Keynote Speech

Research to Meet Global Challenges

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Global Challenge of Food Production for Growing Population

Population growth is expected to reach 10 billion by 2050, more than 8.5 billion in the developing countries (Figure 1). These figures will help estimating the future food production needs globally as well as regionally.

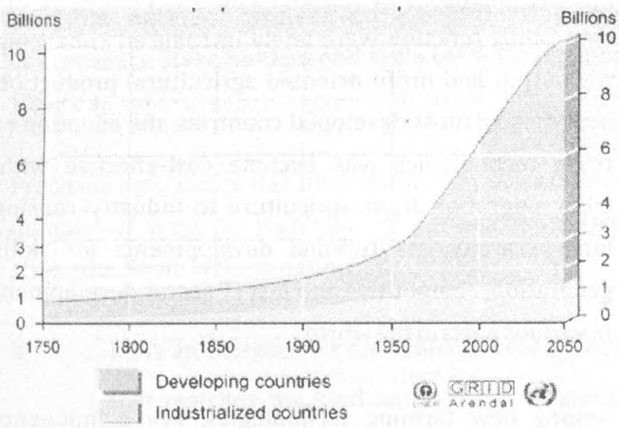

Figure 1: World population development (FAO Statistics online)

Food Security Indicators

According to FAO guidelines and predictions, a per capita food intake of 2,200 kcal/day is taken as very poor level of food security, with a large proportion of the population affected by malnutrition. A level of more than 2,700 kcal/day indicates that only a small proportion of the population affected by malnourishment. With more access to food, per capita food intake increases rapidly but levels off in the mid 3,000s. These levels in kcal/day is only an indicator of food security, adequate nutrition requires in addition to calories, a balanced diversity of food including all necessary nutrients. Figure 2 shows the trends and statistics of grain production and fertilizer use. In 2009, to produce 1.8 billion grain required 180 million tons of fertilizer..

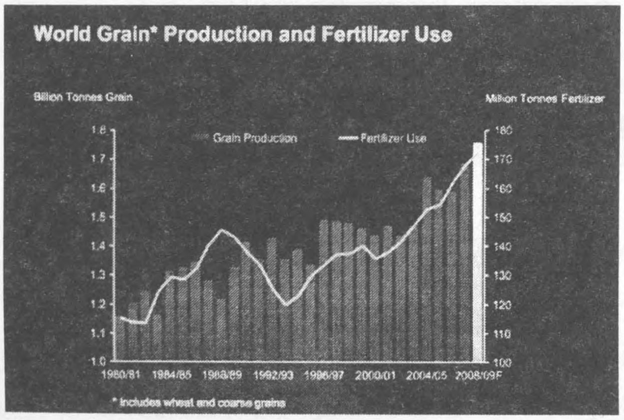

Figure 2: World grain production and fertilizer use (FAO Statistics online)

Fresh Water Needs for Global Food Production

The amount of water involved in food production is significant, and most of it is provided directly by rainfall. A rough calculation of global water needs for food production can be based on the specific water requirements to produce food for one person. Depending on the composition of meals and allowing for post-harvest losses, the present average food ingest of 2,800 kcal/person/day may require roughly 1,000 m^3 per year to be produced. Thus, with a world population of 6 billion, water needed to produce the necessary food is 6,000 km^3 (excluding any conveyance losses associated with irrigation systems). Most water used by agriculture stems from rainfall stored in the soil profile and only about 15% of water for crops is provided through irrigation. Irrigation therefore needs 900 km^3 of water per year for food crops (to which some water must be added for non-food crops). On average, about 40% of water withdrawn from rivers, lakes and aquifers for agriculture effectively contribute to crop production, the remainder being lost to evaporation, deep infiltration or the growth of weeds. Consequently, the current global water withdrawals for irrigation are estimated to be about 2 000 to 2,500 km^3 per year. On average, it is estimated that overall water use efficiency of irrigation in developing countries is about 38% (FAO Statistics online).

Need for Efficient Use of Resources

In addition to population growth and the climate change effect in progress, there are many socio-economic issues threatening the food production. During and the post world war II era, people realized the challenges and efforts have been made to develop technologies and skills for efficient use of limited resources. A significant capital investments are being allocated every year globally for such developments and need to continue investments.

History of Developments in farming Technologies

The modern Agricultural Systems are as a result of the experience gathered through different eras in Agricultural Development. Human civilization progressed with crop cultivation, in one stage slash and burn type primitive techniques. Following stages in sequence can be considered as various eras passed during the 19th and 20th centuries indicating efforts made for improving agricultural productivities.

- Mechanical Era - Mechanization and management to increase cropping intensity, yields
- Fertilizer Era - yield increase through nutrient supply.
- Plant Breeding and Genetic Era - improvement in quality, cropping intensity and yields
- Herbicide, Insecticide and Fungicide Era - crop protection minimizing yield losses
- Biotechnology Era - improvement in quality, crop vigor, productivities
- Computer and Information Technology Era - improved management

What are the New Farming Technologies?

With the transformation to Computer and IT era, and when the cost of new technology was became affordable and available to normal applications, technology adoption in agricultural production sector took place. This began with data (database) use and management on spatial and temporal basis, effective data interpretation, later using GIS and GPS technologies. Modeling and optimization techniques as decision making function and robotics and automation as the controlling function were lately introduced enhancing the output and profit oriented agricultural production activities. In most developed countries, the adoption of these technologies was become cost-effective with, labor migration from agriculture to industry causing labor scarcity, institutional developments for skills generation, competitive and fast IT sector development in various parts of the world.

Among new farming technologies, key components defined in Precision Agriculture (PA) technology (in sections below) cover most of them, some are integrated or interpenetrated with many other sectors; socio-

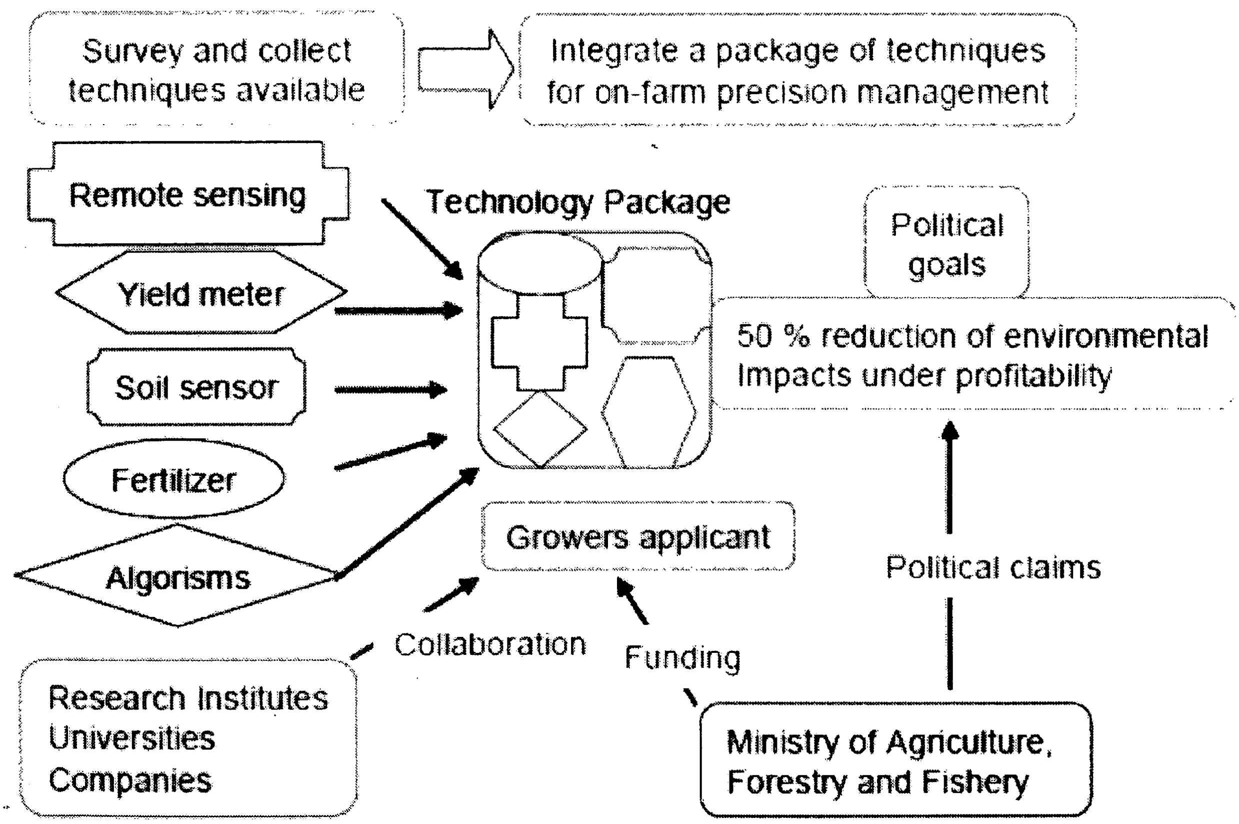

Figure 3: Scheme of national project on PA indicating key components and stake holders

economic concerns, environmental safety, food safety and security, postharvest processing and handling including value addition, traceability and supply chain management.

New Technologies and/or Precision Farming

Precision Farming or Site-specific Agriculture: Precision Agriculture, is not a new thing, farmers in various parts of the world including Asia has used this concept for more than many decades, however it was surfaced more less two decades ago with cutting-edge technologies and new terminologies. Scheme of possible national project on PA indicating key components, stake holders and cycle of PA is shown in Figure 3.

Precision agriculture has been defined by scientists in number of ways to highlight its various important strengths. Some of those definitions include:

- PA is an integrated crop management system that matches the kind and amount of inputs with the actual crop needs for small areas within a farm field.
- PA is based on the principle of achieving the optimum level of productivity without harming the environment and using cutting edge information technology along with old fashioned scientific research.
- PA is often termed as GPS agriculture or VR (Variable Rate) farming.
- PA differs from traditional agriculture by its level of management. Instead of managing whole fields as a single unit, management is customized for small areas within fields.
- PA is a systems approach to farming in which both economic and environmental benefits are considered.
- PA gives farmers the ability to more effectively use crop inputs including fertilizers, pesticides, tillage and irrigation water. More effective use of inputs means greater crop yield and (or) quality, without polluting the environment.

Does these New Farming Technologies Hold Valid for Developing Countries?

Although the above definitions hold true, with given limitations, for the conditions entitled; yet in context of Developing countries, PA could be envisaged as *Environment-friendly, Input-minimizing, Cost-effective and Knowledge-based intensive agriculture, which matches the input supply with spatially varying demand.*

Precision Agriculture (PA) has recently been talked about several references - one of them is the concern that questions the validity of employing such a high-end technique to the low-end activity of agriculture in developing countries. Developing countries - mainly from Asia and Africa rely heavily on agricultural based economies - are characterized by small farms (< 2ha).

Out of an estimated 525 million farms worldwide, 85% are plots of land of less than 2 ha. Asia is a home for 87% of these small plots, followed by Africa (8%) and Europe (4%). The average farm size in Asia and Africa is 1.6 ha in contrast of, Europe (27 ha), Lain America and Caribbean (67 ha) and Northern America (121 ha). Given the statistical evidence of smallholders, and the apparent financial- and technical complexities associated with PA techniques, the questionability of PA adoption appears reasonable. Considering the fact that the development of current PA methods is extensively contributed by developed nations - who register relatively larger farms, one should first validate the appropriateness of PA adoption in the context of developing countries. It is though established that the returns get amplified as the variability increases - or farm size under PA increases, in other words.

Low-Cost or Appropriate Technology for Developing Countries

Most developing countries have highest population growth rates; obligatory to produce more food for increasing population. The production and productivity should not be hindered by the barriers for implementing new technologies.

Precision Agriculture is not limited to the technology- and capital-intensive methodologies. There are low-cost and simpler versions of PA principles, which count on a logical blend of historical information on field variation, indigenous knowledge, and minimum know-how of advanced technologies. With in-depth discussion on management zoning, site-specific management approach, GIS/GPS integration, field scouting and mapping, resource optimization, low-altitude remote sensing, variable rate technology, etc., and examples of appropriate technology adoption, it is concluded that the PA has the potential to be applied in developing countries. Only need is to tailor them up to right-sized dimension to suit smallholders with affordable components.

Pros and Cons of Adopting New Farming Technologies

Advantages of PA encompass a considerably large number of items, namely: Reduced agronomic inputs; Better record keeping; Improved production decision; Uniform yield throughout the field; Reduced use of excess doses of fertilizers/chemicals – resulting in good environment, healthy product; Reduce wastage of input resources; Higher marginal rate of return [MRR] over traditional farming; It support automation and simplification of the process of collection and analysis of information; Quicker management decisions in a larger field; Reduces environmental pollution in developed countries; Increases efficiency of input use in developing countries; Increased profits through increased efficiency; On-farm research; Reduced environmental impact; and Property advantages.

Along with its benefits, PA is also accused of several issues. Some of them could be considered as threats to agriculture, whereas other might be merely misconception about PA:

- ➢ PA will result in automation of agriculture, which in turn, lay off a very large number of agricultural labors – resulting in *unemployment* in developing countries that have plenty of excess men-power.
- ➢ A *very high capital requirement* in PA [with hi-tech] will limit the agricultural works within big farmers or industrial groups, eventually small/marginal farmers will be starving for livelihood.
- ➢ A very high level of educational background and technical know-how is necessary in PA, which may not be available in developing countries' farmers.
- ➢ Farmers with a sufficient level of existing management can benefit from PA.
- ➢ Effective use of PA techniques requires a long and solid database for the field in which PA is going to be applied.
- ➢ Cost-effectiveness is still not favorably defined for PA. For small farms, it is about a dream to use PA techniques at small scale.
- ➢ PA increases more management tasks, will be a problem for small farmers.

In addition to the afore-mentioned issues, there are several obstacles to PA in Developing countries: Cost of Technology Adoptions: particularly in the case of low commodity prices; Reluctance towards accepting high investment costs; Time and expertise needed to learn how to use the equipment and software; Training and Consultation: no access to sufficient training to be fully competent; Data Quality Control: difficulty in maintaining good quality data collection; Consumer Guide: not such manual/guide available in simple format; Land tenure: lease basis, short tenure; Credit and finance; Choice of equipment; Subsidies and price support; Technical assistance; Manufacturers, distributors, and dealers of PA equipment; and Consumer protection.

Sharing Experience with Research Studies (details in the presentation)

- Precision Resources Utilization and Management / Land-use and Farm Planning
- Precision Nutrient and Pesticide Management Strategies through LARS
- Precision Application of Fertilizer and Pesticides / Variable-rate Technology
- Precision Water Management/Irrigation Scheduling
- Precision Mechanization Planning
- Precision Farm Energy - Production and Utilization

- Plant Factory Concept
- Good Agricultural Practices (GAP) and Traceability

Conclusive Remarks

It is very clear that there is an urgent necessity for making efforts in skills, technology and recourses development in agricultural sector in order to meet the global challenge of increased food production for growing population.

Global, regional and institutional levels efforts are need to bring forward for the development and implementation of new farming technologies. The allocation of a significant portion of the global economy annually for such technological developments will be necessary.

The site specific or precision farming techniques found to be fulfilling the most current needs for new technological inputs for agricultural production.

The capital investment, and skills requirements for such implementations are found to be a barrier in developing countries, however low-cost and appropriate technologies are possible and need for more research in the case of developing countries.