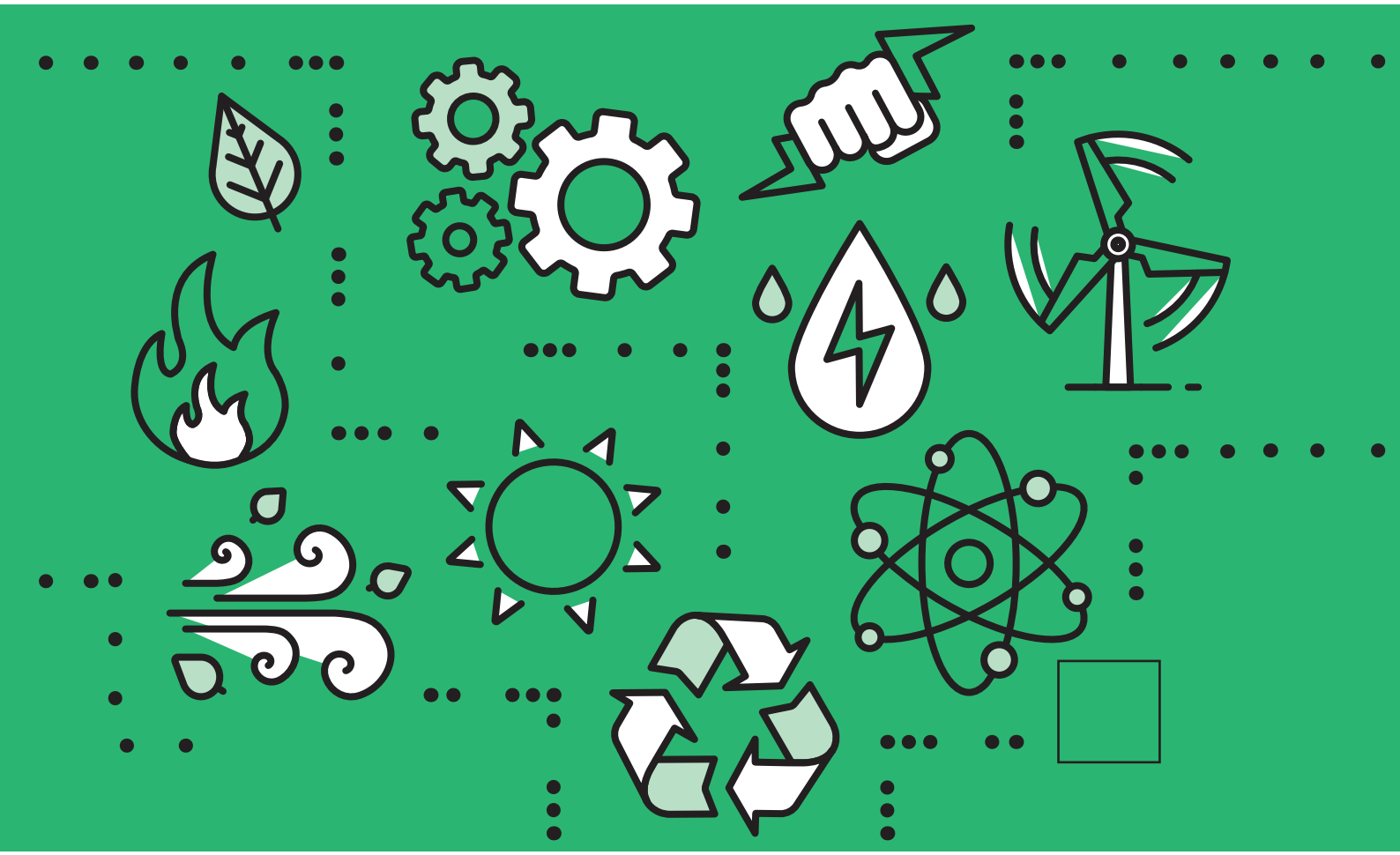

PROVINCIAL ENERGY PLAN FOR AGRICULTURE, FISHERIES AND LIVESTOCK (AFL) SECTORS IN THE NORTH WESTERN PROVINCE

Under the Biogas, Biomass and Solar Trilateral Cooperation Project

September 2021

Prepared by
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Prepared For
United Nations Development Programme (UNDP) in Sri Lanka

United Nations
Office for South-South Cooperation

Acknowledgement

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I wish to express my sincere thanks to UNDP Sri Lanka for the trust and confidence placed in me by entrusting this task and thereafter very enthusiastic encouragement, assistance and excellent cooperation extended by the Project Management Unit guided by Dr. Buddika Hapuarachchi - Policy Specialist and Team Leader, Climate and Environment Team and Ms. Sureka Perera - Programme Quality & Design Analyst and led by Mr. Sampath Ranasinghe (Programme Coordinator), Eng. Suranga Karavita (Technical Coordinator) and Mr. Dasitha Premarathne (Project Assistant) in performing this task.

On behalf of UNDP project Management unit, I highly value and appreciate the guidance and support given by the partners of the project, Professor Dong Renjie and Dr Zhou Yuguang Associate Professor of the Chinese Agricultural University, Officials of Administrative Centre for China's Agenda 21 (ACCA 21) and Regional Coordinator Dr. Denis Nkala and team of the UNOSCC for making this valuable exercise possible.

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Last but not least, I wish to express my sincere thanks and profound gratitude to all other parties without whose valuable contribution this report would not have been possible including district level officers, farmers and all others.

Eng M. M. R. Padmasiri

National Consultant Development of Energy Plans for the Agricultural Sector in Five Provinces
Trilateral South-South Corporation (TSSC) Project
UNDP Sri Lanka

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LIST OF ABBREVIATIONS

AFL Sector	- Agriculture Fisheries and Livestock setor
CCS	- Climate Change Secretariat
CEB	- Ceylon Electricity Board
DIM	- Direct Implementation Modality
GHG	- Green House Gas
NAMA	- Nationally Appropriate Mitigation Actions
NWP	- North Western Province
RETs	- Renewable Energy Technologies
SLSEA	- Sri Lanka Sustainable Energy Authority
TSSC Project	- Trilateral South South Corporation Project
UNDP	- United Nations Development Programme

EXECUTIVE SUMMARY

Energy and agriculture sectors are the largest Green-House Gas (GHG) emitters in Sri Lanka, representing around 59%, and 27% respectively of the total national GHG emissions (SNC, 2011). Thus, implementing energy efficiency measures and renewable energy technologies (RETs) in these sectors can have a significant impact in terms of emission reductions apart from significant socio-economic benefits to the country. However, the energy use and the energy generation (eg. Biogas) in agriculture, fisheries and livestock practices are not separately accounted in national or provincial level energy balances yet. The main reason may be the practical difficulties of collection of reliable and accurate data from the fields due to decentralized and scattered nature of operation. This report has been developed under the Biogas, Biomass and Solar Trilateral South South Cooperation (TSCC) Project which has been implemented with the objectives of introducing technologies and systems to enhance the Sustainable Energy Use in the Agriculture, Fisheries and Livestock (AFL) sector in Sri Lanka. Production and semi production process of the above mentioned sectors have been considered as the boundary of this analysis and technically viable renewable energy technologies have been analyzed and included in this action plan.

Agriculture Sector: There are about 300,000 hectares of agricultural land in North Western Province, and out of this about 90,500 hectares are paddy lands, 12,500 ha are vegetable cultivating lands and around 13,500 ha are fruit cultivating lands. Balance is for coconut and other crops [6].

According to the land use pattern, Norochcholai and Kalpity areas are very specific and climatic condition is almost uniform throughout the year. Rainfall is very low in these areas but the farmers are cultivating most of the upcountry vegetables pumping ground water without any major issue. Also, they are cultivating around 4 to 5 seasons with short rotation vegetables like beetroot, cabbage etc..

Around 269.408 million liters of auto diesel, 181.47 million liters of petrol (Octane 92) and 1372.122 GWh of electricity was used in 2019 [9] in North Western Province. Out of these around 8.0% of diesel, 1.0% of petrol and 01.4% of electricity is used in agriculture sector.

The energy consumption in paddy cultivation is the highest in North Western Province and rest of the energy is shared among vegetable and fruits cultivation. Out of the total energy consumption in agriculture sector (cultivation) land preparation and harvesting consume 56.5% and 24.7% respectively. Water pumping is the next and it shares around 12.73% of the total energy. In short rotation vegetable crops, more than 50% of total energy consumption shares are for water pumping and approximately 31% for land preparation.

Fisheries Sector: Production and semi production processes in marine fishing, inland fishing, ornamental fishing and shrimp farming are considered as the boundary of this report under fisheries sector. There are no field level fish storage facilities in the North Western Province and all the stocks are sent to the processing centers just after harvesting.

Marine fishing is carried out in Puttalam district in North Western Province. The total annual marine fish production is in the range of 60,000 to 75,000 tons per annum and this shares approximately 15.0% of the national marine fish requirement [8].

Inland fishing is also popular in the North Western Province and it contributes to supplying around 12.5% of the inland fish requirement of the country amounting 10,500 tons per annum [8].

Puttalam and Batticaloa are the two Districts producing shrimp in the country and out of the total 85% of production comes from Puttalam District.

Out of the total energy use in North Western province, around 3.2% of diesel, 5.5% petrol consume in multi day and single boats and 0.5% of electricity is used in paddlewheels in shrimp farms.

Livestock Sector: Livestock sector productions and earnings in the North Western province is contributing substantially to the national GDP in Sri Lanka annually. Out of the total national requirement about 18% of cow milk, 9% of buffalo milk, 12.25% of beef and 9.6% of mutton is produced in the North Western province [7]. Also, the North Western province is the biggest egg and pork producer to the local consumption.

Use of evaporative cooling technology in broiler chicken industry and use of coolers for preserving milk are the major energy utilizers in livestock sector but it has not been properly recorded.

Action Plan: This report presents a comprehensive activity plan to optimize the energy use in the Agro-Industry including agriculture, fisheries, and livestock sectors. The activity plan introduces 8 sector specific and cross sectoral interventions diverging in to 18 sub activities covering all major aspects including training and capacity building, renewable energy technology development, and financial mechanisms.

The energy share for land vehicles (land preparation and harvesting activities) in agriculture sector has been identified as the major contributor in the energy balance. Enhancement of energy efficiency in these machineries have been identified as one of the important activity but this has to be done in national level. Setting standards and quality control measures on machinery imports is more appropriate, as it will gradually lead efficient equipment to penetrate in to the market. Regulatory provisions are already available in section 35(2) and 36(2) of Sri Lanka Sustainable Energy Authority act no 35, 2007 for this purpose.

NDC Actions: Government of Sri Lanka submitted updated nationally determined contributions (NDCs) in July 2021 and it is expected to achieve a reduction of GHG emissions against the BAU scenario by 7% in the agriculture and livestock sectors (4% unconditionally and 3% conditionally) equivalent to an estimated mitigation level of 2,477,400 MT CO2e unconditionally and 1,858,000 MT CO2e conditionally (total of 4,335,400 MT CO2e) of carbon dioxide equivalent during the period of 2021 to 2030 by implementing the updated NDCs. Energy related sub NDC actions in agriculture and livestock sectors have been identified under this NDC submission and implementation of this action plan will give an additional support when reporting the achievements of the above targets.

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION TO THE REPORT

This report has been developed under the Biogas, Biomass and Solar Trilateral South South Cooperation (TSCC) Project which has been implemented with the objectives of introducing technologies and systems to enhance the Sustainable Energy Use in the Agriculture, Fisheries and Livestock (AFL) sector in Sri Lanka. This is a 2-year project and the Sri Lanka Sustainable Energy Authority (SLSEA), Ministry of Power and Energy, and the Provincial Councils (Five Provinces-North Western, Southern, Uwa, Eastern and Northern) are the project implementing partners whereas UNDP Sri Lanka provides the implementation support through Direct Implementation Modality (DIM).

Agriculture, fisheries and livestock (AFL) sectors have been considered under this report as the Agro-Industry prevailing in the North Western Province. Production and semi production process of the above mentioned sectors have been considered as the boundary of this analysis and technically viable renewable energy technologies have been analyzed and included in this action plan.

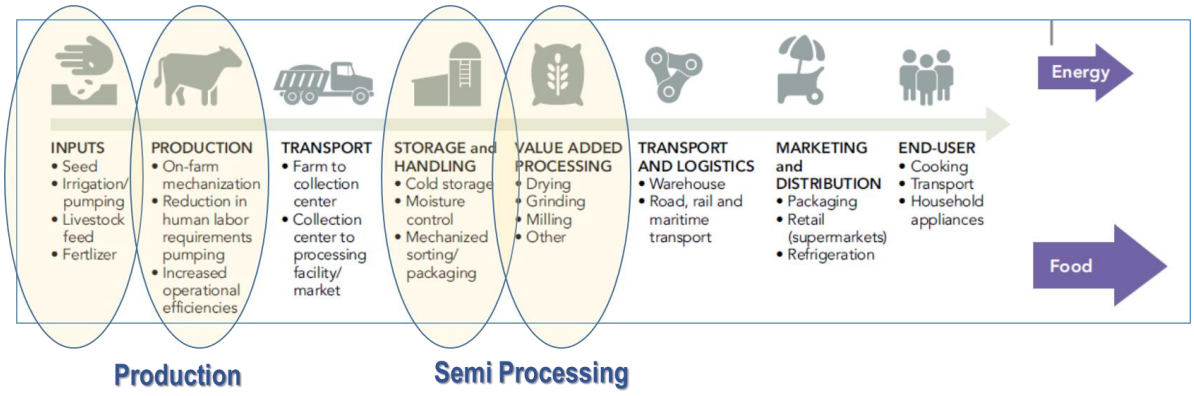


Figure 1.1: Boundary of this analysis reprot

Exceptions: Plantation sector (Tea, rubber, coconut, cashew etc.) and industry sector (Ice making etc.) has not covered under tis analysis since these sectors have been addressed under other sectors.

1.2 BACKGROUND

Energy and agriculture sectors are the largest Green-House Gas (GHG) emitters in Sri Lanka, representing around 59%, and 27% respectively of the total national GHG emissions (SNC, 2011). Thus, implementing energy efficiency measures and renewable energy technologies (RETs) in these sectors can have a significant impact in terms of emission reductions apart from significant socio-economic benefits to the country. However, the energy use and the energy generation (eg. Biogas) in agriculture, fisheries and livestock practices are not separately accounted in national or provincial level energy balances yet. The main reason may be the practical difficulties of collection of reliable and accurate data from the fields due to decentralized and scattered nature of operation.

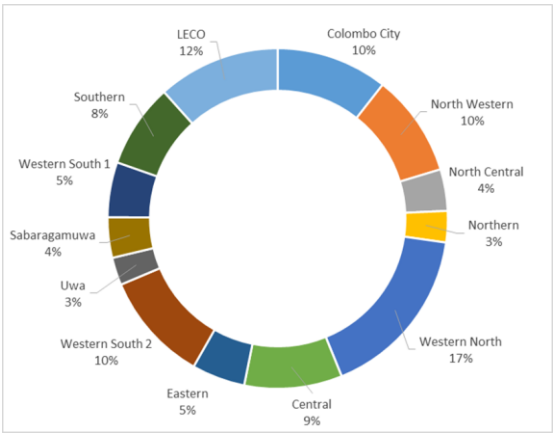


Fig 1.2: Electricity share by province

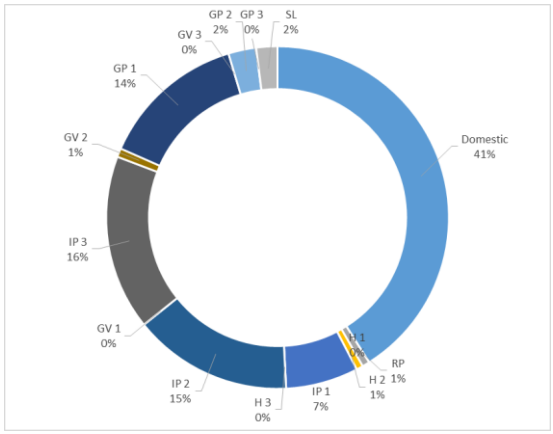


Fig 1.3: Electricity share by different categories in NWP

Government of Sri Lanka submitted updated nationally determined contributions (NDCs) in July 2021 and it is expected to achieve a reduction of GHG emissions against the BAU scenario by 7% in the agriculture and the livestock sectors (4% unconditionally and 3% conditionally) equivalent to an estimated mitigation level of 2,477,400 MT CO_{2e} unconditionally and 1,858,000 MT CO_{2e} conditionally (total of 4,335,400 MT CO_{2e}) of carbon dioxide equivalent during the period of 2021 to 2030 by implementing the updated NDCs [2]. Adoption of renewable energy technologies in crop farming, livestock applications have been identified as prospective NDCs under this report.

1.3 AGRICULTURE SECTOR – NORTH WESTERN PROVINCE

1.3.1 OVERVIEW

The energy use in crop cultivation and semi processing such as threshing & winnowing have been considered as the boundary of this analysis. There are about 300,000 hectares of agricultural land in North Western Province, and out of this about 90,500 hectares are paddy lands, 12,500 ha are vegetable cultivating lands and around 13,500 ha are fruit cultivating lands. Balance is for coconut and other crops [6].

According to the land use pattern, Norochcholai and Kalpity areas are very specific and climatic condition is almost uniform throughout the year. Rainfall is very low in these areas but the farmers are cultivating most of the upcountry vegetables without any major issue. Also, they are cultivating around 4 to 5 seasons with short rotation vegetables like beetroot, cabbage etc.

1.3.2 ENERGY USE

Water pumping is the major energy consumer in vegetable cultivation and approximately 61% in terms of energy, and 73% in terms of cost of energy shares are invested in water pumping. Next to water pumping, energy requirement for land preparation holds the other major share. Energy consuming machineries such as sprayers, mini tillers etc. are used in agriculture industry but the energy or energy cost share is not considerable. The detailed analysis of energy use is given in Chapter 4.

1.3.3 IMPLEMENTED AND ONGOING PROGRAMMES

1.3.3.1 Projects Implemented by the Ministry of Agriculture - NWP

Ministry of Agriculture in North Western Province providing agriculture machineries to the farmers at 50% or 100% grant basis annually and the summary of the projects implemented are given in the following table.

Table 1.1: Details of projects implemented in NWP

Projects Details (Related to Energy) NWP - Agriculture				
Year	**Project**	**No of Beneficiaries**	**Specifications**	**Unit Cost - LKR**
2021	Poly tunnels - Chile	20	1000 sqft	
	Poly tunnels - Organic Farming	20	550 sqft	
	Poly tunnels - High Tech	10	2000 sqft	2,400,000.00
	Solar Water Pump System	37	1.5" & 2hp	
	Water Pump	800	2 " & 2hp , 3hp	
	Inter cultivator - Backpacks	250	Fuel Consumption - 1 l/h	35,000.00
	Multi Chopper - Electric	400	8 hp	
	Multi Chopper - Engine Driven	40	13 hp	
2020	No Projects			
2018/19	Solar Water Pump System	75	1.5" & 2hp	
	Water Pump	400	2 " & 3hp	
	Planting Machine	70	Fuel Consumption - 0.5 l/h	
	Inter cultivator - Backpacks	600	Fuel Consumption - 1 l/h	

1.3.3.2 Pre-feasibility study

A pre-feasibility study has been carried out by the International Solar Alliance (ISA) in 2019 for implementation of 2000 solar pumps in North Western and North Central Provinces in Sri Lanka. But this proposal has not been implemented yet [3]. However, solar pump sizing methodology and international solar experiences are included in this report.

1.4 LIVESTOCK SECTOR

1.4.1 OVERVIEW

Livestock sector productions and earnings in the North Western province is contributing substantially to the national GDP in Sri Lanka annually. Out of the total national requirement about 18% of cow milk, 9% of buffalo milk, 12.25% of beef and 9.6% of mutton is produced in the North Western province [7]. Also, the North Western province is the biggest egg and pork producer to the local consumption.

1.4.2 ENERGY USE

In addition to the energy usage, substantial amount of energy is generated through biogas for domestic usage from this sector. Use of evaporative cooling technology in broiler chicken industry and use of coolers for preserving milk are the major energy utilizers in livestock

sector. In addition to this, water is being used in different stages in all the meet and egg production processes and there is not much details recorded on that.

1.5 FISHERIES SECTOR

1.5.1 OVERVIEW

Production and semi production processes in marine fishing, inland fishing, ornamental fishing and shrimp farming are considered as the boundary of this report under fisheries sector. There are no field level fish storage facilities in the North Western Province and all the stocks are sent to the processing centers just after harvesting.

Marine fishing is limited to Puttalam District. The total annual marine fish production in Puttalam District is in the range of 60,000 to 75,000 tons per annum and this shares approximately 15.0% of the national marine fish requirement [8]. The major bottleneck for enhancing the marine fish production in the North Western Province is absence of proper fishing harbor for handling the multi day boats. However, a new harbor is being developed at Wellamankada in Vennappuwa area and after coming in to operation this new harbor, the production will be enhanced.

Inland fishing is also popular in the North Western Province and it contributes to supplying around 12.5% of the inland fish requirement of the country amounting 10,500 tons per annum [8]. There are about 100 perennial tanks and around 200 satellite tanks for farming inland fish in North Western Province.

Puttalam and the Batticaloa are the two Districts produce shrimp in the country and out of the total 85% of production comes from Puttalam District [8].

1.5.2 ENERGY USE

Fuel use in multi day boats, single day boats and electricity usage in ice production process are the major energy utilizing areas in fisheries sector. In addition to this, electricity or diesel use in aerators and water pumping in shrimp farming and ornamental fish farming accounts to substantial amount of energy.

1.5.3 IMPLEMENTED AND ONGOING PROGRAMMES

There are no energy related significant projects that have been implemented in the North Western Province during recent past. Street light project has been implemented in few small harbors but most of such lanterns are not operating now may be due to damage or sometimes thefts.

1.6 ASSISTANCE FOR IMPLEMENTATION OF GREEN ENERGY IN THE NOTRH WESTERN PROVINCE

1.6.1 NAMA PROJECT

Nationally Appropriate Mitigation Actions (NAMA) in the Energy Generation and End-use Sectors in Sri Lanka Project was executed by the United Nations Development Programme (UNDP), Sri Lanka Sustainable Energy Authority (SLSEA), and the Climate Change Secretariat of Sri Lanka (CCS) to support appropriate climate change mitigation actions in the energy generation and end-use sectors as part of the initiatives to achieve the voluntary GHG mitigation targets of Sri Lanka and to develop a robust, transparent and functional NAMA framework along with clear inventory and Monitoring, Reporting, and Verification (MRV)

system with supporting governance and oversight in Sri Lanka that will systematically quantify Green House Gas (GHG) savings and benefits of the mitigation interventions using a bottom up approach to aggregate from the provincial and sub-sector levels to the national and sectors level.

Under this NAMA project two pilot projects were implemented in THE North Western Province for testing of MRV system. The first pilot project was implemented to test the MRV in biogas sector and introduced 186 biogas units in different scale. Solar with battery storage has been tested under the second pilot project and implemented 98 units. Part financing were made as grants under the NAMA project.

1.6.2 ELECTRICITY TARIFF FOR AGRICULTURE SECTOR

Agriculture, fisheries, and livestock sectors have been included in to industry category under the CEB tariff structure and separate tariff has been announced by the Government of Sri Lanka on 06th March 2015 but it has been noticed that no one is aware about this initiative. The electricity bill can be brought down with this new tariff structure.

The Gazette of the Democratic Socialist Republic of Sri Lanka

EXTRAORDINARY

අංක 1904/58 - 2015 මාර්තු මස 06 වැනි සිකුරාදා - 2015.03.06

No. 1904/58 - FRIDAY, MARCH 06, 2015

(Published by Authority)

PART I : SECTION (I) — GENERAL

Government Notifications

SRI LANKA ELECTRICITY ACT, No. 20 OF 2009

Publication under Sub - section (2) of the Section 30

AS per the Cabinet decision (ref: 35/2014/PE) dated 12.11.2014 and by virtue of the powers vested under Sub - Section (2) of the Section 30 of the Sri Lanka Electricity Act, No. 20 of 2009 (as amended), the Public Utilities Commission of Sri Lanka does hereby amend the definition for consumers of electricity to be qualified under the 'Industry' category as *"Supply of electricity to be used for 'Agriculture', 'Forestry and Fishing', 'Mining and Quarrying', 'Manufacturing', 'Electricity, Gas, Steam and Air Conditioning Supply', 'Water Supply; Sewerage, Waste Management and Remediation Activities' morefully described under the relevant sections of the detailed classification published in schedule hereunto."*

The previous 'Industry' category definition published under section 9 of 'Decision on Electricity Tariffs 2013', June 2013 is hereby revoked.

Chairman,
Public Utilities Commission of Sri Lanka.

Level 06,
Bank of Ceylon Merchant Tower,
No. 28, St. Michael's Road,
Colombo 03.

1.6.3 AGRICULTURE SECTOR MODERNIZATION PROJECT

Agriculture Sector Modernization Project has been initiated with the assistance of the World Bank and the objective is to support increasing agriculture productivity, improving market access, and enhancing value addition of smallholder farmers and agribusinesses in the project areas. More specifically seeks to promote commercial and export-oriented agriculture; attract and leverage investments from farmer producer organizations and agribusinesses for high value agriculture production and value addition; and provide the enabling environment,

incentives, and access to finance for such investments through matching grants, technical assistance support, linkages to the commercial banking sector, and a Partial Credit Guarantee (PCG) facility. Also, the project is aiming enhancement of productivity through supporting smallholder farmers to produce competitive and marketable commodities, improve their ability to respond to market requirements, and move towards increased commercialization.

1.7 BARRIERS TO IMPLEMENTATION

The energy usage in the AFL sector has not been properly accounted in national or regional level balance sheets and due to this less attention has been paid on implementation of energy efficiency or renewable energy projects in these sectors. To overcome this issue a separate chapter is recommended in the national energy balance published by Sri Lanka Sustainable Energy Authority.

Lack of end user awareness, lack of technical capacity among end users and officials in the AFL sector on renewable energy and energy efficiency technologies are some of other challenges faced when implementing energy projects. Comprehensive training and capacity building programmes are essential to overcome this issue. Also, demonstration of new technologies and systems through pilot projects can overcome most of these issues.

Even though the regulatory mechanisms are in place to eliminate the low-quality solar energy powered products coming in to the local market, low-quality products are still available and it is very difficult to recognize the best product by visual inspection. With this situation, the level of confidence about these appliances among the farmer community is decreasing day by day. This situation has been experienced during the questionnaire survey carried out in Norochcholai area.

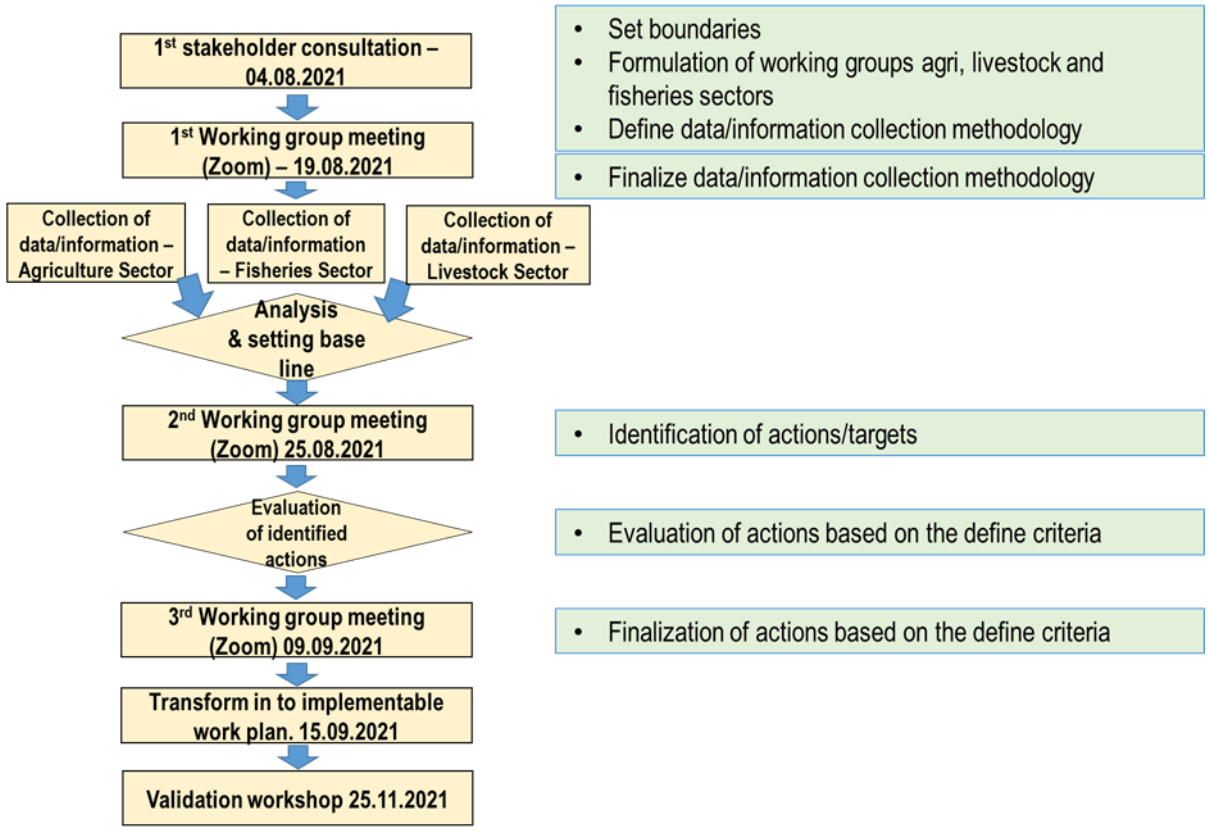
It is obvious that the general public is always trying to move towards convenient life styles and they are not paying much attention on complex operations like domestic biogas systems even though it gives better return on investment (RoI). This is why the solar systems are becoming popular even with high initial cost. Once a solar system is installed on the roof top, there is not much operation and maintenance involvement except cleaning the panel when required. When introducing a technology or a system, it is needed to take in to account these social aspects, otherwise the entire project will fail.

Agro-industry is one of the major income generating industries in Sri Lanka and with high return on investment (RoI) in most of the commercially viable technologies. With this background it seems that the financial assistance is not required for commercialization of these technologies. However, if it is possible to develop and introduce most of the interventions as projects packaging essential elements together (soft financing, technology demonstration, pilot projects, awareness programmes and monitoring) the rate of implementation can be enhanced.

1.8 METHODOLOGY ADOPTED

Since the energy usage details in most of the ground work operations in the AFL sector is not readily available, more effort has been given to establish those details. Some of the required details have been taken from the information available in open sources mainly in web sites of ministries and departments and other ground information was collected conducting a questionnaire survey. The reference of web sites from which details were taken are given in the reference section and the details of interviewed farmers and other officials are given in the annex.

The steps followed for development of this action plan are presented in the following diagram and most of the group meetings were conducted online due to prevailing pandemic situation.



CHAPTER 2:
GOVERNMENT POLICIES, DIRECTIVES AND COMMITMENT

2.1 INTRODUCTION

The energy aspect in the Agro-industry covered by different policies, directives and commitments is discussed in this chapter. These policy directives have been accounted when developing the prospective actions under this energy plan.

2.2 GOVERNMENT DIRECTIVES

The present Government has given a directive to agriculture sector to eliminate the use of chemical fertilizer with immediate effect and introduce/promote organic fertilizer to all crops. Under this directive in-house organic fertilizer manufacturing will be promoted and the machinery and energy requirement will be enhanced.

In addition to the policy directives given in the national energy policy document, present Government has given a directive to enhance the percentage of renewable energy in energy generation mix up to 70% by 2030.

2.3 ENERGY POLICY

The latest version of energy policy has been published on 09th Friday 2019 by the Ministry of Power & Energy. Working through the conflicting demands from the security, equity and sustainability dimensions, known as the energy trilemma, Sri Lanka today is seen to be moving away from the delicate balance of these three forces. The national energy policy is thus founded on ten pillars, rooted in the broad areas impacting the society, economy and the environment, in an effort to counter balance the forces through enhanced equity, security and sustainability, respectively. The strategies directly effecting to the agriculture sector are given in the following table.

Table 2.1: The strategies directly effecting agriculture sector under the energy policy

No.	Pillar	Strategy
01	Providing Access to Energy Services	New productive uses for electricity in agriculture, rural and primary industries will be encouraged with emphasis on empowerment of women and youth
		To encourage prospective small and medium scale industries and businesses, the initial cost of obtaining an electricity connection, which may be considerable at present compared with the capital cost of the business, will be reduced by offering a special concessionary package under which the entire cost of the transformer for contract demands up to 100kVA will be waived-off and be socialized through distribution tariffs. This should be fully implemented from January-2021by CEB/LECO, accompanied with an appropriate campaign giving wide publicity through media.
02	Improving Energy Efficiency and Conservation	Expert energy advisory services will be offered through state and private sector service providers to promote energy efficiency, conservation and energy cost reduction across all end use sectors.

2.4 NATIONALLY DETERMINED CONTRIBUTIONS (NDCs)

Government of Sri Lanka submitted updated nationally determined contributions (NDCs) in July 2021 and it is expected to achieve a reduction of GHG emissions against the BAU scenario by 7% in the agriculture and livestock sectors (4% unconditionally and 3% conditionally) equivalent to an estimated mitigation level of 2,477,400 MT CO2e unconditionally and 1,858,000 MT CO2e conditionally (total of 4,335,400 MT CO2e) of carbon dioxide equivalent during the period of 2021 to 2030 by implementing the updated NDCs [2]. The energy related NDCs identified in this document is given following table.

Table 2.2: The NDCs directly effecting to the agriculture sector

NDC No.	NDC and Action
NDC 03	**Improve adoption of renewable energy for crop farming/value addition**
	3.1 Application of solar PV and wind energy (or hybrid) for agriculture practices
	3.2 Promote grid electricity use in place of fossil fuel driven engine powered pumps
	3.3 Renewable energy powered mini grid for clustered agriculture farming in vulnerable areas (as a pilot)
	3.4 Explore and develop small hydro power potential in irrigation water canals for agriculture purpose
NDC 06	**Adopt renewable energy for livestock applications** E.g. small-scale solar-powered refrigeration to increase the milk storage facilities, solar-powered can-coolers for milk producers, solar energy for milk collection, chilling centers, farm operation and processing; and introducing biogas digesters for large scale livestock & poultry, dairy processing and abattoirs

2.5 AGRICULTURE POLICY

The Government has unveiled the drafted National Agriculture Policy towards achieving the vision of "sustainable food security to achieve national prosperity. The policy is primarily focused on food and feed crops, and sustainable food security with improved food quality and has set multiple goals to be achieved by 2030. The drafted policy has identified fifteen policy statements under ten thematic areas and 144 policy actions. Out of these the energy related policy actions are given in the following table.

Table 2.3: Energy related policy actions in the National Agriculture Policy

No.	Thematic Area	Policy Statement	Policy Action
01	Eco-friendly Operations	Support sustainability in agriculture development through conservation and utilization of natural resources while safeguarding ecosystem services	Take appropriate measures to **increase the use of renewable energy in agriculture** – e.g. financial incentives to access solar-energy and wind powered technology/ battery-powered technology for irrigation, cold-storage systems and use of biogas
02			Introduce and adopt eco-friendly agricultural practices across agro-ecosystems to support environmental conservation
03	Input Management	Strengthen delivery and management	Establish a mechanism to **certify machinery** and other agricultural inputs to be used in Sri

		operations of physical inputs for their judicious use	Lanka (e.g. a central regulatory entity for auricular inputs)
04		Enhance rational use of irrigation water through participatory management to improve the irrigation water use efficiency	Take appropriate regulatory measures to avoid excessive use of ground water
05		Encourage development and adoption of appropriate innovations and technologies during pre- and post-harvest management for sustainable agricultural production	Provide financial and institutional support to develop cost-effective technology using locally-available resources
06			Promote adoption of technologies targeting value addition for perishables
07			Strengthen technology transfer mechanisms
08			Revisit and restructure existing authoritative body responsible for agriculture research to focus on establishing an Agriculture Research and Development/Extension Council
09			Introduction of proven and appropriate technology in to the sector through field validation
10	Agri-Entrepreneurship and Markets	Streamline and explore the domestic and international market systems with appropriate logistic services in compliance with national and international standards	Adopt warehouse receipting system for durables (e.g. grain crops) by encouraging PPP, establishment of databases, etc.
11			Establish cold storage and cold chain facilities for perishables through PPP
12	Knowledge Management and Agricultural Extension	Constitute a centrally-controlled information development and dissemination system to manage research, development and extension systems, and recruitment related to the agriculture sector	Provide appropriate incentives (financial & physical) to promote R&D for technology development

CHAPTER 3:
DATA AND INFORMATION

3.1 INTRODUCTION

Data and information related to energy and machinery use in the AFL sectors in Sri Lanka is not readily available in open sources. The national energy balance is published by Sri Lanka Sustainable Energy Authority every year but the energy use in AFL sectors are not separately represented and it is accounted under domestic sector. Some information about the cost of machinery use in cultivation of vegetable and fruits are available in the booklet "Cost of cultivation of agriculture crops" an annual publication by the Socio Economic and Planning Center, Department of Agriculture, Peradeniya and production details of paddy, vegetables, fruits and other crops are available in both Ministry of Agriculture and Department of Agriculture web sites. Also, production statistics in fisheries sector and livestock sector are available in statistics reports published by Ministry of Fisheries and Department of Animal Production and Health, Peradeniya.

Due to the absence of energy consumption data in cultivation, growing and semi processing, sample survey has been carried out both in Kurunegala and Puttalam District and the summary of those data are presented in this chapter. Considering the prevailing COVID-19 situation, this survey has been carried via online.

The specific energy consumption for each operation has been established based on the details taken from the questionnaire survey and the results are given in the following tables.

3.2 DATA AVAILABLE IN OPEN SOURCES

3.2.1 AGRICULTURE SECTOR

Table 3.1: Land use, yield and details of machinery use in vegetable and other crop cultivation

	Tomato	Bean	Capsicum	Carrot	Cabbage	Pumpkin	Brinjal	Potato	Ground Nut	Red Onion	Big Onion	Chilli	Green Gram	Cowpea	Black Gram	Soy Bean	Maize	Beet root	Raddish	Leaks	Knokhol	Long Bean	Bushitavo	Okra	Luffa	Snake Gourd	Leaf Vegetable	Bitter Guard	Cucumber	Winged Bean	Ash Plantan	Sweet Potato	Kurakkan	Gingelly
Total cultivated area - ha (Both seasons)	157	30	719		295	958	696		3208	1590	53	2081	1591	1094	853	2011	2436	642	623		34	1656		823	309	247	137	436	397	93	28	103	358	826
Yeild - ton	2871	154	8354		8838	14548	10623		4695	19675	845	22379 (G), 816 (D)	1424	1044	973	3610	8822	13560	12594		714	17605		10132	4126	5084	1422	9026	6499	1426	378	1461	235	609
Machninery Cost Rs./Acre																																		
Land preparation - Machinery cost	8857	9529	9121	10409	8937	6238	8846	8906	5742	3125		7337	4342	5803	6352		8585																	
Digging holes														1966																				
Water pumping / irrigation	6533		8161	7468	11159		19583	11455	RW	6466			RW	RW	RW		RW																	
Water pumping / irrigation (New technology)	5521									710																								
Harvesting / Threshing													1350		3770		2099																	
Transport up to stores						2135			1022	4184					304		1124																	

Source: https://www.doa.gov.lk/SEPC/images/cost_of_cultivation/cost_of_cultivation_19.pdf

Table 3.2: Land use, yield and details of machinery use in fruit cultivation

	Banana	Pineapple	Mango	Passion Fruit	Papaw	Rambutan	Lomon	Orange	Avacado	Guava	Mandarin	Pomegranate	Watermelon
Land area ulilyze - Hactares or both seasons	5380	2264	1871	152	1314	164	303	827		309		201	798
Yeild - ton	44565	10630	13100	328	10482	330	200	4025		955		116	22380

Source: https://www.doa.gov.lk/SEPC/images/cost_of_cultivation/cost_of_cultivation_19.pdf

3.2.2 FISHERIES SECTOR

Key statistics of the fisheries sector in the North Western Province is given in the following table.

Table 3.3: Key statistics of the fisheries sector in the North Western Province

No.	Description	Results
	Marine Fishing	
01	No of multi day boats	148
02	Out-board engine fiberglass reinforced plastic boats	4215
03	Motorized traditional boats	187
04	Non-motorized traditional boats	2785
05	No of small harbors (Thotupola)	150
	Inland Fishing	
06	No of inland tanks	Major – 02, Medium – 14, Small - 85
07	Total tanks area	14,100 hectares
08	Alternative tanks	200
09	Inland fishing crafts	885
	Ornamental Fishing	
10	No of stations	500
11	Major energy consuming equipment	Pumping water, ½" to 1" pumps and aerator blowers
	Shrimp Farm	
12	No of ponds	3264
13	Total pond area	1626 hectares
14	Annual production	5437 tons
15	Major energy consuming equipment	Water pump and paddle wheel (aerate the pond)

Source: Fisheries Statistics 2020, Ministry of Fisheries

3.2.3 LIVESTOCK SECTOR

Table 3.4: Key statistics of the livestock sector in the North Western Province

No.	District	No of Chilling Centers	Chilling Capacity (Liters)	Milk Collection (Liters)
01	Kurunegala	40	158,250	40,553,867
02	Puttlam	11	41,550	8,804,138

Source: LIVESTOCK STATISTICAL BULLETIN 2019, Department of Animal Production and Health Peradeniya - Sri Lanka

Table 3.5: Number of Livestock Farmers - 2020

District	Cattle and/or Buffalo (Local)	Cattle and/or Buffalo (Improved)	Goat	Swine	Poultry					
					Local Poultry	Broiler Farmers		Egg Producing Farmers		Total
						No. of Chicken Below 1000	No. of Chicken Over 1000	No. of Chicken Below 1000	No. of Chicken Over 1000	
Kurunegala	14,389	12,751	2,627	791	9,587	853	682	1,572	732	13,426
Puttlam	5,464	4,545	3,306	2,973	10,738	369	280	1,064	120	12,571

Source: http://www.statistics.gov.lk/Agriculture/StaticalInformation/rubb6

3.3 DATA COLLECTION THROUGH A QUESTIONNAIRE SURVEY

3.3.1 AGRICULTURE SECTOR

Table 3.6: Machinery usage in cultivation

No.	Crop	Machine	Work	Time Spend	Fuel Usage	No of seasons
Land Preparation						
01	Vegetables in Norochcholai	4 Wheel tractor with rotor vane	1st and 2nd plough per season	2 hrs per acre for disc plough and 2 hers for rotor vane plough	6 liters per hour	4 seasons, Average 2 months per season
02	Chili in Norochcholai area	4 Wheel tractor with rotor vane	1st and 2nd plough per season	2 hrs per acre for disc plough and 2 hers for rotor vane plough	6 liters per hour	2 seasons, Average 4 months per season
03	Paddy	2 Wheel tractor	1st, 2nd and 3rd plough per season	4 hrs per acre	3.2 liters per hour	2 seasons
04	Fruits (Yearly crops eg, papaya, water melon)	4 Wheel tractor	One plough per year	1.5 hrs per acre per plough	6 liters per hour	One season
05	Fruits (Mango, guava, Rambutan etc.)	Grass cutter	Grass cutting	0.5 acre per day	3 liters per 0.5 acre	-
Weeding and Soil turning/softening						

04	Vegetable like Okra, chili having 2 feet space	Mini tiller	Weeding	3 hrs/Acer and two time per season	Petrol 4 liters per acre	5 seasons for vegetables and 2 seasons for chili
Water Pumping						
05	Vegetables, Chili etc.	2 inch electric pump. One pump per acre	Water pumping	8 ~ 10 hrs per day	12 kWh per day per acre	5 seasons for vegetables, Average 2 months per season. 2 seasons for chili, Average 4 months per season
06		2 inch solar pump. One pump per acre		6 hrs per day	Solar. Total 150 pumps are available. Only about 20 pumps are operating in Norochcholai area (About 2%)	
07		3 inch pump. One pump per 2 acre		10 hrs per day	10 liters/day	
Spraying						
08	Vegetables, fruits	Petrol engine driven sprayer	Spraying	3.5 hrs per acre	1.5 liters/acre	One or two times per week
09	Paddy	Petrol engine driven sprayer	Spraying	2.0 hrs per acre	1.0 liters/acre	Two times per season
Harvesting						
10	Paddy	Combine harvester (Bhuthaya)	Harvesting	1.5 hrs per acre	9 liters per hour	2 seasons

3.3.2 FISHERIES SECTOR

Table 3.7: Energy and production data in the fisheries sector

No.	Description	Results
01	Diesel usage in multi day boats	3000 to 4500 liters per run
02	Kerosene consumption in day boats	40 to 50 liters/day
03	Average No. of days per trip (Run) of multi day boats	17 days
04	Average catch per trip	6000 kg
05	Average sales as fish	60%
06	Percentage fish production in coastal area	85% of the total production
07	Average catch per single day boat	180 kg
08	Amount of ice use in multi day boats	9.6 tons/trip
09	Power of the aerator blower in ornamental fish farming	250 W
10	No. of ornamental fish farms	500

3.3.3 LIVESTOCK SECTOR

Table 3.8: Details of milk chilling centers

No.	Description	Details
01	No of milk can coolers with 500 liters capacity	17
03	Potential for milk can coolers – 500 liters	1,000
04	Power requirement in can coolers Small Can cooler (50 liters) Mini cooler (200 liters) Mini cooler (300 liters) Mini cooler (500 liters)	 0.5 kW 1.2 kW 1.5 kW 3.5 kW

Table 3.9: Energy usage details in the poultry industry

No.	Description	Details
01	Energy use in broiler chicken industry Birds in one room – (Average) Evaporative coolers in one room Capacity of one evaporative cooler Room temperature maintained Light bulbs in one room Power of one light bulb No of water pumps Average capacity Average electricity bill for one room Electricity consuming appliances	 25,000 06 2.2 kW 23 ^{0}C 130 13W 2 1.2 kW Rs. 75,000.00 Evaporative cooling system for controlling the room temperature
02	Egg production Average monthly electricity bill of a farm with 50000 birds Electricity consuming appliances No. of farms with 50,000 birds No. of farms with 75,000 birds No. of farms with 100,000 birds or above	 Rs. 15,000 Feeding system and lighting 300 100 10

Table 3.10: Details of biogas units

No.	Description	Details	Cumulative Capacity – m^3
01	No of biogas unit available Large scale Small scale	 11 (above 100 m^3 by volume) 185	 1949.5 1809.0
02	No of potential biogas unit Large scale Small scale	 10 350	

CHAPTER 4:
BASELINE ANALYSIS

4.1 INTRODUCTION

As indicated above, analysis of baseline of energy use in the AFL sector is a difficult task due to absence of readily available data. However, an attempt has been taken to establish a few baselines taking the data and information presented in chapter 2 and making several assumptions, and the results are presented in this chapter.

Most of the vegetables are harvested within 45 to 55 days. Considering this the farmers in some areas are practicing 4 to 5 cultivation seasons for these vegetables. Norochcholai area is a good example for this and the farmers in this area are cultivating 4 to 6 seasons depending on the variety. These seasonal variations, mainly the rainfall have been accounted when establishing baseline details below.

Multiplied the specific energy use (eg. Diesel consumption for plough per acre) with the total volume (eg. Total land area) and thereby the total energy consumption has been established in each operation.

4.2 LIMITATION OF THIS ANALYSIS

The accuracy of these analysis is depending on the accuracy of the data and information. The data taken for this analysis have been taken from open sources and a questionnaire survey. The data gathered from the questionnaire survey is accurate but operating frequency of the machineries (Land preparation, water pumping, spraying etc.) are varying from area to area. Taking in to consideration all the variables, average figures have been established and presented in this chapter.

Recommendation for enhancing the accuracy of data

It is recommended to carry out the data collection survey in detail enhancing the survey population every year and establish more accurate specific indicators.

4.3 FORECASTING

Forecasting in agriculture sector is a regular exercise and it is being done in provincial and national level in two scenarios. One is immediate forecasting for next season and the other one is five-year forecasting development of programmes accordingly. However, with the present Government's new directives of achieving 100% organic fertilizer, it is required to re-visit these plans and amend accordingly. The recommendations made in this document will be useful when amending these plans.

Forecasting in fisheries sector is conducted with different models developed (eg. Auto Regressive Integrated Moving Average model) mainly for enhancing the fish catch. With these new technologies the traveling time can be minimized and thereby the overall energy usage can be optimized.

4.4 AGRICULTURE SECTOR

4.4.1 AVERAGE VALUES TAKEN FOR ESTABLISHING THE ENERGY USE

Following average values have been taken from the data presented in chapter 3 when estimating the energy use in agriculture industry

- Diesel consumption in 4 wheel tractor - 10.8 liters /acre
- Diesel consumption in 2 wheel tractor - 12.0 liters /acre
- Diesel consumption in combine harvester - 13.5 liters/acre
- Availability of electricity or solar powered pumps - 80% of total land area
- Loading factor of a pump -75% (due to the availability of rain, supplying water is not necessary at all the time period)

4.4.2 RESULTS

Table 4.1: Energy use in paddy cultivation

Description	**Results**
Specific energy requirement per acre per season	39.1 liters diesel and 2 liters of petrol
Total land area for both seasons	453,400 Acres
Total energy requirement per year	
Land preparation	11,607,170 Liters of diesel
Harvesting	6,120,975 liters diesel
Spraying	906,800 Liters of petrol

Table 4.2: Energy use in vegetable cultivation – 4 seasons per year

Description	**Results**
Specific diesel/kerosene requirement per acre per season for land preparation	24 liters diesel
Specific electricity requirement per acre per season for water pumping	273 kWh
Specific diesel requirement per acre per season for water pumping	21 Liters of diesel
Specific electricity generation per acre per season for water pumping in solar pumps	5.6 kWh
Specific electricity requirement per acre per season for spraying	6 liters of petrol
Total land area per seasons	7348.75 Acres
Total energy use in land preparation	705,480 liters
Total energy use in water pumping Electricity Diesel/kerosene Electricity saving use of solar pumps	 8,024,850 kWh 617,300 liters 164,600 kWh
Total energy use in spraying	176,370 Liters petrol

Table 4.3: Energy use in vegetable cultivation – 2 seasons per year

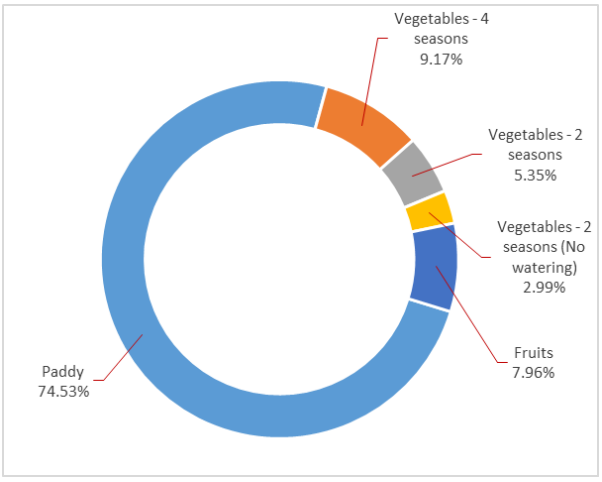
Description	Results
Specific diesel/kerosene requirement per acre per season for land preparation	24 liters diesel
Specific electricity requirement per acre per season for water pumping	468 kWh
Specific diesel requirement per acre per season for water pumping	36 Liters of diesel
Specific electricity generation per acre per season for water pumping in solar pumps	9.6 kWh
Specific electricity requirement per acre per season for spraying	7.5 liters of petrol
Total land area per seasons – watering crops	7,750 Acres
Total land area per seasons – non watering crops	15,500 Acres
Total energy use in land preparation	1,116,300 liters
Total energy use in water pumping Electricity Diesel/kerosene Electricity saving use of solar pumps	 4,836,000 kWh 372,000 liters 99,200 kWh
Total energy use in spraying	116,250 Liters petrol

Table 4.4: Energy use in fruits cultivation

Description	Results
Specific diesel/kerosene requirement per acre per season for land preparation	24 liters diesel
Specific electricity requirement per acre per season for water pumping	936 kWh
Specific diesel requirement per acre per season for water pumping	72 Liters of diesel
Specific electricity generation per acre per season for water pumping in solar pumps	19.2 kWh
Specific electricity requirement per acre per season for spraying	7.5 liters of petrol
Total land area per seasons- Watering fruits	24,390 Acres
Total land area per seasons- Non watering fruits	9567.5 Acres
Total energy use in land preparation	585,360 liters
Total energy use in water pumping Electricity Diesel/kerosene Electricity saving use of solar pumps	 5,707,260 kWh 439,000 liters 117,100 kWh
Total energy use in spraying	254,700 Liters petrol
Total energy use in grass cutting	172,200 liters petrol

4.5 ENERGY BALANCE

4.5.1 SHARE OF ENERGY IN AGRICULTURE SECTOR



The total energy balance by crops in agriculture sector is given in the figure 4.1. The energy consumption in paddy cultivation is the highest in North Western Province and rest of the energy is sharing equally among vegetable and fruits cultivation

Figure 4.1: Share of energy by crop

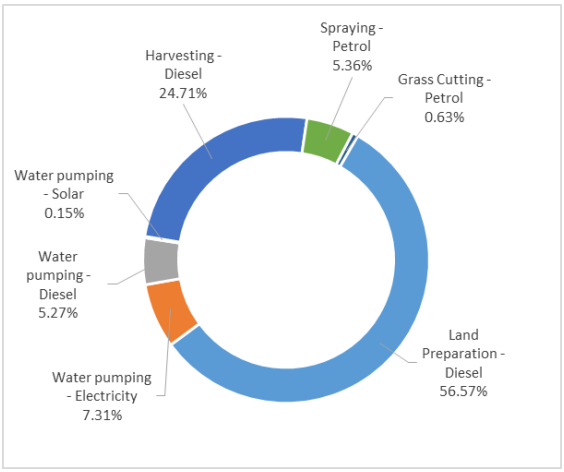


Figure 4.2: Share of energy by process

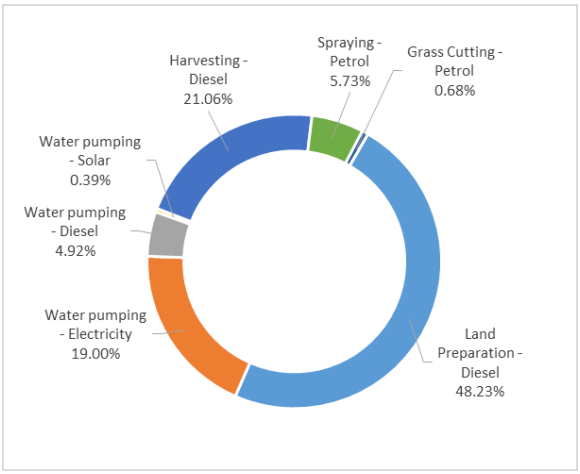


Figure 4.3: Share of energy cost by process

Out of the total energy consumption in agriculture sector (cultivation) land preparation and harvesting consume 56% and 24% respectively. Water pumping is the next and it shares around 12.5% of the total energy.

4.5.2 SHARE OF ENERGY IN PADDY PRODUCTION

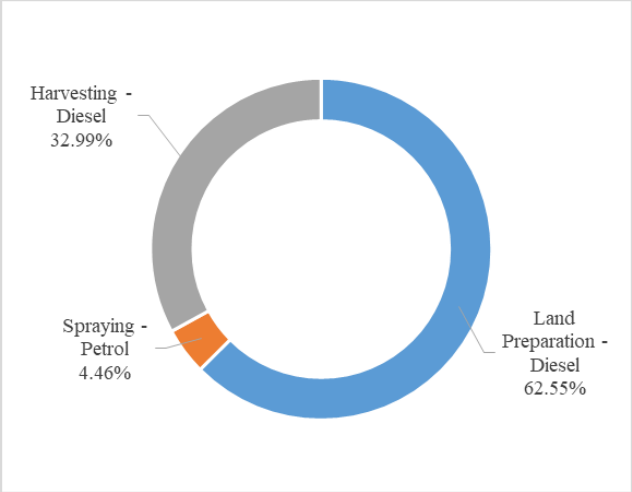


Figure 4.4: Energy usage pattern in paddy production

4.5.3 SHARE OF ENERGY AND ENERGY COST IN VEGETABLE (4 SEASONS PER YEAR) CULTIVATION

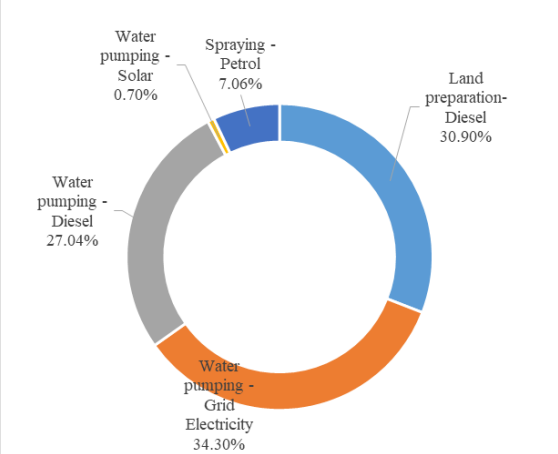


Figure 4.5: Energy share by process

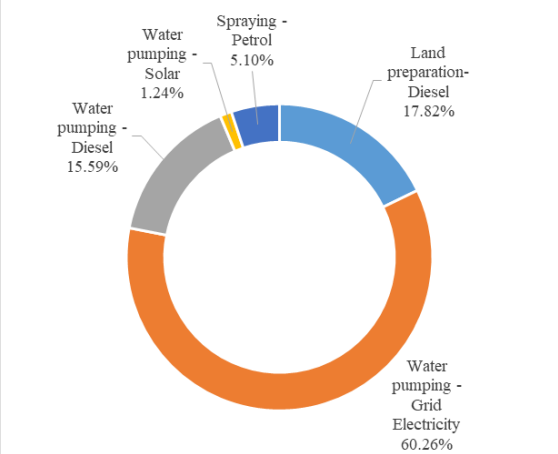


Figure 4.6: Energy cost share by process

The energy consumption and energy cost variation pattern in short rotation vegetable crops are given in the above figures. More than 50% of total energy consumption shares water pumping and approximately 31% for land preparation.

4.5.4 SHARE OF ENERGY AND ENERGY COST IN VEGETABLE (2 SEASONS PER YEAR) CULTIVATION

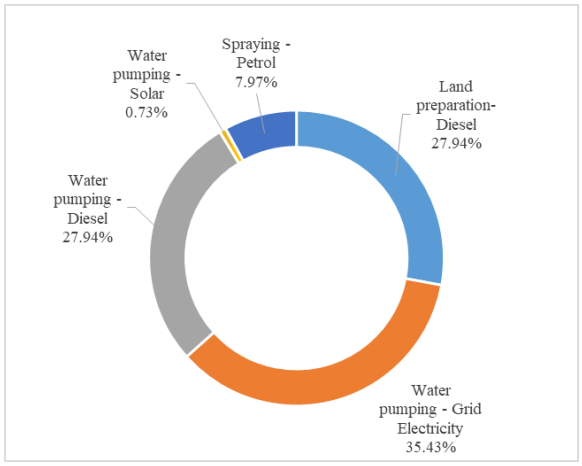


Figure 4.7: Energy share by process

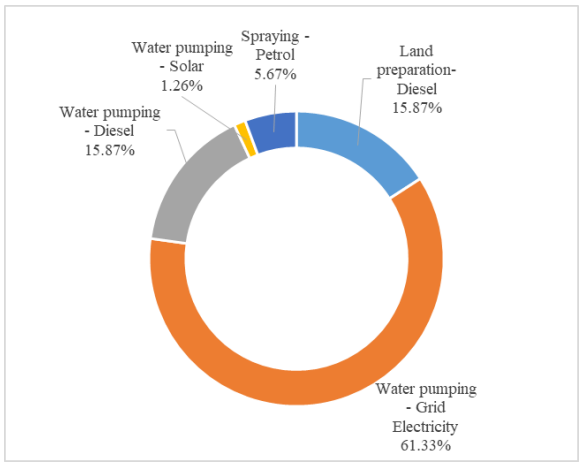


Figure 4.8: Energy cost share by process

The energy consumption and energy cost variation of vegetables which are cultivated two seasons per year are given in the above figures. Similar to short rotation vegetable cultivation, this also follows the similar variation pattern.

4.5.5 SHARE OF ENERGY AND ENERGY COST IN FRUITS CULTIVATION

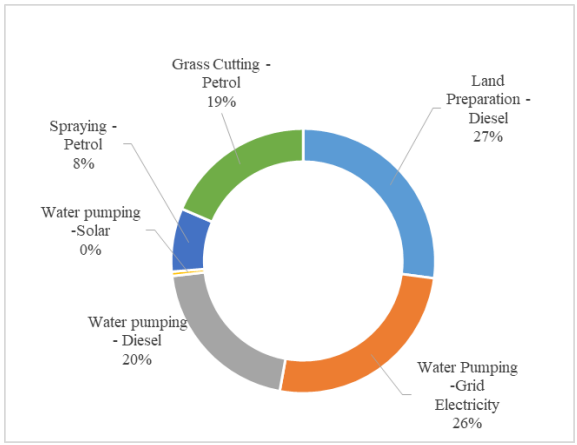


Figure 4.9: Energy share by process

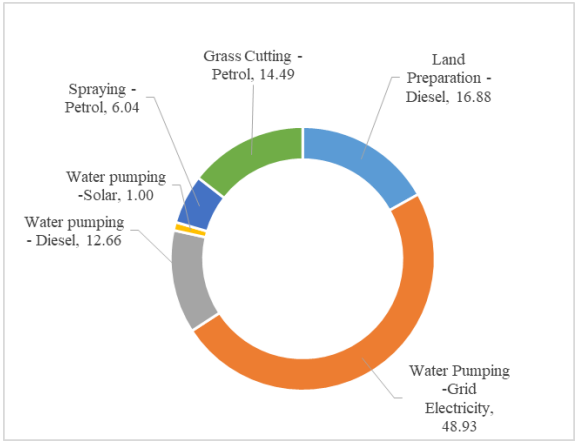


Figure 4.10: Energy cost share by process

4.5.6 THE ANALYSIS OF EMBEDDED ENERGY

The analysis of embedded energy or the energy required to produce one kg of paddy, vegetable or fruit is given in the following table. The average embedded energy in paddy production considering only the direct fuel usage is 9.5% and it is little lower in vegetable and fruit cultivation.

A production process with share of embedded energy less than 10% has been cited as productive in international research literature. The above cultivation processes can be found within that range. Ideally in the calculation of embedded energy indirect energy usage in the entire product lifecycle should also be accounted, but it would still not exceed the 10% margin and therefore is considered negligible in this case.

Table 4.5: Energy usage in agriculture sector

Crop	Embedded Energy (Emergy) - kJ/kg of product	Total Energy in Food - kJ/kg	%
Paddy	1098	11524	9.53
Vegetables - 4 seasons	448	16500	2.71
Vegetables - 2 seasons	594	16500	3.60
Vegetables - 2 seasons (No watering)	1260	16700	7.55
Fruits	831	15100	5.50

4.6 FISHERIES SECTOR

4.6.1 ASSUMPTIONS MADE FOR ESTABLISHING THE ENERGY USE

Table 4.6: Assumptions made for establishing the energy use in fisheries sector

No.	Description	Results
01	Average kerosene consumption in inland fishing boat (Oruwa) in night time	1 liter/day
02	Average fishing days per year per boat	300
03	No of paddle wheels in one acre shrimp tank	5 with 2kW motor

4.6.2 RESULTS

Table 4.7: Energy usage in fisheries sector

No.	Description	Results
01	Total annual diesel usage in multiday boats	8,836,000 liters
02	Total annual kerosene/petrol usage in day boats	10,014,200 liters
03	Annual kerosene usage in fishing in Kalpitiya Lagoon	36,500 liters
04	Average kerosene consumption in inland fishing	265,500 liters
05	Electricity usages for operating aerators in shrimp ponds	6,585,300 kWh

4.7 LIVESTOCK SECTOR

4.7.1 RESULTS

Table 4.8: Energy use in livestock sector

No.	Description	Results
01	Electricity consumption in broiler chicken industry	671,400 kWh
02	Electricity consumption in egg production process	40,900 kWh

Table 4.9: Energy generation in livestock sector

No.	Description	Results
01	Energy generation in biogas units	1100 m^3

CHAPTER 5:
ANALYSIS ON GREEN ENERGY POTENTIAL IN AGRO-INDUSTRY

5.1 INTRODUCTION

This analysis has been done based on the results of the baseline analysis presented in the chapter 04. Further, this analysis has been limited to energy consumption in production (growing, farming and fishing) and semi processing activities. Commercially and technically proven technologies have been considered under this section. Also, the up-scaling potential and operating performance under the local climatic condition have been considered when analyzing green energy potential in AFL sectors.

5.1.1 OFF-GRID RENEWABLE ENERGY APPLICATION

5.1.1.1 Solar Water Pumping

It has been estimated approximately 1500 diesel water pumps are being operated for vegetable cultivation in the North Western Province. These pumps are operating in electricity non-accessible areas/places. In average 3 to 5 liters of diesel consumes per acre per day in vegetable farming and one diesel pump is serving for two acres. This operation can be partially replaced with 2-inch solar powered pump in day time. In early stages of the vegetable cultivation, water is supplied in early mornings and evenings and direct solar pumps are not suitable for this operation unless high head (approximately 60 foot) storage is available and only the day time diesel pumps usage can be eliminated.

The cost of the solar water pumps is not uniform in Sri Lankan market, however cost of a standardized solar pump is in the range of Rs. 500,000.00 to Rs. 800,000.00. The approximate diesel saving would be around 130 liters per month per pump and the simple payback period of this replacement would be around 2.6 years to 4.2 years.

5.1.1.2 Other Solar Applications

Solar insect traps are available in international market with 12V battery and solar charging system and can be used as an off-grid system. These traps are generally used for night time flying insects and need to select the appropriate system before using. The energy usages in these units are not significant and equivalent CO_2 savings are negligible, but practically it has an impact on increasing productivity in agriculture sector. Use of solar energy in ***elephant fences*** are recommended since most of those operations are in remote areas where grid electricity supply is not available. The electricity usage in these units is considerably small and the technology has been developed with battery storage for easy operations and those systems are available with attractive price in the open market now. ***Solar home standalone systems*** are available in open market similar to the elephant fencing technology and can be used in both huts, shelters in agricultural lands and in night time inland and lagoon fishing. With this intervention, the existing kerosene usage can be minimized. The other technology is ***solar powered aerators for shrimp farming.*** Battery operated aerators or aerators only for day time without battery are available in the market. There are 3264 shrimp farming ponds having 1626 hectare land area in North Western Province and approximately 4 to 5 aerators are utilized in one acre area. The power requirement in one aerator (paddle wheel) is

approximately 1-2.2 kW and the equivalent CO_2 saving would be around 9,550 tons per annum with this solar technology intervention.

5.1.1.3 Biomass Applications

Use of high-quality energy sources like electricity is not encouraged for low temperature (low quality) applications as per the principals of thermodynamics. There are plenty of low temperature drying and low temperature hot water applications available in Agro-industry mainly for drying crops and washing, cleaning and cooking in institutions like training centers. Locally fabricated low temperature dryers and low temperature hot water generators fueled by biomass are available in open market now with attractive prices. Potential is there to eliminate the existing electricity, kerosene or LPG usage in Agro-industry by introducing these systems and thereby reduction of carbon foot print.

5.1.1.4 Biogas for thermal applications

Use of biogas in thermal application is not a new intervention but the issues existing in this sector have not been properly addressed. Most of the individual small scale biogas units have been abandoned in the North Western Province mainly due to social aspects. Therefore, it is better to carry out a situation analysis on use of biogas and establish proper criteria on suitability of use of biogas. There are 54,277 cattle farms and 4534 swine farms in the North Western Province and theoretically establishment of biogas units in all these places are possible.

5.1.2 ON-GRID RENEWABLE ENERGY APPLICATIONS

5.1.1.1 Solar roof top systems

Solar roof top systems are encouraged by the Government of Sri Lanka under three systems viz. solar net metering, solar net accounting and solar net plus scheme. The national grid is acting as an energy bank and the generated electricity during day time either can be utilized at the site or excess can be fed in to the grid. Electricity generation and the consumption are metered in separate meters and electricity bill is calculated end of the month accordingly. More details about solar roof top are available at the Ceylon Electricity Board, Sri Lanka Sustainable Energy Authority and Public Utilities Commission of Sri Lanka web sites.

The electricity consumption can be offset with the net metering scheme and a sample analysis of solar roof top system is given in the following table. In general maximum 5 kW solar system is recommended by CEB for a house with single phase electricity supply. If someone needs to enhance the solar capacity further, three phase supply is required and the solar roof top system capacity can be enhanced up to 15kW.

Table 5.1: Investment and payback period for solar rooftop systems

No.	Land area - hectares	Average monthly electricity use including house load - kWh	Monthly electricity bill – Rs.	Equivalent solar roof top system - kW	Simple payback period - Years
01	1	226	6133.50	2	4
02	2	352	11803.50	4	4
03	3	550	20713.50	5	3

Since the electricity supply is available island wide, electrically driven Agro machineries such as water pumps, milk can coolers, sprayers, threshers, dryers etc. are favorably utilizing the CEB national grid in many areas rather introducing solar standalone systems. The overall energy efficiency in the solar standalone water pumping system is comparatively lower than the solar roof top system. This is due to storing electricity in batteries and conversion from DC to AC. The required electricity can be offset through solar roof top system. Since the electricity network has reached 100% households and installation of solar rooftop systems are possible in most of the areas, it will be a more practical reliable solution since the solar roof top systems are regulated through Sri Lankan Standards SLS 1552, SLS 1542 to SLS 1547, SLS 1553 and SLS 1554.

5.1.3 BIOMASS APPLICATIONS- SMALL SCALE POWER GENERATION

A feasibility study has been carried out by UNDP Sri Lanka office to ascertain the viability of establishing small scale biomass power plants in Sri Lanka. As per the results of this study, the most viable technology for small scale biomass power plant is steam turbine-based power generation system. According to the analysis done under this study, six strategic locations have been identified in the North Western Province with total potential capacity of 6MW and annual biomass requirement to run these systems would be around 111,690 tons. Agriculture waste has been considered as the prospective source of biomass under this study and if these proposals were implemented, potential market will be there to supply biomass at a reasonable cost.

5.1.4 BIOGAS APPLICATIONS- POWER GENERATION

Power generation with biogas driven engine is not a new application to Sri Lanka. There is a grid connected power plant in Attanagalla with 80kW generating capacity driven by biogas and biogas is generated using poultry waste.

5.1.5 ENHANCEMENT OF ENERGY UTILIZATION EFFICIENCY

Energy consumption in paddy cultivation is substantially higher than the energy consumption in other crops and this is mainly for land preparation and harvesting. Four-wheel tractors, two-wheel tractors and combine harvesters are being utilized in many places for this purpose and introduction of productive machineries (having higher output and less down time) in these categories are very much encouraging and there by potential saving of diesel is substantial.

CHAPTER 6: RECOMMENDATIONS

6.1 INTRODUCTION

The results of the questionnaire survey and the results of the analysis done in chapter 5 have been considered when developing these recommendations.

6.2 POPULARIZATION OF TECHNICALLY AND COMMERCIALLY VIABLE TECHNOLOGIES

A number of programmes have been initiated for introduction of green energy technologies in the North Western Province of which some have succeeded and others failed. Some of these projects are assisted by donors and others are partially or fully funded by the Government. Taking in to consideration the success and failure factors of past programmes, it is recommended to design a comprehensive programme to introduce technically and financially viable green energy technologies to the AFL sectors.

6.3 CROSS-SECTORAL RECOMMENDATIONS

6.3.1 INTRODUCTION OF SOFT LOAN FACILITIES

One of the major difficulties faced in promoting and implementing RE applications in the Agro-Industry is lack of financial capability and the investment load. Many of the RE technology applications require a very high initial cost, which creates a wide gap in the technology requirement and actual application. Therefore, it is essential to incorporate financial assistance models when introducing these technologies to the market.

There is a substantial number of soft loan schemes available through both public and private banks in Sri Lanka, but awareness level is very low within the farmer communities. The information should be effectively communicated to the farmers and the loan facilities should be easily accessible.

6.3.2 INTRODUCTION OF NEW TECHNOLOGIES

The importance of use of machineries for cultivation and semi processing activities has been emphasized in many occasions when carrying out the field data survey for collection of energy consumption details in cultivation and semi processing. The main objective of this initiative is to reduce the manpower involvement in this sector. Farmers highlighted two major issues. Moving away of the young generation from agriculture activities is the first issue and gradual reduction of human power is the second issue. One of the direct solutions to overcome the negative impact of the above mentioned issues is introduction and enhancement of use of machineries and systems in agriculture sector. Use of mini tillers, use of sprinkler and drip irrigation systems are some of the examples and they are expecting advanced technologies for other activities such as planting seeds and plants, weeding, applying fertilizer etc.

6.3.3 ENHANCEMENT OF KNOWLEDGE ON RENEWABLE ENERGY & ENERGY EFFICIENCY

One of the major reasons for RE and EE applications to backfire is the lack of knowledge and awareness among the farmer communities. It is very important to educate the farmers and other sector related persons including government officials, service providers, and technology suppliers. It should be emphasized that the government is encouraging 100% organic farming, and use of clean energy sources combined with energy efficiency measures have a number of benefits including creating environmental sustainability, reducing energy cost, and increasing income margins.

6.3.4 DATA RECORDING AND INFORMATION SHARING

With the technological developments in the agriculture field, the need for a reliable and accessible information network has become prominent. As a promising solution the Food and Agriculture Organization (FAO) and International Telecommunication Union (ITU) have introduced the concept of e-agriculture, developing the 'Sri Lanka E-Agriculture Strategy' and 'E-Agriculture Action Plan 2016-2020). This discusses the methods of integrating agricultural technology with ICT introducing recommended actions for practical implementation. Recommended actions include increasing the availability and accuracy of agricultural information by creating, updating, analyzing and linking critical databases, developing accessible, affordable, and secure ICT platforms, networks, and devices, and improving the financing, investing and banking outreach to agriculture sector leveraging on electronic and mobile technologies. Unlike in the old days, the younger generation is more familiar with digital interfaces and smart applications creating high probability of success for this e-agriculture concept. A preliminary initiative has been taken under the UNDP NAMA project jointly with SLSEA by creating the EnerGIS data reporting web portal. This should be further enhanced to upload and share agro data.

6.3.5 DEMONSTRATION SITES

Demonstration sites are proved to be effective extension tools used in the AFL sectors. They provide an opportunity for the farmers to observe and study new technologies under similar environmental and practical conditions they are familiar with. This approach is quite welcome in the farmer communities as it enables them to reach out for better technological options without any investment risk. With the hands-on experience gained through training at demonstration sites, they are capable of making educated choices with more confidence.

Existing sites with sufficient facilities (i.e: land extension, accessibility) can be developed in to demonstration sites to practice sustainable energy solutions including EE measures and RE technologies with predicted beneficial outcomes. How the site is to be funded needs to be clear and guaranteed for the proposed life of the demonstration site. Standard practices and conditions that need to be maintained should be clearly defined and a reliable recording system and an effective communication plan needs to be developed.

6.4 RECOMMENDATIONS - AGRICULTURE SECTOR

6.4.1 EFFICIENCY ENHANCEMENT IN AGRICULTURE MACHINERIES

The future of Agriculture field is largely relying on machineries and tools with the technological developments in the sector. Use of machineries for cultivation and semi processing activities has enabled covering up for the decrease in man-power and has enhanced the productivity. Continuous research and field trials are needed for the improvement of the machinery as well as to enhance the efficiency.

6.5 RECOMMENDATIONS - LIVESTOCK SECTOR

6.5.1 STUDY ON UTILIZATION OF BIOGAS UNITS

Biogas technology has been in existence since early 1970's in Sri Lanka, but has not become popular compared to other RE technologies such as solar energy. Even though large scale biogas units are a highly preferred solution for the AFL sectors considering the clean energy production, environmental friendly organic waste management, and generation of bio fertilizer, its application is seen mostly limited to lighting, cooking and heating in domestic level and small-scale production of bio fertilizer in the agro-industry. Several studies including the UNDP Energy NAMA project have been performed over time to identify the issues related to backfiring of biogas application. These studies have conveyed that the bio degradation process itself and the routine maintenance practices required to function the system smoothly have been largely disregarded when promoting the technology within farmer communities. Further studies should be conducted with practical intervention and trial studies to assess the compatibility of the biogas technology with existing practices in AFL sectors.

6.5.2 ENHANCEMENT IN ENERGY UTILIZATION EFFICIENCY IN POULTRY INDUSTRY

North Western Province is the major egg and chicken producer in the country. Evaporative cooling technology is being used in controlling temperature in most of the broiler chicken farms and less studies have been carried out in these areas yet. It is recommended to carry out a sample study in these areas and evaluate the energy saving or renewable energy options following that.

6.6 RECOMMENDATIONS - FISHERIES SECTOR

Since renewable energy and energy efficiency interventions are still at the preliminary phase in the fisheries sector, it is recommended to introduce new technologies through research & trial, pilot studies, and practical demonstrations.

Energy consumption in shrimp farming process in North Western Province is substantial. Mainly the aerators of the shrimp ponds are the major energy consumer. Since the grid electricity is available in most of these places, solar roof top systems are recommended to offset the grid electricity consumption and battery operated aerators are recommended to the places where the grid electricity is non accessible.

CHAPTER 7:
ACTIVITY PLAN

7.1 INTRODUCTION

The results based action plan is considered for implementation of green energy technologies and systems in the AFL sectors in North Western Province. The priority has been given to easily implementable and high impact actions and new technologies considered separately under R&D section since these have not been proven as commercially and technically viable technologies.

7.2 ACTIVITIES

Table 7.1: Recommended activities for the action plan

No.	Sector	Intervention	Activity
1	Cross-Sectoral Activities	Training And Capacity Building on RE And EE technologies/systems	Training Agriculture Inspectors
			Training programs for farmer producer organizations
2		Renewable Energy Applications	Introduction of solar roof top systems
3			Solar home systems for sheds, huts, farms
4			Establish demonstration sites
5		Data recording and information sharing	Upgrading energy consumption and production data platforms
6		Financial assistance through commercial/regional banks	Introduction of soft loan facilities
7		Application research on new technologies	Solar powered battery-operated insects control system
8			Testing of new machineries for land preparation, digging holes, planting, fertigation, weeding, etc.
9	Agriculture Sector	Popularization of commercially viable technologies	Solar water pumps supportive programme
10			Introduction of battery operated sprayers
11			Temperature and RH controlled food storage system
12			Chipping machines for green matters (pruning material, grasses, branches etc.)
13			Biomass fired food dehydrators – maize, fish
14	Livestock Sector	Popularization of commercially viable technologies	Small scale milk can coolers
15			Biogas systems – large units
16	Fisheries Sector	Popularization of commercially viable technologies	Solar powered aerators for shrimp farming
			solar thermal powered fish dryers

AG -01 Training and Capacity Building on RE & EE Technologies

Background: One of the main barriers in promoting sustainable energy technologies in the Agro-Industry is lack of knowledge and awareness among the sector community. It is very rarely that the energy and agricultural sectors collaborate to make sustainable development plans, or foster an effective approach for smooth technology transfer. This results in isolated energy systems that are non-productive and non-progressive. Knowingly, the very few energy related projects considering the Agro-Industry in Sri Lanka have not been sustained well in the industry. This failure is largely owing to the fact that there is no accessible and reliable knowledge regarding the adopted energy systems, and technology support is not readily available.

It is a priority requirement to create awareness and provide training and capacity building on sector related energy aspects and the RE & EE Technologies among different levels in the Agro-Industry, including government officials, service providers, technology suppliers, and farmer communities.

Objective: Creating awareness and capacity building on sector related energy aspects and the RE & EE technologies among different levels in the Agro-Industry

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets based on the following strategy/ies.

1. Training of trainers – i.e. Training of Agriculture Inspectors and using them as focal points
2. Reaching out for Energy Services Companies (ESCOs) such as the Industrial Services Bureau (ISB)
3. Assistance from relevant authorities such as SLSEA

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -02 Solar water pumps supportive programme

Background: Water pumping is one of the major energy consuming process in agriculture sector. Electricity, fossil fuel (diesel/kerosene) or solar powered pumps are being used for this purpose and out of these about xx% of pumps are operating with fossil fuel.

Solar powered water pump is not a new technology for North Western Province. The first solar pump project has been implemented in 2006. However, lifetime of most of the pumps introduced during last 16 years period were not more than 2 years. This is mainly due to selection of low-quality technologies and absence of proper after sales services. In this situation, farmers are very reluctant to use solar powered water pumps as an alternative source to the kerosene pumps. Some of the pumps are being successfully operated during last five to seven years period with proper maintenance and most of these pumps are produced under European standard.

Compared with the kerosene or diesel engine driven pumps, solar powered water pumps are economical and the simple payback period would be around 2.5 to 3.0 years. The major issue in solar powered water pumps are intermittent operation (Fluctuation of the output with respect to the variation of solar irradiation) and to eliminate this issue, water storage at a higher elevation is required.

It is expected to provide technical guidance for existing users in operation and maintenance and potential users in selecting and purchasing the pumps through this supportive system.

Objective: Introduction of technology sound solar powered water pumping system as an alternative to the diesel/kerosene pumps with proper after sales services and affordable cost.

Main Targets: To be set by the executing party

Recommended Actions

1. Conduct a comprehensive study on the performance of solar powered water pumps in agriculture sector and identify failures and success stories and identify suitable technologies (eg. AC power pumps with inverters, DC power pumps, pumps with oil cooled motor and electronically controlled, pumps with water cooled motors etc.)
2. Develop few demonstration sites with best technologies covering major agriculture areas
3. Education and training programmes on solar pumping and solar technologies
4. Implement star rating system for solar water pumps and discourage use of low performance pumps
5. Introduce lifecycle-based procurement system

Stakeholders

As identified by the executing party

Responsibility	**Estimated Budget – LKRM**
To be assigned	To be assigned

AG -03 Introduction of battery-operated sprayers

Background: Sprayers are widely used in agriculture to apply pesticides, herbicides, and fertilizers to the field. Currently there are two types of sprayers used in Sri Lanka, the conventional hand operated sprayers and the petrol engine driven sprayers. Hand operated sprayers work through an air pump that compresses air and release the liquid with a pressure. The applicator must pump the air with a handle lever before spraying. This is suitable for small plantations, but is not feasible for large scale plantations spreading over several acres.

Petrol engine driven sprayers use the technology of a DC motor pump powered by a rechargeable battery. They require much less man power, are less heavy, and are more convenient to use compared to the hand operated sprayers. Both the grid electricity and solar charging can be used to recharge the batteries, and once charged it can spray up to 20 tanks making it very convenient to use. Some models come with the pump control feature including a speed regulator so as to control the speed of the pump output that suits your spraying needs. Many long-term benefits are associated with the petrol engine driven sprayers including cost and time efficiency. These are low maintenance devices and spare parts are readily available in the market.

Objective: Applying RE based technologies for creating user-friendly, easily operated and reliable technological advancements and attending to gender responsive technology needs

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Introducing suitable financial assistance model (i.e. 50% government fund and 50% owner's fund)
2. Introducing easy payment modes
3. Introducing soft loan schemes through development banks

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -04 Temperature and RH controlled food storage system

Background: Food products are easily perishable under ambient temperatures, and therefore it is very important to maintain controlled environment in storage spaces to increase the shelf life of stored food preserving their nutritional qualities. The study is focused on short term storage of agricultural crops on site during the transfer period from farmers to transporters. Amongst the existing technologies, thermally driven air conditioner and relative humidity control systems are favoured currently. Optimum conditions are maintained at 25-35 C temperature and 60-65 % RH for most of the food products including potatoes, ginger, turmeric, black pepper and other spices. This storage system has been effectively adapted in Dambulla and Jaffna for the storage of enasal (cardamom) and onions respectively. Storage capacity for a substantial storage of 100*30 ft is approximately 600 – 700 K kilograms of onion which requires a 1.5 kW machine to run the system maintaining optimum conditions. Energy use is negligible compared to the output and the payback period for the investment in building the system is usually less than one year depending on the market parameters.

Objective: Introduce RE based advanced technologies to minimize wastage of food and ensure constant market supply

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Awareness through demonstration sites
2. Financial support systems (grants /soft loan facilities)

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -05

Chipping machines for green matters (pruning material, grasses, branches etc.)

Background: Discarding agricultural waste is a problem faced by many small-scale farmers. Cutting, drying, and processing bio waste is strenuous and time consuming, and first-hand burning is harmful for the environment. As a solution for this, small-scale chipping machines/ agricultural shredders can be used for chopping agricultural waste, farm waste and garden waste and convert them to compost manure. Government is encouraging 100% organic farming, and the use of these shredders to produce natural compost manure with bio waste would be both economically advantageous and promoting sustainable agriculture technology. Additionally when plant waste is directly used in composting process, some parts will remain undigested which have to be separated from the manure. Chipping will eliminate this need enhancing the productivity of composting process. A range of bio waste products such as pruning material, dry and wet coconut fronds/husks, harvested banana trees can be processed in these chipping machines. Different models are available such as Tractor PTO agriculture shredders (prevalent in Sri Lankan market), Mini Tractor operated shredder machine, Electric shredder machine, Coconut Shredder Machine, and Garden Shredder Machine, etc.

Objective: Applying RE based technologies for introducing user-friendly, easily operated and reliable technological advancements and attending to gender responsive technology needs

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Awareness through demonstration sites
2. Financial support systems (grants /soft loan facilities)

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -06 Biomass fired food dehydrators

Background: Drying/ dehydration is a critical step in post-harvest treatment procedure, which is necessary to avoid spoilage/molding of crops due to moisture and increase shelf life during storage. Food products with low-medium moisture content (<30% wet basis) such as paddy, maize, sesame seeds, legumes, etc. are dried and food products with high moisture content (>50%) such as fruits, vegetables, fish, meat, etc. are dehydrated in the process. Traditionally drying involved capturing direct heat from the sun, but with the technological advancements in the Agro-Industry mass harvesting is more common making it difficult to use sun drying effectively. Using biomass fired food dehydrators is a more efficient and convenient option for the drying process. They are designed optimizing parameters like the moisture removal rate, drying rate, thermal efficiency, and heat transfer efficiency to obtain optimum results while preserving the physical and nutritional qualities of the food products. Biomass pellets, saw dust, wood pellets can be used as the heat source in these dehydrators and the capacity can be as high as 500 kg/hr.

Objective: Establishing Micro industries in rural level and value addition of agricultural products

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Awareness through demonstration sites
2. Financial support systems (grants /soft loan facilities)

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -07 Small scale milk can coolers

Background: Small scale dairy farming is a common livelihood among the farmer community in the North Western Province of Sri Lanka, housing 54,000 cattle farmers. The milk produced is transported to collecting centres without any form of cooling. The hygiene and quality of the milk largely depends on how fast the collecting and transporting process is, because fresh milk tends to exceed the maximum bacterial count decided by food safety laws in about 2-5 hours when left in the open under the warm climatic conditions of Sri Lanka. A cow produces around 10 litres of milk in the morning, and 6 litres in the evening. Due to lack of facilities farmers have stopped collecting the evening milk causing additional on-farm losses.

Small scale on-farm milk cooling systems with insulated milk cans are being used worldwide as an immediate solution to these issues. They are designed with a commercially available DC refrigerator and an ice maker with insulated cylindrical cans to store milk. Local manufacturing is done by Milco Sri Lanka making it possible to purchase at affordable prices. The cooling systems can also be coupled with independent solar units, but in long term aspects a grid connected system will be more convenient to use, while using a solar roof top system to compensate the energy use.

Objective: Optimizing the yield and encouraging maximum milk production locally

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Enhancing technology availability in the market
2. Introducing suitable financial assistance model/ easy payment modes

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -08 Biogas Systems- Large Units

Background: Biogas technology has been in existence since early 1970's in Sri Lanka, but has not become popular compared to other RE technologies such as solar energy. Biogas application is seen mostly limited to lighting, cooking and heating in domestic level and small-scale production of bio fertilizer in the agro-industry. Several studies including the UNDP Energy NAMA project have been performed over time to identify the issues related to backfiring of biogas application. These studies have conveyed that the bio degradation process itself and the routine maintenance practices required to function the system smoothly have been largely disregarded when promoting the technology within farmer communities. Hence lack of knowledge and preparedness causes efficiency drop in the biogas systems and raise dissatisfaction among its users. There are no proper regulations or policies related to biogas promotion and application in Sri Lanka, except for some environmental standards imposed on solid waste management and waste water treatment in swine farming. If these issues are addressed properly, large scale biogas units are a highly preferred solution for the Agro-Industry considering the clean energy production, environmental friendly organic waste management, and generation of bio fertilizer.

Objective: Popularization of commercially viable technologies through establishment of demonstration sites

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Identifying potential implementation sites
2. Providing site specific solutions to overcome implementation barriers
3. Awareness through demonstration sites
4. Financial support systems (grants /soft loan facilities)

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -09 Solar powered aerators for shrimp farming

Background: Shrimp farming is popular in the coastal areas of Sri Lanka including the Puttalam District in the NWP. Adequate aeration is critical for shrimp farming, to keep the water clarity and produce healthful harvest. A sort of mechanical aeration is used for this purpose, most commonly being floating electric aerators with plastic paddle wheels and long arm aerators in the Asian culture.

This utilizes a considerable amount of energy, and most of the shrimp farms are located in places that find it difficult to access the national grid. As an alternative, solar powered push flow aerators with rotating impellers can be used with a high success rate. They are small, simple floating devices that can be easily used as an off-grid application. Use of renewable energy makes it more sustainable and environmental friendly, and will increase the income margin due to decrease in energy cost.

Objective: Popularization of commercially viable technologies through establishment of demonstration sites

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Enhancing technology availability in the market
2. Awareness through demonstration sites

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -10 Solar thermal powered fish dryers

Background: Raw fish meat contains around 80% moisture making it a highly perishable food. Drying is an important technique used in the fisheries sector to preserve fish increasing the shelf life and storage period, preventing wastage of excess harvest, and maintaining a consistent a supply to the market. Open sun drying is the most attractive and prevalent method used, as it is very effective in tropical regions such as Sri Lanka, is easy to handle, and does not require much technical or financial capacity. But it also has its disadvantages like requiring a large open space exposed to direct sunlight, slow and non-uniform drying, and low hygiene due to fish being exposed to dust, bird and animal attacks. Solar thermal powered fish dryers are a simple and preferable alternative to open sun drying, that make use of solar energy with more advanced and efficient technology. It is more suitable for drying small fish and the only disadvantage compared to other drying methods is not being able to use when there is no sun light.

Objective: Popularization of commercially viable technologies through establishment of demonstration sites

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Enhancing technology availability in the market
2. Awareness through demonstration sites

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -11	Introduction of solar roof top system (Domestic level)

Background: "Sooryabala Sangraamaya" Battle of Solar Energy is a government program to power up the country with renewable energy up to a 50%, by year 2025, reaching for the target of 100% renewables by 2050. Under this program, domestic level consumers are encouraged to install solar roof top systems up to 5kW under one of the three connectivity plans; net-metering, net-accounting, and net plus schemes. Soft loan facilities are available with most of the prominent banks at interest rates as low as 4%. Even though the solar power generation is popular among industrial and commercial sectors, the knowledge is lacking in the domestic levels. Stand-alone off-grid solar applications are used to some extent, but the grid connected systems are more reliable and useful compared to these. It is important that the function of these systems, their benefits and economic advantages are clearly transmitted to agricultural communities through awareness programs, and the systems should be promoted through introducing affordable technical and financial aid.

Objective: Popularization of commercially viable technologies

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Introducing and popularizing ongoing schemes
2. Creating links to the available financial tools

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -12 Solar home systems for sheds, huts, farms

Background: Despite the technological advancements in the Agro-Industry some traditional farming practices are continued up to date in the rural areas. For example, to protect the crops from wild animals, farmers keep watch during the night in small tree houses built in the field. Some stages of harvesting and post-harvest handling including threshing requires overnight field work. Usually kerosene lamps are used to light up the sheds, huts, and farms during the night.

Solar home systems are battery operated solar powered lighting systems with a simple plug and play technique, that can be used to replace the kerosene lamps. They are compact, portable, and durable devices that can light up to 3 LED bulbs. They usually come with a USB output that can be used to charge a simple device such as a mobile phone. It is an easy to use and environmental friendly alternative to the harmful kerosene lamps.

Objective: Popularization of commercially viable technologies through establishment of demonstration sites

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Enhancing technology availability in the market
2. Awareness through demonstration sites

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -13 Establishment of Training and Demonstration Sites

Background: Demonstration sites are proved to be effective extension tools used in the Agro-Industry. They provide an opportunity for the farmers to observe and study new technologies under similar environmental and practical conditions they are familiar with. This approach is quite welcome in the farmer communities as it enables them to reach out for better technological options without any investment risk. With the hands-on experience gained through training at demonstration sites, they are capable of making educated choices with more confidence.

Existing sites with sufficient facilities (i.e: land extension, accessibility) can be developed in to demonstration sites to practice sustainable energy solutions including EE measures and RE technologies with predicted beneficial outcomes. How the site is to be funded needs to be clear and guaranteed for the proposed life of the demonstration site. Standard practices and conditions that need to be maintained should be clearly defined and a reliable recording system and an effective communication plan needs to be developed.

Objective: Popularization of commercially viable technologies through establishment of demonstration sites

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Identifying potential demonstration sites
2. Introducing funding and maintenance systems for the sites

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -14 Soft loan schemes through regional banks

Background: One of the major difficulties faced in promoting and implementing RE applications in the Agro-Industry is lack of financial capability and the investment load. Many of the RE technology applications require a very high initial cost, which creates a wide gap in the technology requirement and actual application. Therefore, it is essential to incorporate financial assistance models when introducing these technologies to the market.

There is a substantial number of soft loan schemes available through both public and private banks in Sri Lanka, but awareness level is very low within the farmer communities. The information should be effectively communicated to the farmers and the loan facilities should be easily accessible.

Objective: Popularize RE based advanced technologies through financial support models

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Increase awareness on available financial support systems
2. Establishing a communication network for information sharing and coordinating the facilities

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -15 Solar powered battery-operated insect control system

Background: Pest control is an important requirement in farming, and chemical pesticides are still used as the fastest and most effective method for this purpose. However, chemical pesticides are health hazards and environmental pollutants, and with the government encouraging 100% organic farming practices, it has become a concern of the farmers to look for pest control methods other than the use of pesticides. Traditional methods of pest control such as crop rotation, intercropping, and growing insect repellent weeds are usually effective but the knowledge and practical experience on how to apply these methods properly have not been passed through generations. The solar powered insect traps are a very attractive effective alternative developed with the advancements in agricultural technology. They are simple devices that include a rechargeable battery powered by solar energy, which is used to light a LED bulb that lure and trap the insect pests. The bulb can automatically light up when there is no sun, and stay up to 4 hours after sunset.

Objective: Popularization of commercially viable technologies through establishment of demonstration sites

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Enhancing technology availability in the market
2. Awareness through demonstration sites

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

AG -16

Testing of new machineries for land preparation, digging holes, planting, fertigation, weeding, etc.

Background: The agriculture sectors in all the leading countries with an agriculture-based economy such as China, India, and Bangkok have been developed with research and experiment. It is essential that new machineries are tested and developed regularly for introducing to the field, as the man power in agriculture sector is visibly decreasing. Many people from the younger generation are shifting to livelihood methods other than farming, and the fitness and strength of people have also become less, reducing the capacity to engage in field work.

Objective: To enhance overall productivity of the Agro-Industry

Main Targets: To be set by the executing party

Recommended Actions

It is recommended to build actions to deliver targets through the following strategies.

1. Continuous updating of technology database
2. Conducting trial studies through research and development

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

No	Action	Targets	Strategy	Responsibility	Supportive agencies	Budget - MLKR	KPIs					Funding Sources					MRV
							2022	2023	2024	2025	2026	Self Funded	Consolidated Fund	Donor Funds	CSR Funds	Sponsorships	
1	**Solar water pumps supportive programme**	Introduction of 250 solar water pumps	Financial assistance maximum up to 25% of the total cost	Ministry of Agriculture NWP													
			Coordinate with local banks and arrange soft loans														
			Training programs on effective use of solar pumps		SLSEA												
2		Introduction of 250 electrically driven water pumps															
3		Introduction of 500 solar roof top systems															
4		Introduction of 200 solar home systems for inland fishing boats															

CHAPTER 8:
IMPACT ASSESMENT OF PROPOSED ACTIONS

Nos.	Technology	Capacity of the proposed intervention	Minimum land area required for introduction of new technology- Acres	Cost of a unit - LKR	Base case	Existing Energy Use	Units	RE technology	Specific base case energy cost - LKR/kWh, Liter	Simple pay back period - years	Potential sites for new intervention	Emision factors kg of CO2/kg of fuel	CO2 saving potential - tons/year
1	Electricity driven water pumps + solar rooftop system (5kW)	5kW	5	1,150,000.00	Electricity	6,600	kWh/year		35.00	5.0	100,000	0.722	476,520
2	Solar water pumps	2kW	2	500,000.00	Diesel	840	lires/year	Sola pumps	111.00	5.4	3,000	3.17	8,000
3	Sprayer		2	12,500.00	Petrol	48	lires/year	electricity	127.00	2.00	100,000	3.13	15,000
4	Sola home system	3 lamps	any	20,000.00	Kerosene	150	lires/year	Solar home system	80.00	1.7	2,000	3.15	950
5	Solar rooftop systems for shrimp farming	12 kW	1	2,100,000.00	Electricity	10,800	kWh/year		22.00	9.0	2000	0.722	15,600
6	Temperature and RH controlled food storage systems	These technologies are being proposed for valuve addition to the agriculture, fisheries and livestock sector outputs. Since there is not a base case for these technologies, potential reduction of CO2 emision is not arrised.											
7	Biomass fired food dehydrators												
8	Small scale milk can coolers												
9	Solar thermal powerd ih dryers												
10	Solar powered battery operated insects control systems												

CHAPTER 9:
IMPLEMENTALION ARRANGEMENT OF THE ACTION PLAN

9.1 INTEGRATION OF FIVE-YEAR VISION ORIENTED SUSTAINABLE DEVELOPMENT PLAN FOR THE NWP

Sustainable Development plan is being implemented in the North Western Province since 2020 targeting five-year development horizon. UNDP has been facilitating the development stage of this plan and the technical support has been given by the University of Colombo and Wayamba University.

Development activities have been addressed under this plan in all the sectors and training, awareness, productivity enhancement through new innovations, technology support, establishment of demonstration sites etc. have been identified as the prospective actions. However, the green energy aspects have not been addressed separately in this development plan. There is not much difficulty for integrating the proposed green energy actions in to the ongoing sustainable development plan without any major changes. For example, while introducing new technologies to the end users, integrating green energy requirement in to the product specification can be done. Green energy action plan can be treated as an addendum to the ongoing five-year sustainable development plan.

9.2 IMPLEMENTATION ARRANGEMENT OF THE GREEN ENERGY ACTION PLAN

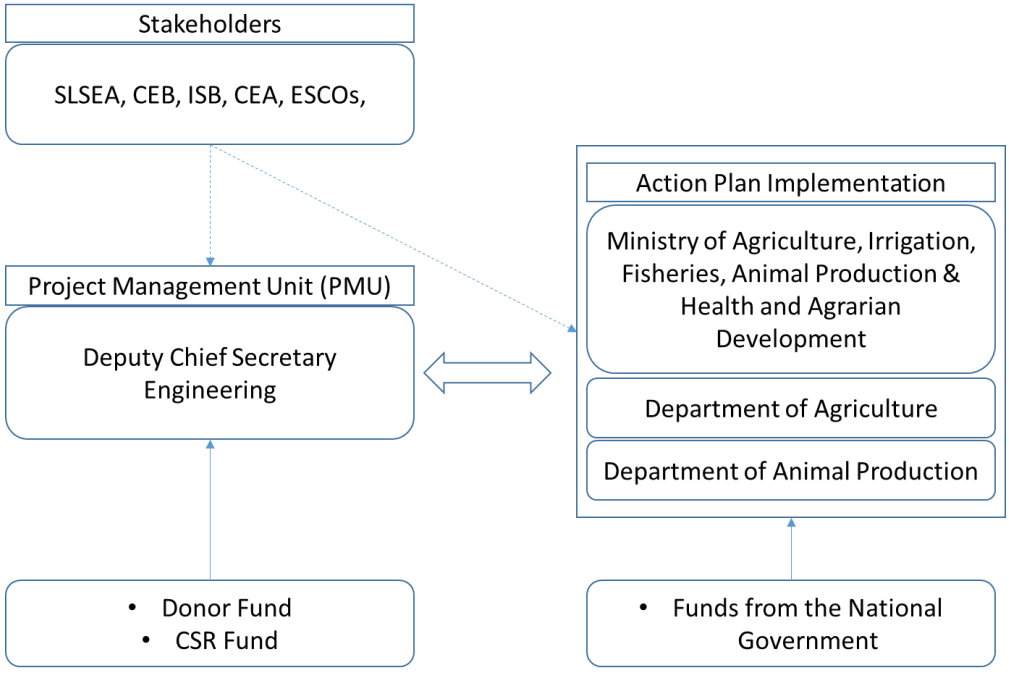


Figure 9.1: Implementation arrangement of the action plan

9.2.1 GOVERNING FRAMEWORK

Coordination, monitoring and implementation assistance will be done by the Focal Point-Project Coordination established in Deputy Chief Secretary Engineering office and implementation of the action plan will be done individually by the relevant Ministries and the departments.

Focal Point- Project Coordination will be specifically responsible for:

Liaising with the donor agencies, CSR funding sources and channeling the fund for implementing partners.

Coordination with relevant institutions for obtaining technical assistance in implementation of the action plan.

Monitoring the progress and ensuring smooth operation.

Implementing partners will be specifically responsible for:

Liaising with the Financial Commission, and line Ministries for budgeting requirement.

Development of annual action plan based on the available resources and Government directives.

Implementation of the action plan and reporting the progress.

9.2.2 STEERING COMMITTEE FOR IMPLEMENTATION OF THE ACTION PLAN (SC)

Chairman: Chief Secretary, North Western Province

Secretary: Deputy Chief Secretary Engineering, North Western Province

Responsibility: Guidance & direction for enhancing the overall productivity

Meetings: Once in 4 months

A Steering Committee (SC) for implementation of the green energy action plan will be officially appointed by the chief secretary. The SC will include members representing the Agriculture, Fisheries and Livestock sector relevant institutions. The heads of participating public sector institutions will be invited to SC meetings as necessary. The Deputy Chief Secretary Engineering will act as the Secretary and convener of the SC. The SC will meet as often as required, but will meet at least once in every 4 months.

9.2.3 FINANCIAL MANAGEMENT

Finances available at donors and CSR funds will be channeled through the Focal Point- Project Coordination and the implementation progress will be monitored. Government funds will be directly channeled to the relevent implementation institutions following the existing prevaling mechanisms.

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ANNEXURES

ANNEX 1: CONTACT DETAILS OF WORKING COMMITTEE- FOCAL POINTS (NWP)

Formulation of provincial energy plans for the agriculture, livestock and fisheries sector

No	Name	Designation	Ministry /Department	Contact No	E mail
01	Dr. B.C.S Perera	Provincial Director	Department of Animal Production & Health	071-8363439	bcsperera123@gmail.com
02	P.S Kumara	Provincial Director	Agriculture Department	071-2143127	pdoanwp@gmail.com
03	Geethanjalee Bandaranayake	Director (Planning)	Chief Secretary's Office	077-7724266	sgbandaranayake@gmail.com
04	K.M.A.Jayathilake	Deputy Director (Planning)	Ministry Of Agriculture & Fisheries	071-4398273	ajanthajayathilaka@gmail.com
05	S.A.G.Sooriyakumari	Deputy Director (Planning)	Ministry of cooperative Electricity & Energy	071-7706939	gayaniherath73@gmail.com
06	Suraj Sirisena	Deputy Director	Fisheries Department	071-4416911	surajmof@gmail.com

ANNEX 2: CONTACT DETAILS OF SURVEY RESPONDANTS- FARMERS (NWP)

Project on Solar and Bio Energy - Transitioning to Sustainable Energy Uses in the Agro-Industry – UNDP Questionnaire Survey – Energy Usage in Agriculture Sector - NWP				
Farmer Details				
District	**Crop**	**Name of the Farmer**	**Telephone Number**	**GS Division**
Puttalum	Fruits & Vegetables	M.Jesus	753624127	Navakkadu
Puttalum	Fruits & Vegetables	R.U.C.J.Jude	763153702	Navakkadu
Puttalum	Fruits & Vegetables	D.Sujikaran	756279789	Navakkadu
Puttalum	Fruits & Vegetables	A.C.R.Dharshikan	767828268	Naarakkalliya
Puttalum	Fruits & Vegetables	J.K.Lakshman Thamil	778037889	Illanthaiyadi
Puttalum	Fruits & Vegetables	S.A.Dimuthu Kalum	722858982	Illanthaiyadi
Puttalum	Fruits & Vegetables	S.A.Sashika Pushpakumara	773619087	Illanthaiyadi
Puttalum	Fruits & Vegetables	A.J.E.Mahesh	770162168	Mampuri
Puttalum	Fruits & Vegetables	A.T.Manchu Fernando	717022877	Nirmalapura
Puttalum	Fruits & Vegetables	M.R.F.Pulle	725205807	Mampuri
Puttalum - Wanathavilluwa	Paddy	P.Anura Palitha	715794694	Mailankulam
Puttalum - Wanathavilluwa	Paddy	H.G.Sanjaya Priyadharshana	767026124	Mailankulam
Puttalum - Wanathavilluwa	Paddy	J.A.Ananda Sumith Kumara	728518405	Wijayapura,North
Puttalum - Wanathavilluwa	Paddy	C.F.A.Jude Fernando	724603396	Vanathavilluva,North
Puttalum - Wanathavilluwa	Paddy	P.P.Suranga Kumara	763034185	Aluth Elluvankullama
Puttalum	Paddy	E.P.Susantha Kumara	761947399	Parana Elluvankullama
Puttalum	Other Crop	I P Rajapaksha	070-4555387/077-4794009	Periyankulama
Puttalum	Other Crop	B M Rupasinghe	071-3838113/077-5736896	Uriyawa
Puttalum	Other Crop	A H M Jothipala	077-9645357	Thathawa

Puttalum	Other Crop	D M Gunnathilake	071-0471113	Uriyawa
Puttalum	Other Crop	A H M Padmini Kumari	071-3716710	Thathawa
Puttalum	Other Crop	A H M Chandrapala	071-3716710	Thathawa
Puttalum	Other Crop	W B Ranbanda	076-1207433	Paramanandinawa
Puttalum	Other Crop	A H M Dharmawathi	032-5712946	Thathawa
Puttalum	Other Crop	H M A C Bandara	077-6805808	Thathawa
Puttalum	Other Crop	A H M Wimalarathna	071-5427832	Thathawa