XII. POST-HARVEST RESEARCH AND DEVELOPMENT IN VIET NAM

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A. Introduction

Located at the eastern part of the Indo-China Peninsula, Viet Nam is a tropical country of the northern hemisphere. Its territory comprises a total landmass of 329,241 km^2 and the coastline extends over 3,260 km. Crop production accounts for about 18% of GDP and 20% of exports; the rice sub-sector contribute to some 40% of agricultural GDP. Paddy production growth rates grew 5% per year between 1986 and 1996, outperforming population growth and transforming Viet Nam from a food importing country to a leading exporter. Viet Nam has become the third largest rice exporter after Thailand and the United States. Viet Nam exported 3.7 million tons of rice valued at 23.4% of the total export turnover of agro-forestry products in 2001[2].

1. Rice

The Mekong Delta and Red River Delta account for 51% and 18% of Vietnamese rice production, respectively. In the Mekong River, Delta (MRD) rice farm size is reported to be about a hectare, and in the Red River Delta it is less than a hectare. Over 90% of rice production is from the early maturing, higher yielding varieties and some 30% of production is exported. The rice quality produced is considered low. The Mekong Delta alone produced 16.7 million tons of rice in 2000 of which 72% enters the market system[3]. Cropping intensities in the rice deltas are 1.6 to 1.8. Paddy yields have increased from 3.2 tons/ha in 1990 to 4.3 tons/ha in 2000. Nationwide, cropping intensity has risen from 1.3 in 1985 to 1.6 in 1995, or 2% a year. The range of farmers' yields, up to 7 or even 8 tons/ha in some instances, indicate that future increases in yields are possible, with introduction of hybrid rice and greater water control. However, the economic benefits from such high yields is questionable, especially as the farm gate price has declined in real terms. Economic gains may better be achieved by reducing losses and improving quality.

For rice, the Mekong Delta has 3 major cropping seasons:

- Winter - spring rice (WSR)
- Summer - autumn rice (SAR)
- Wet season or autumn - winter rice (AWR)

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[2] Annual Report Vietnamese Agriculture in 2001, Hanoi.

[3] Statistics of Agriculture and Rural Development, 1996 – 2000.

When exports started in 1989, the domestic market consisted primarily of low-income consumers, where cost was the primary concern, and that the quality of rice remained low. Initial exports were therefore also of low quality. Exports were primarily to Latin America and Africa region which imports low quality rice. Over the years, however, high quality rice exports have risen from less than 2% of exports in 1989 to 55% by 1995.

By 2000, the main destinations of Vietnamese rice exports were also the ones that absorbed the greatest share of high quality rice, namely to the markets such as Hong Kong and Singapore that require considerably higher quality. Rice reprocessing was an initial response to local difficulties of meeting quality standards for export, but this is an inefficient, partial, and stop-gap measure as it involves double-handling and additional losses. In the medium term, Viet Nam aims to concentrate more efforts on fast growing steady importers such as Latin America, Middle East, Europe, Africa and parts of Asia (Hong Kong, Singapore and Malaysia). Under GATT, Japan and even Korea may become steady importers. Yet to pursue these export markets will require further improvements in rice quality, port efficiency, and increased reliability.

The focus on quality must now turn to other parameters such as discoloration, homogeneity, variety, fragrance, and length. The current grading system only distinguishes by percentage of damaged rice whereas nowadays rice grade often specify other characteristics.

In Viet Nam, rice exports are the monopoly of the State-Owned Enterprises (SOEs), particularly Vinewood I and II, but since 1998 the market has been liberalised through a licensing and quota system. To date, the primary concern of the SOEs is quantity rather than quality-related. At present, the marketing system does not convey consumer needs to farmers, add value, nor reward quality. Failure to deal with these issues will result in large price fluctuations in farm gate price.

2. Maize

Maize is grown on 650,000 ha throughout the country, but more than 40% is grown in the northern Uplands. Production is mainly for animal feed, with just 15 to 20% for human consumption. Maize output increased at an yearly average rate of 10.6% between 1995 and 2001[4]. About half of this growth is due to expansion in maize area, particularly in the northern Uplands and central Highlands. The other half is due to yield improvements, which have increased at about 6% per year.

The expanding private sector feed milling industry and growing demand for livestock products will most probably raise demand for maize. Yields are still low and vary widely, indicating substantial opportunity for improvement. Productivity is increasing with availability of hybrid seed, but production on marginal lands and weak world prices will constrain future growth.

[4] Statistical Yearbook – GSO, 2002.

3. Legumes

Grain legumes have experienced an increase in demand and offer an opportunity for small-scale producers. From a very low base, there has been growth in area and productivity, most noticeably in the Red River Delta and surrounding highlands. The legume oil extraction industry, however, is antiquated, and seed supply remains insufficient. Peanut production in Viet Nam was 244,900 in 2000[5]. Production is concentrated in the Southeast and the North Central Coast. Peanut output has increased by 7.7% annually since 1990, with area expansion and yield improvements contributing equally to growth. Peanuts are produced for human consumption and to make cooking oil and for export. Soybean is planted on 126,000 ha, 60% of which is grown in the Northern Uplands and Red River Delta. Soybean production has grown 6.3% since 1990, reaching 141,000 tons. Most of the growth is due to productivity (yield) improvement.

4. Fruits and vegetables

The majority of fresh fruits and vegetables are now domestically consumed in open markets. There has been increasingly a considerable demand for processed products such as: soups, drinks, puree, concentrates, canning. However, equipments and technologies as well as experiences in this subject are still poor, requiring investment.

In order to cope with the problems above, the Government developed a plan for fruits and vegetables until 2010. A survey of feasibility of building new factories with special attention on raw material production areas and markets as well is being carried out. For achieving a 14% increase of industrial gross revenue in 2003, several processing factories of pineapples, bamboo shoots, cold storage and longan drying have been built. In addition, small-scale processing equipment and chains are being transferred to farmers.

The objective (up to 2010) of national programme of fruits and vegetables as follows:

- Gross output of 20 million tons
- Post-harvest losses of below 15% (3 million tons)
- For domestic: vegetables of 8 million tons and fruits of 6 milliom tons
- 60-70 kgs of fruits per capita
- 80-90 kgs of vegetables per capita
- Export: vegetables of 1.4 million tons and fruits of 1.6 millions
- Exported value of US$ 1 billion compared to the level of US$ 17 millions (1997), US$ 70 millions (1999) and US$ 215 millions (2000), including tropical and sub-tropical fruits and vegetables in ecology area of Viet Nam.

[5] Statistics of Agriculture and Rural Development – GSO, 2002.

National programmes for fruits and vegetables have the export target of US$ 1 billion by 2010. A number of R&D projects have been implemented, most of them focused on determination of appropriate harvesting timeliness/maturity of litchi, plum, mango, longan, and dragon fruits. Advanced technologies such as MAP, irradiation and traditional ones as low temperature, chemicals have been applied to many kinds of fruits to reduce post-harvest losses.

B. General information on the post-harvest situation

Post-harvest losses are reported to be 1 to 2% of GDP, but with considerable variation between season, commodity, and region. Economic losses are the sum of quantitative and qualitative losses resulting from low price due to low quality or possible rejection of a consignment that does not meet the contractual standard. However, only quantitative losses, measured as physical losses have been studied and reported. The reported physical losses therefore probably understate the problem. There is a need to identify the extent of quality loss. Rice is the major crop in Viet Nam and accounts for the largest share of economic losses during the post-harvest stage. Several factors account for post-harvest rice losses; the following, based on physical determination of physical losses refers to the situation in the MRD[6]:

a. Losses due to harvesting / cutting and collection operations may include several elements such as inappropriate variety, late harvest, lodging at time of harvest, bad weather, binding and carrying, etc. On average, the losses due to cutting for WSR is 2.1%, SAR 3.3% and AWR 3.2%.

b. Losses due to threshing are lower than cutting. The loss in SAR was highest at 2.4% compared to WSR, 1.6% and AWR, 1.2%. These losses may be due to grain being stuck with straw, feeding while threshing and bad weather.

c. Losses due to drying depend on drying method. Losses due to sun drying may be caused by bad weather, grains scattering and sometimes continuous rains making grains germinate. Losses due to drying in SAR are very high (2.7%) compared to AWR (2.1%) and WSR (1.7%).

d. Losses due to storage include rodents and insects. However, farmers usually store their rice for a short time and in many cases farmers often sell paddy immediately after drying. On average, losses due to storage for WSR is 1.6% and for SAR and AWR about 1.5 and 1.1%, respectively.

Overall post-harvest losses excluding transport and milling are:

- SAR 9.9%
- AWR 7.6%
- WSR 7.0%

[6] The data on losses were compiled froma series of baseline studies commissioned by the PHHC in the MRD.

1. Post-harvest needs

The smallholder's participation in the post-harvest chain is limited compared with those of the service providers, processors and traders. The farmer's role is only in field operations where there is still no value added. Nevertheless, additional income from reduction in post-harvest losses in quantity and quality would benefit smallholders who have the least capacity to absorb such losses. One method by which the farmer could add value to the paddy is by drying. In most cases, farmers choose to sell wet produce and pass the burden of drying to the trader or miller. Even though the technology is available, drying by the smallholder has not been widely adopted due to low returns, high investment cost that is not justified for a small volume of crop, seasonal use of dryer and low value-added. In the absence of a paddy grading system, there is no significant quality premium to motivate investors.

2. Organisation of the post-harvest system

The quality of rice produced by Viet Nam is rather low, and qualitative as well as quantitative post-harvest losses are high. This is to a large extent the consequence of low investment in technology at all points along the post-harvest chain. However, investment in technology depends on the market and the capital available for investment. It appears that in Viet Nam, more efficient processing technology has not caught up with the demand for quality rice in the world market. Part of the problem lies with the approaches taken in upgrading the sector, which has been focused on individual unit operations. Upgrading post-harvest technology requires a whole system approach – such that all points along the post-harvest chain undergo upgrading to a level, which is determined by market demand for quality product.

3. Technical issues in quality rice production

There are a number of quality factors that affect the price of milled rice, many of which are poorly controlled in Viet Nam, including: moisture content, degree of milling, percent broken grains, discoloration of the grain kernel, the presence of impurities or contaminants, and other factors that affect cooking and eating qualities. These quality factors are specified in the national grades and standard specifications for the guidance of the industry. In the international market, buyers may specify their own grade requirements, which can be assessed by independent surveyors. Moisture content of milled rice affects its storability. The rice trade standards specify 14% (wet basis) as the standard moisture level for weight and pricing. Deviations in moisture can attract penalties or outright rejection of the lot. The degree of milling refers to the removal of the bran layers in the whitening – polishing process in the mill. Good quality rice requires the removal of all the bran layers, and the uniform polishing of the grain to remove the bran dust. Market demand for well-polished grain, however, results in lower milling recoveries. In rice deficit countries, the government specifies

under-milled rice, since the bran contains rich nutrients.

Different grades of milled rice for the market specify the size and amount of broken grains in a lot. The most common premium grade allows up to 5% damage. Milled rice coming straight out of the polishers of rice mills usually is reported to be about 42% whole grains (head rice). Good post-harvest practice and technology can produce 70 to 80% whole grains. The final mix of broken grains to whole grains can be controlled by grain size separators and blending stations in the milling plant. Premium grades sell at top prices. The brokens sell for half the price of regular grades and the minor brokens are usually used for animal feed.

Physical contaminants include yellow kernels, weed seeds, paddy grains, and other foreign matters. Consumer quality is determined by a number of factors that consumers look for in rice, manly cooking and eating quality. For example, steamed rice, chopstick, or finger users prefer the softer and fluffier texture. Restaurants that offer fried rice prefer a non-sticky texture. The texture is of various characteristic, which depends on the inherent bio-chemical properties such amylose content, etc. Because of the variance in cooking characteristics of different varieties, varietal purity is essential. This presents a problem in Viet Nam, as many varieties are released by the experimental stations, and therefore grains delivered to the mills are far from homogenous. Large capacity processing plants that are not integrated with the farm production network find this situation difficult for quality assurance.

4. Drying technology

Paddy becomes stable and can be stored for a prolonged period under the correct storage environment at 14% moisture content. In the tropical humid climates of the Mekong Delta, where rice for export is grown, grain drying has become a critical problem. Sun-drying of the harvest is the traditional practice, but this practice is not feasible during the Summer-Autumn rainy months. Even sun-drying is not good enough, and controlled systems are preferred, ensuring high quality rice that fetches premium prices.

Practically all technologies developed are demonstrated in Viet Nam, but they have not gained acceptance. Drying capacity is estimated as only 15% of production during the rainy season in some areas of the Mekong Delta. If Viet Nam must enter the higher end export market, or sustain its growth, it must develop its capacity to dry its harvest to maintain grain quality that is competitive in the export markets. Continued research is done to develop/modification of dryers of different scales, but the basic question as to what is the most appropriate dryer for Viet Nam, has not been explored.

5. Upgrading of rice-milling technology

The core of the value-adding process is related to rice-milling. The rice milling technology can be the weakest link in the chain of operations. A good rice milling is required for the export markets. It is reported that in the northern part of the country there are some 278 rice mills under SOE control (4 with capacity 60 tons/shift; 46 with 15-30 tons/shift; 228 with capacity 5-10 tons/shift) in addition to some 13,000 private rice mills. In the southern part, 348 mills are under SOE control (mostly with a capacity of 15-30 tons/shift) and over 30,000 private rice mills (mostly with a capacity of 8-15 tons/shift). Many of these mills still use run stone disk hullers, compartment separators, and 2-stage cone whitener-polisher. Mills that sell their output for the export channels have indented cylinder length graders. Engineering performance tests and economic analysis should be undertaken to examine the economic advantages of investing in good mills.

6. Paddy storage technology

Paddy is stored at the households for their future requirements. Paddy is also stored for food security reasons in government facilities. Processors also purchase and store paddy in their warehouses to keep their mills running between harvest seasons. The traditional way for storing paddy is in large baskets, or in small wooden granaries, or in jute bags of 50 to 100 kgs. Millers in Viet Nam store paddy in jute bags in an open warehouse, except for a few modern mills that use bulk bins inside the warehouse. Open or sealed silos are not used.

C. Post-harvest research in Viet Nam

Viet Nam must be congratulated for the massive investments in research and technology development that has helped bring about the dramatic increases in output seen in recent years. However, a similar investment in resources has not been made with respect to post-harvest research. In the medium term, the situation may change as a number of government policies become effective that promote post-harvest and processing.

1. Institutes involved in post-harvest related activities

Only a small number of the institutes are involved, directly or indirectly, in post-harvest research activities. All the relevant institutes were visited by the review team. The institutions are:

Under MARD

- Cuu Long Delta Rice Research Institute (CLRRI)
- Institute of Agricultural Economics (IAE)
- National Institute for Agricultural Planning and Projection (NIAPP)
- Viet Nam Institute of Agricultural Engineering and Post-Harvest Technology (VIAEP) – North and South branches
- Viet Nam Agricultural Science Institute (VASI)
- (VIAE) – North and South branches

Under MOET

- Hanoi Agricultural University
- Hanoi University of Technology
- University of Agriculture and Forestry, HCM
- Cantho University

Under the Ministry of Industry

- Research Institute for Agricultural Engineering

2. Status of post-harvest research

In a number of recent international studies, four broad areas of post-harvest research have been defined.

- Variety improvement: This area comprises research on end use quality and industrial processing characteristics of primary products, including germplasm enhancement.
- Post-harvest technology: Research in this area encompasses post-harvest loss reduction, for example through harvest mechanization, improved storage facilities, pest and disease management, and germplasm enhancement to increase product resistance.
- Utilization and marketing: This area includes end-use quality characteristics as affected by post-harvest handling and technology, the development of new products, and product diversification through new processing techniques for both primary products and by-products.
- Policies and institutions: This area includes strengthening or support to the institutional and policy framework, which enhances agricultural production, including the agri-business sector, infrastructure and small-scale enterprises. This includes the organization and innovation of technology development and its dissemination. Other issues covered are the impact of macroeconomic and trade policies and political stability as

well as micro arrangements for production and processing.

3. Research status and needs

Post-harvest technology

This is the main area of post-harvest research in Viet Nam at the present time. The emphasis has been on mechanization and physical loss reduction. Despite the fact that quality losses can account for a substantial proportion of lost product, no research has attempted to determine a value for these losses. Losses, quantitative and qualitative, in the post-harvest chain are due to inadequate handling, drying, transportation, storage, and processing. In addition, quality is also effected by micro-organisms, insects and rodents, bio-chemical and microbiological degradation.

There is a need to improve the adoption and efficiency of mechanisation to reduce labour inputs, ensure more timely completion of an activity, and improve quality and efficiency. However, if these technologies are not suitable, they themselves can contribute to quality and quantitative losses. In Viet Nam a key issue is not the technology capabilities of the researchers, but problems stemming from farmers not accepting new technology for which there is no clear advantage or economic returns. Farmers often perceive new technologies to be inappropriate to their needs or work environment.

Most of the research in this topic has been problem-driven and adaptive rather than innovative. Many of the research outputs have been criticised as not appropriate to farmers' needs. This could stem from poor problem identification or a consequence of widely different requirements imposed by the varying agro-ecological zones and climates within each zone. Some of the post-harvest achievements and current needs are listed below:

(a) Harvesting

Harvesting generally refers to all operations carried out in the field which include cutting the rice stalk or reaping the panicles, either laying out the paddy-on-stalk or stacking it to dry, and bundling for transport. This is an important stage as there is a positive relationship between the method of handling and degree of losses. Excessive paddy-handling leads to both in qualitative and quantitative losses. Each handling step may contribute to a loss of 1 to 2 percent for some varieties. The sequence of manual harvesting, field drying, bundling and stacking in traditional systems can incur losses anywhere from 2 to 7 percent.

Harvesting in Viet Nam is still done by hand which often results in delays in harvesting owing to the use of inefficient tools and methods; a drain on the limited availability of farm labor during peak harvest season; high in-field losses in

harvesting, handling, and threshing operations and low labor productivity. In an effort to address these issues researchers have attempted to mechanize this stage in a bid to improve the traditional method of cutting rice with a sickle.

One machinery item that can help improve the efficiency of rice farmers is the windrow reaper. This machine could reap and then drop the crop in a continuous windrow to the side of the reaper, making it easier to pick and manually tie into bundles. These machines are appropriate for tropical rice growing areas, where hand-harvesting results in labor-shortage and productivity problems. Despite the importance of this equipment, research efforts have only achieved moderate success. Some of the problems encountered are sinking of heavy machines in soft wet field conditions, expensive machine designs, complicated mechanisms for local production and maintenance, equipments that are not affordable to farmers or easy to operate. Ideally a windrow reaper should be locally designed and manufactured with low repair and maintenance costs.

(b) Threshing

Threshers are the main output of the research institutes in Viet Nam. Consequently, there are many different mechanical threshers available to the farmers. There are issues relating to optimization of portability and designs to prevent losses and breakages of the whole rice grain. No results are available yet on the impact of operating parameters on grain quality.

Considerable amount of design efforts has focused on developing a suitable combine harvester. However, the immediate problem is not related to deriving technical solutions, but rather building a machine locally that is robust enough.

There is a need to better understand how to harvest and thresh rice and maize in a most efficient manner. If these early activities are not done in an appropriate manner than other preventative measures to minimize losses may prove to be of little value. For example, the husks of grains should not be broken during harvesting in view of infestation and insect attack will develop more quickly.

(c) Transportation

Transportation of rice and maize throughout Viet Nam needs to be improved to decrease grain losses. However, before strategies are proposed it would be wise to understand the reasons and extent of losses due to poor transport and handling. There has been little or no research in this area.

(d) Drying

Drying of rice and maize has been a priority focus for researchers in Viet Nam –

there are therefore a plethora of technologies available in all scales and prices. However, the uptake of this technology has been poor – only about 15% of the rice produced in the MRD is dried mechanically. Despite the resources invested in developing mechanical drying solutions, high grain losses continue to be an issue due to inappropriate sun-drying methods. This is especially troublesome in the wet harvest season, when sunny days cannot always be relied on. Understanding the reasons for the poor adoption of dryers by farmers is required before further investment in technology is made. The technology solution is likely to be more attainable than actually persuading farmers/communities to accept the new technology. If the farmer's acceptance is achieved, then the dryer must be affordable, has a capacity that matches the requirements of the households; larger dryers could be developed for service providers.

(e) Storage

There is a need to improve the number, capacity, and quality of rice and maize storage facilities throughout Viet Nam. To take advantage of surpluses for exports, better storage systems are required. At another level, to protect the farmers especially in the south, from economic exploitation it is necessary to provide an alternative solution possibly at the community-level storage. Storage facilities do provide an opportunity to insulate the farmers from potentially exploitative action by the market intermediaries. Developing storage and handling procedures especially for rice and legumes that minimize aflotoxin production are also desirable. Research in Viet Nam has examined a number of engineering deigns for improving traditional storage facilities, development of IPM storage techniques and the use of natural insecticidal compounds.

(f) Processing

The current emphasis is on producing for the commodity rice markets. However, as the demand for quality rice increases it may be unreasonable to expect farmers with limited access to resources to produce the quality rice, especially with the wet season crops. Thus, the present drive to promote the use of dryers for improved quality and to circumvent the problems of sun-drying during the wet season may not be the most appropriate for some sectors of the farming community. Developing the capability to process rice for other uses could be an alternative solution, and one that is more attainable for some sectors of the faming community. However, there is only limited research in this area undertaken in Viet Nam.

(g) Post-harvest pest and disease

The loss of rice and maize post-harvest as a result of insect and rodent infestation

is a key issue that needs to be addressed. Strategies that reduce the amount of chemical insecticides are also desirable given many instances of mismanagement of these compounds in Viet Nam. Understanding how to use and apply existing chemical insecticides is a priority but their use needs to be coupled with the development of suitable storage facilities at the farm level. Several centres are undertaking research on IPM of stored products and in the use of natural chemical insecticides. Research results need to be more rapidly disseminated from the laboratories to farming fields.

(h) Quality, grades and standards

This is a new area of research in Viet Nam, which is not surprising given that until very recently the country was trying to produce sufficient grains to feed its population. Self-sufficiency and indeed production of a surplus in grain has been achieved, the next stage in development will be a move to higher quality grain. Grain quality will become increasingly important in driving demand for rice in its export as well as domestic markets. The numbers of markets accepting low quality rice are diminishing as their populace become wealthier – as people become richer they do not eat more rice, but will pay higher prices for better taste. To be able to support demand for higher quality rice will require much more involvement on the part of national research centres to develop varieties specific to their consumers' preferences, and to develop improved systems for post-harvest handling that assure the preservation of such qualities through the supply chain. It will also be important to develop equitable reward systems for farmers to encourage them to invest in producing quality rice. The lessons learnt in other markets is that a point is reached where increases in productivity will fail to compensate farmers for lower unit price. The only option then will be to attract higher unit prices by improving quality.

One of the manifestations of the rapid expansion of production is that for rice, Viet Nam has reached the status of a major exporter but without developing qualities that are known internationally according to a detailed set of grades and standards for either rice or paddy. As a result, the country is mainly seen as a source of relatively low quality rice products with cheap price. In addition, the lack of standards acceptable by some buyers and low confidence among the foreign buyers demand detailed specifications of each consignment in their contracts for export. The need is to move towards a system that allows the product to be graded ready for export and then sold purely on the basis of specification. The first stage of such a move must be the establishment of new, more sophisticated system of grades and standards. These should be developed in close collaboration with all parties involved in the production, processing and trading of the product, including foreign buyers.

D. Recommendations and priorities for research and development

Viet Nam has made impressive progress in increasing the production of rice.

However, the lessons learnt in other markets is that a point is reached where increases in productivity will fail to compensate farmers for lower unit price. The only option then will be to attract higher unit price by improving quality. Viet Nam is now recognizing the potential of new market opportunities in parts of Asia such as Japan, Korea, Hong Kong and Singapore. However, to access these potential export markets, which are traditionally importers of high quality rice, Viet Nam will have to further improve the quality of its rice. In addition, attention must be paid to other parameters of quality rice such as discoloration, homogeneity, variety, fragrance and length. Viet Nam lacks the resources to measure such quality characteristics, and there is little or no information on how such properties are affected by the different processing steps.

At the present time the farmer's role is only in field operations where there is still little addition in value. Nevertheless, additional income from reduction in post-harvest losses in quantity and quality would benefit smallholders who have the least capacity to absorb such losses. The problem remains as to how to convince these farmers of the benefits of post-harvest technologies and supply them with appropriate and affordable technology solutions. For example, even though the technology is available, drying by the small-size farm has not been widely adopted due to low returns, high investment cost that are not justified for a small volume of crops, seasonal use of the dryer and low value-added. In the absence of a paddy grading system, there is no significant quality premium to motivate investors. The lack of farmer incentives to adopt new technologies does have a major impact on successful technology development. Ultimated adoption of the technology is up to farmers and if the products of research are not adapted to the market, then long-term sustainability of research is questionable. At present, farmers are reluctant to adopt new technology – even that which addresses their needs/requirements. This creates problems in terms of the standardization of produce quality. Fundamental changes to the Vietnamese farming system are necessary to make the agricultural industry profitable and competitive. Post-harvest research can play a very important role in these changes. The industry needs to be more organized to make small farmers more receptive and adaptable to modern technologies. These changes will take place only when the farmers are confident that the choices they make will be of direct benefit to themselves and when safeguards are built into the system assuring the farmers will receive a fair and equitable reward for their product and improved quality. Without creating an enabling environment in which new technologies are accepted by the farmers, it will be difficult to move research results out of the laboratories.

There is a strong need to improve the adaptation and efficiency of mechanisation to reduce labour inputs, ensure more timely completion of an activity, and improve quality and efficiency. However, if these technologies are not locally suitable, they can contribute to negative consequences in quality and quantity losses. In Viet Nam at the present time, a key issue is not the technology capabilities of the researchers but problems stemming from inadequate identification of research projects and the most appropriate method for transferring technology to the different actors in farming. This is seen by the fact that of the many technologies developed and/or adapted, only handful has been successfully commercialised.

Despite the resources invested in developing post-harvest technologies such as mechanical drying solutions, high grain losses continue to be an issue. Understanding the reasons for the poor adoption of technology by the farmers is one issue that will be addressed in another project, but just as important is enabling the farmers to start to climb up the quality ladder through modest investments in new technology.

There is a need to improve the number, capacity, and quality of rice and maize storage facilities throughout Viet Nam. To promote grain surpluses for export, better storage systems are required. At another level, to protect the farmer, especially in the southern Viet Nam area, from economic exploitation it is necessary to provide an alternative solution, possibly at the community-level storage. Storage facilities do provide the opportunity to insulate the farmers from potentially exploitative action by the market intermediaries.

Post-harvest losses of rice cited by different groups or provinces are often disputed and making comparisons between provinces difficult because of the lack of standardised methodology. Though post-harvest losses figures are often estimated from field conditions, the prevailing stratification of the various field conditions, sampling design, and analysis of variance and the level of confidence is often not explained. There is an urgent need to develop and adopt methodology for measuring post-harvest losses, enabling inter-provincial comparisons and more accurate planning.

If maize and groundnuts are not handled properly, as in traditional post-harvest practices, post-harvest losses will accrue. Such practices are common in Viet Nam as many farmers still rely on traditional post-harvest methods. Although it is often stated that post-harvest losses are high in Viet Nam for these crops, there is little or no data detailing post-harvest losses for maize and groundnuts. Without knowing the extent of such losses, formulating planning and intervention strategy would be difficult as symptoms of operational, management, or technology problems cannot be identified reliably.

Formally, there have been many incidences of poisoning of domestic livestocks in Viet Nam in recent years as a result of consumption of feeds contaminated by moulds. The problem of moulds and their toxins is particularly serious yet aflotoxin can be managed through integrated control strategies.