NTRP Food Security- Report to the Management

Executive summary

The National Thematic Research programme (NTRP), conducted by the National Science Foundation during the period 2012-2017 has been successfully completed having achieved most of its objectives.The NSF focused on the following five programmes under its NTRP on Food security namely, a) Continuous mapping of production, marketing and supply, b) Internal and external trade policies,c) Integrated food production systems, d) Post-harvest technologies and e) Food safety and quality standards.The outcomes from the research projects are expected to contribute towards the increased availability of nutritious and quality food for the people.

Out of the nine projects, eight have been successfully completed and yielded valuable results. Of the eight projects, two were on trade policies, two on the use of web based (IT) technology for crop forecasting and four on improving household food security, food safety and quality standards and decreasing post harvest losses in agricultural products.

All eight projects generated new knowledge pools that would be useful in increasing food availability at the national level. The two projects that assessed internal and external trade policies provided outcomes that would be useful to policy makers, economists and other relevant parties in the development of policy interventions for ensuring food security in the country. The IT related projects and the technology projects developed products and/or services that could be used for the advancement of the agriculture sector of the country. The integrated food production systems (home gardens) developed for farmers in the Northern Province improved the livelihood of resource poor/resettled farmers, as home gardens provided fresh fruit and vegetables for home consumption and in some cases for exchange with/sale to, neighboring families.

All projects had research teams either from the same institute or from different institutions. Out of nine projects, seven projects had local collaborators while the projects namely, “Use of web based technology” and “Improving household food security” had University of Western Sydney, Australia and Michigon State University, USA as foreign collaborators, respectively.

Four projects were carried out islandwide while others worked in specific locations as approved by the Steering Committee.

Four project teams have conducted farmer workshops (9) / training programmes (4) /stakeholder workshops (2 with more than 25 participants) / participated in exhibitions to disseminate knowledge and to transfer technology to suitable stakeholders. A number of students were trainedon short term basis (36) in five projects while two projects had students who were reading and completed PhD degrees (3). Results of six projects were disseminated through local and 8 foreign publications including high impact journals, 7 local and 21 foreign communications and also through 106 newspaper articles.

The projects had created links with external entities and stakeholders when carrying out the projected activities, information gathering, organizing workshops and conducting research trials. Apart from government institutes, Private sector and non-governmental organizations were also involved.

The following diagram depicts the collaborations made during the NTRP on Food Security program. The areas benefitted by this program are shown in the map.

Program 1	Department of Agriculture, University of Colombo School of Computing, LINK Natural products, Hector Kobbekaduwa Agrarian Research and Training Institute (*HARTI*), University of Western Sydney, Australia
Program 2	Department of Agriculture, University of Sri Jayawardenepura, The Open University
Program 3	Medical Research Institute, Lady Ridgeway Hospital, Colombo South Teaching Hospital, Maligawaththa Hospital, National Institute of Health Sciences, Kaluthara
Program 4	University of Peradeniya, University of Wayamba, United Nations World Food Program, Coordinating Secretariat for Science, Technology and Innovation (*COSTI*),National Aquatic Resources Research and Development Agency (*NARA*), Ministry of Agriculture, Department of Agriculture, Horticultural Crop Research and Development Institute (*HORDI*), HARTI, Rice Research Institute, Ministry of Fisheries and Aquatic Resources
Program 5	*HORDI*, University of Peradeniya, Institute of Fundamental Studies University of Jaffna, Department of Agriculture, LINK Natural Products, Non-Governmental Organizations, Michigan State University, USA

Areas /districts benefited in Sri Lanka by NTRP Food Security program

NTRP/2012/FS/PG-05/P-02

NTRP/2012/FS/PG-05/P-01

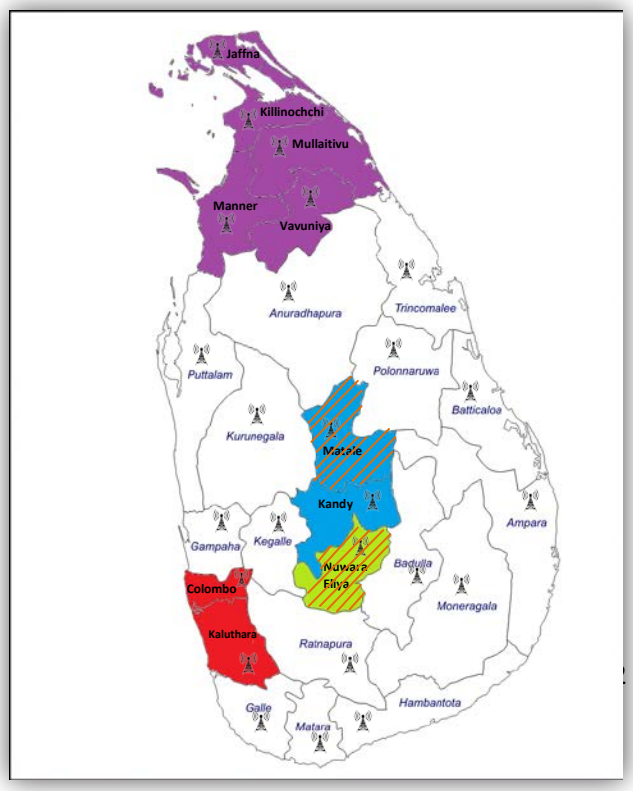
NTRP/2013/FS/PG-02/P-01

NTRP/2013/FS/PG-02/P-02

NTRP/2012/FS/PG-03/P-01

Island Wide

- NTRP/2012/FS/PG-04/P01
- NTRP/2012/FS/PG-04/P02
- NTRP/2012/FS/PG-01/P01
- NTRP/2012/FS/PG-01/P02



Expansion of the food security program, to particularly address food safety, nutrition & health and to broaden and deepen socio-economic benefits, is highly recommended.

The outputs generated by all successfully completedprojects have a very high economic value.

Key words: food security, food safety, pre harvest technology, post harvest technology, nutrition security, trade policy

Initiation of the National Thematic Research Programme (NTRP) on Food Security

1.Designing, implementing and conducting a National Thematic Research Programme (NTRP)

What is a NTRP?

A National Thematic Research Programme or NTRP is conceptualized as a mission oriented, multidisciplinary collaborative research programme with a view to addressing a national need and drive the national research system to produce well defined outputs that could be harnessed and applied for national development.

Identifying suitable themes

The first stage is an inclusive consultative process that focuses on a framework for setting priorities.

The second stage would be the setting of national research priorities. Inviting public opinion would be a useful tool. An expert advisory committee has toexamine public submissions and a short-list for consideration of the Board of Management of the NSF would be developed. The Board of Management of the NSFcould consider these suggestions and arrive at specific themes of long-term importance to the country. In developing the priorities, the initial focus would be on the contributions of science and technology.

In the third stage, the Board of Management of the NSFwill work with the research communities to encompass their knowledge and contributions in order to refine and elaborate the selected priorities.

Approach to identifying issues

Once a theme is identified and approved by the Board of Management of the NSF, a task force/group of experts will be appointed by the Board to develop a Theme Paper on the given theme, through brain-storming workshops and meetings.

The objective of the theme paper would be to provide a clear picture on the theme and to outline thenational needs regarding it. As such, the theme paper will be developed in 04 sections, according to the
following guidelines:

1. The Section I, of the theme paper should provide a clear background of the theme including a broad definition that should also depict the current status-quo, both local and international, which will clearly describe the policies, practices and legislations, related to the given theme.

2. Section II should include a review on past and on-going local research on the theme and global work where relevant.

3. Section III should outline the gaps in knowledge, strengths and opportunities. Further, this section should illustrate the problems and impact of those problems on different aspects of the society (Eg: social, economical, political, health) and *vice versa*.

4. The identification of issues/programmes, expected research outputs, recommendations and the way-forward (short term and long term) will be stated in the Section IV. The stakeholders and other target groups should be portrayed in this section.

The identified issues and expected outputs from the assignments must be as specific as possible andnot broad based. It must as far as possible identify research topics to be addressed.

Call for Expression of Interest

The research projects will be implemented through institutional partnerships, engagement of research institutions, government institutions, private sector, community based organizations and different community groups, which will facilitate the integration of information and knowledge in decision making. This will also facilitate the information and knowledge flow across different levels of the society without additional effort.

Applying for research grants

Groups of researchers are invited to conduct research to address the issues identified in the programmes, as outlined in the Programme Documents.

Those interested are requested to submit an Expression of Interest (EOI), clearly stating the objectives and expected outputs in a given format.It is essential that the EOI proposes objectives and outputs covering the scope outlined in the relevant Programme Document, clearly mapping out the strategy for achieving these objectives and expected outputs, resulting in the required outcomes of the programme.

2.The National Thematic Research Programme (NTRP) on Food Security

Activity Plan that was followed for starting the Food Security Program

1. Planning Workshop 1 - After selecting research teams based on the expressions of interest, with the participation of relevant end-users. (Objective – Alignment of the EoI with the Theme Paper and assessment of the applicability to the end-users)
2. Planning Workshop 2 - to plan the proposals and to workout budgets (discussions held among research groups under each Programme on separate days)
3. Planning Workshop 3 - to finalize projects, identify responsibilities and performance indicators. At this workshop each project will be allotted to a member of the Steering Committee (Project Advisors) depending on their expertise, for advice and guidance
4. Immediately after finalizing the projects, a meeting held with the Theme Coordinator (TC), Project Advisors (PA) and all Project Leaders (PL), to fine tune the projects and initiate work

Framework used for identification of research gaps

Food security, as defined by the United Nations' Committee on World Food Security, is the condition in which all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Accordingly, household food security is the application of this concept to the family level, with

individuals within households and families as the focus of attention. Consequently, food insecurity exists when people do not have adequate physical, social or economic access to food.

Based on the above definition of Food Security, the following four dimensions of food security were used to identify research gaps on food security.

1. Availability:Adequacy, Nutritious food with high quality, Uninterrupted supply
2. Accessibility: Purchasing power, Even distribution of food produce
3. Use and Utilization: Proper utilization of available food
4. Resilience: Political & economic crisis, Climate change, Seasonal crop failures, Disaster events

While accepting the importance of all four above dimensions of food security, the NTRP programme concentrated essentially on dimension 1 - The uninterrupted availability of nutritious and quality food for the public. Accordingly, NSF focused on the following five programmes under its NTRP on Food security since outcomes from such research were expected to contribute towards the availability of nutritious and quality food for the people.

a) Continuous mapping of production, marketing and supply
b) Internal and external trade policies
c) Integrated food production systems
d) Post-harvest technologies
e) Food safety and quality standards

The NSF having called for proposals selected 9 projects for financial support, after a thorough scrutiny of the submitted proposals by a team of experts.

3.Action Plan of the NTRP Food Security Program – A Schematic Representation

Appointing a Steering Committee

Steering Committee consisting of 10 Members appointed in 2012

Steering Committee meetings to finalize the Theme Paper

Advertise for Expressions of Interests (EoIs)

Out of 26 EoIs 7 were shortlisted initially

Presentations conducted by shortlisted candidates

Identification of potential projects for funding

Organizing Planning Workshops for research teams to finalize and develop full proposals

Obtain Board approval and award of new grants

2012 - 7 grants were awarded
2013 - 2 new grants were awarded

Analyze gaps in the program

Identify possible partners to fill these gaps and monitoring of the ongoing projects

9 approved projects were closely monitored

Organizing the 1st RCM (Research Coordination Meeting)

53 Steering Committee Meetings held including progress reviews; 5 onsite evaluation visits were conducted

Organizing 1st, 2nd ,3rd RCMs & have the Final Review (4th RCM) and Follow up

- **1st RCM** - 28th November 2012
- **2nd RCM**- 28th January 2014
- **-3rd RCM** - 8th September 2015
- **-4th RCM** - 20th December 2016

2 Stakeholder workshops were held.

4.Objectives of Projects implemented under the NTRP on Food Security Program

a) Continuous mapping of production, marketing and supply

Two research projects were selected for funding under this programme

i Development of a web-based crop forecasting system in Sri Lanka

Project Leader: Dr. R.M. Herath, Department of Agriculture

A reliable and appropriate crop monitoring and forecasting system that can be used for monitoring, planning as well as strategic and tactical decision-making process can contribute towards ensuring food security in Sri Lanka. This requirement is further intensified by the significant effects and impacts of changing climate which threatens sustainability in agricultural production in the country. Our conventional method of monitoring and forecasting is through the collection of data from the field through relevant field officers and subsequent monthly progress review meetings based on aggregated field data. This system has shortcomings such as major delays in accessing data (often outdated) and the inability to find out the areas that should receive greater attention and focus.

The objective of this study was to develop a web-based system to provide timely and reliable information on crop yields and area planted and production through the collection of agronomic and other farm information at farm level.

ii A social Life Network to enable farmers to meet the varying food demands of the population, by providing needed information just in time (real time basis) and better monitoring and management of crop production (A Mobile based Agriculture Information System for Farmers)

Project Leader: Prof. Gihan Wickramanayaka, University of Colombo School of Computing

Farmers require information at all stages of the farming life cycle in order to make optimal decisions. The required information includes not only prior knowledge in crop production but also real time information on market prices and current production levels of a given crop. Some of the information needed by farmers is provided by government organizations in the form of leaflets, publications etc. and are available at various locations. Although farmer is the most important stake holder in agriculture there has not been any concerted effort to provide some of the vital information to farmers on real time basis. Lack of such information has created many difficulties to farmers (e.g. over production and lack of a market for the produce) as they have not been able to make the right decisions at the right time relating to their farming activities.

The increasing accessibility of mobile phones to Sri Lankan population has provided a unique opportunity to allow farmers cultivate and market the required crops in a cost-effective in any desired geographical location. This would also encourage the development of a systematic way to assist farmers by providing real-time (just-in-time) assistance within the context of the available information and communication infrastructure throughout the food production cycle (i.e. Crop selection, growing and selling). The sensors in mobile phones could be used to capture required information in real time.

Based on assessment made through formal and informal interviews of farmers and agriculture officers and the reaction of farmers towards mobile technology including their ability to adapt the new technology, a mobile based prototype was developed. The Mobile Agriculture Information System will be able to register a farm and a farmer, select crops and varieties suitable for a location, estimate the cost of production based on information on fertilizer and pesticide requirements and their present market price, view prices being offered to the particular crop on real time basis in and around the site of cultivation, and even get advice from relevant authorities in case of a pest or a disease outbreak.

b)Internal and external trade policies

Two research projects were selected for funding:

i Assessing internal and External Trade Policies and Practices affecting food security in Sri Lanka, and identifying areas for improvement

Project Leader: Prof. Udith K Jayasinghe-Mudalige, Wayaba University of Sri Lanka

Three main factors contribute to fulfilling the domestic demand for food products. They are domestic production, imports and trade policies. Increased domestic production and imports play a very important role in meeting increased demand. Markets and trade ensure that food is efficiently distributed.

Policy interventions are the main tools which drives a government to achieve a food secured nation for which fiscal and monetary policies play an important role. Nevertheless, limited information is available in the context of food system in Sri Lanka combining the actual behavior of households and the food supply chain (in terms of production, prices and consumption) and the government (facilitative and regulatory policies). This acts as a larger impediment for policymakers to design incentive-based people-oriented policies.

Markets and trade also play a crucial role in achieving food security by increasing access to food. At the simplest level, trade allows food to flow from areas of surplus to areas of deficit—in local, regional, and global markets. Well-functioning markets transmit price signals, which allow changes in demand to be met by supply. When demand is greater than supply, producers increase production in response to price signals, and this increased production, in turn, helps to stabilize prices. By transmitting information in this way, markets help to reduce price volatility.

This project was aimed at achieving three objectives, namely (1) reviewing internal and external trade policies in-effect that has an impact on the food system in Sri Lanka, (2) modelling the behavior of food prices of major food items that have been produced and consumed domestically (e.g. paddy, vegetables) and have largely been imported to (e.g. sugar, milk, dhal) and exported from (e.g. tea, desiccated coconut) the country, and (3) to assess the impact of expected changes in trade policies and food prices (predicted from above) on food production and consumption patterns, and in turn, the levels of food security of urban, rural and estate sectors in Sri Lanka.

Several food items of national importance in terms of domestic production and import trade, having a direct impact on the state of household food security – paddy, potato, big onions, sugar and wheat – were selected for the study.

ii A study of supply and price behavior relating to Selected Crops and Livestock products in Sri Lanka
Project Leader: Dr Athula Senarathna, Institute of Policy Studies

This study examined and analyzed demand, supply and value chains of rice, fish and dairy products with respect to their contribution to the food security in Sri Lanka. Rice is the major source of energy in Sri Lankan diet whereas fish and dairy products are the key sources of animal protein.Hence their contributions are critically important for food security in Sri Lanka.

Key objectives of the study were to:

- Understanding the nature of demand formation and supply response relationships of rice, fish and livestock products,
- Analysis of value chain relations and identify market structures of rice, fish and livestock products,
- Identify policy, institutional and technical constraints that affect functioning of markets,
- Recommend feasible policy interventions to overcome constraints and barriers

c) Integrated food production systems
I Development of sustainable integrated food production systems to enhance household food and nutritional security, economic growth and livelihood of resource poor families in the Northern Region of Sri Lanka
Project Leader: Prof. G Mikunthan, University of Jaffna

Family food production systems, which serve as a source of food security, are found in most regions of many countries worldwide, which are known as home, mixed, backyard, kitchen, farmyard, compound or homestead gardens.

Usually, the functions and output of the home garden complement field agriculture. Whereas field crops provide the bulk of energy needed by the household, the home garden supplements the diet with vitamin-rich vegetables and fruits, as energy and animal protein sources and/or herbs and condiments. These gardens have an established tradition and offer great potential for improving household food security and alleviating micronutrient deficiencies. Gardening can enhance food security in several ways, most importantly through: 1) direct access to a diversity of nutritionally-rich foods, 2) increased purchasing power from savings on food bills and income from sales of garden products, and 3) fallback food provision during seasonal lean periods.

Even though criticism prevails that gardening is only feasible for households with access to land, water and technical assistance, leaving out many of the food insecure, even very poor, landless or near landless, people practice gardening on small patches of homestead, vacant lots, roadsides or edges of a field, or in containers. Gardening may be done with virtually no economic resources, using locally

available planting materials, green manure, “live” fencing and indigenous methods of pest control. Thus, home gardening at some level is a production system that the poor can easily adopt.

The project was aimed at developing a sustainable and integrated food production system in the households to enhance household food and nutritional security, economic growth and livelihoods of resource poor families in the Northern Region of Sri Lanka. After the war ended in 2009, the war affected families were resettled in various places in Northern Province.

ii Development of Household Food Security models for poverty stricken areas of Sri Lanka
Project Leader: Dr. S Pathmarajah, Faculty of Agriculture, University of Peradeniya

The main objective of this study was to develop household food security models to ensure nutritional security and food safety in poverty stricken areas of Sri Lanka. However, the team was directed to restrict the study to the central province which consists of three districts namely, NuwaraEliya, Kandy and Matale. Since Nuwara Eliya district consists predominantly of plantation population whose poverty dimension is different from the other rural population of Sri Lanka, this district was not included in the study. As such, poverty stricken two DS divisions from Matale and two from Kandy districts were selected for the study based on the published information by the Department of Census and Statistics.

d) Post harvest technologies
i Application of novel techniques to minimize postharvest losses of five selected fruit and vegetable varieties
Project Leader: Prof K K D S Ranaweera, University of Sri Jayawardhenepura

It is reported that post-harvest losses of fruits and vegetables in Sri Lanka varies between 15-40%. Therefore, minimizing such losses is a major challenge in the agriculture sector. While recent developments in packaging and transport may have reduced these losses to a considerable extent, post-harvest losses in fruits and vegetables is still a subject to recon with, which requires urgent attention.

The project was designed to introduce new techniques to minimize post-harvest losses of selected crops namely leeks, tomato, capsicum, and banana.

ii Food Security through Adoption of Pre-harvest Technologies: Improving Quality of Fresh Produce by soil application of potassium and Silicon
Project Leader: Dr H L D Weerahewa, OUSL

Postharvest losses of vegetables and fruits account up to 30-40% mainly due to multitude of problems at all stages of postharvest chain. The magnitude of losses and the impacts are well known but very little success have been achieved in reducing these losses. In this context, development and implementation of pre-harvest strategies, particularly the low cost technologies are imperative.

The proposed research focuses on the development of pre-harvest technologies, ie. application of extra doses of potassium and silicon (as a form of partially burnt rice hull), to the soil to improve the

quality, disease resistance and shelf life of perishable produce commonly grown in Matale and Nuwara-Eliya districts, thereby reducing post-harvest losses. Three commonly grown vegetables tomato, capsicum and leek were selected for the study.

e)Development of Food safety and quality standards
i Establishing a national system for ensuring microbiological food safety
Project Leader : Dr T B Ananda Jayalal, Ministry of Health

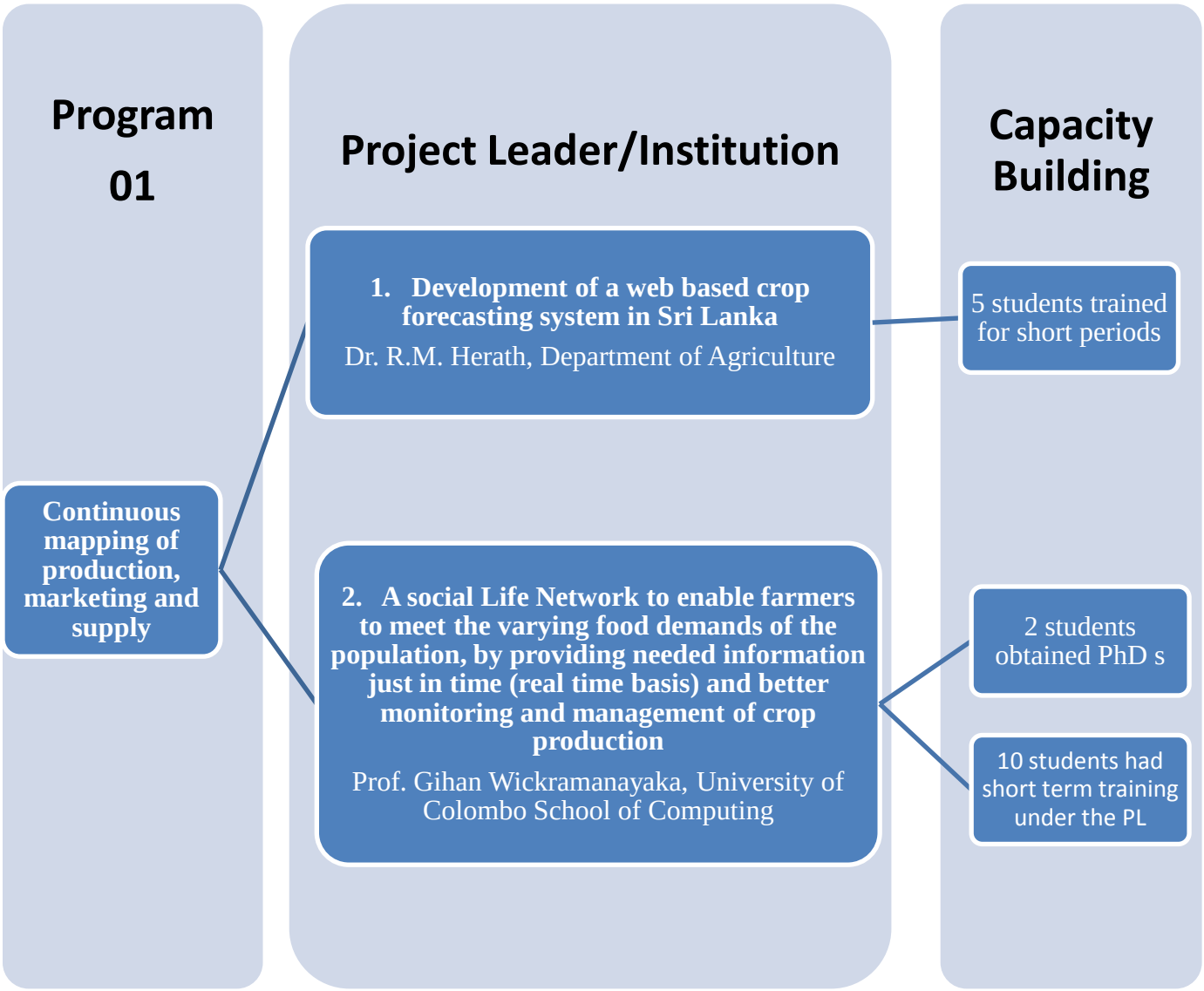
The present system of food borne disease outbreak notification is as follows. Following a food borne disease outbreak patients are either admitted to a hospital or treated as out patients. The medical officer will fill H544 notification form and send this information to the Epidemiology Unit through the Infection Control nurse, who will be responsible for maintaining the records. Stool samples collected will be processed in the microbiology laboratory of the hospital. If food poisoning is suspected samples will be collected by the PHI and sent to MRI for analysis. Results are reported to the relevant institution over the phone.

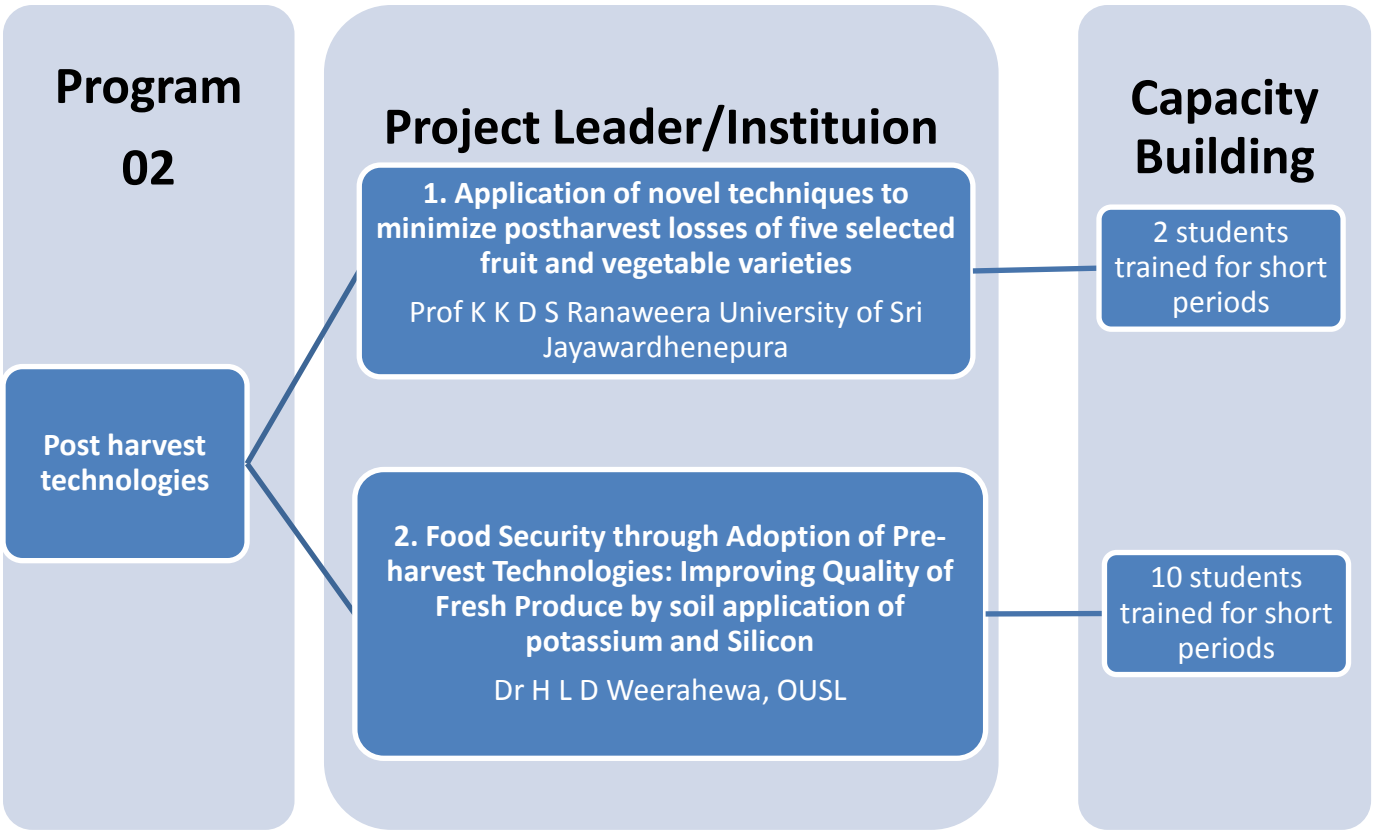
Following gaps have been identified in the existing system.

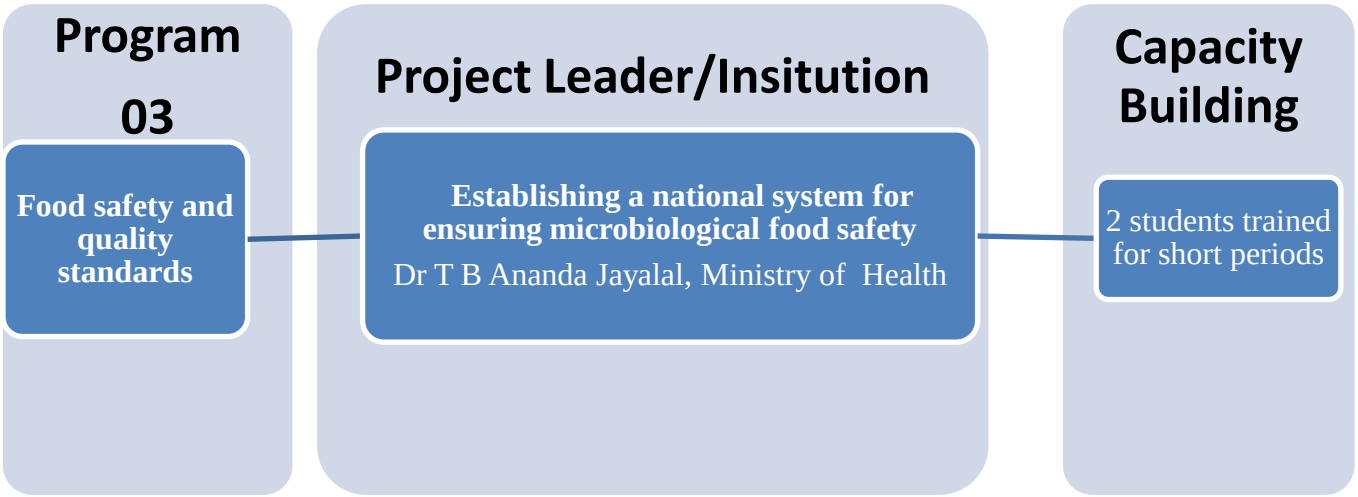
- There is under-reporting because only data related to in-patients are reported.
- There is a lack of communication between the responsible bodies. There is no systematic way for sharing information.
- While the Infection Control Unit has records of outbreaks they do not have records on laboratory results or the causative agents
- Reports of outbreaks are limited to only to major outbreaks
- Sample numbers are limited as patients are generally reluctant to give stool samples
- There are delays in notification
- Present system does not allow a way to find the cause of the outbreak. Therefore control measures may not address the origin of the outbreak.

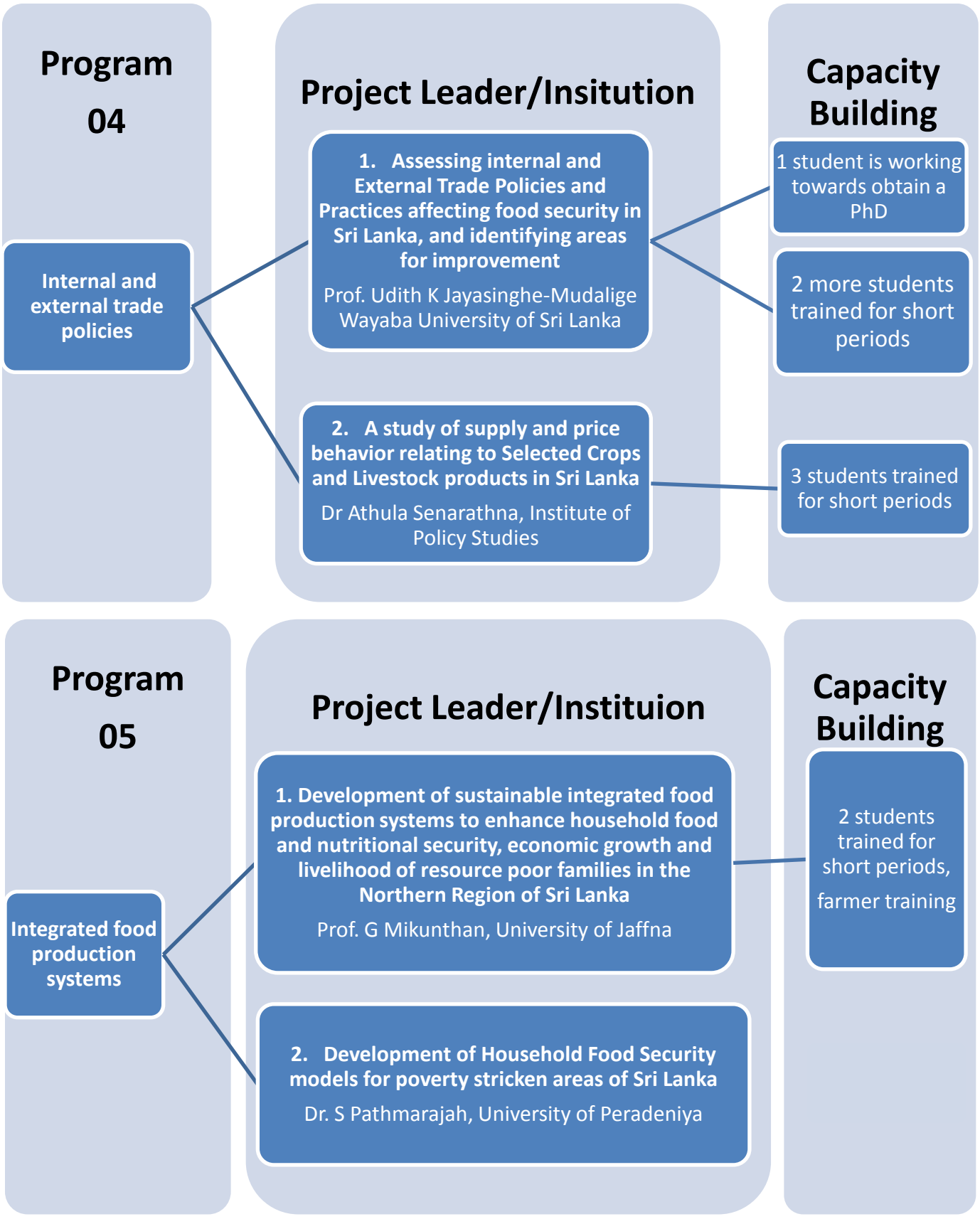
Accordingly, the study envisaged the collection of data on the current mechanism of notification of foodborne diseases/outbreak in Sri Lanka from relevant Institutes, revise and strengthen the notification system of food borne illnesses and existing laboratory surveillance and establish a web-based system for foodborne outbreak notification.

5. Project teams involved and capacity building achieved




Program 02
Post harvest technologies
Project Leader/Instituion
1. Application of novel techniques to minimize postharvest losses of five selected fruit and vegetable varieties
Prof K K D S Ranaweera University of Sri Jayawardhenepura
2. Food Security through Adoption of Pre-harvest Technologies: Improving Quality of Fresh Produce by soil application of potassium and Silicon
Dr H L D Weerahewa, OUSL
Capacity Building
2 students trained for short periods
10 students trained for short periods


Program 03
Food safety and quality standards
Project Leader/Insitution
Establishing a national system for ensuring microbiological food safety
Dr T B Ananda Jayalal, Ministry of Health
Capacity Building
2 students trained for short periods


Program 04
Internal and external trade policies
Project Leader/Insitution
1. Assessing internal and External Trade Policies and Practices affecting food security in Sri Lanka, and identifying areas for improvement
Prof. Udith K Jayasinghe-Mudalige Wayaba University of Sri Lanka
2. A study of supply and price behavior relating to Selected Crops and Livestock products in Sri Lanka
Dr Athula Senarathna, Institute of Policy Studies
Capacity Building
1 student is working towards obtain a PhD
2 more students trained for short periods
3 students trained for short periods
Program 05
Integrated food production systems
Project Leader/Instituion
1. Development of sustainable integrated food production systems to enhance household food and nutritional security, economic growth and livelihood of resource poor families in the Northern Region of Sri Lanka
Prof. G Mikunthan, University of Jaffna
2. Development of Household Food Security models for poverty stricken areas of Sri Lanka
Dr. S Pathmarajah, University of Peradeniya
Capacity Building
2 students trained for short periods,
farmer training

6.Project monitoring process and fund disbursement

All the awarded projects were monitored closely under the supervision of the Steering Committee members who had expertise in areas related to food security. On-site field evaluation visits, progress review seminars and research coordination meetings were held to monitor the progress of each project.

Under the program, 53 Steering Committee Meetings were held including progress reviews, and 5 onsite evaluation visits in Jaffna, Kandy, Colombo and Dambulla areas.

Four Research Coordination Meetings (RCMs) were held to monitor the progress of the projects and to recommend the budget for the activity plans submitted for the ensuing year.

- **1st RCM** - 28th November 2012
- **2nd RCM**- 28th January 2014
- **3rd RCM**- 8th September 2015
- **4th RCM**-20th December 2016

Funds were disbursed for the first six months initially and then annually after ensuring that the projects were progressing well. Funds were requested by the investigators at Research Coordination Meetings supported by an activity plan, which was then recommended by the Steering Committee and subsequently approved by the Board of Management.

7.Number of people who benefited by this programme

a) Development of a web based crop forecasting system in Sri Lanka

On pilot scale farmers in the Central province benefited from this project as they could forecast Crop yield/production during the cultivation season. They were also able to obtain information on extent of cultivation of a given crop in the given area as well as forecast production of the crop.

With the deployment of the system island wide by the Ministry of Agriculture, more farmers are expected to benefit in the future.

b)A social Life Network for farmers – A Mobile based Agriculture Information System.

On-site testing showed that the Mobile based Agriculture Information System would enable farmers to meet the varying food demands of the population, by obtaining needed information on a real time basis. This system supported the better monitoring and management of crop production as well.Farmers in the central province benefited by the pilot project. However, more farmers are expected to benefit once the system is introduced to other areas of the country.

c)Assessing internal and External Trade Policies and Practices and supply and price behavior relating to Selected Crops and Livestock products in Sri Lanka.

Both projects assessed internal and external trade policies and outcomes of these projects will be useful to policy makers, economists and other relevant parties in the future activities.

d)Pre and post harvest Technologies

The benefits to the farming community on above two aspects will be visible once the technologies are fully developed and disseminated.

e)Food safety and quality standards.

The benefitsto thecommunity is subject to the development of a more suitable (real time based) reporting system. The project identified the gaps that are required to be addressed.

f)Development of sustainable integrated food production systems to enhance household food and nutritional security, economic growth and livelihood of resource poor families in the Northern Region of Sri Lanka

The householders from the 5 districts who participated in the project were the direct beneficiaries from the project. They would have benefited health wise because of the several fold increase in vegetable consumption, harvested from their home gardens.

In addition other house holders who participated in the training programmes began to be engaged in home gardening and would undoubtedly benefit in the future.

8. Potential socio-economic and environmental impacts

Socio-economic Impacts

Out of the nine projects funded by the NSF, six have been successfully completed, two partially completed and one terminated prematurely. Of the successfully completed projects, two were on policy formulation, two were on the use of information technology (IT) and two on generation of new technologies. The two partially completed projects produced good outputs but they require further development to realize their full potential.

All eight projects generated new knowledge pools and the IT projects, and the technology projects developed products that could be used for the advancement of the agriculture sector of the country. Accordingly, outputs generated by all eight projects have an economic value.

Quantification of the economic impact of the project outputs to the society at large is not a straight forward exercise. This is more so with respect to the two studies on policy formulation. However, several non-monetary economic benefits can be cited. The two policy studies documented agricultural policies implemented by the successive governments of Sri Lanka, put-together a large spectrum of data pertaining to production, consumption, trade, prices, policy levels etc. in relation to various agricultural sub-sectors, analyzed the data using various techniques and made observations/recommendations. The acceptance of such observations/recommendations by the policy makers should lead to policy recommendations. If accepted by the government, there will be benefits to the citizens at large and more specifically to the food insecure groups.The intermediate outputs of the project such as policy documentations and data sheets will be a useful resource for the next generation of policy analysts.

The economic benefits of the two projects on IT are clear. Once the packages developed are provided to the farmers, they will be able to make better decisions with respect to agricultural production. The Ministry of Agriculture is already considering the output of the project on “Development of a web based crop forecasting system in Sri Lanka” to be used as a risk mitigation device. As mentioned in the dissemination plan, the other project on “Mobile Agriculture Information System for farmers” is a mobile app-based system and requires a corporate sector investor with agricultural background anda Mobile Network service provider to implement the programme. Economic benefits of this project are obvious but yet to be quantified.

Among the four projects on technology development, two were on home garden development. As mentioned earlier, one project failed to deliver any output. The other project on “Development of Sustainable Integrated Food production system to enhance household food and nutritional security economic growth and livelihood of resources poor families in the Northern Region of Sri Lanka” has developed several model home gardens which can readily be adopted by the home-gardeners in Northern Province. It will certainly help in improving household income and alleviate poverty and malnutrition in the region.

When considering both social and environmental impact of the home garden project in the Northern Region, it was clearly seen that in Kudarappu, Jaffna the initial status of the household & garden prior

to interventions was a land with sandy soil with hardly any vegetation. But after interventions over 3 years through the Home Gardening project fruits trees (mango, guava and banana) and vegetables (onions, moringa, brinjals and leafy vegetables) could be seen growing successfully providing supplementary food and additional income to the farming family. The adjoining land has now become a playground for children. A Grama Niladhari office has also been set up, providing additional social benefits to the community. Therefore, the expansion of the food security program to particularly address nutrition and health effects to broaden and deepen socio-economic effects are strongly recommended.

Other two projects on postharvest losses need further development to realize their full potential. The project on improving quality of fresh produce by soil application of Potassium and Silicon yielded some good outputs. The team has already conducted a financial analysis and showed that the technologies developed were financially feasible and the adoption of the two technologies by farmers can be increased if they are provided with credit facilities. The beneficiaries of the technology include not only the farmers who adopt it, but also the users of the produce such as processors, exporters and consumers of the products because of improved quality, disease resistance and increased shelf life. The project on application of novel techniques to minimize postharvest losses of five selected fruit and vegetable varieties yielded some outputs but the economic impacts of these outputs could only be appraised when the project is completed and the new technologies adopted by the farmers.

All in all, the output of the eight projects will help in increasing food availability at the national level. If implemented, the outputs of two policy projects could address food insecurity at the household level and the output of the successful home-garden project could alleviate food insecurity at household/individual level in the Northern Province.

9. Budget spent and reasons for not spending allocated funds

Total of Rs 54,643,540/- was distributed among institutes to carry out the NTRP research program. The researchers have spent Rs 41,974,670.16/- and returned the balance amounting to Rs 12,668,824.84 /- . 23% of the allocated money was not spent (reasons given below).

Grant No/Project Leader	Total Funds disbursed (Rs)	Total Expenditure (Rs)	Balance returned to NSF (Rs)	Reasons for not spending allocated fun
NTRP/2012/FS/PG-01/P-01 Dr. R M Herath Dept. of Agriculture	8,297,000.00	1,850,819.83	6,446,180.17	The team was planning to install a data warehouse with a central server in Peradeniya to collect data from regional centres. However, they could not implement it as planned due to the long delay in developing the software by the UCSC. Furthermore, the software has been taken over by the Ministry of Agriculture to be used island wide
NTRP/2012/FS/PG-01/P-02 Prof. G.N. Wikramanayake UCSC	7,308,000.00	5,545,438.48	1,762,516.52	Most of the funds returned comes from the Travel vote which has not been utilized. Project concentrated on software development
NTRP/2013/FS/PG-02/P-01 Prof. K.K.D.S. Ranaweera University of Sri Jayawardenepura	2,659,600.00	1,586,108.00	1,073,491.44	Some of the proposed objectives could not be achieved because project activities were affected by unexpected rain and flood conditions
NTRP/2013/FS/PG-02/P-02 Dr. H.L.D. Werahewa OUSL	5,830,000.00	5,418,452.58	411,547.42	Some of the proposed objectives could not be achieved because of unexpected rain and flood conditions in the location
NTRP/2012/FS/PG-03/P-01 Dr. T.B. AnandaJayalal Ministry of Health	1,070,000.00	818,373.88	251,626.12	-
NTRP/2012/FS/PG-04/P-01 Prof. Udith K Jayasinghe-Mudalige, Wayamba University of Sri Lanka	3,795,300.00	3,272,092.95	523,207.05	-
NTRP/2012/FS/PG-04/P-02 Dr. AthulaSenaratna Institute of Policy Studies	17,193,000.00	17,186,028.80	6,971.20	-
NTRP/2012/FS/PG-05/P-01 Dr. S. Pathmarajah, University of Peradeniya	2,400,640.00	1,353,690.80	1,046,949.20	Prematurely terminated for inadequate progress
NTRP/2012/FS/PG-054/P-02 Prof. G. Mikunthan, University of Jaffna	6,090,000.00	4,943,664.28	1,146,335.72	Funds allocated for extension of the outcomes, returned as requested by NSF

10. Overall Outcomes

While accepting the importance of all four dimensions of food security, namely i) Availability, ii) Accessibility, iii) Use and utilization and iv) Resilience, the NTRP programme concentrated essentially on dimension i) The uninterrupted availability of nutritious and quality food for the public. Accordingly, NSF focused on the following five programmes under its NTRP on Food security since outcomes from such research were expected to contribute towards the availability of nutritious and quality food for the people.

f) Continuous mapping of production, marketing and supply
g) Internal and external trade policies
h) Integrated food production systems
i) Post-harvest technologies
j) Food safety and quality of standards

I Continuous mapping of production, marketing and supply

The web-based crop forecasting system that has been developed by the Department of Agriculture with technical expertise from the University of Colombo School of Computing, was deployed by HE the President on 10th January 2017. When operated throughout the country, it will provide timely and reliable information on extent of cultivation, expected production, marketable surplus etc. of various food crops grown in the country. This information accessible at Agrarian Service Centers, or any other point at District and National level, could be used as a risk mitigation device as well as in decision making when planning and implementing crop production programmes. The present method of data collection through monthly progress review meetings and aggregate data collected through field officers are often too late for timely decision making in relation to planning, cultivation, harvesting and marketing of field crops.The Ministry of Agriculture intends to use this programme in the future for monitoring food production programmes island wide and implement the fertilizer subsidy and crop insurance schemes.

The programme was deployed by HE the President on 10th January 2017.

The Mobile based Agriculture Information System that has been developed by the University of Colombo School of Computing in collaboration with three foreign institutions, is a Mobile App that provides a unique opportunity to farmers on an individual basis, to cultivate and market the required

crops in a cost-effective way in any desired geographical location. Installed on a smart phone it can provide real-time information for selecting crop varieties suitable for a given location, estimate the cost of production based on information on fertilizer and pesticide requirements and their present market price, view prices being offered to aparticular crop in and around the site of cultivation, and even get advice from relevant authorities in case of a pest or a disease outbreak. Lack of relevant information on a real-time basis has created many difficulties to farmers (e.g. over production and lack of a market for the produce) as they have not been able to make the right decisions at the right time relating to their farming activities.

The App on a smart phone

ii Internal and external trade policies

The outcomes of analysis, which were reported in the form of 5 specific reports to provide specific details and facilitate data visualization, suggest, more specifically, that the trade policies in Sri Lanka from 1970s to date are in the form of "protectionist" policies either as tariff measures or non-tariff measures. The level of protectionism has, however, been "varied" over the years in most agricultural commodities showing inconsistencies in policy. The previous policies have led to an increase in local production in most cases (i.e. increases the 'availability' – a key facet of food security), but they could not bring the nation to self-sufficiency. Further, the behavior of prices (i.e. economic accessibility) can be attributed into three broad conclusions, i.e. 'real' prices reduce; 'nominal' prices increase, and the 'variability' of prices increase. Economy wide simulations of trade liberalizing policies show that liberalization policies increase 'food consumption/utilization', which is also considered a key facet in food security. Moreover, field level verifications by household data with 'direct food security measures' show that domestic price increases (either because of tariffs/sales taxes) reduce the food security levels of households.

What is evident through the modeling exercises are,that thefertilizer subsidy and output price support policies maintained by various governments had helped to increase the rice production, and which in turn, has led to a decline in real prices over time. This increase in supply and decrease in prices indicate the increase in 'food availability' and 'food accessibility' for households.

It is recommended that government policy should be aiming towards long-run increases in supply, which would keep retail prices at bay and assisting local producers. The policies practiced hitherto have been able to achieve this objective to a considerable level; so they should be retained**.**

Liberalization policies seem to work in terms of food security but policy should be directed at reducing volatility of food prices (e.g. investment on buffer stocks, market information); policies on most cases are 'ad hoc'; greater policy predictability should be guaranteed, and a combination of policies on productivity improvements and liberalization may be the way forward.

In a study of supply and price behavior of rice, fish and dairy products in Sri Lanka, consumption patterns varied by different categories of consumers. Declining expenditure elasticities were indicated for rice with higher expenditure quartiles whereas opposite was reported for fish and dairy products. This implies that anincreased share of fish and dairy products in household expenditure can be expected with rising income while the share of rice will be declining.

Supply analysis indicated that total production of rice and fish has been positively influenced by structural factors relating to respective production systems that acted as supply shifters. In case of rice, increase in land extent under cultivation still play a major role in supply whereas increased fishing effort is the main contributing factor in supply of fish**.** Estimation of supply elasticities was not possible for dairy products due to poor availability of data but descriptive analysis indicates gradual increase in the share of local production in the total supply dominated by imports.

Examination of value chains suggests that rice and paddy markets are quite competitive against the popular belief. Hence, the state interventions in the market through price support policies need reassessment. In contrast, value chain of dairy products show significant concentration of market power in the hands of few suppliers in certain layers highlighting the importance of competition promotion policies.

The two policy studies documented agricultural policies implemented by the successive governments of Sri Lanka, put-together a large spectrum of data pertaining to production, consumption, trade, prices, policy levels etc. in relation to various agricultural sub-sectors, analyzed the data using various techniques and made recommendations to the government of Sri Lanka. The acceptance of such recommendations by the policy makers is yet to be observed. If accepted, there will be benefits to the citizens at large and more specifically to the food insecure groups.The intermediate outputs of the project such as policy documentations and data sheets will be a useful resource for the next generation of policy analysts.

iii Integrated food production systems

In relation to Integrated Food Production Systems, two projects were funded. The successfully completed project- the 'Development of sustainable integrated food production systems to enhance household food and nutritional security, economic growth and livelihood of resource poor families in the Northern Region of Sri Lanka', selected five districts namely, Jaffna, Kilinochchi, Vavuniya, Mullaitivu and Mannar. Based on the resettled map, places were selected and based on the population of resettled families a survey was conducted to assess the livelihood of the people especially on the resources available, both in terms of manpower as well as infrastructure, income generation, their diets and living standards. Afterthe survey, one home garden was selected in each district and keeping them as a model, training programs were conducted periodically to educate other families to understand the role of home gardens, their composition and provision of food and other services necessary to uplift their livelihoods.

Over the reporting period (3 years) the livelihood of the resettled people improved immensely. The simple innovations/interventions, eg.cages and baskets made of old bicycle rims, vehicle tyres, palmyrah leaf etc., and the use of household waste to enrich the sandy soils, allowed the families to grow leafy vegetables and other vegetable crops in their home gardens, which improved their nutritional status. The home gardens also provided fresh fruit such as mango, guava and banana and vegetables such as onions, moringa and brinjalsfor home consumption. These became supplementary sources of food and in many cases brought-in an additional income to the family as excess production was sold to neighbours (or sometimes exchanged for other goods). It is reported that some families earned as much as Rs. 10,000/- per month as additional income from their home garden.

Cages made out of palmyrah leaves and bicycle tyres for growing leafy vegetables

As shown in the two examples below, there was also a visualimprovement of the land associated with home gardens. For example, in the model home garden in Kudarappu in Jaffna district, the land that was of pure sandy soil and of little productivity (with hardly any vegetation) was converted to a relatively high productive land with vegetable crops and trees. With continuous enrichment of the soil the family started growing perennial crops such as coconut and common fruit trees like mango, guava and cashew. As a result of this development the adjoining land was converted to a play ground for children by the governing council of the area. The Grama Niladhari Office for the area was also located in the same premises. Such activities by the government not only meant the recognition of the efforts of the people but also paved the way to improve the social and economic benefits to the people.

The home gardens, established in the households of the resettled areas of the five districts in the Northern Region which are generally poverty stricken with inadequate and imbalanced diets, enhanced food security in several ways, most importantly through direct access to a variety of nutritionally-rich foods, and increased purchasing power from savings on food bills and income from sales of garden products.

Example 1. Home garden in Kudarappu in Jaffna district

The initial status of the household &home garden prior to interventions shows a land with sandy soil with no vegetation.

Above home garden after interventions over 3 years

Fruit trees such as mango and vegetables such as onions and moringa became well established in the sandy soil

Adjoining land is now a play ground for children. Grama Niladhari Office is also located in the same land

Examples 2. Below are two home gardens along the A9 Road in Killinochchi with fruits and vegetablesand a well established pineapple crop.

Iv Innovations for reducing post-harvest losses of fruits and vegetables

Post-harvest losses of fruits and vegetables in Sri Lanka varies between 15-40%. Therefore, minimizing such losses is a major challenge in the agriculture sector. While recent developments in packaging and transport have reduced these losses to a considerable extent, post-harvest losses in fruits and vegetables is still a subject to recon with, which requires urgent attention.

This project was designed to introduce new techniques to minimize post-harvest losses of selected crops namely leeks, tomato, capsicum, and banana.

An initial survey revealed that: among the selected crops tomato has the highest total loss of 20% followed by leeks (18%), capsicum (12%) and banana (4%). At the farmer level post-harvest loss varied from 1-5%. At the retailer and customer level post-harvest losses ranged from 5-8% and 4-9%, respectively. Large bundle size and poor packaging methods increased post-harvest losses of leeks. To minimize losses of tomato the strength of the boxes have to be improved with proper covering of boxes. Existing packaging method of using polysack bags for capsicum is un-suitable. An improved packaging system must be introduced for capsicum. Lack of concern on quality by transporters and their workers leads to physical damage to banana while handling and transporting.

Ripening of Embul banana can be delayed up to 8 days by establishing a modified atmospheric condition with 200 G polyethylene bags and adding 0.1 % $KMnO_4$. A cookie and jam can be produced using overripe embul banana to minimize waste. Banana chips made by ash and seeni banana could be a good substitute for French fries in the fast food industry.

While the project is yet to test on a large scale, it has been shown that using air column packaging material is better than air bubble packaging material for transporting vegetables such as leeks and capsicum.

Pre-harvest strategies can also reduce post-harvest losses of fruits and vegetables. The project on application of extra doses of potassium and silicon (in the form of partially burnt rice hulls) to the soil clearly showed that such technologies could improve the quality, disease resistance and shelf life of perishable produce such as tomato, capsicum and leeks. Application of increasing doses of potassium increases resistance to fungal disease anthracnose, both in tomato and capsicum**.** The quality of fruits in terms of fruit firmness (hardness) and cell wall thickness were found to increase with the increasing levels of potassium application in both crops.

Cost effectiveness of application of potassium and partially burnt rice hulls show that the extra cost due to increased levels of potassium or partially burnt rice hullscan be overcome by the increased yields as well as reduced postharvest losses of tomato, capsicum and leeks.

11. Dissemination of knowledge

The software developed under the project NTRP/2012/FS/PG-01/P-02 of Prof Gihan Wickramanayake, which was target to be used island wide, held 9 workshops for farmers at Dambulla, Pollonaruwa, Galewela and Galawitiyawa. It also had collaborations with the Department of Agriculture, University of Colombo School of Computing, LINK Natural products, Hector Kobbekaduwa Agrarian Research and Training Institute (*HARTI*) and with University of Western Sydney, Australia. The knowledge created was also disseminated through 15 foreign communications and through 3 foreign publications, one with an Impact Factor of 1.98. The other software developed by the project awarded to the Department of Agriculture (NTRP/2012/FS/PG-01/P-01) also planned to implement the software island wide and the findings were disseminated through 2 communications.

Under program 2, Project Leaders had collaborations with the University of Sri Jayawardenepura, Department of Agriculture and the Open University. Some of the field trials of NTRP/2013/FS/PG-02/P-02 were conducted with farmers at Dambulla, Matale and Nuwara Elya and the Project Leader had 5 foreign publications and 8 communications at the end of the period of the project.

The project awarded under the program 3 (NTRP/2012/FS/PG-3/P-01) held one workshop on Food Borne Outbreak investigation- for MOH officers Gampaha. It also had collaborations with Medical Research Institute, Lady Ridgeway Hospital, Colombo South Teaching Hospital, Maligawaththa Hospital and with the National Institute of Health Sciences, Kaluthara.

NTRP/2012/FS/PG-04/P-02 and NTRP/2012/FS/PG-04/P-01, two projects on policy studies awarded under program 4, had collaborations with the University of Peradeniya, University of Wayamba, United Nations World Food Program, Coordinating Secretariat for Science, Technology and Innovation (*COSTI*),National Aquatic Resources Research and Development Agency (*NARA*), Ministry of Agriculture, Department of Agriculture, Horticultural Crop Research and Development Institute (*HORDI*), HARTI, Rice Research Institute, Ministry of Fisheries and Aquatic Resources. The project NTRP/2012/FS/PG-04/P-01 has conducted a nutritional survey using 4000 Households Island wide including coastal estate rural and urban areas and also conducted a stakeholder workshop involving 30 participants. The project awarded to the Institute of Policy Studies also conducted a similar stakeholder workshop with 40 participants and also has published their findings in 3 local communications.

Project NTRP/2012/FS/PG-05/P-01, aimed at introducing home gardens for poverty stricken areas of Kandy and Matale districts held 2 field training workshops about Home Gardens at Horticultural Crop Research and Development Institute. It also had collaborations with the University of Peradeniya and Institute of Fundamental Studies. With the project NTRP/2012/FS/PG-05/P-02, the Project Leader has introduced and implemented successful Home gardens on sandy soils at Jaffna, Kilinochchi, Mulathiv, Mannar, Vavunia districts especially to the re-settled community. He also has created links with Department of Agriculture, LINK Natural Products, Non-Governmental Organizations, and Michigan State University, USA and disseminated the knowledge about Home gardening to the community through 3 local communications and 106 news paper articles. Further, training about Home Gardens and vermicomposting for farmers in Northern Province and organizing a stall about Home gardens at the exhibition conducted by Sidddha medicine unit, University of Jaffna were conducted.

12. Constraints and barriers faced and ways to overcome them

1. One of the major constraints experienced during the NTRP project was the insufficient involvement of the project teams in the planned activities of the project. The team members selected by the Project Leaders should be dedicated and have sufficient time and commitment to devote to project activities. Lack of support from the members will leave the Team Leader to carry out the activities by him/herself and this could lead to disastrous consequences. This was the main reason for the failure of NTRP/2012/FS/PG-05/P-01.

It is proposed that prospective Project Leaders are adequately briefed of the necessity to have the active participation of all members, prior to finalization of projects. A well prepared contractual agreement could strengthen this process.

2. NSF has many research grant schemes but the numbers of takers are limited to a handful of active scientists. It is evident that most of the prospective applicants tend to look for grant schemes that have additional benefits such as training and overseas travel opportunities. Fulltime involvement in an NTRP could deprive scientists of such opportunities through other Grant Schemes.

Therefore, an NTRP programme should have at least some financial benefit to the team leader as well as other members of the project team. A proper mechanism for this should be established **prior** to the initiation of the programme.

3. One of the reasons for inadequate involvement of team members in project activities could be the involvement of team members in academic or research activities related to their employment limiting the availability of time for work related to a NTRP.

One way to overcome this situation would be to allow the project to have fulltime post graduate student(s). This will also lead to capacity building in the specific area of activity.

4. Since the projects depend on natural conditions, the effect of weather conditions should be taken in to account when designing projects.

To overcome such issues a process should be established to make available adequate/additional finances in such situations and to have provisions to extend the grant periods if required.

5.Inability of the NSF to disburse funds on time as well as the stringentnational procurement procedures also affected the progress of the projected activities.

Introducing flexible procurement procedures for RDI activities is an immediate need for the NSF.

6. Awarding all grants at the same timecould also be used as a solution for close monitoring purposes and timely fund disbursements.

7. Seeking for a revised financial management system with adequate funding being available to the grantees at all times (within the total approved) would no doubt facilitate research activities.

8. In some projects, the Project Leaders (PLs) changed due to various reasons such as their retirement. Some PLs were changed due to lack of cooperation from other external entities to acquire data and information. As an example, the project awarded to the Faculty of Medicine, University of Colombo initially, had to face the difficulty of acquiring information from Ministry of Health. Thus the PL changed and the progress got hindered.

Ensuring adequate and sufficient cooperation between parties involved in the project from inception and strengthening the Contractual Agreement to reflect same accordingly could be proposed as a solution.