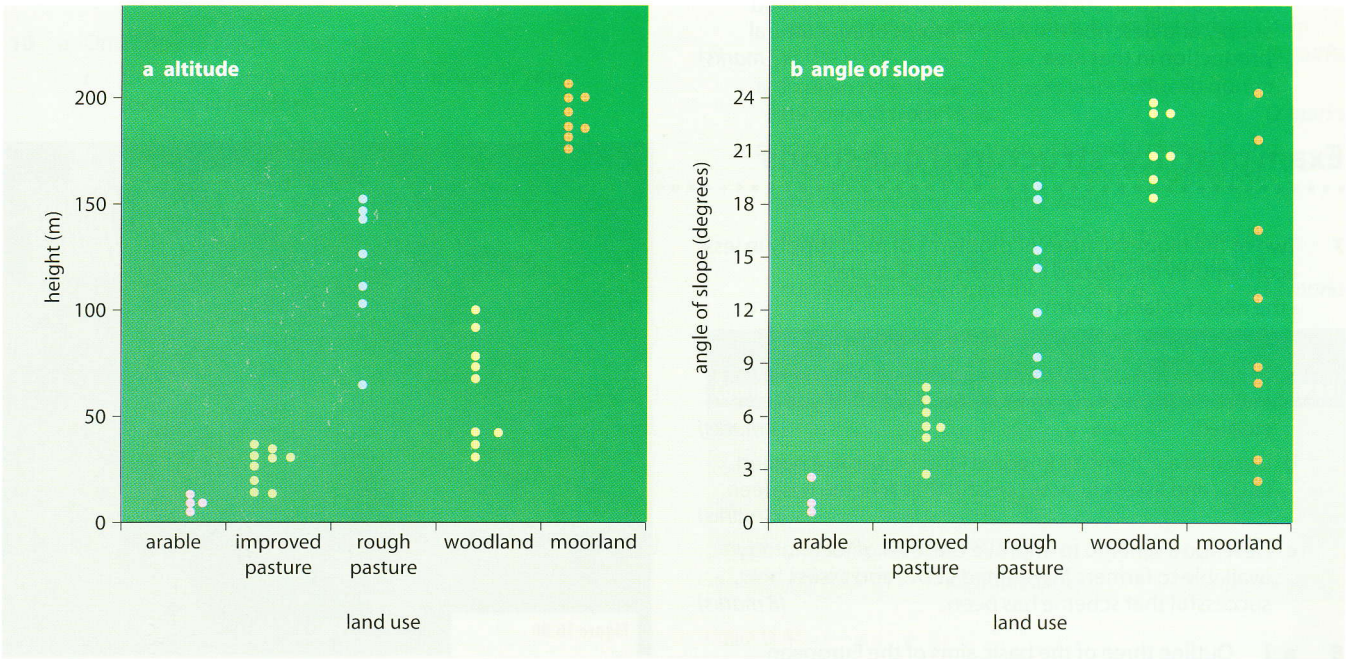
- extensive farming
- capital-intensive farming
- labour-intensive farming? *(3 marks)*

ii Name **one** area where capital-intensive farming has developed. Explain how market conditions in that area have encouraged the development of this type of farming. *(5 marks)*

iii Name one area where labour-intensive farming with low capital inputs has developed. Explain how physical and social conditions have encouraged the development of this type of farming. *(5 marks)*

Figure 16.79

Relationships between land use, altitude and slope in south-east Arran



3 **a** Modern farming practices threaten the environment in many ways. Describe one problem that can result from each of the following practices:

i increasing use of chemicals on the land *(4 marks)*

ii increasing the size of fields *(4 marks)*

iii draining wetlands. *(4 marks)*

b Choose **one** of the problems that you described in **a**. Explain how changes in the management of the land can reduce this problem. *(6 marks)*

c 'I would like to manage my farm in a more eco-friendly way, but I feel that I must farm as intensively as modern scientific techniques will allow. Farmers like me must produce maximum possible yields in order to feed the starving millions in poor countries throughout the world.'

Imagine that a farmer who ran a very intensive farm in East Anglia made the statement above. How might you reply if you wanted to convince him that he ought to consider a less intensive form of farming? *(7 marks)*

Exam practice: basic structured questions

4 **a** Physical controls have an important effect on the type of farming in most agricultural areas. Choose **two** of the following physical factors. For each of your chosen factors, explain how it influences farming. Illustrate each part of your answer with reference to a named area.

i temperature

ii precipitation

iii soil. *(8 marks)*

b The use of technology can reduce the farmer's dependence on physical factors. Explain how this has happened in:

i a named farming region in a more economically developed country *(5 marks)*

ii a less economically developed country where intermediate technology has been used. *(5 marks)*

c Explain what is meant by 'organic farming' and explain why it has grown in importance in recent years. Illustrate your answer by reference to one or more case studies. *(7 marks)*

5 **a** Name **one** region where commercial grain production makes an important contribution to the world's food supply and describe the main features of agricultural production in that area. *(7 marks)*

b Name **one** region where farming mainly for subsistence is still important. Outline the main features of the farming system and explain why subsistence farming is still important there. *(8 marks)*

c With reference to **one or more** crops, discuss the strengths and weaknesses of the plantation system of agriculture. *(10 marks)*

6 **a** Name a less economically developed country (LEDC) that has suffered / is suffering from famine. Explain the causes of the famine. You should refer to both natural and human causes. *(10 marks)*

b 'Famine and food shortage are likely to increase in future.' Give two reasons why this is likely. *(5 marks)*

c i With reference to one or more named case studies, explain how land reform can improve total food production in LEDCs. *(5 marks)*

ii With reference to one or more case studies, explain how appropriate technology (intermediate technology) can help increase agricultural yields in LEDCs. *(5 marks)*

Exam practice: structured questions

7 Two of the biggest causes of problems of food supply in less economically developed countries (LEDCs) are:

- the need for land reform
- the need for access to improved technology.

a Explain why each of these presents problems for farmers in LEDCs. Refer to one or more examples that you have studied. *(9 marks)*

b Describe a scheme to improve land tenure in a named LEDC, and assess how successful that scheme has been. *(8 marks)*

c Describe a scheme to improve the level of technology available to farmers in a named LEDC, and assess how successful that scheme has been. *(8 marks)*

8 **a i** Outline three of the basic aims of the European Union's (EU) Common Agricultural Policy (CAP). *(3 marks)*

ii Why did the CAP lead to overproduction and surpluses in the 1980 and 1990s? *(5 marks)*

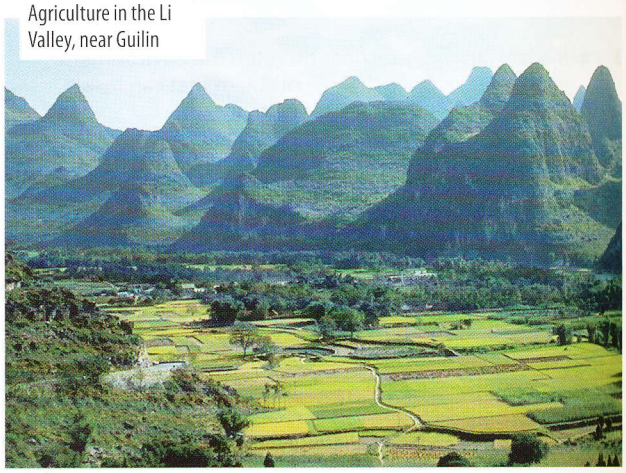
b Recent reforms of the CAP have led to the introduction of a number of schemes that are designed to improve the rural environment.

i Describe the policy of 'set-aside' and explain its role in improving the environment. *(5 marks)*

ii Explain how improvements in the rural environment in the UK can be brought about by **either** the introduction of Environmentally Sensitive Areas (ESAs) **or** Stewardship schemes. *(12 marks)*

9 Study the photographs in Figure 16.80. They were both taken near Guilin in China.

Figure 16.80
Agriculture in the Li Valley, near Guilin



a i Describe evidence in photograph B which shows that farming is intensive in this area. *(4 marks)*

ii Two crops per year can be taken from farmland in photograph A. Suggest how the land is kept fertile, even though the people cannot afford inputs of artificial fertiliser. *(4 marks)*

iii Land in the background of photograph A is not farmed. Suggest why not. *(4 marks)*

b • Before the revolution in 1949, farming in this part of China was mostly subsistence farming. Farms were small and fragmented and tenants had to give up to half their produce to absentee landlords.

• After the revolution, land was divided amongst the peasants, but most plots were too small to support the families who worked them.

• After several experiments the government created 'people's communes' in which around 15 000 people pooled their land and labour to run the farm.

• Since 1979 individual farmers have been given more responsibility, and now they are allowed to sell surplus crops at local markets, and to keep the profits.

Suggest why yields are higher under the present system than they have been under any of the previous systems. *(13 marks)*

10 a On a copy of Figure 16.81 add:

i net profit curves for dairying and wheat when locational rent for:

• dairying is £120 at the market and £0 at 60 km

• wheat is £80 at the market and £0 at 80 km. *(6 marks)*

ii labels to show:

• the margin of transference from market gardening to dairying

• the margin of transference from dairying to wheat

• the margin of cultivation for wheat. *(3 marks)*

b Explain why land use changes at the margins of transference. *(4 marks)*

c i Explain why von Thünen's model is difficult to apply to agricultural patterns in the modern world.

ii In what ways is von Thünen's model still useful to an understanding of modern agricultural geography? *(12 marks)*

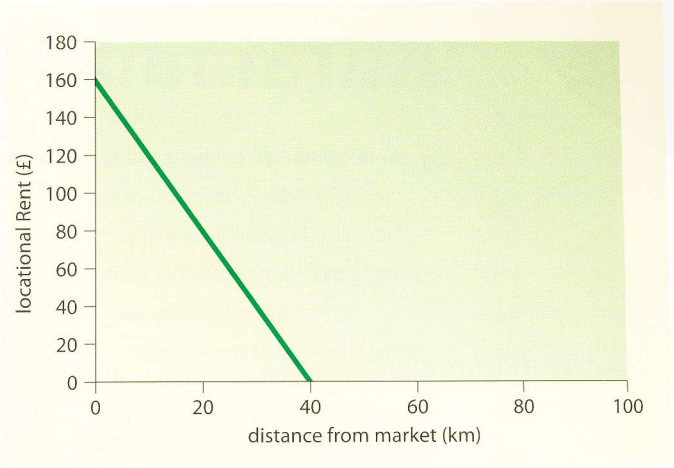


Figure 16.81

Net profit curve for market gardening around a town on a uniform plain

11 Study Figure 16.82.

a Explain how the Common Agricultural Policy of the European Community (now the European Union) led to the development of surpluses like those shown in the table. *(6 marks)*

b Explain how these surpluses were reduced during the period from 1986. *(7 marks)*

c Increasing intensification of farming in the UK and other parts of the European Union has damaged the environment in several ways.

Evaluate methods that have been introduced by the EU and the UK government to encourage the sustainable development of farming. *(12 marks)*

Commodity	January 1986 (figures in thousand tonnes unless otherwise stated)	January 1992 (figures in thousand tonnes unless otherwise stated)
Butter	1400	300
Skimmed mild powder	800	0
Beef	500	800
Cereals	15 000	7 000
Wine/alcohol	4 000 (hectolitres)	2 500 (hectolitres)

Figure 16.82

EU food surpluses

Exam practice: essays

12 'Modern agri-business is not a sustainable form of farming.'

Discuss this statement using the following headings:

• What is the nature of modern agri-business?

• Is modern agri-business sustainable?

• Can agri-business be made less damaging to the environment? *(25 marks)*

13 'As farming becomes more modernised the influence of economic factors increases while the influence of physical factors decreases.'

Discuss this statement with reference to farming in regions at varying levels of development. *(25 marks)*

14 'Since the 1950s increased food production has meant increased food security for most of the world's people, but there are exceptions to this pattern. Moreover, food production cannot go on increasing for ever.'

Discuss this statement, with reference to countries at different stages of development. *(25 marks)*

15 Evaluate the outcomes of the Green Revolution and consider how the lessons from this should influence the introduction of modern developments such as GM crops. *(25 marks)*