Agriculture, Environment and Food Security in the Context of Rice

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Abstract

Agriculture requires inputs, which can be found within the system or need to be supplied from outside. The latter, referred to as the 'Green Revolution' in the 1950s and developed as the high external input agriculture, has spread over the world as a solution to the food crisis that arose due to World War II. The drive embraced a special package including high- yielding crop varieties, inorganic fertilizer, agro-chemicals and farm machineries. As a result, farmers in many developing countries began to practice mono-cropping with high external inputs. This has turned traditional ecological agriculture into environmentally destructive food production systems, which provided huge amounts of produce causing serious environmental damage. During the 'Green Revolution' traditional crop varieties were replaced by high-yielding new improved varieties, which had higher yield potential. However, natural pest resistance of these high-yielding varieties was generally poor, while nutritive requirements were high. Increased use of pesticides and chemical fertilizer is a matter of concern. Some of the issues and problems due to indiscriminate use of pesticides are: a) pest resistance; b) pest resurgence; c) health hazards; d) environmental pollution; and e) lower profits to farmers. Extensive use of chemical fertilizer has created environment issues such as nitrate leaching, release of greenhouse gases and eutrophication of inland water bodies.

Millennium development goals earmark the eradication of extreme poverty and hunger, while ensuring environmental sustainability. This dispels the concept of achieving food security in any country through the adoption of high external input agriculture.

Sri Lanka remains vulnerable to natural disasters such as floods, droughts, cyclones, landslides, epidemics etc., causing substantial threats to the food security situation of the country. Challenges posed by external factors due to globalization and open-economic policies have directed the country's agriculture to move away from self- reliance. This situation demands a firm and perfect policy for the country's agriculture. Furthermore, present agriculture does not show any indication of sustainability as it has ignored the centuries-old wisdom of traditional agriculture. Farmers' dependency mentality evolved due to modern agriculture and government policies, which dealt with agriculture from time to time. This should be gradually replaced by developing farmers' self-confidence, self-motivation and empowerment.

There is a great potential to increase productivity in Sri Lanka as only 40 % of the average potential for grain yield was achieved in different ecological and hydrological regimes. By narrowing this gap between actual and potential yield, Sri Lanka will not only increase productivity but also increase the competitive advantage for rice with other countries in the region. The experiences of the present productivity improvement program of the Department of Agriculture (DOA) have clearly shown that the average yield could be increased.

In achieving food security in the country, a major set back in the development process is that institutional linkage among agencies responsible for water, land, agriculture and environment is very weak, and they work in isolation, setting their own targets. The need is felt for the immediate formulation of a firm policy to implement a sustainable agricultural production program in the country in order to ensure the food security in Sri Lanka.

Introduction

Any kind of agriculture practiced in the world requires various inputs such as water, seeds, nutrients etc. These can be found within its environment or need to be brought from outside. Depending on the manner in which the inputs are supplied, the dependence and sustainability of agriculture can vary widely. World agriculture has moved from internal low input agriculture to external high input agriculture as greater food production is demanded by a rapidly increasing world human population.

Sri Lanka had been self-sufficient before it came under the British rule. The population up to independence was relatively small and, hence, food requirements remained at a low level. Agriculture was practiced with low external inputs. Mixed cropping, except in paddy fields, was more popular under rain-fed conditions. Under such a diverse system of cultivation, there is a low possibility for the multiplication of pests and for disease to spread. Nevertheless, traditionally grown crop varieties were well adapted to the environment, hence pest attacks did not occur at significant levels.

Traditional Farming

Farming methods in the past also incorporated traditional crop protection methods such as '*kem krama'*, rituals etc., and relied on cosmic influence to protect the crop from pests and diseases. The fertility of the land was ensured through fallowing and by incorporating organic matter such as straws, lopping from hedges and fences, dung and other animal waste to the soil. Once the paddy crop was harvested, cattle were allowed to feed on the stubble. This helped not only in destroying weeds but also enriching the soil by adding a considerable amount of cow dung and urine to the field.

Biodiversity

Despite its small size, Sri Lanka has a varied climate, topography and soil, which have resulted in rich biodiversity, and was distributed within a wide range of ecosystems. In terms of species, genes and ecosystems, Sri Lanka has a very high biodiversity, and it is one of the 18 hot spots in the world declared by Conservation International. Also it is one of the 250 sites of prime importance identified for the conservation of the world's floristic diversity. Sri Lanka

has the highest biodiversity per unit area of land among Asian countries in terms of flowering plants and all vertebrate groups except birds. The vegetation of Sri Lanka supports over 3,350 species of flowering plants and 314 species of ferns and fern allies. It is also noted for its high proportion of endemic species among its fauna. There is also considerable invertebrate faunal diversity. The provisional list of 'threatened' faunal species of Sri Lanka includes over 550 species, of which over 50 % are endemic.

In addition to the crop diversity seen in coarse grains, legumes, vegetables, roots and tubers and spice crops, there are over 170 species of ornamental plants. Among domesticated animals of economic value are some indigenous species of buffalo, cattle, fowl and fish.

Forest Cover

The forest cover in Sri Lanka shows a steady decline from 44 % in 1956 to 23.9 % in 1992 and dropping further to 22.4 % in 1999. The total forest cover in 1999 was 2.02 million hectares. The reduction of forest cover is strongly related to the increase in population of Sri Lanka. Colonization in major irrigation schemes, clearing of lands for rain-fed cultivation and the removal of natural vegetation for plantation crops such as coffee, tea and rubber collectively diminished the forest cover in Sri Lanka. Furthermore, inappropriate land use trends, unsuitable forestry practices and the high market price of timber are some other causes for deforestation. The destruction of the forest-related ecosystem threatens the survival of many species of fauna and flora.

Irrigated Agriculture

Once the '*Rajakariya'* system' was abolished in 1832, nobody was found responsible for maintaining irrigation systems. Subsequently the British rulers realized the necessity of introducing regulations for the management of the irrigation system and passed the first Irrigation Ordinance in 1856.

During the latter part of British rule, the importance of and need for irrigated agriculture to feed the increasing population was realized. The British repaired abandoned tanks and constructed new irrigation schemes. Since independence in 1948, the government embarked on a massive irrigation project and brought large new areas under paddy cultivation. The Accelerated Mahaweli Development Project that was implemented in the 1980s is the best example. However, opening up a new area for agriculture and other development projects has resulted in reducing the forest area in the island.

Green Revolution

Annual cereal production in the world has more than doubled within 25 years since 1961. Annual rice production in Asia too has shown the same pattern. This growth is often attributed to the increase in irrigated area complemented by Green Revolution technology that is considered as a package including high-yielding varieties and inorganic fertilizer. The concurrent application of agro-chemicals and increased use of farm machinery were also contributed to the transformation of traditional agriculture to a high external input regime.

In Sri Lanka, the sources of growth in rice production are identified: a) as a greater area planted with rice (32 %); b) as an increased irrigated area (25 %); c) as an increased application

of fertilizers (22 %); and d) from the inherent high-yielding quality of modern rice varieties (21 %).

Traditional farming systems were characterized by a mixture of rice tracts intermingling with other natural habitats of varying types. Major irrigation systems also lead to the expansion of contiguous areas of large paddy tracts leading to a reduction of natural biodiversity. Additionally, intensive paddy monoculture systems, popularized by the green revolution, created an environment that is conducive to pest growth. The increased cropping intensity also contributed with the same magnitude to biodiversity loss as species adapted to the fallow phase of paddy fields were forced out both spatially and temporally.

It has been realized by many that bringing the agricultural technology developed in western countries to many of the peripheral countries has been a factor in jeopardizing their century-old and ingenious agricultural systems and the wisdom that is associated with them, which had been instrumental in maintaining sustainability and environmental harmony. The introduction of new agricultural technology has resulted in many disastrous situations such as bio-degradation, soil fertility depletion, pest and disease invasion, food poisoning, collapse of food sovereignty etc. At present, attempts are being made to study this burying knowledge by a few international organizations and to restore under the prevailing environmental, economic and sociological conditions.

Use of Pesticides

Pesticides guarantee against crop failure, and were considered as a necessary input in modern rice production. The use of chemical insecticides as primary agents of pest control is a widely adopted cultivation practice. The use of pesticides has contributed to improved productivity in rice.

The introduction of a limited number of rice varieties on a very large scale to replace a diverse array of plant races grown previously has been the major factor responsible for the rapid multiplication of rice pests and diseases. The widespread promotion and indiscriminate use of insecticides has aggravated the situation further.

Although rice insect outbreaks have been recorded over the last 1,300 years, they are more frequent and damaging today than before. Also, insect pest complexes have undergone rapid changes during the last three decades. Although insecticides are known to have rapid curative action in preventing economic damage, the indiscriminate use of insecticides has led to the destruction of natural enemies, causing the resurgence of several primary and secondary pest species and the development of insecticide-resistant pest populations. Other detrimental effects of pesticide misuse include human health impairment due to direct or indirect exposure to hazardous chemicals, contamination of ground and surface waters through runoff and seepage, and the transmission of pesticide residues through the food chains.

Pesticides used in rice cultivation can have a devastating effect on living organisms other than those targeted for shorter or longer periods of time. The impact of biocides used in rice cultivation on vertebrates inhabiting rice fields and surrounding aquatic habitats has been investigated by researchers in the Philippines and South America. In Sri Lanka, the use of pesticides continue to be the most popular method of pest control despite the known harmful effects of such usage on human health, the ecosystem, and the environment. The misuse of pesticides is very common in Sri Lanka. Farmers often ignore technical recommendations, and use their own experience leading to the indiscriminate use of pesticides. Although alternatives

such as varietals resistance and Integrated Pest Management (IPM) are well known, the relative importance of exclusive chemical pest control methods has increased.

High-yielding Varieties

Traditional seeds that were used in the past have been replaced over the years. The 'Green Revolution' made most of our farmers to move away from traditional rice varieties to modern improved varieties. However, high-yielding varieties could not continue to give better yields without the additional supply of nutrients. Because bumper harvests removed most of the nutrients as yield and caused faster depletion of soil fertility, the application of chemical fertilizers became a convenient way to meet crop nutrient requirement. Long-term application of chemical fertilizers led to the fast disappearance of organic matter content of the soil, thereby affecting the physical fertility of the soil.

'Germ-plasm' of traditional rice varieties has been preserved locally but most of them are also available in international 'germ-plasm' depositories. It is unlikely that Sri Lanka's prior consent will be obtained or that it will share any benefit if its traditional 'germ-plasm' in these depositories is used in the development of new commercial seeds.

Millennium Development Goals

Sri Lanka remains vulnerable to natural disasters such as floods, droughts, cyclones, landslides, epidemics etc. This situation causes a substantial threat to the food security of the country. Challenges posed by external factors due to globalization and open economic policies have directed the country's agriculture to move away from self- reliance. This situation demands a firm and perfect policy for the country's agriculture. Furthermore, present agriculture does not show any indication of sustainability as it has ignored the centuries-old wisdom of traditional agriculture. The farmers' dependency mentality evolved due to modern agriculture and government policies, which dealt with agriculture from time to time. This should be gradually replaced by developing self- confidence, self-motivation and empowerment.

Though considered not very profitable, the production of rice is not necessarily highly capital-intensive. Increased productivity would provide rice with a comparative advantage over other crops and it would be able to compete with imports. Paddy irrigation contributes to generate other benefits including, flood prevention, groundwater recharge, prevention of soil erosion and land slides, water and air purification, enhanced eco-systems, cultural heritage, aesthetic value and cooling effect.

Therefore, it appears that there is a better potential for continuing with irrigated agriculture in Sri Lanka, compared to other countries. The U.N Millennium Development Goals (MDGs) also subscribed to by Sri Lanka in 2000, have relevance to water sector strategies and goals. Target 10 of goal seven (on environmental sustainability) deals with water supply. The global target is to have by 2025 the problem of people without sustainable access to safe-drinking water halved with around 75 % of the country population having access to safe-drinking water.

Population growth, requirements of the economic policy and food security considerations need an increase of food production without damaging ecosystems. The production increases have to be attained in a situation where resources for irrigated agriculture such as land and water are limited.

Cropping intensity and yield need to be increased while lowering the damage to ecosystems and preserving biodiversity. In order for government efforts to be effective, complementary investment by farmers in irrigated agriculture is necessary. This can be achieved by increasing their income from agriculture, if the efforts are concentrated in areas with high cropping intensity.

Challenges Ahead

The current population of 20 million in Sri Lanka is expected to increase to around 23 million and stabilize by the year 2025. Based on the past experience of increase in per capita rice consumption, demand for rice in the future will continue to grow. The demand for rice- based food products are on the rise and demand for rice is intensifying. According to the Department of Census and Statistics (2009), of the 10.5 million ha of rice cultivated in 2007/2008 cultivation year, 55 % was grown during the *maha* season. Major, minor and rain-fed areas, respectively, accounted for 53 %, 25 % and 22 % of the annual rice area.

Issues

The annual cropping intensities of major irrigation schemes vary. Low cropping intensities generate lower annual incomes for farmers. When annual returns are low, returns from investments are also low. Water scarcity is one of the major reasons for low cropping intensities in major irrigation systems. The productivity of minor irrigation is less than that of major irrigation. However, minor tanks generate other social benefits from uses such as bathing, washing, and livestock watering and cleaning, fishing and also serve as an easily accessible source of water in the rural villages. Unfavorable weather conditions, inadequate availability and use of resources and technology, low productivity, high cost of production, lack of infrastructure and inconsistent government policies are some of the factors that hinder the sustainability of food production. The full potential of irrigation systems with respect to both minor and major systems has not been reached. It has been shown that rice farming would be profitable when the grain yield is at or above 6 tonnes/ha. This target could be easily achieved from the dry zone. The profit margin can be further increased or unprofitable areas can be made profitable, if special rice is produced for specialized markets.

Management of Water Resource

By the year 2025, the country's population is estimated to reach 23 million. If current consumption/production patterns are to remain constant, annual consumption requirement of rice would increase up to 4.5 million kg. According to production patterns in 2007 and 2008 cropping intensity of major irrigation is 1.96 and 79 % of the annual rice production, respectively. Assuming production from other regimes remain constant, production from major irrigation should be increased to 3.3 million tonnes. If current yield remains unchanged it would be required to increase the area under irrigated rice to 0.69 million ha. As the current cropping intensity is close to 2.00 (200 %) the only way of achieving this target is via expansion of the irrigated area, which is a difficult task as almost all potential areas are already developed for irrigation. Table 1 indicates the requirement of expanding irrigated area and development of

storage capacities, both of which are difficult targets to achieve and very expensive. A scenario could be suggested that if the irrigation effectiveness could be increased from the present level of 32 % to 41 %, the need for spending money for irrigation structures and for additional land development would not arise. This clearly shows the importance of efficient water management in a country's agricultural practices. Therefore, our future vision should be to make the most efficient use of our reservoirs, canals and other water management structures to obtain maximum effectiveness, and promote farmers for efficient management of the water resource in agriculture.

Table 1. Scenario analysis on production requirement of rice in 2025.

	2007/08	2025	
		Projected	Proposed
Population (million)	17.2	23.0	23.0
Total rice demand (mil. mt)	3.87	4.5	4.5
From other regimes			
Rice production (mil. mt)	1.20	1.20	1.20
From major irrigation			
Share of production	0.69	0.73	0.73
Rice production (mil. mt)	2.67	3.30	3.30
Irrigated rice area (mil. ha)	0.55	0.69	0.55
Yield (kg/ha)	4,775	4,775	6,000
Cropping intensity[1]	1.96	2.42	1.96
Irrigation water requirement (m ha.m) [2]	0.86	1.02	0.86
Crop ET[3]	4,775	4,775	6,000
Irrigation effectiveness	32 %	32 %	41 %

Notes: Production and yield figures are from the Department of Census and Statistics (2009)

[1] Assuming all major irrigation areas that are suitable for rice are cultivated in the *maha* season

[2] Based on current irrigation water use presented in Dharmasena (2004)

[3] Based on 1,000 liters per kg of rice yield

Some of the strategies to increase irrigation effectiveness to attain the above-mentioned level during a period of 5 years are given below.

- Increase productivity of unit of water through improved cropping and irrigation techniques in existing as well as new schemes. Water productivity to be increased at least by 20 % in major schemes and by 10 % in minor schemes during the period of 5 years.
- Improve the management of existing major schemes, by successfully implementing participatory management systems in these schemes.
- Improve the existing systems of operation and maintenance (O&M), through participatory approaches and establish viable funding mechanisms.

- Improve the watersheds of small, medium and large systems through participatory approaches.
- Implement watershed management programs, soil water conservation programs and biodiversity conservation programs.

Management of Soil Fertility

There is a great potential to increase productivity in Sri Lanka since only 40 % of the average grain yield of its potential was achieved in different ecological and hydrological regimes. By narrowing this yield gap, Sri Lanka will not only increase productivity but also increase the competitive advantage for rice with the other countries in the region. The experiences of the present productivity improvement program of the Department of Agriculture (DOA) have clearly shown that the average yield could be increased.

The Granary Area Program (GAP) of 2003 was initiated by the Government of Sri Lanka with the objective of achieving a sustainable irrigated agricultural system that would contribute to greater food security, and generate enhanced incomes and improve living standards with the commercialization of small farm agriculture (concentrating on high potential rice areas). The program included: a) provision of agriculture extension and support services; b) improvement of water management through effective water management practices; c) credit facilitation and input supply; d) farm mechanization at field level; and e) promoting marketing, product improvement, processing and storage. The program has emphasized the addition of organic matter, use of quality seeds and integrated pest management. Outcomes expected from this program are: 1) an increase of rice yield from 4.5 t/ha to 6 t/ha; 2) a 20 % increase in cropping intensity; and 3) an increase of production from high potential areas to meet 70 % of the national requirement (52 % in 2003). Data shown in Table 1 indicates some success of this program.

Food Security

The formal definition for food security for many years was “the availability of food to balance unequal food distribution regionally and nationally.” Subsequently, it was admitted that availability, though a necessary element, is not sufficient for food security, because food may be physically existent, but inaccessible for those who are in need. The World Bank (1986) suggested a new definition of food security as “the access by all people at all times to the food needed for an active and healthy life.” The FAO/WHO (1992) came up with a more specific definition, which is an extension of the World Bank definition as “food should be sufficient in terms of energy, but also in protein, fat and micronutrient. It should be adequate with regard to quantity, quality, safety and it should be culturally accepted.” Rather it is dependant on what is meant by food security when applying this term. Various development projects highlight their activities to improve food security, but many of them are limited to aspects of food availability and access, but do not include any interventions to improve the use and utilization of food.

In 2003, the Sri Lanka Country Office of the United Nations World Food Program conducted a mapping exercise on vulnerability to food insecurity in Sri Lanka. This study covered all (323) Divisional Secretary Areas of the country and defined food insecurity as “limited or uncertain availability of nutritionally adequate and safe food or limited or uncertain

ability to acquire acceptable foods in socially acceptable ways." Findings indicated Jaffna, Mullaithivu, Killinochchi, Mannar and parts of Vavunia, Moneragala, Batticaloa, Trincomalee and Ampara districts as the most vulnerable districts for food insecurity. This indicates the need for close attention to ensure food security to the whole nation.

In achieving food security in the country, a major set back of the development process is poor institutional linkage among agencies responsible for water, land, agriculture and environment. These agencies often work in isolation and set their own targets and as a result, various programs and projects often stand apart without synergy. There is diffused jurisdiction of functions and uncoordinated actions by different implementing agencies. For example, as suggested by National Council for Economic Development (NCED), many programs involved in poverty alleviation ensuring food security can be mainstreamed through the implementation of the new NPRGS (National Poverty Reduction and Growth Strategy). The proposed structure will comprise a reformed Samurdhi Program, which will be the main and largest poverty alleviation program, and all other sub-programs organized in a well-planned and coordinated manner. The need is also felt for urgent attention to formulate a firm policy to implement a sustainable agricultural production program in the country in order to ensure food security in Sri Lanka.

Conclusions

As a result of the 'Green Revolution', traditional crop varieties have been replaced by the high-yielding new and improved varieties, which despite of their high-yield potential are low in natural pest resistance and require a high level of nutrients.

- Extensive use of pesticides has developed the resistance of pests to pesticides, pest resurgence, health hazards, environmental pollution and lower profits to farmers. It has created environment issues such as nitrate leaching, release of greenhouse gases and eutrophication of inland water bodies.

- Sri Lanka remains vulnerable to natural disasters such as floods, droughts, cyclones, landslides, epidemics etc., aggravated due to human activities causing substantial threats to the food security situation of the country.

- Challenges posed by external factors due to globalization and open-economic policies have weakened the self-reliance of the country's economy. This has to be corrected by a firm and sound policy for the country's agriculture.

- It is possible to increase productivity further in Sri Lanka as only 40 % of the average potential of grain yield has yet been achieved in different ecological and hydrological regimes. By narrowing this yield gap, Sri Lanka will not only increase productivity but also increase the competitive advantage for rice with the other countries in the region.

- In achieving food security in the country, a major set back of the development process is that institutional linkage among agencies responsible for water, land, agriculture and environment is very weak. A collective effort is very much needed through the formulation of a firm policy to implement a sustainable agricultural production program in the country in order to ensure food security in Sri Lanka.

References

Department of Census and Statistics. 2009. Paddy Cultivation Seasonal Reports. Colombo, Sri Lanka: Department of Census and Statistics.

Dharmasena, P. B. 2004. Small Tank Heritage and Current Issues, Proceedings of the Symposium on 'Small Tank Settlements in Sri Lanka' organized by HARTI held on August 2, 2004 at HARTI, Colombo, Sri Lanka. pp. 31-39.

FAO/WHO. 1992. International Conference on Nutrition – World Declaration and Plan of Action for Nutrition. Rome, Italy: FAO/WHO.

Kikuchi, M.; Barker, R.; Weligamage, P.; Samad, M. 2003. *Irrigation sector in Sri Lanka: Recent investment trends and the development path ahead*. IWMI Research Report 62. Colombo, Sri Lanka: International Water Management Institute (IWMI).

World Bank. 1986. Poverty and Hunger – Issues and Options for Food Security in Developing Countries. Washington, D.C., USA: World Bank.