CHAPTER 2

The Transformation of Agriculture

The world was formed about 4,600 million years ago. The eukaryotic life forms appeared 3,600 million years later. The first hominid hunters and gatherers were recorded recently in comparison, i.e. about 4-7 million years ago. They have their origins in tropical East Africa, present day Chad, Ethiopia and Kenya. They first gathered wild fruits and hunted. Later on plants and animals were domesticated. A social structure that promoted cooperation was established. This resulted in sharing knowledge on cultivation techniques and later on specialised skills related to domestication of particular plants or animals for food.

2.1 Prehistoric era through the middle ages and domestication of plants and animals

Recorded history began about 7000 years ago in the Tigris-Euphrates valley. Before that period, about 5000 years earlier, human have already started farming during what we called the pre-historic era.

Initially, grain crops such as wild rye, barley and wheat were cultivated. This was followed by cultivation of peas and beans. The sites where such activities originated were believed to be in:

(i) Western Asia - includes Turkey (then Asia Minor), Iran and Iraq (Fertile Crescent of Tigris-Euphrates), Israel, Jordan and Syria
(ii) The Nile Valley
(iii) Europe (Danube river valley and Macedonia)
(iv) Indus valley of India-Pakistan
(v) Yangtze & Yellow River valleys of China
(vi) Tehuacan valley of Central Mexico.

Wheat was the first crop to be grown and harvested (using a sickle) on a significant scale. Cultivation practices changed with climatic conditions and social structure (individual vs community).

Global agricultural transformation

It started between 850-1650 BC. Domestication of plants and animals was a milestone in early agriculture. Full dependency did not begin until the middle Bronze Age when use of metal tools became widespread. Domestication involves deliberate husbandry and breeding of plants and animals. Breeding involves selection of desirable traits brought about by genetic changes.

Domesticated animals are reared and used as working animals in the farm and also as sources of food (meat and milk), leather and wool. These animals are hardy, docile and non-territorial.
Large scale farming was started by the Sumerians who were in the stage of empire building. There was similar expansionary development with the Nile valley inhabitants. There were improvements in agriculture with the passage of time:

(i) Rotating with legumes and root crops
(ii) Employing scientific method in agricultural research
(iii) Transferring crop and animal germplasms from their lands of origin
(iv) Using fuel powered machines to increase yield and reduce labour
(v) Introducing mechanisation
(vi) Performing rudimentary food-processing

Agriculture in the middle ages (500-1500 A.D.)

Much of the advancement was made by the Muslims during the golden era of Osmaniah (early 9th century). It took place in the Near East, North Africa and Spain, regions that had extensive irrigation and cultivation knowledge. Revolution in agriculture was spearheaded by four key factors:

(i) An advance irrigation system that made use of machines, dams and reservoirs.
(ii) A scientific approach to farming that adopted improved farming techniques aided by published manuals that enabled raising of crops and animals away from place of origin.
(iii) Incentives in the form of land ownership, workers rights and financial rewards commensurate with efforts.
(iv) Introduction of new crop and plant species and new cultivation techniques derived from research.

By the 14th century, plants and animals were shuffled across the Atlantic from the old world to the new world. Wheat and cereals from the Old were added on to maize, tomatoes and potatoes. At about this time the concept of agribusiness was introduced resulting from large scale cultivation of commodities like linen and silk for export.

Modern agricultural transformation

It started in the 1950s when yield per land unit has increased many times more with tremendous improvement in agricultural practices.

The 20th century saw a rapid rise in mechanization that enabled farm activities to be performed with a speed and on a scale never imagined before. This led to greater efficiency and higher quantity and quality of production. The Green Revolution has begun. This occurred between 1940s and 1960s.

Utilization of human labour, animals, machines, information and biotechnology

This is a reiteration of the story of agriculture. As had been mentioned earlier, agriculture started with human labour (first confined to family members and later extended to hired hands), with heavy duties performed by animals.
Tools and machinery invented decreased burden and increased efficiency. However, some jobs cannot be replaced by machines such as picking fruits and vegetables, rubber tapping and harvesting oil palm fruits.

Agriculture has now moved into the fast lane. Information technology enables quick dissemination of knowledge. Innovative technologies such as remote sensing and precision farming help increased yields and varieties. Genetic engineering creates transgenic life forms superior to their original versions. A brave new world has begun.

2.3. Values, customs and taboos in traditional and modern agriculture

2.3.1 Traditional agriculture

In general, it is still practiced in the 3rd world countries such as in Africa, Asia and Latin America. In Europe and North America, as they entered the 20th Century, traditional agriculture has practically become non-existent.

There are well defined characteristics or practices in traditional agriculture:

(i) The local agroecosystem is fully utilised. Inputs are acquired in production and processing, and wastes are recycled;
(ii) The food production is more akin to an art and craft. Knowledge and skills are handed orally from one generation to the next;
(iii) Food is a question of survival for the community. As such production must be enough and sustainable;
(iv) Land preparation and utilisation is through gentle use of human labour and animal, as land is considered a living entity. No machinery is allowed;
(v) Labour is intensive and control of pests and diseases is by cultural means;
(vi) Natural resources such as rain and natural enemies of pests are fully capitalized;
(vii) Organic fertilizers, land fallowing and plant-microb symbiosis play important roles in providing nutrients; and,
(viii) Native varieties are used as it is believed to have an influence on crop performance due to the natural spirit residing in the plants. However, exchange of seeds among the locals within the community is allowed.

2.3.2 Modern agriculture

Advances in science and technology have paved the way for man to move from traditional agriculture to modern agriculture which not only relies on findings in biological sciences but also in related sciences like chemistry (fertilizers & pesticides), physics (remote sensing), medicine and pharmacy (biotechnology), engineering (mechanisation), ICT (transfer of agricultural technology) and economics (efficient farm management) that have accelerated the development of modern agriculture. It is clear that modern agriculture depends on new knowledge, skill and technology. However modern agriculture is blamed for the disturbance in the local ecosystems relating to excessive use of chemicals.
Characteristics of modern agriculture:

(i) Intensive and mass production as requisites of agribusiness;
(ii) Extensive use of machinery and electronics, from land preparation to harvesting;
(iii) Extensive use of chemicals for fertilizers and pests control;
(iv) Widespread use of clones, hybrids and selected high yielding varieties;
(v) Employment of highly knowledgeable and skilled workers;
(vi) Industrial approach with monocultural system and highly efficient management; and.
(vii) No attention given to tradition and taboos by professionals who manage the system.

2.3.3 Nomadic agriculture

Also known as “slash and burn” or Swidden Agriculture. It is still practiced in Asia (Sarawak and Indonesia), Africa dan Latin America. It is an ancient agricultural practice which has its beginnings in the Neolithic era (Stone Age).

Characteristics of nomadic agriculture:

(i) It is short term where planting lasts only for 2-3 seasons. Crops grown are annuals such as beans, root crops, maize and hill padi. The area is then left fallow for a long period. The community leaves to plant on a new site;
(ii) Cultivation is either on fertile virgin jungle soil or on hill slopes (Gua Niah in Sarawak);
(iii) Customs and taboos have a place in daily farm activities where the headman plays a significant role in decisions made;
(iv) Yields are poor, sufficient only for the immediate family and deteriorate every year;
(v) There is minimal fertilizer input resulting in loss of nutrients and fertility;
(vi) If planting is done on water catchment areas flood can result, disrupting the ecosystem; and
(vii) Plant species and valuable herbs are lost through indiscriminate clearing which affect biodiversity.

2.3.4 Sedentary agriculture

It denotes cultivation on the same piece of land year in year out where the community remains sedentary. It is performed on a specific area by rural folks on a small scale or in big commercial ventures.

2.4. Influence of religion on agriculture

Islam, and for that matter other religions too, gives a lot of attention to agriculture based on many Quranic versus. One that has been mentioned many times is An Nahl which reveals the importance of bees in producing honey as food, but more importantly, as medicine. Other
versus on plants and domestic animals are found in Surah Al Baqarah (verse 22), Surah Al Kahfi (verses 32-41; 45), Surah Yaasin (verses 33-36) and Surah Luqman (verse 10).

Christians believe that since God created nature, agricultural practices should not contribute in any way to the detriment of the environment. The proper model for the caretaking of nature from a biblical perspective is the Christian stewardship model (Genesis II; Luke 12; 16). The Christian steward of nature first recognizes the nature, like everything else in heaven and earth, was created by God, belongs to God, and is valued by God for itself.

In the Hindu caste system, the vaishas are Aryans who tended cattle. Islam has placed agricultural activity as fardhu kifayah where there must be at least a person in a community who is involve in agriculture as a career.

A shaman will perform certain agricultural rights when opening a new piece of agricultural land or starting a crop season, asking for rain in times of drought or requesting for bumper yield.

### 2.5 Influence of lifestyle on agriculture

Modern style of living uses agriculture as a business enterprise rather than as a way of life. The lifestyle and size of a community influences agricultural activities. Trends such as Valentine’s Day, Mother’s Day and convocation result in the demand for certain agricultural products such as flowers and chocolates. On many other occasions, gift from agriculture related materials are common such as handcrafts, pets (companion animals) e.g. cats, dogs, rabbbits, ornamental fish and birds.

More important, today’s consumers have high expectation particularly of the agricultural food products they purchase and consume. There is increasing demand for food of high quality and safety, but cheap. Globally, knowledgable consumers are questioning the system of food production, environmental management and welfare of animal farmed for food or non-food purposes. This trend has strong influence on the farming system that also affects the cost of production. Modern agricultural production system demands more knowledgable human resources, technology and capital.

Agricultural transformation started with the Green Revolution. This occurred in 1960s as a result of increased food production with improved crop variety and yield. In under-developed and developing countries, this revolution elevated famine.

Presently we have a Blue Revolution that aims to provide enough water for consumption and for agricultural irrigation in the world. This must be carried out in a manner which is ecologically sound and sustainable. Water supply has become critical, and the United Nations has estimated that by the year 2025, 2.7 billion people will be facing water shortage to domestication of particular plants or animals for food.
## 2.6 Reasons to modernize agriculture

### Resource limitation and constraints

Since the world population has increased, demand for food has also increased. However, the natural resources for food production such as arable lands and diversity of living organisms are diminishing.

1. **Fertile land**

   Agricultural production is proportional to land availability and its fertility. Arable land for agriculture is decreasing, so agriculture has to move into less arable, infertile and problem areas such as sandy and tin-tailing soils. The main difficulty is with the water availability due to the physical nature of the soil like its sandy texture that lead to low water holding capacity. Reduction in fertility is also caused by erosion of surface soils especially along slopes.

   Problem soil in the tropics is weathered soil that is synonymous with lack of nutrients and acidic. A low pH causes poor uptake of *macro-nutrients* like phosphorus, calcium and magnesium. Conversely, *micro-nutrients* such as ferrum, manganese and zinc become too soluble and easily absorbed resulting in plant toxicity. Addition of fertilizers and lime will help improve this condition.

2. **Labour and mechanisation**

   In Malaysia, agricultural labour force has reduced because not many youth are interested to work in agriculture. This leads to large tracks of abandoned agricultural land, with commercial agriculture resorting to import labour. However, this problem increases the impetus to mechanise.

   All this constraints lead to insufficient food production and increase in food imports (approaching 13 billion ringgit annually in Malaysia). A need to reduce deficit in our balance of trade provided another trigger in agricultural revolution.

3. **Population increase**

   World population increase has not slowed down. Malaysia has 26 million, while the world’s population has surpassed 6.5 billion in 2006. It has taken only 12 years to add 1 billion (5.5 billion in 1996); the current birth rate is 4.5 born each day but only 1.5 died per day. This requires increase in world food supply.

4. **Need for diversity of products**

   An agriculturally balanced ecosystem requires product diversity. Niche demands must be fulfilled, for example age brackets and dietary preferences (baby food, fast food, health food, vegetarian food, snacks). Different livestock must be raised and plants cultivated for a sustainable agricultural system.

5. **Trend towards environmental friendly practices**
Conventional agriculture which is mainly monoculture is highly intensive in nature. It requires high inputs of fertilizers and pesticides. Usually, the input is in excess of what is recommended. Soil pollution can occur when nitrate (NO$_3^-$) and phosphate (PO$_4^{3-}$) fertilizers are not completely taken up by the plants, leached into the soil and contaminate the groundwater. Contamination from pesticides will enter the food chain leading to biological magnification. As such, a more environmental friendly approach in agriculture is needed.

vi. Technological advances

Older technologies use outdated implements which cannot produce quality products in required quantities. Current technologies are needed to get quality and the required quantity with minimum labour input. Knowledge, skill and capital are required to ascertain productivity.

2.6.2 Characteristics of Modern Agriculture

i. High yielding and disease resistant varieties

To increase the yield, high quality germplasm must be used which is achieved through research, for example, MARDI has produced a high yielding padi variety (MR219, MR220) and superior quality rice (MRQ50, MRQ74). Similarly, improved rubber clones, fruits and vegetables were produced. Another characteristic selected for is disease resistance that could reduce the use of pesticides by adopting the following methodologies:

ii. Tissue culture

This technique involves breeding without seed to produce exact copies in large numbers. The technique involves the use of any growing plant part (eg. leaf, shoot and meristem) cultured in tubes containing nutrients supplemented with growth hormones. Examples are orchids, bananas and herbs like “tongkat Ali” and Tahitian noni. The maturity time is shorter and the plantlet is free of disease and shares the quality of the parent.

iii. Genetic engineering

This technique involves manipulating genes to produce new breeds. For example, a new breed of papaya resistant to Ring Spot virus and maize that can kill stem borers due to incorporated $B. thuringiensis$ gene.

iv. Use of chemicals and bioagents

Application of these substances improves yield and quality. When chemicals are used, rates must be followed to minimize environmental pollution. Biocontrol agents are introduced to reduce the use of chemical pesticides. Parasitic insects and predators are biocontrol agents of insect pests while the barn owl $Tito alba$ controls the rats in oil palm and paddy fields. Microbe such as $Trichoderma$ is an antagonist against the pathogenic fungi $Fusarium$ while $Beauveria$ and $Nucleopolyhedrovirus$ (NPV) kill insect pests and mites. Other beneficial microorganisms include nitrogen fixing bacteria, $Mycorrhiza$ and probiotics.
2.6.3 Precision agriculture

It is a comprehensive system designed to optimize agricultural production and achieves specific targets through the application of crop information, technology and management practices.

An organic farming system has a specific target for chemical free products disallowing chemical fertilizers and synthetic pesticides. Instead, organic fertilizers like compost, animal excreta and green manure.

Cultural (crop rotation) and biological control methods are adapted to combat pests and diseases. Computers, sensors, GIS and satellites are used to gather and process information.

2.6.4 Innovations in mechanisation and automation

They save energy and time while producing quality products. They are incorporated in many applications including irrigation, fertigation and controlled environment systems.

2.6.5 Agricultural biotechnology

It is a revolutionary technology which employs advanced processing methods and genetically modified organisms to improve yield and quality. It provides new food materials for consumers and environmentally friendly ways of pests and disease control. Examples can be seen in the production of high yielding clones, fast and frozen foods, dehydrated fruits, nutriceuticals, antioxidants, vitamins, cosmetics and enzymes.

2.6.6 Agricultural enactments and schemes

Department of Agriculture in Malaysia encourages good practices to ensure competitiveness in the global market. Examples include Good Agricultural Practice (GAP), Good Manufacturing Practice (GMP), “Malaysian Organic Scheme” (SOM) and Malaysian Good Farm Practice Scheme (SALM). All the above will ensure sound agricultural practices based on environmentally friendly concept to provide healthy products that are safe to eat. There exist a Quarantine Act to protect the agricultural industry from the import of harmful pests and organisms. Permits are required for importing plants, microorganisms, soils, composts and organic fertilizers.