THE GREEN REVOLUTION: AN UPDATE

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COUNTRIES IN ASIA and Central America (Figure 1) experienced rapid increases in food production through the introduction of new technology between 1968 and 1983. This was known as the **Green Revolution.** Yields of the staple crops of wheat, rice and maize increased by using the land available more intensively rather than by a large-scale increase in the area cultivated. These technologies were:

- hybrid seeds producing higher crop yields (**high-yielding varieties** or **HYVs**)
- irrigation facilities
- machinery to replace manpower and animal labour
- chemical fertilisers and pesticides.

This unit looks at whether this growth in agricultural output has been sustained in Asia since 1983 and whether there now needs to be a second Green Revolution.

Beyond the Green Revolution

Figure 2 shows how agriculture had changed in Asia by the end of the 20th century when 70% of wheat areas and 74% of rice areas were sown with HYVs.

However, as Figure 3 shows, since the early 1990s the rate of growth of food grain production has begun to slow down and in the 21st century the rate of population growth in a number of Asian countries is threatening to overtake the increase in food production.

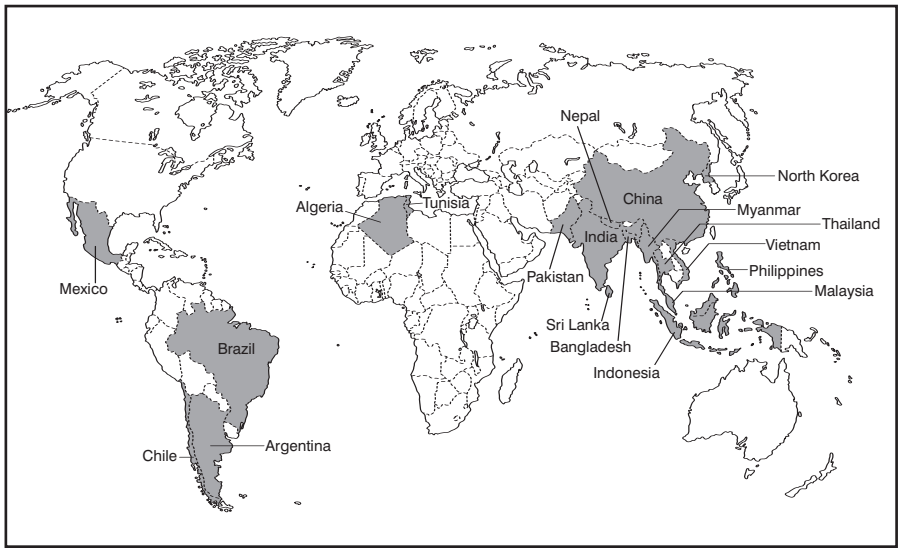

Figure 1: **Countries that experienced increased food output using the Green Revolution technology, 1960–80**

	1961	2000
Cereal production	309 million tonnes	962 million tonnes
Irrigated area	86 million hectares	176 million hectares
Tractors used	0.2 million	5 million
Fertiliser consumption	2 million tonnes	70 million tonnes

Figure 2: **Changes in agriculture in Asia since the onset of the Green Revolution**

Source: Borlaug & Dowswell, FAO Committee on World Food Security, 2004

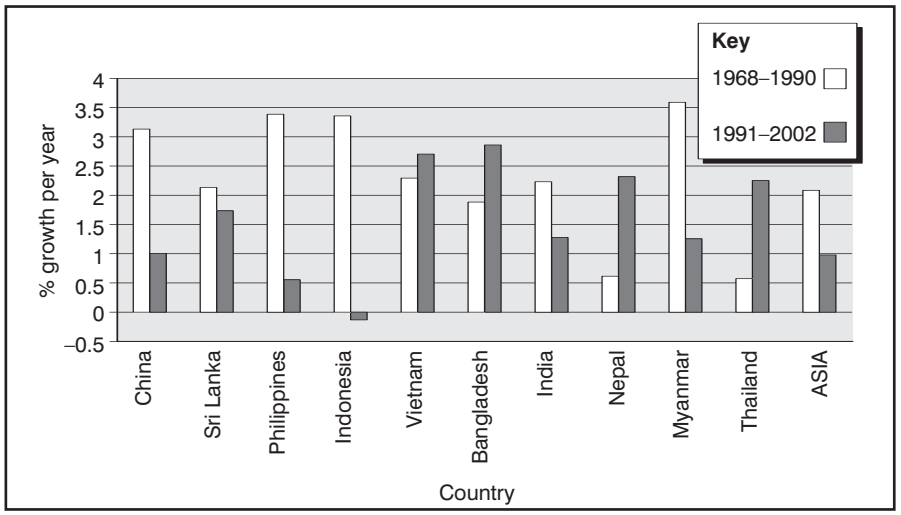

Figure 3: **Change in the rate of growth of rice production in selected countries**

Source: India Development Report, 2004–05

Case Studies

1 India

By the beginning of the 21st century, India had changed from being a country experiencing famine to becoming one of the world's leading cereal producers. Government investment encouraged this huge growth.

- Wheat production increased from 10 million tonnes in 1968 to 73 million tonnes in 2006. It peaked at 76 million tonnes in 2000 when India became the world's second largest wheat producer.
- By 1994, 94% of the wheat area and 65% of the rice area were sown with HYVs.
- Production of wheat per hectare (ha) increased from 851 kg/ha in 1960 to 2,607 kg/ha in 2006. Rice increased from 1,013 kg/ha to 2,093 kg/ha.
- In 2004, 88% of wheat areas were irrigated (32% in 1960) and 52% of rice areas (37% in 1960).
- Tractors increased by 35% as a source of agricultural power while power from animals decreased by 32% between 1971 and 2001.
- Between 1960 and 2003, fertiliser consumption increased by 15 million tonnes.
- The percentage of malnourished people in the country fell from 39% in 1970 to 20% in 2001.

In the 21st century, while rice exports have continued to grow, wheat exports from India have been decreasing and in 2006 India imported 3.5 million tonnes of wheat due to domestic shortages.

India's agricultural success over the past 50 years has been very uneven across the country. The greatest success has been in the 'bread basket' of north India. The north is blessed with fertile alluvial soils and plentiful water from the tributaries of the Indus and Ganges rivers and the annual monsoon. Punjab accounts for 60% of India's wheat output and 43% of its paddy rice. In the drier, hilly areas of the central states such as Madhya Pradesh, HYVs are less successful.

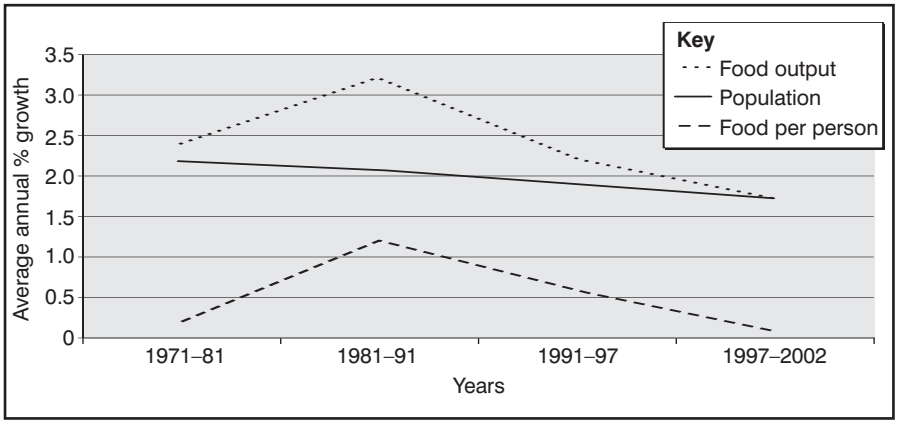

Figure 4: **Changes in population and food output in India**
Source: FAO STAT, 2003

During the Green Revolution higher yields were achieved without huge increases in land under cultivation. Now, at the beginning of the 21st century, the land under cultivation is simply unable to produce more crops.

A number of environmental problems have helped slow down the growth of India's agricultural output in recent years.

- 4 million hectares of soils have become infertile as a result of a build-up of salt due to uncontrolled irrigation (salinisation).
- Over-use of groundwater for irrigation means that there may be insufficient water resources to sustain future yields. The increasing demand for domestic water supplies in the rapidly growing cities is also reducing the amount available for farmers.
- The use of chemical fertilisers and pesticides, which are necessary to achieve the best yields, have led to concerns about water pollution.

India still has more people suffering from malnutrition than anywhere else in the world. As Figure 4 shows, whilst the birth rate has fallen and rates of population growth have slowed, the growth of food output has slowed even more.

During the 1990s and 2000s, severe droughts and floods have played their part in disrupting farm production. However, there has also been a decline in government investment in agriculture, and stagnation in farm incomes.

2 The Philippines

Rice HYVs were first developed at the International Rice Research Institute (IRRI) on the Philippine island of Luzon. **Hybrids** are created by cross-breeding. HYVs have shorter stems so that the energy goes into developing a full ear of grain, and the plant is less likely to fall over, so making it easier to harvest using machinery.

- By 2006, output of rice in the Philippines had jumped to over 15 million tonnes, from just 4 million in 1965 (Figure 5).

Year	Total rice production	Irrigated rice production
1994	10.4	7.5
1995	10.5	7.6
1996	11.3	8.2
1997	11.3	8.5
1998	8.5	6.7
1999	11.8	8.9
2000	12.4	9.4
2001	12.9	9.8
2002	13.2	9.9
2003	13.5	10.2
2004	14.5	10.9
2005	14.6	11.2
2006	15.3	11.6

Figure 5: **Changes in rice and irrigated rice production in the Philippines (million tonnes)**
Source: Philippine Department of Agriculture: Bureau of Agricultural Statistics

- By 2006, 96% of the rice-growing area was sown with HYVs (from 77% in 1980).
- The rice yield per unit area increased from 2.3 tonnes/ha in 1983 to 3.68 tonnes/ha in 2006.
- Between 1965 and 2006 the rice area irrigated increased by 1.9 million ha (930,000 ha 1965).
- Between 1965 and 2005 fertiliser use increased by 800,000 tonnes (53,000 tonnes in 1965).
- Between 1969 and 2003 the number of malnourished people decreased by 33%.

However, population pressure has led to a decline in average farm size which could lead to lower output per farmer, less income and then less improvement.

A second Green Revolution?

The Green Revolution technologies succeeded in raising agricultural production in Asia. By 2030, though, it is predicted that the world population will have increased by a further 2 billion people and in order to meet the increased demand, we will need to double the current amount of food grains produced. But there are huge limitations.

Increasing population pressure means that this next increase in food output will have to be achieved once again by more efficient and intensive farming, in an environment where there are already serious limitations on water availability (2 tonnes of water are needed to produce just 1 kg of rice). Global concerns over climate change may mean restrictions being placed on the fossil-fuel based production of chemical fertilisers and pesticides. So, with such limitations, how can food production again be raised?

What is the Green Revolution technology of the future?

- **Hybrids:** The IRRI is producing new 'super-hybrids' of rice which have increased yields per unit area by a further 20% on the original Green Revolution varieties. However, there is still a need to develop cereal hybrids that can succeed on the drier uplands which depend on lower rainfall and where irrigation is limited.
- **Genetically modified (GM) crops:** Genetic modification uses a more exact science through gene transfer, rather than random cross-breeding (Figure 6). Supporters say GM could raise crop yield through changes in crop height, through increasing the ability of roots to take up nutrients and through crops making the most of available light. GM can reduce the need for chemical inputs and varieties can be bred to be drought resistant. Critics voice concern over their production by huge private seed companies rather than the government-supported research centres such as IRRI. Private seed companies may make the price of seeds too expensive for the small farmers, though this cost could be offset by the reduced need for chemical inputs.
- **Integrated crop management:** A low-technology solution is being introduced by the UN Food and Agriculture Organisation. Farmers are encouraged to get the maximum yield from their ground through the balanced use of water and fertiliser inputs, timing of crop sowing, weeding, and using crop residues as organic fertilisers.

What about Africa?

The first Green Revolution had little impact in Africa. Rice and wheat are not the staple crops and the climatic conditions, lack of irrigation potential and political instability were additional limitations. In 2000, 200 million people in sub-Saharan Africa were suffering from malnutrition. A new HYV of rice is currently being developed in West Africa using local varieties. Further developments are being made in developing HYVs of the local crops of millet, sorghum and barley.

If the world food grain output is to increase then Africa needs to be part of the growth. Here there needs to be an increased output of 5.6% per year in order to meet demand.

Hybrid
Cross-pollination of different rice or wheat plants in greenhouses gradually produces new varieties. By crossing plants with certain characteristics – eg a dwarf rice variety with a rice plant that copes better in droughts – a new rice variety can be bred that has a combination of these characteristics. Cross-pollination to achieve new varieties can only be done between the same plant species: rice to rice, wheat to wheat. It may take the development of many new crops before a useful variety is produced.

Genetic modification (GM)
In a laboratory and using modern technology, the particular genes that give certain characteristics – eg resistance to a certain pest or the ability to cope without water for long periods – can be inserted into the cells of a different plant so that it will develop the new characteristics. It is a much more exact technology and there is the potential to use genes from plants that are unrelated to those they are being added to.

Figure 6: **Some definitions**

Conclusion

World population growth in developing countries is putting pressure on farmers to produce more food from the available farmland. It would seem that a second Green Revolution is needed in order to meet this new demand. But what sort of revolution should it be in the 21st century?

Activities

1 Choose and copy into your notebook the correct definition for the following terms:
(a) *Green Revolution*
i The increase in grain production in Asia and Central America through the use of new farming technologies.
ii The use of renewable energy sources to increase food production in Asia and Central America.
(b) *High-yielding variety*
i A crop variety that has been genetically modified in a laboratory to produce high yields.
ii A crop variety that has been developed by cross-breeding of varieties of the same crop.
(c) *Irrigation*
i Drainage of soil to get rid of excess water.
ii Adding water to crops from river or groundwater through canals, sprinkler systems or wells.

2 State whether the following statements are **true** or **false**. Correct any that are false.
(a) The Green Revolution successfully raised food output in all developing countries.
(b) The Green Revolution has not solved the problem of malnutrition in India.
(c) The Green Revolution introduced genetically modified grains to the developing countries of Asia and Central America.
(d) Not all farmers in the Philippines can use HYV seeds effectively because they cannot irrigate their land.

3 Use Figure 6 to draw a double line graph to show the changes in rice production in the Philippines.

4 Copy and complete the following paragraph, which describes the graph you have drawn in activity 3.

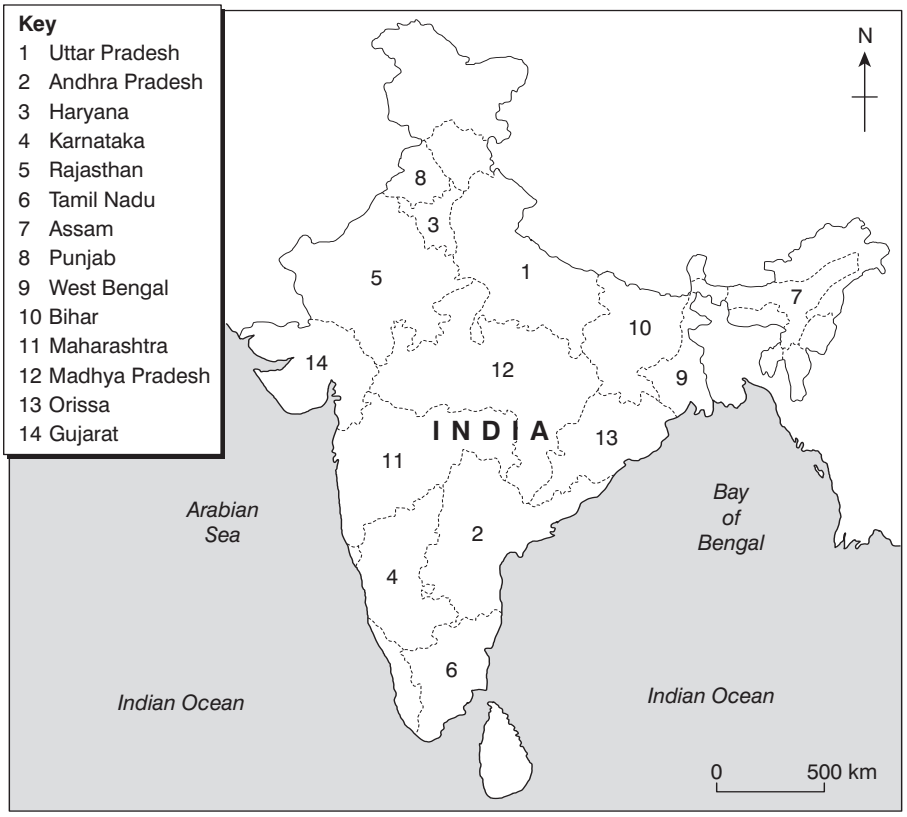

Figure 7: **India's states**

From 1994 to 1997 there was a _____ _____ in the total rice output in the Philippines, from 10.4 million tonnes to just over _____ million tonnes. In 1998 the total rice production _____ to 8.5 million but since then has _____ _____ until 2006 when it reached a ____ of ____ million tonnes. The amount of irrigated rice has also _____ . Since 1999 it has _____ by _____ million tonnes to 11.6 _____ _____ in 2006. The overall _____ in total rice production between 1994 and 2006 is just under 5 million tonnes.

5 In 1998 South-east Asia suffered from droughts caused by the El Niño climate event. What is the evidence for this in your graph? How do you think people were affected?

6 (a) Using a copy of Figure 7 and data in Figure 8, create a choropleth map of cereal output in India in 2001.
(b) Describe the variation in output in India.

7 In pairs, discuss how the variable success of the Green Revolution in India would have had an impact on:
(a) the people living in rural farming communities
(b) the environment
(c) The rates of rural–urban migration.

8 Why do you think it is so important to increase the yield 'per unit area'?

State	Production (million tonnes)
Uttar Pradesh	42.32
Punjab	25.32
Andhra Pradesh	14.53
West Bengal	13.83
Haryana	13.25
Bihar	12.06
Karnataka	10.95
Maharashtra	10.08
Rajasthan	10.04
Madhya Pradesh	8.93
Tamil Nadu	8.90
Orissa	4.98
Assam	4.17
Gujarat	3.68

Figure 8: **Cereal production in selected states of India, 2001**
Source: Federal Ministry of Agriculture, Government of India

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