



Adaption of Agriculture to the Growth in World Population and Accommodating Environmental Challenges

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The continued growth in the world human population brings with it a progressive increase in the demand for food and the productivity of the world agriculture. The response to this pressure will vary from nation to nation depending on many factors such as their physical characteristics, farm size, scope for more intensive agriculture and the value placed on protecting the environment. A key question through the endeavours to feed the growing population is what legacy is handed on to future generations in terms of the earth's natural resources.

The growth in world population has steepened in recent decades from 2.5 billion in 1950 to 7.8 billion in 2021 followed a population of 9.4 billion forecast by UN for 2050. Compounding this trend there is progressive migration from the rural areas to the cities, an expression of this demographic shift is the number of megacities i.e. cities with > 10M, from 2 megacities in 1950 to 33 now, 2021, and a forecast 50 megacities, mostly in Africa and Asia, by 2050. Unfortunately, the cities are invariably located over arable soils and close to supplies of water, which means that their growth is devouring the natural resources which otherwise would have been available for agriculture. The result is that there is an increase in the demand for food and fibre in cities to be provided by agriculture.

There are many daunting challenges for agriculture adaptation and food distribution in the future, not the least of which is the range of different conditions, styles of the agriculture and degree of intensity that already exists. There are, for example, in China and India, with their large populations, small farm size (median size < 3ha), and financial constraints. the response by farmers there,

whether they be owners or tenants, may be difficult as the occupation is so closely related to the land they live on and the degree of intensity that already exists. Whereas for other countries, where the farm median size is much larger, such as the USA, Canada and Australasia, they should be better placed to respond to the increase in demand for food by increasing intensity, specialization and consolidation.

Assuming population growth in the foreseeable future is inevitable then there are seen to be 3 "options" one can take for countries to increase the supply of food and its security: extend land available for agriculture; Intensification of agriculture and efficient and flexible trade in food.

Common to these options is the need to minimize food waste to plan for and adjust to climate.

Examining each of the three options for increasing food production and distribution

Extending land available for agriculture

Historically the spread of human population has occurred in surges, particularly related to European colonisation beginning over the 16 to 20th centuries. In this process natural ecosystems began to be deforested, indigenous people often displaced and habitat destroyed, leading to the extinction of thousands of species of animals and plants. Deforestation and draining of wetlands continue; in recent years in the tropics, Himalayas, Andes, the Amazon Basin. Simultaneously with search for more land is the demand for more fresh water, both surface and groundwater, for agriculture and human consumption. Apart from the pressures on land, the

seas, which cover over 71% of the Earth's surface, are also under pressure, with fish stocks depleted; but desalination of seawater is expected to make up part of the scarcity of fresh water on land; although this in turn places a huge demand on energy and cost.

Concurrently with this pressure to extend the land for agriculture there is also an appreciation of the dwindling environment and understanding of reality of man-induced climate change and the predicted effects this may have on agriculture. There are many reasons protecting natural ecosystems, such as acting as sinks for carbon thus reducing man-induced climate change, pollination, and preserving the genetic pool from which to develop other plant species and medicines.

Intensification of agriculture

The intensification of agriculture, or the increase in production per unit of input of water, labour, time, fertilizer, seed or cash, offers is an alternative that is sustainable food production with minimal impact on the environment.

The techniques which can be included for improving current production systems, will vary depending of the farm product and physical conditions and access to capital and labour. It is important to investigate the adaptive capacity of local farms and regions to identify and rectify factors that may lead to successful intensification. Some of the techniques to consider are:

- Increasing nitrogen efficiency
- Changing plant varieties for productivity and resilience to drought
- Changing livestock varieties for breeds with higher productivity
- Improved protection against weeds
- Applying drip irrigation
- Increasing multiple cropping
- Water harvesting
- Minimizing tillage
- Applying crop rotation
- Mulching soils
- Improved pest and disease control
- Increasing nutrient use combined with efficiency of nitrogen-based fertilizers
- Reducing agricultural waste

- Installing greenhouses
- Combining agroforestry
- Minimizing waste

Improving trade of agricultural products

Trade under the market system, whether it be domestically or internationally, leads to efficiency of supply and demand. By providing access to food that can be grown more cheaply and efficiently elsewhere. Trade also leads to more efficient and sustainable allocation of input factors of production such as land and water. Domestically there is the ongoing demands caused by urbanisation and the need of rapid and safe distribution of foods from rural areas to cities.

Open international trade compliments domestic production by ensuring food security also satisfying changes in diet. Indeed, every country is dependent to some degree on trade to fulfill its food needs According to FAO in this year of the pandemic the global trade for food and agricultural products has been high and the provisional bill for imports for 2021 is estimated to be \$1.72 trillion.

Ideally under open market conditions agricultural supply chains could adapt to occasional temporary challenges if there is finance available. But many nations have border intervention policies unless they are part of larger trade blocs to protect the domestic production.

In the long run there is a case for reducing or eliminating the current distortions in international agricultural trade, such as tariffs and subsidies, and also develop a system of global food reserves in order to ensure global security even for the poorer nations or time of crises.

In conclusion challenges for the future are: to slow the growth of the world human population, increase the world agricultural production yet protect the environment, plan for adjustments for climate change, and ensure an efficient and trade system for food which is safe and consideration is given to accommodation.

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