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IMPROVEMENT OF SOIL CARRYING CAPACITY FOR BETTER LIVING

Y.M. Khanif

Department of Land Management, Faculty of Agriculture
Universiti Putra Malaysia, 43400, Serdang Selangor Malaysia
khanif@agri.upm.edu.my

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ABSTRACT

Soil is the most important resource for food production. The increase in world population puts pressure on the soil resource to continuously provide food security for the population. The per capita arable land is 0.22 ha per capita and it is expected to reduce due to population increase, land degradation processes and competition for non-agriculture land use. The agricultural sector has been successful to continuously supply food for the growing population. This is brought about by the green revolution resulting from technological improvement through advancement in scientific knowledge. With more constraints and greater challenges the agriculture sector requires more efficient and productive technology. Since horizontal increase through expansion of arable land is restricted the increase in food production has to be achieved vertically by increasing soil productivity. The use of fertilizer for improvement of soil productivity is one of the widely practices worldwide. The use of fertilizer has no doubt increased the soil productivity; however it has also created serious environmental problems. As an example, the efficiency of N fertilizer is often low due to losses and the N that leaks to the environment causes serious environmental problems such as ground water pollution, emission of greenhouse gases, eutrophication and nitrate pollution. For sustainable fertilizer management, the loss has to be minimized to subsequently increase fertilizer efficiency. Application of balanced plant nutrients had been shown to increase soil productivity. Addition of small amount of micronutrients in certain soils can result in tremendous yield increase. Other technologies that increase soil productivity and reduce its degradation will enhance the soil carrying capacity. The public awareness on the importance of soil resource for food production and human survival should be provided through the education system. Research for public good on sustainable soil management must be given top priority alongside the market driven research, to ensure the agriculture sector continues to supply us with food from the growing population.

Key words: Soil resource, food security, arable land, population carrying capacity

INTRODUCTION

Soil is the single most important resource required for food production. The early human civilization started in areas with deltas and valleys endowed with rich and fertile soil that enable agriculture for food production. The Mesopotamia civilization in the Tigris Euphrates, the Nile valley, Hwang Ho and Yang Tze Kiang in China and the Indus Valley are examples of these civilizations which owed their origin to fertile soil. The word agriculture originated from a Latin words *agre* and *cultura*, in which *agre* means land and *cultura* means cultivation, thus agriculture means cultivation of land The significance of soil in agriculture and its role in food production cannot be disputed. Thus sound soil conservation and management are vital to support human lives on this planet. Its effect is not only relevant to the current inhabitants but also to the unborn in the future.

The performance of the agriculture sector has been very assuring, at every meal a variety of food in sufficient quantity can be found on our table. Can this situation be taken for granted? Will the soil resource continue to be sufficient to support agriculture so that our dinning table will continue to be replenished with food indefinitely? It was however reported, famine did occur in certain part of the world due to food shortage.

Soil is nature's gift; it cannot be produced within human life span. Thus the available arable land area globally is fixed and cannot be extended. The arable land up till now can support the global population, which stands at 6.4 billion with 800 million of the world population undernourished (Eswaran et al 1999). The global population, however, increases at the rate of about 1.14% annually. At every one second 4.1 new babies are born. Thus with the increase in world population the per capita arable land decreases. The decrease in the per capita arable land is further aggravated by the process of land degradation and irreversible land use for non agriculture purposes brought about by population pressure. Both these factors i.e. land degradation and population increase threaten the ability of the soil resource to support agriculture for food supply. If population increase is unavoidable, serious effort should be focused to reduce land degradation and agricultural productivity has to increase to cope with the food demand of the growing population.

Soils are not created equal, some soils are fertile require little input while some are poor that require high input and special management. It is an irony that Asia and Africa being the most populous region of the world are provided with low quality soil, while the temperate regions of Europe, America and Australia are blessed with very productive soils that require minimal input. In addition to the presence of poor soils, the soils in the Asian and African regions are situated in the vulnerable climatic condition which exposes the soils to excessive land degradation processes. The Asian and African regions often referred to as the third world, will have to strive harder to provide food to the ever increasing population with low fertility soil and under adverse climatic condition favoring land degradation. Is it a coincidence; poor countries have poor soils?

This paper attempts to elucidate the significance of soil as a natural resource for food production that supports human life. It also examines the soil carrying capacity to support human life at the global and national level.

Food Security

The most important development in the twentieth century has been our ability to produce larger harvest, thereby ensuring food stability and security for the constantly growing population. This great achievement however was unnoticed, largely because most people do not realize how insecure and unstable agriculture was in the past. In Malaysia the 1997-98 economic crisis and the hike in food price in 2008 served as wake-up calls. It was suddenly realized that in 1998 Malaysia imported a hovering RM13 billion of food and the value keep on increasing. This is the result of the country bias towards the other more lucrative economic sectors and neglecting the agriculture, especially the food production sector. All countries in the world have no choice; they have to depend on agriculture for food supplies. The choice is whether domestic agriculture or the agriculture beyond the national border. This leads to the issue of food security, which has strong political, economic and sovereignty implications.

Food security is defined as "providing physical and economic access to balanced diets and safe drinking water to all people at all times" (Swaminathan,1986). Food produced domestically ensure stable long term supply and political sovereignty. It is less vulnerable to political, economic and military instability. It is the best option if the soil resource is available.

Learning from the Asian economic crisis Malaysia had declared agriculture as the third engine of growth, with creation of new wealth, improvement of the rural economy and ensuring food security as the main thrust. This simply means that while the country embarks on the industrial and service sector to fuel the economy the agriculture- food sector would not be neglected. In fact the agriculture sector specifically the oil palm industry has proved to be resilient. In the Asian economic crisis it was the oil palm industry that provides the export earning to sustain the economy. Malaysia at present is one of the main palm oil producers, contributing about RM 50 billion to the county's export earning. It is the food production sector that requires the needed push to support the nation food security agenda.

Based on the available arable land, it is reported that China and India with a combined population of 2.3 billion and occupying more than 14 million km^2 of land will find difficulty in feeding their population unless these countries employ high level agricultural technology (Beinroth et al, 2001). Afghanistan, Bangladesh and Pakistan are other Asian countries that are facing food security problem due to limited arable land to support the ever increasing population. Base on the report Malaysia has a medium risk to food security at low level of technology and is classified as low risk with medium technology level. This means that Malaysia has sufficient soil resource to support its population up to 2020 with the expected population of 30 million, provided improved agricultural technology is being employed. In the Asian countries with the exception of Laos, Kampuchea and Papua New Guinea the region will have declined markedly in its capacity to sustain food security.

Arable land and global population

The distribution and area of land under different land use world wide are given in Table 1.The total area of land not covered by sea is 14.6 billion ha (Nat. Geog. Atlas of the world, 1981). Of this total area of land only 1.48 billion ha is arable land suitable for food production, a major portion of the land area are not suitable for agriculture either due to their unsuitable topography or adverse climatic condition. The arable land distributed in various continents where most of the arable land is in America, Canada, Europe and Australia. The arable land in Asia, however, is relatively less especially when the magnitude of the population is being taken into consideration.

Table 1. Major areas and water areas.

Earth	**Tons or ha**
Mass	5.974 x 10^{21} tons
Total Area	51,006,600,000 ha
Land	14,642,900,000 ha
Water	36,163,700,000 ha
Arable Land	1,480,000,000 ha

(Source: National Geography Atlas of the World, 1981)

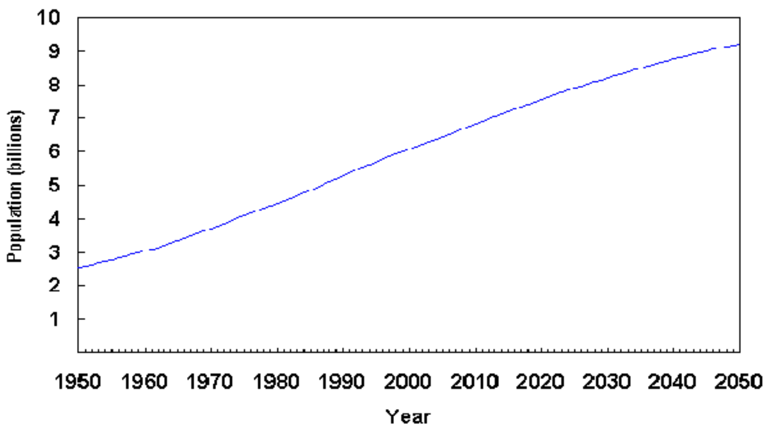
The number of the world population and its demography in relation soil resource is important to asses the distribution arable land per capita of the population. The world population at for the period 1950 t0b 2050 is given in Figure 1.

The current world population is 6.7 billion. In 2020 the world population is expected to increase to about 8 billion. The world population increase at the rate of 1.14 % per year. Most of the population increase occurs in the third world countries especially the Asian country. With current population the mean of arable land is 0.22 ha per capita. Each hectare of the arable land is expected to produce sufficient food for four persons. Based on the FAO land carrying capacity data the 0.22 ha per capita arable is above the critical value of 0.07 ha per capita considered sufficient for food production.

Although the world per capita arable land is above the critical level, a closer examination reveals that some of the countries such as China, Indonesia and Bangladesh have very low per capita arable land. The high per capita arable land is located in Australia, Canada and America. Thus the populous country of the world will have to depend on the west for their food supply in the future.

Given the increasing population, land degradation processing and urbanization the per capita available land for food production will continue to decrease. For the world to support the growing population on the decreasing soil resource tremendous advance in science technology is required to increase the soil productivity vertically as oppose to horizontal increase when soil resource is in abundance. The use of fertilizer, agro-chemical, machineries, precision farming and biotechnology will be the tools to bring about this needed change. The agriculture sector in the future should be knowledge and science driven not as in the past where it was land driven.

World Population: 1950-2050



(Source: U.S. Census Bureau, 2005)

Fig. 1. World population from 1950 to 2050

Population carrying capacity

The current world population is 6.7 billion. In 2025 the population is expected to reach 8 billion and about 97% of this increase will occur in the developing countries (Swaminathan, 1994; World Bank, 1992). The population of Malaysia now is 26 million and expected to increase to about 30 million in 2025. The urban population worldwide will increase from 1 billion to 4 billion in 2025.

With steady increase in the world population, there is a greater challenge for the agriculture sector to supply food. The increase in food production in the future has to come from increase in land productivity. The increase in food production through increasing land area is minimal because of limited land area is available. With population increase there is a tendency for more rapid land degradation process and the per capita arable is expected to diminish. Advances in science and technology in agriculture is required to sustain the increasing world population. Application high level technology is required for increasing the production capacity as to minimized land degradation.

Malthus in 1798 created awareness on global food supply in relation to the population increase. He stated that, with time the rate of population increase would be much greater than the rate of the world capacity to produce food. The pessimistic concept is controversial and has not been realized until today. The world continues to increase its food production (Table 2) and provides sufficient food for the increasing population.

Table 2. The world total cereal production, average yield and area harvested from 1960 – 2004.

Year	**Total production (metric ton x billion)**	**Average yield (ton/ha)**	**Area harvested (ha x 100 million)**
1960	0.877	1.35	6.48
1970	1.19	1.77	6.76
1980	1.55	2.16	7.17
1990	1.95	2.75	7.08
2000	2.06	3.06	6.74
2004	2.25	3.30	6.81

(Source: FAOSTAT 2005 http://faostat.fao.org)

The ability of the world to supply food to the growing population until today is because of the advances in knowledge and science which manage to increase the agricultural productivity over less unit area of land. The discovery of new varieties, fertilizer, pesticides, machineries, irrigation system etc. as the results of R& D are responsible for the productivity increase. The advances in biotechnology are expected to increase the agricultural productivity higher to a magnitude beyond our imagination in the near future. Thus the Malthus prediction will never be fulfilled for a long time to come. As long as the human has the ability to discover new knowledge and technology for the agriculture system, the Malthus theory will not be realized.

The world ability to supply food for the growing population depends on the population carrying capacity. The population carrying capacity depends on the soil quality and the level of technology applied (Beinroth et al. 2001; Eswaran et al., 1999). The soil quality is based on its natural properties and the climate. The soil quality is classified into nine classes (from I to IX) in a descending order. The distribution of the soil based on the soil quality classification indicates that most of the class I and II soils are found in the temperate region, while the soil of class III, IV and V are found in the Asian region. In Malaysia no class I and II soils are found, thus Malaysia requires more inputs for food production as compared to the developed countries.

The level of technology used is important in determining the level of soil productivity. The soil productivity increases with higher level of technology. A combination of class I soil with high technology will give the highest productivity. While the poor class soil with low technology level will give the lowest productivity. The number of population that a hectare of land can support with different combination soil quality class and level of technology applied range between 0 to 10 person per ha. (Beinroth et al., 2001).

Other reports on the value of the carrying capacity did not consider the soil quality and technology level factors. The values of the number of person the land can support for food production range from 1 to 14 persons per ha. The reciprocal of the population carrying capacity gives the land area requires to provide food for one person. The carrying capacity value of 14 is being used by the FAO as the critical value. The accuracy of the value is sometimes doubtful thus further study is required to accurately determine the value. Based on the analysis by Eswaran et al 1999 the population carrying capacity of the world is 6.159 billion at low level of technology, 8.725 billion with medium level of input and 19.816 with high level of input.

Land degradation

Land degradation occurs when soil loss its quality, productivity and utility. The degraded land lost its ability to support crop production. The important physical processes resulting in land degradation are erosion, desertification and destruction of soil structure. Significant chemical processes include acidification, soil contamination, salinization, and nutrient mining. While biological processes involved are loss of organic matter and loss of soil biodiversity. Erosion and desertification are the most serious land degradation processes responsible for reducing the area of arable land for agricultural production.

Several reports had shown that land degradation reduced farm yield and resulted in loss of income (Lal, 1998, UNEP 1994, Pimental et al., 1995). In south Asia, annual loss in productivity is estimated at 36 million tons of cereal valued at US$ 5.4 billion (UNEP 1994). On a global scale the annual loss of 75 billion ton of top soil cost the world about US$400 billion per year (Lal, 1998) the economic impact of land degradation is extremely severe in the densely populated South Asia and sub Saharan Africa. In Malaysia perhaps soil erosion is the main cause for land degradation, especially in the areas with sloping land. Severe soil erosion occurs in Malaysia due to high rainfall.

With population pressure and limited land area excessive land degradation processes will reduce the capacity for food production. Thus globally land degradation issue is being given top priority in international forum and it is recognized as the important global agenda.

Improvement of soil productivity

The current issues on food security, population, land degradation and scarcity of arable land indicate that the land carrying capacity has to be maximized to ensure the world population to have sufficient food supply. Improvement of soil productivity through fertilizer use is viable and reliable option. In modern agriculture the use fertilizer to provide plant nutrients had increase crop yield and had increase soil productivity. The increase in crop yield due fertilizer application has provided more harvest per unit area with increasing land area. The use of fertilizer in crop production has put more food from the soil to the table. Nitrogen is the most required nutrient by plants and the demand cannot be sufficiently supplied by soil. Thus N fertilizer is the most common fertilizer use in crop production and it is used in large amount. Besides N , P and K are major plant nutrients applied as fertilizer. Other nutrients especially micronutrients are often neglected in most fertilization program. In recent years more evidences indicated that the micronutrients are required to sustain soil productivity for high crop yield. For sustainable crop production balanced fertilizer application is advocated. Other technologies that increase soil productivity and reduce its degradation will enhance the soil carrying capacity.

Excessive use of fertilizer has also being reported to cause environmental problems. High application of N fertilizer can result in groundwater contamination, N_2O emission and nitrate pollution. These problems can be minimized with sustainable management practices based on scientific knowledge and understanding.

CONCLUSION

The public awareness on the importance of soil resource for food production and human survival should be provided through the education system. Research for public good on sustainable soil management must be given top priority to ensure the agriculture sector continues to supply us with food for the growing population.

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