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# The Resource Pool System on a Rice Farm Based on Pumping Irrigation from Tempe Lake, Indonesia

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The resource pool is a model that helps to meet water needs in rice farming. Each production factor has incentives and risks based on the value of resources. The research objective is to value the production factors used on a rice farm. The research method used to achieve this includes a case study on a group of rice farmers around the edge of Tempe Lake. Financial analysis is also used as a basis for valuing the resources incorporated into rice farming. Farmers as owners of labour, capital and skills have a higher benefit and risk, followed by land owners and providers of irrigation services. Risks faced by landowners include the opportunity cost of land, rent and high land values. The risk for irrigation service providers is the total operational costs and the depreciation of equipment, which is equivalent to land rent. Break Event Point (BEP) productivity is inversely proportional to business risks and incentives. BEP for productivity is 1.8 for farmers, 2.37 for land owners, and 2.27 for irrigation service providers. The share of water resources can be used as a reference for water fees for conventional irrigation.

**Key words:** *Land value, water value, risk.*

## Introduction

The resource pool is a model for merging resources used to increase productivity, efficiency, and sustainability (Subrahmanyeswari & Chander, 2013) and is suitable for developing small scale businesses such as in the agricultural sector that handles food crops (Ranjan, 2014). SMEs cluster, packaging house, and several partnership patterns have been applied by

several countries, including Indonesia (Li & Qian, 2007; Sodiq et al., 2018). Land, human labour, capital and water are the main resources in the agricultural sector (Friedrich, Derpsch, & Kassam, 2017).

Water has been widely used for free in rice farming due to it being obtained from public water, rain water or from irrigation infrastructure which is provided by the government. As a result of this, water has not been considered a factor of production and is not paid for using conventional agricultural irrigation. Agricultural irrigation is considered a public good and a gift from God, therefore, it can be used for free like rainwater (Saadah, Darma, & Mahyuddin, 2012).

The world is currently faced with a range of issues and problems, such as a lack of energy, food and water to keep humanity going. (Rosengrant & Cai, 2002; Jury & Vaux, 2007; Hanjra & Qureshi, 2010; Ludi, 2009). The lack of water is caused by the continuous increase in population, and therefore a greater demand from growing communities that have many families, which is becoming a major problem for the community, including the food crop sector (Ludi, 2009; Sang-arun, Yamaji, & Boonwan, 2010; Tuong & Bouman, 2009).

Water is one of the most essential natural resources in life (Dudgeon et al., 2006) and even the fulfilment of water has been preached as a basic human right as well as food (Roaf, Albuquerque, & Heller, 2019). It can be said that water is with life and agriculture (Falkenmark, 2013).

Water is one of the factors of production and natural resources that cannot be substituted, but its use can be saved. Many agricultural technologies can only be applied if they are supported by the availability of water, both in technical use and in the timing of their use. Water as a factor of production should be valued like production factors, such as land, labour, capital and skill (Ward & Michelsen, 2002; Friedrich et al., 2017). The function of water can be used as a basis for calculating yield sharing or incentives from its use in the rice farm. The value of water is used as the basis for developing a corporate model or partnership in the farm. Rice is the main food crop for most farmers in Indonesia who are faced with water problems, not only in irrigated areas, but also in areas where the availability of water is limited.

Many cooperation models in the form of resource pools have been implemented and published, such as cooperative farming, profit sharing systems and other partnership models for farming development in Indonesia. (Hasnah, Fleming, & Coelli, 2004; Hasnah et al., 2004). The partnership model on pump irrigation-based rice farming has been widely implemented by the community, but water as a production factor has not yet been widely studied and published. Water is still considered as part of the indirect benefit approach within

the economic valuation method of a resource (Elame & Doukkali, 2012). The resource pool in rice farming is reviewed as a pool of resources from different owners. Farmers have labour and capital production factors, land for landlords, and water for water pump entrepreneurs. This model raises awareness in the community that water is a resource, has value and has the same reward as the land in rice farming.

The research objective is to calculate the resource incentives used in rice farming and at the same time, compare the risks and benefits for the resource owner of a partnership. The results of this study form the basic framework for evaluating the factors of production from human resources, capital, land and water, which can be used as more of a fundamental, economic calculation framework. In addition, as a basis for determining the value of water in conventional irrigation, it has so far been considered a public good. Farmers who use conventional irrigation are not yet willing to pay water fairly as a factor of production.

**Research Method**

The Diamond-Water Paradox claims that water has no value, but has an essential function in life, whereas diamonds have almost no function, but the price is very expensive (Choi, 2014). This paradox is no longer valid because water is scarce and people's awareness and education has increased over the function of resources (Parekh, 2018). Disrupted environmental balance, climate change, and damage to natural resources all contribute to water being limited. The function of conventional irrigation, which is free, has declined and been replaced by pumped irrigation due to the growing demand for food and limited water (Mushtaq et al., 2008).

The lake as one of the water reservoirs is used by the population for various reasons, including meeting water requirements in rice farming (Soeprobowati, 2015). Despite the water in the lake being abundant, it costs money to procure it into irrigation water for rice farming, therefore, that water is recognised as one of the factors of production and has a value. Utilisation of water on the rice farm is managed as an item or service that creates high value while being counted as one of the important production factors in the agricultural sector. Provision of irrigation water privately is a type of business which encourages the improvement and sustainability of production on each farm (De Fraiture & Giordano, 2014). Agricultural technology can be applied well, if it is supported by the availability of sufficient amounts of water, time, and space/land (Mariano, Villano, & Fleming, 2012; Olen, Wu, & Langpap, 2016). The status of water is one of the factors of production, therefore, it is counted as a resource and has value in the same way as do human resources, land, equipment, and capital (Zoebl, 2006). Management of rice farms by pumping irrigation has developed in Indonesia, especially in areas where water is limited or there is no agricultural irrigation (Saleh, 2016). Water as one of the factors of production is pooled in a rice farming

management in the form of corporate farming. But the pattern of corporate farming that has been done countlessly is different; uniting land resources and capital plus each one is done by the land authority or marketing activities combined (McMichael, 2006; White, 2013). Corporate farming practised in Indonesia has not yet been developed due to social and cultural issues (Manzilati et al., 2010). For example, land is united without ownership borders, only the size of the area becomes a reference for ownership, and production is shared equally, whilst the productivity of each part of the unified land is different. The difference between corporations in pump-based rice farming is the unification of different factors of production that are managed by farmers.

The purpose of the resource pool or corporate farming in a small scale farm is to improve business efficiency and sustainability in agriculture (Agarwal, 2018; Ervin et al., 2019; Setiawan Hirawan & Toha, 2013). Parties that collaborate in rice farming are farmers as the owners of capital and labour production factors, landlords as the owners of land production factors, and irrigation pump operators as the owners of water production factors. Humans, capital, land and water are combined for use in a farm, which is always managed by the farmer. Determination of incentives from resource use is based on the level of risk that is faced (Shavell, 2006). The calculated risk is the loss of potential income due to crop failure which is used in agricultural insurance (Fahad & Jing, 2018; Adjabui, Tozer, & Gray, 2019). Farming in Tempe Lake is faced with the risk of crop failure due to the floods that occur regularly. The peak floods that occur twice a year, usually between the beginning and the end of the crop season, both pose a risk of crop failure if the planting schedule is incorrect. Floods in Tempe Lake are caused by water entering from two rivers during two different rainy seasons. Water flows from the Walane River between October and January, and from the Bila River between February and June. (Asti, 2016; Setiawan & Wibowo, 2013).

This research was conducted in the Tempe Lake area with a case study in a pump irrigation management unit located in Mallusesalo Village, Sabbangparu Sub-district, Wajo District, South Sulawesi, Indonesia. The study approach is qualitative, with information collected through in-depth interviews with the farmers, farmer group administrators and the pumping irrigation managers. The information collected is the type of work or outflow of labour in rice farms, the use of labour, the use of production facilities and other expenses on the farm. These other expenses include the production sharing system, the value of water paid by farmers and the distribution of the risk of production failure value. The latter comprises the institutional system that regulates the tasks and functions of each collaborated party, such as the tiller and labour for farmers, the land for landowners, the pump operators who are the providers of production factors.

In paddy farming, it takes 4-5 months from land preparation to harvest. Production costs are divided into two types; variable costs and fixed costs. Fixed costs incurred by farmers are set

costs for land preparation, fertiliser, pesticides, and labour. This total cost does not change in number even if production succeeds or fails. On the contrary, variable costs involve water fees and harvest wages. Fixed costs for irrigation service providers are operational costs, depreciation of equipment and machinery, and the work force of machine operators. The variable costs of irrigation service providers are labour management costs whose amounts are affected by water incentives. Landowners only bear fixed costs in the form of opportunity costs for land rent.

Presentation of data in the form of a farm analysis, with several productivity level scenarios, has implications for the incentives received by each partner. The risk scenario is calculated based on the level of productivity and benefits each partner receives. BEP productivity is calculated by adopting the conventional IRR (Internal Rate of Return) calculation method, which is the weighted value of productivity with a positive benefit value and productivity with a negative benefit value.

## Result and Discussion

### *Mallusesalo Village as Study Site*

Mallusesalo Village as the selected research site is located on the edge of Tempe Lake, therefore it is strongly influenced by the lake ecosystem. Routine flooding is caused by incoming water flowing from the Walane River between October and January, and from the Bila River between February and June. The water of Tempe Lake flows out to Bone Bay and passes through the Cenranae River in the Bone District (Setiawan & Wibowo, 2013). A cycle of large floods occur twice a year, which affects the livelihood patterns of the community in this village, including activities on the rice farm. Tempe Lake has an endowment that supports the lives of residents living around the lake, influencing occupants to stay despite the inevitable threat of extreme flooding.

The area of Mallusesalo Village is dominated by many agricultural areas. The area of 475.2 ha consists of 132 ha of rice fields, which is 27.77 percent of 93.0 percent of the total agricultural area. The remaining 5.47 percent is for housing plus other buildings and 1.53 percent is for other open spaces. The population of Mallusesalo Village consists of 1511 people, 59.76 percent are women and 40.23 percent are men. The education of this population is very low with 43.82 percent being illiterate, 28.92 percent completing elementary school, 9.59 percent finishing junior high school and 7.42 percent graduating from senior high school. The remaining 5.89 are not in school and 4.36 percent have graduated from higher education. The working population is 540 (35.74%) people which is dominated by farmers and fishermen as their main occupations. The percentage of farmers is 54.6 and the percentage of fishermen is 27.7. The remaining 17.7 percent are government employees, traders, and service business people.

***Rice Farm-Based Pump Irrigation***

Rice farming is the main source of income for most of the population and around 54 percent of them are farmers with a production sharing system. The water used is from a lake that must be paid for with a pump system. Irrigation systems are very different in other areas in general, which flow into the fields by gravity and are used free of charge (Saadah, et al., 2012). Water around the lake has a status as a factor of production and is the same as land resources. In the production share-cropping system of the rice farm, there are three parties consisting of farmers, landowners, and irrigation service providers. The sharing system is based on the value of resources and the risks faced by each party.

**Table 1:** Revenue sharing system between farmer and landowners on the rice farm-based pump irrigation

| No. | Cost and Revenue Components | Share System | Notes |
|---|---|---|---|
| 1 | Land preparation | Farmer | Responsible by farmer |
| 2 | Input production (seed, fertiliser, pesticide) | Equal | All are borne by the farmers if the harvest fails |
| 3 | Harvesting cost (8.33 % of gross production) | Equal | One unit of fee out of 12 units of production |
| 4 | Fee of pumping water use 20 % from production. | Equal | No water fee for production failure |
| 5 | Share tenant system after deduction of input production harvesting, and water fee | Farmer 60 % Land owner 40% | Tillage and labour cost borne by farmer |

Table 1 shows that farmers received 60 percent of the revenue share and 40 percent of the land from the value of production. Payment is received after all the production costs are incurred, except the use of tractor services for land preparation. Land preparation is the farmer's responsibility, but the land tax is borne by the landowner. The rice production is not shared if crop failure occurs or production is less than one ton per hectare. The value of one ton of production can only cover all costs borne by farmers, consisting of fertilisers, pesticides, seeds and tractor services for land preparation. The highest level of loss is suffered by farmers if there is a total production failure due to flooding.

Almost all farmers are assisted by means of production, especially fertiliser from irrigation service providers. The cost of fertiliser is paid for after harvest or postponed until the next harvest without additional costs in the case of crop failure. The compensation for irrigation service providers is from marketing farmers' production through pump operators and the added value of fertiliser sales. The distribution of benefits and risk management between the

three parties in partnership is considered fair so the pattern of corporate farming can take place sustainably around Tempe Lake.

The productivity of rice farming in conditions with no disruption from floods and other disasters ranges from 5-7 tons / ha. The average productivity of one farmer group with 30 farmers is 6.22 tons / ha. The level of productivity achieved above 4 tons / ha makes all partners enjoy the results of corporate farming.

**Table 2:** Financial analysis and benefit share to the party on a rice farm-based pump irrigation

| No. | Description | IDR |
|---|---|---|
| 1 | Total Revenue (6215 kg/ha xIDR4800/kg) | 29 829 600 |
| 2 | Seed | 375 000 |
| 3 | Fertiliser | 875000 |
| 4 | Tillage (Tractor fee) | 1 300 00 |
| 5 | Pesticide | 355 000 |
| 6 | Labour for cultivation | 1 900 000 |
| 7 | Land tax (0.5xIDR 70 000/year) | 35 000 |
| 8 | Depreciation of equipment | 335 000 |
| 9 | Harvesting fee (1 of 12 or 8.33 % of total revenue) | 2 485 800 |
| 10 | Share for water (fee= 20% of total revenue) | 5 965 920 |
| 11 | Total cost of production =2+3+4+...+9 | 13 626 720 |
| 12 | Net Revenue of farm = 1-11 | 16 202 880 |
| 13 | Share to farmer (60% of (net revenue-tillage)+tax-tillage = 0.60x(11+6)+4-6 | 9 166 728 |
| 14 | Share to land owner 40% of (net revenue + tillage)-tax = 0.4x(11+6)-4 | 6 983 652 |

Table 2 shows that the net benefit received by each partner is a farmer of around IDR 9.1 million, a land owner of IDR 6.9 million and an irrigation provider of IDR 6.0 million per hectare. The total revenue generated is divided into costs in the production process of 25.86 percent and the remainder is part of the landowners, farmers, and irrigation service providers. The share for farmers is as much as 30.73 percent, while landowners receive 23.41 percent and water providers obtain 20 percent. The share received by the irrigation service provider has not been deducted by operational costs, depreciation and labour. Water in Tempe Lake has a high value, although water is not a limited resource. The value of water is a consequence of investment, operational costs, and labour to pump water up from the lake for it to then flow into the rice fields.

**Benefit-Risk Share System**

Agriculture as a business is faced with the risk of uncertainty. High uncertainty due to climate change, markets and pests and disease attacks. The other risks faced involve production failure or low production prices. To reduce these risks, the production sharing system in food crops, especially in rice farming, is widely practiced in Indonesia.

Farmers as the main actors in agriculture, are faced with a high risk. In the production sharing system, farmers get the most benefits, followed by land owners then irrigation service providers. The risk of failure for farmers is the value of production inputs and labour that is spent at the same value as the total costs incurred by the irrigation service provider plus opportunity costs in the form of rent for landowners. Opportunity costs are costs borne by the landowner if production fails. The landowner loses a potential income of IDR 2.5 million per hectare which is an opportunity cost if the land is leased. The average land rent is around IDR 2.5 million per planting season and is leased for a minimum of 2 years which is paid at the beginning of the year. Land that is rented for two years can be cultivated twice a year or four times in two years.

**Table 3:** Financial analysis of corporate rice farming based on costs borne by partners

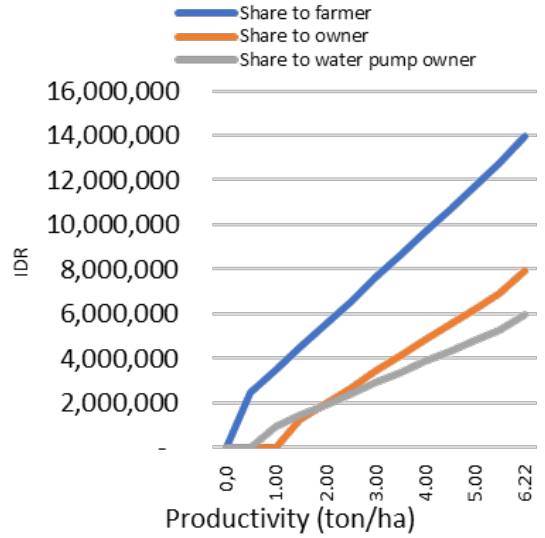
| Parties | Cost component | Cost (IDR1000/ha) | Gross Return (IDR1000/ha) | Net Return (IDR1000/ha) | R/C-ratio | BEP of production (ton/ha) |
|---|---|---|---|---|---|---|
| Land owner | Opportunity cost of land rent IDR 2.5 million | 2 500 | 6 985 | 6 985 | 2.79 | 2.27 |
| Farmer | Input production (seed, fertiliser, pesticide), labour for tillage and input applied | 4 805 | 13 972 | 9 167 | 2.91 | 1.80 |
| Pump irrigation enterprise | Pump machine and equipment depreciation and cost operation | 2 246 | 5 966 | 3 720 | 2.66 | 2.36 |

Table 3 illustrates that farmers have the highest financial feasibility compared to landowners and pumps. A high R/C ratio indicates high business risk. The risk of landowners is relatively low compared to pump operators, but when compared to the value of capital on land, it is

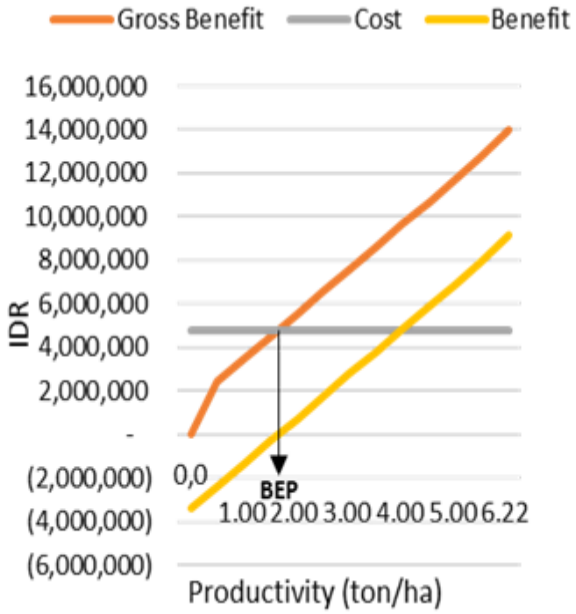
high compared to the value of existing capital at pump operators. The investment value of pumps is around IDR 1.1 million per hectare, while the land value is around IDR 100-150 million per hectare. Land values tend to increase or appreciate, while the value of pump assets decrease or depreciate over time. Capital costs in the form of opportunity costs on land are not calculated because they can be covered by the increasing appreciation value.

Comparison of benefits with risks received in farming can also be seen from the value of Break Even Point (BEP) productivity. The higher the risk faced by the party, the higher the benefits obtained. High benefit value and high risk have a smaller BEP productivity. Farmers as owners of labour, capital and management get a higher share and risk, followed by land owners, then providers of irrigation services.

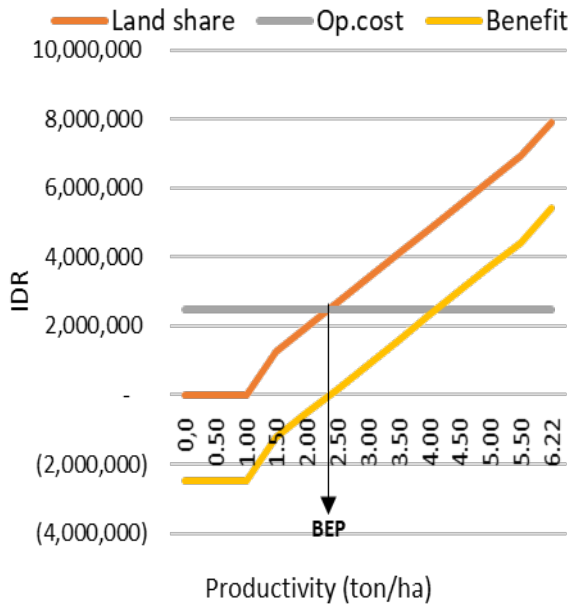
**Graph A.** Comparison Share to Parties




**Graph B.** Break Event Point for Farmer 1.8



**Graph C.** Break Event Point for Land 2.37




**Graph D.** Break Event Point for Water 2.27

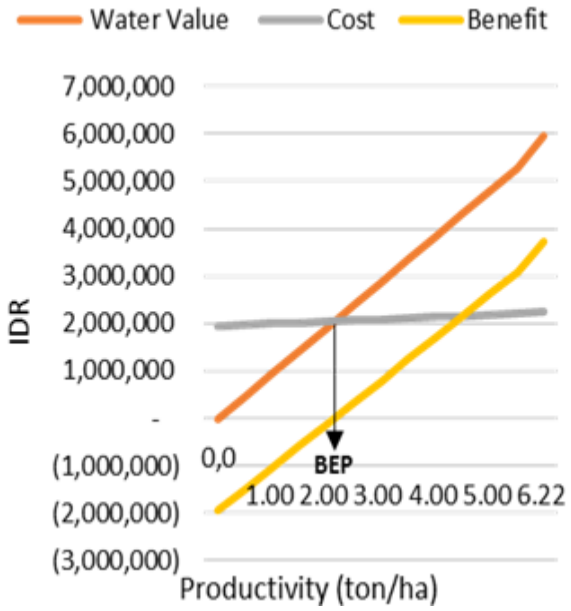



Figure graph level of share benefit to each party on corporate rice farming system

The graphs from A to D in the tables above indicates that BEP productivity is inversely proportional to business risks and benefits. Benefits, costs, and BEP productivity for each party shows that the highest net benefits are received by farmers, followed by landowners and then pump service providers (see also Table 3). BEP productivity is 1.8 for farmers, 2.37 for landowners, and 2.27 for irrigation service providers. Farmers as the owners of labour, capital and management get a higher share and have higher risk, followed by landowners and providers of irrigation services. Risks faced by landowners include the opportunity cost of leasing land plus the high value of land capital. In contrast, the risk for irrigation service providers is the loss of operational costs and the depreciation of equipment that is equivalent to the opportunity cost of land rent.

## Conclusion and Policy Recommendation

The combination of production factors of labour, capital, land and water is a resource pool model in rice farming. Farmers as owners of production inputs and management have higher incentives and risks than irrigation service providers and landowners. The value of farmer incentives is relatively the same as the number of incentives for water service providers and landowners. Risks faced by landowners consist of the opportunity cost of leasing land and the high value of land capital. The risk for irrigation service providers is operational costs and depreciation of equipment equivalent to the opportunity cost of land rent. BEP productivity is inversely proportional to benefits and risks. BEP productivity is 1.8 for

farmers, 2.37 for landowners, and 2.27 for irrigation service providers. Water has a value in the pump irrigation system and one of the factors of production in rice farming. Incentives for the use of water in Tempe Lake is a factor of production, it can be used as a reference in the application of water levies in conventional irrigation for the improvement in the quality of irrigation services.

## Conflict of Interest

There is no conflict of interest and all data generated or used during the study are available from the corresponding author on request.

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