SUSTAINABILITY OF PUMP IRRIGATION: THE CASE OF NGAWI, EAST JAVA

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INTRODUCTION

Shallow ground water has been widely used for irrigation in many places in the Asian countries such as in Bangladesh, China, Thailand and Indonesia as well (Ando et al., 1991). The way how the ground water is used nowadays has been modernized from the traditional open dug-wells to driven tube-wells provided motorized water pump.

In the early years of Pedia II (Second Five Year Development Plan), the Government of Indonesia (GOI) launched Ground Water Development Project (PZAT) as a part of the National Water Resources Development Program. The projects were undertaken by the Department of Public Work (PU). Through the project, the GOI intended to develop ground water for irrigation as supplement for surface water irrigation.

The development of ground water use for irrigation have been characterized by massive investment in developing deep tube wells provided by large size of pump units. The wells have been drilled, pump set have been provided and distribution channel have been constructed by the PZAT. Since responsibility for operation and maintenance (O & M) of the pump units is turned over to local government agency which then pass it on to the local water user association (USAID, 1993). Such pump irrigation have been developed as in Gunung Kidul, Maduran, Ngajuk, Madura, Surabaya and in some other potential areas.

At the same time, farmers in some areas where shallow ground water is potential, have also been utilized the ground water for irrigation particularly during dry season when surface water is scarce. The use of ground water is characterized by constructing open dug-well and the water is lifted manually, or by constructing open or tube wells provided by small size of pump unit (Anonymous, 1992).

The use of ground water for irrigation had made a substantial contribution to the regional as well as national crops production. However, the technology of deep tube wells and large size of pump units are faced with many technical, economical and institutional problems particularly during the O & M stage. This is indicated by the fact that many large pump units developed by the PZAT have been working below the expected technical and management performance, even some of them have not been working. Meanwhile, the smaller size of pump units is tending to be widely used by farmers in many ground water potential areas.

Study on technical and economical aspects of pump irrigation have been done by many scholars and donors...
agencies (Ando, et al., 1991; Arief, et al., 1992; ITPAN-USAIID, 1995; Eriaga Elkepatra, 1994). Most of the studies, however, have been concerned more to evaluate technical performance and economic feasibility of the pump irrigation system, and they only pay a few attention in assessing socio-economic aspect and implications of the introduction of the pump technology. For this reason, therefore, a case study to assess economic viability and social acceptability of pump irrigation technology is still necessary to be done. Result of the study may be valuable to be used as input to making proper policy and strategy is pump irrigation development in the future.

2. Concept of Sustainable Development

Recent thinking has converged on sustainable development as world-wide commitment in natural resources development and environmental management (World Bank, 1992). Some concept and methodological approach to monitor and assess sustainability in agriculture and irrigation development have also been developed by many scholars (Farshad, 1993; Dewees, 1988; James, 1988; Kawasaki, et al., 1988; Biswas, 1993). The concept of sustainable development is emerging in line with the emergence of national and international awareness about limited natural resources which have to be managed and used efficiently. While in the other side, there are many environmental degradation as the impact of improper environmental management and inappropriate development approach.

In contrast with the previous concept of development, which were oriented only to economic growth, the concept of sustainable development recognizes that the world natural resources are finite. It suggests that wasteful use of existing resources today will cause an unnecessary sacrifice of income, wealth and welfare in the future (World Bank, 1992).

For agricultural development in where, irrigation is included in, a broad definition proposed by the FAO could be used to develop parameters in assessing sustainable agricultural development. The definition stated that "sustainable development of agriculture requires sound management and conservation of natural resources base, and the orientation of technological and institutional changes in such a manner to ensure the attainment and continue the satisfaction of human needs for present and future generation. Such sustainable development conserve land, water, plant and animal genetic resources. It should be environmentally non-degrading, technically appropriate, economically viable and socially acceptable" (FAO, 1990). The definition explicitly acknowledge that appropriateness of technology used, economic viability and social acceptability are the main prerequisite of sustainable agricultural development.

For irrigation development, sustainability of an irrigation system is much determined by the availability of water resources, economic and social acceptability and adaptability of the introduced technology to local environmental factors. Regarding the availability of water resource, adaptability of the introduced technology to local environmental factor and socio-economic acceptability, then become the most important criteria in assessment of sustainability of an irrigation system. The last two parameters are considered as the main attributes of appropriate technology as has been defined sharply by USAID (1993). The definition acknowledge that appropriateness of a technology is attributed by social acceptability, sensitivity to human and adaptability to local environment. Moreover, a technology is considered to be appropriate if it can engage many participants and diminish dependency of participant either financially or technically from certain elite or group of donor or government agency to operate and manage the technological system (Fujimoto, 1985).

METHODOLOGY OF STUDY

The study is undertaken in Paron Irrigation Area (PIA) which administratively located in Ngawi Regency. The area is situated in lowland plains of Madura Basin. Hydrogeologically, the aquifer in the study area consists of moderate to highly permeable sand and gravel of alluvial deposits.

Survey and field observation to the small size of shallow tube-well (STW) irrigation and large size of deep tube-well (DTW) irrigation in the PIA were carried out. Data which have been collected in the study are including (1) technical specification of the pump units, (2) cost for investment and operational and maintenance cost, (3) daily hour operation and maintenance schedules, (4) source of finance to purchase and maintenance, (5) service capability of each pump unit and (6) water accessment, allocation and distribution system.

In contrast with some previous studies which mostly more interested to technical performance and economic feasibility of pump irrigation system, this study is focused on the assessment of social acceptability and economic viability of pump irrigation system in the study area, and assessing farmers dependency toward government assistance and incentives during implementation, operation and
maintenance of the pump units. The criteria used in the assessment of social and economic acceptability and farmers' dependency were developed based on the concept of appropriate technology proposed by the USAID.

Parameters used in assessing economic viability and acceptability are including financial capability of farmers, purchasing power per unit and present cost for O & M of the pump, rate of irrigation cost per unit irrigated area, and farmers or water user capability to pay the irrigation cost. Farmers' acceptability to the pump technology is assessed by distribution and density of the developed STWs in the study area, farmers' response and attitude towards pump irrigation system and water accessibility. While farmers' dependency is assessed by proportion of financial and works contributed by government or group of donors during the development and O & M stage, spurt part and fuel availability and accessibility, and government intervention in decision making concerning institutional arrangement and irrigation practice.

RESULT AND DISCUSSIONS

1. Characteristics of Pump Irrigation System in Ngawi

The PIA is situated in Lowland Plains of Madura Basin. The plans mainly consist of alluvial deposits. Hydrogeologically, the aquifer in the area consists of moderate to highly permeable sands and the gravel of the alluvial of other alluvial Quaternary deposits, and also of Quaternary volcanoclastics. These materials are thick in Madura – Ponorogo and the Sragen intermontane basins, so that the ground water potential of these basins is considerably high (Hydrogeological Maps of Indonesia, 1982).

The transmissivity of the loil aquifer in the Madura basin where the PIA is included in many exceed 1,000 square meters per day. The presence of impervious beds consisting of clay tuffs gives rise to the accumulation of unconfined ground water in the shallow layers, and confined ground water in the deeper layers, with piezometric head up to few meters above the ground surface. The equipotential lines of the piezometric surface in the area ranges from 30 m to 80 m relative to mean sea level.

Shallow tube-wells provided by small size pump unit have been developed by farmers since about 1972. The majority of small pumping units are purchased and installed by farmers individually or in a group with their own fund. Typically, these smaller pump units use locally available expertise, equipment and spare parts for installation and maintenance. Beside this, because they are implemented piecemeal and “informal”, they do not need institutional arrangement for implementation (USDA, 1999). Farmers individually or in group operate and maintain the pump units by their own fund, and government intervention is less during the implementation up to operation and maintenance (O & M) stages.

In contrast, the Ground Water Development Project (P2AT) of the Ministry of Public Works has also initiated to develop the ground water for irrigation in the area. The P2AT mainly develops the deep (confined) ground water. The development is characterized by massive investment in developing deep tube wells provided by imported and large capacity of pump units. The wells have been drilled, pump set have been provided and distribution canals have been constructed by the P2AT. Responsibility for O & M of the pump and water allocation and distribution is turned over to local government agency which then passes it on to the local water user association (P3A). The implementation of the project is financed by donors and designed by consortia of foreign and local consultant. Thus the design is a “formal” and top-down process and need several years to implement the project plan.

The summary of characteristics of pump irrigation in the study area is shown in Table 1. The marked differences in pump irrigation system developed by the P2AT and farmers are not only in the source of funds for purchasing the unit pumps and other complementary structures, but also in service capability of pump units. O & M activities, method of water allocation and distribution in the field and economic value of the water, which is expressed in the cost of irrigation per unit area of irrigated land.

Regardless of cost for investment and maintenance, the common rate irrigation cost for farmers' STWs is about Rp 1,500, – per hour. While from the P2AT pumps in Rp 5,000, – per hour. The higher irrigation cost from the DTWs of the P2AT pumps is because they generally have larger water discharge than the STWs.

The other marked difference is in the distribution of pumping logics. The location of the DTWs is determined by feasibility studies. The survey and feasibility studies are undertaken by the consultant. Conversely, the location of the STWs developed by farmers is depending on location of land ownerships, availability and accessibility to surface irrigation and economic capability of the farmers. Table 2 shows the distribution of pump ownerships in the PIA. Regardless economic capability of
farmers, the distribution of pump ownership indicates the
degree of irrigation water shortage in the study areas.
In area where availability of the irrigation water is
limited, farmers tend to purchase water pump, either
by cash or credit system. More pumps owned by farmers
in Kereta, Bangar, Semen and Beran indicated that avail-
ability of surface water in those areas are less reliable
than others area particularly during dry season.

It is estimated that the number of shallow tube-
well installed in the field could be more than that of the
existing pump units in each village because the farmers' pumps are not installed permanently in each STW but by mounted system so that the pump unit can be trans-
ferred from one location to another. Each pump unit	therefore, can serve more than two shallow tube wells with
the command area about two hectare of rice field each.

<table>
<thead>
<tr>
<th>No.</th>
<th>Method of Use</th>
<th>PIA</th>
<th>Farmer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Water source</td>
<td>Deep drawer wells</td>
<td>Shallow ground water</td>
</tr>
<tr>
<td>2.</td>
<td>Pump size</td>
<td>More not 50 Hp</td>
<td>4 Hp - 6 Hp</td>
</tr>
<tr>
<td>3.</td>
<td>Development pump</td>
<td>Formed through survey, installation, pumping and design</td>
<td>Implemented permanenly</td>
</tr>
<tr>
<td>4.</td>
<td>Implementation</td>
<td>Cured out by project engineers</td>
<td>Cured out by farmers or local contractors for solo installation</td>
</tr>
<tr>
<td>5.</td>
<td>Investment Cost</td>
<td>Rs 35,000/-, up to Rs 75,000/-, per pump depend on pump site</td>
<td>Rs 1,20,000/-, per pump</td>
</tr>
<tr>
<td>6.</td>
<td>O &amp; M cost (average)</td>
<td>Rs 11,000/-, per year</td>
<td>Rs 2,500/-, per year</td>
</tr>
<tr>
<td>1.</td>
<td>Field source</td>
<td>Drawn through Project</td>
<td>Farmer individually or in area</td>
</tr>
</tbody>
</table>

| 8.  | Responsibility | Before depending Project | After depending, area: Farmers/PIA |
| 9.  | Water exchange | 40 - 30 Ph | Ac: 1 - 4 Ph |
| 10. | Service capacity | 30 - 40 Ib/min | 1 - 4 Ib/min |
| 11. | Pump installation | Installed permanently, provided by water division, water division and local contractors |
| 12. | Pump operation | Under PIA decision based on farmers demand | Under pump owners based on local water conflict |
| 13. | Water distribution | Under responsibility of farmers | Under responsibility of owner of PIA |
| 14. | Rate of water use | Rs 5/-, per m³ | Rs 15/-, per m³ |

*Source: Field survey, 1995*

<table>
<thead>
<tr>
<th>Rekjorn</th>
<th>No of Pump</th>
<th>Irrigated Area (Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Berah</td>
<td>44</td>
<td>866</td>
</tr>
<tr>
<td>2. Sinigam</td>
<td>58</td>
<td>709</td>
</tr>
<tr>
<td>3. Kerota</td>
<td>459</td>
<td>888</td>
</tr>
<tr>
<td>4. Bangar</td>
<td>240</td>
<td>915</td>
</tr>
<tr>
<td>5. Semen</td>
<td>171</td>
<td>633</td>
</tr>
<tr>
<td>6. Payton</td>
<td>78</td>
<td>662</td>
</tr>
<tr>
<td>7. Beran</td>
<td>115</td>
<td>678</td>
</tr>
</tbody>
</table>

**Total**: 1,156 | 5,341

*Note: Rekjorn is a unit of irrigated area*

Examining water distribution in the field, seems that the lifted water of the STWs distributed plot to plot and there-
fore there are no distribution canals needed in the field. Nevertheless, the water can be distributed easily to the
whole assigned field, because the service area of each pump unit is commonly about 2.0 - 4.0 Hect. There is unwater rule in water distribution practice in the field, the first priority can be given to an assigned field when necessary, depending on water scarcity of the field and user request.

It seems the pump irrigation practice in the PIA is
done in collective manner, in a sense that each farmers has similar right to use the ground water. In practice, how-
ever, farmers tend to do their irrigation individually, because not all farmers in the area operate pump. For small farmers and share croppers, they generally rent a pump unit from the land owners or ask to use water from the farmers who operate pump by paying certain com-
mon rate of cost for water used. It means that accessi-
bility to water is actually depending on farmers capability to pay the irrigation cost either by operating pump unit or purchasing water from other farmers. The practice that has generated farmers in the area become more individual in their agricultural activities and irri-
gation as well. As an impact, competition in ground water use will emerge and the existence of user water asso-
ciation (PIA) in the assigned command area has not been considered by farmers as a need. This is indicated by the development of PIA in areas served by STW pump. Although PIA are officially existent, but there are no such significant activities in O & M of pump ir-
grigation.
Conversely, the DTWs developed by the P2AT are mostly operated by farmers. The operations are assigned in the P3A, and therefore their responsibility also to the P3A. The rule of pumps operation as well as water allocation and distribution is based on decisions made in the members’ meeting. Unlike the individual STWs, the water is distributed through the existing field distribution canals. The use of the distribution canal because each pump unit could serve a command area of about 30 – 40 ha. In order the pump unit can operate and maintained properly and the water can be distributed equally among the assigned users. Farmers who have benefit from the DTWs therefore, consider that the existence and role of water user organization (P3A) is a need.

2. Economic Viability

In order to know the economic viability and acceptability of pump irrigation in the study area, an analysis to determine irrigation cost or water price per unit of irrigated land has been carried out. The analysis is based on the data collected from the field survey during the dry season of 1993. Three assumptions are used in the calculation. There are:

1. Depreciation of the unit pumps follows a straight line
2. The technical lifetime of the unit pumps is 20 years and 15 years for the P2AT and farmers’ pumps respectively
3. The interest rate of the investment is 12% per year.

The result of the analysis shows that irrigation cost per unit irrigated area served by the P2AT pump is Rp 25,000, – per hectare. While for the irrigated area served by farmers’ pumps is Rp 6,120, – per hectare. It means that irrigation cost of the P2AT pump is almost four times of that of the STW, operated by farmers. This extremely high irrigation cost is not only due to the higher fixed cost for the P2AT pumps, but also to the higher in yearly operation and maintenance cost. Under the working hour of 3600 hours per year, the 60 HP of the P2AT pumps could irrigate only 2000 ha. While the 6 HP of the farmers’ pumps under the working hours of 1400 hours year could serve about 240 hectares. On the other hand, the operation cost for the P2AT pumps is Rp 15,120,000, – per year, compared to only Rp 979,200, – per year for the farmers’ pumps.

Although the fixed cost of the P2AT pump units (cost for drilling, purchasing pump unit and other related infrastructures) is financed by the government through the P2AT budget, however, farmers who get the benefit from the pump units have to be responsible for the O&M, after the pumps have been handed out to the farmers. The fund is collected through water fee, organised by P3A. Result of the analysis suggest that the technology of pump irrigation of developed and managed by farmers is economically more viable than those of the larger size of DTWs developed by the P2AT. It is supported also by the fact that most of farmers (70%) consider that the rate of irrigation cost is reasonable.

3. Social Acceptability and Farmers Independence

It is estimated that the wide use of the tube-well irrigation technology started about ten to fifteen years after the government of Indonesia disseminated the intensification program in the production. Meanwhile, during that time small capacity of water pumps were already available in local markets complete with after-sale service. Some farmers then tired to use water pumps replacing the traditional dug-well practices. Nowadays, the pump technology for ground water irrigation has been widely used by farmers, particularly in the area where shallow ground water is potential, such as in Lebar, Citra, Brebes, Madiun, Nganjuk and Kediri.

The contributory factors for the widely use of shallow pumps for ground water irrigation (STW) in the area are availability and accessibility of pumps unit and it accessories, spare parts and fuel supply in the local markets. The main part of the engines and pumps can be obtained easily at my agricultural implements shops in the nearest town. For small parts, farmers even can obtain them at shops in sub-district town. There are also no such considerable constraints to obtain fuel and oil for lubrication, because there are many fuel supplier in the nearest villages. Such conducive factors has led farmers in the area to use shallow pump irrigation for their agricultural field.

Considering the widespread of tube-well irrigation technology in the PIA as well as Ngawi area, it can be said for sure that the technology is already well known and accepted by farmers in the area. This can also be attributed by the fact that for all stages of the tube-well development up to the O&M activities were done by farmers without any technical and financial assistance from government agencies or groups of donor.

The final survey concerning the implementation of the STW’s irrigation in the area suggests that most of the pump owners (88%) purchase their pump unit by their own funds, 9% of them obtained through credit system.
and only 3% of them are subsidized by the government through certain programs. Similar things are also true in pump operation and maintenance. Farmers drill the wells, install the tubes and operate the pumps using their own expertise or done by local village contractors without any assistance from local government agencies. This reveals that farmers in the PIA have sufficient capability to implement as well as manage the shallow tube-wells’ irrigation without any finance support or incentives from government or other donor groups.

Dealing with the practice of pump irrigation and method of water distribution, most farmers (74%) responded that the practice is acceptable for them, since they feel that the technology of pump and STW are well known, and easier process to request water for their field. Farmers have also free choice to decide when and how many hours per day the pumps should be operated, and how much the users should pay for the water. Moreover, most of farmers in the area seem to accept the practices of water distribution method and water price, yet only 26% of them argued that the practices should be improved.

The results of the study have important implications to the new government policy in privatization and farmers’ participation of irrigation development program. The high farmers’ independency in pump irrigation is necessary to be maintained and developed further in the future, when policy of privatization in small scale irrigation will be implemented. Beside that, the result of the study reveal that local resources and farmers know how can actually be utilized to develop and manage their agriculture and irrigation activities, and this means could reduce the burden of the government in irrigation development and share the responsibility of irrigating O & M.

Finally, farmers’ independency, economic viability and social acceptability is used to assess the technological appropriateness of pump irrigation in the study area, it could be said for sure that the technology of shallow tube-wells provided by small size pump units for ground water irrigation such as adopted and developed by farmers in the PIA is considered to be more appropriate than the larger pump size of DTHW as developed by IED&T.

There is also another sociological implication regarding the widespread of pump irrigation in the study area to farmers awareness and perception concerning agricultural practice as well as irrigation. By applying pump irrigation to their agricultural practices, farmers need additional investment and agricultural production cost. Realizing this, farmers then become aware that water is one of the important agricultural production factors which cannot be obtained freely, but should be purchased as other inputs. This has generated farmers in the area become more rational in their agricultural practice. They have to decide what kinds of crops and when they should grow them on their own field, considering the availability of agricultural inputs, water and market attractiveness of the agricultural produces. Moreover, the situation has also generated a positive independent mentality among farmers towards government’s initiatives and incentives.

Problems which may emerge due to the very intensive and uncontrolled ground water use in the area are quite a few. First, is an over investment in irrigation and agricultural activities. As a consequence, agriculture will tend to be more capital intensive and commercialized and individual. Meanwhile, the increase of crop production will also tend to be unproportional with the increase of investment and production cost. The second problem which may emerge is a high competition in ground water use among farmers and between users. An over depleted aquifer due to very intensive and uncontrollable ground water exploitation may be emerge is the future when the water requirement for agriculture and non-agricultural sectors increases. When the ground water level decreases, the sustainability of the irrigation system as well as water availability for domestic use of surrounding villages will be threatened accordingly. To control the over depleted aquifer in the area and other areas where ground water irrigation has been practiced by farmers, the government agencies concerned with the agricultural development, particularly the irrigation and agriculture agencies, should make certain realistic and operationable efforts based on the existing environmental condition and legal aspects. Adequate control and monitoring of ground water exploitation either for irrigation or other purposes is a must.

CONCLUSION

Form the foregoing discussion, conclusions which can be withdrawn are as follows:

1. As general, technology of pump irrigation characterized by shallow tube-wells provided with small size of pump unit as developed by farmers, is more appropriate than the deep tube-wells system provided by large size pump units. The appropriate technology of pump irrigation in the area is considered as the determinant factor for sustainability of the irrigation system developed in the study area.

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2. The contributory factor for the widely use of small size pump irrigation is availability of pump unit and it spare parts in local market. Beside that, the small size pump irrigation system is more attractive for farmers due to "informal" development process, it needs only less organizational arrangement for implementation and operation and maintenance. The small size of pump irrigation system provides also more simple and reliable access to water.

3. Farmers actually have sufficient capability to develop and manage their own agricultural and irrigation activities by their own resources and funds. The potential capability could be mobilized to share government responsibility and burden in irrigation development and O & M activities. Farmers participation in irrigation development and O & M activities will in turn enhance sustainability of the developed irrigation system.

4. Although irrigation cost as a component of crop production cost has been realized by farmers, it will really threaten them as additional burden, particularly for sharecropper and small farmers. This is because, the increase of production cost is sometimes unproportional with the increase of crop yield from their small piece of land. In order to evaluate the role of ground water irrigation in increasing crop yield per unit area of the irrigated land, a further empirical study may be required.

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