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Postharvest Losses of Main Food Commodities in ASEAN Countries

Final Report

Based on the Joint ASEAN Secretariat – UNIDO Workshop
(16-18 July 2012 in Jakarta, Indonesia)
and Six Baseline Studies for the development of technical assistance projects on the reduction of PHL in exporting and importing countries

September 2012

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 2012

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Executive Summary

Food security and the need to provide sufficient food, both in quantitative and qualitative terms, to an ever increasing world populace remains an urgent matter. Even though food production per capita has been increasing since the 1960s, an estimated 925 million people worldwide are undernourished and two billion people lack food security intermittently. Clearly, food availability and affordability play a crucial role. Most notably, food prices over the past few years have increased dramatically. Unprecedented peaks in world food prices in late 2006 through 2007 and in the first and second quarter of 2008 created political and economic instability, social unrest in both poor and developed nations, a host of humanitarian and developmental challenges and, particularly, immediate hunger needs.

Increasing overall food production is the main, and most obvious, focus for long-term strategies to reduce poverty and feed a growing population. But the fact that globally approximately one third of food produced for human consumption is lost or wasted emphasizes the importance of reducing such losses as a crucial strategy for increasing food supply without having to intensify production and exerting additional pressures on scarce natural resources. While in medium- and high-income countries, food waste at consumer level plays a large role for total food loss, in low-income countries food is mainly lost during the earlier stages of the food supply chain. In fact, more than 40 percent of the food losses occur at the postharvest (including processing) stages. Developing an efficient postharvest system, covering all stages along the value chain from production to consumption (i.e. harvesting, handling, storage, processing, packaging, transportation and marketing) is therefore paramount.

Despite the enormous capacity to produce food in Asia and the Pacific, the region is home to 51 percent of the world's people living with food insecurity. There is only little comprehensive and comparable data available, but estimates suggest that inefficient and inappropriate postharvest management leads to losses along the postharvest value chain in ASEAN countries that range between 20 and 50 percent, depending on type of produce (perishables vs. durables), postharvest operations and country context. This is equivalent to over 100 million tons of food production lost, or a value of USD 5 billion.

The following report summarizes UNIDO's enquiry into "Postharvest Losses (PHL) of Main Food Commodities in ASEAN Countries". First, baseline studies were conducted in 2011/2012 in Cambodia, Indonesia, Laos, the Philippines, Thailand and Vietnam to paint a detailed picture of PHL in agro-value chains from farm to retail in importing and exporting countries in the ASEAN region. The specific objectives were to identify the points of losses and quantify PHL at the different stages of postharvest operations, to assess postharvest technologies currently in use, and to identify the support framework for different sectors and the support institutions assisting in technology transfer and adaptation. Based on the assessment, recommendations for PHL reduction were derived to provide the necessary information to guide the development of technical assistance projects.

The studies, which are summarized in Section 3 (below), cover a range of agricultural and agro-industry sectors, i.e. rice and maize (in all six countries), cassava (in all countries but the Philippines), fishery (in Cambodia and the Philippines), coffee as well as a selection of fruits and vegetables (in the Philippines only). For more comprehensive sector analyses in the individual countries, please refer to the Compilation Report of the six baseline studies (UNIDO, 2012).

In addition to the baseline studies on PHL reduction, a Joint ASEAN Secretariat – UNIDO Workshop on "PHL of Main Commodities in ASEAN Countries" was held on 16 to 18 July 2012 in Jakarta, Indonesia. The Workshop provided a platform for exchange of information and insights among the participating countries and experts. Besides presentations of the six baseline studies by representatives of the study teams of Cambodia, Indonesia, Laos, the Philippines, Thailand and Vietnam, the Workshop agenda (refer to Annex A for more detail) included presentations on

- The importance and challenges for reducing PHL worldwide, with particular emphasis on Asia and the Pacific region;
- The results of the UNIDO – ICS Workshop on "Postharvest, Quality and Food Safety of Tropical Fruit Production in South East Asian Countries", held in Bangkok on 30 April to 4 May 2012;
- The challenges of moving produce from field to storage: handling and transportation operations in Bangladesh;
- Packaging solutions for the developing countries: innovation and trends for the future;
- The case of a comprehensive and innovative exhibition of agro-products.

Together with the recommendations of the baseline studies (presented by product and country in Section 4.1 below), the Workshop presentations and discussions identified a number of challenges and recommendations for successful design and implementation of future projects to reduce PHL (Section 4.2). Themes that featured in the Workshop included, for instance, the importance of a holistic approach, the scope and significance of South-South cooperation, and the potential of postharvest storage systems, packing innovations and bio-based materials for successfully reducing PHL.

The findings of the baseline studies and the Workshop are expected to be beneficial for policymakers and stakeholders of the whole system of the commodity supply and value chain, especially farmers. They create the background for clearly focused follow-up projects that address the needs identified at the respective country levels. Three proposals for technical assistance projects on the reduction of PHL have already been submitted to UNIDO and were presented at the Workshop. The proposals (see Section 4.3) involve

- Improving the quality and safety of fishery products in Cambodia for better access to domestic and international markets;
- Developing postharvest technology and trade compliance in the tropical fruits sector in Indonesia;
- Applying modern technologies in the fruit and vegetable chain from agricultural production to final consumption in Vietnam.

Moreover, the findings and recommendations of the Workshop and the baseline studies will provide an important input for ASEAN working groups to emphasize the importance of reducing PHL in the member states and to provide guidance for future ASEAN projects. In addition to country level impact, the recommendations are thus hoped to create a visible impact at the regional level, contributing to intra-regional cooperation and exchange.

1 Food security and the role of postharvest losses (PHL)

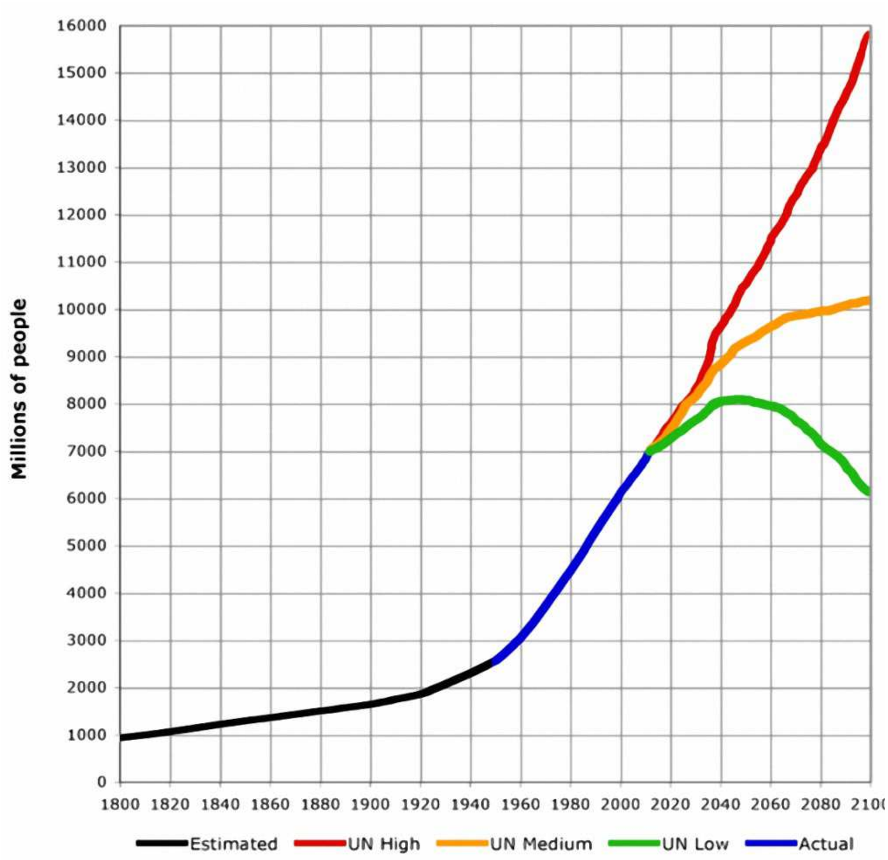
Food security is a major concern in the world. The World Food Summit of 1996 defined food security as existing "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life". According to the World Health Organization, food security is defined as having three pillars: (i) food availability, which refers to having available sufficient quantities of food on a consistent basis; (ii) food access, which means having sufficient resources, both economic and physical, to obtain appropriate foods to meet dietary needs as well as food preferences; and (iii) food use, which is the appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation. The FAO adds a fourth aspect, i.e. the stability of the first three dimensions of food security over time.

The right to food has been recognized as a human right since the Universal Declaration of Human Rights in 1948, in numerous binding and nonbinding legal instruments, e.g. Article 11 of the International Covenant on Economic, Social and Cultural Rights (ICESCR). The right to adequate food is defined as follows: "Right to adequate food is a human right, inherent in all people, to have regular, permanent and unrestricted access, either directly or by means of financial purchases, to quantitatively and qualitatively adequate and sufficient food corresponding to the cultural traditions of people to which the consumer belongs, and which ensures a physical and mental, individual and collective fulfilling and dignified life free of fear."

It involves all normative elements explained in detail in General Comment 12 of the ICESCR, which states that: "The right to adequate food is realized when every man, woman and child, alone or in community with others, has the physical and economic access at all times to adequate food or means for its procurement". However, it was only in 2004 that guidance on its implementation became available, when the FAO Council adopted by consensus the 'Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security'. Given the prevailing high levels of hunger and malnutrition, the Guidelines were provided to address these issues using a rights-based approach.

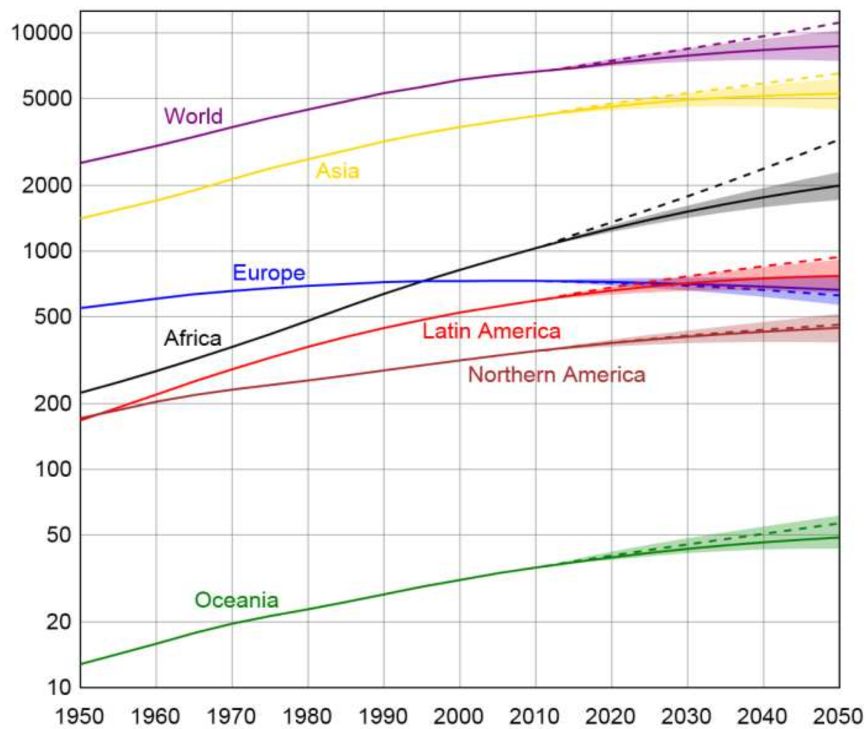
The need to provide enough food, both in quantitative and qualitative terms, to an ever increasing populace remains an urgent matter. As Figure 1.1 – based on historical estimates by the US Census Bureau and UN 2004 projections – illustrates, world population has been increasing since 1800 and will continue to do so at least until 2040. In 2006, the United Nations stated that the rate of population growth was visibly diminishing due to the on-going global demographic transition. In the long run, future population growth is difficult to predict. The United Nations and the US Census Bureau provide different estimates, even for current world population size: according to the US Census Bureau, world population reached seven billion in March 2012, while the UN stated this figure for late 2011. UN population projections (in 2009) for 2050 ranged from about 8 billion to 10.5 billion. If population climbed to 9.2 billion, it is estimated that world food output would have to rise 70 percent by 2050. But according to the highest estimate, world population may even rise to 16 billion by 2100.

Figure 1-1. World population 1800-2100



Source: UN DESA

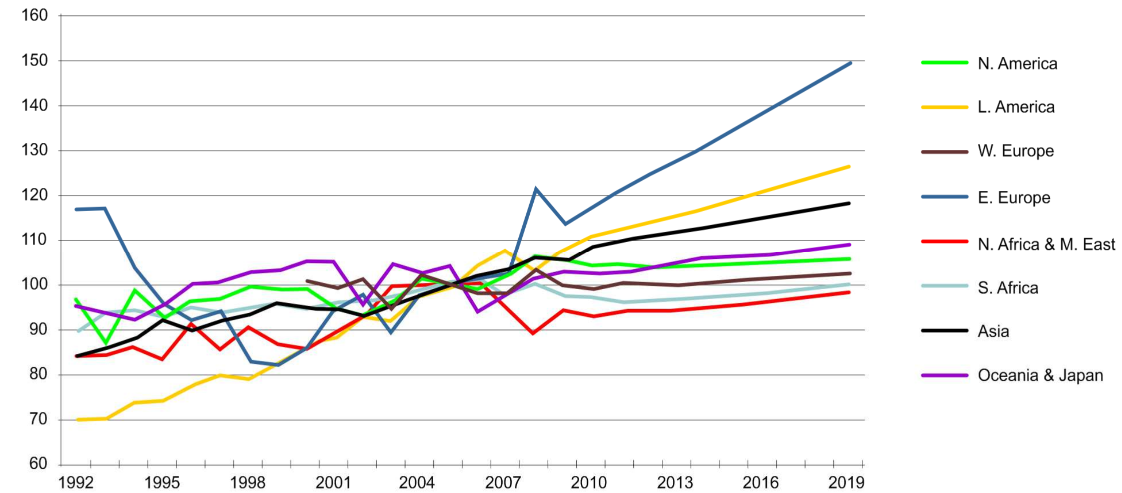
Figure 1-2. Population evolution in different continents



Source: UN

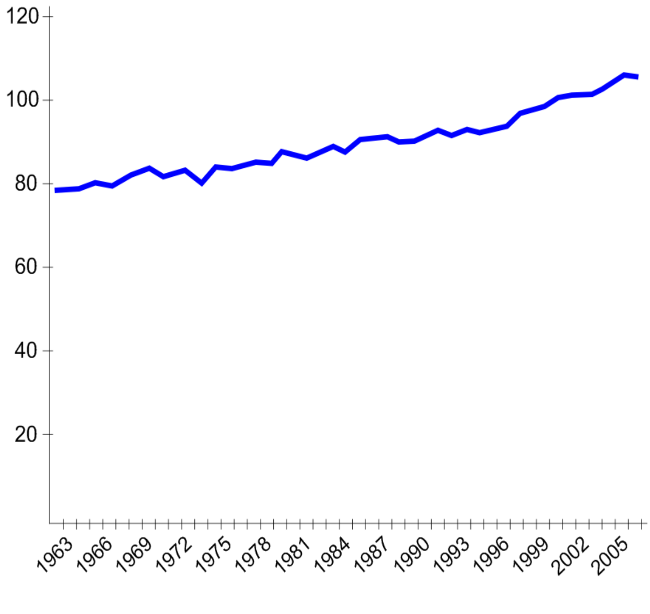
Despite dwindling natural resources such as land and water, and climate change, net agricultural production displays increasing trends worldwide (Figure 1-3), and food production has even exceeded population growth, as evidenced by increasing global food production per capita over the past few decades (Figure 1-4).

Figure 1-3. Net agricultural production for world and economic groups



Source: FAO (index 2004-06=100)

Figure 1-4. Food production per capita

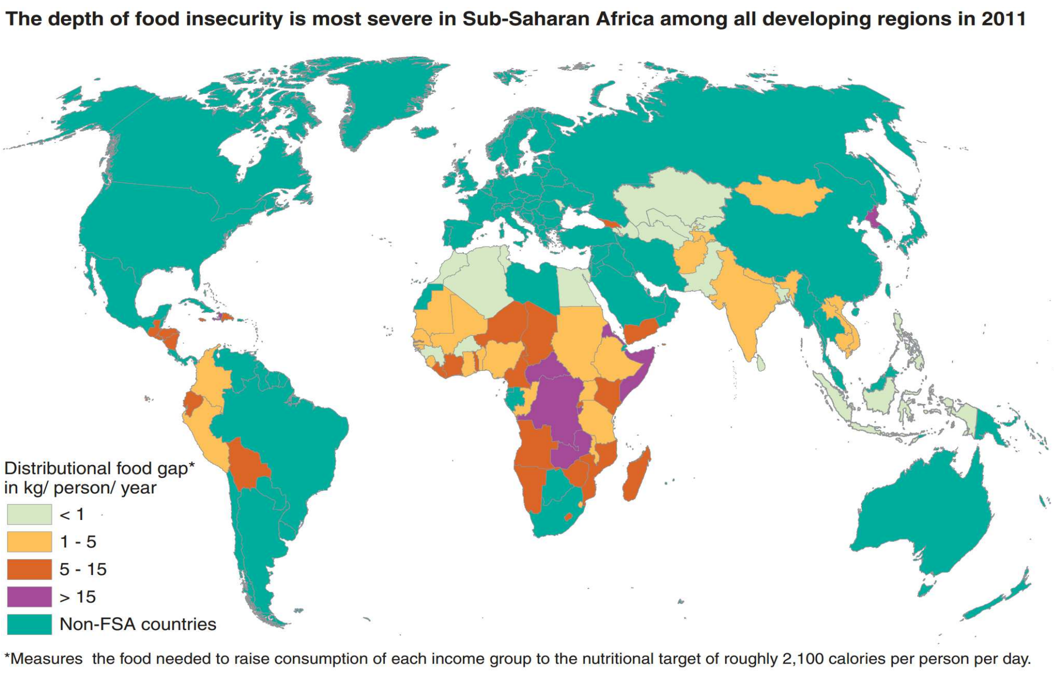


Source: World Resources Institute

In 2006 it was reported that more than one billion people were overweight and that this number has in fact surpassed the number of those who are undernourished. But an estimated 925 million people worldwide are still undernourished, two billion people lack food security intermittently due to varying degrees of poverty and about 25,000 people die of hunger or hunger-related causes every day. As these facts, as well as the definitions above, illustrate, food security not only remains an important issue to be addressed, but it is more complex and goes beyond food production alone.

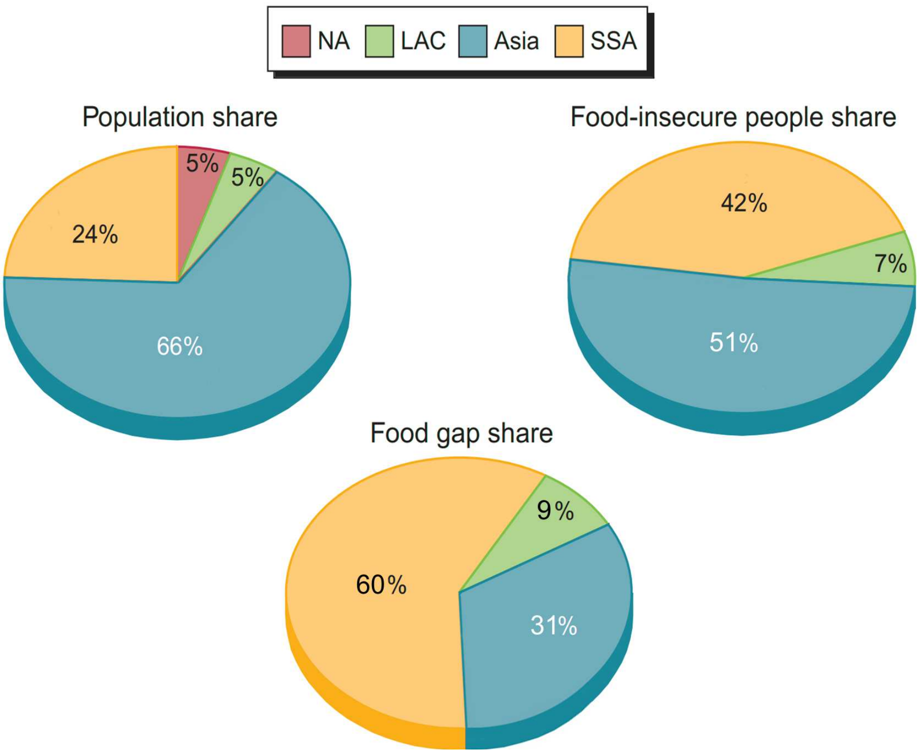
Clearly, the availability and affordability of food play a crucial role. More than half of the world's food insecure people live in Asia. But as the following illustrations show, Sub-Saharan Africa is the most food insecure among developing regions. FAO figures indicate that there are 22 countries, 16 of which are in Africa, in which the undernourishment prevalence rate is over 35 percent. Disproportionately to its population share of nearly one quarter, the share of food gap and food insecure people in Sub-Saharan Africa amounts to 60 and 42 percent, respectively.

Map 1-1. Availability of food worldwide, 2011



Source: International Food Security Assessment July 2011

Figure 1-5. Population affected by food insecurity, 2011



Source: International Food Security Assessment July 2011

The world food situation is rapidly being redefined. Most notably, food prices over the past few years have increased dramatically. Unprecedented peaks in world food prices in late 2006 through 2007 and in the first and second quarter of 2008 created political and economic instability, social unrest in both poor and developed nations, a host of humanitarian and developmental challenges and, particularly, immediate hunger needs. Increasing food prices is a trend which is expected to continue over the next 10 years. As the FAO Food Price Index, a measure of the monthly change in international prices of a basket of food commodities, shows, food prices between 2008 and mid-2012 remained well above 2002-2004 level, threatening the food security of millions of people in developing and even developed countries.

Figure 1-6. FAO Food Price Index, 2008-12

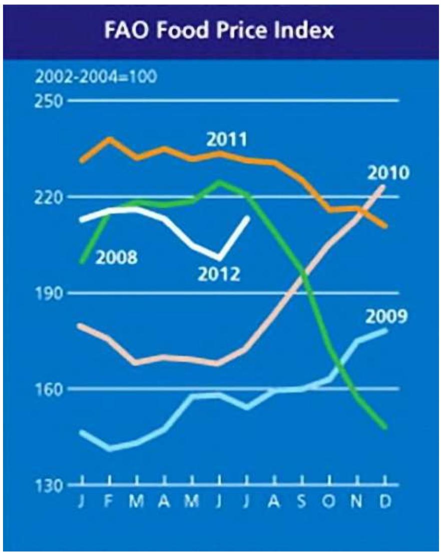


Figure 1-7. Agriculture Prices, June 2009-11

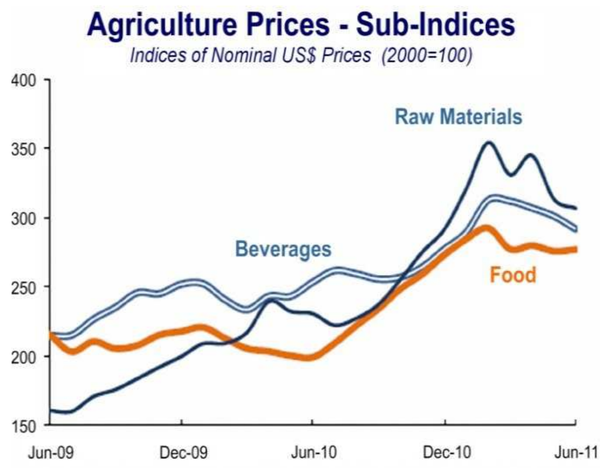
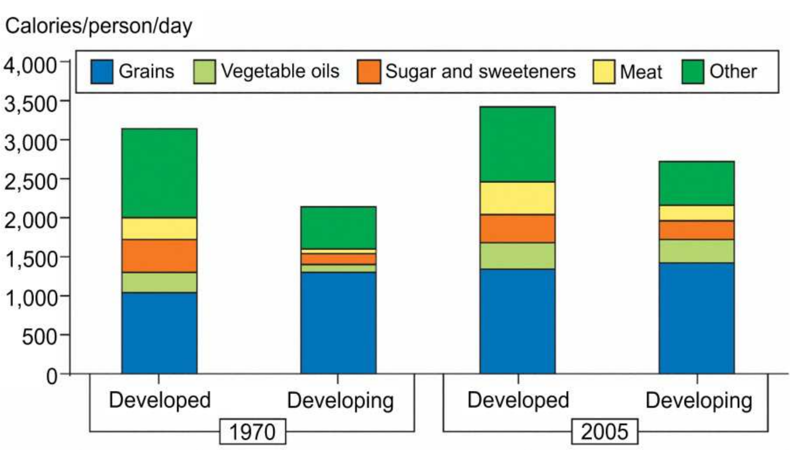


Figure 1-8. Diet Composition of developed and developing countries



Among the many reasons identified for contributing to increases in global food prices is the gradual but significant change in diet resulting from the growth in food consumption in developing countries. Between 1970 and 2005, per capita consumption in the developing countries rose from 2,134 to 2,722 calories per day. While grains continue to dominate the diet of developing countries, the increase in grain consumption was much lower than the overall increase in calories consumption increase. Consumption of higher value food items, on the other hand, recorded large increases: per capita consumption of e.g. meat, eggs and vegetable oils increased by approximately 200 percent, and that of sugar increased by 66 percent.

The underlying reasons behind these changes in diet are, among others, decades of declining real food prices and high per capita income growth, especially in population rich countries such as China, Brazil and India. In addition, increasing urbanization has brought about changes in lifestyle (e.g. higher female participation in the workforce, increasing role of supermarkets) and eating habits, leading to a demand for greater variety, more processed/value added foods. And this urbanization process is only just beginning in Africa and Asia. Based on FAO data and World Bank Development Indicators, urbanization is expected to accelerate over the next 30 years.

One effect of the 2007-08 world food price crisis – and a further challenge for food security – is the issue of large-scale land acquisitions, called "land grabbing". It refers to the buying or leasing of large pieces of land in developing countries, by domestic and transnational companies, governments and individuals, and often goes hand in hand with "water grabbing". Motivated by food security fears among developed countries and economic incentives of agricultural investors, land grabbing aims mainly at acquisitions in Sub-Saharan Africa (70 percent), as well as Southeast Asia and Latin America, for food and biofuel production. While initially welcomed for agricultural development, it has become a controversial issue, criticized for its effect on local communities and food security. As the former head of FAO, Jacques Diouf, has warned, land grabbing could become a form of "neocolonialism" in which poor states produce food for rich ones at the expense of their own hungry people. Kofi Annan, former Secretary-General of the United Nations, stated in 2011 "It is neither just nor sustainable for farmland to be taken away from communities in this way nor for food to be exported when there is hunger on the doorstep. Local people will not stand for this abuse –and neither should we."

A number of strategies have been developed to address global food security concerns. Increasing overall food production is the main, and most obvious, focus for long-term strategies to reduce poverty and feed a growing population, but such an approach needs to be balanced with environmental concerns too. Key strategies therefore, as identified by the World Resources Institute, include restoration of degraded land, increase of productivity on existing land and management of food demand in developed and developing countries, e.g. by changing diets, reducing food waste and promoting programs that encourage sustainable food production (WRI, 2012).

Already in 1945 when FAO was established, the importance of reducing food losses was recognized. In 1974, at the First World Food Conference, the reduction of postharvest losses was again identified to address world hunger. According to estimates, approximately one third of food produced for human consumption is today lost or wasted globally, amounting to about 1.3 billion tons of food per year. The improvement of agro-value chain efficiency and the reduction of postharvest losses (PHL) have thus emerged as a crucial strategy for increasing food supply without intensifying production and exerting additional pressures on natural resources. An efficient postharvest system, covering all stages along the value chain from production to consumption (i.e. harvesting, handling, storage, processing, packaging, transportation and marketing), aims at minimizing losses and maintaining the quality of produce until it reaches the final consumer.

There are many reasons behind quantitative or qualitative losses along the agro-value chain resulting from inadequacies during agricultural production and in the postharvest system. They include incorrect harvesting methods and timing, poor communication and training, inappropriate technologies and facilities for storage, processing, marketing or transportation. More specifically, losses are the result of e.g. mechanical damage, spillage, pest and mould damage, over-ripening, diseases and food waste at the customer stage (Table 1-1 below).

Table 1-1. Examples of food losses and waste along the food supply chain

	stage	examples of food waste/loss characteristics
(1)	harvesting - handling at harvest	edible crops left in field, ploughed into soil, eaten by birds, rodents, timing of harvest not optimal: loss in food quality crop damaged during harvesting/poor harvesting technique out-grades at farm to improve quality of produce
(2)	threshing	loss through poor technique
(3)	drying - transport and distribution	poor transport infrastructure, loss owing to spoiling/ bruising
(4)	storage processing	pests, disease, spillage, contamination, natural drying out of food
(5)	primary processing - cleaning, classification, de-hulling pounding, grinding, packaging, soaking, winnowing, drying, sieving, milling	process losses contamination in process causing loss of quality
(6)	secondary processing - mixing, cooking, frying moulding, cutting, extrusion	process losses contamination in process causing loss of quality
(7)	product evaluation - quality control; standard recipes	product discarded/out-grades in supply chain
(8)	packaging - weighing, labelling, sealing	inappropriate packaging damages produce grain spillage from sacks attack by rodents
(9)	marketing - publicity, selling, distribution	damage during transport: spoilage poor handling in wet market losses caused by lack of cooling/cold storage
(10)	post-consumer - recipes elaboration: traditional dishes, new dishes product evaluation, consumer education, discards	plate scrapings poor storage/stock management in homes: discarded before serving poor food preparation technique: edible food discarded with inedible food discarded in packaging: confusion over 'best before' and 'use by' dates
(11)	end of life - disposal of food waste/loss at different stages of supply chain	food waste discarded may be separately treated, fed to livestock/poultry, mixed with other wastes and landfilled

Source: Parfitt et al., 2010

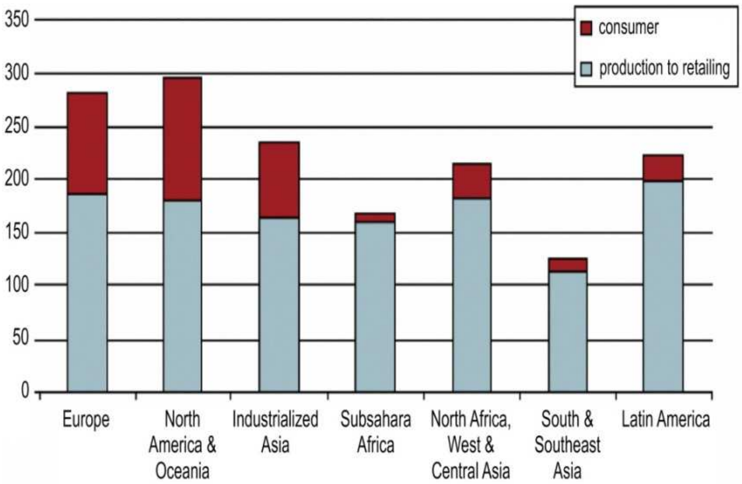
These PHL take various forms. There is physical loss where the volume of produce is reduced by waste and physical damage due to inappropriate handling, packaging and transporting, pests or fungi. Nutritional loss occurs when nutritional value or bioavailability are reduced due to product deterioration. Financial loss refers to the reduction in unit value and total sales revenue, while opportunity loss marks the loss of access to certain markets when product quality has deteriorated.

In addition to this, there are losses in resources such as land, water, energy, labor and other inputs (e.g. seeds and fertilizer), that were required to produce the crop. When 30 percent of a harvest is lost, 30 percent of all the factors that contributed to producing the crop are also wasted. This is even more significant in developing countries, where resources are limited and the rural population depends on agricultural production for livelihoods and food security. Moreover, greenhouse gas emissions resulting from production were caused for no purpose if the product is lost later along the chain.

While some losses seem inevitable, particularly high losses have been reported for developing countries, where as much as 60 percent of fresh vegetables and fruits and 20 to 40 percent of grains are lost on the way from farm to consumer. Rodents alone are estimated to consume six percent of the Asian rice production – an amount equivalent to the rice consumption of about 225 million people in this region. The implications of these losses go beyond production: the availability and/or nutritional value of food is reduced, the sectoral value added decreases, the costs of product handling, storage, transportation, marketing and distribution effectively increase, and ultimately economic growth and the livelihoods and incomes of the individuals involved in the production process are affected, with potentially adverse social consequences.

Food is wasted throughout the food supply chain, starting at agricultural production through handling and/or processing down to final consumption. As the following figure illustrates, all regions worldwide display large food waste and losses per capita, ranging from approximately 125 kg/capita/year (South and Southeast Asia) to nearly 300 kg/capita/year (North America and Oceania). The total per capita food production is estimated to reach about 900 kg/year in Europe and North-America and 460 kg/year in sub-Saharan Africa and South/Southeast Asia.

Figure 1-9. Per capita food waste and losses (in kg/year)



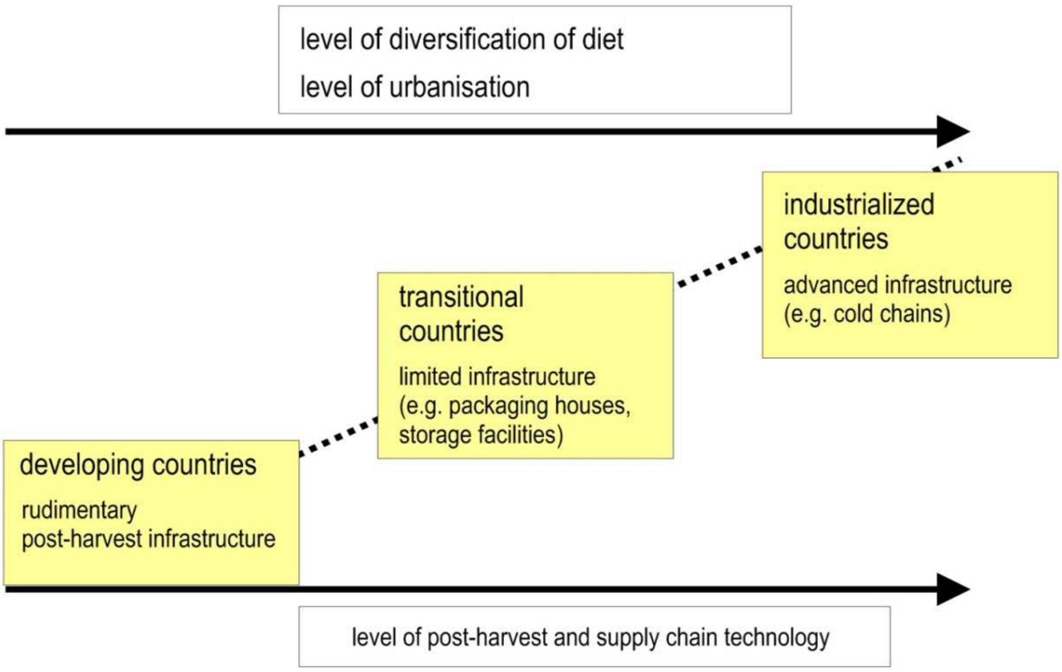
Source: FAO, 2011

In all regions, losses that occur during production to retail exceed losses due to food waste. But notably, both total loss per capita and consumer waste are higher in the industrialized countries than in developing countries. In medium- and high-income countries it is found that food is to a great extent thrown away even if it is still suitable for human consumption.

As WRAP (2011) illustrates at the example of the United Kingdom, large volumes of food are wasted every year in industrialized countries, especially at household level and in the hospitality sector. It is estimated that only 20 percent of wasted food and drink in the UK are associated with food processing, distribution and retail, whereas household food waste is the largest single contributor. Figures for 2010 show that household food waste amounts to an estimated 7.2 million tons, of which 4.4 million tons would have been avoidable and 1.4 million tons would possibly have been avoidable. The most common reason for food being wasted is that it is left unused. Moreover, large volumes of food are prepared and then wasted.

In low-income countries, on the other hand, household waste is significantly lower. FAO (2011) estimates that per capita food waste by consumers in Europe and North-America is 95 to 115 kg/year, while in Sub-Saharan Africa and South/Southeast Asia it only amounts to 6 to 11 kg/year. However, in low-income countries food is mainly lost during the earlier stages of the food supply chain. More than 40 percent of the food losses occur at the postharvest and processing stages.

Figure 1-10. Food supply chains by level of postharvest technology

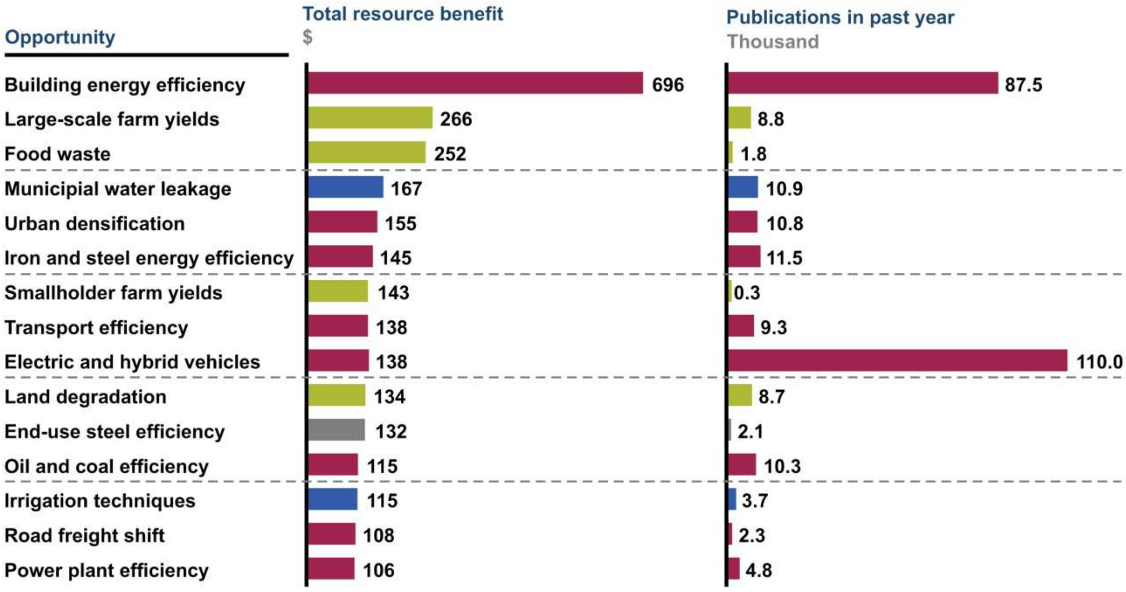


Source: Parfitt et al., 2010

As Figure 1-10 shows, postharvest losses are partly a function of the technologies available and the extent to which markets for the agricultural produce have developed. In general, industrialized countries benefit from advanced infrastructure and technology, whereas postharvest infrastructure in countries in transition is limited and in developing countries rudimentary or altogether non-existent. The level of urbanization is an important factor, since urbanization creates longer food supply chains to feed the urban population and necessitates improved physical and marketing infrastructure. Dietary changes, as described above, imply a diversification towards food stuff with e.g. shorter shelf-life, thus negatively impacting on food waste.

Despite the huge volume of PHL, the serious economic and social implications, and a large positive effect on food security, poverty and sustainability by reducing PHL, postharvest sector research suffers from a lack of resources: it was found that less than five percent of the funding of agricultural research is allocated to postharvest research areas (Kader, 2003). Challenges for reducing PHL, such as constraints in farm inputs, food preservation and distribution, mechanization/productivity, processing and handling, have received relatively little attention to date. According to McKinsey (2011), research on postharvest related issues such as food waste, large-scale farm yields and smallholder farm yields, would have been among the top seven research themes in terms of total resource benefit. However, looking at the actual publications over the past year, it is evident that those topics have been neglected, with as little as 300 publications on smallholder farm yields, 1,800 on food waste and 8,800 on large-scale farm yields. Meanwhile, electric and hybrid vehicles, for instance, have generated disproportionately high interest with 110,000 publications.

Figure 1-11. High potential research and actual publications in past year



Source: McKinsey, 2011

There is a wide range of postharvest and supply chain technology available, which can be adopted to improve the efficiency of the postharvest system and thus reduce losses. Recommended technologies vary depending on product, value chain components and country context. In industrialized countries consumer attitudes as well as abundance and affordability of food lead to high waste. This should be addressed by strategies that target public awareness and a change in consumer behavior towards food waste.

In contrast, in developing countries, where food is mostly lost during postharvest operations, strategies should address, among others, organisation of producers, especially smallholders; production management, harvesting time and techniques; infrastructure for transportation, storage and markets; processing facilities, capacity and efficiency; technical and managerial knowledge and skills in food production and postharvest operations; food safety; and policies to support a favourable environment. Especially in low income countries, the investment required to reduce PHL could be modest with a potentially large positive effect on value chain efficiency and the rural economy in general. In addition, technology advances should make PHL reduction more feasible and less expensive.

The challenge in devising appropriate and effective strategies lies in the fact that the food supply chain is a complex system, which touches on many different economic, institutional, social and environmental aspects, such as agriculture, technology, industry and trade policy; access to appropriate technology and equipment; access to output markets; human and organizational behaviour; and cultural practices.

Therefore, reducing PHL is a challenge with multiple and complex elements that requires addressing the whole system of food production, processing and consumption. There is no standard solution for enhancing postharvest handling since each value chain is unique. But there are many potential intervention points, and various solutions are available at each point. What is needed is a concerted approach by the different players.

The government plays an important role for creating a motivating and enabling environment for investment and reducing PHL. In fact, past experiences have shown that where local government policies and investment were absent, large-scale capital investment in the food supply chain has often failed (Parfitt, 2010). The government should therefore give food losses a higher priority and support public awareness campaigns on e.g. consumption behaviour, health and nutrition. To address inefficiencies along the postharvest supply chain, it should direct publicly funded research at addressing priority problems such as production and processing yield, resource use and storage practices. It should support postharvest players by investing in critical public infrastructure, including roads, communication, market information and extension services and by enhancing human capital development through vocational training and education services. Moreover, policies, e.g. for private initiative, access to finance and risk capital, should be improved, as well as regulations, standards and international promotion be developed to support postharvest players and their access to viable markets.

Apex organisations have a significant function for improving the business environment: they should document the problem with direct or sponsored research and analysis, increase public awareness and advocate for change in policies or regulations, e.g. with regards to the role of state agencies or enterprises, price/quality controls and trade restrictions. Apex organisations can further support human capital development, develop business service providers for technology transfer and train trainers, find and disseminate successful solutions via benchmarking and best practices, and reward excellence.

The private sector should adopt standards and good practices, exchange best practices in postharvest handling, storage, distribution and financial services, and share supply chain management know-how through technical assistance and training of e.g. suppliers. In a supportive business environment, it should invest in critical capital assets, such as drying facilities, elevators, packing plants, cold stores, distribution centres and refrigerated trucks, develop new products and better risk management mechanisms.

To sum up, future strategies for food supply must not be limited to ensuring food availability but must also deliver sufficient quantities of food contributing to a healthy diet for all, no matter whether few or sufficient means. While a large group of the world’s population will still struggle for satisfying their daily needs in calories, there will be a growing group of consumers concerned about the origin of their food, its impact on health, method of production but also its price. Both groups will continue to create a challenge for policy, agriculture but also the food industry. The need to respond to the social, economic, political and environmental changes will continue to be part of the agenda, and the responsibility of all stakeholders involved in the food supply chain will remain enormous.

2 PHL in the Asian region

Despite the regions' enormous capacity to produce food, Asia and the Pacific are home to 51 percent of the world's people living with food insecurity (International Food Security Assessment July 2011). As discussed, increasing food production is only part of the solution to address food insecurity and hunger. The extent of PHL plays an important role. To reduce PHL is a challenge faced by every country, no matter whether industrialized or low-income, but what differs are the points of intervention: consumer stage vs. production/processing stages.

There is only little comprehensive and comparable data available for PHL in Asia and the Pacific, but the evidence suggests that postharvest management is far from satisfactory: inadequate labelling and packaging, pesticides exceeding permissible limits and incidents of food-borne diseases and poisoning have a negative impact on the countries' economies and the health of their population. Losses along the postharvest value chain in ASEAN countries are estimated to range between 20 and 50 percent, depending on type of produce (perishables vs. durables), postharvest operations and country context. This is equivalent to over 100 million tons of food production lost, or a value of USD 5 billion.

A wide range of challenges must be addressed, which contribute to high losses along the agro-value chain and diminished returns for producers, thus reinforcing poverty and food insecurity in the region. Among them, less-developed postharvest technologies, weak transport and handling systems, poor communication facilities with too many uncoordinated and diverse actors, lack of quality standards, and low levels of skills and awareness among farmers, traders/wholesalers, processors and retailers. The importance of appropriate postharvest handling and the challenges faced by a developing country in Asia shall be illustrated in the following at the example of Bangladesh (see Hassan, 2012).

Bangladesh produces a large variety of fruits and vegetables, such as banana, mango, pineapple, papaya, potato, eggplant, okra, cabbage and many more. The country has a strong rice sector too. In 2010 total rice production amounted to 49 million tons. Bangladesh thereby ranked fourth after China, India and Indonesia (FAOSTAT, 2012). Fruits and vegetables are a rich source of phytochemicals (vitamin, minerals and antioxidants). While over the past 15 years their consumption has been increasing at the expense of rice, it remains nationally on a very low level (i.e. 110 g/day per capita, compared to the minimum requirement of 400 g/day per capita according to FAO/WHO).

Despite large and diverse agricultural production, Bangladesh faces severe challenges in its postharvest system, which leads to large losses in food production and income for actors along the value chains. As Table 2-1 shows, postharvest losses for fruits and vegetables can be as high as 44 percent for perishable products such as jackfruit. Metabolic changes (like ripening), mechanical injury, moisture loss, physiological and pathological breakdown and insect damage lead to high PHL. The resulting annual economic loss is estimated at BDT 34,420 million for selected fruits and vegetables, which is equivalent to USD 490 million.

Table 2-1. PHL of selected fruits and vegetables in Bangladesh

	Production (in mt)	Actual loss (in %)
FRUITS		
Mango	767,000	27.4
Jackfruit	926,000	44.0
Banana	1,005,000	23.9
Litchi	44,000	28.4
Pineapple	238,000	40.4
Papaya	96,000	39.9
Orange	12,000	22.2
VEGETABLES		
Tomato	143,000	32.9
Cauliflower	156,000	34.3
Brinjal	222,000	18.3
Okra	39,000	32.3
Cucumber	53,000	18.5

As agricultural produce moves from the field through some or all of the stages of trimming, grading, pre-cooling, packing, storage and distribution through wholesalers and retailers, inappropriate handling, transportation and marketing practices lead to high losses.

Sorting is practiced manually for most fruits and vegetables to remove damaged, diseased and insect infested produce on the basis of visual observation in Bangladesh. In developed countries different types of sorters are used such as belt conveyor, push-bar conveyor, roller conveyor. Washing is a standard postharvest handling operation for many fruits and vegetables to remove adherences, dirt, latex and external pathogenic structures. Appropriate chlorination of the wash water is very important, as it can reduce the spread of contamination form one item to another during the washing stage. In Bangladesh, however, fruits and vegetables are hardly washed before entering the marketing channel. Where washing does take place, it is in often unhygienic conditions. This contributes to poor quality and considerable losses of the produce.

Picture 2-1. Washing of potatoes and sorting/grading in Bangladesh

Grading is an important postharvest operation. In developed countries automatic grading of fruits is a common practice, e.g. an automatic rotary cylinder sizer is used to grade fruits. In Bangladesh, however, grading is practiced in limited scale based on size, especially for mango, banana, pineapple, papaya and jackfruit. There are no scientific methods of grading or grade standards of fruits and vegetables in the country. This highlights the importance of EurepGAP (called GLOBALGAP since 2007), i.e. a common standard for farm management practice introduced in Europe in the late 1990s and now the world's most widely implemented farm certification scheme. Thus, emphasis must be given to develop GAP (Good Agricultural Practices) for horticultural produce in Bangladesh for export and domestic market development in order to ensure quality and safety in the horticultural supply chain.

Packaging is another essential postharvest handling step that usually protects food between production/processing and final usage by the consumers. Proper packaging throughout the entire handling system is an important step in assembling the produce in convenient units for transportation, marketing and distribution, so to ensure maximum storage life and maintain produce quality. It is especially crucial for long-distance transportation and storage of fruits and vegetables. Packaging must withstand rough handling during loading and unloading; it should be strong enough to minimize impact and vibration damage during transportation; it should have adequate ventilation holes and display proper labelling with relevant information for value addition and enhanced marketing.

However, the present packaging systems for perishables in Bangladesh lack modern, scientific methods. Use of traditional forms of packaging like bamboo baskets, especially at the growers' level, is still predominant. Other packages at the growers' levels include polystyrene and jute sacks. The use of corrugated fibreboard (CFB) packages is very limited. For bulk transportation, the intermediaries rely on large packages made of local materials like bamboo baskets, jute sacks, jute ropes, leaves and vines. Often, the packages are unhygienic and lack adequate aeration facility. These packages are also unsuitable in relation to convenience, handling and stocking: often very large packages, for which the capacity varies from approximately 300 to 600kg per package, are used. Hence, there is high risk of damage to the produce during transportation and subsequent handling.

Improved packaging such as plastic crates (stackable and nestable), woven plastic sacks, plastic net bags, corrugated fibreboard cartons, waxed cartons and wooden crates should be used instead of the conventional bamboo made packages, which cause substantial damage to the produce during handling. Although more expensive, they would also be cost effective, especially for domestic marketing.

In fact, plastic crates have recently been introduced for some valuable horticultural produces like mango and tomato in Bangladesh. Rigid plastic containers are used extensively in many countries for fruits and vegetables packaging. For domestic marketing, plastic crates provide excellent protection for produce and adequate ventilation during handling, cooling, transport and storage. But crates and plastic containers should be cleaned on a regular basis with chlorinated water and detergent to reduce the chances of spreading decay from one load to the next. Furthermore, the packages should not be overloaded and the produce should not be held too tightly or too loosely to minimize damage during transportation and handling.

The harvested produce is first transported from the place of harvest to the packing house, where the produce is subjected to postharvest operations such as cleaning, sorting, grading and packaging. As packaged produce, it is then transported to destinations like distribution centres, wholesale markets, supermarkets and retail markets. To limit damages during transport, refrigerated vehicles should be used for perishables to control temperature and humidity; loads should be stacked to enable proper air circulation; produce mix should be avoided as the liberated gas (ethylene) from one group of produce may badly affect the quality of another group; and workers should not stand upon the produce during loading and unloading. Worker safety during loading/unloading is another important consideration.

In a developing country like Bangladesh, the main problem is the absence of refrigerated vehicles in the supply chain. The Hortex Foundation of Bangladesh recently introduced a few such refrigerated vehicles to carry fruits and vegetables. However, the involvement of truck brokers and different transport federations is a problem. In addition, there are no ideal storage facilities for fruits and vegetables in assembling and wholesale markets, where, unprotected through proper packaging, products are mixed and exposed to unhygienic conditions. To resolve these problems, government agencies and private enterprises should come forward to improve the transport system.

Picture 2-2. Mango transportation and wholesale market in Bangladesh

Short and long-term storage is the most crucial postharvest operation in the fruits and vegetables supply chain. In developed countries, there is a variety of storage facilities available at different levels of marketing from growers to retail shops. Cool chain management is ensured to maintain produce quality. Moreover, the growers use suitable postharvest treatments to prolong the shelf life of produce. Common storage methods include low temperature storage, controlled atmosphere storage and modified atmosphere storage. Commonly practiced postharvest treatments are fungicidal dips, ethylene scavenging chemicals and edible coating like chitosan. Such postharvest technologies ensure a high quality and long marketing life of the produce.

These are just some of the issues that need to be considered to improve sub-standard storage practices and facilities in Bangladesh. For instance, low cost but effective storage technology for fruits and vegetables like earthen cooling pots should be distributed to retailers and consumers to minimise loss and extend shelf life for a significant period of time. When adequate storage facilities are not available, establishing small or large scale processing plants could be an alternative. Losses could be greatly reduced by a strong link between growers and processors. Currently, there are only a few large scale processing plants in Bangladesh, so the scope for development is enormous.

The postharvest challenges, illustrated here at the example of Bangladesh, are typical for many developing countries in Asia, as the discussions and presentations of 13 country reports at the UNIDO – ICS Workshop on "Postharvest, Quality and Food Safety of Tropical Fruit Production in South East Asian Countries" (Bangkok, 30 April - 4 May 2012) showed:

- In Cambodia growers have very limited knowledge of appropriate postharvest handling and technology. Traditional manual practices for harvesting and primary processing (e.g. threshing and drying) prevail.

- The Indian food processing sector has an immense growth potential due to increases in urbanisation, disposable incomes, numbers of nuclear families and working women, all of which leads to a higher demand for processed and functional foods. However, supply chain infrastructure gaps (lack of primary processing, storage and distribution facilities), inadequate links between production and processing (e.g. lack of varieties suitable for processing), seasonality of operations and low capacity utilization, insufficient attention on quality and safety standards, lack of product development and innovation, as well as institutional gaps in the supply chain lead to high waste of agricultural produce.

- In Indonesia there are quality standards for agricultural produce but their implementation is poor, thus having a negative impact on product quality and consumer satisfaction. Existing national quality standards are limited to export commodities of horticulture, and every supermarket applies individual quality standards for purchase. Moreover, GAP and Standard Operation Procedures (SOP) have been set up, but not yet been applied by most farmers and traders.

- In Laos high quantitative and qualitative PHL are caused by unsuitable harvest methods and rough handling by workers, poor transportation practices (e.g. long delays in transport and inappropriate packing and loading), exposure to high temperatures and rainfall, lack of hygienic postharvest practices and poor awareness by stakeholders.

- In Malaysia better handling systems have been practiced by growers of highly priced fruits such as starfruit, jackfruit and guava, especially for export markets. But poor practices and technology in harvesting, transporting, sorting/grading, packaging, labelling, storing etc. for other agricultural produce continues to be a major problem resulting in severe damages and losses along the agro-value chain.

- In the Philippines, again poor transport practices are identified as a major contributing factor to high losses in fruits and vegetables. To address these issues, the National Cold Chain Program and the Agricultural Tramline Program have been introduced, among others. The first refers to the private sector receiving assistance in acquiring and establishing cold chain centres or facilities. The latter refers to an innovative way of solving the problem of transporting and hauling agricultural products in mountainous and inaccessible production areas.

- Sri Lanka suffers from poor food safety and quality issues due to improper pesticide and fertiliser use, inadequate application of postharvest management techniques, poor handling during collection, transportation and storage, a high incidence of pest and diseases and a lack of awareness and training of stakeholders resulting from inadequate numbers of extension staff and limited knowledge on their behalf. Moreover, fruit and vegetable marketing is poor as market information is insufficient and producers are ignorant of consumer preferences.

- Postharvest problems in Thailand, including incorrect harvesting and handling practices, damage by diseases and insects as well as physiological disorders, result in inferior fruit quality and quantitative losses. Awareness programs for producers, dealers and transporters on postharvest handling, introduction of modern packing materials and transport systems, development of storage structures, creation of urban mega markets and food parks, development of processing and packaging industry, and research on value addition and supply chain management have been suggested to address those issues.

- In Vietnam, fruit production is scattered on small scale farms causing difficulties for transferring technologies. Current storage and transport systems are very simple and lead to high losses. Moreover, farmers lack the information necessary for accessing foreign markets. Only limited quantities of fresh fruits meet US and EU market requirements.

In conclusion, it is found that quantitative and qualitative PHL in Asia could be reduced significantly by introducing proper postharvest practices and technologies along the agro-value chain. Importantly, this needs to include training of stakeholders, from farmers to retailers. In order to improve product quality, also pre-harvest management should be addressed by growers in collaboration with technical experts. The optimum date of agricultural treatment (from pruning to fertilization/chemical treatments or picking), for instance, should be determined by experts and quickly communicated to growers, e.g. by text message. For improvements in postharvest operations to be successful and sustainable, stakeholders, especially producers, must be rewarded for higher quality produce, which is presently often not the case.

There is high potential in international demand for Asian agricultural produce. As the UNIDO - ICS Workshop in April/May 2012 pointed out for the case of tropical fruits, they could be marketed not only as part of a healthy, nutritious, tasty and safe diet, but also for ethical objectives such as supporting fair trade and local smallholders and making a contribution to sustainable development. In that sense, postharvest technology and fruit processing should aim at prolonging the shelf life, preserving the content of anti-oxidants and enhancing disease resistance by biotechnology. Pre- and postharvest technology should ensure plant disease control by using natural compounds (plant extracts), biological control, Generally Recognized As Safe (GRAS) compounds, physical means (heat, cold, controlled atmosphere and radiation) and Integrated Pest Management (IPM). Also active and degradable packaging could be a helpful tool in order to achieve these results (Koslanund, 2012; Boselli, 2012).

Following the discussion above, postharvest challenges across Asian countries appear to be broadly similar. However, successful interventions need to address specific value chains and their inherent problems, including the policy and institutional environment of individual countries and sectors. Six in-depth baseline studies, covering various agro-value chains from harvest to retail across six countries in Southeast Asia, are therefore presented in the following section.

3 Baseline studies in 6 ASEAN countries on PHL

In 2011/2012, six baseline studies were conducted to paint a detailed picture of PHL in agro-value chains of importing and exporting countries in the ASEAN region. The specific objectives were to

- identify the points of losses and quantify PHL at the different stages of postharvest operations
- analyze in-depth the value chain from farm to retail
- describe postharvest technologies currently in use, their advantages and drawbacks
- identify support institutions assisting in technology transfer and adaptation, and describe their role and set up
- identify and describe the existing support framework for the different sectors, both government and private sectors, and
- develop recommendations derived from the PHL assessment, which will provide the necessary information to guide the development of technical assistance projects on the reduction of PHL.

The baseline studies take a holistic and integrated value chain approach, which is of necessity as PHL may occur in various parts of the chain and may result from weaknesses in the enabling environment, including factors such as research and development, information services, public and private investments (policy, legislation, infrastructure, etc.), and training and capacity building. The studies therefore explore the political, economic and technological framework governing selected sectors.

The six countries selected for this in-depth analysis of postharvest value chains are Cambodia, Indonesia, Laos, the Philippines, Thailand and Vietnam. The studies cover a range of agricultural and agro-industry sectors, i.e. rice and maize (in all six countries), cassava (in all countries but the Philippines), fishery (in Cambodia and the Philippines), coffee as well as a selection of fruits and vegetables (in the Philippines only).

Study teams in the six countries were from the Faculty of Agro-Industry at the Royal University of Agriculture in Cambodia; the Institut Pertanian Bogor of the Faculty of Agricultural Engineering and Technology in Indonesia; the National Agriculture and Forestry Research Institute of the Ministry of Agriculture and Forestry in Laos; the College of Agriculture at the University of the Philippines Los Banos; the National Food Institute in Thailand and the Institute of Agricultural Engineering and Postharvest Technology in Vietnam.

In each case, the study team conducted an initial desk study in 2011/2012, which included a review of previous studies on postharvest operations and revealed policy, economic and technical aspects of the postharvest systems. Subsequently, primary data was collected through surveys and field observation. For the survey, respondents, such as farmers/farmer groups, owners of agricultural machinery, transporters, collectors/traders and processors, were selected by purposive sampling to cover the whole supply chain. They were interviewed by team members with the help of structured questionnaires to provide information on PHL. Furthermore, Focus Group Discussions (FGD) were organized by coordination with local agricultural authorities, and interviews were conducted with Ministries and Provincial Departments of Agriculture, financial institutions, the agricultural machinery industry and other institutions. In addition to survey and interviews, study teams made observations on postharvest chains and losses, technology and machinery currently used for handling and operations, technology transfer, sector support systems, current problems and development needs.

The following will provide an overview of the baseline studies, with a selection of sectors and postharvest chains, as presented at the Joint ASEAN Secretariat - UNIDO Workshop (16 to 18 July 2012) in Jakarta, Indonesia. For more detail, please refer to the individual studies or the compilation report. The recommendations that follow from the findings and upon which projects for technical assistance will be built are discussed in the next section.

3.1 Cambodia

Rice and cassava - postharvest analyses of which are presented in the following - are important crops in Cambodia. According to national data, the total cultivated area for rice amounted to 2.8 million ha and production to about 8.25 million tons of paddy by 2010. It has a very important position as staple food in the Cambodian diet. Cassava cultivated area was about 206,226 ha, with a production of around 4.25 million tons in 2010. In recent years, production increased strongly due to high demand in local consumption and in export as raw material for processing industries. However, the two sectors face a number of notable constraints along the chain from production to final consumption. Among them, inadequate and improper postharvest practices, which contribute to the poor quality perception of domestic products.

3.1.1 Rice

Conventional agriculture still dominates rice production as the availability of technology is limited by farmers' financial means. Farmers can harvest manually or by reaper, which is commonly practiced for wet rice season, but is not easily operated in lowland rice fields. A technology commonly used for dry season rice is the combined harvester, which harvests, threshes and cleans. Harvest takes thereby less time and, because threshing and cleaning is included in the operation, paddy rice harvested by combine harvester can be dried or sold directly through a collector/trader. In contrast, harvesting by reaper or by hand will require other operations, such as threshing and cleaning. In case threshing is done manually, cleaning must be done with conventional tools as well.

After harvest, the paddy rice is generally transported to the threshing area/machine or to the drying area, followed by storage activities before undergoing milling to produce milled rice for consumption. The majority of farmers sell their paddy rice immediately to rice collectors, who transport the paddy rice to millers, who have a larger space to store paddy rice.

Sun drying is the only drying method used by Cambodian farmers. Farmers lay rice on a mat on the ground. Rice millers also use the sun drying method, but the rice is put on concrete ground instead. The solar drying system is being introduced in Cambodia, but it is still very limited. Recently, a modern miller has established his own drying oven or warehouse in order to produce quality rice for export.

In those cases where farmers store their paddy rice, it is usually in open storage inside the barn. In a modern system, storage is combined with the drying house at the rice miller and trader. This kind of system is costly, but temperature and relative humidity are controlled and it is thus very efficient to maintain rice quality and prolong the shelf life before milling.

Millers are usually the main actors along the postharvest chain, acting also as traders who sell the rice to retailers. Small milling is generally found at village level for daily consumption of villagers. In a remote area hand milling is practiced, but this is rare. The operation of medium size millers has not changed over the past two decades, but recently some new modern mills have been installed, which aim at rice export, especially to Europe.

Apart from millers/traders, there are some traders, particularly international traders, who buy milled rice or paddy rice from millers for distribution without owning milling facilities. They work with local rice facilitators (rice commissioners). At other times, traders buy paddy rice from local collectors to sell to millers/traders in neighboring countries (Vietnam or Thailand), or international companies contact millers directly.

Rice retailers in Cambodia are usually rice shops, which specialize in both wholesale procurement and sales of rice, and market stalls that sell limited varieties of rice in the market. There are also grocery stores and a few supermarkets that sell milled rice.

Losses occur at every stage of the chain from harvest to retail (see Table 3.1): Selected farmers estimate that their losses during harvest amount to approximately three percent. The main causes are rodents and poor operation management of harvesters. At transport, losses occur when the rice bundles are carried by oxcart or power tiller to the home and threshing area, and when it is transported from harvesting area/storage to selling store or trader. During threshing rice can spill over the mat used for threshing or the grains cannot be separated from the straw. Higher moisture content of rice results in a higher loss. Average losses ranged from 1.4 to 2 percent for dry and wet season rice, accordingly.

Table 3-1. PHL estimates for dry and wet season rice

Postharvest operation stages	Percentage of Losses (%)					
	Dry season rice (N=21)			Wet season rice (N=31)		
	Min	Max	Average	Min	Max	Average
Harvesting	1	5	2.98	1	10	3.01
Bundle drying	0.5	2.5	1.29	0.3	3	1.55
Transportation	0.5	4	1.64	0.2	5	1.79
Threshing	0.3	3	1.35	0.2	6	2.01
Drying (sun drying)	0.1	2	1.40	0.1	4	1.42
Storage	0.5	3	1.57	0.5	8	2.69
Total	**6.5**	**14**	**10.08**	**3**	**28**	**12.47**

Source: Survey in Battambang, Pursat and Takeo Province, March-May 2011

Picture 3-1. Spillage from harvesting device and during transport

During drying, chickens are the most common cause for loss. In addition, there is weight loss due to drying. Losses are estimated at an average of 1.4 percent. At rice millers, it was slightly below, at around one and 1.5 percent for sun drying and oven drying, respectively. Losses at the milling stage can be intentional, where the miller steals milled rice from the paddy rice owner, or unintentional, caused by technological errors, spillage during milling, rice being attached to the roller and low quality of paddy rice. It was estimated by the millers that losses during milling are about 0.1 to 10 percent. Milling loss is heavily dependent on the quality and the capacity of the milling machine, the requirement of rice polishing level and miller skills. Generally, the recovery rate is at 64 percent of milled rice for domestic consumption and below that for export rice. The low recovery rate is mainly caused by the absence of a quality market and of a contract between millers and farmers.

Storage loss at farm level depends on the facility, but it is estimated to amount to 1.6 and 2.7 percent for dry and wet season rice, respectively. Loss in storage at the miller was estimated at 2 to 5 percent for paddy rice and 0.1 percent for milled rice. The main reasons for storage loss include damage by rodents, insects and fungus, as well as weight loss.

Picture 3-2. Loss at storage: punctured sacs and bird damage

The rice export strategy of 2010 is a newly established strategy with the ambitious goal of exporting one million tons of rice per year from 2015. The strategy paves the way for a number of governmental institutions to take on roles for supporting rice export.

In terms of institutional support, there are three technical organizations within MAFF that are already relevant to Cambodia's postharvest system for rice and other products. The Department of Rice has direct responsibility for the rice production system. The Department of Agro-Industry supports all activities related to postharvest technology in terms of service provision and quality and safety management of all agricultural products. The Department of

Agricultural Engineering supports machinery technologies. Other organizations under MAFF, such as the Department of International Relations and the Department of Agricultural Extension also work in the field of the rice postharvest system, depending on availabilities of funds.

Furthermore, the general Department of Industry, MIME, plays an important role for overseeing the milling industry of Cambodia and promoting effective and efficient implementation related to food processing. Agricultural academic institutions share knowledge on postharvest issues and provide up to date information to all of the above institutions.

Another major contributor to rice technology and industry development in Cambodia is Cambodia Agricultural Research Development Institute (CARDI). CARDI continues to develop the rice sector by developing seed production and breeding varieties. Many varieties have been bred and improved to increase productivity without compromising grain quality and to meet domestic and export demand.

In addition to this, there is collaboration with different donors, who have been working to improve the postharvest system in Cambodia, such as FAO, USAID and GIZ, to name but a few.

3.1.2 Cassava

Cassava is easy to grow, but, at 62 to 65 percent moisture content, it is a very perishable tuber crop with a storage life of less than 48 hours. Traditionally, research has focused on improving production output through better crop quality, harvest and storage. But in order to help boost profits of farmers and other supply chain actors, efforts should now be made to reduce PHL of cassava, which are estimated to range between 16 and 73 percent along the cassava supply chain (below). The following assessment is based on Pailin and Kampong Cham, which are important provinces for cassava production in Cambodia.

Harvesting cassava is labor intensive and almost exclusively done by hand. On average, harvesting one ha of cassava requires 240 to 320 man-hours and 168 to 248 man-hours for handling. The number of labor per ha varies depending on soil condition, cultural practice and the variety of cassava.

After harvest, the cassava roots are collected with common bamboo baskets and carried to the truck where they are piled up or sometimes put in 50kg sacks for transport. The roots are either sold directly to traders/exporters or processors, or sold through a network of collectors and middlemen to factories in Cambodia, Vietnam and Thailand. Normally, the roots are transported on the same day; later transport will result in weight loss and damage to the root.

According to farmer responses, PHL at farm level ranged between 0.5 and 9 percent in Pailin Province and between 0.2 and 5 percent in Kampong Cham Province. The difference in PHL may be explained by the on average smaller cassava cultivation area per household in Kampong Cham. Other factors include variety selection, soil preparation, soil profile and structure as well as harvesting method.

The main causes for PHL during harvesting are physical loss (roots damaged during harvesting, left in the ground or field due to oversight), followed by physiological and biological loss (insects, rodents and diseases). In some provinces, e.g. in Kampong Thom, physical loss also occurs due to thievery, which is not included in the PHL figure above.

Physiological loss due to the reduction of moisture of fresh roots accounts for a 10 percent loss within one day of storage, and a 50 percent loss within three to four days. The biological loss accounts for 0.5 to 4 percent according to farmer estimates. Biological loss can be very high too: e.g. in one particular case, 30 to 70 percent of production was destroyed by disease prior to harvesting. In addition, unfavorable weather can contribute to further PHL.

PHL during transportation from farms to collection centers is not negligible, accounting for 0.5 to 3 percent. The loss is caused mainly by spillage. Either there are gaps and holes in the walls of the transporting trucks or, where sacks are used, transporters are careless or sacks are punctured. The PHL during transportation from farm to collectors is still the farmers' responsibility.

Picture 3-3. Cassava transportation

To prepare for drying, the fresh roots are chopped into small pieces using a knife (farmers) or a chopping machine (traders). Farmers chop the roots on the field, using an old tarpaulin or PVC sac as drying surface or sometimes just laying the slices directly onto the ground. Drying takes place at the farm level only if a farmer cannot transport the fresh roots to the market on time, the farmer's production volume is low or the market price is unfavorable. Otherwise, drying is done at the collection center or at trader level. Drying takes about three to four days, during which the fresh roots lose 50 percent of their moisture content. Traders with only a small drying yard will dry the roots only if they cannot be sold within two to four days. Small scale traders and farmers prefer to sell fresh roots because drying is time consuming and losses occur.

At trader or collection center level, total PHL ranges from five to ten percent. Losses at the collection center occur during chopping, drying, storage and transport for processing or export: during the chopping process cassava flour is scattered from the drying yard or pieces of cassava and cassava flour are attached to the chopping device; during drying wind or rain lead to losses of about four to five percent; and during storage 0.5 to 2 percent are lost due to pests, spillage, spoilage and diseases. The condition of storage is an important factor for the extent of quantitative and qualitative PHL since dried chips are very sensitive to temperature and humidity. Further loss during transportation for processing or export is estimated at around 0.5 to 3 percent, depending on distance and type of truck. It is mainly caused by spillage and weight loss during transportation.

Table 3-2. Causes and extent of PHL along the cassava supply chain

Causes of losses		Losses (in %)
At farm level		**11 - 63**
	Physical loss: left underground, damaged roots, spillage during transport to trader	0.5 - 9
	Physiological loss: moisture loss	10 - 50
	Biological loss: pests, disease	0.5 - 4
At trader level		**5 - 10**
	Drying	4 - 5
	Storage	0.5 - 2
	Transport	0.5 - 3
Total		**16 - 73**

Source: Survey data from Pailin and Kampong Cham Provinces, March 2011

According to the Ministry of Commerce (2011), there are about a dozen cassava processors in Cambodia, located in Battambang, Kampong Cham, Kandal and Phnom Penh. Their products include cassava starch, animal feed or bio-ethanol. However, those companies are run as joint ventures with Thai, Vietnamese or Korean enterprises and specialise on unique cassava products. In Pailin, there is little further processing besides simple boiling of cassava and production of Num Bak Bin (dessert) for home consumption or for sale in small shops within the province.

In Kampong Cham Province there are some processing facilities in form of micro and small scale enterprises that produce Sago, Saray and dried and wet cassava flour for domestic supply. According to the agro-industry office of Kampong Cham Provincial Department of Agriculture, there were 262 such cassava processing enterprises in 2007, but by 2011 only five or six were remaining. According to the Royal University of Agriculture, this decline is due to processors facing problems such as high production costs, low market prices for final products, insufficient labor and capital and lack of production area.

3.2 Indonesia

In Indonesia three commodities, i.e. rice, maize and cassava, were selected to be studied for PHL in the agro-value chain from producer to consumer. In 2010, Indonesia produced 38 million tons of milled rice, 17.6 million tons of maize, and 22 million tons of cassava (BPS, 2011). PHL ranged from 10 to 20 percent, and varied depending on location, season and manual or mechanized operations. The survey on PHL was conducted in four provinces: West Java and South Sulawesi for rice, and East Java and Lampung (in Sumatera) for both maize and cassava.

3.2.1 Rice

In Karawang District (West Java) rice farmers harvest the paddy manually by sickle. This leads to 2.5 percent losses. Reapers are sometimes utilized by farmers who own large areas, thus reducing the harvest loss to 1.5 percent. But they are used for less than one percent of rice production. In addition, harvesting is often early, even though farmers are aware that this may have a negative impact on rice quality. The practice was common for the following reasons: the price of paddy decreases as increasing volumes of produce enter at the peak harvest season; farmers have the impression that their income is higher by harvesting early since the weight of paddy reaches its maximum prior to optimum harvest time; employing farm workers for harvesting may not always be possible at the time of ideal level of paddy moisture content; and farmers fear for their production due to a harmful environment, such as a sudden breakout of pests and diseases, and adulteration by human beings.

Manual threshing by beating the paddy to a wooden triangle on the paddy field contributes to five to six percent of losses. While mechanical threshing could reduce the losses to around one percent, threshers are only used for 1.6 percent of total paddy production, way below the average 12 percent use of threshers in West Java. Transportation of grain to the next postharvest players is done in plastic bags, carried by truck, thus not incurring any significant losses.

Drying of rice to about 14 percent moisture content is largely conducted by rice milling units (RMUs), the rest by small-scale farmers for domestic consumption. While all the large RMUs dry rice using continuous dryers and automatic controlled dryers, farmers still employ sun drying methods. Estimated sun drying losses may reach 2.5 percent due to the delay of drying caused by weather uncertainty. On the other hand, mechanical drying losses are of no significance, amounting to less than 0.5 percent. Storage is generally practiced by large RMUs using well maintained warehouses for staples of rice bags or silos, thus, no significant losses occur in this handling system.

Small RMUs usually do not have the capital to purchase stock so they keep only the rice in rice bag staples for a two to three day milling capacity. Milling losses are estimated to be a maximum of one percent at small RMUs, and range from 0.4 to 0.5 percent for large RMUs and RPCs. The estimated total possible PHL by manual operation amounts thereby to a maximum of 12.5 percent, the estimated total possible PHL by mechanical operation is a maximum of 4.5 percent (Table 3-3).

Table 3-3. PHL of rice in Karawang, West Java

Postharvest Operation	Farmers	Small RMUs	Large RMUs
Manual harvesting	2.5		
Mechanical harvesting	1.5		
Manual threshing	5.0 – 6.0		
Mechanical threshing	1.0		
Sun drying	2.5		
Mechanical drying		0.5	0.5
Rice storage			Not significant
Rice milling		1.0	0.4 – 0.5

Source: Standard National Indonesia (SNI)

3.2.2 Maize

In central Lampung District (Lampung Province), maize is harvested either at high moisture (30 to 40 percent) or low moisture content (17 to 20 percent). Harvesting at high moisture content usually takes place within the rainy season close to rice planting time. Harvesting is also carried out depending on the income needs of farmers. When harvesting at high moisture content, the quality of maize is reduced. This is reflected in a high value of rafraksi, i.e. a price reduction by buyers according to maize moisture content.

Farmers either sell their product to collecting traders directly or through an agent. Agents act as brokers between a collecting trader or a small warehouse and a farmer. Fees for the agent are the responsibility of the collecting trader or the small warehouse owner. These parties use agent services when maize production is low. Supplies to large warehouses are maintained continuously, according to work contract. Inter province collecting traders sell maize grains with a moisture content of 14 to 16 percent to poultry farms outside Lampung.

Shelling is carried out mechanically with a 24 HP maize sheller by custom service units (UPJA) or collecting traders. The lower capacity maize shellers operated by UPJAs produce ash, which, mixed with the grains, reduces the grain selling value. Packaging of maize cobs and grains is carried out inside plastic bags having a capacity of 50 to 60 kg. Bags used by the farmers and the collecting traders are secondhand bags. The price of new bags, approximately IDR 1,500 per piece, is considered too expensive. Damaged second hand bags therefore may cause losses during transportation and loading.

Drying of grain is performed naturally under the sun by the farmers. The drying takes place on the sun drying floor, with a thickness of about three cm. The drying time will take three to five days. Farmer groups who received maize shellers from a government grant carry out shelling and drying themselves. The drying aims to reduce grain moisture content to 18 to 20 percent. At this moisture content, the grains are sold to collecting traders or small warehouses. Small warehouses generally have a storage capacity of 2,500 tons. They will further dry the grains with a mechanical dryer to a moisture content of 14 to 15 percent. This dryer has a capacity of 600 tons per day. Total possible losses along the postharvest chain amount to 10 percent (Table 3-4).

Table 3-4. PHL of maize in Central Lampung District

Postharvest operation	Losses, dry matter	Reasons
Harvesting	<0.1%	Cobs left on the field
Sun drying	2-5%	Delay of drying
Mechanical drying	< 0.1%	Loading and unloading
Shelling at high moisture content	1-2%	Foreign matters mixed with grains
Shelling at low moisture content	<0.1%	Grains left on cobs and in working areas
Packaging	Not significant	
Transportation of cobs	Not significant	
Transportation of grains	0.5-1%	Spilling out if damaged second hand bags used
Storage in small warehouses and by famers	2%	When stored longer than two months

Central Lampung has several supporting institutions: 311 Gapoktan (Organization of Farmer Groups), village workshops, 35 UPJAs (Unit of Agricultural Machinery Services) and one UPJA center. Agricultural machinery operated by UPJA includes hand tractors, transplanters, water pumps, maize shellers and rice milling unit. Agricultural machinery manufactured by the village workshops include maize shellers, winnowers and mechanical dryers. Table 3-5 lists the government programs to improve the postharvest handling system of maize.

Table 3-5. Government programs to improve postharvest handling system of maize

Programs	Activities	Target	Implementation year	Financial source
SLPTT	Training and supervision, at least 8 times each planting time, and seed aid. Facilitators: extension workers, BPTP, POPT.	Farmer groups	2008 - present	Central government IDR 3 millions for each farmer group with arable land of 15ha
BLBU	Providing maize seeds	Farmer groups	2007 - present	Central government
Agricultural Machinery Grant	Mechanical dryer and silo	Gapoktan	2007	Central government
Agricultural Machinery Grant	Mechanical maize sheller	Farmer groups	2007	Central and regional government
Equipment Grant	Tarpaulin	Farmer groups	2008	Central and regional government
Agricultural Machinery Grant	Sun drying floor	Farmer groups	2008	Central and regional government

BLBU: Direct Aid of Excellent Seeds
SLTP: Field School of integrated crop management
POPT: Controlling Pest Plant Organisms
BPTP: Assessment Center of Agricultural Technology

3.2.3 Cassava

In Central Lampung, cassava harvest is generally done manually by pulling out the cassava stem along with the roots. In the rainy season the soil is softer and manual harvest encounters no problems. However, in the dry season farmers are forced to use leverage to dig the soil around the plants. Harvesting is usually done by farm workers in a group of five to eight persons with the capacity of harvesting two tons per day.

PHL is measured from the wet cassava mass weighed by farmers right after the cassava is uprooted. In this condition, farmers include soil and foreign matter in the yield. Cassava harvest losses are influenced by the season: the average cassava loss in the rainy season is 0.01 to 0.05 percent, while in the dry season it increases to one to three percent due to broken roots being left uncovered in the earth during hand pulling. Losses in the temporary pool site refer to the vaporization of moisture content from fresh cassava roots. Even though there is commonly only a delay of one to two days, the weight difference may amount to 7 to 15 percent. Quality checks performed by the receiving industries deduct a significant percentage (8 to 35 percent) from the weight of cassava. Immaturity due to early harvest adds to the losses (Table 3-6).

About 60 percent of cassava production is sold to collecting traders, 40 percent directly to the tapioca industry through industry buying agents, who work as freelance matchmakers between farmers and industry. The collecting traders also sell the roots to the tapioca industry (58 percent) and bioethanol industry (two percent). Pick-up vehicles with a capacity of six to seven tons are used by collecting traders to transport the cassava roots from the farms to a temporary pool site. The collecting traders will further carry the cassava in dump truck with a capacity of 12 tons from the temporary pool site to either the tapioca or bioethanol industry. 98 percent of cassava production is consumed by the tapioca industry.

Table 3-6. Postharvest losses of cassava in Central Lampung

Postharvest operation	Losses	Reasons
Harvesting	0.5-3%	Broken roots left in earth; uncovered roots during dry season
Transportation	0%	
Delay in the temporary pool site	7-15%	Delayed by 1-2 days, losses incurred mainly due to moisture content reduction
Quality checks by receiving industry	8-35%	Weight losses due to subtraction of soil and foreign matters, and/or cassava maturity

Picture 3-4. Cassava harvesting, cutting the roots from the stem, temporary pool site and dump truck carrying cassava to tapioca industry

3.3 Laos

Agricultural production in Lao PDR is predominantly based on traditional production systems. Most of the supply chains are inefficient multi-tier chains. Products change hands many times before finally reaching the end-users. Postharvest technology is poorly developed. Improper handling of agricultural produce after harvest often results in quality deterioration and significant economic loss. PHL in Laos have been reported to vary between 20 and 30 percent. In some instances, the figures can exceed 30 percent, depending on the handling and distribution chain, which varies among different regions. PHL can be attributed to several factors, however, improper handling and packaging, low-level technology, lack of basic equipment and facilities or packing houses and lack of trained personnel are large contributing factors, creating huge wastage and compromising quality and food safety.

For the study of PHL in Lao PDR, three commodities were selected, i.e. rice, maize and cassava, of which Laos produced 3.1, 1 and 0.5 million tons, respectively, in 2010 (MAF, 2011). Six locations were selected according to their importance in the production of the given commodity.

3.3.1 Rice

In Thoulakhom and Paksan Districts, the locations in the Vientiane Plain selected for the analysis of the rice postharvest handling system and PHL, rice farmers plant and harvest the paddy twice a year. The peak harvest season are usually the rainy months of October and November and the second harvest is during the dry months of March and April. Rice production follows traditional methods and productivity is low, around four to five tons paddy (19 to 20 percent moisture content wet basis) per ha. But this is already above the national average of three to four tons paddy per ha.

PHL incur at all stages of the postharvest system. During harvest already, early or unexpected rains or a labor shortage can lead to spoilage. In the rainy season, paddy is generally harvested at a high moisture content of 22 to 27 percent, because farmers often practice early harvesting. Harvesting usually incurs two to three percent losses. During drying of cut paddy, which takes about two to three days, fungi develop due to rains or rodents and birds damage the production. Drying in the field incurs losses of approximately 10 percent during the milling process when poor paddy quality leads to breaking of grains. Where the drying was less good, this figure increases to about 14 percent. While there is a good rice milling design available from Thailand, the recovery rate is low at 55 percent. Furthermore, poor maintenance and hygiene in milling, as well as under-investment in milling facilities leads to losses at this postharvest stage.

When farmers practice manual threshing by beating the paddy to a wooden triangle on the paddy fields, this contributes to another four to five percent of losses. Mechanical threshing, used by most farmers, could reduce the losses to around one to two percent. But threshing suffers from a low efficiency of threshing machines. Transportation of grain to the next postharvest player is done in plastic bags carried by hand, tractors or trucks. Reported losses ranged between two and eight percent. As to storage, most farmers are found to keep rice in their own rice storage, which again leads to PHL: storage at high moisture content facilitates the development of fungi and leads to a low germination rate for seeds, and birds, rodents and insects further damage the seeds. Total grain loss is therefore estimated to amount to approximately 20 percent.

In terms of institutional support, there are government programs which support the rice farmers by promoting agricultural inputs for rice planting, supporting production related technology transfer and providing agricultural credit schemes for farmers, groups of farmers and agribusiness development. A few years ago, the National Agriculture and Forestry Research Institute of the Ministry of Agriculture and Forestry (NAFRI) implemented a project to support the use of postharvest equipment by farmer groups in the provinces of Vientiane, Khammouane, Savannakhet and Champassack. Future NAFRI activities aim at improving and adapting the postharvest equipment and facilities to suit local farmer needs. Using more locally available materials is desirable to reduce costs. In addition, training is required for farmers, and opportunities for farmer exchanges and replication of success stories to other locations should be explored.

Picture 3-5. Manual rice harvest and threshing in Laos

Picture 3-6. Rice harvest machine and introduction of a new grain dryer and a modern rice mill

3.3.2 Maize

From being a crop for household consumption, maize production has developed to become one of the most important cash crops in Laos over the last decade. More than 90 percent of the maize production is exported to China, Vietnam and Thailand, and the rest is consumed within the country.

Paklai District (Xayaburi Province) and Hun District (Oudomxay Province) are two major maize production areas in the country. Paklai produces maize for export to Thailand, whereas Hun produces for export to China. Maize farmers in these areas plant two maize crops a year, which they harvest and thresh manually. Qualitative loss occurs when the maize is harvested too early or late. At early harvest, there is a high moisture content, which increases problems for drying and storage. Late harvest, on the other hand, risks spoiling the crop due to kernel sprouting and pest damage (e.g. rats in farm fields). Another reason for yield loss was that not all maize cobs had been harvested from fields. The farmers interviewed showed that the loss of maize amounts to approximately 5 to 10 percent of the total maize production, which is equal to 30 to 55 percent of total losses.

Drying of grain is performed by farmers and takes place either on the cob in the field or on the sun drying floor where the grains are spread with a thickness of about two to three cm. The drying will take three to five days, during which time the maize is unprotected from e.g. birds, free range chickens and rats. Only in some areas there are drying machines available which belong to the private sector or traders. During the drying process recorded losses ranged from 12 to 22 percent.

Traditionally, shelling the grain is done by hand, which, however, is very labor intensive. In addition, it has a low productivity of approximately 5 to 20 kg/hour. Some farmers therefore invented a simple tool for shelling using a bicycle wheel. Also, there are electric or fuel operated shelling machines available for farmers to hire at an extra cost. Their productivity ranges from 300 to 2,000 kg/hour, depending on grain type and size of the equipment.

Cleaning the grains is very useful, because it increases purity, reduces mould and insect development and avoids the propagation of weed seeds in the grain. Conventionally, farmers drop grains from a certain height and use the natural wind to remove dust and weed seeds. The shelling and cleaning process could produce physical grain damages. Small maize kernels will also be blown out with dust and weed seeds, which provides for weight yield losses. In this process, it is estimated that maize loss varies from 3 to 10 percent of overall grain loss.

Shortly after harvest, farmers sell the seed with a high humidity of 22 to 28 percent to local traders. Farmers always receive low farm gate prices, particularly for the rainy season crop, due to the lack of appropriate storage and postharvest technology such as dryers, which has a negative impact on the quality of maize produced.

Maize grains are packaged in plastic bags having a capacity of 40 to 50 kg. Bags used by farmers and collecting traders are secondhand bags either from manufactured feed bags or fertilizer bags. Damaged secondhand bags may cause losses during transportation and loading.

In large maize production areas silo storage for many hundred tons of maize is available. In some upland areas, farmers heap maize cobs on the barns or maize cobs in sheaths are stringed and hanged about a fire place, especially for seed production. Traditional storage methods lead, however, to pest and insect infestations and fungi introduced mycotoxins and aflatoxin. Depending on the period of storage and the quality of the storage facility, maize grain or cob losses range from 10 to 30 percent of total losses.

PHL therefore occurred in all of the stages of the maize postharvest chain. Total yield loss was estimated by farmers to range between 5 and 15 percent of the whole maize production. The highest loss of maize occurred during the harvest process, which accounted for more than 55 percent of total losses. This is followed by storage and shelling.

At present, the private sector promotes a better postharvest handling system in Paklai and Hun Districts, e.g. by using better dryers and storage. The role of the private sector is therefore very important in reducing PHL. Since 2006, the government recognizes the importance of the postharvest system and encourages the private sector to invest in postharvest technology, such as drying and storage facilities for maize.

Picture 3-7. Harvesting maize by hand, shelling with a bicycle wheel and traditional storage

3.3.3 Cassava

Since 2007, in many countries, including Laos, cassava has been changing from a subsistence crop to a commercial crop. Farmers are nowadays not only growing varieties that are good for direct human consumption, but also those varieties that are high-yielding and with a high starch content suitable for the starch industry as well as for animal feeding. So far, there is no ethanol industry in Laos. Cassava production in Laos has been increasing rapidly for the past five years due to the need of raw materials in neighboring countries. By 2010 19,940 ha were planted with cassava and production reached a total of 500,090 tons.

Pak Ngum (Vientiane Capital) and Pakading District (Borikhamsay Province) are now major areas of cassava production. A number of cassava processing plants have been constructed and operated in these areas, but the postharvest handling system of cassava is not developed yet. In the survey locations, cassava farmers manually harvest by pulling the cassava stem along with the roots. Losses are higher during the dry season. When harvested by hand or machine, the roots break and remain in the soil. Observation showed that although harvesting by machine is faster, it is less efficient than manual methods. Moreover, roots remain not only under but also on the ground, as farmers did not collect all roots when loading the trucks. Harvesting losses are estimated to be around 15 to 30 percent of total production.

After harvest, farmers sell the raw roots to the processing plants at a good price (about 400,000 to 500,000 kip/ton). Some farmers chop the cassava roots and dry them for two to three days in the sun to reduce humidity and save on transportation costs by selling dry cassava chips. Drying can incur high losses of between 15 and 20 percent if there is not sufficient sunshine during the cold weather period, there is sudden unexpected rain or farmers are inexperienced.

Losses in the temporary pool site are due to the vaporization of moisture content from the fresh cassava roots. Even though the delay amounts usually to just one to two days, the weight difference may reach 5 to 15 percent. Quality checks done by the receiving industries cut a significant percentage (10 to 20 percent) from the weight of cassava. Immaturity due to early harvest adds to the losses.

In the survey locations mostly Hyundai pick-ups were used to transport the cassava. Some farmers own the pick-up and transport to the processing plants. But in most cases collecting traders transport the cassava roots by pick-up vehicle with a capacity of five to six tons from the farms to a temporary pool site. Collecting traders will further carry the cassava in dump truck with a capacity of 10 to 12 tons from the temporary pool site to the tapioca industry to facilitate loading and unloading, and to reduce transportation costs.

There is very little research on the cassava production chain and cassava PHL in Laos. However, primary data suggests that losses along the cassava handling chain, including harvest, transportation, drying, storage and starch processing, amount to an estimated 15 to 30 percent of total cassava production.

Picture 3-8. Cassava harvesting by hand and roots remaining in the soil


3.4 Philippines

The Philippines is a predominantly agricultural economy, with a large production of agricultural commodities every year. At each of the points along the supply chains, however, losses occur due to the nature of the produce (perishable vs. non-perishable), improper handling and poor transport facilities. In 2001, the Department of Agriculture reported that postharvest losses in grains (rice and corn), fruits and vegetables reached 15, 28 and 40 percent, respectively.

Recognizing the importance of reducing such losses to enhance food stability without adding pressure on dwindling natural resources, the Philippines targeted the reduction of postharvest losses of six crops through its Philippine Development Plan 2011-2016 (NEDA, 2011). Implementing agencies are the Department of Agriculture (DA) and the Philippine Center for Postharvest Development and Mechanization (PHILMech) or the Bureau of Fisheries and Aquatic Resources (BFAR) in the case of the fisheries sector.

Table 3-7. Targets for PHL reduction in 6 sectors in the Philippines

Commodity	Baseline		Target (%)
	Year	Value (%)	
Rice	2008	14.8	12.4
Corn	2009	7.2	6.6
Fisheries	2008	25.0	18.0
Banana	2009	16.0	13.0
Mango	2009	30.0	24.0
Eggplant	2002	39.0	31.0

There are a number of institutions and programs to support technology transfer and adaptation for improving postharvest operations. The Department of Agriculture (DA) and Department of the Science and Technology (DOST) are the two government institutions that are on the forefront of research and development, technology transfer/adaptation and policy setting in agriculture from production to post-production activities. Various state universities and colleges are also undertaking these activities and provide assistance to these two government agencies. Furthermore, local government units are also mandated to conduct technology transfer/adaptation and provide assistance to their respective constituents. Moreover, private organizations such as commodity groups, farming/fishery organizations and cooperatives, and other non-governmental organizations also lend a hand in this endeavor, primarily focusing on the small farmers/fisher folks.

The Department of Agriculture provides the necessary interventions for the various stakeholders in agriculture in order to increase productivity, minimize postharvest losses and establish an efficient marketing system with the primary aim of food sufficiency. This is achieved through various commodity programs, i.e. the Rice Program; Corn Program for corn and other root crops (cassava, etc); High Value Commercial Crops Development Program for fruits, vegetables, industrial crops and other commodities; Livestock Program for livestock and poultry; and Fishery Program for the fishery sector. Each of the programs developed a strategic plan, implemented through the DA-Regional Field Units and other bureaus/attached agencies (crop and animal programs) or BFAR (fishery program).

3.4.1 Durables: Rice, corn and coffee

While PHL tends to be lower for durables compared to perishables, it is on the farmer side where high PHL were incurred for durables, as critical factors are harvesting and drying operations. Drying is an important activity, which greatly influences the recovery of the commodity both in quantity and quality during threshing (palay), shelling (corn) and milling (coffee). Even though the data shows that a lower loss was reported for drying, higher losses were experienced by farmer respondents in subsequent activities (threshing, shelling and milling).

For the study on rice/palay PHL, the five major rice producing provinces in the country, i.e. Isabela, Nueva Ecija, Iloilo, Bukidnon and South Cotabato, were selected. Harvesting took generally place twice a year, with manual harvesting being the most common method practiced. After harvesting, the rice was hauled manually or by animal-drawn sled to form a pile to facilitate threshing, which was undertaken by farmers using a mechanical thresher. Only very few farmer-respondents possessed an air blower or mechanical dryer, which are important postharvest equipment to ensure good quality harvest and better recovery during the milling operation. Instead, the most common method of drying was sun drying (92 percent) before selling to traders. Storage of palay was generally not practiced by the farmer respondents, only a small portion was retained and stored for home consumption.

Picture 3-9. Hauling harvested rice manually or by animal-drawn sled

The mean total loss from harvesting to marketing was 12.5 percent of the total weight of dry harvest. During harvesting, farmers experienced shattering of grains from the panicle and unharvested or spilled panicles. The underlying reasons were inherent characteristics of the variety, unskilled labor or the unscrupulous practice of harvesters to intentionally leave panicles, which they would gather later, or labourers being in a hurry so they could still harvest on other farms, and late harvesting. As with harvest, the major source of losses during piling was the shattering of grains during the operation due to the carelessness of the harvesters in handling the cut palay stalk.

Losses in threshing can be traced to the inefficiency of the threshers and/or condition of the palay during threshing. Grains were blown away and mixed with the chaffs or good grains were not threshed and went with the spent stalks. Other than the inefficiency of machines, losses during threshing can also be attributed to the practice of threshing immediately, even if grains had high moisture content, to take advantage of the high price when supply was low in the market. As to drying, the sources of losses were spilled grains that could not be recovered and those eaten by animals. Only a few farmer respondents experienced losses during marketing of their produce. This occurred only when sacks containing the palay had holes in it.

Quality losses were experienced during harvesting when panicles were submerged in water for a prolonged period lasting for several days. During piling, quality losses happened when there was prolonged inclement weather immediately after harvesting. Piling enhanced heating of the grains thereby hastening their deterioration. Furthermore, threshing with high moisture content of the grains resulted in a high mechanical damage which adds to loss in quality of product. Moreover, discoloration of palay had a corresponding quality loss.

PHL reported by farmers deviated from previously reported loss figures since almost all of the sampled provinces were influenced by the damages brought by the strong typhoons that hit the country during the harvesting seasons in 2011. In addition to the inclement weather, there was a lack of labour during the harvesting period since neighbouring farmers were also busy on their own farms trying to save what was left after the calamity. The results showed the vulnerability to high losses due to high rainfall as shown by the relatively high farmer respondent estimates on losses at farm level involving harvesting, piling and threshing operations.

Compared to previous studies, a relatively lower loss estimate was given for the drying operation. This is explained by the growing practice of traders to buy wet palay, leaving only a small manageable portion (10 to 34 percent) of the total palay harvest with the farmers to dry primarily for home consumption.

Traders were generally involved in hauling palay from the farm to their respective warehouses, for drying, storing and marketing, while millers/wholesalers were involved in milling, storage, distribution as well as drying. The majority are wholesaler/retailers who handled milled rice sourced from the farms within the municipality and the province to market it locally. The fresh harvests purchased by the trader/miller respondents were sun dried using drying pavements or cemented roads/highways. Most of the municipal- and provincial-based traders handled already dried paddy coming from the barangay (village)-based traders.

For trader/millers, PHL were highest for drying. Palay storage duration ranged from half a month to three months in the warehouses of traders/millers, and losses were attributed to infestation of rodents, feeding of birds and other storage pest. As far as milling losses were concerned, traders/millers considered them minimal since spillage could be retrieved and reprocessed. For small millers, they used either a stationary or mobile single-pass rice mill, while the big millers use a multi-pass rice mill. The former rice mill resulted in a higher percentage of broken grains, whereas the latter mill produces better quality grains being whole and well-polished.

Table 3-8. Summary of estimated PHL along the palay supply chain

Stakeholder	Operation	Loss (in %)
Farmer		
	Harvesting	4.85
	Piling	2.06
	Threshing	4.07
	Drying	1.05
Trader/Miller		
	Hauling	0.28
	Drying	4.33
	Storage	0.20
Total		**16.84**

Corn is the second most important grain crop grown in the country. There are two general types of corn being grown in the country: yellow corn used for feeds in the livestock and poultry industry, and white corn used as staple instead of rice in the Visayas and Mindanao areas. It is grown throughout the country mostly in rainfed areas. Survey work was undertaken in the same provinces as for rice.

Nearly all farmers practiced manual harvesting, during which ear corn was detached, with or without husk, from the plant and placed in a collection basket to be transferred by an animal drawn-cart for transport to the piling area. Nearly all farmers practiced piling after harvesting to facilitate mechanical shelling, which was practiced by all farmers since corn kernel is the one being sold/traded in the market. The majority of farmers scheduled their shelling operation on the availability of dryer to be used. For those that rented shellers, corn cobs were piled in areas that would be readily accessible to the service provider of the mechanical sheller and/or near a drying pavement to facilitate immediate drying.

Picture 3-10. Corn shelling with 2 kinds of shellers: hopper at the side and on top

Nearly 80 percent of farmer respondents dried their corn kernels after shelling and before selling. The common practice of drying was by sun drying. Mechanical dryers were used by 6 percent. 21 percent did not conduct any drying as they sold the corn immediately after harvest. In terms of marketing, 65 percent had their produce picked up by the traders, the remaining 35 percent delivered their produce to the trader for sale.

Quantity loss during harvesting was in the form of unharvested and/or spilled ear corn, mainly due to the work of hired labourers, the variety grown and late harvesting. During piling losses were less likely, but where they occurred, they were attributed to the shattering of the kernel and consumption by animals. During shelling losses were attributed to unshelled grains coming out with the spent cobs and the mixing of good grains with the spent cobs. The shelling loss could also be due to inefficient and/or depreciated machines and the moisture content of the kernel. Nearly all farmers reported loss in quantity during drying due to spillage and consumption by animals. Similarly, loss occurred during marketing due to spillage, especially when old sacks with holes were used. Overall quality loss was reported by the majority of farmers, mainly due to inclement weather and high moisture content during harvesting, piling, shelling and drying, resulting in a price reduction.

Most of the corn traders were wholesaler/assemblers supplying local and institutional markets. Those buying wet shelled corn also engaged in sun drying, otherwise their major operations were transporting the produce from farms to their warehouses, storage and transport. A negligible amount of loss occurred during hauling and sun drying. Since the volume of procured wet corn was relatively small in relation to the dry corn procured, quantity loss in drying was also considered low. For traders, pests such as rodents and weevil were the main source of losses during storage.

Table 3-9 shows the total loss incurred in corn along the supply chain, as estimated by the survey respondents. It amounted to 13.07 percent of total harvest. It was on the farmer side where the greatest loss occurred, contributing to nearly 80 percent of total loss. The trader/miller had much smaller losses.

Table 3-9. Summary of estimated PHL along the corn supply chain

Stakeholder	Operation	Loss (in %)
Farmer		
	Harvesting	3.21
	Piling	0.78
	Shelling	2.47
	Drying	1.96
	Marketing	1.96
Trader		
	Hauling	Trace
	Drying	Trace
	Storage	2.69
	Transport	Trace
Total		**13.07**

Coffee is a popular product in the Philippines and worldwide. Four species of coffee are being planted in the country: Robusta, Arabica, Liberica and Excelsa. Robusta, Liberica and Excelsa are generally grown in lowland areas, while Arabica is cultivated in the highlands. Robusta and Arabica are the most popular species being cultivated by farmers due to the demand by various processors such as Nestle (Philippines) Inc. (NPI), Universal Robina Corp. (URC), Commonwealth Foods Inc. (CFC), and various specialty shops. Liberica and Excelsa are popular in Batangas/Cavite provinces and known locally as "Barako" in the market. In 2010, 94,536 tons of dried berry (the form that is generally traded by farmers) were produced, on an area of 121,399 ha.

The survey was conducted in the major growing areas of coffee. Farmers generally practiced multiple cropping systems. The harvesting of coffee was highly seasonal and labor intensive. Two methods of harvesting followed were priming and stripping. The majority of farmers did not realize that losses occurred during the harvesting operation. Where losses were reported, these were due to dropping of the ripe berries on the ground, carelessness of the harvesters, unharvested berries and pest infestation (berry borer).

After harvesting, there were two methods that were available to farmers to process their coffee berries. The first method was to dry the berries immediately by sun-drying and then passing through a dehuller and winnowing to extract the coffee beans. The second method is known as the wet method, whereby only ripe berries are processed by passing them through a depulper or pounding to remove the pulp. The depulped berries are then fermented to remove the mucilage. Sun-drying of the beans took two to three days. These were then passed through a dehuller and winnowed to get the coffee beans. This wet method is commonly done in Cordilleras (highland areas) for Arabica coffee. The beans have better quality compared to those processed through the dry method since these were all coming from ripe berries. The processed coffee seeds are known as green beans.

Picture 3-11. Mechanical and wooden depulpers used in wet processing of coffee

The moisture content of the dried berries and beans are critical to the buyers. For the dried berries it should be 12 to 14 percent in order to get a high recovery during the milling process. Theoretically, the recovery should be 60 percent beans. For the beans, the desired moisture content is 12 percent or less, irrespective of the method of processing, as desired by buyers. Farmers determined the moisture content of their dried berries/beans qualitatively, either by biting into them or by the rattling sound when dried berries were shaken.

As reported by farmers, bean recovery after the depulping and winnowing processes (milling) averaged at 51.5 percent. These losses were due to broken beans (3.5 percent), black beans (fungal infection, 3.4 percent) and foreign matter (1.6 percent). The depulping machine also contributed to the inefficiency in bean recovery since most of the machines available in the countryside were primarily used for milling rice and corn and not particularly suited for dried coffee berries.

Farmers experienced various problems in cultivating coffee. These were mainly inadequate drying facilities particularly during rainy days, inadequate depulping/dehulling equipment, pest incidence, quality requirements of buyer and the high cost of transport.

Coffee beans were generally sold to traders (81 percent) by farmers with 10 percent of them selling directly to NPI, provided that the beans passed the company's requirements in terms of moisture content, percentage defect and cup taste. Traders/wholesalers primarily collect, sort and sell the product on to other buyers/assemblers and coffee processors such as NPI, URC, CFC, Monk's Blend and specialty shops in MetroManila. Losses during transport occurred due to the presence of holes in the sack and pilferage. Some of the problems encountered by trader/wholesaler respondents were a high moisture content, pest affected beans, the presence of foreign material and black beans.

Picture 3-12. Sorting of coffee beans and storing in plastic sacks at Monk's Blend

Total quantitative PHL was estimated between 15 and 20 percent along the coffee supply chain. The highest losses were observed during the milling process (8.5 percent of loss) (see Table 3-10).

Table 3-10. Summary of estimated PHL along the coffee supply chain

Stakeholder	Operation	Loss (in %)
Farmer		
	Harvesting	2.5
	Milling	8.5
Trader/wholesaler		
	Sorting	2.3
	Transport	1.3
Buyer		
	Nestle	Trace
	Monk's blend	5.0
Total		**14.6-19.6**

3.4.2 Perishables: Fruits, vegetables and fish

PHL in perishables tend to be higher than in durables due to product characteristics (higher moisture content). PHL are greatly borne by the farmer and retailer, with the trader experiencing the least losses. At the farm stage, it is the sorting where produce is rejected due to improper production technologies used in producing the crop (10 to 32 percent). The retailer, who is at the tail end of the supply chain, absorbed all losses occurring due to improper handling practices along the commodity supply chain. This will be illustrated at the example of papaya below. For the fishery sector, PHL among the various stakeholders are more or less spread evenly. Icing or chilling the fish after harvest until it reaches the consumer is the primary factor that affects the degree of PHL loss in this sector.

Papaya, of which several varieties are grown in the country, is produced both for domestic and export markets. In 2010, total production was 165,981 tons on an area of 8,751 ha (BAS, 2011). For the baseline study, the supply chain follows the 'Solo' papaya. Farmers in Tupi, South Cotabato, were interviewed, then wholesalers/retailers mostly from Divisoria and some from Balintawak, as well as retailers from Laguna and Metro Manila. An actual loss assessment from one farmer and two wholesalers and retailers each was also conducted and losses from harvesting, field sorting, market sorting and marketing on wholesale and retail level were measured.

Harvesting, sorting, wrapping and packing of fruits in crates were done manually, usually by hired laborers. During harvesting two persons were assigned per tree: one to harvest the fruit using a harvesting tool called "selector" and a catcher who essentially caught the fruit and piled them in between the rows of plants with a layer of papaya leaves serving as liner. Sorting, wrapping and packing in wooden crates was immediately done after harvesting. Other postharvest practices included trimming of the pedicel, wiping or washing the fruits with water and alum, particularly when there was a heavy infestation of white flies and aphids, and wiping the stem end portion of the fruit with benomyl (a systemic fungicide) to prevent stem end rot.

Picture 3-13. Harvesting and wrapping of papaya

All farmer respondents reported losses during harvesting. The most common reasons for rejection of fruits were the presence of "choco" spots, deformed/misshapen and over maturity. Choco spots developed due to the attack of a fungus (not yet identified), while fruit deformation, also known as "cat faced", was due to the phenomenon of sex reversal which occurs in papaya as a response to unfavorable conditions such as moisture or stress. The main problems experienced by farmers related to high input costs, insect and disease damage and delayed payment.

Picture 3-14. Deformed/misshapen, choco spots and insect damage

The two common marketing practices were: (1) growers harvested their fruits, which were picked up by buyers or shippers (two thirds of cases), and (2) the buyer-shipper harvested and transported the fruits. The road infrastructure was apparently good. But losses occurred due to over-ripening and mechanical damage in the form of compression, which in turn could be attributed to the amount of fruits packed in a crate.

Wholesaler respondents from Manila purchased their fruits directly from the farmers from South Cotabato. They had no specific criteria for the fruits. Their main concern for the delivered fruits was the quality (external appearance) and peel color. Most of these wholesaler respondents accepted whatever was delivered as long as the fruits had no serious defects. Fruits were purchased either by weight (three quarters) or by container (one quarter) on a cash basis. The wholesaler respondents in Divisoria transported the fruits from MetroManila port to the market. The delivery was usually disposed in two to three days, but during lean buying times it could take up to five days.

Wholesaler respondents did not have any method to preserve or extend the marketable shelf life of the fruits. All wholesaler respondents encountered losses. The causes included fruits being too soft, over-ripe, damaged by diseases, failing to ripen and mechanical damages, mainly due to compression. The main problem of wholesaler respondents was the high initial rejection upon arrival in Manila. These problems were very much felt when the market demand for papaya was low resulting in the fruits staying in their warehouses for more than three days.

Retailers were concerned about the color and peel quality when purchasing the fruits. They purchased the fruits in the wholesale market by weight either on cash or consignment basis, and then transported them to their respective retail markets. Purchased fruits were packed in plastic bags, carton boxes or wooden crates. The normal shelf life of their papaya fruits was one to three days.

Retailer respondents reported losses from 5 percent to as high as 60 percent. These losses were attributed to decay, over-ripening and mechanical damages. Furthermore, retailer respondents did not know any method to preserve or extend the shelf life of papaya fruits. The most common problem encountered by the retailer respondents was the slow rate of selling papaya fruits resulting in over-ripening of fruits leading to greater losses. Another problem was the complaints of customers saying that papaya fruits were not sweet enough and had off-flavor.

Table 3-11. Summary of papaya PHL (in %)

	Based on interview	Based on actual assessment	Average
Farmer	18.5	45.3	31.9
Wholesaler	10.0	16.5	13.3
Retailer*	23.0	15.2	19.1
Total	**51.5**	**77.0**	**64.4**

*3-4 days selling period

Along the fish value chain, large PHL are experienced too, but, as mentioned, they are spread more evenly between the various stages. The Philippines has vast fishery resources, upon which a multitude of stakeholders depend for their living, including municipal and commercial fishers, aqua culturists, canneries, fish markets and various ancillary industries. In 2009, total production amounted to 5.08 million tons, including fish, crustaceans, mollusks and aquatic plants.

The majority of fisher folks operate on a small scale in municipal waters, doing aquaculture. Their catches are either brought to the local market or purchased by traders/middlemen for transport to populated areas such as big towns and cities. 65 percent of producer respondents were members of a fishery organization/cooperative. They were provided with trainings, particularly on entrepreneurship, fish culture technology, coast watch, fish breeding, organic aquaculture, seaweeds culture, food safety/HACCP training and fish processing. The Bureau of Fisheries and Aquatic Resources (BFAR), the Department of Trade and Industry (DTI), the Local Government Units and the University of the Philippines were listed as the main institutions providing these trainings.

Losses reported for harvesting ranged from less than 1 up to 30 percent, with an average of 5.47 percent. These were attributed to inadequate supply of ice, poor handling, undersize fish (rejects), net entanglement, bad weather and strong wave/current. In terms of quality loss, an average of 6.31 percent was reported with the similar range of less than one up to 30 percent. The lack of ice and poor handling technique were the main reasons identified. Putting ice in the container to prolong the shelf life of captured fish was the most common practice of producer-respondents, but 12 percent were not using ice at all or selling their produce in live form (9 percent).

After harvesting, most producers undertook sorting or grading of their harvested/caught fish. This was being done manually by size/weight, quality or species. Average loss during this stage was nearly 8 percent. Timing was important in order to minimize spoilage and command a better price for the fresh fish. Nearly half of the producers transported their produce to the market (during which losses occurred) and the other half indicated that their produce were sold right where they produced or landed to consignees, fish brokers, other traders including wholesalers and retailers, local walk-in clients and street vendors.

Traders got their fish products directly from aqua-farms, trading posts, fish ports or landing centers, from where they were transported either live, fresh, chilled or dried in insulated vans, delivery trucks and fish carriers. Transport again led to quantitative or qualitative losses due to poor handling (including overloading during transport), lack of ice and delay in transporting. Wholesalers and retailers were sourcing their fish products either directly from the producers, from trading posts, or from other traders who were delivering the products to them, or from other bigger markets. In general, the products were in good quality during transport.

The number of hours or days the fish and fishery products stayed on the shelves varied. Seven to 10 days for the dried or smoked fish products, and a few hours to a couple of days for fresh or chilled fish that were applied with ice. In terms of losses incurred by the wholesalers/retailers, an average of 12.56 percent of the volume traded/transported was reported by the respondents, with a range of 2 to 30 percent. In terms of quality, however, an average of 10.2 percent of the products marketed was observed to have reduced quality. Poor handling and lack of ice were again the main reasons for the loss, while others also reported delays in marketing due to competition, supply glut, competition among products (i.e. fresh water vs. marine species) and high farm gate price, which made it difficult to sell the produce at the wholesaler/retailer level.

Table 3-12 shows the average quantitative estimate of losses as reported by the various stakeholders along the supply chain. Total loss amounted to nearly 40 percent. The biggest loss was experienced on the producer side, amounting to 16.4 percent, while for the trader and wholesaler/retailer the extent of losses ranged from 11 to 12.6 percent.

Table 3-12. Summary of fish PHL

Stakeholder	Operation	Loss (in %)
Producer		
	Harvesting	5.47
	Sorting	7.59
	Marketing	3.32
Trader		
	Transport/marketing	11.01
Wholesaler/Retailer		
	Transport/marketing	12.56
Total		**39.95**

3.5 Thailand

Thailand produces a wide range of agricultural commodities. In 2010 around 93 percent of agricultural land was used to produce rice and other field crops such as maize, sorghum, cassava, sugarcane and soybean. The country is the main food exporter in the world. Nevertheless, PHL can be high, depending on the sector.

Three commodities, i.e. rice, maize and cassava, were selected for the study of PHL. Thailand is a well-known rice exporter and rice production is an important sector nationally. In 2010/2011, there were 3.7 million households engaged in rice production and 31.7 million tons of rice were produced. Maize production, on the other hand, is only sufficient for domestic consumption with a total production of 4.4 million tons in 2010/11.

Cassava is becoming an important crop in Thailand. Most of the production is used for the feed industry, but the cassava flour industry and ethanol industry raise demand for cassava. In 2010/2011, there were 440,959 households engaged in cassava production, on 1.1 million ha. Cassava production ranged between 22 and 30 million tons since 2008. Cassava products come mainly in three forms: chip, pellet and flour. The latter is the main exporting product, largely to China, European countries, Japan, Indonesia and Taiwan. The maize and cassava sectors are strongly linked: both are used in the feed industry, and growers often switch from producing cassava to maize and vice versa.

3.5.1 Rice

The typical rice farm in Thailand produces rice once a year. For harvesting, a rice harvester machine is widely found. It cuts the rice and processes it to paddy during the harvesting process. Harvest machine operators not only take the rice from the field, but they also provide transportation to the rice mill.

At harvest, the moisture content of rice is around 20 to 25 percent, which after two to three months storage falls to 14 percent. There are various techniques to reduce moisture. The most popular is sun drying and using a cyclone dryer. The problem with sun drying is that the rice quality cannot be controlled. In the past, drying usually took place in the field. However, as the rice market developed, drying practices shifted to the rice milling manufacturer. Each milling factory has a big cement floor for drying. Rice farmers conduct drying only to reduce moisture content up to the price requirement standard to get the guarantee price. In some cases, farmers bear the cost reduction due to high moisture content. Small scale farmers might form farmers' groups to set up a sundry floor. And in some provinces where rice production is high, the rice milling manufacturer rents drying floor to the farmers. Notably, the cost of moisture content reduction is considerable. It is carried by one of the actors along the chain, depending on the bargaining power of rice farmer, sundry operator and rice mill manufacturer.

Picture 3-15. Harvesting machine

As drying shifted to the rice milling manufacturer, the key point of PHL at farm level is now farm management and how the farmer selects the suitable harvest time. In most areas there are rice harvesting operators available to farmers. They are specialized in harvesting at maximum yield, and in return receive not only the rental cost of machine, but also a share of the selling price. PHL for the rice farmer is minimal – an estimated 5 to 10 percent – especially in the dry season. In some areas, however, harvest machines are in short supply and farmers have to reserve a time for harvest. This could lead to early or late harvest, because cancelling the reserved time slot with the harvest machine operator could mean that the farmer is left without harvest machine.

Transportation plays a crucial role in the postharvest chain. Transport operators work together with harvesting machine operators. They have information on selling price and good buyers, and they play an important role for the development of harvesting machines.

In 2011 there were over 36,300 rice milling manufacturers in Thailand. The high number of rice milling factories has led to farmers directly selling to mills instead of stocking paddy. In order to get a high milling yield, millers have to reduce the moisture to 13 percent. There are two types of storages: paddy dumped on the floor in the storage house or put in bags. In the first method, paddy is prepared for milling, while the latter method is used for rice aging, producing a higher rice quality. Altogether, the largest share of PHL occurs at the milling stage.

Table 3-13. Rice PHL: Causes, effects and measures

Stage	Causes	Effect	Measures
Physiological maturity	Delayed or early harvest Varieties susceptible to diseases and pests	Losses in quality and quantity	Timely harvest Planting resistant varieties
Harvesting	Poor soil condition, e.g. wet soil	Losses in quantity	Timely harvest
Mechanical damage during harvest	Poor handling Poor threshing or shelling practices	Low harvesting yield	Careful handling of produce Threshing and shelling methods should minimize damage
Drying and storage	High temperatures Storage pests and fungi Insufficient drying before storage Moisture in storage area High relative humidity	Losses in quality, such as high level of broken milled rice	Avoid artificial drying Control storage pests Dry produce sufficiently before storage

Institutional support is provided by many players: e.g., there is one government agency responsible for rice development, called the Rice Department. In addition, there are rice research centers in major rice growing areas. The centers train, develop and distribute rice varieties to farmers. In order to distribute sufficient rice seed to farmers, R&D centers set up farmer production groups in each province. Members of these groups produce only rice seed for the center to redistribute for farmer.

The Ministry of Commerce sets the rice standard for growers and rice mills to support agricultural development and trade. Furthermore, Kasetsart University and the National Science and Technology Development Agency (NSTDA) work together to develop new varieties based on needs in specific areas. NSTDA as an organization under the Ministry of Science and Technology conducts also DNA laboratory services to inspect the rice variety mixture on the field.

Besides this, private companies play an important role in rice development. They develop specific varieties for farmers in different regions and they work closely with the rice research centers to supply rice seed.

3.5.2 Maize

Maize and cassava are grown in rotation and have the same value chain. Maize is grown in two seasons and can be harvested by hand or machine. As maize shelf life depends mainly on temperature and humidity, growers have to manage those factors to ensure high quality output. It is recommended to lower the moisture content to reduce the risk of alphatoxin. Field pre-drying techniques are fairly widespread: growers use pre-dried standing in the field before proceeding to hand-harvest the ears. But this procedure entails great risks of product loss, especially if the varieties grown are particularly sensitive to rain, humidity and pest.

When the maize is properly dry, pickers pull the ears from the stalks. The removal of the husks is done on the field during harvest. In large areas, growers use a harvesting machine, such as a corn snapper, corn picker-husker, corn picker-sheller or corn combine harvester. Harvesting by machine is fast, especially when labor is in short supply. However, the effectiveness of machine harvesting varies, and the harvesting technique used may lead to damage. In addition, during the wet season, machines can produce a low harvesting yield.

In the past, maize growers conducted most of the postharvest operation. They milled their output in the field and stored it in basic storage facilities. Nowadays, farmers' postharvest practices are limited as business practice forced growers to concentrate on grain quality and to transfer the maize for further processing, such as sundry operations by either private middlemen or cooperative groups.

Table 3-14. Maize PHL: Causes, effects and measures

Stage	Causes	Effect	Measures
Physiological maturity	Delayed harvest (increased exposure to pests, livestock and animals) Varieties susceptible to diseases and pests	Losses in quality and quantity	Timely harvest Planting resistant varieties Protecting crops from livestock, etc.
Harvesting	Poor handling Poor threshing or shelling practices Termites and rodents	Losses in quantity	Careful handling of produce Pest control Timely harvest
Mechanical damage during harvest	Poor handling Poor threshing or shelling practices	Quality decreases, increased vulnerability to pests and diseases	Careful handling of produce Threshing and shelling methods should minimize damage
Drying and storage	High temperatures Storage pests and fungi Insufficient drying before storage Moisture in storage area High relative humidity	Losses in quality Possible production of mycotoxins Swelling and germination of grain	Avoid artificial drying Control storage pests Dry produce sufficiently before storage Storage facility should be moisture proof and adequately aired

Source: IRRI

Drying takes place mainly at sundry operators, where the maize is spread for two to three days on a large sundry floor. Where growers form cooperative groups, they use the cooperative sundry floor to temporarily store their maize until they get a satisfactory price. But this practice may increase PHL (Table 3-14).

Most PHL for maize occurs due to bio-deterioration and during the drying process. An estimated 5 to 10 percent of losses occur during harvest. In some cases, growers have to take maize out of the field and put them onto the cement floor, which may decrease quality and increase the risk of toxin. In the wet season, growers face problems of high moisture content and high costs of labour, which affects harvest and can lead to early or late harvest. In the late dry season, farmers often harvest early for fear of rain. This, however, means that the drying process will be longer, during which damages to the production might occur. Farmers might therefore decide to quickly sell maize to middlemen, accepting a price cut of up to five percent compared to market price.

During drying, even though operators are very familiar with the procedures, problems may arise, such as a shortage of sundry floor and storage during high season and development of alphatoxin during drying and storage. The strategy of the operators is therefore to transfer maize to further processing as swiftly as possible.

In terms of support, the following institutions play an important role for maize production and its postharvest value chain:

- Ministry of Agriculture and Cooperatives: it has the powers and duties with respect to agriculture, water sourcing and irrigation development, agricultural promotion and development, and promotion and development of the cooperative system. Its mission is to promote agricultural units and to encourage them to be self-reliant, to promote production of agricultural produce and food that meet market demand and consumer standards, to research and develop the infrastructure for agricultural production, and to develop and transfer agricultural technology focusing on effective, sustainable and environmentally friendly use of agricultural resources.
- Department of Agriculture: its mission includes research and development, and the provision of information services to growers and the private sector. Its organizations relating to growers include the Field Crop Research and Energy Crop Institute, the Research and Development Institute and the Postharvest and Agricultural Processing Institute.
- Department of Agricultural Extension: it is responsible for agricultural promotion. The department has provincial offices all over Thailand, and growers can use the offices for information services and for establishing links with other organizations.
- Department of Cooperative Development: it focuses on cooperative and farmer groups, providing capital and equipment to enhance the production and marketing capacity. In the case of cassava, rice and maize, some cooperatives have received sundry cement floor, equipment such as a harvesting tractor or training.
- Ministry of Commerce: it introduced an export standard for maize, among others.

3.5.3 Cassava

The production of cassava is strongly influenced by three factors, which also play an important role for productivity along the postharvest chain, i.e. variety selection, soil management and crop management. Farmers use a large number of varieties, some of them unregistered, which produce high yields but are not supported by the institutions (DOA and Kasetsart University) in case of production problems. A widespread problem currently faced by cassava growers is infestation by the Phenacoccus manihoti insect. To counter this, growers need to have a good crop management practice. Each cassava variety has a recommended harvest time for optimum yield. However, farmers take other – economic – factors into consideration when deciding on the harvest time, e.g. price, distance to processors and availability of harvesting machine.

At harvest, cassava growers use a harvesting machine, mostly provided by harvesting operators. Harvesting machines are well developed in Thailand, but losses due to technical problems still amount to an estimated 5 to 10 percent. Harvest is very time consuming. It is estimated that one machine can harvest 0.8 acres/day and requires 10 to 20 workers, who have to take the cassava root from the harvesting range, cut it and load it on a truck.

Swift transportation after harvest is the key to good cassava quality. The period between harvest and further processing should not exceed two days, or else there will be PHL due to loss of starch content and other damage (Table 3-15)..

Table 3-15. Starch content and damage to cassava roots after harvest

Days after harvest	Starch (in %)	Damage (in %)
0	23.01	0
2	23.07	1.62
4	20.07	10.80
6	13.13	23.92
8	9.94	35.21

Source: Pungpetch et al., 1979

There are middlemen or primary processing operators who provide transportation for growers. In some areas, where production is not far from the factory, growers have their own truck for transportation. An important step in transportation is the arrangement of cassava roots on the truck to prevent damages, especially bio-deterioration.

There are three main types of cassava use: cassava flour, feed and energy manufacturing. A new sector, which is increasingly absorbing cassava roots, is the syrup industry. Cassava flour, syrup and energy manufacturers use fresh cassava roots, while feed manufacturers can use dry cassava for their production. The distance of cassava growers and flour, syrup and energy manufacturers is usually in the range of one to two days transportation. Cassava producers for the feed industry, however, are widely found all over Thailand.

For those, fresh cassava roots are pre-processed by either sundry floor operators or agricultural groups, especially cooperative groups. The roots are chipped using a locally manufactured machine, sundried on cement floor for three to four days to reduce moisture, during high season put into cyclone to prevent damage from moisture, stored and sent to the feed industry, which produces cassava pellets for animal feed by grinding, steaming, pelleting and cooling the pre-processed cassava chips. There are no estimates available for loss during the drying process, but loss caused by wind and fermentation of chips are common problems of cassava sundry operators.

Picture 3-16. Sundry operator, the local chipping machine and chipping equipment

Flour manufacturers and the ethanol industry buy the roots at factory price. This means growers or middlemen have to bear the transportation costs. All cassava output surrounding manufacturing is accepted. But at purchase, the roots are graded and inspected. In terms of quality requirements, foreign material and soil should not be greater than three percent, and the percentage of starch should be at least 20 percent.

The selling behavior of growers depends on the distance to manufacturing. In areas located further away from processing, growers sell fresh cassava to middlemen, who play an important role in postharvest management. As growers do not wish to keep their product in the field for too long in order to prevent crop damage, they usually sell the production at off-farm price. The middlemen know how to manage fresh cassava for high return. They calculate the volume of fresh cassava in a certain area, collect them by sending trucks to growers and transfer the fresh roots directly to the factory. Thus, the postharvest operation is shifted from growers to middlemen, who have better information in determining how to manage the cassava output.

Table 3-16. Cassava PHL: Causes, effects and measures

Stage	Causes	Effect	Measures
Physiological maturity	Delayed harvest or early harvest Varieties that are easy to harvest	Losses in quality and quantity	Timely harvest Planting resistant varieties
Harvesting	Proper machine and labor	Losses in quantity High % of roof left in the ground	Use machine with enough worker Timely harvest
Mechanical damage during harvest	High percentage of taking roots out of the ground	Use more workers for machine	Develop new equipment to have high percentage of extracting cassava roots
Drying and storage	Improper moisture content in storage area	Losses in quality; cassava chips fermented	Use hot air in wet season

Source: NFI interview, 2012

A number of institutions provide support for cassava production and postharvest operations:

- The Ministry of Agriculture and Cooperatives, which is responsible for supporting growers. Major departments are the Department of Agriculture and the Department of Agricultural Extension. In addition, the government encourages growers to establish cooperative groups. Thus, the Department of Cooperative Development plays an important role for networking.
- Kasetsart University is well known for developing new improved varieties for the cassava sector, such as KU-50, which is used in most of the cultivated area.
- The Technology Suranaree University in Nakorn Ratchasima Province plays an important role in technical consultation for helping growers. The main project aims at solving the problem of hardpan, where soil overuse leads to a very dense layer of soil. Researchers work with growers and flour manufacturers for alleviating these hardpan problems.
- In the non-government sector, the Thailand Tapioca Development Institute (TTDI) is involved in cassava development. TTDI diagnoses cassava yield and emphasizes good practice of cassava plantation, e.g. by use of proper variety and production management.

3.6 Vietnam

From a country used to import food, Vietnam has transformed its agriculture over the last 30 years to become the second largest rice exporter in the world. Thanks to technological advances, e.g. in seed, farming, fertilizer and pesticides, the yield of staple food crops such as rice, maize and cassava has made remarkable achievements and annual total output of agro-products is increasing.

Rice, the first most important staple food crop of Vietnam, has been cultivated mainly in the Red River Delta (RRD) and the Mekong River Delta (MRD). By 2011, 42 million tons of rice were produced on 7.7 million ha. The country exported 7.35 million tons of rice for USD 3.5

billion. Maize, the second most important staple crop, can grow well either in lowland or dry high land, producing high yield. Among the agricultural crops, the maize growing area (1.1 million ha) constitutes more than 10 percent. In 2011 maize production reached 4.6 million tons. Cassava, the third most important crop, grows well on hilly and sloping land, i.e. in midland, mountainous areas and plateaus. In 2010, the nationwide total area under cassava was estimated at nearly 0.5 million ha with a total output of 8.5 million tons.

But despite agricultural industrialisation and modernisation, food production in Vietnam still highly depends on natural conditions and is affected by disasters and pests. Every year there are considerable losses caused by spillage, pests, mold etc. A number of state policies, programs and projects were devised to reduce PHL, e.g. by supporting science and technology, as well as the purchase of machinery and equipment for agricultural production, processing and storage. Annual average rice loss due to weaknesses and inadequacies in the postharvest stage, however, still amounts to 12 percent, or 4 million tons, which is equivalent to the total rice output of Hanoi, Thai Binh, Nam Dinh and Hung Yen Provinces. PHL for maize nationwide was 18 to 19 percent of production.

3.6.1 Rice

Rice harvest in Vietnam is either manual, semi or fully mechanised. Usually, the rice is cut and gathered in a pile before being transported to the edge of the rice field or the threshing sites. The use of a combine harvester is still modest in the surveyed provinces. The main reasons are small plot sizes of cultivated land, many turnings at the head and end of each plot and lack of skilled operators. The harvest stage is mechanized to some extent for only 23 and 36 percent of the whole cultivated area of the RRD and MRD, respectively.

Some rice varieties have a higher resistance against mechanical impact while being harvested. Meanwhile, other varieties with a high risk of lodging due to strong wind or grain fall during harvest are still grown in some localities such as Thanh Hoa and Nghe An. As a consequence, when harvested by machines, many unharvested rice hills remain in the field. To solve those constraints, new varieties with hard stem, little lodging and good resistance against mechanical impact during harvest are introduced to replace old varieties.

Harvesting conditions are found to have a considerable impact on losses along the rice value chain. In favourable weather the loss ratio of rice at harvest is usually low for all varieties. In unfavourable weather, however, the loss ratio of varieties with high risk of lodging, grain fall and less resistance against mechanical impact will be very high at the harvest and transport stages. To reduce PHLs, managers of many localities have provided guidance on cultivation time to avoid the frequently bad weather. Namely, in Yen Dinh District (Thanh Hoa Province) rice cultivation starts ahead or behind seasonal time by 20 days. This limits the adverse impact of the weather on postharvest activities.

Using manual methods for harvest always prolongs harvest time, especially under unfavourable weather conditions, leading to a high loss rate. Besides, hired labour for rice reaping is becoming increasingly common, but poor labour awareness and hurry in cutting causes more grain to fall and unharvested ears of rice to remain in the field. Compared to mechanical harvest by combine harvester, PHL in manual harvest are higher. But even the currently used Chinese rice combine harvesters have a high rate of loss due to grain being blown away with straw and lodged rice not being cut.

When harvest is ahead of time, the ratio of immature grains is high. Thus, while threshing, the rate of grains blown away with straw increases. This often appears to be the case in areas where harvest time is in a race against time to avoid flooding. Rice harvesting on time is a big problem in many localities, because rice fields are scattered and labour is in short supply. Therefore, harvest is mostly behind time. This is a major cause for increasing the ratio of lodged rice in the field and grain fall when harvested.

Presently, all of the harvested rice is transported by simple carts driven by humans or animals, powered vehicles or small trucks. Hence, the ratio of grain fall is limited. The rice is usually transported to the ends of the path at the edge of rice field or an empty site near the field to be threshed. The transport distance is short, leading to fewer losses.

In Nam Dinh, a plain province with good traffic infrastructure in the field network, transport of harvested rice from fields to threshing sites is relatively good and threshing activities often take place right in the field. In Nghe An Province, the inter-field traffic system is not favorable to transport. Harvested rice is generally transported to the home yard and average loss is 2.2 percent. In Thanh Hoa Province, the inter-field traffic system is not good for transport and about 50 percent of rice is threshed right in the fields.

Rice losses during threshing mainly depend on varieties, time of harvest, types of threshers and skills of operators. Around 80 percent of harvested rice is threshed by powered machines. The rest is threshed by either pedal threshers or other methods (mostly in mountainous districts of Nghe An and Thanh Hoa Provinces). The loss ratio when threshing dry rice is lower than that of threshing wet rice. In Nam Dinh Province, 100 percent of the threshing is machine powered. Canvas is used for collecting threshed grains. Thus, spillage of grain is limited. Rice grain blown with straw is rather low, because harvested paddy is dry at threshing. In Nghe An and Thanh Hoa Provinces, rice threshing machines are power or pedal operated. Threshing activities often take place on home yard or empty ground sites. Rice grain blown with straw is high, because the rice is wet at threshing.

In the RRD almost all of the commercial rice is dried in the sun on large drying platforms, leading to a quite high rate of loss. In mountainous districts (Nghe An and Thanh Hoa Provinces), however, weather during harvest time is even more unfavorable because of heavy rain and storm. Drying time is prolonged and the loss rate due to spillage, germination etc. is high. Only rice seeds are dried by driers, but this is a very small volume due to high equipment costs, which are often not affordable for farmers or production units. Even so, dryers are mainly horizontal batch bed-type with low cost, simple technology. As a result, technological parameters and product quality are difficult to be controlled.

Rice is often cleaned and sorted by electric fans or box winnowers. Sometimes cleaning is done by wind. Commercial paddy is usually stored short term and the loss rate is lower than that of paddy stored for family need. Each family usually stores about 500 to 700 kg. Safe moisture content for storage of rice is around 13 to 14 percent. Losses of rice during storage are often caused by insects (one to two percent) and by rats (at a very high rate). Loss of rice stored in corrugated, wooden barrels or boxes is lower than when stored in PP packing.

At a small scale, rice storage is conducted in traditional ways with less innovation and use of scientific and technical achievements to prevent pests and fungi. In addition, knowledge of farmers about techniques for preventing insect and fungi damage is very limited, especially for farmers in the midlands. In Nam Dinh Province, paddy is often sold immediately after harvest or when the price is good. It is often sold to traders at the farmer's home. The amount of rice used for family needs is not much, but – as in Thanh Hoa – rice is stored in PP packing, so it is often eaten by mice and damaged by weevils.

Enterprises often store paddy and rice for a short time only because of lack of modern stockpiles. Recently, many new stockpiles have been built in the MRD. A common current measure is to use phosphine to fumigate the grain bulk in the rice stockpiles. But almost none of the stockpiles can meet technical requirements because of lack of natural air ventilation. Many stockpiles are located in inconvenient places, far from production areas and ports. Non-state owned enterprises have not invested in modern stockpiles due to limited funds. Also, they have not seen clearly the benefits of investment. Staff of the National Reserve Department, however, researched and applied technology for rice storage with nitrogen (N2), carbon dioxide, deoxidiser and vacuum. The results showed that time of storage of rice could be prolonged from one to two years with good quality.

Qualitative losses are results of many factors such as chemistry, biochemistry, physics, physiology etc., as well as poor management and outdated postharvest technology. During storage, many types of fungi and bacteria appear and develop rapidly. They cause significant reduction of amino acids and loss of protein. This reduction and loss brings about changes of color, smell and taste, mold contamination, reduction of nutritional value and market value, and can even cause food poisoning in humans and animals.

At the milling stage, losses are mainly results of inappropriate technology. Many milling plants are too old and outdated to be used. Also, losses come from mixed seeds, spillage during transport etc. Currently, farmers cannot control the moisture content of grain before milling. When paddy is milled at a moisture content of more than 16 percent, the quality of the finished rice will be degraded and the loss rate amounts to more than three percent.

The qualitative decrease also shows clearly in a low recovery rate (nationwide average rice recovery rate is 63 to 65 percent), in an increased rate of broken grains because of improper technical process of harvest. Although milling has been mechanized at a high rate, the rice processing system is divided into piecemeal, different varieties of rice are purchased from small millers and are subsequently mixed. This leads to an increase of percentage of broken rice, a qualitative decrease of finished rice, which is reflected in a lower price. Total average losses range between nearly 9 percent (Nam Dinh Province) and 17 percent (Nghe An and Thanh Hoa Provinces). Nationwide, the rate of PHLs of rice due to weakness and inadequacies in the postharvest system was 12.7 percent in MRD, and 11.6 percent in RRD and the central region.

Table 3-17. Average rice PHL rates in three selected provinces in Vietnam

Province	Loss rate (in %)								Total loss (in %)
	Harvest	Transport	Threshing	Drying	Cleaning	Grading	Storage	Milling	
Nam Dinh	2.22	0.55	2.43	1.40	0.28	0.10	2.02	0.37	8.75
Nghe An	2.66	2.17	3.19	2.98	0.76	0.44	1.95	2.07	17.13
Thanh Hoa	3.57	1.32	3.21	4.15	0.32	0.07	3.88	0.28	16.98

3.6.2 Maize

Like rice, there are maize varieties with high yield, low tumbling and good resistance against insects, but farmers continue to cultivate many varieties with less resistance against rain and wind and a high risk of insect and mold damage right in the field. The selection of those varieties contributes to increased PHL rates. During harvest, losses are mainly due to quality reductions by fungi like aflatoxin and ochratoxin, which develop quickly when harvesting in rainy times. Currently, in the identified provinces 100 percent of maize is manually harvested.

Following harvest, maize is transported to the farmer's home for husking, drying and shelling, or to the path near the cornfield where the production will be sold. Losses depend on weather during harvest and transport methods. In all three provinces, maize is shelled by hand shellers or powered machines. The loss rate is rather small.

Drying practices have again an important impact on losses. Where dried in a house on stilts (Son La) losses are considerably lower than when sun dried (Nghe An and Thanh Hoa). Drying maize by dryers is still not common. Only 10 to 15 percent of maize are machine-dried nationwide, with low level equipment and technology (see rice).

In the next step, the cleaning stage, Nghe An has a higher rate of loss as varieties with bad resistance against rot and weevils are cultivated. Rice and maize are often cleaned by electric fans or box winnowers, and sometimes by wind. PHL of maize during the threshing, drying and cleaning stages amounts to seven to eight percent in Vietnam.

Since there is a shortage of modern stockpiles, farm households usually store maize only for a short time before selling. Most of the commercial maize produced in Nghe An is sold immediately after harvest. Farm households only store enough maize for livestock needs. In Thanh Hoa and Son La Provinces, on the other hand, commercial maize is stored for up to four to five months in inadequate conditions, in PP packing or on the floor of a house on stilts, where the maize is easily damaged by the environment or insect intrusion. In Son La chemical preservatives are applied to store maize, but their efficiency is not very high because of poor conditions of stockpiles and limited knowledge of farmers about techniques to prevent insects and fungi, especially among farmers in midlands, mountainous areas and Central Highlands. Misusing regulations and wrong dosage of chemical preparations in maize storage is quite common.

Currently common methods are phosphine fumigation in storage facilities. Losses of maize after six months of storage without preservatives to eradicate insects can reach up to 20 percent. For hybrid maize conventional ways of storage are not appropriate, because it is easily damaged by moths within just two months. The annual average loss rates in maize storage amounts to seven percent in Vietnam.

During the milling stage losses occur, similar to rice, due to inappropriate technology. Many milling plants are too old and outdated to be used, so that losses for maize (grain) reach four percent at this stage. To sum up, weaknesses and inadequacies along the postharvest stage led to nationwide losses of maize between 18 to 19 percent. The total average loss rates of maize along the postharvest chain in the selected provinces of Nghe An, Son La and Thanh Hoa range from 10 to 13 percent, which is at the lower end of maize PHL estimates. This is explained by the fact that maize production and postharvest operations took place under favorable weather conditions in 2011.

Table 3-18. Average maize PHL rates in three selected provinces in Vietnam

Province	Loss rate (in %)								Total loss (in %)
	Harvest	Transport	Shelling	Drying	Cleaning	Grading	Storage	Grinding	
Nghe An	1.10	1.03	1.14	2.40	0.63	0.32	2.04	1.26	9.92
Son La	2.80	0.54	1.13	0.12	0.01	0.14	5.42	.0034	10.19
Thanh Hoa	2.37	0.16	1.11	1.97	0.12	0.00	6.83	.0137	12.69

3.6.3 Cassava

Cassava production and postharvest operations were studied in two provinces in Vietnam: Nghe An and Thanh Hoa. After harvest, cassava is typically gathered in a pile and sold right in the field or transported home for cleaning and grading. At the farm, cassava is further dried as a whole tuber or after primary processing (i.e. slicing or chopping).

In the selected provinces, loss rates during harvest and transport stages are quite high due to missing/not uprooted and/or broken-down tubers during harvest and spillage during transport. Current high-yield varieties with short tubers grown in clusters could help reduce loss rates.

The drying stage of cassava is very poor, mostly limited to sun drying. Only a small volume of cassava is dried – by simple equipment and technology. During sun drying sliced and chopped cassava are easily contaminated by mold or quickly rot when they get wet by rain.

After being traded, dry cassava tubers are re-dried and sold to animal feed processing companies by the traders. Presently, dryers are horizontal batch bed types – as in rice and maize processing – with low cost, simple technology and limited control over product quality and equipment parameters.

In terms of storage, farmer's households only keep enough cassava for their family needs. Storage lacks innovation and use of scientific and technical achievements to prevent pests, mold and micro-organisms. With conventional ways of storage, where the dried cassava is stored on the floor of house on stilts, the loss rate is very high for cassava after only four months, mainly because of moths. In addition, knowledge of farmers about techniques for prevention of insects and mold is limited, and misuse of regulations and dosage of the chemical preparations for cassava storage is relatively common too.

Table 3-19 below shows the average rate of cassava losses in all the postharvest stages of the identified provinces. It ranges from 8.7 percent in Thanh Hoa to 9.6 percent in Nghe An, which is close to the minimum value as assessed by the PRA workshop. Cassava production in 2011 in the two provinces took place in favorable weather conditions, where dry fields, timely harvest and proper application of harvest technology limit losses during production and postharvest.

Table 3-19. Average cassava PHL rates in two selected provinces in Vietnam

Province	Loss rate (in %)					Total loss (in %)
	Harvest	Transport	Treatment	Drying	Storage	
Nghe An	3.34	2.21	0.53	0.30	3.22	9.60
Thanh Hoa	2.51	0.68	0.53	1.77	3.17	8.66

4 Recommendations and Next Steps

The baseline studies, presented at the Joint ASEAN Secretariat - UNIDO Workshop in July 2012 in Jakarta and summarized above, brought forward a number of tangible recommendations (Section 4.1 below), which are expected to be beneficial for policymakers and stakeholders of the whole system of the commodity supply and value chain, especially farmers. The recommendations will create the background for clearly focused follow-up projects that address the needs identified at the respective country levels. Three such proposals are presented in Section 4.3.

Together with the Workshop findings (Section 4.2), the country recommendations will also provide an important input for ASEAN working groups to emphasize the importance of reducing PHL in the member states and to provide guidance for future ASEAN projects. The findings and recommendations are expected to facilitate discussions on how the national projects could feed into regional policies and vice versa. In addition to country level impact, the baseline studies and Workshop recommendations are thus hoped to create a visible impact at the regional level, contributing to intra-regional cooperation and exchange.

4.1 Recommendations from the Baseline Studies

The following tables summarize the findings and recommendations, recorded by product across the various countries: (1) rice, (2) maize, (3) cassava, (4) fishery, (5) fruits and vegetables and (6) coffee.

Table 4-1. Country study recommendations – Rice

Cambodia	Indonesia
Support good practice of seed selection Improve postharvest technology application by providing training in operation, repair and maintenance for e.g. farmers, millers and owners/users of power tillers, tractors, threshers, combine harvesters, drying ovens etc. Improve access and conditions of loans for traders and millers as financing is a serious constraint for business development, increasing milling capacity and improving storage and drying facilities Implement and strengthen existing policy, regulation and standards related to rice postharvest operation	Karawang, West Java: increase use of flatbed dryers to improve quality of dried paddy at farmer and small rice mill unit (RMU) level; shift from manual harvesting and threshing to use of reaper and power threshers Bone, South Sulawesi: construct temporary storages with appropriate design in market area Implement fully automatic rice milling machineries at large RMUs to compete with imported premium rice
Laos	**Philippines**
Shift from manual harvesting and threshing to appropriate mechanisation and use of technologies Establish a national postharvest team with key members from public and private sectors (e.g. as a Learning Alliance) Provide capacity building for farmer intermediaries (i.e. the Learning Alliance members) in the use of postharvest technologies Implement good drying operations; advocate for decision makers (awareness and support) to re-start dryer technology transfer and provide appropriate policy for promoting and engaging with more manufacturers Introduce safe storage and make hermetic storage systems locally available	Provide efficient equipment/machineries to producers: e.g. dryers and moisture meters; dryers are particularly important where harvesting coincides with rainy days Develop service facilities and village level processing facilities (e.g. operated by farming organizations/cooperatives), which can also perform product marketing functions Increase capability building of stakeholders in supply chain, specifically farmers, e.g. with trainings, seminars and tech-demos for proper methods/technologies in postharvest handling; strengthen extension services of lower government units Enhance postharvest research and development efforts to develop new affordable, sustainable and eco-friendly technologies and techniques to minimize PHL
Thailand	**Vietnam**
Introduce a high quality standard to encourage farmers to change farm management, including care for plantation and selection of harvest time Consolidate a national training course on postharvest practice, with practical use and easy access to training documents/materials for growers Encourage harvesting operators, who play increasingly major role in high harvesting yield Improve drying process, raise efforts by supporting units, government and non-governmental organizations to reduce sundry costs for growers	Select and adopt high quality varieties, e.g. with high yield and good resistance against pests, lodging, grain falling, etc. Conduct research and tests on agricultural machines, equipment and facilities, especially reapers/harvesters, dryers, stockpiles etc. Organise training courses on farm technologies, operation of farm machinery and equipment, especially rice reapers and combine harvesters for farm operators Transfer technologies and support investment in grain drying for intensive rice production areas Research and transfer removable storage facilities convenient for farm households in shortage of space; equip households with simple and low-cost facilities

Table 4-2. Country study recommendations – Maize

Cambodia	Indonesia
Harvesting only when maize fully matured and prepare clean containers for harvested maize Improve drying practices: dry on clean concrete floor, use solar dryers and/or electric dryers and control final moisture depending on intended storage time Greater attention to the threshing process Proper labeling and branding of the produce, and fixing of bag net weight Improving storage by e.g. using clean and dry warehouse, building elevated storehouses with roof, allocating space for ventilation and implementing proper pest control	Encourage use of power shellers and mechanical dryers among farmers, collecting traders and warehouses; facilitated by provision of guarantee credits for Gapoktan and UPJA by central and regional government Reinforced efforts by extension workers to inform farmers in Central Lampung on balancing cropping between maize and cassava
Laos	**Philippines**
Shift from manual harvesting and threshing to appropriate mechanisation and use of technologies Raise efforts by extension workers informing farmers on improvements in the cropping systems Encourage use of appropriate sheller and mechanical dryer among farmers, groups of farmers, collecting traders and warehouses Improve sanitary and phytosanitary measures to facilitate the export of maize Obtain credit for investment in power shellers and mechanical dryers for farmer groups (e.g. from Agricultural Development Bank)	Provide efficient equipment/machineries to producers: e.g. dryers, moisture meters and dehullers; dryers are particularly important where harvesting coincides with rainy days Develop service facilities and village level processing facilities (e.g. operated by farming organizations/cooperatives), which can also perform product marketing functions Increase capability building of various stakeholders in the supply chain, specifically addressing farmers, e.g. with trainings, seminars and tech-demos for proper methods/technologies in postharvest handling; strengthen extension services of lower government units Enhance postharvest research and development efforts to develop new affordable, sustainable and eco-friendly technologies and techniques to minimize PHL
Thailand	**Vietnam**
Encourage growers' groups Reduce sundry costs for growers, support development of cooperative sundry floors Consolidate a national training course on postharvest practice, with practical use and easy access to training documents/materials for growers Training on good practice in maize storage at grower and further processing stages	Select and adopt high quality varieties, e.g. with high yield and good resistance against pests, lodging, grain falling, etc. Conduct research and tests on agricultural machines, equipment and facilities, especially reapers/harvesters, dryers, stockpiles etc. Organise training courses on farm technologies, operation of farm machinery and equipment Research and transfer removable storage facilities convenient for farm households in shortage of space; equip households with simple and low-cost facilities, e.g. wooden/tin containers

Table 4-3. Country study recommendations – Cassava

Cambodia	Indonesia
Introduce labor saving agricultural mechanization appropriate for cassava harvesting conditions Improve yields by providing better cassava varieties Encourage cassava processing, which is severely limited due to lack of techniques, market access and financial support Increase investment in postharvest activities, e.g. drying and storage facilities, by public and private actors Capacity building, product development and manufacturing of processing technologies and transfer to target beneficiaries and development of clusters to supply identified markets Implement government policies effectively to produce beneficial effects of agricultural research and technology improvements	Central Lampung: no recommendations where large scale tapioca industries purchase most of the fresh cassava roots Pacitan: encourage development of 100 ha pilot project for cassava production, establishment of small tapioca industries and their use of machinery
Laos	**Philippines**
Shift from manual harvesting to appropriate mechanisation and use of technologies Train farmers to have better understanding of how losses occur and how they can be prevented, e.g. educate on importance of swift postharvest transport Carry out research on soil improvement and sustainable production systems Further in-depth study of PHL in the cassava handling chain to improve the understanding of process value and technology More support from government policy to develop appropriate postharvest technology	*Not studied*
Thailand	**Vietnam**
Encourage use of certified cassava varieties Introduce a clean cassava standard, which would provide incentive for better postharvest practice by farmers Consolidate a national training course on postharvest practice, with practical use and easy access to training documents/materials for growers Introduce new, high yield harvesting machines that are easy to use, leave less roots in the ground and require fewer workers for operation Improve drying practices to reduce loss through wind and fermentation; reduce sundry costs for growers	Select and adopt high quality varieties, e.g. with high yield and starch content and good resistance against pests Conduct research and tests on agricultural machines, equipment and facilities, e.g. for drying operations Organise training courses on farm technologies, operation of farm machinery and equipment Research and transfer removable storage facilities convenient for farm households in shortage of space; equip households with simple and low-cost facilities, e.g. wooden/tin containers

Table 4-4. Country study recommendations – Fishery

Cambodia	Philippines
Upgrade the entire fish postharvest handling system, especially the practices of food processors, to improve sanitation conditions and quality of processed fish	Provide efficient icing or chilling equipment for fish after harvest until the product reaches consumers Increase capability building of various stakeholders in the supply chain, specifically addressing fisherfolks, e.g. with trainings, seminars and tech-demos for proper methods/technologies in production and postharvest handling; strengthen extension services of lower government units Develop service facilities and village level processing facilities (e.g. operated by farming organizations/cooperatives), which can also perform product marketing functions Continue to develop cold chain system and change attitude of consumers to accept chilled and/or frozen commodities Enhance postharvest research and development efforts to develop new affordable, sustainable and eco-friendly technologies and techniques to minimize PHL

Table 4-5. Country study recommendations – Fruits & vegetables

Philippines
Provide efficient equipment/machineries to producers, e.g. chillers and ice making machines, to reduce moisture loss and delay development of diseases during transport Increase capability building of various stakeholders in the supply chain, e.g. trainings, seminars and tech-demos for proper methods/technologies in postharvest handling; strengthen extension services of lower government units Develop service facilities and village level processing facilities (e.g. operated by farming organizations/cooperatives), which can also perform product marketing functions Provide tramlines, especially in hilly/mountainous areas where vegetables are produced, to facilitate transport and reduce costs Advocate changes in policy of shipping lines for agricultural produce, e.g. charging shipper by weight not container Continue to develop cold chain system and change attitude of consumers to accept chilled and/or frozen commodities Enhance postharvest research and development efforts to develop new affordable, sustainable and eco-friendly technologies and techniques to minimize PHL

Table 4-6. Country study recommendations – Coffee

Philippines
Provide efficient equipment/machineries to producers, e.g. depulpers, dryers
Increase capability building of various stakeholders in the supply chain, especially growers, e.g. with trainings, seminars and tech-demos for proper methods/technologies in postharvest handling; strengthen extension services of lower government units
Develop service facilities and village level processing facilities (e.g. operated by farming organizations/cooperatives), which can also perform product marketing functions
Enhance postharvest research and development efforts to develop new affordable, sustainable and eco-friendly technologies and techniques to minimize PHL

4.2 Workshop Recommendations

At the Joint ASEAN Secretariat – UNIDO Workshop on "PHL of Main Commodities in ASEAN Countries", which was held from 16 to 18 July 2012 in Jakarta, participants discussed on the basis of the country reports summarised and the additional presentations (see Annex A) broader implications or recommendations to consider when designing and implementing projects to address PHL reduction in the ASEAN countries. Pertinent themes that featured in the Workshop discussions included:

- *Holistic approach:* The Workshop findings stress again the importance of a holistic approach for a successful reduction of PHL. Such a holistic approach would need to consider all the factors along the chain from pre-harvest to consumer and tackle the weakest part of the chain as this determines the productivity of the whole. It would need to address preconditions for the shift from subsistence household economy to modern industry and agribusiness growth, and would require mobilizing a country's productive potential. In terms of policy and investment, such an approach would involve identifying "binding constraints".

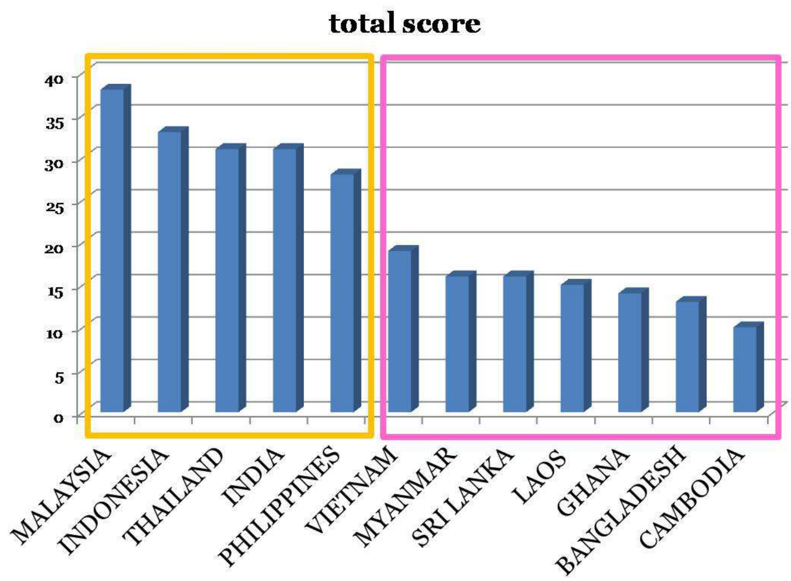
  Another consideration that was highlighted in the country studies and at the Workshop and that relates to a holistic approach addressing agricultural production as part of the agro-value chain, is the importance of creating incentives for agricultural producers to supply higher quality products. This is regarded as important not only for implementing but also sustaining good practices.

- *South-South cooperation:* The fact that there appears to be a lot of experience and resources in the region with regards to postharvest management, underlines the vital role for South-South cooperation. According to this concept, countries with more experience and skills advise their neighbors on technology application appropriate for the stage of development. It has the advantage of replacing top down models with cooperation and experience sharing among peers. In addition, it makes use of the fact that the countries have a better understanding of each other's culture as well as the trade mechanisms in the region.

  The scope for regional cooperation is supported by the findings of the survey on national capacities in postharvest science and technology, conducted at the UNIDO – ICS Workshop. Participating countries were asked to rate their science and technology level in the following fields: ripening control, harvesting system, cold storage, processing technology, packaging, transportation, food safety, quality control, traceability labeling and communication science. The results showed that the Asian countries can be subdivided into two groups: those with higher use of modern science and technology in postharvest operations, i.e. Malaysia, Indonesia, Thailand, India and the Philippines; and those with less developed science and technology application, i.e. Vietnam, Myanmar, Sri Lanka, Laos, Bangladesh and Cambodia.

  South-South cooperation would therefore clearly benefit the improvement and modernization of postharvest operations in a number of Asian countries and should be encouraged in the context of projects on PHL reduction. It was suggested, for instance, that Vietnam's model centers of excellence could be transferred to neighboring countries. Similarly, countries in the region can learn from Thailand's experience with harvest mechanization or the Philippines' innovative approach to transport in mountainous and inaccessible production areas. A strong role for facilitating this kind of South-South cooperation could potentially be played by ASEAN through its regional programs.

Figure 4-1. Science and technology levels in postharvest operations



Source: Boselli and Mezzetti, 2012

- *Postharvest storage systems:* Based on the findings of the ASEAN – UNIDO Workshop and the preceding ICS – UNIDO one, it was suggested to develop and propose a new project specifically addressed to study new postharvest storage systems that would be able to guarantee the quality standards requested by the market. Furthermore, integrated technologies should be applied to generate the energy needed for the local storage and packing house by using product waste and loss. Prior to introducing any sophisticated technology, however, a profitability assessment should be carefully carried out, as emphasized at the Workshop.

- *Packaging innovations and bio-based materials:* Based on the presentation on innovation and trends in packaging solutions (see Annex A) and the ensuing discussions, the Workshop supported the finding that packaging innovations can be very useful in extending the shelf life of the product. Contrary to common belief that packaging has a damaging effect on the environment, it was shown that appropriate packaging can in fact contribute to increasing sustainability, reducing food losses and carbon dioxide emissions, thus reducing global warming and anthropogenic climate change.

  Moreover, bio-based materials, derived from renewable sources that are largely available particularly in underdeveloped countries, can contribute significantly to these achievements. One example elaborated on was chitosan, which is derived from the shells of shrimp and other sea crustaceans – a by-product readily available, e.g. in Thailand's fishery industry. Besides its use in agriculture (as a natural seed treatment, plant growth enhancer or ecologically friendly bio-pesticide) or biomedicine (e.g. used in bandages), new research suggests that chitosan could be used for manufacturing innovative packaging.

Against the background of its expertise and extensive experience in developing and implementing programs for the development of the agro-industry sector (see, for instance, the Accelerated Agribusiness and Agro-Industries Development Initiative, "3ADI"), UNIDO offers to facilitate and lead the brokering of relationships and partnerships at the national level and involving chain actors and development partners (AfDB, IFAD, WB, FAO, etc.) for project ideas presented at the Workshop and others under development by ASEAN member countries. UNIDO can help identify and prioritize agro-value chains, undertake holistic agro-value chain analyses in cooperation with its partners, and design strategies for the implementation of interventions and support.

With regards to the food industry, the UNIDO service focuses on waste reduction through technology improvements, process optimization and the utilization of by-products. To promote food safety and help developing countries access world markets, UNIDO assists in implementing good hygiene practices and achieving compliance with the Sanitary and Phyto-Sanitary Agreements, and introduces food-safety systems based on risk analysis, prevention and traceability. Ultimately, these services aim at reducing PHL, adding value to agricultural output, generating increased employment opportunities and contributing to increased food security and a sustainable reduction of poverty.

4.3 Current project proposals

Three proposals for technical assistance projects on the reduction of PHL were submitted to UNIDO and presented at the Joint ASEAN Secretariat – UNIDO Workshop in July 2012. The proposals aim at: (i) improving quality and safety of fishery products in Cambodia for better access to domestic and international markets; (ii) developing postharvest technology and trade compliance in the tropical fruits sector in Indonesia; and (iii) applying modern technologies in the fruit and vegetable chain from agricultural production to final consumption in Vietnam.

4.3.1 Cambodia

Project Title: Better Quality and Safety of Fish and Fishery Products for Improving Fish Trade Development in Cambodia.

Overall Strategic Goals: To enhance Cambodia's fish trade development by improving the capacity of those who engage in postharvest fisheries for better quality and value of fish and fishery products and by increasing access to domestic and international markets.

Target Stakeholder/s: Fishers, processors, traders, fisheries administration and other related governmental agencies would benefit from this project.

Origin of Proposal: Ministry of Agriculture, Forestry and Fisheries, Fisheries Administration.

Budget and Proposed Funding Sources: Royal Government of Cambodia; Trade Development Support Program (TDSP). The proposed budget amounts to USD 1,257,807.00.

Duration: 2 years.

Problem/s Assessment: Cambodia's postharvest fisheries sub-sector plays an important role for the management and development of fisheries postharvest technologies and trade toward achieving the national fisheries development objectives in optimizing the role of fisheries in food security and nutrition and poverty alleviation of the country. Postharvest fisheries include the grading, processing, preservation, storage, transportation and trade of fish.

Much of the development potential of Cambodia's postharvest fisheries sub-sector in terms of both economic development and foreign exchange balance will again be dependent on achieving sustainability of fish supplies and it will be important to work with other sub-sectors to ensure this. It is also possible to increase the diversity, quality and volume of value-added products going for export and so get higher returns.

This can be done by improving processing methods, improving sanitation, improving access to higher paying foreign markets, improving credit for export processors, promoting research into fish technology and quality assurance, promoting the transfer of appropriate technologies and promoting cooperation between market actors. It will also be necessary to ensure increased confidence in product quality by improving quality assurance and food safety practices, by meeting international standards and by transparent regulation of the sub-sector. Adaptations of such internationally recognised practices such as mechanisms like GAP/GHP/GMP will be important. There are also opportunities for improving the sub-sector efficiency by increasing vertical integration of postharvest processes. These then are some of the main broad development options for the sub-sector.

Identified Solutions: This project will address low value in the fisheries sector by improving storage capabilities and improve handling and hygiene practices for SMEs and brokers by (1) disseminating GAP, GHP and GMP to relevant stakeholders in the value chain, (2) improve fish process and trade activities, and (3) improve the official inspection system by making it more relevant and effective.

Sustainability and Upscaling: This will be achieved through assisting the government in setting up the enabling environment, strengthening support institutions, institutionalizing skills development and vocational training for staff along the shrimps/fisheries value chain, establishing vocational training centers, creating links to international acting sector institutions, direct interventions at the factory level, and involvement of the private sector in analysis of official controls.

4.3.2 Indonesia

Project Title: Implementation of Postharvest Technology and Trade Standard Compliance for Tropical Fruit Supply Chain in Indonesia.

Overall Strategic Goals: To develop appropriate postharvest technology to be implemented in every stakeholder level in the tropical fruits agro-industrial supply chain (e.g. mangosteen and salak), and to increase awareness of target beneficiaries on good postharvest handling implementation and trade standard compliance in quality and food safety.

Target Stakeholder/s: Growers, packing houses, processors, trade intermediaries, supplying industries and service providers, business membership organizations and trade, related government agencies, universities and public research institutions.

Origin of Proposal: Faculty of Agricultural Engineering and Technology, Bogor Agricultural University.

Budget and Proposed Funding Sources: Around USD 500,000 from UNIDO.

Duration: 39 months (three agricultural cycles plus three months).

Problem Assessment: The horticultural business sector contributed Rp 76.79 trillion to Gross Domestic Product in 2007. By 2008 it had increased by 4.55 per cent to Rp 80.29 trillion. But the fresh product exporters (including supplying farmers) are struggling with logistic, marketing, packaging and particularly compliance issues in food quality and safety. Awareness of benefits of standard compliance and certification are low; growers and producers have limited knowledge and skills in product management; and there is a lack of proper technology, knowledge in quality assurance and control system (i.e. GGAP certification assurance) and coordination among public sector agencies (trade policy/export promotion).

Quality of fruits during off farm activities must be improved through appropriate postharvest handling, which will also increase product shelf life. In addition, development of human resources, implementation of appropriate agricultural technologies, development of agricultural research and product marketing, as well as supportive government policies would have a big impact on agricultural sector development.

These interventions would have synergies with on-going government efforts, such as the training program in good handling practices for horticultural farmer groups and the packing house program in production centres and other facilities.

Identified Solutions: The project will address the identified problems in the tropical fruit supply chain by helping producers obtain international trade standard certificates, reinforcing implementation of postharvest technology on every level of the agro-industrial supply chain, increasing the involvement of business units and establishing a model of tropical fruits agro-industrial supply chain supported by a sustainable provider of logistics.

Sustainability and Upscaling: The Ministry of Agriculture is the authority dealing with farmers and inputs for farming in cooperation with others, such as the Ministry of Industry, Cooperatives and SMEs, the National Bureau of Statistics, and financial institutions. Programs are planned to introduce farmers to Good Postharvest Practices with the help of extension workers in all regions of Indonesia, and to support the development of a packing house in the production centres.

4.3.3 Vietnam

Project Title: Strengthening of the supply capacity of the fruits and vegetable sector by applying proper technologies along the value chain.

Overall Strategic Goals: The aim of this program is to assist in the modernization and improvement of the food supply chain from basic production to food processing and the consumer through reduction of postharvest losses and market related technical assistance.

Target Stakeholder/s: The rural poor in selected provinces, enterprises in the selected sectors, public and private institutions.

Origin of Proposal: Vietnam Institute of Agricultural Engineering and Postharvest Technology (VIAEP).

Budget and Proposed Funding Sources: The total proposed budget of USD 1,200,000 consists of an expected ODA fund of USD 700,000, including 7% UNIDO support costs and 1% One Plan Fund Administrative Agent support cost (One Plan Fund IV, Line Agency: Ministry of Agriculture and Rural Development (MARD)), and an expected co-financing of USD 500,000 by ROK, including 7% UNIDO support costs.

Duration: 4 years, 2012-16.

Problem/s Assessment: About 85 per cent of rural households in Vietnam grow at least one fruit or vegetable crop, of which about two thirds are sold to the market. About one-quarter of rural Vietnamese households have fruit and vegetable sales that are equivalent to over half of their total consumption expenditure. Fruit and vegetable production and postharvest practices, however, suffer from a lack of skills, knowledge and appropriate technologies, which lead to poor income and employment generation in the fruits and vegetable sector.

Identified Solutions: In the project framework, two production models, covering pre-processing, packaging and preservation of fruit (Mekong River Delta) and vegetables (Red River Delta), are expected to be built in Vietnam. The main components of the project are technology transfer through the set-up of a community centre (Centre of Excellence) for conservation and packaging purpose in rural areas; skills development in the field of conservation, management, accounting and certification process, dissemination of good practices, norms and standards at community levels, and value addition through simple packaging methods (cutting and packaging).

Specifically, the project will provide the participants of the selected pilot value chain with the improved technical and managerial skills in addition to processing technologies that enable them to increase their participation in employment opportunities on and off-farm, thereby increasing and stabilizing their incomes, and to reduce postharvest losses in rural communities through strengthening income generating activities for poor farmers.

The objective is to improve the organizational and managerial structure of production through strengthening the organizational and managerial capacities of smallholders, to improve the quality of agricultural products and reduce postharvest losses through strengthening productive capacities in terms of production techniques, management and value addition, and to increase the income of smallholders through the provision of appropriate technologies for conservation and value addition.

The outcomes of the project will be pilot applications for reduced postharvest losses through strengthened productive capacities in terms of production/processing techniques, management and value addition in selected fruits and vegetable sectors; improved organizational and managerial structure along the value chain of the selected sectors; and an increased income of organized smallholders.

The rural poor in selected provinces will benefit through job creation and income generation as well as the establishment of outlets for their product, both, raw and processed. The participating enterprises out of the selected sectors will benefit from the assistance and will have the chance to increase their national and international market share and sales through upgraded technology and improved product quality and the connection to the international market. And the involved institutions (public and/or private) will strengthen their capacity in providing support and advisory and control services to the food industry in the fields of processing technologies, food safety/quality, marketing and product development.

Sustainability and Upscaling: The project is based on the principle of ownership by the counterparts and beneficiaries. A demand and not supply driven approach as used also in the project development has proven successful in this regard in many countries and especially in the previous project implemented by UNIDO in Vietnam itself.

Through the involvement of state and local administrations the local ownership of the project will be secured. Local authorities, processors and farm management realise that sustainable and more efficient use of raw materials produced locally will bring an advantage in the mid- to long-term prospective. The additional capacity and capabilities acquired from the project will enable them to improve their operation in a sustainable manner.

The establishment of a pool of experts enabled to spread acquired knowhow to other parts of the country will build the backbone for replication and sustainability. The involvement of national specific institutions will create the necessary imbedding of the experts in the existing structure. In addition, the utilisation of experts from VIAEP and RIFAV in the project implementation will secure the focus on the existing needs, scientific backing and allow further distribution of project results beyond the project area and period.

After completion of the project, besides the trained farmers and workers – both capable to apply newly transferred technologies – a pool of trainers and at least one processing centre will be established and available to sustain the project's impact. The outputs from the Centre of Excellence have a twofold purpose: the Centre will act as model application for appropriate technologies and its transfer to SMEs acting in the sector will continue the training efforts started during project implementation; and it will remain an outlet for the goods produced by the farmers of the region. As the Centre gains experience and maturity, it could become a driving force in the development of the selected sector.

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Annex A. Workshop Agenda

<u>Monday 16 July 2012, Day 1</u>

8:30 – 9:00	Registration of participants	
9:00 – 10:00	Welcome addresses (UNIDO, ASEAN)	**Mr. Imran Farooque, UR, UNIDO**
		Dr. Somsak Pipoppinyo, Director of FIID, ASEAN
10:00 – 10:30	Introduction of the workshop and presentation of the programme	
10:30 – 11:00	*Coffee Break*	
	Press conference	
11:00 – 12:00	Gain More - Loose Less	**Karl Schebesta, UNIDO**
12:00 – 12:30	Discussion	
12:30 – 14:00	*Lunch break*	
	Country presentations	
14:00 – 14:30	Indonesia	**MARDJAN Sutrisno**
14:30 – 15:00	Thailand	**SRIPOTI Thepchoo**
15:00 – 15:30	Laos	**BOUNPHANOUSAY Chay**
15:30 – 16:00	*Coffee break*	
16:00 – 16:30	Cambodia	**BUNTONG Borarin**
16:30– 17:00	Vietnam	**NGUYEN Thai Duong**
17:00 – 17:30	Philippines	**ESPINO Rene**
17:30 – 18:00	Discussion	
Evening	*Welcome dinner. Pan Pacific*	

Tuesday 17 July 2012, Day 2

9:00 – 10:00	Post harvest losses in fruits and vegetables in South East Asian Countries. The cases of Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand and Vietnam Results of the UNIDO – ICS workshop on "Postharvest, Quality and Food Safety of Tropical Fruit Production in South East Asian Countries" (Bangkok, 30 April-4 May 2012)	**Prof. Emanuele Boselli; Ancona, Italy**
10:00 – 10:15	Discussion	
10:15 – 11:15	From field to storage - handling and transportation	**Prof. Kamrul Hasan; Mymensingh, Bangladesh**
11:15 – 12:15	Packaging solutions for the developing countries - innovation and trends for the future	**Prof. Luciano Piergiovanni; Milan, Italy**
12:15 – 13:15	From postharvest to consumers' table - the case of a comprehensive, innovative exhibition	**Prof. Luciano Piergiovanni; Milan, Italy**
13:15 – 15:00	*Lunch*	
15:00 – 16:00	Discussion and collection of proposals	
16:00 – 17:00	UNIDO's response	**Karl Schebesta, UNIDO**
17:00 – 17:30	Wrap up and closing	
Evening	*Free time*	

Wednesday 18 July 2012, Day 3

08.00 – 12.00	Factory visit: PT Sewu Segar Nusantara, Jalan Gatot Subroto (Telesonic Dalam) Km 8, Bitung, Tangerang
12.00 – 13.30	*Lunch*
13.30 – 16.30	Factory visit: PT Indo Beras, Jalan Raya Renggas Bandung Km 60, Lemah Abang, Bekasi
16.30 – 18.00	Back to Jakarta

Philippines		
ESPINO Philippines		
NGUYEN Thai Duong Vietnam		
NGUYEN Quoc Viet Vietnam		
NGUYEN Thai Duong Vietnam		
CALICA Gigi Philippines		