

PROVINCIAL ENERGY PLAN FOR AGRICULTURE, LIVESTOCK AND FISHERIES SECTORS IN THE SOUTHERN PROVINCE

Under the Biogas, Biomass and Solar Trilateral Cooperation Project

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Prepared by
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Prepared For
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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

| | |
|-------|---|
| CCS | - Climate Change Secretariat |
| CEB | - Ceylon Electricity Board |
| SP | - Southern Province |
| GHG | - Green House Gas |
| NAMA | - Nationally Appropriate Mitigation Actions |
| RETs | - Renewable Energy Technologies |
| SLSEA | - Sri Lanka Sustainable Energy Authority |
| 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 (TSSC) 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 260,000 hectares of agricultural land in Southern Province, and out of this about 110,000 hectares are paddy lands, 15,000 ha are vegetable cultivating lands and around 13,000 ha are fruit cultivating lands. Balance is for coconut and other crops. Out of the total agricultural land, 228,000 hectares are owned by the small holders and the balance is for estate sector [6].

According to the geographical variations and land conditions, most of the paddy fields in Galle and Matara Districts are having muddy soil and most of the time two-wheel tractors are utilized for land preparation. Also, the use of combined harvester in paddy harvesting is limited due to this land condition.

Hambantota district is unique and out of the total production in Southern Province, 50% of paddy production and 80% of vegetable productions are shared in this district. Dry zone agriculture practices are followed in this district and properly designed water tanks and irrigation channels are available in most of the areas for supplying water.

Around 277.67 million liters of auto diesel, 154 million liters of petrol (Octane 92) and 1132 GWh of electricity has been used in 2019 [9] in Southern Province. Out of these around 5.2% of diesel, 2.4% of petrol and 0.194% of electricity is used in agriculture sector.

The energy consumption in paddy cultivation is the highest in Southern 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 45.3% and 23.1% respectively. Water pumping is the next and it shares around 12.6% of the total energy. In short rotation vegetable crops, more than 45% of total energy consumption shares are for water pumping and approximately 36% 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 Southern Province and all the stocks are sent to the processing centers just after harvesting.

Marine fishing is available in all the Districts in the Southern province. The total annual marine fish production in the Southern Province is in the range of 130000 to 140,000 tons per annum and this shares approximately 32.0% of the national marine fish requirement [8].

Inland fishing is also popular in the Southern Province and it contributes to supplying around 10% of the inland fish requirement of the country amounting 8,800 tons per annum. There are about 130 perennial tanks and around 250 satellite tanks for farming inland fish in the Southern Province [8].

Out of the total energy use in North Southern Province, around 2.0% of diesel, 9.2% petrol consume in multi day and single boats.

Livestock Sector: Livestock sector productions and earnings in the Southern province is contributing moderately to the national GDP in Sri Lanka annually. Out of the total national requirement about 6.5% of cow milk, 23.3% of buffalo milk, 2.8% of beef and 3.2% of mutton is produced in the Southern province. Southern province is the second largest buffalo milk and curd producer to the local consumption [7].

Energy usage in livestock sector in the Southern Province is almost negligible. Electricity is used for lighting in many places and other than this there are no livestock machineries used substantially in the Southern Province.

Energy use in boiling milk in curd making process is substantial and in most of the places, firewood is used for this purpose. LPG burners are there in small scale curd making centers and enhancement of energy utilizing efficiency is probable in both firewood and LPG systems.

In addition to the energy usage, substantial amount of energy is generated through biogas for domestic usage from this sector.

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 Cooperation Project which has been implemented with the objectives of introducing technologies and systems to enhance the Sustainable Energy Use in the Agro-Industry (Agriculture, Fisheries and Livestock industries) 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.

Agriculture, fisheries and livestock sectors have been considered under this report as the Agro-Industry prevailing in the Southern 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.

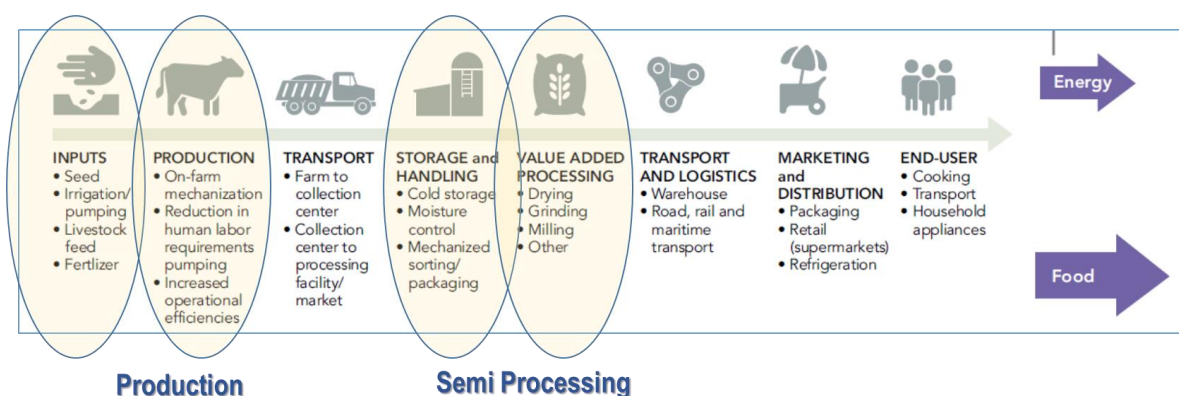


Figure 1.1: Boundary of this analysis report

Exceptions: Plantation sector (Tea, rubber, coconut, cashew etc.) and industry sector (Ice making etc.) has not covered under this 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, 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.

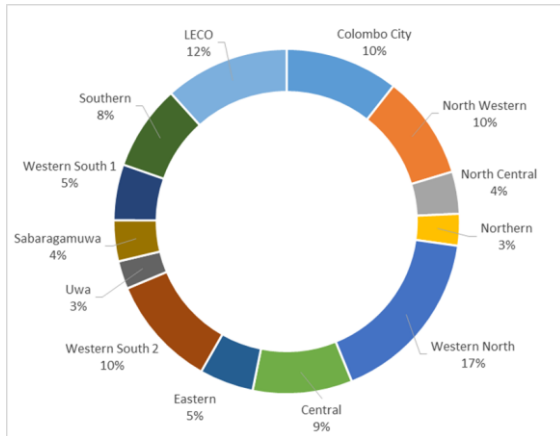


Fig 1.2: Electricity share by province

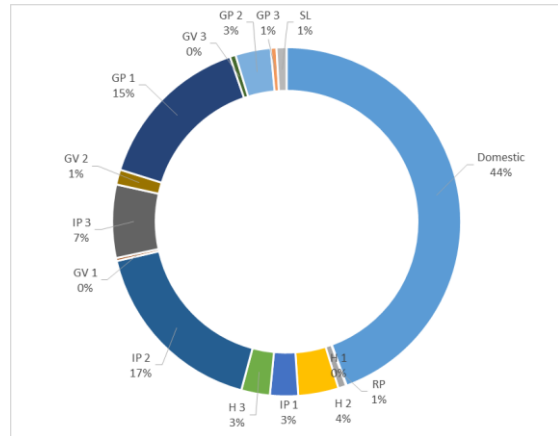


Fig 1.3: Electricity share by different categories in SP

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. Adoption of renewable energy technologies in crop farming, livestock applications have been identified as prospective NDCs under this report.

1.3 AGRICULTURE SECTOR - SOUTHERN 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 260,000 hectares of agricultural land in Southern Province, and out of this about 110,000 hectares are paddy lands, 15,000 ha are vegetable cultivating lands and around 13,000 ha are fruit cultivating lands. Balance is for coconut and other crops. Out of the total agricultural land, 228,000 hectares are owned by the small holders and the balance is for estate sector [6].

According to the geographical variations and land conditions, most of the paddy fields in Galle and Matara Districts are having muddy soil and most of the time two-wheel tractors are utilized for land preparation. Also, the use of combined harvester in paddy harvesting is limited due to this land condition.

Hambantota district is unique and out of the total production in Southern Province, 50% of paddy production and 80% of vegetable productions are shared in this district. Dry zone agriculture practices are followed in this district and properly designed water tanks and irrigation channels are available in most of the areas for supplying water.

1.3.2 ENERGY USE

Water pumping is the major energy consumer in vegetable cultivation and approximately 76% in terms of energy, and 80% 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 is given in Chapter 4.

1.3.3 IMPLEMENTED AND ONGOING PROGRAMMES

1.3.3.1 Projects Implemented by the Ministry of Agriculture - SP

Ministry of Agriculture in Southern 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 Southern Province

| Projects Details (Related to Energy) Southern Province - Agriculture | | | | |
|---|-------------------------------------|----------------------------|---|------------------------|
| Year | Project | No of Beneficiaries | Specifications | Unit Cost - LKR |
| 2019 | Dry chilies production programme | 50 | Sprinkler systems suitable for ½ acre land | |
| | | 50 | 2 inches 4Hp water pumps (Diesel & electricity) | |
| | | 50 | Insects control nets | |
| | Establishment of GAO villages | 40 | High pressure sprinklers | |
| | | 5 | 2 inches 4Hp water pumps (Diesel & electricity) | |
| | | 215 | Grass cutters (50% grant) | |
| | | 20 | Irrigation systems (50% grant) | |
| | Drip Irrigation systems | 55 | Drip Irrigation systems (50% grant) | |
| | | 155 | Water pumps (50% grant) | |
| | Commercial water management systems | 12 | Agriculture wells (50% grant) | |
| 2021 | Certified paddy production | 5 | Weighing scale (50% grant) | |
| | | 39 | Power Spray (50% grant) | 396,825.00 |
| | Water management | 10 | Mini sprinkler systems | |
| | | 11 | 1 inches 1/2Hp water pumps | |
| | | 17 | 2 inches 2Hp water pumps | |
| | | 10 | 2 inches 2Hp water pumps (Diesel) | |
| | | 77 | Sprinkler systems for ½ acre land | |
| | | 40 | Sprinkler systems for ¼ acre land | |
| | | 22 | Sprinkler systems for 1 acre land | |
| | | 2 | Drip irrigation systems | |
| | | 17 | Agriculture wells | |

1.4 LIVESTOCK SECTOR

1.4.1 OVERVIEW

Livestock sector productions and earnings in the Southern province is contributing moderately to the national GDP in Sri Lanka annually. Out of the total national requirement about 6.5% of cow milk, 23.3% of buffalo milk, 2.8% of beef and 3.2% of mutton is produced in the Southern province. Southern province is the second largest buffalo milk and curd producer to the local consumption.

1.4.2 ENERGY USE

Energy usage in livestock sector in the Southern Province is almost negligible. Electricity is used for lighting in many places and other than this there are no livestock machineries used substantially in the Southern Province.

Energy use in boiling milk in curd making process is substantial and in most of the places, firewood is used for this purpose. LPG burners are there in small scale curd making centers and enhancement of energy utilizing efficiency is probable in both firewood and LPG systems.

In addition to the energy usage, substantial amount of energy is generated through biogas for domestic usage from this sector.

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 storage facilities in the Southern Province and all the stocks are sent to the processing centers just after harvesting.

Marine fishing is available in all the Districts in the Southern province. The total annual marine fish production in the Southern Province is in the range of 130000 to 140,000 tons per annum and this shares approximately 32.0% of the national marine fish requirement.

Inland fishing is also popular in the Southern Province and it contributes to supplying around 10% of the inland fish requirement of the country amounting 8,800 tons per annum. There are about 130 perennial tanks and around 250 satellite tanks for farming inland fish in the Southern Province.

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 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 Southern Province during recent past. Small scale solar dryer project has been initiated in collaboration with the Faculty of Engineering, University of Ruhuna recently and the trial is being tested at Deundara. This project is focusing to produce dry fish within three days and this dryer is most suitable for domestic use to produce day to day dry fish requirement.

1.6 ASSISTANCE FOR IMPLEMENTATION OF GREEN ENERGY IN THE SOUTHERN 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 one pilot project was implemented in the Southern Province for testing of MRV system in biogas generation. Under this pilot project 149 biogas units have been implemented in different scales and part financing was made as grants under the NAMA project.

1.6.2 ELECTRICITY TARIFF FOR AGRO-INDUSTRY

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 Agro-industry 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 Agro- industry 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.

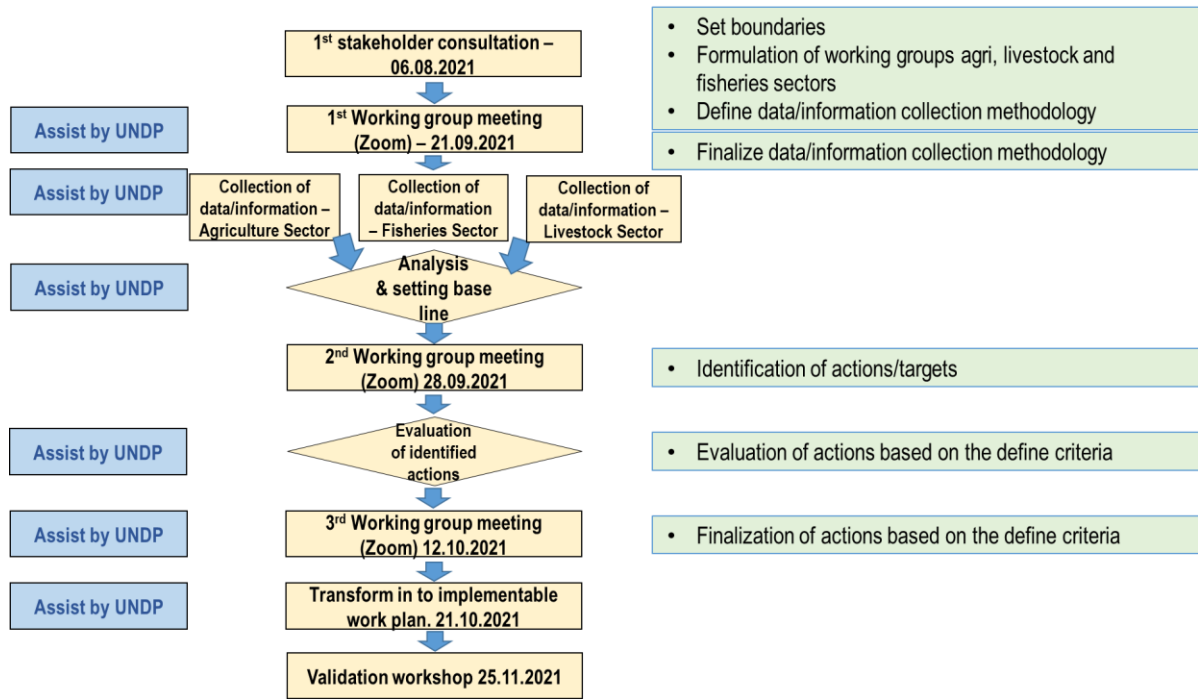
It is obvious that the general public is always trying to move towards convenient life styles and they are not paying much attention on complex operations like domestic biogas systems even though it gives better return on investment (RoI). This is why the solar systems are becoming popular even with 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 Agro-industry 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 survey participants 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 STATUTORY POWERS

The power for developing renewable energy and generating power and energy from renewable energy from renewable energy sources within the province is vested in the provincial council through the gazette no. 1532 Statute of Alternate Power and Energy No. 2 of 2007, published on 11th January 2008. Southern Province is the only province that has such statutory powers vested in the provincial council.

2.4 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-2021 by 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. |

2.5 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. 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 centres, farm operation and processing; and introducing biogas digesters for large scale livestock & poultry, dairy processing and abattoirs |

2.6 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 | 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 |

| | | | |
|----|---|---|---|
| | | through conservation and utilization of natural resources while safeguarding ecosystem services | 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 operations of physical inputs for their judicious use | Establish a mechanism to certify machinery and other agricultural inputs to be used in Sri 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, | Provide appropriate incentives (financial & physical) to promote R&D for technology development |

| | | | |
|--|--|--|--|
| | | development and extension systems, and recruitment related to the agriculture sector | |
|--|--|--|--|

CHAPTER 3: DATA AND INFORMATION

3.1 INTRODUCTION

Data and information related to energy and machinery use in the Agro-industry 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 agriculture sector is 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 Galle, Matara and Hambanthota Districts and the summary of those data are presented in this chapter. Considering the prevailing COVID-19 situation, this survey has been conducted via online method.

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 Plantain | Sweet Potato | Kurakkan | Gingelly | Murunga | Manioc | Ind.Tuber & Roots |
| Land area for both seasons - ha | 311 | 8 | 142 | 2 | 3 | 1184 | 1117 | 0 | 540 | 64 | 18 | 578 | 2524 | 404 | 93 | 26 | 781 | 4 | 493 | 0 | 7 | 873 | 40 | 646 | 747 | 241 | 209 | 937 | 669 | 179 | 115 | 17 | 1336 | 601 | 0 | 102 | |
| Yeild - ton | 4789 | 30 | 754 | 16 | 44 | 21950 | 16365 | 1003 | 448 | 256 | 2089 | 2361 | 404 | 184 | 26 | 2381 | 32 | 5594 | 100 | 6454 | 181 | 6893 | 17544 | 13243 | 2395 | 14276 | 10205 | 1396 | 1242 | 201 | 1100 | 510 | 1465 | | | | |

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 | Lemon | Orange | Avacado | Guava | Mandarin | Pomegranate | Watermelon |
|--|--------|-----------|-------|---------------|-------|----------|-------|--------|---------|-------|----------|-------------|------------|
| Land area ulilyze - Hactares for both seasons | 5981 | 515 | 2133 | 346 | 1101 | 1163 | 453 | 771 | 77 | 162 | 37 | 193 | 148 |
| Yeild - ton | 48488 | 5662 | 9107 | 1575 | 11474 | 6541 | 851 | 1725 | 143 | 159 | 62 | 570 | 976 |

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 Southern Province is given in the following table.

Table 3.3: Key statistics of the fisheries sector in the Southern Province

| No. | Description | Results |
|---------------------------|--|---|
| Marine Fishing | | |
| 01 | No of multi day boats | 2300 |
| 02 | Out-board engine fiberglass reinforced plastic boats | 2000 |
| 03 | Motorized traditional boats | 600 |
| 04 | Non-motorized traditional boats | 1550 |
| 05 | Total annual fish catch | 143270 t/year |
| Inland Fishing | | |
| 06 | No of inland tanks | 136 |
| 07 | Total tanks area | 10,680 hectares |
| 08 | Alternative tanks | 200 |
| 09 | Inland fishing crafts | 1000 |
| 10 | Total annual fish catch | 9560 t/year |
| Ornamental Fishing | | |
| 11 | No of stations | 520 |
| 12 | Major energy consuming equipment | Pumping water, ½” to 1” pumps and aerator blowers |

3.2.3 LIVESTOCK SECTOR

Table 3.4: Key statistics of the livestock sector in the Southern Province

| No. | District | No of Chilling Centers | Chilling Capacity (Liters) | Milk Collection (Liters) |
|-----|-------------|------------------------|----------------------------|--------------------------|
| 01 | Galle | 2 | 6,300 | 871,250 |
| 02 | Matara | 3 | 9,230 | 734,840 |
| 03 | Hambanthota | 2 | 12,930 | 12,388,350 |

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 | |
| Galle | 2,731 | 668 | 634 | 22 | 2,128 | 53 | 21 | 448 | 12 | 2,662 |
| Matara | 2,281 | 478 | 323 | 7 | 1,458 | 44 | 9 | 383 | 8 | 1,902 |
| Hambanthota | 3,962 | 707 | 189 | 29 | 1,526 | 90 | 11 | 551 | 4 | 2,182 |

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 Hambantota District | 4 Wheel tractor with rotor vane | Two plough per season | 3 hrs per acre for disc plough and 1.5 hers for rotor vane plough | 6 liters per hour | 4 seasons, Average 2 months per season |
| 02 | Chili in Hambantota District | 4 Wheel tractor with rotor vane | Two or three plough per season (Including rotor vane) | 3 hrs per acre for disc plough and 1.5 hers for rotor vane plough | 6 liters per hour | 2 seasons, Average 4 months per season |
| 03 | Paddy | 4 Wheel Tractor | Two plough per season | 3 hrs per acre | 5 liters per hour | 2 seasons |
| 04 | Paddy | 2 Wheel tractor | Two plough per season | 3 hrs per acre | 3 liters per hour | 2 seasons |
| 05 | Fruits (Yearly crops eg, papaya, water melon) | 4 Wheel tractor | Two plough per year | 3 hrs per acre per plough | 6 liters per hour | One season |
| 06 | 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 | | | | | | |
| 07 | 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 | | | | | | |
|---------------|------------------------|--|---------------|--------------------|---|--|
| 08 | | 2 inch electric pump. One pump per acre | Water pumping | 8 ~ 10 hrs per day | 10 kWh per day per acre | 5 seasons for vegetables, Average 2 months per season. 2 seasons for chili, Average 4 months per season |
| 09 | Vegetables, Chili etc. | 2 inch solar pump. One pump per acre | | 6 hrs per day | Few amount of water pumps are available | |
| 10 | | 3 inch pump. One pump per 2 acre | | 10 hrs per day | 3 liters/day | |
| 11 | Banana | Water is taken from irrigation channels for around 75% of total banana cultivation and no water lifting. | | | | |
| Spraying | | | | | | |
| 12 | Vegetables, fruits | Petrol engine driven sprayer | Spraying | 3.5 hrs per acre | 1.5 liters/acre | One or two times per week |
| 13 | Paddy | Petrol engine driven sprayer | Spraying | 2.0 hrs per acre | 1.0 liters/acre | Five times per season |
| Harvesting | | | | | | |
| 14 | Paddy | Combine harvester (Bhuthaya) | Harvesting | 3 hrs per acre | 5 liters per hour | 2 seasons |
| 15 | Maze | Combine harvester (Bhuthaya) | Harvesting | 20 minutes | 1 liter per acre | 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 | 30 days |
| 04 | Average catch per trip | 6000 kg |
| 05 | Average sales as fish | 60% |
| 06 | Percentage fish production in coastal area | 60% of the total production |
| 07 | Average catch per single day boat | 200 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 | 520 |

3.3.3 LIVESTOCK SECTOR

Table 3.8: Details of milk chilling centers

| No. | Description | Details |
|-----|--|---------|
| 01 | No of milk chilling centers are available with 500 liters capacity | 04 |
| 02 | Power requirement in can coolers | |

| | | |
|--|------------------------------|--------|
| | Small Can cooler (50 liters) | 0.5 kW |
| | Mini cooler (200 liters) | 1.2 kW |
| | Mini cooler (300 liters) | 1.5 kW |
| | Mini cooler (500 liters) | 3.5 kW |

Table 3.9: Details of biogas units

| No. | Description | Details | Cumulative Capacity - m ³ |
|-----|-----------------------------|---------|---|
| 01 | No of biogas unit available | 149 | 1746 |
| 02 | No of potential biogas unit | | |
| | Large scale | 10 | |
| | Small scale | 350 | |

CHAPTER 4: BASELINE ANALYSIS

4.1 INTRODUCTION

As indicated above, analysis of baseline of energy use in the Agro-industry 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 few assumptions, and the results are presented in this chapter.

Most of the short rotation 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. Water is pumped in non-rainy period for short rotation vegetable cultivation. The seasonal variations, mainly the rainfall pattern (the rainy days and non-rainy days) 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 and following assumption have been made when estimating energy use in water pumping

- Availability of electricity or solar powered pumps - 20% 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 | 37.5 liters diesel and 10 liters of petrol |
| Total land area for both seasons | 276,040 Acres |
| Total energy requirement per year | |
| Land preparation | 6,210,900 Liters of diesel |
| Harvesting | 4,140,600 liters diesel |
| Spraying | 2,760,400 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 | 27 liters diesel |
| Specific electricity requirement per acre per season for water pumping | 36 kWh |
| Specific diesel requirement per acre per season for water pumping | 30 Liters of diesel |
| Specific electricity generation per acre per season for water pumping in solar pumps | 2 kWh |
| Specific electricity requirement per acre per season for spraying | 15 liters of petrol |
| Total land area per seasons | 66585 Acres |
| Total energy use in land preparation | 719,145 liters |
| Total energy use in water pumping | |
| Electricity | 948,870 kWh |
| Diesel/kerosene | 799,050 liters |
| Electricity saving use of solar pumps | 53,270 kWh |
| Total energy use in spraying | 399,525 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 | 27 liters diesel |
| Specific electricity requirement per acre per season for water pumping | 95 kWh |
| Specific diesel requirement per acre per season for water pumping | 120 Liters of diesel |

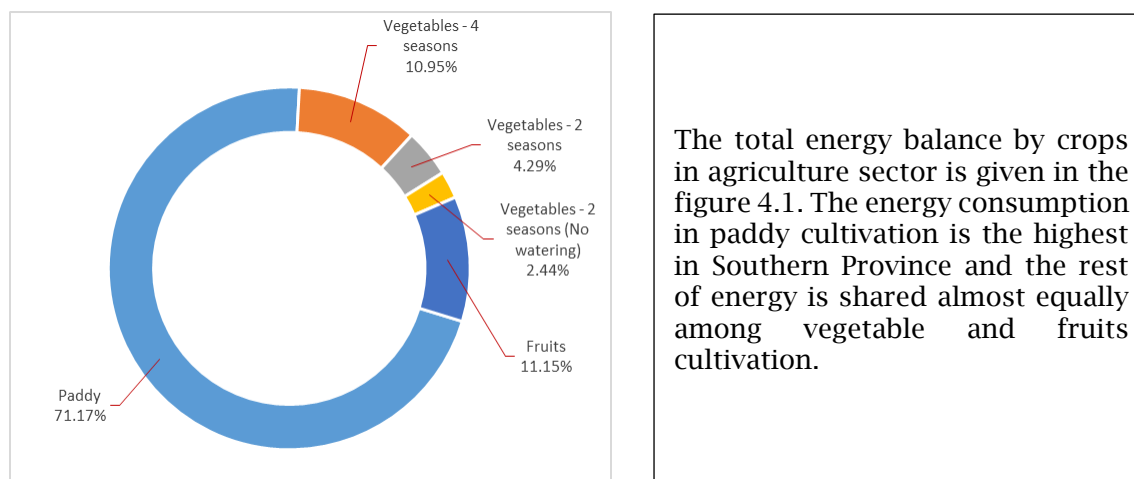
| | |
|--|----------------------|
| Specific electricity generation per acre per season for water pumping in solar pumps | 4 kWh |
| Specific electricity requirement per acre per season for spraying | 7.5 liters of petrol |
| Total land area per seasons - watering crops | 3,928Acres |
| Total land area per seasons - non watering crops | 8,174 Acres |
| Total energy use in land preparation | 653,535 liters |
| Total energy use in water pumping | |
| Electricity | 373,230 kWh |
| Diesel/kerosene | 471,450 liters |
| Electricity saving use of solar pumps | 15,715 kWh |
| Total energy use in spraying | 58,931 Liters petrol |

Table 4.4: Energy use in fruits cultivation

| Description | Results |
|--|-----------------------|
| Specific diesel/kerosene requirement per acre per season for land preparation | 27 liters diesel |
| Specific electricity requirement per acre per season for water pumping | 95 kWh |
| Specific diesel requirement per acre per season for water pumping | 120 Liters of diesel |
| Specific electricity generation per acre per season for water pumping in solar pumps | 4 kWh |
| Specific electricity requirement per acre per season for spraying | 7.5 liters of petrol |
| Total annual fruits (banana, papaw etc.) cultivation area | 19,362 Acres |
| Total permanent fruits (mango, orange etc.) available area | 13,052 Acres |
| Total water pumping required area | 8,148 Acres |
| Total energy use in land preparation | 522,790 liters |
| Total energy use in water pumping | |
| Electricity | 774,100 kWh |
| Diesel/kerosene | 977,775 liters |
| Electricity saving use of solar pumps | 32,600 kWh |
| Total energy use in spraying | 243,110 Liters petrol |
| Total energy use in grass cutting | 234,945 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 Southern Province and the rest of energy is shared almost equally among vegetable and fruits cultivation.

Figure 4.1: Share of energy by crop

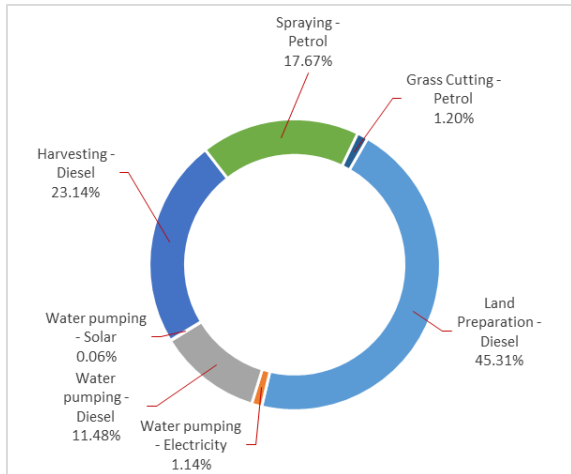


Figure 4.2: Share of energy by process

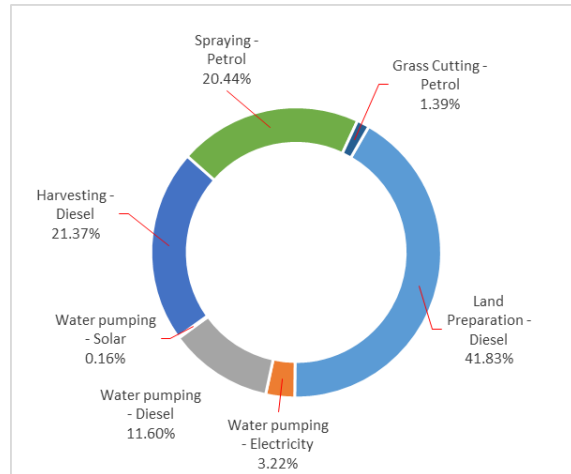


Figure 4.3: Share of energy cost by process

Out of the total energy consumption in agriculture sector (cultivation) land preparation and harvesting consume 44% and 23% respectively. Water pumping is the next and it shares around 15.6% of the total energy.

4.5.2 SHARE OF ENERGY IN PADDY PRODUCTION

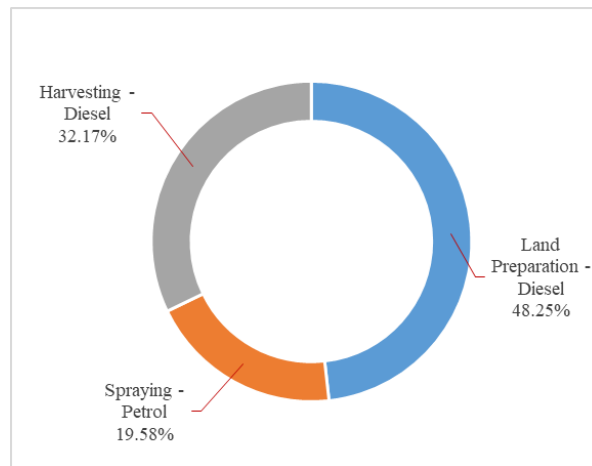


Figure 4.4: Energy usage pattern in paddy production

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

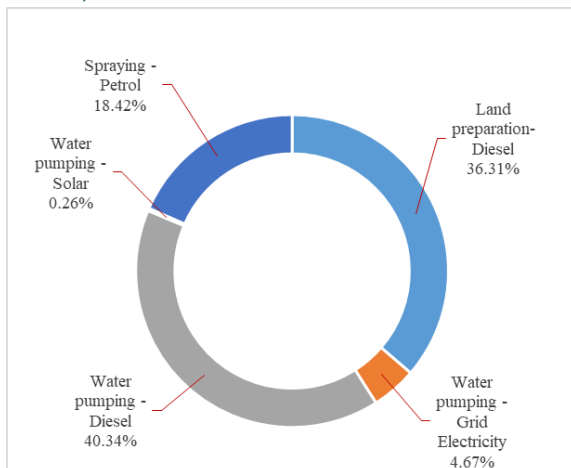


Figure 4.5: Energy share by process

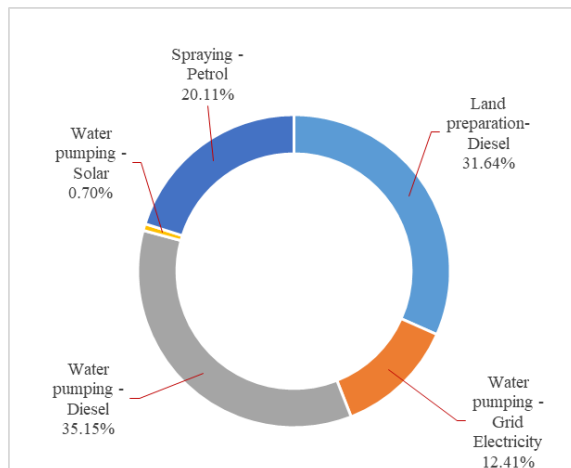


Figure 4.6: Energy cost share by process

The energy consumption and energy cost variation pattern in short rotation vegetable crops are given in the above figures. Nearly 50% of total energy consumption shares are for water pumping and approximately 36% for land preparation.

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

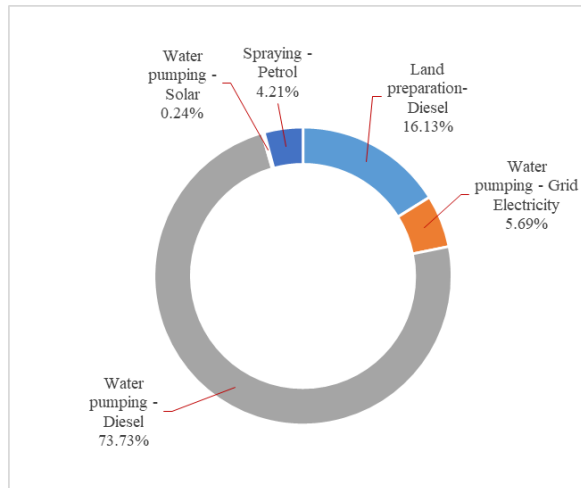


Figure 4.7: Energy share by process

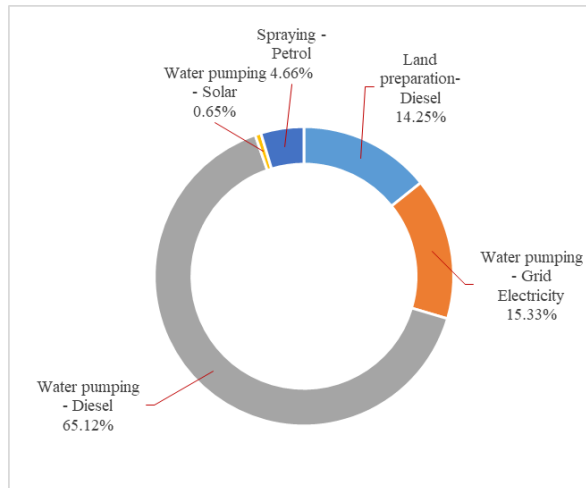


Figure 4.8: Energy cost share by process

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

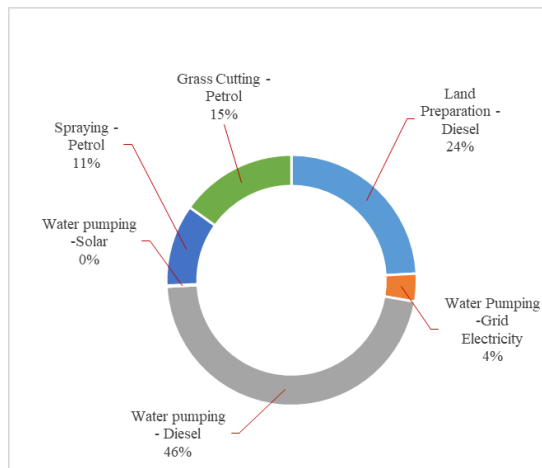


Figure 4.9: Energy share by process

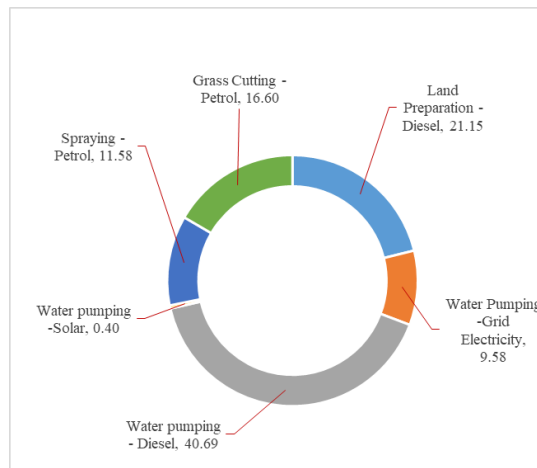


Figure 4.10: Energy cost share by process

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 6.6% and it is very much 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 (Energy) - kJ/kg of product | Total Energy in Food - kJ/kg | % |
|--------------------------------------|--|-------------------------------------|----------|
| Paddy | 1152 | 11524 | 10.00 |
| Vegetables - 4 seasons | 881 | 16500 | 5.34 |
| Vegetables - 2 seasons | 681 | 16500 | 4.12 |
| Vegetables - 2 seasons (No watering) | 1497 | 16700 | 8.97 |
| Fruits (Annual) | 948 | 15100 | 6.28 |
| Fruits (permanent) | 553 | 15100 | 3.66 |

4.6 FISHERIES SECTOR

4.6.1 RESULTS

Table 4.6: Energy usage in fisheries sector

| No. | Description | Results |
|------------|---|-------------------|
| 01 | Total annual diesel usage in multiday boats | 55,716,100 liters |
| 02 | Total annual kerosene/petrol usage in day boats | 15,043,350 liters |
| 03 | No. of multi day boats runs | 15920 |

4.7 LIVESTOCK SECTOR

4.7.1 RESULTS

Table 4.7: 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 Agro-industry.

5.1.1 OFF-GRID SOLAR APPLICATION

5.1.1.1 Solar Water Pumping

It has been estimated that approximately 7500 diesel water pumps are being operated for vegetable and fruit cultivation in the Southern Province. Hambantota area being situated in the intermediate-dry zone shows the highest requirement for solar water pumping, compared to Galle and Matara areas in the wet zone. 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 CO₂ 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.

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/boiling in institutions/industries like curd production, training centers etc. Locally fabricated low temperature dryers and low temperature hot water generators fueled by biomass are available in open market now with attractive prices. Low temperature fish dryers have been distributed in areas like Mirissa on several occasions through projects conducted by UNDP and SLSEA. Potential is there to eliminate the existing electricity, kerosene or LPG usage in Agro-industry by introducing and upscaling 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 many areas in the country 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 10,827 cattle farms and 58 swine farms in the Southern 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 grid electricity 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 and reliable solution with the solar roof top systems which 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, three strategic locations have been identified in the Southern Province with total potential capacity of 3MW and annual biomass requirement to run these systems would be around 55845 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. This model can be applied to potential areas island wide with location specific modifications.

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 COMMERCIALY VIABLE TECHNOLOGIES

A number of programmes have been initiated for introduction of green energy technologies in the Southern 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 Agro-Industry 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 Agro-Industrial practices.

6.5.2 BIOMASS HOT WATER GENERATORS FOR CURD INDUSTRY

Boiling milk in curd making process is mainly done using either biomass stoves or LPG stoves. Controlling the temperature precisely in this process is difficult. Also, maintaining the hygienic condition is difficult since most of the stoves are built in open spaces.

Use of biomass fired hot water generator is an ideal solution to overcome these issues and the quality of products can be enhanced. A yoghurt manufacturing facility is available at Dikoya which is equipped with a biomass hot water generator and overall productivity has enhanced in to a better level than the business as usual operation after this initiative.

6.5.3 FODDER PELLETIZING MACHINE

Pelletizing the animal feeds enhances the productivity in a number of ways. The nutritional level can be adjusted precisely at the pelletizing stage when necessary compared to the direct feeding. Pelletizing enhances the productivity in mass transport and storage.

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 conduct introduce new technologies through research & trial, pilot studies, and practical demonstrations.

CHAPTER 7: ACTIVITY PLAN

7.1 INTRODUCTION

The results based action plan is considered for implementation of green energy technologies and systems in the Agro-industry in Southern 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 | | | 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 | | | Solar water pumps supportive programme |
| 10 | Agriculture Sector | Popularization of commercially viable technologies | 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 | | | Biomass fired hot water generators for curd making process |
| 17 | Fisheries Sector | Popularization of commercially viable technologies | Solar thermal powered fish dryers |

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

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 –
LKR**

To be assigned

AG -03**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

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 – LKR

To be assigned

AG -05

Upgrading energy consumption and production data platforms

Background: With the technological developments in the agriculture, fisheries, and livestock sectors 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 energy consumption and production data of all sectors.

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. Technology development
2. Awareness building and training

Stakeholders

As identified by the executing party

Responsibility

To be assigned

**Estimated Budget –
LKR**

To be assigned

AG -06

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 –
LKR**

To be assigned

AG -07

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 -08

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

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 Sri Lanka. 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

To be assigned

Estimated Budget – LKRM

To be assigned

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

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

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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

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

Background: Small scale dairy farming is a common livelihood among the farmer community in Southern Province of Sri Lanka, housing 10,800 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

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.

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

Stakeholders

As identified by the executing party

Responsibility

To be assigned

Estimated Budget – LKRM

To be assigned

Background: Value added productions like buffalo curd holds an important share of small-scale dairy farming business in Sri Lanka. In most of the cases this is a rural family business or cottage industry where the know-hows are passed from generation to generation. As the first step in the curd production buffalo milk is boiled over an open fire for 20-30 minutes and then cooled to 35-40 °C. Heating is obtained by burning firewood. This is a crude technique associated with several disadvantages such as the inability to control temperature and mixing of burnt ash with product.

Use of biomass fired hot water generators is an ideal solution to overcome these issues and the hygienic conditions and quality of products can be enhanced through this. This application has already been introduced to Dickoya area under the UNDP Biomass Project with proven capacity enhancement and can be developed further with sufficient financial aid.

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

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 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

Proposed Template for Schedule of Activities

| 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 | Emission factors kg of CO ₂ /kg of fuel | CO ₂ 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 | Biomass fired hot water heaters | 150 liters /hr | - | 850,000 | LPG | | | Biomass | | 2.2 | 50 | | 850 |
| 6 | Temperature and RH controlled food storage systems | These technologies are being proposed for value addition to the agriculture, fisheries and livestock sector outputs. Since there is not a base case for these technologies, potential reduction of CO ₂ emission is not arried. | | | | | | | | | | | |
| 7 | Biomass fired food dehydrators | | | | | | | | | | | | |
| 8 | Small scale milk can coolers | | | | | | | | | | | | |
| 9 | Solar thermal powerd ih dryers | | | | | | | | | | | | |
| 10 | Solar powerd battery operated insects contorl systems | | | | | | | | | | | | |

CHAPTER 9: IMPLEMENTATION ARRANGEMENT OF THE ACTION PLAN

9.1 IMPLEMENTATION ARRANGEMENT OF THE GREEN ENERGY ACTION PLAN

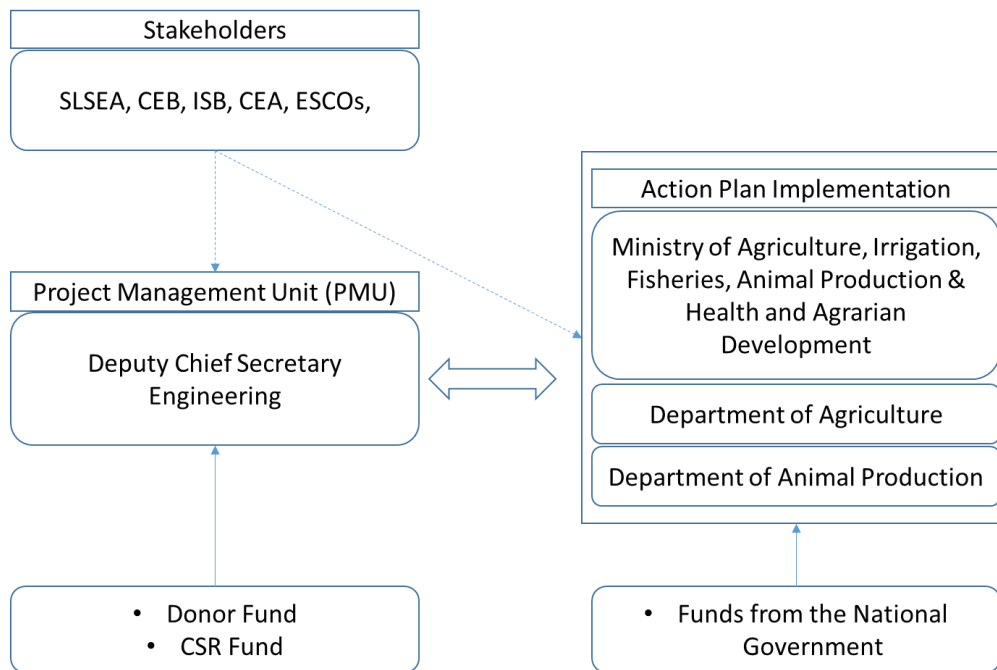


Figure 9.1: Implementation arrangement of the action plan

9.1.1 GOVERNING FRAMEWORK

Coordination, monitoring and implementation assistance will be done by the Focal Point-Project Coordination established in the Ministry of Power- SP 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.

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

Chairman: Chief Secretary, Southern Province

Secretary: Secretary- Ministry of Power (SP) or his nominee

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.

9.1.3 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 relevant implementation institutions following the existing prevailing mechanisms.

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ANNEXURES

ANNEX 1: CONTACT DETAILS OF FISHERIES SECTOR (SP)

| No | Name | Designation | Organization | District | Contact No. |
|----|--------------------|-----------------------|----------------------|---------------|--------------|
| 01 | Mr. Madushanka | Assistant Director | Fisheries Department | Galle/ Matara | 070- 2985534 |
| 02 | Mr. Chandana | Provincial Director | Fisheries Department | Hambantota | 071-6840840 |
| 03 | Mr. Chandrakeerthi | Assistant Director-SP | NAQDA | | 071-8034866 |
| 04 | Ms. Asanka | | NAQDA | Galle | 071-8134647 |
| 05 | Mr. Sanjeewa | | NAQDA | Matara | 071-4405095 |
| 06 | Mr. Gayan | | NAQDA | Hambantota | 071-3146814 |

ANNEX 2: CONTACT DETAILS OF AGRICULTURE SECTOR (SP)

| No. | District | Zone | Assistant Director- Agriculture (Name/ Telephone) | Agriculture Inspector (Name/ Telephone) |
|-----|------------|----------|---|---|
| 1 | Galle | Eastern | Ms. Maya Wickramasinghe (070 -4667433) | Mr. Nimal Kariyawasam (071 - 7245490) |
| | | Central | Mr. Deepal Gunasekera (071-6508560) | Mr. Saman (071 - 9887835) |
| | | Western | | Mr. Dimuthu (071 - 9420062/0718961391) |
| 2 | Matara | Nothern | M s. Seetha Wanigasekera (071 - 8134182) | Mr. Nalaka Gamage (070 -2567793) |
| | | Southern | Ms. Pushpa Kanthi (071 - 9862561) | Mr. J.L..A.S.Roshantha (071-6721769) |
| | | Central | Mr. N. Dharmapriya (071-8145110) | Mr. Dimuthu Rubasinghe (071 - 3177303) |
| 3 | Hambantota | Zone 1 | Mr. Saman Vidanagamage (071 -4395963) | Mr. Indika Prasad (071-4547177) |
| | | Zone 2 | | Mr. P.V.Indika (071 - 9275760) |
| | | | Ms. M.W.R.Wasana (071-8053668) | Mr. W.A.P.Kulasinghe (071- 8307380) |