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AGRICULTURE, POPULATION AND THEIR IMPACT ON THE GLOBAL ENVIRONMENT

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ABSTRACT Perhaps, the global warming is the most serious problem that humankind faces today. Agriculture not only supplies food, feed and fiber but also is the source of energy. The combination of population growth and economic development with the decreasing per capita land area, growing needs of energy and increasing demand of quality food, especially in the developing countries, puts a great stress on arable land, water, energy and biological resources. The rush toward liquid biofuels affects virtually every aspect of the field crop sectors, ranging from domestic demand and exports to price and the allocation of land area among crops. This study reveals that the global environment is influenced by cropping patterns, dietary choices, food supply and international trade, and population growth might be the main key. Production of genetically modified (GM) crops might be useful in reducing growing pressure on natural resources and on the environment, if that does not conflict with safety and biodiversity. If the population can be stabilized to a 1990-level and food spoilage and other waste limited to 10%, then about 28% of the present world food supply could be conserved. It may facilitate the countries to export their surplus food to the food deficient countries and may play an important role to reduce food insecurity and poverty, and reduce the pressure on land, water and other natural resources, help abate environmental burden, as well as might open the door for future liquid biofuels to build a sustainable world.

Keywords: Agriculture, Population, Food supply, Dietary choices, Global environment.

INTRODUCTION Greenhouse gas emission, which has increased remarkably due to tremendous energy use, has resulted in global warming, perhaps the most serious problem that humankind faces today. Efforts are underway in every sector of human activities to conserve the available natural resources, abate global warming potential and to improve the energy and food security. Agriculture not only supply food, feed and fiber but also is the source of energy. If agriculture fails to produce adequate amounts of foods containing enough nutrients in balance to meet human needs, people's health will deteriorate, national morbidity and mortality rates will rise, national development will decline, social and political disruption will evolve and human suffering will severely increase.

Insufficient output of even one essential nutrient over a long time will produce these dire consequences (Graham et al., 2001). However, it is very hard to imagine how we can grow enough crops to produce renewable energy and at the same time meet the enormous demand for food.

The combination of population growth with the decreasing per capita land area and growing needs of energy puts a great stress on arable land, water, energy and biological resources to provide an adequate supply of food while maintaining the ecosystem. In recent years, the rapid expansion of biofuels affects virtually every aspect of the field crop sectors, ranging from domestic demand and exports to price and the allocation of land area among crops. As a consequence, farm income, government payments and food prices are also changed. Therefore, strategies for the future must be based on the conservation and careful management of land, water, energy and biological resources needed for food and renewable energy production. Transitory food insecurity and health risk would be the big challenge humankind might have to solve in the near future. Hence, the authors intend to discuss agricultural production and population growth, cropping patterns (conventional, organic and genetically modified crops), dietary choice, food supply chains and international trade, and their impact on the environment.

AGRICULTURE AND POPULATION GROWTH The world population continues to grow geometrically, great pressure is being placed on arable land, water, energy and biological resources to provide an adequate supply of food while maintaining the ecosystem. The estimated per capita arable land was 0.26 and 0.21 ha in 1990 and 2007, respectively. With the increase of world population the per capita arable land area will be decreased further. Land allocation is changing all over the world, however in the developing countries to an extreme and possibly dangerous extent. It seems that land under agriculture in most of the developed countries is decreasing, which might be because of industrialization, changing life style or unwillingness of the new generation to work in agriculture. In contrast, area under agriculture is increasing in most of the developing countries to keep the food production in step with population growth and increasing demand for quality food. The main driving force behind decreasing trend in forest area, especially in the developing countries believed to be the cutting down of the rain forest for hardwood and cash crops production. In addition, the growing population growth coupled with the changing social behaviour led to increase the number of single households (residential area in both the developed and developing countries) and other infrastructure. The substantial increase in the others-land category is also observed in all countries (except China) supports the earlier statement.

As population growth is increasing, substantial increases in crop yields are needed for food security, especially in the developing countries. Although crop production has significantly increased with the use of improved varieties and technologies, and increased cropping intensity, FAO reported that 864 million people were under nourished worldwide in 2002–04 (FAO, 2006). Rice is the staple food for nearly two-third of the world's population. The production is found to be increased in different countries, except Japan, even the harvested area has decreased in some countries (China, Japan) (Fig. 1). The harvested area found to be increased after a certain time span might not only because of the increasing demand for the staple grains which seems to be led by population growth, but also with the decreasing land productivity in that period. Figure 2 shows the productivity in different countries and in the world. It seems that the land productivity

remained flat for a certain period or even decreased and then again increased may be because of the introduction of improved varieties, methods of cultivation, use of chemical fertilizers, irrigation and management technologies. Although rice production has significantly increased, per capita production remains almost flat or even decrease in some countries (Fig. 3) which depict that highly populous countries (such as Bangladesh, India and Indonesia) will be vulnerable to food insecurity, unless the population growth is controlled.

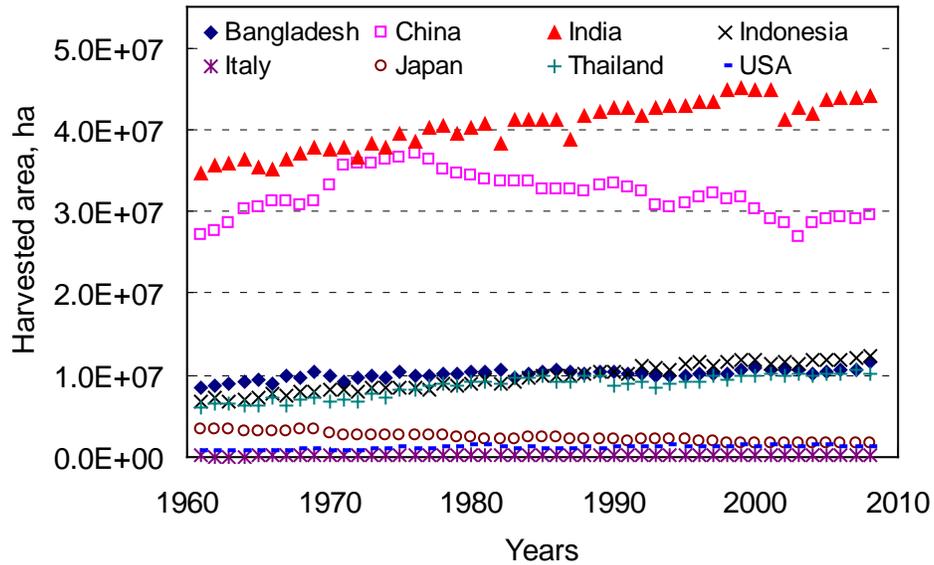


Figure 1. Rough rice harvested area in different countries (data source: FAO, 2010).

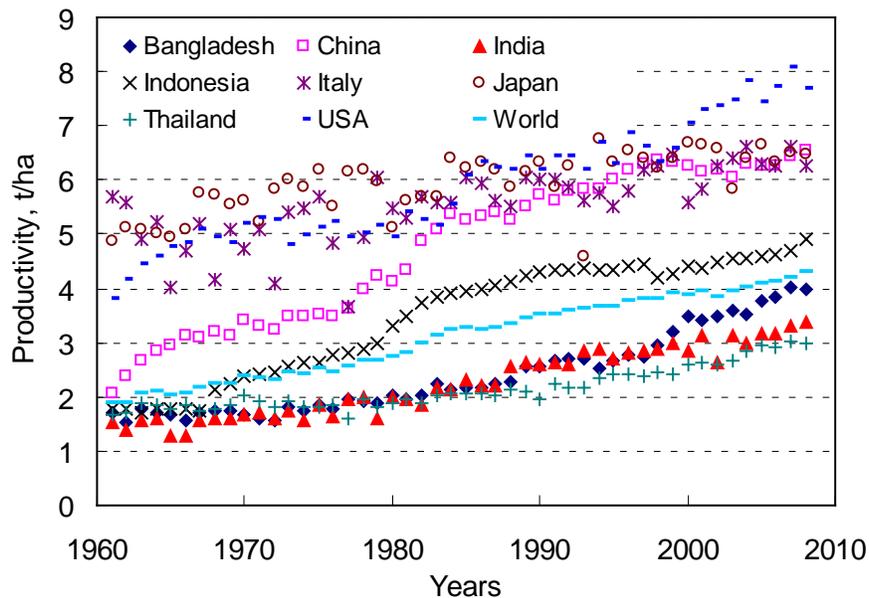


Figure 2. Land productivity in different countries and the World (data source: FAO, 2010).

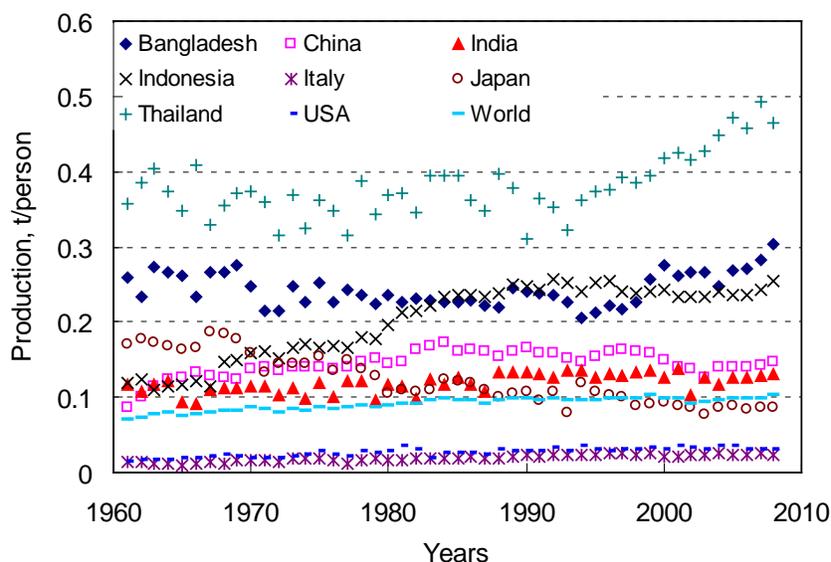


Figure 3. Per capita rough rice production in different countries and in the World (data source: FAO, 2010).

Cropping intensity has grown in many places around the world over the decades so that the food production could keep up with population growth, especially in the developing countries. This increasing cropping intensity resulted in farms being over-ploughed and in overuse of agro-chemicals and irrigation, which affects all aspects of the soil, water, land, biodiversity and the services provided by an intact ecosystem, and began to bring the yield growth rate down (Pandey, 2009). Conventional agriculture uses greater amounts of chemicals compared to organic agriculture, but organic or conservative agriculture may require more arable land. Genetically modified (GM) crops can serve various purposes, such as increasing the yield and offering resistance to plagues or harmful insects or pesticides, increasing the share of useful components or decreasing the need for artificial fertilizers or water, and also improves land productivity and farm income (ScienceDaily, 2005; Bennett et al., 2004). However, its use as food and feed is not widespread due to safety concerns, even strong opposition from different groups is also exist. Recently, violent demonstration against Bt-Brinjal has been reported in India (TOI, 2010). Many researchers noted the merits and demerits of GM crops which have to consider for any change in adopting the innovative varieties.

DIETARY CHOICES AND HEALTH Although food choices are often based on behavioral or social motives, people should always be allowed to choose the diet they want. However, the current pressures on the environment, resource scarcity and the commitment of countries to reducing GWP has prompted research on changes in dietary choices to reduce the environmental load of the food industry. Several researchers have worked on the effect of dietary choices on the GHG emissions. These studies depicted that emission is dependant on the dietary choices (Carlsson-Kanyama, 1998; Dalgaard et al., 2003; Eshel and Martin, 2006; Håkansson, et al., 2005; Ozawa and Inaba, 2006; Roy et al., 2007, 2009). A comparison of four meals shows that a meal with tomatoes (grown in greenhouse), rice and pork has nine times higher emissions than a meal made from potatoes, carrots and dry peas with same dietary value (Carlsson-Kanyama, 1998). Ozawa and Inaba (2006) concluded that CO₂ emission is higher for protein-rich products

followed by carbohydrate-rich products. Dalgaard et al (2003) reported that substitution of pork with vegetables reduced the environmental impact. Poultry meat production is reported to be the most environmentally efficient, followed by pig meat and sheep meat with beef the least efficient (Williams et al., 2006; Roy et al., 2008a).

Consuming more or lesser calories than expended will result in weight gain or loss. The world health organization (WHO) recommendation is to maintain a body mass index (BMI: a measure of obesity or thinness or energy deficiency, expressed as weight/height²) in the range of 18.5-24.9 kg/m². The recommended food intake is reported to be approximately 2200 kcal/person/day (9.2 MJ) for healthy diets to avoid undernourishment (FAO, 2001). The WHO has formulated a diet which depicts the dietaries and their sources for a healthy and balanced diet to avoid undernourishment and food related chronic diseases (WHO, 2003). It suggests that 10–15% of total human energy consumption should come from proteins and 10–25% of dietary protein should be of animal origin, i.e., animal protein should contribute only about 2.2% of the total caloric intake if the average of the WHO recommended range is used. However, food choices are seems to be protein rich (especially, animal proteins) in most of the developed countries. Figure 4 shows the per capita food supply in different countries and in the world. The average food supply is found to be greater in the developed countries and lower in some of the developing countries compared to the recommended food supply. Per capita supply of vegetable protein is slightly higher in developing countries, while the supply of animal protein is three times higher in industrialized countries (WHO, 2003). In Japan, food from animal origin contributes to about 23.5% and 53.4% of energy and protein intake, respectively in 2004 (MHLWJ, 2004) and the contribution of animal food is reported to be increased, may have resulted in health related problems. According to WHO, worldwide more than 1.2 and 0.25 billion people are overweight and obese, respectively. It is also predicted that about half of European adults will be obese 2030 (IFIC, 2001).

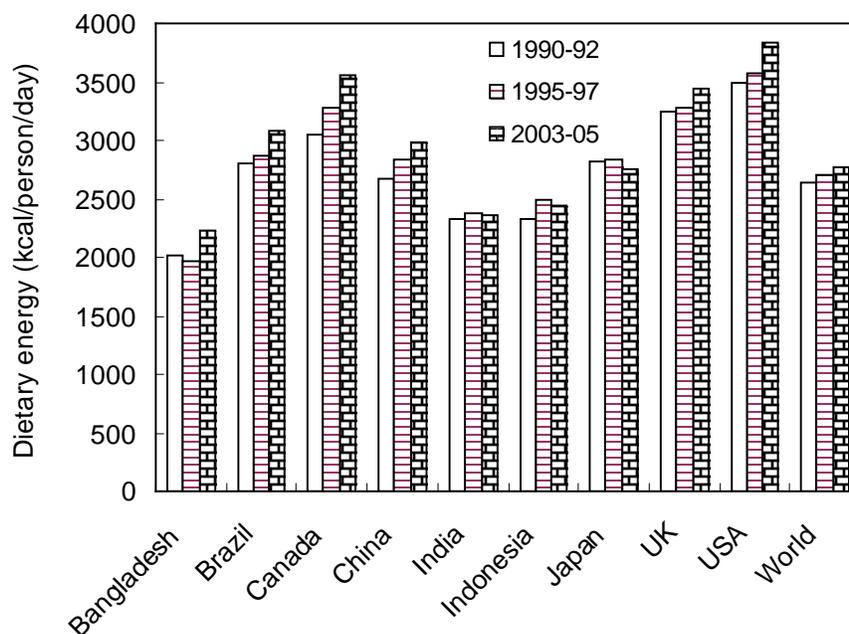


Figure 4. Food supply in different countries and in the World (data source: FAO, 2008).

Improvements of national economy in the developing countries, especially in India and China where one-third of world population live would change food choices, aggravate the food demand and food price. Roy and Shiina (2010) noted that GDP has a strong effect on food consumption and the Japanese food consumption patterns can be used as a guide to estimate demand of food in the developing countries, especially in Asia and might help to mitigate the food insecurity. A large increase in consumption of milk and eggs has been reported in India and other south-east Asian countries (Staal et al., 2005). It has depicted that when people change their dietary habits from cereals and vegetables to meat and dairy products too rapidly, metabolic disorders are more likely to occur resulting a significant growth in the numbers of obese and overweight people (IFIC, 2001). Although the majority of Indians are undernourished (53%), a group of wealthy Indians is becoming obese. Similar problem has also been reported in other developing countries (emerging economy), such as Malaysia and China. Therefore, it seems that food choice can play an important role to avoid food related diseases. The changing trends of food consumption in developing countries need to be considered for food supply and demand strategies to stabilize the food prices and food security. Nutrition awareness can help people make healthy food choices.

It is reported that diseases result in the poor utilization of food calories after food consumed enhance malnutrition through a combination of reduced food intake, malabsorption, anemia, and other nutrient loss (Tomkins and Watson, 1989). It may result not only in the effective waste of food, but also required medication, hence increase GHG emissions. If we are to reduce malnutrition around the world and prevent much human suffering resulting from the ever increasing demand on our food systems for nutrient resources by the increasing population, emphasis must be placed on the adequate amount of food production and consumption with the utilization of minimum resources. Therefore, any change in agricultural policies, i.e., food production should be guided by both the health and environmental considerations.

FOOD SUPPLY AND INTERNATIONAL TRADE The global food system may influence the global environment in a variety of ways. The direct impacts of agriculture on the environment include modification of land for agricultural purposes and byproducts of production. Indirect impacts include the effects of energy, materials, constructing and maintaining equipment, production of agro-chemicals, transportation and storage facilities, and other infrastructure used in food production, fisheries, and related activities, and in supporting the populations involved in them. Post-harvest practices affect the quality of food. If inappropriate measures are employed, the quality of food might deteriorate during transportation and distribution and thus cause food loss. Williams et al. (2008) reported that there are obvious potentials to increase customer satisfaction and at the same time decrease the environmental impact of food packaging systems, if the packaging design helps to decrease food losses. Quality deterioration and loss of food lead to more production to meet the food demand and increase the LCI (life cycle inventory). On the other hand, a heavily equipped quality control system results in an increase in LCI. Shiina (1998) has reported the relationship between relative LCI and loss of food, and concluded that there should be the optimum point of loss to minimize the LCI for food supply chain. Hence, the packaging or any other means of quality control activities on food should be based on optimum point of loss of a certain food.

It is always argued that the local production, distribution and consumption results low food mileage are preferable for the environment. Several researchers noted that food mileage would not be the only determinant since there is a wide variation in the agricultural production in different parts of the world. For example, in the winter imported tomato (produce under plastic cover) from tropical countries would be environmentally preferable than local tomato produce under greenhouse (Roy et al., 2008b; Foster et al., 2006; Carlsson-Kanyama, 1998). International food trade benefits consumers through year-round supplies and a greater quality and variety of food. It may allow the countries to export their surplus food to the food deficient countries and has an important role to play in improving food and nutrition security. International trade issues would need to be considered in the context of improving diets. However, international trade of food could be responsible for new food safety risks and raise production costs due to the involvement of various parties (producers, inter-border traders and consumers). Therefore, food safety enhancement is essential to consumer welfare. International trade might also improve the food quality worldwide and the developing countries need to maintain quality and adapt higher standards of food safety to compete in the international markets. To improve the food security flexible bilateral or international treaties are essential, which might allow the countries to release their excess stock to the food deficit countries.

DISCUSSION The necessary expansion of global food production is becoming increasingly difficult to achieve. Water scarcity together with soil erosion, land degradation and climate change are the main threats to future increases in productivity. The improved efficiency of energy use and renewable energy sources will be essential to meet growing demand of energy for sustainable food, feed and fiber production. The policies motivated by concerns about energy security and smooth economic growth, high oil prices, GHG emissions and climate change are driving the latest expansion in the global biofuel industry. Roy and Shiina (2010) noted that GHG emission is guided by GDP and the energy sector is found to be the key contributor, which might led to search for a clean and renewable energy sources, i.e., biofuels. The rush towards biofuels is threatening world food production and lives of billions of people. However, it is very hard to imagine how the world would grow enough crops to produce renewable energy and at the same time meet the enormous demand for food. Genetically modified (GM) energy crops can be grown in arid, semi-arid, degraded and marginal land, which are unstable for food production and be used for biofuel crops to reduce the pressure on the land that is used for food, feed and fiber. Biotechnological revolution is must to reduce cost of second generation bioenergy which may compete with the fossil fuels.

It seems that stabilization of world's population might be the main key in the near future to reduce environmental burdens and food insecurity. The population growth is declining in most of the developed countries and rising in the developing countries. Now the main question is whether we can stabilize the world population. Perhaps it is achievable even not an easy task. It is known that China is successfully stabilizing her population and improving food supply, hence the demographic indicators. The amount of food available for human consumption is estimated to be 2770 kcal/person/day in 2003-2005 (FAO, 2006). It is found that about 30% of food lost in USA due to food spoilage and other waste (USDA, 2009). In Japanese homes, 7.7% of food is discarded, for reasons ranging from expiration of the consumption date to preparation of more than the family can consume (Fitzpatrick, 2005). Recommended food intake for whole population is reported

to be approximately 2200 kcal/person/day for healthy diets. Therefore, food supply should be about 3143 kcal/person/day if the loss retains to 30%. Figure 5 shows the effect of world population on the food supply. The food supply increased with the world population and need to be raised more to meet the enormous demand of healthy diets which might aggravate the global environment. With the projected population food supply need to be increased about 59% by 2050 compared to that supplied in 2003-2005, which might be hard to achieve. However, if food spoilage and other waste can be reduced to 10% then required improvement in food supply would be about 24%. The required food supply will be 120210.1 TJ/day and 93475.5 TJ/day for healthy diets, if food loss is controlled to 30% and 10%, respectively. Hence, the dietary energy conservation would be about 26734.6 TJ/day.

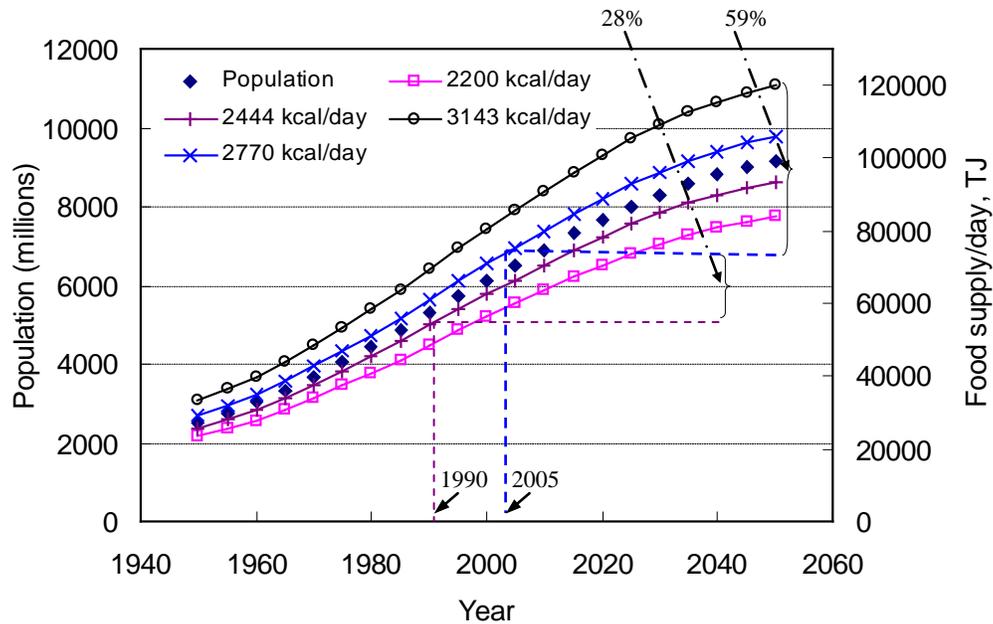


Figure 5. Effect of world population and energy intake on food supply.

According to the Kyoto Protocol, countries have agreed to stabilize the GHG emission to the 1990-level by 2012, which means they need to reduce their present level. If countries agree to stabilize their population to the 1990-level, then there will be a surplus in food supply, provided the yield of agricultural products can be maintained at the present rate. Figure 5 depicts that about 28% of the food supply can be conserved if the population is stabilized to the 1990-level, and spoilage and other waste is controlled to 10% (i.e., food supply is 2444 kcal/person/day). Therefore, stabilization of the world population would not only improve food security and ensure a healthy diet for human well-being, but also would reduce pressure on the agricultural land, water and other natural resources and reduce environmental pollution. Moreover, conserved food energy can be diverted to biofuel industries and help in building not only a sustainable agriculture, but also a sustainable world. Although, carbon trade has already been initiated to mitigate GHG emission and climate change, initiative may also need to be taken for fuel efficient modern technology (instead of ancient or old technology), especially in the developing countries. Finally, we may need to initiate the human trade, but not trafficking for a sustainable world which would help stabilizing the population of the countries where it is declining, and reduce the burden of population where it is rapidly increasing, especially in the

developing countries. However, a strict rules and regulation need to be enforced, and social and cultural motives need to be deeply considered for any such change.

CONCLUSION The global environment seems to be influenced by cropping patterns, dietary choices, food supply and international trade, and the population growth might be the main key. The rush towards renewable biofuels affects virtually every aspect of the field crop sectors, ranging from domestic demand and exports to price and the allocation of land area among crops. Controlling the ever growing population growth, especially in developing countries, would be the key for future energy and food security. Stabilization of the world population to the 1990-level, and control of food spoilage and other waste to 10% would lead to conservation of about 28% of world food supplied in 2003–2005. Conservation of food supply not only reduces pressure on land, water and other natural resources but also improves energy and food security.

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