ព្រះរាជាណាចក្រកម្ពុជា
ជាតិ សាសនា ព្រះមហាក្សត្រ

# ផែនការយុទ្ធសាស្ត្រអភិវឌ្ឍន៍វិស្វកម្មកសិកម្មនៅកម្ពុជា ២០១៦-២០២០

# Strategic Development Plan of Agricultural Engineering for Cambodia 2016-2020

*ឈានឆ្ពោះទៅធ្វើទំនើបកម្មនិងពាណិជ្ជបនីយកម្មកសិកម្មកម្ពុជា*

*Towards modernization and commercialization of Cambodian agriculture*

*រៀបចំដោយ: នាយកដ្ឋានវិស្វកម្មកសិកម្ម នៃអគ្គនាយកដ្ឋានកសិកម្ម*

*Prepared by: Department of Agricultural Engineering, General Directorate of Agriculture*

*ខែកក្កដា ឆ្នាំ២០១៦ - July 2016*

អាស័យដ្ឋាន: លេខ ៦៣ មហាវិថីភ្នំពេញ ហាណូយ សង្កាត់ភ្នំពេញថ្មី ខណ្ឌសែនសុខ រាជធានីភ្នំពេញ កម្ពុជា
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FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

# ផែនការយុទ្ធសាស្ត្រ
# អភិវឌ្ឍន៍វិស្វកម្មកសិកម្មកម្ពុជា ២០១៦-២០២០

## រៀបចំដោយនាយកដ្ឋានគ្រឿងយន្តកសិកម្ម នៃអគ្គនាយកដ្ឋានកសិកម្ម
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ភាសាខ្មែរ

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# Strategic Development Plan of Agricultural Engineering for Cambodia 2016-2020

Prepared by the Department of Agricultural Engineering,
General Directorate of Agriculture, MAFF

July 2016

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English Version

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# PREFACE

The Ministry of Agriculture, Forestry and Fisheries formulated the Agricultural Sector Strategic Development Plan 2014-2018, which is an important milestone in giving direction and actions for medium-term implementation to accelerate the agricultural sector development. The plan is in line with the Rectangular Strategy Phase III and the National Strategic Development Plan 2014-2018 of the Royal Government of Cambodia, with overall goal of poverty reduction and economic growth through enhancement of sustainable agricultural development.

Agricultural production in Cambodia has been constrained by lack of labor due to migration of work force from rural areas to urban centers or abroad to work in the industry and services sectors, and by vulnerability to climate change. To overcome these constraints, agricultural machinery is gaining popularity in replacing human labor and its number is increasing annually. However, lack of operational and maintenance skills leads to very high cost for owning a machine. It was estimated that farmers unnecessarily spent about 15-20 million US dollars annually on repairing due to improper use of their machinery. Besides, field irrigation is still constrained by inadequate on-farm infrastructure, while post-harvest handling also need to be improved. Thus, a clear plan is very essential to strategically resolve these problems, and to strengthen and develop the agricultural engineering sub-sector.

The current Strategic Development Plan of Agricultural Engineering for Cambodia 2016-2020 themed “towards modernization and commercialization of Cambodian agriculture” is a continuing phase of the Strategic Plan for Agricultural Engineering in Cambodia 2011-2015 themed “shifting from subsistence agriculture to commercial agriculture”. The document was prepared by the Department of Agricultural Engineering under the General Directorate of Agriculture in accordance with the existing policies and strategies, and is to further define the policy goals in this sub-sector.

The General Directorate of Agriculture sincerely thanks to the management and staff of the Department of Agricultural Engineering, and concerned stakeholders who actively involved in the formulation process and committed to fully implement the Strategic Plan for the development of this sub-sector in Cambodia.

The General Directorate of Agriculture expects that this document will serve as a road map and as an encouragement for the participation and cooperation from relevant and concerned institutions at all levels including international communities for the successful development of agricultural engineering sub-sector, and ultimately modernization of Cambodian agriculture.

Phnom Penh, July 2016
General Directorate of Agriculture

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# List of Abbreviations

| | | |
|---|---|---|
| ADB | = | Asian Development Bank |
| AMS | = | Agricultural Mechanization Strategy |
| ANTAM | = | Asian and the Pacific Network for Testing of Agricultural Machinery |
| ASDP | = | Agricultural Sector Strategic Development Plan |
| ASEAN | = | Association of Southeast Asian Nations |
| AusAID | = | Australia Agency for International Development |
| CAC | = | Census of Agriculture in Cambodia |
| CARDI | = | Cambodian Agricultural Research and Development Institute |
| CDRI | = | Cambodia Development Resource Institute |
| CIRAD | = | French Agricultural Foreign Aid Agency |
| CSAM | = | Center for Sustainable Agricultural Mechanization |
| CTAM | = | Center for Testing of Agricultural Machinery |
| DAEng | = | Department of Agricultural Engineering |
| EU | = | European Union |
| FAO | = | Food and Agriculture Organization of the United Nations |
| GDA | = | General Directorate of Agriculture |
| GDP | = | Gross Domestic Product |
| Ha | = | Hectare |
| HP | = | Horse Power |
| IFAD | = | International Fund for Agricultural Development |
| ISC | = | Institute of Standards of Cambodia |
| JICA | = | Japan International Cooperation Agency |
| KOICA | = | Korea International Cooperation Agency |
| MAFF | = | Ministry of Agriculture, Forestry and Fisheries |
| MDG | = | Millennium Development Goals |
| MFI | = | Micro Finance Institution |
| MIH | = | Ministry of Industry and Handicraft |
| MOP | = | Ministry of Planning |
| NGO | = | Non-government Organization |
| NSDP | = | National Strategic Development Strategy |
| PDR | = | People Democratic Republic |
| RAEDC | = | Regional Agricultural Engineering Development Center |
| RGC | = | Royal Government of Cambodia |
| Rice-SDP | = | Climate-Resilient Rice Commercialization Sector Development Program |
| RUA | = | Royal University of Agriculture |
| SAMS | = | Sustainable Agricultural Mechanization Strategies |
| SCAESP | = | Steering Committee of Agricultural Engineering Strategic Plan |
| SHG | = | Self Help Group |
| WB | = | World Bank |
| WFP | = | World Food Programme |
| UNESCAP | = | United Nations Economic and Social Commission for Asia and the Pacific |
| UNIDO | = | United Nations Industrial Development Organization |
| USA | = | United States of America |
| USAID | = | United States of America Agency for International Development |
| VAT | = | Value Added Tax |
| WTO | = | World Trade Organization |
| ZHC | = | Zero Hunger Challenge |

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# ACKNOWLEDGEMENT

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- **H.E. So Khan Rithykun**, Director General of the General Directorate of Agriculture
- **Mr. Pech Sovanno**, Deputy Director General of the General Directorate of Agriculture
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- **Prof. Dr. Ngo Bunthan,** Rector of the Royal University of Agriculture, RUA;
- **Prof. Dr. Kang Krisna**, Dean of Husbandry and Veterinary Faculty, RUA;
- **Mr. Lor Lytour,** Interim Dean of the Faculty of Agricultural Engineering, RUA;
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- **Mr. David Moles,** Team Leader of Rice-SDP;
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- **Mr. Jock Struthers,** International Business Financing and Credit Specialist of Rice-SDP;
- **Dr. Francesco Goletti,** International Policy Development Specialist of Rice-SDP;
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# EXECUTIVE SUMMARY

The strategic plan for Agricultural Engineering in Cambodia 2016-2020 reflects the development of agricultural engineering sub-sector and the strong commitment of DAEng to ensure food Security and promote sustainable agriculture in Cambodia. It is also a road map in line with the National Rectangular Strategy, National Strategic Development Plan and Agricultural Sector Strategic Development Plan.

Agriculture remains one of the main priority areas of the Royal Government of Cambodia. It contributes about 28.6% to the GDP and employs 60% of total population (MAFF 2015). Agricultural growth had shown steady improvement averaging 5.3% annually during 2004-2012, which was among the highest in the world. However, the growth had slowed down to around 1-2% in 2013-2014 (World Bank 2015).

Cambodian farming systems are largely subsistence oriented and are dependent on rainfed conditions thereby excessively exposing producers to production uncertainties. Most systems are centered on paddy rice production, which is a staple food in the country and 84% of total area is under wet season rice (MAFF 2014). Although new irrigation facilities have been constructed and old schemes have been rehabilitated to allow multiple cropping per year, they have yet met with the demand. This restricts the majority of producers to a single rain-fed rice crop per year.

Improvement of the agricultural sector is paramount in poverty reduction. Commercializing smallholder agriculture and accelerating its growth rate is essential in increasing agricultural production as a means of pulling the majority of the rural poor out of poverty. Given the generally abundant land resource, efforts to increase agricultural production should include both technologies to expand utilized land area and intensification of the existing cultivated area. This may be achieved through mechanization and adoption of other improved technologies such as improved seed, use of fertilizers, agro-processing and accessibility to markets.

The agricultural engineering deals with the design of farm machinery, the location of farm structure, farm drainage, soil management and erosion control, water supply and irrigation, bio-technology and with the efficient planting, harvesting, storage, and processing of farm commodities.

Farm machinery includes three main power sources that is human, animal and mechanical. Under the tropical heat, a health adult using a hand hoe can work about 0.5 ha per season thus limiting the area under cultivation to 2 ha only for an average family of four adults. On the other hand, a family owning a pair of draught animals can manage 5 - 8 ha per season while a 60-70 hp tractor can manage more than 80 ha in a season.

Mechanization enhances the human capacity, leading to intensification and increased productivity as a result of timely planting, weeding, harvesting, post harvesting handling and accessibility to markets. Also it reduces drudgery making agriculture an attractive enterprise. It therefore has the potential to turn idle land into productive land for national economic growth, food self-sufficiency, industrial growth and employment, leading to poverty reduction. Cambodia needs to mount a long-term effort to develop a modern agriculture, mechanization playing a leading role.

Modernization and mechanization in agricultural sector are becoming increasingly important in addressing the shortage of farm power in rural areas. This is because the agricultural labor force is declining as a result of rural-urban and abroad migration, and non-farm employment opportunities. Besides, climate change has put more constraints to complete any specific operation on time to avoid defects and losses. This is hardly done without the help of mechanization.

**Strategies formulated in this document envision that by 2020 at least mechanization level 68% of rice field operations from land preparation up to milling will be reached. Enabling profitability of agricultural engineering; skill development and capacity strengthening; improving agricultural productivity and rural livelihoods; and improving policy, legal and regulatory environment will serve as the key drivers in this transformation.**

The development of agricultural mechanization in Cambodia shall lie with private sector with the government as a catalyst in sustaining mechanization in the country. It is important to initially assess the performance and profitability of mechanization options in the different ecosystem zones, and make appropriate modifications before farmers and other end-users are advised of the options. The current use of power tillers and tractors are mainly

for land preparation. Hence 68% of the mechanization target level shall be achieved by promoting the multiple usability of the two machines equipped with implements for planting, weeding and fertilizer application and other post-harvest operations.

Providing access to credit to farmers who would not otherwise be able to adopt mechanization options is critical in providing the transformation. Here it will be important to help farmers' cooperatives leverage their collective bargaining power by assisting in establishing business plan, financial integrity and wherever applicable guarantee loans.

Technical skills need to be developed at grass-root levels involving rural artisans, operators, mechanic, service providers, farmers and other end-users. Development of agricultural engineering sector in the country will enable creation of new designs of ergonomic tools for human labor and draught animals, and further widen the choice of mechanization options for local conditions. Mechanization options that help conserve natural resources such as land, soil fertility and water need to be developed and endorsed. Cambodia needs a massive adoption program on mechanization delivering knowledge and awareness amongst farmers through potential entrepreneurs and extension agents of mechanization at village level.

The modernization and commercialization of agriculture requires integration of mechanization options in commodity chains. By enhancing the quality, value and therefore the marketability of farm produces, the introduction of mechanization in commodity chain will substantially improve the profitability of the farmers. Farmers and potential entrepreneurs need to be educated and trained on the various avenues of mechanization in post-harvest handling, storage, and primary-and secondary agro processing enterprises. Linkages along the continuum of production, processing and marketing need to be strengthened through incentives and entrepreneurial spirits. Introduction of mechanization at various stages of processing will not only improve the agricultural commodity chains but also enhance rural employment opportunities and livelihoods in Cambodia.

Favorable policy is the critical for the promotion of agricultural mechanization in the country. All the different policy viz. agricultural, industrial, labor, energy, export/import etc. are needed to be streamlined for promotion of agricultural mechanization. The law, sub-decree and other regulations and guidelines on the promotion of agricultural mechanization will be prepared and adopted. These documents will be served as a road map in the field of mechanization development and be enacted with a view to encouraging and supporting peasants, and agricultural and operation organization to use advanced and applicable agricultural machines, promoting the mechanization of agriculture and developing modern agriculture.

The first regulation needs to be adopted in the near future is the sub-decree on the management of workshops for repair, modification and assembly of agricultural machinery and its associate equipment. The second is legal measures for standardization and certification. Center for Testing of Agricultural Machinery (CTAM) is proposed to establish to undertake machinery testing, quality control and standardization. By ensuring quality and safety, the center will play a very important role in protecting the interests of both farmers and manufacturers.

## 1. BACKGROUND

Cambodia has an area of 181,035 km$^2$, sharing its 2,438 km land border with Thailand, Lao PDR and Vietnam. The country's central plain, which comprises 75% of the total land area, is 10 to 30 meters above sea level. The plains area is drained by the Mekong, Tonle Sap Lake, and Bassac Rivers through the Mekong Delta in southern Vietnam. Other areas of the country are heavily forested, with mountainous area forming the border with Thailand and encircling Cambodia's central plains. To the north, the sandstone Dangrek Range extends eastward along the Thai border, falling abruptly southward to the plain. To the southwest are the granite Cardamom Mountains, with the highest peak at 1,813 meters. Extending south and southeast from the Cardamom, the Elephant Range separates the central lowlands from the narrow coastal plains on the Gulf of Thailand. In the northeast, the hills of the Darlac Plateau rise as high as 2,743 meters.

Agriculture remains one of the most important sectors in Cambodia which is the main source of income for rural households. However, the farming systems are largely subsistence oriented and are dependent on rainfed conditions thereby excessively exposing producers to production uncertainties. Most systems are centered on paddy rice production, which is a staple food in the country and 84% of total area is under wet season rice (MAFF 2014). Although new irrigation facilities have been constructed and old schemes have been rehabilitated to allow multiple cropping per year, they have yet met with the demand. This restricts the majority of producers to a single rain-fed rice crop per year. Other livelihood options for smallholders include rearing livestock (mostly poultry and pig production), fishing in rivers and wage employment on larger farms/plantations.

The contribution of agriculture in Cambodian GDP has been decreasing in the last few years (Figure 1). The increase or decrease of the contribution of agriculture sector resulted from the increase or decrease of other 2 sectors (industry and services). In 2014, agriculture contributed 28.7% to GDP, decreasing from about 34% in 2010, while industry and services accounted for 25.5% and 40%, increasing from about 22% and 38% respectively.

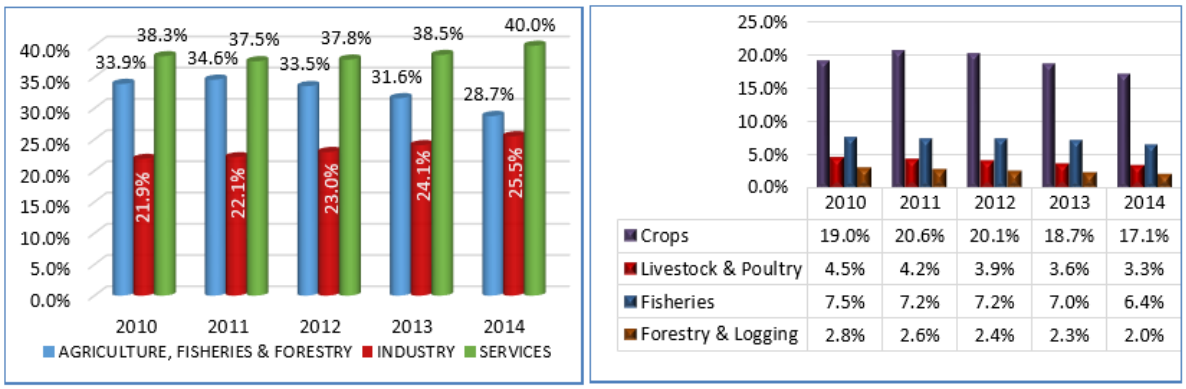


Figure 1. Share of agricultural sector and its sub-sectors in GDP from 2010 to 2014 (MOP, 2014)

Cambodia grows a range of agricultural crops over a cultivated area of 4,505,267 ha, of which rice accounts for 3,052,420 ha, subsidiary and industrial crops 941,028 ha, permanent crop 183,048 ha and rubber plantation 328,771 ha (MAFF, 2013). The main crops are paddy (wet season, dry season, receding and floating), corn, soybean, mung-bean, cassava, sugarcane, peanut, sesame, sweet potatoes, Chinese cabbage, cauliflower, lettuce, water melon and tobacco. Plantation and industrial crops include rubber, cashew nut, pepper, palm sugar, palm oil and fruit trees (mango, pineapple, jackfruit, durian, rambutan and banana). Teak wood and acacia are two of the main commercial forest timber species and non-timber forest products include bamboo, grass, fodder, honey and mushrooms. Firewood is also collected.

Within agricultural sector, crop production constitutes more than half of total production, being at 59.4% in 2014. The rest are fisheries (22.2%), livestock (11.3%) and forestry (7%) (Figure 2).

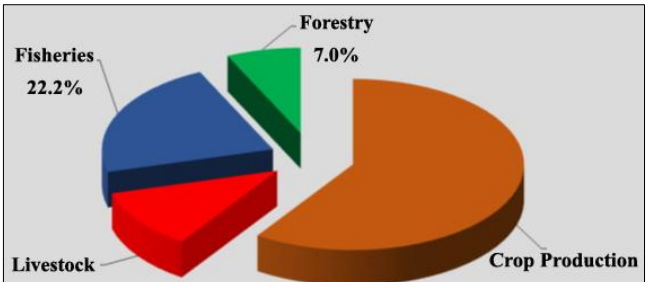

Figure 2. Share of Agricultural sub-sectors in 2014 (MOP, 2014)

Labor force in Cambodian economy is categorized into three important sectors including agriculture, industry and services (Figure 3). Agriculture saw a significant reduction in labor force in the last five years due to demand resulted from growth in the other two sectors. The share of labor employed in agriculture decreased about 9% from 57.6% in 2009 to 48.7% in 2013, whereas industry and services saw their share increased 4% and 5% respectively during the same period. One reason is increasing migration of rural people to urban centers to work in industry and service sectors.


Figure 3. Share of Labor by sector 2009-2013 (MOP, 2014)

The main pull factor for migration from rural areas may be the increasing gap between the income from farming and from other sectors. The average income of rural households in 2012 was only one third of the household income in Phnom Penh or half of household income in other urban areas (Table 1). In the rural areas of Cambodia, the main source of income comes from agriculture which contributed around 33% of total income per capita (CDRI, 2013). In urban areas, income from working in industry or service sectors is the main source of income.

Table 1 Average Household Income per Month

| Year | 2009 | 2010 | 2011(*) | 2012 (*) |
|---|---|---|---|---|
| **Cambodia** | | | | |
| Income (Riels) | 747,000 | 901,189 | 887,660 | 1,018,989 |
| Income (US$) | 187 | 225 | 222 | 255 |
| **Phnom Penh** | | | | |
| Income (Riels) | 2,039,000 | 1,987,305 | 1,819,144 | 1,886,388 |
| Income (US$) | 510 | 497 | 455 | 472 |
| **Other urban** | | | | |
| Income (Riels) | 1,101,000 | 1,504,400 | 1,171,965 | 1,504,177 |
| Income (US$) | 275 | 376 | 293 | 376 |
| **Other rural** | | | | |
| Income (Riels) | 563,000 | 696,824 | 728,359 | 815,655 |
| Income (US$) | 141 | 174 | 182 | 204 |

Source: Ministry of Planning (2013)
Note: Exchange rate, 1 US $ = 4100 Riels
(*) Preliminary results

In light of labor shortage due to migration of labor force from rural areas to urban areas and abroad, there is increasing needs of sustitute, i.e. machinery.

Agricultural mechanization is generally used to achieve results well beyond the capacity of human labor. It refers to application of mechanical power and technology in farm operations. Mechanization includes, but not restricted to, the use of tractors. It shall also include animal-, human-, solar-, electric-and fuel-powered energy conversions. Hence mechanization is often recognized as a means to enhance productivity of human labor in farming. Besides field operations, mechanization can be used in irrigation systems, transport, food processing and related technologies and equipment.

Agricultural mechanization includes three main power sources, that is human, animal and mechanical. Under the tropical heat, a health adult using a hand hoe can work about 0.5 ha per season thus limiting the area under cultivation to 2 ha only for an average family of four adults. On the other hand, a family owning a pair of draught animals can manage 5-8 ha per season while a 60-70 hp tractor can manage more than 80 ha in a season (R. M. Shetto, 2005).

In several developing countries in Asia and Latin America, agricultural mechanization has made significant contributions to agricultural and rural development. Levels of production have increased, soil and water conservation measures constructed, the profitability of farming improved, the quality of rural life enhanced, and developments in the industrial and service sectors stimulated. However, until recently, full swing mechanization efforts in Cambodia have been gradually attracted and encouraged after the subsequent realignment of priorities. In the current context however, agricultural mechanization has become more important due to the following reasons:

1. Food security and market-oriented: To improve food security for its growing population, the country needs to enhance its surplus production for export. The country needs to increase its food production by increasing the area under production and by raising the productivity levels of existing lands.
2. Urban migration: The changing lifestyles, raising incomes from non-agricultural activities and the subsequent trends in urban migration pose challenges in long term sustainability of growth in agricultural production. The general belief that agriculture and even potential commercial farm activities involves hard physical labor and drudgery further worsens the disenchantment amongst the rural youth.
3. Seasonal labor constraints: The nature of farming in Cambodia, labor shortages are becoming a new trend during peak seasons, especially during land preparation and harvesting.
4. Drudgery: The excessive reliance of Cambodian farmers on human muscle, and in many cases, aged people's muscle for the hard tasks in farming poses serious threat on productivity and the long term sustainability of growth in agricultural production.
5. Water scarcity: The climatic change and the recent drives in crop intensification require efficient management and equitable distribution of water amongst farming community. Machineries such as pumps, diesel engines and related equipment shall facilitate equitable access to water, especially for small holder farmers.

While there are arguments about the displacement of labor and the small and fragmented nature of land holdings by only use of animals, small and large machinery care should be taken to ensure trend of technological, cultural, economical and social development in order to reduce any socioeconomic consequences of mechanization and to enable well-balanced adoption of mechanization in Cambodia.

It is therefore important to create a policy, institutional and market environment in which farmers and other end-users in Cambodia have the appropriate choices of farm power and equipment within a sustainable delivery and support system. This forms the objective of formulating agricultural engineering strategic plan.

## 2. VISION

**The Department of Agricultural Engineering (DAEng) under the General Directorate of Agriculture is committed towards contributing to poverty reduction, ensuring food security, and adapting to climate change.**

## 3. MISSION

The DAEng is to become a reliable center for effective services of farm machineries, on-farm infrastructure including irrigation, bioenergy and processing of farm-based products.

## 4. GOALS AND OBJECTIVES

The proposed strategic plan aspires to apply mechanization as one of the major inputs in agriculture and thereby serving as a catalyst for rural development. More specifically, the mechanization efforts aim to achieve the following objectives:

- Raise the power inputs of farming activities, thereby putting more land into production;
- Decrease drudgery in field operations, thereby enhancing quality of life of rural men and women;
- Improve the timeliness and efficiency of field work;
- Carry out tasks that are otherwise difficult to perform without mechanical means;
- Advance the quality and value of agricultural produce and processed products of Cambodia;

- Provide entrepreneurship opportunities and sustainable rural livelihoods; and
- Facilitate crop processing and thereby improving rural economic opportunities.

## 5. STRATEGY FRAMEWORK

### 5.1. Strategic Analysis

Agricultural engineering initiatives of the General Directorate of Agriculture are coherent with rural development policies and are in consistence with major development orientations envisaged at the national and international levels.

#### 5.1.1. National context

##### 5.1.1.1. Promotion of Paddy Production and Rice Export

The vision of the Royal Government of Cambodia (RGC) is to transform Cambodia into a "rice basket" and a major rice-exporting country in the global market. In this regard, the RGC has set the year 2015 as the target year to: (1) achieve paddy surplus of more than 4 million tons and achieve rice export of at least 1 million tons; and (2) ensure the international recognition of Cambodian rice.

The RGC implemented the strategy based on two important approaches. First, for the short and immediate term, promoting paddy production to meet market demand and promote rice export by shifting from the informal export of paddy to a formal rice export. Second, for the medium and long term, to focus on enhancing competitiveness in rice export through: promotion of production technology; management of soil fertility; management of water; seeds and fertilizers; organization of farmer associations; quality rice processing; physical infrastructure including roads, railways, seaports, energy sources; land use management; short- and long term credit; trade facilitation; and exploring market opportunities.

The target of 1 million tons has not been achieved by the end of 2015. The figure stood just over half a million (538,396 tons). Meanwhile, the climate resilient rice commercialization sector development program funded by ADB targeted to increase paddy production to 9.5 million tons by 2018 and increase rice export 1.2 million tons by 2018. The Cambodia Rice Federation is developing its five-year strategic plan and set a new target for rice export at 1.5 million tons by 2021.

##### 5.1.1.2. Rectangular Strategy

The second phase of the RGC's Rectangular Strategy has indicated to enhance the agriculture sector for economic growth and poverty reduction mainly focused on "improved agricultural productivity and diversification" and "commercialization of agriculture" thereby enabling the agriculture sector to serve as the dynamic driving force and ensuring sustainable natural resources management.

The four sides of the Rectangular Strategy are: (i) improving agricultural productivity and diversification; (ii) land reform and de-mining; (iii) fisheries reform; and (iv) forestry reform. The RGC's overall goal is "poverty reduction and economic growth through enhancement of agriculture sector development". The agriculture sectoral goal is to "ensure food security, increase incomes, create employment and improve nutrition status for all people by improving productivity and diversification, and commercialization of agriculture with environmentally sound protection and food security".

##### 5.1.1.3. National Strategic Development Plan

The Cambodian National Strategic Development Plan update 2014-2018 (NSDP) was formulated for the implementation of the Rectangular Strategy Phase III with the identification of the priorities, indicators and timeframe for the implementation and with the identification of mechanism for the Monitoring and Evaluation of the Result Framework, especially setting the responsibility of the line ministries and agencies within each angle in order to gain high benefits from ASEAN Economic Integration in 2015 and to move out of the Least Developed Countries and to be become an Upper-Middle-Income Country in 2030.

The NSDP recognizes the need to address rural development and makes improving the lives and livelihoods of the rural poor a top priority. Agricultural productivity improvement, diversification and commercialization are the core strategy to meet this need.

The planned actions of mechanization to implement the prioritized policies are as follows:

1. Selecting appropriate agricultural machinery for Cambodia and improving agricultural machinery supply-chain, and improving users' skills, especially for reducing costs;

2. Providing agricultural machinery service through enhanced knowledge on technology use among farmers, manufacturers and service providers;
3. Promoting research and development in pre- and post-harvest technologies using machinery;
4. Strengthening knowledge on farm infrastructure technology including delivery canals; and
5. Promoting networks between researchers, traders, manufacturers, agricultural machinery sellers and farmers' cooperative.

#### 5.1.1.4. Agricultural Sector Strategic Development Plan

An "Agriculture Sector Strategic Development Plan: 2014-2018 (ASDP)" was prepared by the Ministry of Agriculture, Fisheries and Forestry (MAFF) in May 2015 in order to achieve the RGC's strategic goals as well as NSDP update 2014-2018. The overall goal is to increase agricultural growth to around 5% per annum through enhancement of the agricultural productivity, diversification and commercialization and livestock and aquaculture farming by taking into account the consideration of sustainable forestry and fisheries resource management.

The ASDP 2014-2018 defined MAFF's main policy goals into four "basic pillars" as follows:

- Pillar-1: Enhancement of the agricultural productivity, diversification and commercialization;
- Pillar-2: Promotion of livestock and aquaculture;
- Pillar-3: Sustainable Fisheries and Forestry Resources Management; and
- Pillar-4: Strengthening the institutional capacity and increasing efficient supporting services and human resource development.

The pillars are set to achieve through the implementation of 5 priority programmes:

1. Programme-1: Enhancement of Agricultural Productivity, Diversification and Commercialization;
2. Programme-2: Promote Animal Production and Animal Health;
3. Programme-3: Sustainable Fisheries Resources Management;
4. Programme-4: Sustainable Forestry & Wildlife Resource Management
5. Programme-5: Strengthening Institutional Capacity, enhancing efficiency of supporting services and Human Resource Development.

The key actions to overcome related to agricultural mechanization are:

1. Conduct research and experiment works for improvement of agricultural machinery and equipment supporting to agricultural production chains and agricultural processing which will be suitable for different kind of crops, soil condition, geographical area and affordable by the users;
2. Conduct technical training and dissemination on operation and maintenance of agricultural machinery and equipment to government staff at national and sub-national level and farmer through provision of training courses, demonstration and agricultural machinery supporting activities;
3. Improvement of cultivation land and on farm irrigation system following technical norm in order to increase productivity and profit and resilient to climate change;
4. Develop and disseminate relevant legal and technical documents for development and management of agricultural machinery.

### 5.1.2. Regional context

The national issues related to agricultural revitalization and its implications on national economic development are reflected also in the Millennium Development Goals (MDG). Under MDG, one of the approaches for development in Cambodia is sustainable agriculture. It also includes food security, quality improvement and competitiveness. MDG envisages improvement of rural livelihood by raising the value of agriculture commodities. MDG emphasizes that increase in food production through development and rehabilitation of irrigation facilities, post-harvest mechanization are the proposed strategies. The strategic plan contributes to the post-2015 Sustainable Development Goals.

A UN initiative "Zero Hunger Challenge" aims at ending hunger, food insecurity and malnutrition sustainably by 2025. Priorities for action by member countries in food, agriculture, rural development and nutrition to meet the ZHC in Asia and the Pacific under the 5 pillars as follows:

1. 100% access to adequate food all year round
2. Zero stunted children less than 2 years of age
3. All food systems are sustainable
4. 100% increase in smallholder productivity and income
5. Zero loss or waste of food.

The Centre for Sustainable Agricultural Mechanization (CSAM), which is a regional institution of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), started operations in 2004 with the vision to achieve production gains, improved rural livelihood and poverty alleviation through sustainable agricultural mechanization for a more resilient, inclusive and sustainable Asia and the Pacific.

CSAM's objectives are to enhance technical cooperation among the members and associate members of UNESCAP as well as other interested member States of the United Nations, through extensive exchange of information and sharing of knowledge, and promotion of research and development and agro-business development in the area of sustainable agricultural mechanization and technology transfer for the attainment of the internationally agreed development goals including the Millennium Development Goals in the Asia-Pacific region.

In the above regards, FAO and CSAM commissioned the preparation of the Sustainable Agricultural Mechanization Strategies (SAMS) for countries in the Asia-Pacific Region which aims to address the Millennium Goals Nos. 1 and 7 (food security, poverty alleviation and environmental sustainability) through sustainable intensification of agriculture by creating an enabling environment through a SAMS for the region. The goal was set to be achieved through activities developed under five strategic pillars:

- Pillar 1: Surveys, assessments and analyses of the current status of agricultural mechanization;
- Pillar 2: Enabling policies and institutions for SAMS development;
- Pillar 3: Human capacity development;
- Pillar 4: Financial support to enhance investment in SAMS;
- Pillar 5: Advocacy on sustainable agricultural mechanization.

The Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM) was launched on 18 November 2013 with its secretariat hosted by CSAM aims to promote trade and adoption of safe, efficient and environmentally friendly agricultural machinery through harmonization of testing Codes and procedures.
ANTAM has been developing testing codes for power tiller and powered knapsack misters-cum-dusters and many more codes are planned for other agricultural machines. By adopting the ANTAM codes, the following benefits will be achieved:

- Enhanced safety and performance of agricultural machinery;
- Facilitated cross border trade;
- Uplifted regional standards and converge with global standards;
- Stimulated technological innovation;
- Promoted sustainable agriculture for the attainment of sustainable development goals of the United Nations.

### 5.1.3. Agricultural mechanization in Cambodia

#### 5.1.3.1. Definitions

**Agricultural Mechanization**

It refers to the use of tools, implements and machines for agricultural land development, crop production, harvesting, and preparation for storage, and on-farm processing. It includes three main power sources: human, animal, and mechanical. Based on these three power sources, the technological levels of mechanization have been broadly classified as hand-tool technology, draught-animal technology and mechanical-power technology.

The manufacture, distribution, repair, maintenance, management and utilization of agricultural tools, implements and machines is covered under this discipline with regard as to how to supply mechanization inputs to the farmer in an efficient and effective manner.

At the first stage, the subsistence stage, farm mechanization is just beginning. No machinery is needed for any kind of farm work at this stage. It exists in remote and less developed areas when technology, infrastructure, institution, information and culture are isolated. It happens if communication between a village and the market is closed or limited, for example, in a transmigration area. This situation will change if the isolation is ended, and communication develops step by step and the market works. If the farmers feel any additional income or profit can be made by using machinery, they will adopt only the machinery for land preparation but also those for post-harvest processing, through innovation process. This will spread from the individual farmer to the community, the region and the nation via the market. The changes will move up from the subsistence to the mixed, diversified and commercial farming systems, and then farm mechanization will follow this path of development (Table 2).

Table 2: Evolutionary Process of farm mechanization related to farming system stages

| Variables | Farming stages | | | |
|---|---|---|---|---|
| | Subsistence | Mixed | Semi-commercial | Commercial |
| Seed input | On farm production, farmer-to-farmer exchange | On farm production, farmer-to-farmer exchange, some purchase | Frequent purchase | Permanent purchase (annually) |
| Farm worker | Family workers | Partly hired labor | Mostly hired labor | Hired labor and specialist |
| Output Utilization | All consumed for the whole family | Mostly consumed and partly sold | Sold at the local market or nearby market | Commercially sold to the big market |
| Product diversification | Limited | Mostly simple diversification for the family | Already diversified but in small part | Specific product and highly for commercial market |
| Institutional set-up | Local and traditional information; farmer to farmer | Use local market and limited information | Local and regional institution set up, farm association built, market available | Full market orientation; financial backing by farmer's bank or investment |
| Mechanization level | Limited with simple tools | Mostly manual and simple tools with the help of animal power | Small mechanization with limited capacity for selected work | Use mechanization for any kind of work that is suitable |
| *Source: Handaka, 2005* | | | | |

**Agricultural Mechanization Strategy (AMS)**
It provides outlines or the ways in which mechanization policies are to be implemented. Therefore, it involves guidelines on how to create conditions that are conducive to the adoption of appropriate farm tools, implements and machinery in a most effective and efficient way. The output of AMS consists largely of policy and institutional recommendations and reforms. In a dynamic environment, conditions change over time and therefore an AMS will need to be regularly refined, revised and adjusted; an AMS should be dynamic.

**Hand tool technology**
It represents the simplest and most basic level of agricultural mechanization. The term refers to tools and implements which use human muscle as the power source.

**Draught animal technology**
It refers to a wide range of implements, machines and equipment used in agriculture which are powered by animals; usually buffalo, oxen, horses, mules, donkeys or camels.

**Mechanical-power technology**
It is the highest level of mechanization commonly used in agriculture today. It takes many forms: a wide range of tractor sizes which are used as mobile power for field operations and transport, or as stationary power for many different machines; engines or motors using petrol, diesel fuel or electricity to power threshers, mills, irrigation pumps, grinders and other stationary machines; aircraft for distributing crop protection materials and fertilizers; and self-propelled machines for production, harvesting and handling a wide variety of crops.

**Farm power** involves the application of power to agricultural production from human, animal and mechanical sources.

**Farm mechanization**
It is technically equivalent to agricultural mechanization but refers to activities normally occurring inside the boundaries of the farm unit or at the farm unit level.

**Appropriate technology**
It refers to the type of mechanization which is best suited *or* introduction and use in a specific development situation. Appropriateness of a mechanization input is determined by the technical, economic, social and political characteristics of each development situation. It is, therefore, not possible to generalize about the appropriateness of a particular type of mechanization technology, nor is it possible to only examine a particular item of agricultural machinery and decide if it is 'appropriate'.

**Agricultural implements** are devices attached to, pulled behind, pushed, or otherwise used with a human, animal or mechanical power source to carry out an agricultural operation. A tractor mounted plough and a hand jabber for planting maize are both considered as "implements".

**Agricultural machine**
An agricultural machine is normally a mechanical device which has a number of moving parts such as a combination seed drill powered by a tractor.

**Agricultural machinery**
It is a general term used to describe tractors, combines, implements, machines, and any other device more sophisticated than a hand tool, which are animal or mechanically powered.

**Agricultural equipment**
It generally refers to stationary mechanical devices such as an irrigation pump set. It may also be used in place of the word 'machine' to describe a stationary thresher or grinder, for example.

**Agricultural engineering sector**
It covers the manufacture, import, distribution, repair and maintenance, and use of agricultural tools, implements, machinery and equipment in association with human, animal or engine power sources. It also deals with the design of farm machinery, the location and planning of farm structures, farm drainage, soil management and erosion control, water supply and irrigation, bioenergy, and processing of farm-based products. Supporting activities, such as research, education and training, extension, credit, product testing and evaluation, and consumer protection are also addressed.

**5.1.3.2. Distribution of Land Resources**
Land is a crucial and productive asset. 60% of the Cambodian people make a living from agriculture activities (ADB 2009). According to FAO Statistics (2007), 5.4 million ha are used for agriculture. The central plains lowland of the country is used for food production, while the upland areas are used for plantations.

Table 3: Land use in Cambodia, 2007

| Type of land | in million ha |
|---|---|
| Country area | 18.103 |
| Land area | 17.652 |
| Protected areas | 5.381 |
| Agricultural land | 5.455 |
| - Cultivated land | 3.800 |
| - Permanent crops | 0.155 |
| - Permanent meadows and pastures | 1.500 |
| Forest area | 10.009 |
| Other land | 2.187 |
| Inland water | 0.452 |
| Area equipped for irrigation | 0.285 |

*Source: FAO Statistics 2007*

According to census of agriculture in Cambodia 2013 (Figure 4), the average agricultural land operated per farm household was around 1.6 hectares (Average area per parcel 0.6 ha). Farm households with total holdings size less than 1 ha and between 1 ha to 3.99 ha account for 47% and 45% respectively.

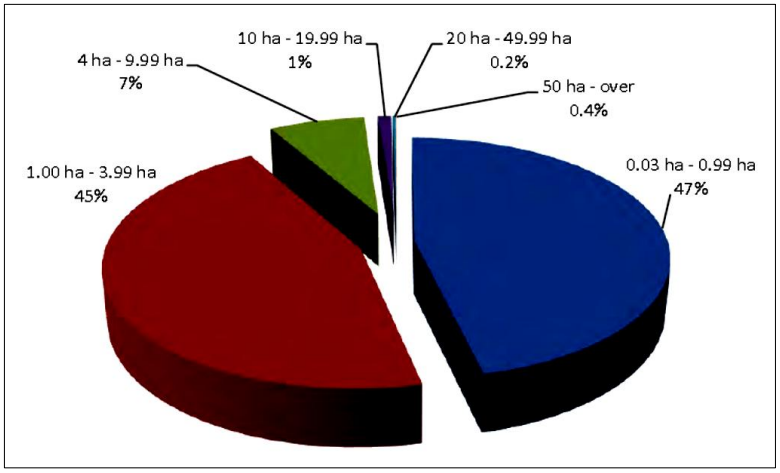


Figure 4. Percentage of agricultural holdings with separate lands by size of holding (CAC 2013)

Average land area of agricultural holding by province is presented in Figure 5. The average area of separate agricultural lands used by the household holdings in the Tonle Sap Lake Zone and Mountainous and Plateau Zone were higher than the national average. Sixteen provinces have average household agricultural holdings larger than the national average of 1.64 ha. The average size in those provinces ranged from 5.01 ha in Oddar Meanchey and 3.01 ha in Banteay Meanchey to 1.75 ha in Kampong Thom and Tbong Khmum. In the Plateau and Mountainous Zone, all provinces (Except Kampong Speu) had an average land size of more than 2 ha. Provinces with the average size below the national average included Kampong Speu (0.96 ha), Kep (0.91 ha), Takeo (0.91 ha) and Kandal (0.83 ha).

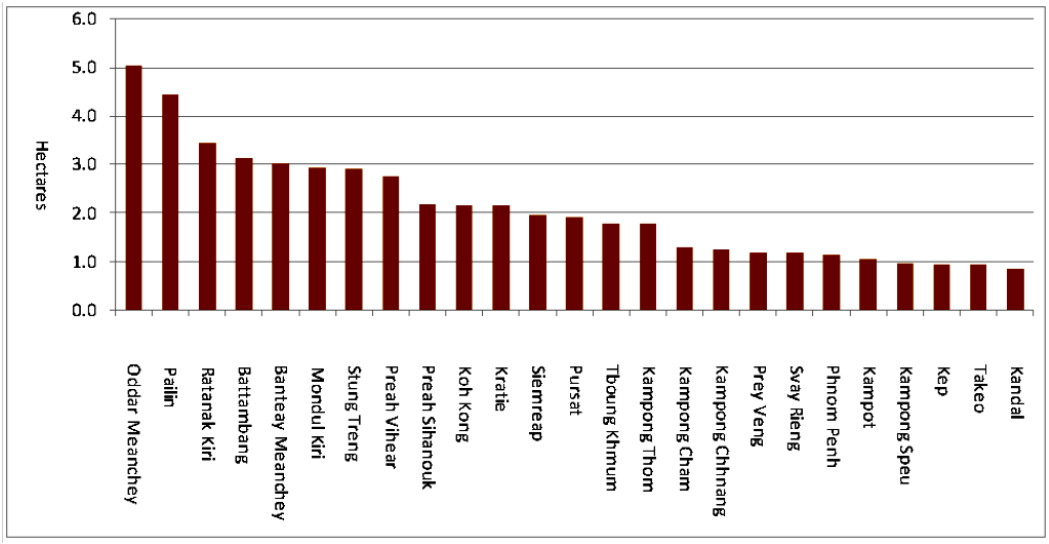


Figure 5. Average land area of agricultural holding by province (CAC 2013)

**5.1.3.3. Farming Systems in Cambodia**

Cambodia is characterized by a diversity of farming systems which can be classified in seven major groups; four rice-based farming systems, two "chamcar" crops based farming systems, and a more limited industrial production system (GRET, IRAM *et al.* 2000). These systems differ in their potential for intensification, diversification and commercialization. However, low productivity terraced rain-fed rice farming systems are undertaken by around 70% of the rural population, representing 80% of the rice cropping area and 70% of paddy production; which explains the low performance observed at the aggregated level.

The four major types of rice farming system include (GRET, IRAM et al. 2000):

1. The one found in non-irrigated terrace zones, characterized by poorly productive and rainfall dependent seasonal rice cropping, frequently associated with sugar palm; this system is the most common among Cambodian farmer. Recent changes include the introduction of double cropping;
2. Flood recession zones where water control allows intensive rice cropping; with good water and soil fertility control, evolution can be rapid towards either specialization in intensive rice farming–with land concentration and development of a salaried workforce -, or towards the diversification of production;
3. Floating rice, in large flooded fields, where the extensive nature of farming practices allows good labor productivity but in which hydraulic risks are higher; these systems are regressing and evolving either into flood recession rice or into irrigated double cropping; and
4. Upland rice-based systems, involving slash-and-burn land preparation, mainly located in less densely populated areas of North-Eastern provinces; these systems are less and less rice based, with increased population inflows and the development of cash crops by migrants.

"Chamcar" cropping refers to widely diversified farming systems in which rice cropping is most often found but where "dry" cropping is prevalent. They can be grouped in (GRET, IRAM et al. 2000):

1. River bank farming systems, dominated by diversified cropping systems following the annual flooding cycle, with a high development potential; land prices are high and land concentration induces the emergence of larger farms with mechanization and use of a smaller workforce; and
2. Red and black soils upland farming systems, where rubber farming is concentrated and other cash crops are developing fast; the future of these systems depends on the restructuring of the rubber industry and to the development of annual crops, notably maize, soybeans, and other tree crops such as cashew nuts or bananas.

The last system is the modern, capital intensive one found mostly near cities, whether in riverbank zones (around Phnom Penh) or in combination of riverbanks and terraces (Battambang, Siem Reap); intensive market garden cropping, industrial chicken farming, orchards, etc. The evolution of this system will depend on the expansion of urban markets, labor costs, and development of alternative uses for capital in other economic sectors, as well as on the evolution of external markets for the main export commodities (oil palm, soybean, cashew nut, etc.) (GRET, IRAM *et al.* 2000).

In addition to the seven major types of farming systems, agrarian structure in Cambodia can be classified into agro-ecological zones and micro-zones as follows:

There are four agro-ecological or ecosystem zones in Cambodia: Northeast, Mekong, Coastal and the Tonle Sap (Figure 6).

Figure 6. Ecosystem zones in Cambodia

Eight provinces constitute the Tonle Sap Lake Zone: Banteay Meanchey, Battambang, Pailin, Siem Reap, Oddar Meanchey, Kampong Thom, Kampong Chhnang and Pursat. Geographically hilly with mountains and plateaus, Pailin and Oddar Meanchey have no villages within the lake area. However, for historical and administrative reasons, these two provinces are still considered within the Tonle Sap Lake Zone, as both were once part of Battambang and Siem Reap. Around 30% of population in Siem Reap, Battambang, Pursat and Kampong Chhnang are situated around the lake.

Seven provinces constitute the Plains Zone: Kampong Cham, Kandal, Phnom Penh, Prey Veng, Svay Rieng, Takeo and Tbong Khmum.

Six provinces constitute the Plateau and Mountainous Zone: Kampong Speu, Preah Vihear, Ratanak Kiri, Mondul Kiri, Kratie and Stung Treng. Ninety percent of villages in Preah Vihear, Pailin and Mondul Kiri, and between 60% and 80% of population in Oddar Meanchey and Stung Treng are situated in hilly, mountainous and plateau areas.

Four provinces constitute the Coastal Zone: Kampot, Koh Kong, Preah Sihanouk and Kep. Within the four provinces, Kep has the largest percentage of villages (44%) located on coastal waters followed by Koh Kong (39% of villages) and Preah Sihanouk (21% in villages). Kampot has the lowest percentages of villages on coastal waters.

There are four microzones in Cambodia which are defined as:

1. Zone A: Fully irrigated zone in dry season;
2. Zone B: Rainfed;
3. Zone C: Zone with supplemental irrigation in the wet season; and

4. Zone D: Chamcar.

Rice-based farming systems include not only rice, but other crops (e.g. vegetables, maize, soybeans), animal production (aquaculture and livestock), and potentially a wider range of horticultural products (fruits, spices, mushroom, flower, herbs, and medicinal plants). The key to unlock the values in rice-based farming system is to increase productivity and diversify into higher value activities, both at the farm level and particularly in the post-production stages of the value chain (processing, marketing, postharvest operations).

In order to increase income of smallholder households, agriculture will need to intensify and lower the cost of production, diversify towards higher value products, and ensure that farmers and enterprises are competitive and well-integrated with rapidly growing urban and international markets. There are, however, numerous constraints that make difficult the process of intensification, diversification, and market integration of Cambodian agriculture, including: (i) technology, (ii) marketing, (iii) water; and (iv) capital.

**5.1.3.4. Current Status of Agricultural Mechanization in Cambodia**

Agricultural mechanization in Cambodia has been increasing widely since 1990s especially in land preparation, irrigation, threshing and harvesting.

The increasing rate of tractors during the last 10 years was about 13% (4,247 units in 2006 and 11,960 units in 2015). The provinces around Tonle Sap Lake and dry season rice areas in the south have higher growing rate. The number of power tiller significantly increased at the rate of about 27% during the last 10 years (29,706 units in 2006 and 228,659 units in 2015). The most significant increase in number was rice combine harvest which was only introduced in 2006. Its growing rate was about 48% from 325 units in 2006 to 5,519 units in 2015.

Similarly, the increased rate of threshers in the same period was about 11%. Water pumps were also widely used in irrigated areas around Tonle Sap Lake and dry season rice in the south (12% increase). The increasing rate of rice milling machines was the least at only about 4%.

Table 4: The statistic of agricultural machineries in Cambodia 2006-2015

| No. | Description | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Combine harvester | 325 | 395 | 430 | 836 | 947 | 1,548 | 4,820 | 4,580 | 5,503 | 5,519 |
| 2 | Rice threshers and pedal threshers | 7,795 | 8,036 | 8,237 | 13,798 | 14,390 | 15,210 | 16,146 | 17,542 | 17,532 | 18,210 |
| 3 | Rice milling | 38,618 | 38,680 | 39,429 | 47,620 | 48,217 | 48,753 | 54,328 | 55,270 | 54,062 | 54,052 |
| 4 | Tractor | 4,247 | 4,475 | 4,611 | 5,495 | 6,200 | 6,786 | 8,961 | 9,467 | 11,940 | 11,960 |
| 5 | Powertillers | 29,706 | 34,639 | 38,912 | 53,220 | 66,548 | 77,421 | 128,806 | 151,701 | 228,456 | 228,659 |
| 6 | Water pumps | 127,610 | 131,702 | 136,061 | 164,974 | 166,633 | 183,502 | 231,942 | 255,954 | 326,832 | 327,010 |

*Source: DAEng 2015*

Currently, farm operations, which were done manually or by draft animal, have been replaced by machineries mainly in land preparation, spraying, weeding, harvesting, threshing, and milling. However, in some regions, animals are still used for land preparation and transportation, especially in those regions where farm infrastructures are not well developed and farm size is small (less than 0.5 ha per household) which is not suitable for the use of machines and difficult to access by road because they are located far from main roads. In the northwestern provinces and the provinces located around Tonle Sap lake such as Battambang, Banteay Meanchey, Pursat, Kampong Chhnang and Kampong Thom where farm size is bigger (1 to 5 ha per household), mechanization is much required to replace animals.

Other farm operations such as transplanting, fertilizing, etc. are still done manually because they are complicated to be mechanized and because of their availability in local market and prices are still issues. Recently, government agencies have introduced direct seeding machines in order to improve the efficiency of sowing. Rice transplanter has also been introduced recently. However, its adoption is still not clear since majority of rice fields are rainfed ones which are difficult to manage water and the land is not leveled.

Power tillers are used throughout the country by farmers with small land holding size. Large tractors are preferred by owners of rubber, cassava and sugar cane plantations, and other concessional lands granted by the government.

The northwestern region (Pailin, Battambang, Banteay Meanchey) is characterized by large land size per household. There, large tractors and combine harvesters are used.

In northwestern region as well as upland region, large tractors with power more than 50 HP are preferred, of which the majority are MTZ tractors from Belarus; Kubota and Yanmar assembled in Thailand; Mahindra and John Deere from India; and Foton from China. Power tillers are imported from Thailand, China, or Japanese brand assembled in Thailand; their powers range from 12 to 15 HP.

In provinces around Tonle Sap Lake, low-lift engine pump is used to irrigate rice fields. Power tiller is used to drive this pump. In southern provinces such as Takeo, Kandal and Prey Veng, where ground water is sufficient for irrigation in dry season, centrifugal pump is used.

Because of labor shortage in rural areas and production intensification, harvesting is commonly performed by combine harvesters. Combine harvesters (small and medium) are accessible mostly through service providers, since their prices are comparatively expensive and the harvesting season is short. To maximize the use of the machine, some service providers move their harvesters around to other areas where harvesting is required for both rainy and wet season rice.

#### 5.1.3.5. Power Supply Chain

**a. Hand Tools**

Hand tools such as hoes, sickles and shovels are local made and imported. Farmers do not find any constraints in availing the tools from the suppliers. The supply chain is demand-driven and executed by the market. It does not need any support services from the government. Knapsack sprayers are also readily available in hardware and agricultural materials shops in Phnom Penh and in district centers all over the country. The sprayers are being sourced from China, Thailand and Vietnam.

Of 2.6 million agricultural households surveyed in the census of agriculture in Cambodia 2013, around 1.5 million used hoes, 1.3 million used sickles, 0.7 million used ploughs, 0.7 million used harrows, 0.5 million used rotavators, and 0.2 million used rakes.

Human labor, the most common farm power, is generally readily available in the country side. The recent efforts on crop intensification in the country prompt sequential cropping and synchronization of farm activities, and migration for work in other industries in the city centers leaves rural areas with inadequate labor force. Hence seasonal labor constraints and the subsequent increase in cost of production have begun to emerge in areas under intensive cultivation. Depending on the course of season, the minimal daily labor wages can range from 20,000 Riel/day to 25,000 Riel. Such variability in wages during a crop season affects timely operations by small holder farmers.

**b. Animal Draft Inputs**

The local metalworkers and the farmers themselves are the only manufacturer of animal drawn equipment identified in Cambodia. The premises have only some very basic tools such as ploughs, harrows and levelers. The quality of such tools is however low. The demand for such tools is generally low due to limited use of animal draft power and unstable supply. Human capacity and skills are major constraints in the manufacturing of animal draft inputs.

**c. Tractors and Related Implements**

There are several private companies dealing with farm machineries and equipment in Cambodia. Most machines are imported from various sources, for instance, Japan, China, Thailand, Vietnam, USA and countries of former Soviet Union. Most companies are local brand-new distributors and some are second hand ones. Limited implements are local made. The imports and distribution of farm machinery and farm equipment meet with the existing levels of demands of the farming community. The repair and maintenance services, however, do not support the efficient use of farm machinery and equipment.

**d. Agro-processing**

Depending on the stages, processing can be classified into primary and secondary processing. In primary processing, the valuable part of the harvested produce is not changed, seed for instance. In the secondary processing, the form of the produce is changed, flour and paste for example. While the primary processing activities can be organized near the farm in rural areas, the secondary processing is often done in a larger scale off the farm. The retail outlets in Phnom Penh and other provinces supply a wide range of machines and equipment from local made and from China and neighboring countries such as washers, crop threshers, graters, shellers, dehullers, bag stickers, electric motors, and pumps.

Industrial processing of some crops is well established in Cambodia. Rubber, Cashew nuts, rice milling, maize, cassava and oil palm are the major crops that are processed on a commercial scale.

There are a number of donors and development partners that are providing support to agricultural post production, including EU, FAO, IFAD, UNIDO, World Bank, ADB, KOICA, JICA, USAID and AusAID.

**5.1.3.6. Development Constraints of Agricultural Mechanization in Cambodia**

The promotion of agricultural mechanization in Cambodia is constrained by a number of factors including: scattered policies and strategies; lack of human resources; limited operational skills; missing link between actors; and short of funding.

**a. Scattered policies and strategies**

There is still lack of clear policy and development plan of agricultural mechanization. The importance of mechanization sub-sector was mentioned a bit here and there in a number of the government's documents (refer to section 5.1.1). Thus, a stand-alone development plan is needed. Furthermore, DAEng is lacking of support laws and regulations to effectively implement its mandate in order to enhance the capacity in manufacturing, assembling, repairing and trading of agricultural machinery and equipment following technical standards; inspect and test agricultural machineries and equipment produced locally and imported for their efficiency, quality, impact and safety; maximize farmers' benefit from using agricultural machineries and equipment; conserve soil and agro-ecology; and encourage stakeholders to develop innovative technologies in agricultural mechanization to keep pace with the demand in agricultural production.

Most of spare parts of agricultural machineries are imported while spare parts of some specific brands are not available in the country or long awaited order. Some spare parts are not obviously distinguishable from other types of machinery; thus their import, which is supposed to be tax-free, is taxed as non-agricultural machinery or equipment. This need a clear policy on the import of agricultural machinery and their associated spare parts.

**b. Human resources in demand**

Skilled workforce is still inadequate in agricultural mechanization at both national and provincial levels. Agricultural mechanization, for quite some time, has not been prioritized by the RGC and other development agencies. Structure of the Provincial Office of Agricultural Engineering is still weak. There is no staff responsible for agricultural mechanization below provincial level. The personnel of DAEng declined sharply from 132 people in 2009 to only 77 people at the end of 2015. There has been only 1-2 new staff allocated to the department per annum.

The shortage of engineers (with diploma or degree in mechanical engineering) in Cambodia makes it difficult to push on mechanization initiatives at the district and sector levels.

According to a survey conducted by DAEng in 2014, mechanics for repair and maintenance of farm machinery and equipment was in great demand. There were only 1.4 workshops per commune providing repairing services. This implies that some of 1621 communes across the country have no repair workshop. In order to receive the services, farmers have to transport their machines to district town which is costlier and time consuming.

However, the emphasis on agricultural mechanization at various levels of educational system is relatively growing in Cambodia. The Royal University of Agriculture (RUA) and Meanchey University offer degree programs on agricultural engineering. Certificate courses on farm machineries are also offered at technical schools and as part of the agriculture/rural development degree programs at some institutions across Cambodia. Nonetheless, the number of graduates and certificate holders is still limited.

**c. Limited operational and maintenance skills**

The repair and maintenance are one of the major constraints in promotion of farm machinery. Proper operations and maintenance could increase the economic life of the machines and as a result reduced cost of crop production. The condition, otherwise, would be reversed. In 2006 a study in Kampong Thom, Kampong Cham and Prey Veng showed that repair and maintenance cost accounts for 28% for power tillers and 20% for tractors respectively in the annual variable cost expensed by the surveyed farmers. Furthermore, according to the report, only 18% and 26% of power tiller and tractor users interviewed know how to properly maintain and repair their machines.

**d. Missing link between actors**

The relationship between public and private sectors has yet been strong. There are still lack of established communication and sharing of information. Generally, the private sector is reluctant to share the information about their businesses, fearing that the released information will benefit their competitors. Currently, there is no association of agricultural manufacturers. It is difficult for them to send a collective message to the government or to resolve conflicts among themselves. Meanwhile, external support and cooperation with development partners on agricultural mechanization is still missing.

The cooperation between DAEng, universities and private sector dealing with farm machinery remains weak. There are only two universities offering bachelor programs related to agricultural engineering. One is the Royal University of Agriculture in Phnom Penh and another Mean Chey University in Banteay Meachey Province. The programs are still in their infant stage.

DAEng has initiated a mechanism of semester meeting with private sector, annual conference and annual contest on the design and modification of farm machineries. However, the mechanism need to be reviewed and focus more on substance.

**e. Short of funding**

DAEng has been making every effort possible to deliver its mandate with fairly good results. However, this effort has remained limited and the vast majority of rural farmers have not benefited from such effort due to lack of financial support. The annual budget allocated by the government to DAEng is limited, about USD 250,000 (55% for running cost and 45% for activity implementation). Development partners, NGOs and credit institutions haven't focus their support in agricultural engineering sub-sector.

There is no credit scheme from the government for buying farm machinery and equipment. To buy new machines, farmers have to use their own saving or borrow from bank, micro-finance institutions or dealers. This also applies to local manufacturers.

**5.1.3.7. Current Policies**

The government is attempting to encourage agricultural mechanization in the country, in consistence with long term strategies. In coherence with its regional and global trade regulations, the government does not subsidize the purchase of machineries and the associated farm implements and equipment. To encourage the use of farm mechanization and to boost investment, the government promulgated No. 303 Prakas (sub-decree) in 2001 to lift value added tax (VAT) on imports and supply of some goods in agricultural sector including machineries for large scale farming.

**5.2. Strategic Objectives**

The strategy targets mechanized production of crops, vegetables, fruits, livestock, forestry, fisheries and rubber. However, the current focus includes but not limited to mechanized production of rice, maize, cassava, vegetables and fruits.

It is envisioned that by 2020 at least mechanization level about 67.78% of rice field operations from land preparation up to milling will be reached in Cambodia.

Enabling profitability of agricultural engineering; skill development and capacity strengthening; improving agricultural productivity and rural livelihoods; and improving policy, legal and regulatory environment will serve as the four key drivers in promoting agricultural engineering in Cambodia.

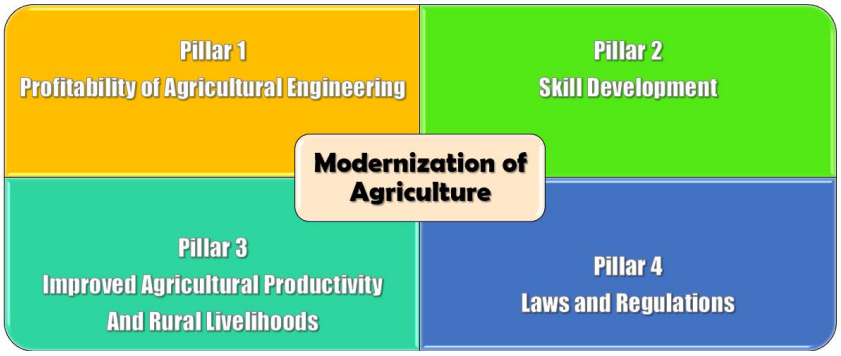


Figure 7. Strategic objectives of agricultural engineering development for Cambodia

### 5.3. Strategies

#### 5.3.1. Pillar 1: Enabling Profitability of Agricultural Engineering

Given the diversity in terrain types of Cambodia, the appropriate choice of mechanized inputs in farm operations have a significant effect on agricultural production and productivity, the profitability of farming, and on the environment. Ultimately, the farmer and other end users should make a decision on usage and the levels of mechanization options.

##### 5.3.1.1. Field Mechanization Options for Cambodia

**a) Mechanization Options**

The three major variables which influence mechanization in Cambodia are terrain, crop type and scale of operation. However, details on the selection process for mechanization in each ecosystem zone need to be further assessed.

Table 6 summarizes the proposed power options for the identified four ecosystem zones. Animal draft power shall serve as a viable option in gentle slopes and in regions where small holding is not likely to be consolidated, even though farmers in other countries find that the resource requirements (human and feed) of maintaining animals are relatively higher than that of machines.

Table 5: Mechanization options for four ecosystem zones in Cambodia

| Ecosystem Zone | Hand Tools | Animal Traction | Four-wheel Tractor | Power Tiller |
|---|---|---|---|---|
| Coastal | Use | Use | Limited Use-Stability problems need to be assessed | Limited to land preparation and transport |
| Mekong-plain | Use | Use | Use for land preparation and transport | Use for land preparation, pumping and transport |
| Plateau-mountainous | Use | Use | Use-Stability problems need to be assessed | Limited to land preparation and transport |
| Tonle Sap | Use | Use | Use for land preparation and transport | Limited to land preparation and transport |

The power source options for field operations are summarized in Table 7. The requirements of power shall generally vary depending on the nature of operations, type of crop and soil type. The scale of operation varies depending on the province with the smallest plots in southern provinces arranging from less than 1 ha to 5 ha (refer to section 5.1.3.2).

Table 6: Implements required for field operations

| Operation | Hand tool Options | Animal Drawn Options | Tractor Drawn Options |
|---|---|---|---|
| Soil loosening depth | Hoe or pick | Moldboard plow | Moldboard or disc plow, heavy disc harrow |
| Creating a fine tilth | Hoe | Tooth harrow | Tooth harrow, disc harrow or rotavator |
| Creating ridges | Hoe/shovel | Moldboard plow, moldboard or disc ridger | Moldboard or disc ridger |
| Crop establishment (planting) | Hoe | Planter or moldboard plow | Planter, broadcaster |
| Fertilizer application | - | Planter | Planter or broadcaster |
| Pest control | Knapsack sprayer | - | Boom sprayer |
| Weed control | Hoe, knapsack sprayer, hand weeder | Moldboard plow, cultivator, weeder | Boom sprayer, mechanical weeder |

The above options are primarily for paddy production, thus mechanization options for other crops will be also reviewed and proposed. Specifically, small scale mechanization options for vegetable and fruit production for rural women will be promoted. The options will be further extended to food processing as additional source of income for rural families.

**b) Target of farm power**

Mechanization in any area is characterized into three levels: low, fair, and high. Low mechanization level means that manual power used exceeded 33%. Fair means that animal power utilization ranges from 34% to 100%. High means that mechanical power utilization ranges from 67% to 100% (Rodulfo, et. al, 1998).

Table 7 shows the level of mechanization in rice farming operations, expressed in three main sources of power, namely: manual, man-animal and mechanical. The data shows that human power constitute almost half of farm operations at an average of 46.65%. Mechanical operations are applied mainly in milling, spraying, land preparation, harvesting and threshing. Animals are limited to land preparation only. Sun drying is still preferred by farmers. In terms of available power expressed as horsepower per hectare (hp/ha), the level of mechanization needs further study and assessment. However, by DAEng's estimation in 2013, farm power available per hectare was about 1.32 kw (1.77 hp).

Table 7: Percentage of rice operations vs. source of power

| Operation | Power Source (%) | | |
|---|---|---|---|
| | Manual | Man-Animal | Mechanical |
| Land preparation | 0 | 12.22 | 88 |
| Planting | 99 | 0 | 1 |
| Weeding | 90 | 0 | 10 |
| Fertilizer application | 99 | 0 | 1 |
| Spraying | 0 | 0 | 100 |
| Harvesting | 30 | 0 | 70 |
| Threshing | 1 | 1 | 98 |
| Drying | 80 | 0 | 20 |
| Milling | 0 | 0 | 100 |
| Average | 44.33 | 1.47 | 54.22 |

Source: Department of Agricultural Engineering, 2015

To accomplish around 68% mechanization level in rice field operations in a total cultivated area of about 3,550,000 ha by 2020, the farmers will use some levels of mechanical/animal power in each operation from land preparation up to storage and milling. The target figures of mechanization levels are shown in Table 8.

Table 8: Targets of rice mechanization level for 5 years (percentage)

| Operation/Year | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Land preparation | 88 | 89 | 90 | 93 | 95 | 97 |
| Planting | 1 | 3 | 5 | 10 | 15 | 20 |
| Weeding | 10 | 11 | 13 | 15 | 17 | 20 |
| Fertilizer application | 1 | 3 | 5 | 8 | 10 | 15 |
| Spraying | 100 | 100 | 100 | 100 | 100 | 100 |
| Harvesting | 70 | 71 | 73 | 75 | 77 | 80 |
| Threshing | 98 | 98 | 98 | 98 | 98 | 98 |
| Drying | 20 | 25 | 30 | 50 | 70 | 80 |
| Milling | 100 | 100 | 100 | 100 | 100 | 100 |
| **Average** | **54.22** | **55.56** | **57.11** | **61** | **64.67** | **67.78** |

It is important to initially assess the performance and profitability of mechanization options in the different ecosystem zones, and make appropriate modifications before farmers and other end-users are advised of the options. The current use of power tillers and tractors are mainly for land preparation. Hence 68% of the mechanization target level shall be achieved by promoting the multiple usability of the two machines equipped with implements for planting, weeding and fertilizer application and other post-harvest operations.

#### 5.3.1.2. Improving Supply Chains

A number of market studies on the supply chains of agricultural machinery and equipment will be periodically performed to inform relevant actors about the current situation and forecasts.

Statistical data on agricultural machineries and equipment is still limited and not in-depth. Most data are based on data collected by district agricultural offices and there is a lack of data on agricultural machineries' distributors, local manufacturers of agricultural machineries and equipment. It is essential to improve the data collection channel to ensure quality and accuracy of the data collected. The data shall be up to date and readily available in the forms of table, graphics and maps. A national machinery database shall be established and accessible by relevant stakeholders. Meanwhile, DAEng shall actively continue involving in the CSAM initiative of reginal database of agricultural machinery in Asia and the pacific.

In agricultural mechanization, investment opportunities include: (i) manufacturing and assembling of machineries and implements; (ii) manufacturing of post-harvest processing machines and storage facilities; (iii) importation and distribution of spare parts; and (iv) establishment of community workshops for repair and maintenance services. The government needs to attract local and foreign investments in the above areas in order to sustain mechanization in Cambodia.

#### 5.3.1.3. Financing

Facilitation of access to credit represents an important strategy in enabling agricultural mechanization. The financial sector must be able to provide the necessary capital for the entrepreneurs, the farming community and

other end-users. In this context, the economic feasibility and the profitability of the various mechanization options must be made available to the stakeholders (farmers, end users, entrepreneurs, private sector) involved in financing in Cambodia.

Special attention should be placed on increasing the profitability of investments in mechanization by encouraging commercial agriculture and focusing investments and support. Currently limited banks and micro-finance institutions (MFI) engaged in leasing farm machineries to farmers and farmer organizations. The government shall expand the sources of credit facilities through other banks and MFIs that have good outreach in rural areas. Since the machineries themselves are used as the security against the loans, the government shall motivate and engage other microfinance institutions in providing loans to farmers.

Efforts are also needed to help farmer organizations establish strong business models and financial plans. The organizations shall use their collective bargaining power to leverage and avail the loan facilities for the machineries. Government shall consider providing credit guarantees to local banks to provide loans to those farmer organizations who have a potential for managing agricultural machinery services and repaying the loans. Government shall also encourage partnerships and strategic alliances among co-operatives, NGOs, equipment suppliers and dealers, and financial institutions. Specific attention should be given to the establishment of women's saving groups for easy access to small credit to do own business and to mechanize.

#### 5.3.1.4. Support Services

There is a strong need to establish efficient and effective distribution channels for equipment, spare parts and repair services, as well as other supplies such as fuel and oil. Initially, the government shall help establish service centers through business ventures with farmer organizations or private entrepreneurs in the regional Agricultural Engineering Development Centers, especially in the existing Tuol Samrong Center in Battambang Province and in Kbal Po Center in Takeo Province. The government shall then gradually withdraw and promote local business in rural areas by encouraging local entrepreneurs in setting up centers/workshops for machinery services and spare parts themselves in other parts of the country.

Agricultural equipment like irrigation pumps, irrigation control systems, pre and post-harvest equipment require technical backstopping for timely maintaining and skill development. Reliable and timely provision of maintenance services, spare parts, fuel, and lubricants for the stated equipment mainly in rural areas is very important in promoting crop production and productivity. Therefore, DAEng shall promote large and medium scale and micro enterprises for effective management of agricultural equipment maintenance. This includes capacity development of farmers in technical issues, business management, and entrepreneurship.

The proposed Center for Testing of Agricultural Machinery (CTAM) under DAEng should establish standards and safety regulations for spare parts, implements and machineries, and certify machineries. Field testing and demonstration facilities for agricultural machinery and equipment for quality control shall also be established in such centers for the benefit of farmers and manufacturers. The regional agricultural engineering development centers and other institutions engaged in agricultural mechanization should recommend and make required amendments to the standards of implements to suit local conditions. CTAM in collaboration with these organizations should routinely examine the standards of service operations. Safety regulations such as roll-over protection features for tractors, operational procedures, and handling of implements should be established, redesigned if necessary and strictly adhered.

#### 5.3.1.5. Enabling Designs

In collaboration with regional and international organizations, institutions such as DAEng, CARDI and universities should engage in research on new designs and/or modifications of available designs that are suited to the local working conditions and the diverse terrains through collaborations with regional/international organizations and institutions.

To reduce drudgery and improve human labor productivity, there is a need to improve the design of existing hand tools. Ergonomic tools and women-friendly tools in farming operations that could significantly enhance human labor productivity in different terrains should be introduced through programs and projects. Draught animal power operations will also require ergonomically designed harnesses and yokes, and improved implements such as seed and fertilizer drills, planters and multi-row inter-culture implements. Emphasis may be given for introduction of multi-crop equipment such as medium range multi-crop planter, multi-crop axial flow threshers, multi-crop harvester and roto-tillers suitable by bringing about design improvement to suit the crops and the terrain.

Environmentally friendly mechanization practices that conserve natural resources such as land, water and soil

nutrients need to be promoted. Mechanization options that allow direct sowing, minimum/reduced tillage, land leveling, retention of crop residues will result in sustainable economic growth. The outstanding success of no-till and conservation agriculture practices currently introduced in Cambodia by French Agricultural Foreign Aid Agency (CIRAD) project is a good example of the approach to be taken. Taxable income concessions on costs incurred in environmental conservation of farming land shall be introduced.

#### 5.3.1.6. Alternative Energy and Inputs for Farm Production

Appropriate incentives and efforts should be provided and done to develop technologies using locally available, alternative energy resources in order to reduce the dependability on ever increasing conventional energy and to reduce environmental pollution by studying on renewable (sustainable) energy sources of the sun and wind and bio-resources for future energy supply such as development of solar dryer, solar pump, bio-fuels for operation of farm implements. Specifically, biogas from farm manure and residues, and biochar from farm residues should be promoted.

### 5.3.2. Pillar 2: Skill Development and Capacity Strengthening

Increasing the capacity and skill levels of human resources should be a major priority in promoting agricultural mechanization in Cambodia. Skills are needed along the entire supply and value chains – artisans, operators, and farmers, other end-users, service providers (mechanics, engineers), suppliers and extension agents.

#### 5.3.2.1. Capacity Strengthening of Public Institutions

The Department of Agricultural Engineering is inadequately staffed and its branch offices in the province remain weak (refer to Section 5.1.3.6). In this regard, replenishment of skilled personnel is urgently needed both at national and provincial levels. The roles and responsibilities of technical offices at national level need to be fine-tuned and re-orientated towards achieving the common strategic goals. Special attention is also needed to review and revitalize the mandate and resources of provincial offices. It is expected that at 5 engineers/specialists will be dispatched to each provincial office including design and manufacturing engineer, pre-harvest engineer, post-harvest engineer, testing and demonstration specialist, and networking and public relations specialist.

Besides human resources, in order to get provincial offices up and fully functioning, they must be fully equipped with necessary facilities and adequately funded.

#### 5.3.2.2. Technical Skills

Lack of basic technical skills, in driving for example, can severely hinder an otherwise potential farmer towards mechanization. To promote basic skills, DAEng can schedule training opportunities for farmers in different parts of the country by sending authorized trainers at regular intervals during the off-season. The trainers shall teach basic operations and safety issues of power tillers, tractors and other machines on a voluntary basis. Car driving schools or regional development centers of agricultural engineering shall be authorized to coach and license driving of agricultural machines.

Training and upgrading sessions for artisans and automobile mechanics shall also be conducted in each sector. Special certificate courses (1 to 6 months) that will develop skills and offer hands-on training on the design, use and maintenance of machineries and implements, and on management of workshops need to be developed for technicians and service providers. Farmers and service providers should also receive training on how to make the integrated use of farm machinery with other inputs more efficient. Such courses shall be offered and sponsored at educational institutions such as RUA and other institutions.

To develop an active agricultural engineering sector in the country, specialized departments shall be set up in major agricultural institutions of Cambodia to support and gear farm mechanization in particular through education, research and development. Key institutions such as DAEng and CARDI should closely work with artisans, farmers and service providers in modifying and developing appropriate tools and machines for local farm use based on their interaction with farmers and their assessment of the potential of the mechanization scenario. In the interim, government shall encourage graduate and/or post graduate students to undertake formal studies in agricultural engineering from reputed institutions abroad to build human capacities in the field of farm mechanization.

A Steering Committee of Agricultural Engineering Strategic Plan (SCAESP) may be set up at national level with MAFF Minister or GDA Director General as its Chairman. The members shall comprise of DAEng, CARDI, RUA, and other relevant departments. The SCAESP shall serve as a nodal agency for implementation of agricultural engineering strategies and policies by establishing linkages with manufacturing, financial, human resources,

technology and extension institutions, and shall constantly monitor the progress of mechanization in the country. Through interactions with other ministries, manufacturers, research and extension agencies, the board may elicit feedbacks for correction in problems as well as for future research and development based on farmers' need.

#### 5.3.2.3. Knowledge creation

The extension programs on mechanization should include front line demonstration, agricultural machinery shows, media, publications and face-to-face contacts with farmers and farmer organizations. The government can absorb and place the new flow of diploma graduates specialized in agricultural mechanization produced as extension agents across the country. In addition to extension network, community workshops shall be established at village or communal level. NGOs and other international aid programs and projects can also play an important role in educating farmers on the feasibility and sustainability of farm mechanization. The extension services should place more emphasis on the development of small-scale farmers in:

1. the use of appropriate and affordable mechanization options;
2. credit acquisition;
3. effective supply of agricultural inputs (including spare parts); and
4. encouraging farmers' co-operatives to participate in availing and providing services of agricultural machineries.

The DAEng should undertake a massive extension program on farm machineries. DAEng should effectively use the proposed community workshops and the graduates specializing in agricultural mechanization. The government should also provide in-service training for existing staff, technicians and artisans to improve their understanding of the different power and mechanization options available to farmers and to expose them to new technologies and opportunities.

Local manufacture of agricultural machineries and implements can be promoted through trainings on village-level craftsmanship, manufacturing technology, operation, repair, and maintenance. Local manufacturers can be provided with technical assistance on the fabrication of prototypes of machines and spare parts.

### 5.3.3. Pillar 3: Improved Agricultural Productivity and Rural Livelihoods

Increased productivity leads to commercialized agriculture. The commercialization, in many diverse circumstances, led both to an increase in household income and to changes in the way household resources are organized to earn that income (J. V. Braun & E. Kennedy, 1994). Specialization and the development of markets and trade that characterize commercialization are fundamental to economic growth. One of the most important factors for maximizing the potential benefits from agricultural commercialization and for minimizing damage is to promote technological change in subsistence food crops along with commercial crop production for household food security.

However, commercialization of agriculture will be a gradual process. It will require increased levels of public and, in particular, private investment at all levels of agricultural activities, including primary production, marketing, input supply and processing.

#### 5.3.3.1. Pre-harvest technologies

**a) Effective pre-harvest equipment and tools**

The farming practice in Cambodia is dominantly traditional with overwhelming participation of small-scale producers with small farm size. Similarly, the status of agricultural production mechanization in crop production for the different steps such as planting, weeding and fertilizer application is very low. Some farm operations are performed with bare hand or using simple hand tools and traditional animal drawn implements. Different implements like ploughs, harrows, planters, and weeder were developed and some were introduced from elsewhere and given out to the farming community. However, effective use of these technologies has been minimal.

Therefore, dissemination and promotion of existing pre-harvest technologies along with adaptation and generation of other improved technologies need to be strengthened together with human and physical capacity building and climate change considerations. The specific interventions are:

1. Strengthening the popularization and dissemination of proven pre-harvest equipment;
2. Encourage suitable mechanical power technology in the form of cooperatives and multi farm use;
3. Develop an industrial extension program for large-scale production, extension and marketing of tools and implements;
4. Providing opportunities for training and train more researchers and extension engineers in RUA or elsewhere;

5. Assisting and strengthen local manufacturers of tools and implement. Form new or strengthen and enhance the capacity of existing micro and small scale enterprises through training and providing opportunity for the establishment of small workshop to manufacturers of improved agricultural tools and implements locally;
6. Introduce and evaluate implements for tillage and planting to improve present traditional practices;
7. Strengthening the introduction of pre-harvest equipment (technology shopping);
8. Design and testing of improved rice pre-harvest equipment;
9. Testing agricultural machines for ploughing field, planting, fertilizing, irrigating and draining.

**b) Better on-farm management**

Given the importance of climatic change, irrigation is likely to become more important for Cambodian agriculture. Since increasing the irrigated area in Cambodia would make a major contribution to its agricultural productivity, public investments in large irrigation schemes shall become a long-term strategy. Yet much can be achieved in small irrigation schemes for small holder farms and in small groups of farms.

The RGC is currently increasing its support and involvement in improving traditional irrigation systems as well as expands areas under modern irrigation to increase agricultural productivity and improve rural livelihood through producing market oriented economic crops which include rice as one of the priority crops.

To increase rice production under irrigation, existing irrigation schemes will be rehabilitated while new irrigation schemes (gravity) will be developed. In the rain fed lowlands, communities should be encouraged to participate in the development of simple and low cost rainwater control structures (various soil moisture conservation technologies) for improved rice production. Staff at all levels and farmers will be trained in the operation and maintenance of schemes.

Land leveling support irrigation system and other on-farm infrastructure such as drainage and on-farm road for better management of water, fertilizer, weeding, insects, diseases and transportation; especially for rice production shall be implemented. Size of land holding is a constraint for using big agricultural machinery. There are two approaches in this regard, and will be done through the establishment of agricultural land use associations.

1. Develop projects of land leveling for high potential crops. This will support irrigation and application of big and high capacity machines.
2. Land consolidation for group farming is a possible way to use big and high capacity machine, especially for maize combine harvester, cassava combine harvester and rice combine harvester.

**5.3.3.2. Post-harvest technologies**

Agricultural mechanization in harvesting, post-harvest handling and storage processes shall initiate the path towards commercialization of agriculture. Farmers in Cambodia need to realize the importance of quality of agricultural produce on the value chain. Besides raising the competitiveness of their products, it will also raise their profitability and sustainability.

**a) Effective post-harvest machines and associated equipment**

Introduction of more efficient technologies for handling, drying, storing, and milling rice at the village level is essential to reduce post-production losses. The present impressions are that post-production is labor intensive and results in poor quality milled rice. Therefore, the strategy would promote the introduction of affordable and efficient small-scale post-harvest tools and equipment. The specific interventions are:

1. Strengthening extension services to ensure rice farmers get appropriate advice for post-harvest management;
2. Enhancing the availability and use of efficient post-harvest handling and processing equipment taking into account the existing constraints such as lack of equipment for milling, grading, packaging and by-product utilization and ensuring that all farmers at grass root level have access to modern processing, packaging and grading technologies;
3. Professional training for researchers/extension officers at masters and/or PhD degree level for selected few will be needed on technology development for primary processing with agricultural engineering background;
4. Promote improved rice by-product (hull and bran) utilization techniques;
5. Strengthening the introduction of post-harvest equipment (technology shopping);
6. Design and testing of improved rice post-harvest equipment; and

7. Strengthening farmer groups, which are present at present and/ or form new farmer groups, at least one sustainable farmer group per village. This will enable farmers to access financial services, for example, loans and farm machinery services more easily and at affordable prices;
8. Besides rice, other crops such as maize, cassava and beans will be taken into account.

**b) Reduced Losses and Improved Quality Products**

Smallholder farmers need to be sensitized on the importance of linkages with processors and market. This shall be done by creating awareness programs emphasizing the importance of post-harvest technologies on efficient processing and its effect on prices. Appropriate use of mechanization options in post-harvest handling such as combine harvesters, mechanical threshers, winnowing machines, shellers, de-hullers, driers (using heat from electrical power or crop residues such as rice husks) and motorized transportation that can, not only reduce the post-harvest losses but also improve the quality of agricultural produces, should be actively promoted.

While secondary processing shall be concentrated on medium to large scale industries, small to medium scale primary processing of rice, maize, cassava, cashew nuts, soybean, groundnut, and beans shall be explored in locations closer to the production in rural areas. Women entrepreneurs capable of setting up small-scale industries on processing and value addition in rural areas (at locations close to the source of production) need to be encouraged. In addition, mechanization that can improve the management of crop by residues such as straws, cobs, shells through composting, pyrolysis or processing should also be promoted. The sustainability of agro-processing shall be ensured by routine examination of standards of machines and operations by CTAM.

One way to promote agro-processing among small holder farmers and small investors in villages is to help them organize into groups or associations. These organizations can establish more efficient scales of operation and utilization for many types of machinery through resource-sharing mechanisms. In this context, members of farmer organizations have a better chance to branch out and become agricultural equipment service providers to their own group members. In this way, business and entrepreneurship can evolve from the bottom up and may spread to medium-scale and larger scale sustainable scenarios.

**C) Building entrepreneurship**

Mechanization of activities in commodity chain enables creation of small to medium scale agro-processing industries in rural areas that can provide employment in handling, packaging, processing, transporting, and marketing of agricultural commodities. Small scale processing requires relatively little capital investment and housing. Government needs to establish environments that are conducive to establishment and operation of agro-processing industries.

NGOs and non-government projects and programs revolving around the theme of commodity chains such as post-harvest handling and storage need to also promote appropriate agro-processing technologies in specific areas where the crop produces of interest are intensively produced. By engaging such stakeholders, the government needs to sensitize and build entrepreneurships through training and workshops on small-and medium scale agro-processing industries. The government shall also build capacity of private agro-processing support service providers by providing training to existing processors. For instance, farmers require training on threshing /de-hulling of cereal grains, processing of cassava and feed mills.

Given the regional dynamics in trading regulations under WTO, ASEAN and its partners, smallholder farmers in Cambodia need to be informed of the importance of competitiveness and newer avenues to access markets. Through various programs and projects, the government shall provide the necessary market information and construct the missing linkages in commodity chains along the production-processing-marketing continuum by offering appropriate mechanization options on post-harvest handling, storage and processing of agricultural produces.

Increased capitalization of agro-processing needs sources of finance from the private sector. The financial sector and government should work with commercially oriented farmers and entrepreneurs in order to strike the necessary financial deals that are required for agro-processing industries. The government shall promote private investments in primary processing by coming out with a clear incentive package.

### 5.3.4. Pillar 4: Better Policy, Legal and Regulatory Environment

Favorable policy is the critical for the promotion of agricultural mechanization in the country. All the different policy viz. agricultural, industrial, labor, energy, export/import etc. are needed to be streamlined for promotion of agricultural

mechanization. Policy support is also needed for following areas for promotion of agricultural mechanization in Cambodia.

- Co-operative farming and land consolidation for agricultural activity;
- Contract hiring of agricultural machinery;
- Support for agricultural machinery manufacturers;
- Standardization and safety of agricultural machinery;
- Promotion for energy efficient machinery;
- Promotion for conservation farming related machinery and green technologies; and
- Promotion for value addition and employment generation related small and medium scale agro-industries.

There is also need for the national, bilateral and multilateral collaboration of institutes related to agricultural mechanization for sharing the experiences and the technologies in their respective countries. This will also help for the exchange of prototypes and experts across the countries. Joint projects could also be formulated to address common problems of the region itself.

#### 5.3.4.1. Formulation of farm machinery laws and regulations

The law, sub-decree and other regulations and guidelines on the promotion of agricultural mechanization will be prepared and adopted. These documents will be enacted with a view to encouraging and supporting peasants and agricultural and operation organization to use advanced and applicable agricultural machines, promoting the mechanization of agriculture and developing modern agriculture. This also provides domestic industry with similar institutional resources to those available to the main competitor countries—providing for reliable governance, policies and regulations that work in practice and provide transparency, consistency and accountability of public processes. The first regulation needs to be adopted in the near future is the sub-decree on the management of workshops for repair, modification and assembly of agricultural machinery and its associate equipment.

There is no institution to undertake machinery testing, quality control and standardization. Even though, Institute of Standards of Cambodia (ISC) under the Ministry of Industry and Handicraft (MIH) provides Cambodian Standard of different products produced in Cambodia, till now it has not made any standard on agricultural machinery. For testing and certification to meet the specified performance and quality and safety standards of locally manufactured as well as imported farm machinery, there is need of an institution in the country. The proposed testing institution, Center for Testing of Agricultural Machinery (CTAM), could be established under DAEng. There is also need for legal measures for standardizations and certification.

CTAM is a national-level agency that will be responsible for testing and selecting agricultural machinery and spare parts, quality certification of agricultural products, management and supervision, vocational skill appraisal and guidance, as well as agricultural machinery repair and maintenance.

Establishment of a regional network for testing agricultural machinery will be useful among national agricultural machinery testing agencies and institutes of member countries for efficient use of agricultural machinery and promotion of green agricultural technology. Cambodia shall actively continue participating in ANTAM initiatives.

#### 5.3.4.2. Cooperation between public and private sector and farmers

There is a need to establish a network of agricultural machinery related institutions/players such as research, training, extension, importers, traders, dealers, fabricators, financial intermediaries, policy makers, universities etc. This network will share their experiences and open platform for collective actions for the promotion of appropriate agricultural mechanization in Cambodia. Moreover, this network can also press the government and policy maker for the favorable policy for appropriate agricultural mechanization.

Meanwhile, DAEng shall continue its initiated mechanism of semester meeting with private sector, annual conference and annual contest on the design and modification of farm machineries.

#### 5.3.4.3. Gender mainstreaming

In Cambodia, all farm household members are commonly engaged in farm activities. Since rice is a labor-intensive crop, the need for household labor is very high. Women are also engaged in most of the farm operations in addition to the load they shoulder in managing the household mainly taking care of children. Women

play a major role in rice production in the country, as they are involved in all aspects of crop value chain particularly planting, weeding, bird scaring, harvesting, processing and trading. It is observed that men are mostly involved in the land preparation. Both men and women are engaged in rice harvesting and threshing. Currently, women are getting more burdens as more men tend to migrate to work in urban centers or abroad. Therefore, the introduction of labor saving technologies in farm operations has paramount importance in addressing gender issues.

Knowing of the labor intensity of crop production and engagement of women and children, and the DAEng's target of addressing gender issues through interventions like introduction of labor saving technologies for crop production and processing, the strategy will consider the gender aspects (women-friendly machineries and tools) starting from technology generation up to markets.

Specific projects will be developed to train women in small scale business management (finance, book keeping, marketing…), operation and economics of small scale machinery use, and to strengthen and sustain the position of rural women in the family and society by acting as entrepreneur and as contributor to additional household income.

#### 5.3.4.4. Environmental Protection and Climate Change

Cambodia is one of the most disaster-prone countries in East Asia, with its vulnerability to annual floods and droughts. One of the reasons why it is vulnerable to climatic events such as recurring floods and droughts is that the livelihoods of the majority of people depend directly upon natural resources, with a large proportion of its population occupied in agriculture and related sectors, including animal husbandry (Oxfam, 2008).

A number of climate change-related impacts have already been observed in the Mekong River region. Climate change seems to be one factor influencing a significant reduction in water supply in the Upper Mekong, water shortages in dry seasons, and deterioration in water quality. The flow of water in the Mekong River is hugely significant for Cambodia as a whole, and it is essential that such impacts on the country are better understood.

The strategic development plan will review and consider the two kinds of climate change adaptation strategy: autonomous adaptation options and planned adaptation options. The former includes storing seed and fodder for the next season, selecting different crops and machinery, and diversifying livelihoods. The latter, planned by government and NGOs, include digging wells and providing pump sets and better crop seeds and farm machinery. While flood response mechanisms are better developed in Cambodia, drought-mitigation programs shall be prioritized.

The plan will also adopt existing regulatory framework of environmental aspects in order to protect and promote environmental quality and public health by preventing and controlling pollution and also by conducting environmental impact assessments on all projects before their implementation.

## 6. ACTIVITIES

The specific activities and their relevant timeframe are presented in Annex 1 Action Plan and Timetable.

## 7. FINANCIAL RESOURCES

The total budget estimate of the strategic plan is **6,688,000 USD** over five years. The financial sources would be available from national budget and foreign aids and assistance. The annual budget DAEng receives from the RGC is approximately **250,000 USD** (55% for running cost and 45% for activity implementation).

Therefore, in order to achieve the goals and objectives set in the strategic plan, GDA and MAFF have to prioritize the programs and projects and allocate appropriate budget to support the sub-sector and there will be support from the RGC with technical and financial assistance from development partners, NGOs and civil societies including private sectors, and participation from local authorities and farmer communities.

## 8. MONITORING AND EVALUATION

### 8.1. Roles and Responsibilities of Stakeholders

The development of agricultural engineering in Cambodia shall rest with private sector. The state shall, however, act as a catalyst ensuring that mechanization, human resources and legal frameworks are geared towards stimulating farm productivity and private investment.

The government (public sector), private-sector agencies and the end-users need to play several important roles in implementation of mechanization strategies. The ideal situation involves "Triple Helix Model" in which government, public institutions and industry are entwined in a mutually supportive cooperative endeavor. Broad partnerships are required between government tasks that will cut across infrastructure, education, health, gender, transport, natural resources (including water), fiscal measures and legislation.

The **government** has a role in the broad field of education and training in the creation, funding and management of institutions responsible for the acquisition of knowledge (adaptive research for the different ecosystem zones), and in its dissemination. Development of the required skills and extension services to farmers and other end-users need to be provided by the government. The government may have a role in facilitating trade relationships with new suppliers of technology or equipment. Support with supply and demand contacts, management and finance securities or tax waivers would help the private sector to come up to gain momentum in a relatively short period.

DAEng, CTAM, CARDI and Agriculture Universities shall be responsible for ensuring the quality and quantity of mechanization in the country. DAEng could play a facilitative role in identifying potential product suppliers and inviting them to attend the field days organized for farmers. The sector personnel should work closely with local level service providers and product retailers.

The **private sector** shall look after the provision of farm inputs including farm machinery and the associated machinery support services (supply, repair and maintenance of equipment). Building close relationships with the farmers, assessing needs and satisfying demands, while competing with peer companies, are all part of the business venture. In such operational scenarios, the demand for mechanization is likely to be satisfied and the agricultural productivity enhanced. Operations are best conducted under commercial enterprises requiring adequate investment and offering the opportunity to make profitable commercial returns. Local manufacturing can be logically preceded by profitable importation, assembly and distribution support businesses in Cambodia.

### 8.2. Coordination, Monitoring and Evaluation

The outputs and the effects on the intended beneficiaries outlined here will be monitored by GDA. The institutions and programs who are assigned with responsibilities of the various activities listed under logical framework of agricultural engineering strategies will need to elaborate and establish further details of methodology and work plan. Each component will be implemented through annual work plans (activities, time frame, and budget) that are formulated in terms of the milestones to be accomplished. The proposed SCAESP shall review all work plans and budgets and will monitor progress internally and annually.

Progress on the activities in general will be regularly evaluated by comparing the outputs and milestones against the proposed key indicators. Information on the progress according to the program's plans and schedules will be gathered. The review will provide decision-makers with detailed assessment of the achievements, failures, weaknesses, constraints, opportunities, challenges, lessons learnt, cases and the way forward arising from implementation of the proposed strategies at organizational and field levels, as they pertain to beneficiaries. Based on the record of outputs, effects and impacts, the strategy activities and work plan shall further be modified to attain the set goals.

## 9. CONCLUSIONS

Agricultural engineering sub-sector played important role to insure food security, poverty reduction and economic development through promoting agricultural intensification and diversification, ensuring the sustainable natural resources management and conservation, and adapting to climate change. In order to achieve this strategic development plan, DAEng under DGA needs support and assistance from the RGC and development partners in terms of financial support and technical assistance to improve agricultural engineering research and development and to strengthen the human resource development.

The strategic development plan for agricultural engineering for Cambodia will be greatly useful in an implementation direction and provide more credible and transparent for development partners to contribute the resources in the priority activities for agricultural engineering development as well as Cambodia's economic growth.

## ANNEX 1. ACTION PLAN AND TIMETABLE

| Objective | Specific Objective | Activities | 2016-2017 | 2017-2018 | 2018-2019 | 2019-2020 | 2020-2021 |
|---|---|---|---|---|---|---|---|
| **1. Enabling profitability of agricultural engineering** | 1.1. Establish mechanization options for the different ecosystem zones (Coastal, Mekong-plain, Plateau-mountainous and Tonle Sap) | 1.1.1. Assess the performance feasibility of the proposed mechanization options | | | | | |
| | | 1.1.2. Amend and recommend appropriate modifications of the options, if any | | | | | |
| | | 1.1.3. Promote and make mechanization options available to farmers, service providers and other end-users | | | | | |
| | | 1.1.4. Determine the economic feasibility of mechanization options for different ecosystems | | | | | |
| | | 1.1.5. Establish the usability of power tillers and tractors in seeding, fustigation, fertilization, and other postharvest operations | | | | | |
| | | 1.1.6. Promote and provide small scale mechanization options for rural women focusing on vegetable and fruits production. Further on food processing as additional source of income for rural families | | | | | |
| | 1.2. Facilitate supply chains governing farm power and equipment | 1.2.1. Perform market studies on the demand for machineries and equipment | | | | | |
| | | 1.2.2. Improve data collection channel of agricultural machinery | | | | | |
| | | 1.2.3. Attract local and foreign investments in manufacturing and/or assembling of spare parts and machineries in Cambodia | | | | | |
| | 1.3. Facilitate improved access to credit of farmers, end-users, manufacturers and service providers on machineries and equipment | 1.3.1. Engage rural banks and microfinance institutions in providing credit to end-users | | | | | |
| | | 1.3.2. Encourage rural entrepreneurs in providing financial and/or mechanization services | | | | | |
| | | 1.3.3. Facilitate accessible loans for small and medium manufacturers of machines and equipment | | | | | |
| | | 1.3.4. Stimulate the creation of women's saving groups for easy access to small credit to do own business and to mechanize | | | | | |
| | 1.4. Develop mechanization service enterprises | 1.4.1. Draft standards of machineries, equipment, spare parts and service operations | | | | | |
| | | 1.4.2. Establish effective and efficient distribution channels for spare parts and repair services | | | | | |
| | 1.5. Assess the existing designs of proposed farm machineries and equipment | 1.5.1. Identify ergonomic tools that would reduce drudgery of human labor and improve the efficiency of draft animals and machines | | | | | |
| | | 1.5.2. Select and promote mechanization practices that conserve natural resources (land, water and fuel energy) | | | | | |

| Objective | Specific Objective | Activities | 2016-2017 | 2017-2018 | 2018-2019 | 2019-2020 | 2020-2021 |
|---|---|---|---|---|---|---|---|
| | 1.6. Create alternative energy and inputs for farm production | 1.6.1. Research and develop biomass production | | | | | |
| | | 1.6.2. Research and development of biochar production and application in crop production | | | | | |
| **2. Develop broad-based skills and strengthen capacity in agricultural engineering** | 2.1. Strengthen organizational structure and improve performance of the Department of Agricultural Engineering at national and provincial levels | 2.1.1. Fine-tune roles and responsibilities of technical offices at national level | | | | | |
| | | 2.1.2. Review and revitalize the mandate and resources of provincial offices of agricultural engineering | | | | | |
| | 2.2. Build basic skills of rural artisans, operators, mechanics and service providers, and technical capacity of personnel engaged in research and development | 2.2.1. Conduct on-farm training on basic operations and maintenance of farm machineries and equipment | | | | | |
| | | 2.2.2. Upgrade rural artisans, mechanics and service providers on the design of farm machineries and equipment | | | | | |
| | | 2.2.3. Offer short-term certificate courses on design, use, maintenance and repair of machineries and equipment | | | | | |
| | | 2.2.4. Raise human capacity in the field of agricultural mechanization | | | | | |
| | 2.3. Raise knowledge and awareness on farm machineries and equipment through extension services | 2.3.1. Prepare multi-media publications and conduct demonstrations and agricultural machinery shows | | | | | |
| | | 2.3.2. Establish community workshops | | | | | |
| | | 2.3.3. Provide in-service training to community workshops, cooperatives, extension agents and local manufacturers | | | | | |
| **3. Improving agricultural productivity and rural livelihoods through mechanized farming** | 3.1. Promote the application of farm machineries and equipment to increase agricultural productivity and resilience to climate change | 3.1.1. Enhance access to effective pre-harvest implements and tools to boost crop yields and resilience to climate change | | | | | |
| | | 3.1.2. Promote on-farm management to reduce production cost, lost and inputs, and improve resilience to climate change | | | | | |
| | 3.2. Improve quality, value added and value chain linkages between farmers and markets | 3.2.1. Enhance access to improved post-harvest technology to increase quality and quantity and value-added | | | | | |
| | | 3.2.2. Promote post-harvest management to reduce losses and improve product quality | | | | | |
| | | 3.2.3. Conduct sensitization stakeholders workshop to nurture opportunities in small and medium processing | | | | | |
| **4. Improving policy, legal and regulatory environment for agricultural engineering** | 4.1. Formulate farm machinery laws and regulations | 4.1.1. Prepare laws, sub-decrees and other regulations for the management and operations of farm machineries and equipment | | | | | |
| | | 4.1.2. Establish Center for Testing of Agricultural Machinery (CTAM) | | | | | |
| | 4.2. Strengthen good cooperation between government institutions, private sector and farmers | 4.2.1. Meet quarterly between DAEng and companies dealing with agricultural machineries, tools and equipment and related institutions | | | | | |

| Objective | Specific Objective | Activities | 2016-2017 | 2017-2018 | 2018-2019 | 2019-2020 | 2020-2021 |
|---|---|---|---|---|---|---|---|
| | | 4.2.2. Organize annual farmer conference to share knowledge and experience | | | | | |
| | | 4.2.3. Organize annual contest of farm machineries and equipment | | | | | |
| | 4.3. Gender mainstreaming | 4.3.1. Integrate gender analysis and sex disaggregated targets and data into the planning and designing agricultural machines, tools and equipment | | | | | |
| | | 4.3.2. Awareness campaign to encourage women to involve in agricultural mechanization | | | | | |
| | | 4.3.3. Specific training for rural women in small scale business management (finances, book keeping, marketing…), operation and economics of small scale machinery use | | | | | |
| | | 4.3.4. Strengthening and sustain the position of rural women in family and society by acting as entrepreneur and as contributor to additional family income | | | | | |

# ANNEX 2. COST ESTIMATE TABLE

| Budget Line | Objectives/Activities | Estimated Cost Per Year (USD) | | | | | Total (USD) |
|---|---|---|---|---|---|---|---|
| | | 2016-2017 | 2017-2018 | 2018-2019 | 2019-2020 | 2020-2021 | |
| **1.** | **Enabling Profitability of Agricultural Engineering** | **296,800** | **656,800** | **517,800** | **217,800** | **217,800** | **1,907,000** |
| ***1.1.*** | ***Establish mechanization options for the different ecosystem zones (Coastal, Mekong-plain, Plateau-mountainous and Tonle Sap)*** | ***219,000*** | ***475,000*** | ***465,000*** | ***165,000*** | ***165,000*** | ***1,489,000*** |
| 1.1.1. | Assess the performance feasibility of the proposed mechanization options | 200,000 | | | | | 200,000 |
| 1.1.2. | Amend and recommend appropriate modifications of the options, if any | 4,000 | | | | | 4,000 |
| 1.1.3. | Promote and make mechanization options available to farmers, service providers and other end-users | | 160,000 | 160,000 | 160,000 | 160,000 | 640,000 |
| 1.1.4. | Determine the economic feasibility of mechanization options for different ecosystems | | 300,000 | 300,000 | | | 600,000 |
| 1.1.5. | Establish the usability of power tillers and tractors in seeding, fustigation, fertilization, and other postharvest operations | 10,000 | 10,000 | | | | 20,000 |
| 1.1.6. | Promote and provide small scale mechanization options for rural women focusing on vegetable and fruits production. Further on food processing as additional source of income for rural families | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 25,000 |
| ***1.2.*** | ***Facilitate supply chains governing farm power and equipment*** | ***25,000*** | ***125,000*** | | | | ***150,000*** |
| 1.2.1. | Perform market studies on the demand for machineries and equipment | | 100,000 | | | | 100,000 |
| 1.2.2. | Improve data collection channel of agricultural machinery | 20,000 | 20,000 | | | | 40,000 |
| 1.2.3. | Attract local and foreign investments in manufacturing and/or assembling of spare parts and machineries in Cambodia | 5,000 | 5,000 | | | | 10,000 |
| ***1.3.*** | ***Facilitate improved access to credit of farmers, end-users, manufacturers and service providers on machineries and equipment*** | ***20,800*** | ***20,800*** | ***20,800*** | ***20,800*** | ***20,800*** | ***104,000*** |
| 1.3.1. | Engage rural banks and microfinance institutions in providing credit to end-users | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 20,000 |
| 1.3.2. | Encourage rural entrepreneurs in providing financial and/or mechanization services | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 20,000 |
| 1.3.3. | Facilitate accessible loans for small and medium manufacturers of machines and equipment | 2,800 | 2,800 | 2,800 | 2,800 | 2,800 | 14,000 |
| 1.3.4. | Stimulate the creation of women's saving groups for easy access to small credit to do own business and to mechanize | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| ***1.4.*** | ***Develop mechanization service enterprises*** | ***8,000*** | ***8,000*** | ***4,000*** | ***4,000*** | ***4,000*** | ***28,000*** |
| 1.4.1. | Draft standards of machineries, equipment, spare parts and service operations | 4,000 | 4,000 | | | | 8,000 |
| 1.4.2. | Establish effective and efficient distribution channels for spare parts and repair services | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 20,000 |
| ***1.5.*** | ***Assess the existing designs of proposed farm machineries and equipment*** | ***4,000*** | ***8,000*** | ***8,000*** | ***8,000*** | ***8,000*** | ***36,000*** |
| 1.5.1. | Identify ergonomic tools that would reduce drudgery of human labor and improve the efficiency of draft animals and machines | | 4,000 | 4,000 | 4,000 | 4,000 | 16,000 |
| 1.5.2. | Select and promote mechanization practices that conserve natural resources (land, water and fuel energy) | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 20,000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***1.6.*** | ***Create alternative energy and inputs for farm production*** | ***20,000*** | ***20,000*** | ***20,000*** | ***20,000*** | ***20,000*** | ***100,000*** |
| 1.6.1. | Research and develop biomass production | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| 1.6.2. | Research and development of biochar production and application in crop production | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| **2.** | **Develop Broad-based Skills and Strengthen Capacity in Agricultural Engineering** | **437,000** | **437,000** | **437,000** | **322,000** | **122,000** | **1,755,000** |
| ***2.1.*** | ***Strengthen organizational structure and improve performance of the Department of Agricultural Engineering at national and provincial levels*** | ***4,000*** | ***4,000*** | ***4,000*** | ***4,000*** | ***4,000*** | ***20,000*** |
| 2.1.1. | Fine-tune roles and responsibilities of technical offices at national level | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 10,000 |
| 2.1.2. | Review and revitalize the mandate and resources of provincial offices of agricultural engineering | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 10,000 |
| ***2.2.*** | ***Build basic skills of rural artisans, operators, mechanics and service providers, and technical capacity of personnel engaged in research and development*** | ***315,000*** | ***315,000*** | ***315,000*** | ***200,000*** | | ***1,145,000*** |
| 2.2.1. | Conduct on-farm training on basic operations and maintenance of farm machineries and implements | 100,000 | 100,000 | 100,000 | 100,000 | | 400,000 |
| 2.2.2. | Upgrade rural artisans, mechanics and service providers on the design of farm machineries and implements | 100,000 | 100,000 | 100,000 | 100,000 | | 400,000 |
| 2.2.3. | Offer short-term certificate courses on design, use, maintenance and repair of machineries and implements | 15,000 | 15,000 | 15,000 | | | 45,000 |
| 2.2.4. | Raise human capacity in the field of agricultural mechanization | 100,000 | 100,000 | 100,000 | | | 300,000 |
| ***2.3.*** | ***Raise knowledge and awareness on farm machineries and implements through extension services*** | ***118,000*** | ***118,000*** | ***118,000*** | ***118,000*** | ***118,000*** | ***590,000*** |
| 2.3.1. | Prepare muti-media publications and conduct demonstrations and agricultural machinery shows | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 40,000 |
| 2.3.2. | Establish community workshops | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 500,000 |
| 2.3.3. | Provide in-service training to community workshops, cooperatives, extension agents and local manufacturers | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| **3.** | **Improving Agricultural Productivity and Rural Livelihoods through Mechanized Farming** | **50,000** | **50,000** | **50,000** | **50,000** | **40,000** | **240,000** |
| ***3.1.*** | ***Promote the application of farm machineries and equipment to increase agricultural productivityand resilience to climate change*** | ***20,000*** | ***20,000*** | ***20,000*** | ***20,000*** | ***20,000*** | ***100,000*** |
| 3.1.1. | Enhance access to effective pre-harvest implements and tools to boost crop yields and resilience to climate change | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| 3.1.2. | Promote on-farm management to reduce production cost, lost and inputs, and improve resilience to climate change | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| ***3.2.*** | ***Improve quality,value added and value chain linkages between farmers and markets*** | ***30,000*** | ***30,000*** | ***30,000*** | ***30,000*** | ***20,000*** | ***140,000*** |
| 3.2.1. | Enhance access to improved post-harvest technology to increase quality and quantity and value-added | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| 3.2.2. | Promote post-harvest management to reduce losses and improve product quality | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| 3.2.3. | Conduct sensitization stakeholders workshop to nurture opportunities in small and medium processing | 10,000 | 10,000 | 10,000 | 10,000 | | 40,000 |
| **4.** | **Improving Policy, Legal and Regulatory Environment for Agricultural Engineering** | **560,000** | **558,000** | **556,000** | **556,000** | **556,000** | **2,786,000** |
| ***4.1.*** | ***Formulate farm machinery laws and regulations*** | ***506,000*** | ***504,000*** | ***502,000*** | ***502,000*** | ***502,000*** | ***2,516,000*** |
| 4.1.1. | Prepare laws, sub-decrees and other regulations for the management and operations of farm machineries | 6,000 | 4,000 | 2,000 | 2,000 | 2,000 | 16,000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | and equipment | | | | | | |
| 4.1.2. | Establish Center for Testing of Agricultural Machinery (CTAM) | 500,000 | 500,000 | 500,000 | 500,000 | 500,000 | 2,500,000 |
| ***4.2.*** | ***Strengthen good cooperation between government institutions, private sector and farmers*** | ***28,000*** | ***28,000*** | ***28,000*** | ***28,000*** | ***28,000*** | ***140,000*** |
| 4.2.1. | Meet quarterly between DAEng and companies dealing with agricultural machineries, tools and implements and related institutions | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 40,000 |
| 4.2.2. | Organize annual farmer conference to share knowledge and experience | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| 4.2.3. | Organize annual contest of farm machineries and implements | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| ***4.3.*** | ***Gender mainstreaming*** | ***26,000*** | ***26,000*** | ***26,000*** | ***26,000*** | ***26,000*** | ***130,000*** |
| 4.3.1. | Integrate gender analysis and sex disaggregated targets and data into the planning and designing agricultural machines, tools and implements | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 5,000 |
| 4.3.2. | Awareness campaign to encourage women to involve in agricultural mechanization | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 25,000 |
| 4.3.3. | Specific training for rural women in small scale business management (finances, book keeping, marketing…), operation and economics of small scale machinery use | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| 4.3.4. | Strengthening and sustain the position of rural women in family and society by acting as entrepreneur and as contributor to additional family income | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 |
| | **TOTAL** | **1,343,800** | **1,701,800** | **1,560,800** | **1,145,800** | **935,800** | **6,688,000** |

# ANNEX 3. LOGICAL FRAMEWORK OF AGRICULTURAL ENGINEERING STRATEGIES

| Objective | Specific Objective | Activities | Expected Outputs | Indicators | Responsibility |
|---|---|---|---|---|---|
| **1. Enabling profitability of agricultural engineering** | 1.1. Establish mechanization options for the different ecosystem zones (Coastal, Mekong-plain, Plateau-mountainous and Tonle Sap) | 1.1.1. Assess the performance feasibility of the proposed mechanization options | 1.1.1.1. Authenticity of proposed mechanization options for different ecosystem zones established | Report on assessment and profitability | |
| | | | | Levels of awareness of mechanization options amongst farmers and extension agents | |
| | | 1.1.2. Amend and recommend appropriate modifications of the options, if any | 1.1.2.1. Guidelines on the use of mechanization options for 4 ecosystem zones | Report on design, technical utilization and requirements of machineries and equipment | |
| | | 1.1.3. Promote and make mechanization options available to farmers, service providers and other end-users | 1.1.3.1. Farm machineries and the suitable equipment for various agro-climatic conditions become available | Number of implements for power tillers, tractors and draft animals produced and presented to farmers | |
| | | 1.1.4. Determine the economic feasibility of mechanization options for different ecosystems | 1.1.4.1. Profitability of owning and provision of farm machineries become available to banks and stakeholders | Guidelines on profitable mechanization | |
| | | 1.1.5. Establish the usability of power tillers and tractors in seeding, fertigation, fertilization, and other postharvest operations | 1.1.5.1. The whole cycle of crop production mechanized | Number of power tillers and tractors used for each stage of crop development and production | |
| | | 1.1.6. Promote and provide small scale mechanization options for rural women focusing on vegetable and fruits production. Further on food processing as additional source of income for rural families | 1.1.6.1. A certain number of rural households earn a large share of additional income from food and vegetable production and from the processing and sales | More women are active in additional income generation for the families | |
| | 1.2. Facilitate supply chains governing farm power and equipment | 1.2.1. Perform market studies on the demand for machineries and equipment | 1.2.1.1. Demand of farm machineries and equipment known to government and private sector | Inventories and forecasts of suppliers and government | |
| | | 1.2.2. Improve data collection channel of agricultural machinery | 1.2.2.1. Quality and accuracy of data made available | Availability of up-to-date statistics | |
| | | | | Number of staff trained in data collection | |
| | | | | National machinery database | |
| | | | | Maps of agricultural mechanization | |
| | | 1.2.3. Attract local and foreign investments in manufacturing and/or assembling of spare parts and machineries in Cambodia | 1.2.3.1. Local manufacturing and/or assembling of spare parts, machineries established | Number of local and foreign investments in farm mechanization | |
| | | | | Number of factories/workshops producing spare parts | |

| Objective | Specific Objective | Activities | Expected Outputs | Indicators | Responsibility |
|---|---|---|---|---|---|
| | | | | Nationwide availability of spare parts for different types of machinery | |
| | 1.3. Facilitate improved access to credit of farmers, end-users, manufacturers and service providers on machineries and equipment | 1.3.1. Engage rural banks and microfinance institutions in providing credit to end-users | 1.3.1.1. Lending credit for the purchase of farm machineries and equipment are available from multiple sources | Number of loans issued to smallholder farmers | |
| | | 1.3.2. Encourage rural entrepreneurs in providing financial and/or mechanization services | 1.3.2.1. Increased solidarity lending and service provision in rural areas available for small holder farmers | Number of leases, lenders and service providers in rural areas | |
| | | 1.3.3. Facilitate accessible loans for small and medium manufacturers of machines and equipment | 1.3.3.1. Increased small and medium manufacturing of machines and equipment | Number of loans provided to small and medium manufacturers | |
| | | 1.3.4. Stimulate the creation of women's savings groups for easy access to small credit to do own business and to mechanize | 1.3.4.1. Rural Women having access to small credit to establish own small business and to mechanize their activities | More rural women are involved in business and use small scale mechanization for their activities | |
| | 1.4. Develop mechanization service enterprises | 1.4.1. Draft standards of machineries, equipment, spare parts and service operations | 1.4.1.1. Improvement in quality of machines, accessories and service provision | Published standards of machineries and equipment | |
| | | 1.4.2. Establish effective and efficient distribution channels for spare parts and repair services | 1.4.2.1. Increased availability of spare parts and hiring services for small holder farmers | Number of retailers, dealers and distributors of spare parts | |
| | | | | Number of farmers providing mechanization service | |
| | | | | Number of community workshops | |
| | 1.5. Assess the existing designs of proposed farm machineries and equipment | 1.5.1. Identify ergonomic tools that would reduce drudgery of human labor and improve the efficiency of draft animals and machines | 1.5.1.1. Reduced drudgery of human labor | Number of ergonomic designs created | |
| | | 1.5.2. Select and promote mechanization practices that conserve natural resources (land, water and fuel energy) | 1.5.2.1. Natural resources are protected from any misuse | Adoption rate of direct seeding, minimum/reduced tillage, and retention of crop residues | |
| | | | 1.5.2.2. Sustainability of mechanization ensured | Cost of production, soil fertility and water use efficiency | |
| | 1.6. Create alternative energy and inputs for farm production | 1.6.1. Research and develop biomass production | 1.6.1.1. Biomass produced using agricultural wastes | Number of biomass structures designed and constructed | |
| | | 1.6.2. Research and development of biochar production and application in crop production | 1.6.2.1. Production technologies are developed for different feedstocks | Biochar for crop production are widely available | |

| Objective | Specific Objective | Activities | Expected Outputs | Indicators | Responsibility |
|---|---|---|---|---|---|
| | | | 1.6.2.2. Promotion of biochar as a production input for soil improvement | Number of farmers used biochar for crop production | |
| **2. Develop broad-based skills and strengthen capacity in agricultural engineering** | 2.1. Strengthen organizational structure and improve performance of the Department of Agricultural Engineering at national and provincial levels | 2.1.1. Fine-tune roles and responsibilities of technical offices at national level | 2.1.1.1. Each technical office is adequately staffed and orientated towards common strategic goals | Number of new qualified staff allocated to each office | |
| | | | | Clear defined roles of public institutions, private sector and farmers | |
| | | | | Number of staff capacity building programs | |
| | | 2.1.2. Review and revitalize the mandate and resources of provincial offices of agricultural engineering | 2.1.2.1. Provincial offices of agricultural engineering reintroduced and functioning | One branch office of agricultural engineering in each province | |
| | | | | At least 5 engineers/specialists per office specialized in (1) Design and manufacturing; (2) Pre-harvest technology; (3) Post-harvest technology; (4) Testing and demonstration; and (5) Networking and public relations | |
| | | | | Number of staff capacity building programs | |
| | 2.2. Build basic skills of rural artisans, operators, mechanics and service providers, and technical capacity of personnel engaged in research and development | 2.2.1. Conduct on-farm training on basic operations and maintenance of farm machineries and equipment | 2.2.1.1. Basic operating and maintenance skills not limiting the adoption of farm machineries | Number of farmers and operators who can drive, operate and maintain tractors and power tillers and other machines | |
| | | 2.2.2. Upgrade rural artisans, mechanics and service providers on the design of farm machineries and equipment | 2.2.2.1. Repair and maintenance services for farm equipment and machineries available in rural areas | Number of artisans, mechanics available in rural areas | |
| | | | 2.2.2.2. Time and cost of repair and maintenance significantly reduced | Number of non-working or unused machineries | |
| | | 2.2.3. Offer short-term certificate courses on design, use, maintenance and repair of machineries and equipment | 2.2.3.1. Self-reliance on fine-tuning and fixing adjustments required for increased local adoption of mechanization | Number of mechanics, service providers trained | |
| | | 2.2.4. Raise human capacity in the field of agricultural engineering | 2.2.4.1. Graduates and post graduates on farm mechanization produced | Number of degree holders | |
| | 2.3. Raise knowledge and awareness on farm machineries and equipment through extension services | 2.3.1. Prepare multi-media publications and conduct demonstrations and agricultural machinery shows | 2.3.1.1. Knowledge on options, benefits and access of agricultural mechanization enriched amongst farmers | Number of leaflets, brochures, media shows (radio, TV) | |
| | | 2.3.2. Establish community workshops | 2.3.2.1. Outreach centers established at community level | Number of community workshop established | |
| | | 2.3.3. Provide in-service training to | 2.3.3.1. Extension network | Number of extension agents and outlets | |

| Objective | Specific Objective | Activities | Expected Outputs | Indicators | Responsibility |
|---|---|---|---|---|---|
| | | community workshops, cooperatives, extension agents and local manufacturers | specialized on agricultural mechanization available throughout the country | | |
| **3. Improving agricultural productivity and rural livelihoods through mechanized farming** | 3.1. Promote the application of farm machineries and equipment to increase agricultural productivity and resilience to climate change | 3.1.1. Enhance access to effective pre-harvest implements and tools to boost crop yields and resilience to climate change | 3.1.1.1. Testing, modification and dissemination of existing pre-harvest technologies | Number of modified technologies and implements and tools disseminated | |
| | | | 3.1.1.2. Research, development and demonstration of pre-harvest technologies | Number of new technologies and implements and tools created | |
| | | 3.1.2. Promote on-farm management to reduce production cost, lost and inputs, and improve resilience to climate change | 3.1.2.1. Establish on-farm infrastructure for better management of water, fertilizer, weeding, insects, diseases and transportation | Number of fields leveled | |
| | | | | Number of agricultural land use associations | |
| | | | | Number of fields with small scale irrigation | |
| | | | | Number of fields with proposed infrastructure | |
| | | | | Decreased production inputs and increased productivity | |
| | 3.2. Improve quality, value added and value chain linkages between farmers and markets | 3.2.1. Enhance access to improved post-harvest technology to increase quality and quantity and value-added | 3.2.1.1. Testing, modification and dissemination of existing post-harvest technologies and agro-processing opportunities | Number of modified technologies and machineries disseminated | |
| | | | 3.2.1.2. Research, development and demonstration of post-harvest technologies | Number of new technologies and machineries created | |
| | | 3.2.2. Promote post-harvest management to reduce losses and improve product quality | 3.2.2.1. Rice harvesters are widely available during harvesting period | Rice is harvested on time and reduced loss during harvest | |
| | | | 3.2.2.2. Increased and improved access to appropriate postharvest and processing technologies | Number of community dryers and post-harvest processing complexes | |
| | | | | Reduction in post-harvest losses | |
| | | | | Improved quality products | |
| | | | | Reduction in socioeconomic gaps in rural areas | |
| | | | 3.2.2.3. Community based organizations (CBO) established and training on post-harvest technologies and processing provided | Number of CBOs engage in postharvest processing | |
| | | 3.2.3. Conduct sensitization stakeholders workshop to nurture opportunities in small and medium processing | 3.2.3.1. The importance of postharvest handling and storage on quality of agricultural | Number of producers and entrepreneurs trained | |

| Objective | Specific Objective | Activities | Expected Outputs | Indicators | Responsibility |
|---|---|---|---|---|---|
| | | | commodities felt by producers | | |
| | | | 3.2.3.2. The spectrum of entrepreneurial possibilities in primary and secondary agro-processing made available | Catalog of potential agro-enterprises on processing | |
| **4. Improving policy, legal and regulatory environment for agricultural engineering** | 4.1. Formulate farm machinery laws and regulations | 4.1.1. Prepare laws, sub-decrees and other regulations for the management and operations of farm machineries and equipment | 4.1.1.1. Draft laws, sub-decrees and other regulations are adopted and put in effect | Number of laws, sub-decrees and regulations put in effects | |
| | | | | Environmental and climate change components are considered and included | |
| | | 4.1.2. Establish Center for Testing of Agricultural Machinery (CTAM) | 4.1.2.1. One center in Phnom Penh and other regional centers are set up and fully equipped | Number of testing centers | |
| | 4.2. Strengthen good cooperation between government institutions, private sector and farmers | 4.2.1. Meet quarterly between DAEng and companies dealing with agricultural machineries, tools and equipment and related institutions | 4.2.1.1. Close cooperation and better dissemination of data and information and sharing resources with effective outputs | Regular meeting report | |
| | | | 4.2.1.2. The working group's secretariat established | One secretariat in operation and one joint-sponsored website launched | |
| | | 4.2.2. Organize annual farmer conference to share knowledge and experience | 4.2.2.1. Farmers, artisans and processors encouraged to present their skills and creativity | Number of award-winning farmers, artisans and processors | |
| | | 4.2.3. Organize annual contest of farm machineries and equipment | 4.2.3.1. The most suitable machines and equipment for Cambodia farming selected | Number of award-winning farm machines and equipment | |
| | 4.3. Gender mainstreaming | 4.3.1. Integrate gender analysis and sex disaggregated targets and data into the planning and designing agricultural machines, tools and implements | 4.3.1.1. Gender issues integrated into planning and designing of agricultural machines, tools and implements | Number of gender based planning and designs | |
| | | | | At least 10% female participated in DAEng's activities | |
| | | 4.3.2. Awareness campaign to encourage women to involve in agricultural mechanization | 4.3.2.1. Women are encouraged to operations, planning and design of agricultural machinery | Percentage of women involved in farm mechanization | |
| | | 4.3.3. Specific training for rural women in small scale business management (finances, book keeping, marketing…), operation and economics of small scale machinery use | 4.3.3.1 Women are able to put the training topics into practice in their own business operation or creation | The knowledge and skill of rural women on business operation and the use of small scale mechanization is increased. | |
| | | | | More women are motivated to create an own business. | |
| | | 4.3.4. Strengthening and sustain the | 4.3.4.1 Rural women getting | Self-esteem of rural women entrepreneurs is | |

| Objective | Specific Objective | Activities | Expected Outputs | Indicators | Responsibility |
|---|---|---|---|---|---|
| | | position of rural women in family and society by acting as entrepreneur and as contributor to additional family income | stronger rule in contribution to the increase of national cross product | increased. | |
| | | | | More women are involved in small business operation and creation. | |

# ANNEX 4. RESEARCH PROPOSAL FOR FUNDING

**I. Researchable Areas**

**1. Farm Machinery**

| No | General researchable area | Specific Researchable Area | Priority |
|---|---|---|---|
| 1 | Development of suitable, seeding, seedling and fertilizer application equipment | Improvement of urinate specific gravity (USG) applicator; improvement of USG briquette machine; development of seedling raising technology; rice transplanter; cassava planter; sugarcane planter, digital testing equipment for fertilizers & soil health; development of direct seeding technology for upland crop; field demonstration & dissemination of matured technology | |
| 2 | Development and adaptation of harvesting and threshing equipment | Quality improvement of rice harvester; harvester for marshy land; modification & adoption of combine harvester; cassava harvester; thresher for beans; dissemination of maize sheller; development of floating reaper for low land rice harvesting | |
| 3 | Utilization of renewable energy in agriculture | Development of solar pump; renewable (solar, wind, bio-fuel, bio-gas etc.) technology development; application of solar energy for rice drying and parboiling; production of bio-fertilizer/compost from agricultural bio mass. | |
| 4 | Motivation and Mass communication | Education and training to extension workers & farmers; demonstration of matured technology; adaptation of quality machine from foreign origin; dissemination of information on matured technology through TV, machinery fair, tele-centers, internet etc. | |
| 5 | Development of improved tillage systems | Zero or reduced tillage, bed tillage; development of power operated weeder; weed control technology; adoption of laser leveler; conservation agricultural equipment for maize, cassava and vegetables; adaptation of higher capacity tillage equipment; power operated furrower for cassava& sugarcane | |
| 6 | Precision Farming | Computer vision/model to identify insect-pest, soil health; application of crop image for identifying precise amount of fertilizer, water & other inputs; modeling of rice cultivation system; modeling of rice milling system | |
| 7 | Fishery, livestock and poultry equipment | Design and development of fishery, livestock and poultry farm equipment; Design of livestock & poultry housing; improvement of biogas plant and its dissemination | |
| 8 | Survey & Policy Research | Survey on current status of mechanization; impact study of mechanization on rural livelihood and environment; policy issues about quality & standardization of agri. machinery; mechanization policy for cultivation; Subsidy for mechanization. | |
| 9 | Manufacture & marketing of farm equipment | Adaptive research capacity building of local manufacturers through training; methodology for maintaining quality & standard of agricultural equipment; marketing chain development and effective service providing mechanism; improvement of local custom hire service | |

Note: Priority rank: H – High; M – Medium; L – Low

**2. Irrigation & Water Management**

| No. | General Researchable Area | Specific Researchable Area | Priority |
|---|---|---|---|
| 1 | Development and dissemination of water saving system/technologies | Upscale of alternate wetting and drying (AWD) technology; development of surface and sub-surface irrigation system; movable irrigation technology; improving irrigation efficiency; development of irrigation facilities in each ecosystem zone | |
| 2 | Water management strategies for major crops due to climate change | Study on crop-water demand in each ecosystem zone; conjunctive use of surface and ground water for rice, maize, cassava, beans & sugarcane production; modeling of crop-soil-water-weather system; studies of crop-water demand. | |
| 3 | Water management strategies for reduction of soil salinity and water logging (Coastal zone) | Water management for coastal saline soil; methods of reducing water logging in cultivable land; technology for conversion of sweet water from saline water; development of drainage system | |
| 4 | Soil conservation and watershed management for sustainable development in hilly areas | Development of watershed, waterfalls (springs), rainwater storage facilities; management of flash flood and soil erosion | |
| 5 | Motivation and Mass communication | Farmers' access to agro-meteorological and disaster forecast; education and training to extension workers & farmers; demonstration on mature irrigation technology; dissemination of information on matured technology through TV, agriculture fair, telecentres, internet etc. | |
| 6 | Ground and surface water pollution and its effects on food chain through irrigation | Ground water zone mapping; Technology for reduction of arsenic pollution in irrigation water; technology for reduction of iron content in irrigation water | |
| 7 | Alternative energy use in irrigation system | Use of compressed natural gas (CNG), biogas, wind energy and solar energy | |
| 8 | Use of rainwater & wastewater for irrigation | Reuse of waste water, runoff water, rain water for irrigation | |
| 9 | Survey & Policy Research | Data bank on surface and ground water using GIS/GPS. | |

**3. Post-harvest Technology (engineering aspects)**

| No. | General Researchable Area | Specific Researchable Area | Priority |
|---|---|---|---|
| 1 | Development of post-harvest technology and post-harvest management systems for cereals, horticultural crops, sugarcane, oil seeds, vegetables & fruits | Post-harvest loss assessment; small & medium scale crop dryer; dryer for seed drying; development of rice parboiling technology; rice milling technology; improved processing, packaging, storage and transportation technology for perishables specially for hilly areas; on-farm technology for preservation of fruits, vegetables, spices and flowers; value addition; study on health hazards of chemically ripening of fruits and pesticides sprayed vegetables. | |
| 2 | Development of post-harvest technology and post-harvest management systems for sugarcane and oil seeds. | Improved oil extraction technology from rice bran, mustard & palm, improved juice extraction for sugarcane and sugar processing; | |

**II. Sub-Sector of Researchable Areas**

**1. Sub-Sector: Farm Machinery and Post-harvest Process Engineering**

| No. | Program/project | Targets | Activities (Program/project) | Program/project Area |
|---|---|---|---|---|
| 1 | Development and dissemination of conservation tillage systems | To conserve soil resources by reduced tillage and managing crop residues | Zero or reduced tillage, bed tillage equipments and tools will be developed for different crops like maize, cassava, beans, etc. | Tillage implements |
| 2 | Development of suitable seeding and fertilizer application equipments | To reduce cost, time and drudgery for seeding and fertilizer application for crop production | Design and develop of appropriate seeder for upland crop and fertilizer applicator for both rice and non-rice crops | Pre-harvest machinery |
| 3 | Development and adaptation of harvesting and threshing equipments | To reduce cost and postharvest losses of cereals, fruits and vegetables | Adaptation of harvesting and threshing machinery including combine for diff. farm condition of Cambodia | Harvesting and threshing machinery |
| 4 | Development of post-harvest machinery and postharvest management systems | To reduce postharvest loss of crops and value additions in crops | Development of drying and storage system and processing of fruits and vegetables | Postharvest technology |
| 5 | Utilization of renewable energy in agriculture | Reduce the dependability on ever increasing conventional energy and reduce environmental pollution | Development of solar dryer, solar pump, bio- fuels for operation of farm implements | Renewable energy |

**2. Sub-Sector: Irrigation and Water Management**

| No. | Program/project | Targets |
|---|---|---|
| 1 | Impact of climate change to agricultural development. | To plan more effective water management strategies of irrigated crops |
| 2 | Development of salinity management techniques in coastal ecosystem. | Adaptations of improved salinity management practices and introduce newly developed irrigation technologies in salinity affected areas. |
| 3 | Soil conservation and water shed management of hilly areas. | To bring about fallow lands of hilly areas under cultivation and enhance irrigation for crop production. |
| 4 | Assessment of arsenic pollution of ground water. | To evaluate the impact of arsenic pollution in ground water used for irrigation and find out probable remedies. |
| 5 | Conjunctive use of ground and surface water for irrigation. | To save irrigation water and improve the water use efficiencies. |
| 6 | Development of technologies to use solar and wind power. | To explore sources of renewable energy for pumping irrigation water. |
| 7 | Accelerate research on possibility of using CNG. | To find out possible alternative source of energy for engines. |
| 8 | Rain water harvest and preservation. | To utilize rain water for supplemental irrigation in fresh water shortage areas. |
| 9 | Reuse of domestic and industrial waste water for irrigation. | To find out alternate source of irrigation for sustainable crop production. |
| 10 | Adoption and dissemination of recently developed irrigation and water management technologies. | To increase awareness and innovativeness of farmers/extension workers through training, demonstration, workshop etc. |