The land use potential of flood-prone rice fields using floating rice system in Bojonegoro regency in East Java

H Irianto¹, Muijyo², E W Riptanti¹ and A Qonita¹
¹ Department of Agribusiness, the Faculty of Agriculture, Universitas Sebelas Maret.
² Department of Soil Science, the Faculty of Agriculture, Universitas Sebelas Maret.

Email: erlynawida@staff.uns.ac.id

Abstract: Bojonegoro regency occupies the largest flood-prone rice fields of about 14,198 hectares, in East Java province. Floods commonly occur due to Bengawan Solo river overburst, particularly in rainy season. The fields are potential for cultivating rice, but floods lasting for months causing these areas to be unproductive. The objective of this article is to examine the potential land use of flood prone rice fields in Bojonegoro regency using floating rice system as an effort to maintain productivity in rainy season. The method of this study is referential study about the rice production using floating cultivation system in other regions, which are later compared with the physical condition of the fields in Bojonegoro. The results of analysis show that rice cultivation using floating system can maintain rice production in flood prone areas during rainy season. The potential production of rice is 5-6 tons/ha. However, technical problems for cultivating rice cannot be ignored since farmers are not familiar with cultivating flooded fields. This article also explains alternatives of floating rice cultivation technique, which can be implemented effectively and efficiently. Pioneer work of developing floating rice in Bojonegoro that has been done by the Team of Faculty of Agriculture of UNS, Surakarta, is expected to serve as a medium for accelerating the adoption of cultivation technology innovation to farmers.

1. Introduction
Food buffer stock, particularly rice, is the main priority in national development. Besides as main staple food for more than 95% of Indonesian people, rice also provides job opportunities for approximately 20 million of farmer households in the village. According to Indonesian Central Bureau of Statistics or [1], in the last five years, rice production in Indonesia increase 3.61% each year. However, rice production rate is not able to meet rice consumption, which reaches 98.63 kg per capita in a year.

Diversity of rice production in Indonesia is influenced by the climate. Extended harvest failure is often attributable to extreme climate, like flood and drought. Results of some studies reveal that failure in harvest resulted from extreme climate, taking forms of flood and drought were tend to increase [2]. In addition, flood potential level also increases in low land areas because of environmental damage in rainwater catchment areas that increases river water discharge in the lower course and the increase of seawater surface [3].

For farmer households living in flood prone areas, flood will cause a loss of agricultural production. In order to cope with that problem, technology of floating rice cultivation is developed. This is a rice cultivation technique that uses rafts as cultivating media as an effort of adapt with flood.
Therefore, the aim of this article is to examine the potential land use of flood prone rice fields in Bojonegoro regency using rice-floating system as an effort to maintain productivity in rainy season.

2. Methods
The basic method of this study is exploratory research, which is a research aiming at seeking for explanation of observed phenomena, problems, or behaviors on potential land use of flood prone rice fields in Bojonegoro using floating rice system [4]. The method of this study is referential study of products of rice cultivation using floating system in other regions, which are later compared with the physical condition of the fields in Bojonegoro. The research location, Bojonegoro regency, was purposively selected by considering that Bojonegoro occupies the largest flood-prone rice fields, 14,198 hectares, in East Java province.

3. Results and Discussion

3.1. The Potential for Developing Floating Rice in Bojonegoro Regency
Bojonegoro is a district implementing regional autonomy whose one of the development missions is “empowering society and optimizing regional potential”. Bojonegoro regency occupies human and natural resources to develop agricultural sector. The resources face some threats from external factors of disasters, like flood. This condition happens nearly every year [5] and [6]. Bojonegoro has the largest flood-prone rice fields, 14,198 hectares, in East Java province [7], parts of flood-prone areas in Bojonegoro, reaching 65,989.13 hectares (Figure 1). Flood is caused by discharge of Bengawan

Figure 1. Map of Flood-Prone Areas in Bojonegoro Regency

Figure 2. Flooded Agricultural Fields in Sedayu Village, Baureno Sub-district, Bojonegoro Regency
One of possible efforts applied to unproductive rice fields in rainy season due to flood is adopting technology of floating rice cultivation. Floating rice system enables farmers to keep nurturing rice even though flood happens. On the other hands, farmers face limitations that their roles as either humans, farming expert, or manager, require a process of accepting or refusing new technology. Farmers’ decision to decline or agree to take an innovation of technology is attributable to their social and economic factors [10]. To ensure that innovation resulted from research by certain institution or research institution can be delivered to target group or farmers needs a process of transferring agricultural information, while the speed of adopting agricultural innovation is influenced by internal and external factors [11]. Thus, it is important to examine more deeply and comprehensively the potential land use of flood prone rice fields using floating rice system, so that farmers can implement technology for cultivating floating rice and be able to improve food security at household and regional levels.

3.2. Alternative of Effective and Efficient Floating Rice Cultivating Technique

Floating rice is a type of plants that can be raised in some regions in the South and Southeast Asia. The viability of rice depends on their ability to cope with water when they are submerged and the duration flooding. Floating rice cultivation technique can also increase production [12]. It is a rice growing technique using the media of rafts to adapt with flood. Rafts function to support rice so that rice will not fall whenever wind blows and will not sink whenever flood happens. Rafts are made of bamboo to make them floating, the central part of it is made of bamboo cut in two and arranged like a fence, which later is filled with straw waste and coconut fiber mixed with organic compost, and the upper part is covered with net. Raft cultivating media can be used up to six growing seasons (3years) [3].

Floating rice cultivation uses System Rice Intensification (SRI) method, which is a method to improve rice productivity with integrated natural resources use and management (plant, soil, water, biota, and nutrition) to improve organic rice productivity [13]. Plants are moved to cultivating media (rafts) after rice seeds have been sown for 10 days and fertilizer is spread to stems and leaves to work more effectively. The organic fertilizers used include is Complementary Liquid Fertilizer and MOL (Micro Organism Local) [3].

The areas for cultivating floating rice are flooded fields. Planting media of rafts are prepared on land. Rafts are made of three stalks of bamboo with minimum diameter of 7 cm and length of 5 m. The planting media include straw waste, coconut fiber waste, and organic compost. Nets are used to keep planting media not scattered during planting process. Floating rice fields in Bojonegoro apply SRI (System of Rice Intensification) method with single rice seeds previously sown in 14 days (14 days after sowing).

Fertilizing floating rice fields is done by observing the development and the age of the plants. During the first cycle or vegetative growth (0-60 days), rice requires fertilizer containing 5% of nitrogen (N) and phosphorus (P). Transition from vegetative to generative growth (55-70 days) of rice requires fertilizers that contain phosphorus (P), and during the last cycle, generative growth (last 2 months), rice requires fertilizers containing potassium (K). Organic liquid fertilizers are obligatory in floating rice fields. Fertilizers can be effectively sprayed directly to stems and leaves.

In general, the steps for cultivating floating rice fields are as follows: (1) ensure that the water height of fields for floating rice media exceeds 20 cm during one planting season, at minimum; (2) prepare organic compost media mixed with soil with ratio of 2:1, processed with decomposer; (3) a. prepare bamboo with minimum diameter of 7 cm and cut 5 m (3 stalks), b. prepare bamboo and cut, 2 meter in length each (5-6 stalks), and then cut into small pieces until they shape like mats, and match the bamboo, as well as tie them at wider parts, (4) bring rafts to flooded areas in which floating rice fields will be located, (5) separated with SRI pattern with seedling period of 10-14 days after sowing, the seeds will be pulled out and moved to floating rice fields, (6) bamboo mats are attached on rafts, in which the softer parts face up, (7) spread organic planting media with 3-5
cm thickness, (8) before the floating rice fields are ready, create lines to help manage planting distance (25 cm x 25 cm), (9) plant rice that have been sowed with L pattern (between root and stem), 0.5-1 cm width, and one seed in one hole, and then prepare 20-30 seeds and plant them at the edge of rafts for refilling, (10) prepare organic liquid composts containing elements required as the media of plant growth regulator (PGR) and complementary liquid fertilizer, (11) spray plant growth regulator (PGR) and complementary liquid fertilizer 3-4 times in a season, (12) observe the growth of pests and control with organic pattern, including refilling when needed, (13) after rice is ripening, harvest them and prepare sacks and boats to bring the crops to land, and then thresh and dry the rice, just like treatments when cultivating conventional rice fields [14].

This floating rice-based agro-ecology system can exploit flood for the life of villagers. It is more important that this system enables farmers to adapt well with flood and they will not encounter scarcity because floating rice can grow well in flood [15]. This proves that floating rice is potential to be developed, particularly on the fields facing annual flooding. Floating rice cultivation technique has both drawbacks and strengths. The strengths of this technique include: (1) it does not require watering and irrigation canals, (2) it does not need tractors to cultivate the soil, (3) it does not need chemical fertilizers and organic pesticides, (4) it does not need certain treatments to clean grass or weed, (5) it reduces straw waste and coconut fiber, (6) it optimizes the use of abandoned/unproductive fields due to prolonged flood (one growing season), and (7) it is free from drought in rainy season, particularly for areas vulnerable to annual flood. Meanwhile, problems in applying floating rice cultivation are among others: (1) technical problems for cultivating rice cannot be ignored since farmers are not familiar with cultivating water-logged fields and (2) making rafts requires a large sum of money, especially in the beginning of planting.

Floating seedling method offers some benefits: (1) preventing plants to be soaked, (2) optimizing growing plants in rainy season so that the following planting period will not be late, (3) saving fields, which are usually cultivated by farmers, and (4) facilitating seed treatment during fertilization and pests and weeds (organism) control. Floating media can be repeatedly applied for the next planting periods, because the sources of water plants do not go up and are sustainable [16]. If all flooded areas are optimized with floating rice, it is possible to improve rice productivity and economic condition of lower-middle class people, farmers can adapt with environmental and climate changes. In addition to floating rice, flooded fields can also be combined with fish cattle [17].

The followings are the results of research conducted in various countries and other regions, including Vietnam, Myanmar, India and Indonesia. In general, the yield of floating rice varies depending on the land elevation. In deeper water, yield is slightly higher. Average yield is about 1 ton/ha. Of all the existing floating rice varieties, the most popular ones are Nang Tay C, Tau Binh, Nang Dum, Nang Kieu, Tau Nut, Trung Hung [17]. In Myanmar, it is reported that the total net benefit of floating rice-leeks shows the highest net benefit (VND 24.8 mil./1000 m2), followed by floating rice-sweet corn- two baby corn crops and cattle systems (VND 18.5 mil./1000m2), and floating rice-chili (VND 16.7-17.7 mil./1000m2). If farmers cultivate monoculture of rice either two or three crops, the net benefits are ranging from VND 2.2-4.8 mil./1000m2 respectively. Alternatively, farmers integrate vegetables; the net benefit was ranging from VND 5.6 to 11.7 mil./1000m2. The net benefit of the two rice crops is the lowest (VND 1.3-2.3 mil./1000m2). Surprisingly, if farmers convert from two intensive rice crops to two maize crops, the net benefit can reach to VND 21 million/1000m2. The results support the argument that the floating rice-based systems allows farmers diversified into profitable upland crops, which can help farmers to improve their total income [18]. The results of other research show that the red floating rice varieties as a low-volume but high-value crop is the development of markets. Floating rice has high protein, vitamin E and anthocyanin compared with high-yield white rice, but has a different texture and flavour [19]. In India, the results of research by [20] reported that the production of rice with floating system ranges from 1,628 to 3,000 kg/ha. Meanwhile, members of Taruna Mekar Baru farmer group in Ciganjeng village, Ciamis Regency, West Java, Indonesia successfully harvested...
rice in flooded fields. IR 64 rice is planted on water of 1 meter in depth, resulting 6.2 tons of rice per hectare [21].

**Figure 3.** Experiment of Floating Rice Cultivation in Bojonegoro Regency by Team of Faculty of Agriculture of UNS Surakarta

Pioneer work of floating rice development in Bojonegoro that was conducted by the Team of Faculty of Agriculture of UNS, Surakarta [22]. The development was initiated by conducting experimental study of floating rice cultivation using growing media and floating materials obtained from Sedayu Village, Baureno Sub-district, Bojonegoro Regency (Figure 3). The design of experiment was Randomized Complete Block Design (RCBD) with 18 types of treatments, each of which is repeated to three blocks. Each experiment unit was 10 m² (2 m x 5 m) in width. The types of treatments were combinations of floating material uses (drum and petung bamboo), mixtures of planting materials (soil : organic fertilizer = 1 : 1, soil : chaff ash = 1 : 1 and soil : organic fertilizer : chaff ash = 1 : 1 : 1), and planting distance (15 cm x 15 cm, 20 cm x 20 cm and 25 cm x 25 cm). The variety of planted rice was IR-64 because farmers are familiar enough to plant this variety and it has high productivity and short harvest time. Rice grew quite well in 25 days after planting, despite the fact that the effect of treatments of the growth and development of plants cannot be reported yet in this paper.

4. Conclusion
Floating rice cultivation is a technique of nurturing rice with the media of rafts to adapt with flood. This is feasible to be further developed on the fields flooded in years because this can maintain rice productivity during rainy season, with potential production of 5-6 tons/ha. However, technical problems for cultivating rice cannot be ignored since farmers are not familiar with cultivating flooded fields. Thus, based on the research results, farmers require development and counseling on floating rice cultivation in order to improve their skills and to yield optimum crops. Pioneer work of developing floating rice in Bojonegoro done by the Team of Faculty of Agriculture of UNS, Surakarta, is expected to serve as a medium for accelerating the adoption of cultivation technology innovation to farmers.

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