I. INTRODUCTION

Increase productivity through intensification, reduce post harvest losses, increase added value and maintain the quality of farm product are the multiple objectives of farm mechanization in Indonesia. In addition to that multiple objectives, the ultimate goals of farm mechanization are also include increase of farm household welfare, and create employment opportunity in the rural area. All of these objectives may not be completed by a single strategy e.g. increasing the number of machinery use for farm production. It will include the long term strategy to re-energize rural development as a whole system, which enable farmers to adjust and improve their own capacity to adopt the suitable technology for their farm business efficiently. Farm mechanization is not only the use of physical machines like tractor, irrigation pump, thresher, or rice milling machinery, but it include the changes of farm culture, process of invention, innovation, adoption and commercialization of technology.

APCAEM is a networking activities which is similar to catalist for increasing the rate of agricultural engineering technology adoption in the developing AP countries. It could help the member countries in analysing the regional situation related to science and technology development, planning and then developing their own agricultural mechanization programme which is very specific by adopting, testing, and modifying for their country benefits.

II. AGRICULTURE IN ECONOMIC DEVELOPMENT IN INDONESIA

2.1. Status of Farm Mechanization in Indonesia

In viewing the progress of farm mechanization in Indonesia, the main road is to learn the growth of rice production as the main staple is shown in the following table. It is indicated that average of rice yield in Indonesia increased from 4.25 t/ha to 4.54 t/ha during 5 years. It is among the highest yield in the Asian countries, which reflects the level of rice intensification in the country. However, it does not reflect the rate of adoption and utilization of farm mechanization. The recent study indicated that level of mechanization is relatively low to high, ranging from 10%-90% depend on the intensity of the farming system. Common figure indicated that average level is 30%.

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2 Diretor, Indonesia Center for Agricultural Engineering Research and Development (ICAERD)
Table 1. Rice Harvest Area, Production and Productivity

<table>
<thead>
<tr>
<th>Year</th>
<th>Harvest Area (million ha)</th>
<th>Production (million ton)</th>
<th>Productivity (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>11.96</td>
<td>50.87</td>
<td>4.25</td>
</tr>
<tr>
<td>2000</td>
<td>11.79</td>
<td>51.90</td>
<td>4.40</td>
</tr>
<tr>
<td>2001</td>
<td>11.50</td>
<td>50.46</td>
<td>4.39</td>
</tr>
<tr>
<td>2002</td>
<td>11.52</td>
<td>51.49</td>
<td>4.47</td>
</tr>
<tr>
<td>2003</td>
<td>11.49</td>
<td>52.14</td>
<td>4.54</td>
</tr>
</tbody>
</table>

Source: Central Bureau of Statistics, 2003

The simplest way to measure the need of rice farm mechanization is increasing number of machinery used. It is not easy to collect data of machinery used, but formally beginning in the middle of 1980, National Bureau of Statistics has collected data of rice cultivation machinery used as shown in Table 2.

Table 2. Number of Selected Farm machinery Used in Indonesia (1999-2003)

<table>
<thead>
<tr>
<th>Type of Machinery</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>Growth %/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand Tractor</td>
<td>84178</td>
<td>86944</td>
<td>99304</td>
<td>86644</td>
<td>103446</td>
<td>6.0</td>
</tr>
<tr>
<td>Pesticide Applicator</td>
<td>1642686</td>
<td>1760543</td>
<td>na</td>
<td>1562217</td>
<td>na</td>
<td>3.4^b</td>
</tr>
<tr>
<td>Irrigation Pump</td>
<td>117340</td>
<td>166030</td>
<td>190013</td>
<td>215774</td>
<td>216643</td>
<td>17.5</td>
</tr>
<tr>
<td>Thresher^a</td>
<td>370426</td>
<td>375299</td>
<td>388609</td>
<td>340654</td>
<td>347658</td>
<td>-1.68</td>
</tr>
<tr>
<td>Dryer</td>
<td>5778</td>
<td>5798</td>
<td>6238</td>
<td>7117</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice Milling Machines</td>
<td>43071</td>
<td>42816</td>
<td>45402</td>
<td>39996</td>
<td>46123</td>
<td>2.2</td>
</tr>
</tbody>
</table>

^a. include pedal thresher and power thresher  
b. data for 1997-2001  

More than fifty percent of power tiller are located in Java even though Java is the most densely populated area. Among four provinces in Java Island, the West Java province has the largest population of power tillers; however, number of thresher is too small compare to other provinces. Even though this province has the highest level of rice intensification, supported by the big irrigation facilities. Other provinces such as South Sulawesi, West Sumatera and Aceh are among the provinces with increasing number of farm machinery.

The use of water pump is depended upon the availability of water, e.g. Ground water exploration. A study on the development of ground water for productive farming by using water in East Java (Abi Prabowo et. all, 2001) indicated that the utilization of water pump has benefited to (a) enable farmers to increase income by increase number of crops, (b) increase the awareness of the farmers on the degradation of quality and quantity of water availability, (c) change orientation from the protective irrigation (using water for protecting crop) to productive irrigation (using water to secure the productivity of the land and added value of the farming system).
In the era of 1980, at least 97% of the total rice production has been processed by rice machinery. Include in this machinery are Small, Medium and Large Rice Milling Machinery. Tjahyo Hutomo (2003) reported that Small Rice Miller produced the lowest milling recovery of 55.7%. The Medium Rice Miller produced a medium range milling recovery of 59.7% followed by the Largest Rice Miller of 61.5%. The quality of rice is also reflected by the level of milling machines. The larger the machine, the better the quality.

At the same time, there is significant growth of mobile rice milling machines in the village area. Thousand of this machine was demanded by small farmers, especially harvester, who owned only 100 kg-200 kg. The reason is very simple, good service and good price. But the problem is low quality and milling recovery. It has made the problem among the millers, the mobile rice milling has decreased the number of small rice milling miller, since the mobile rice miller are working without any control (no business approval from local government).

2.2. The Evolutionary Process of Farm Mechanization.

A historical evidence of farming system development in Indonesia has guided to the need of analysis of the evolutionary process with regards to rice farm mechanization technology. Figure 1 shows the evolutionary process of rice mechanization technology in the country. A farm system moves from the subsistence to the commercial farm along the certain path called a sustainable path. The development stages illustrates the technology adoption capacity that moves from one stage to other stage affected by the existence of variables such as infrastructure, institutional arrangement, cultural endowment, resources endowment, economy, technology innovation, and cultural behavior. The capacity of the farm system to improve their productivity is depended upon their capacity to adopt, adapt and manage technology, institution, resource and capital either form internal or external resources. Government intervention in this case could participate in facilitating the change or providing the good condition for accelerating the move. However, the intervention could also make a premature mechanization if it was not properly plan (non-sustainable path). For example; the subsidy for low price machinery, the huge number of machinery aids for the farmers with minimal assistant or social institutional will create the problem of sustainability.

The critical problems are remaining the homework for the decision makers, researchers, scientists, farm mechanization professionals, and also the users of farm machinery. Do the small rice farmers really need mechanization? What is the suitable rice mechanization system for them? How it should be developed? What condition required adopting and utilizing rice mechanization? These are all question in developing small rice farm mechanization related to the revitalization of agricultural sector of the country.

Accordingly, at the first stage, called as subsistence level, farm mechanization is in the beginning phase. No machinery needed at any kind of farm work. It is exist in the remote and less developed area when technology, infrastructure, institution, information and culture are isolated. It is happened if communication between the villages to the market is closed or limited, e.g. transmigration areas. Situation will change if the isolation is opened, and communication is step by step developed and when the market worked.
Not only the land preparation will be adopted by the farms, but also post harvest will gradually improve if they feel any profit or additional income is made it. Through innovation process technology would be adopted if it could provide benefit for the farms. And it will be spread, adopted and utilized from the individual, community, region and national level by market.


Figure 1. An Evolutionary Process of Farming System and Farm Mechanization

The changes will bring the subsistence system to the mixed, diversified, and commercial farming system and then farm mechanization will follow this development. Moving from the solid line to the dot line indicates the rapid development of the changes. If it is needed, then consequently the changes should be encouraged to facilitate. The details indicators of rice farm mechanization development stages related to farming systems are presented on Table 3.
Table 3. Indicators of Farm Mechanization Development Stages Related to Farming Systems.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Subsistence Farming</th>
<th>Mixed Farming</th>
<th>Mixed and Diversified</th>
<th>Commercial farming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed input</td>
<td>On farm production, farmer to farmers exchange</td>
<td>On farm production, farmer to farmers exchange, some purchase</td>
<td>Frequently purchasing</td>
<td>Permanently purchase (annually)</td>
</tr>
<tr>
<td>Farm worker</td>
<td>Family workers</td>
<td>Partly hired labor</td>
<td>Mostly hired labor</td>
<td>Hired labor and specialist</td>
</tr>
<tr>
<td>Output utilization</td>
<td>All consumed for the whole family</td>
<td>Mostly consumed and partly sold</td>
<td>Sold at the local market or nearby market</td>
<td>Commercially sold to the big market</td>
</tr>
<tr>
<td>Product diversification</td>
<td>Limited</td>
<td>Mostly simple diversification for the family</td>
<td>Already diversified but at small part</td>
<td>Specific product and highly for commercial market</td>
</tr>
<tr>
<td>Institutional set up</td>
<td>Local and traditional information among the farmers to farmers</td>
<td>Use the local market and limited information</td>
<td>Local and regional institution has been set up, farm association build, market available</td>
<td>Fully market orientation. Financial back up by bank or investment</td>
</tr>
<tr>
<td>Mechanization level</td>
<td>Limited with simple tools</td>
<td>Mostly manual and simple tools with the help of animal power</td>
<td>Small mechanization with limited capacity for selective works.</td>
<td>Use mechanization for any kind of work which is suitable</td>
</tr>
</tbody>
</table>

Source: Handaka, 2005, Strategic Position of Agricultural Mechanization in Agribusiness Development. AARD.

In this evolutionary process the government could also encourage the development by enhancing mechanization development, but this policy must design without any distortion of market mechanism to avoid so called premature mechanization (Hayami Y and T Kawagoe. 1989 ).

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3 Modified from modernization of seed industry.
III. AGRICULTURAL ENGINEERING R&D: STRATEGY AND ITS CONSEQUENCES

Based on the current socio-economic, farm infrastructure and farming system characteristics, the existing growth of machinery production, and the speed of technology adoption, the farm mechanization development in Indonesia will still follow and highly depended upon the process of national economic development. Small land holding size will still dominated the process of farm production. Rice and other secondary food is still the strategic crop to be maintained in the food security system in the country. Java and Bali islands as the most fertile land will still produce high portion of rice with very intensive technology, however, it will need to move to high quality rice, which need more advance rice processing technology. Outer Island such as Sumatera, Sulawesi and Kalimantan need to be put in the priority for extensification, the potential swampy and tidal land need to be explored for food availability.

3.1. Strategy Approach

Major national issues

The national issues related to agricultural in the national economic development is agricultural revitalization. It includes food security, quality improvement, added value and competitiveness. Thus consequently brought the science and technology adoption in line with the establishment of the macro policies in price, subsidy, interest, trade, industry along with the improvement of infrastructure, institutional development, human resource for extension and training. It is consequently, the agricultural revitalization is also related to the Millennium Development Goals (MDGs), to reduce the number of poor people, save water and improve the environment.

The approach for development is sustainable agriculture. Good for today generation, better for tomorrow generation and best for economy of the country. Increase food production and provide enough food for the people is essensial for the country. Development and rehabilitation of the irrigation facilities for rice production are among the highest priority for the next five years plan. For the medium range development, post harvest mechanization will be the major strategic technology for the future development system, since the quality and added value are significantly contribute to the farm income. This technology will not limited only to rice and food crops, but also for horticulture, and estate crops that need simple, intermediate and advance processing machinery for fresh handling, primary processing, and also modern processing for food safety when awareness to safety increase. Post harvest mechanization should be strongly encourage to reduce field losses, physical damage during the process, preservation and other advance processing losses. To do this the small agro-machineries industry should be encouraged and be improved.

Current issues related to the increase of price and decreasing of fossil fuel has triggered the new effort and changed the macro economic policy on oil subsidized. The Clean Development Mechanism (CDM) is also one of the reason to pursue the development of renewable energy, especially bio-energy (include bio gas). The doubled of oil price ( diesel and gasoline ) and triple the kerosene price, which closed to the world price has made the poor people, farm operator and machinery owner and business in slow progress. The operational cost of land preparation increased dramatically from Rp 500,000/ ha (US$ 50) to about Rp 750,000/ha (US$ 70). The shortage of labor
added the price is double when needed. It will also affect the price of inputs. The research agenda then move to the more efficient way in generating energy alternative which is renewable, and more environmentally friendly. Two of that area is being done in ICAERD these are Biogas and Jatropha Curcas oil. Other research institutes are also working in bio diesel and other gasohol

To accommodate and achieve the goal of small farm mechanization system development, there are some prerequisite needed which are linked together as a system for development. Those are triangle of the (a) **Academic/ Research Institution**, (b) **Business /Industries**, (c) **Government**. Plus the community as the stake holder or the user of mechanization technology. Institutional improvement such as farmers association, rural industry, private industry, trader which are the stake holder of farm mechanization must a part of the system of the development process

**IV. CONCLUSION**

Farm mechanization in Indonesia is a process of technological evolution. It is one of the technological inputs that are required to improve the modernization process. It has a strategic role in the dynamic transformation from the subsistence to modern farm. That role are : (a) increase production and productivity, (b) increase efficiency of the process and natural resource utilization, (c) improve quality and added value of the agricultural produce, and finally (d) increase income of the farm households.

Government could play an important role in facilitating the favorable role such as extension, training, and education for quality human resources development. It is also providing the contribution directly or indirectly to build the infrastructure (road, irrigation facilities, electrification etc.). In another words, farm mechanization should be developed based on the market mechanism. However the government could also encourage the development process by enhancing mechanization development, but this policy must be designed without any distortion to the market mechanism to avoid so called *premature mechanization*.

The future prospect of farm mechanization in Indonesia for the next five to ten years (2005- 2015) will still be dominated by **small to medium mechanization**. The following will be more prospective in the next mechanization development (a) **Small and suitable field production machinery** (precision planting, nursery industry, and efficient use of water) for small farm where the improvement of **agricultural technology and system management** will be strongly needed. **Post harvest mechanization for processing of agricultural product** will be strongly needed in the rural industrial process and it will more rapidly adopted by the farmers since the nature of its contribution to the beneficiary is more significant than pre harvest mechanization. (b) **Renewable Energy Technology** which will strongly emerge that related to Clean Development Mechanism (CDM).

APCAEM is a networking activity which is similar to **catalist** for increasing the rate of agricultural engineering technology adoption in the developing AP countries. It strongly needed and could help the member countries in communicating among the member, analysing the regional situation related to science and technology development, planning and then developing their own agricultural mechanization programme which is very specific by adopting, testing, and modifying for their country benefits.
REFERENCES


