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Sustainability cultivation and traditional conservation of taro diversity in Bogor Indonesia

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Abstract. Fresh taro and its processed products have been produced in Bogor for decades. It has become a popular commodity from this city and evoked an image of Bogor. The essential component of this issue is the sustainability of taro farming, and farmers are the major preserver who has primary decision-making in agricultural management. It assumes there were unusual agricultural practices that promote the long-term viability of taro cultivation. Farmers' consideration of taro cultivation and their on-farm activities were observed, and the impacted-on sustainability was studied. We surveyed 30 taro farmers in 8 districts Bogor with a rapid rural appraisal and field observation to validate the obtained data and plant diversity analysis. The result showed that taro has provided more income for farmers, and they prefer an intercropping approach in taro farming. Seed availability was the main consideration of farmers in cultivating this plant consistently for a long time. The seed rotation by seed sharing between farmer's communities was the mechanism of seed exchange and spread of taro cultivars. There was also found the diversity of taro that divided into three groups similarities and simply to distinguish by the plant stature, color of petioles and corms cross-section.

1. Introduction

Taro refer to *Colocasia esculenta* is tuber crop in Araceae family. It is the staple food of some countries in the world, especially in Asia and Oceania. Taro is high in carbohydrates, protein, vitamins (A, C, B1, B2), phosphorus, magnesium, iron, calcium, and potassium [1]. Protein contains in taro higher than sweet potato and cassava [2]. It has become a staple food for some people in Indonesia, particularly in the eastern region such as Nusa Tenggara, Maluku, and Papua.

Indonesia is one of the countries with the greatest diversity of taro in the world. There are diversified taro genotypes that are spread in almost all islands of the Indonesian archipelago with various local names. In the Toraja, South Sulawesi discovered 6 cultivars local of taro [3], 5 local cultivars in Papua [4], 5 local cultivars in Malang [5] and 10 local cultivars in Bengkulu [6]. This plant also easily grows



in unfavorable environments and found grow well wildly such as home garden, farmer field, riverbank, swampy area, upland, and the forest margin.

Farmers have high participation in agricultural extension activities average to almost all agribusiness subsystems from upstream to downstream that impacted the increase of production, knowledge, skill, and more profitable farming [7]. Farmers also participated in environmental management practices because they were concerned with the natural environment and to adapt to government agricultural policies [8]. Farmers' involvement in plant diversity conservation has been widely reported that motivated by economic, cultural, traditional, and customary factors. Custom, practices, beliefs, and cultural rights were predisposed indigenous people to play a role in environmental conservation and biodiversity preservation [9].

Bogor Regency is a tourist destination located 60 kilometers south of Jakarta the Indonesian capital city (Figure 1). This city has a long history of producing fresh taro and processed taro products. So, taro has become a popular commodity from Bogor that is frequently bought as a souvenir by visitors. Taro conjures up images of Bogor, so it is like a Bogor icon. The key aspect of this matter is the sustainability of taro cultivation, and the main preserver is the farmer who grows taro consistently for decades. Farmer households play a major role in decision-making unit that directly controls agricultural resources. As a result, farmers' attitudes toward agricultural output and environmental awareness may have an impact on the sustainability of agriculture [10]. The establishment of agricultural sustainability necessitates the integration of continual agriculture practices that productive, competitive, and efficient practices and the benefits that can be obtained by the local community [11]. To produce this crop, both monoculture and intercropping techniques were widely practiced in the farmers' fields. Fresh taro corm and processed products were readily available for sale in numerous crowded locations in Bogor. We hypothesized there was an agricultural custom that promotes the long-term viability of taro cultivation, but it is not known exactly what the farmers consider in deciding taro cultivation for a long time. Here, farmer's consideration of taro cultivation and their on-farm activities were observed, and the impacted-on sustainability was studied.

2. Materials and methods

Primary data were obtained using the Rapid Rural Appraisal (RRA) approach. The RRA technique places a greater emphasis on verbal communication, with outsiders (researchers) being more active in conducting interviews and observations [12]. The total number of respondents was 30 farmers from 8 districts in Bogor (Table 1). The techniques used in data collection were as follows:

2.1. Semi-structured interview

Semi-structured interviews that use interview guides rather than formal questionnaires are also known as deliberate conversations for specific purposes. The guide is designed in such a way that it streamlines the interview process while remaining flexible and controlled enough to ensure that no questions are missed.

2.2. Key informant interview

A key informant is someone who is thought to have extensive knowledge and long experience with taro cultivation, utilization, processing, or trading.

2.3. Direct observation

Direct observations are conducted to confirm or validate the information/data obtained from respondents with actual field conditions.

2.4. Characterization

Morphological characterization was carried out on 4 to 5 months old taro plants for samples. This stage referring to Descriptors for Taro *Colocasia esculenta*, International Plant Genetic Resources Institute

[13]. Analysis clustering of dissimilarity released by DARwin 6 software (downloaded from <https://darwin.cirad.fr/>) in specification weighted neighbour-joining and bootstrap 10,000.

Table 1. Number of respondents in each district in Bogor.

District	Number of respondents
Bogor Barat	5
Dramaga	5
Jasinga	1
Ciampea	2
Kemang	2
Taman sari	1
Sukaraja	1
Babakan Madang	13



Figure 1. Bogor is lied in West Java and is located in the south of the Indonesian capital city (Jakarta) [https://commons.wikimedia.org/wiki/File:Map_of_Western_Java_regions.png][14].

3. Results and discussion

3.1. Taro cultivation

In Bogor, the average area for taro fields under monoculture or polyculture farming was 1,300 m² while the average population was 12,500 plants/ha (Table 2). The number of farmers who did intercropping cultivation is 76.7% or three times higher than the number of the farmer with monoculture planting. This suggests that farmers prefer intercropping planting when growing taro. It indicates that in Bogor taro wasn't always a farmer's major commodity for the source of income. Moreover, land with intercropping cultivation on it appears to be larger than land with monoculture cultivation. Based on the findings on the field survey, taro was intercropped with other tuber crops such as cassava and sweet potato (Figure

2a.) and a few farmers grow taro as a border plant on the vegetable field (Figure 2b). Hence, polyculture farming allows the farmer to earn money from the sale of other commodities besides taro. This system allows a farmer to harvest a few crops from a farm simultaneously [15]. The intercropping system in rural areas has improved the farmers' economy and reduced poverty by raising farm incomes and food security [16]. The presence of agro-ecological factors (e.g. water regime, soil texture, and climate) potentially influence the effect of intercropping on yields and incomes [17]. Farmers get a fairly high income when there is a high demand for taro. On the first and second ranks, the majority of farmers interviewed stated that a lot of sales happen around the new year, Ramadhan, and Eid Al-Fitr (Figure 3). In other words, taro demand will increase during those occasions, and farmers will make a good profit from the sale of taro.

Table 2. Taro cultivation in Bogor.

	Category	Percentage
Field area for taro cultivation (m ²)	Narrowest	100
	Widest	4,000
	Average	1,300
Population average per ha (plants)		12,500
Number of farmer base on the source of seed	Bought from another farmer	23,3
	Gratuitous from another farmer	50
	Gratuitous and bought from another farmer	10
	Providing by their self	16,7
Number of farmer base on cultivation technique	Intercropping	76,7
	Monoculture	23,3
Number of farmer base on source of income	Taro as the main commodity for income	56,7
	Taro as the second commodity for income	43,3
Number of farmer base on the experience in taro cultivation (year)	< 5	56,7
	5-10	13,3
	11-20	13,3
	>20	16,7



Figure 2. Intercropping taro and sweet potato (a) and taro as border plant on vegetable field (b).

There are 43.3% of farmers who have experience growing taro for more than 5 years, while 16.7% have more than 20 years of taro cultivation experience (Table 2). It demonstrates that taro is to be sustain maintained and has long-term supremacy. As many as 56.7 % of farmers have less than 5 years of experience and some of them were likely novices as taro farmers (Table 2). Of fact, this is due to the

attractiveness of taro, which benefits farmers. The possibility of earning more income is the main allure of farmers in choosing the commodities to be planted. According to the data, 60% of farmers said that planting taro was always profitable, 33% said it was sometimes profitable, and the remaining 7%, who was the beginner in taro cultivation, still didn't know whether planting taro was profitable or not (Figure 4). In Bogor, taro is an economically viable commodity to cultivate and being a source of income for farmers, alongside rice, which gives the highest income among tuber crops [18][19]. The farmer's survival in plant cultivation is highly impacted by the sustain of the significant benefit obtained [20]. Taro is Bogor's icon product and is found easily in the market or another busy area. Its popularity has aided the growth of the taro-based processed food industry. Fresh taro tubers and their processed products are typical souvenirs from Bogor, considering that this city is a tourism destination close to Jakarta, the Indonesian capital city (Figure 1).

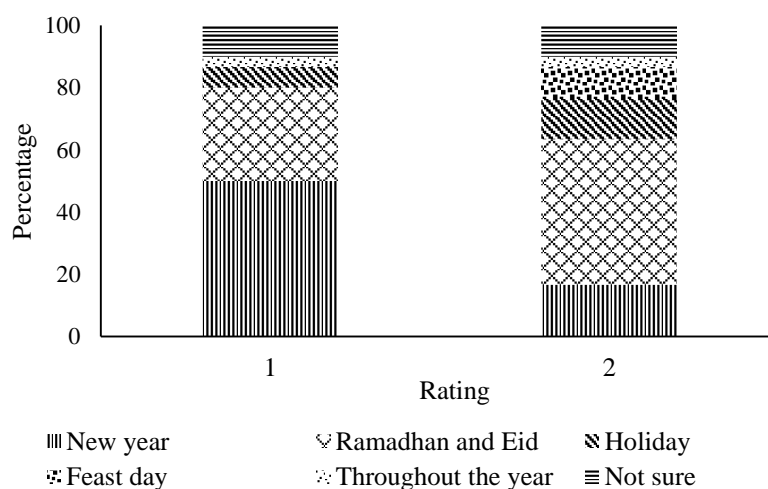


Figure 3. Taro sales season based on ranking by farmers.

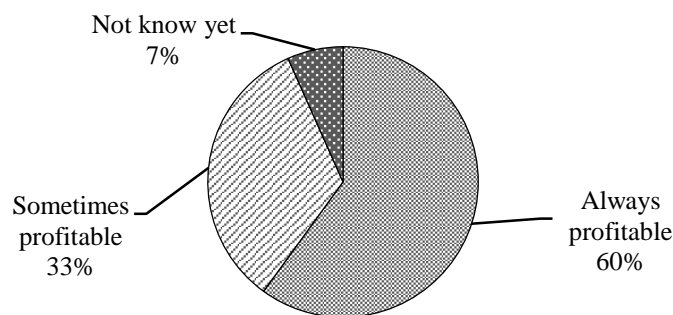


Figure 4. Percentage of farmers based on the profitability of taro cultivation.

Farmer's consideration in selecting taro to plant on their land because of the availability of seeds, the simplicity of cultivation, the ease of sale, and also marketable (Figure 5). According to Figure 5, the availability of seeds is the most important factor considered by farmers. This means that the limitation of seeds will be a barrier in taro cultivation and generally for taro development and conservation. According to the findings, farmers obtained seeds in three ways namely self-sufficient, purchasing, and gratuitously from other farmers. During the maintenance, farmers split the sucker which is an agronomic technique to produce large size tuber (Figure 6). The obtained suckers were replanted on the same field. However, it was not possible for the farmer who had limited field space area, so then the collected sucker

(Figure 6) was sold and also shared with neighbour farmers or other colleagues. This process occurred regularly, forming a cycling habit between farmers. This is thought to be a factor that leads the farmers to have a long experience in cultivating taro and explains why taro is always surely found throughout the year in Bogor. Sufficient seed availability must be met to increase and maintain the sustainability of agricultural commodity production [21], which must be reinforced by systematic site management [22].

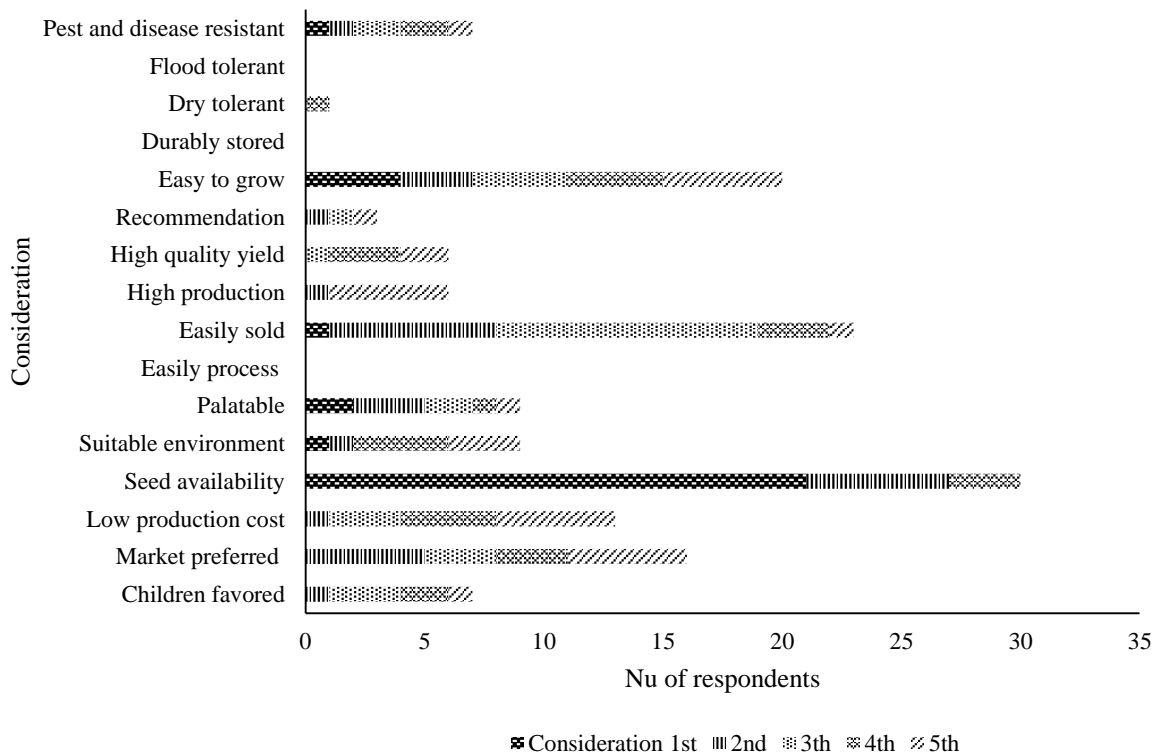


Figure 5. Farmer’s consideration in crop selection.



Figure 6. Separated suckers for seed materials.

3.2. Diversity of taro in Bogor

According to field observations, nearly all farmers interviewed cultivated dasheen type taro or *Colocasia esculenta* var *esculenta*. There were a few taro cultivars found namely Ketan, Bogor, Lampung, Pandan, Taiwan dan Gambir. The majority of farmers planted Taiwan cultivar (87%), Bogor (53%), Merah

(43%) and Ketan (27%) (Table 3). There were 1 to 5 cultivars found in the same field during a planting season (Figure 7). As many as 46.7% of farmers planted 2 cultivars and 26.7% planted 3 cultivars simultaneously (Table 3). The diversity of these cultivars was possibly caused by the seed exchange reciprocally between farmers that was ingrained into the social system. Social differentiation processes have shaped crop genetic diversity in farmer fields by seed exchange and familiarity relationship [23][24].

Farmers' main consideration in selecting a cultivar is seed availability, which Taiwan cultivar seeds are currently being the easiest to obtain. This cultivar dominated in farmers' fields with a population ranging from 1000 to 5000 plants (Table 3). Base on the farmer's evaluation that shows in Figure 8, the quality of cultivars Taiwan, Ketan and Bogor were equal, but cultivar Taiwan showed higher productivity and more resistance to pests and diseases than other cultivars. The Bogor cultivar was the most preferred taro by buyers and farmer families (Figure 8). Farmers were more focused on cultivating Taiwan cultivar because of the resistance to pests and diseases, resulting in tubers with smoother skin and larger size, even though the Bogor cultivar has a more delicate flavor [25]. The Bogor cultivar is well known in Indonesia, and it is a Bogor-specific local taro landrace that has been cultivated for decades and passed over generations. Farmers who chose local landraces were motivated by cultural values, culinary characteristics, nutritional values, as well as the flavor and color of the crops or foods prepared [26]. Long-term germplasm transmission continuously between groups and farmers with formal and informal distribution schemes has aided in the preservation of Bogor cultivar. It signifies that preserving the seed will ensure the survival of the cultivar and plant diversity [27]. The transfer of taro seeds that occurred throughout the years among farmer's communities in Bogor is traditional unplanned conservation. According to [28], seed exchange chains are essential and relevant to many issues of agrobiodiversity conservation even operated outside tend to adhere to unwritten rules.

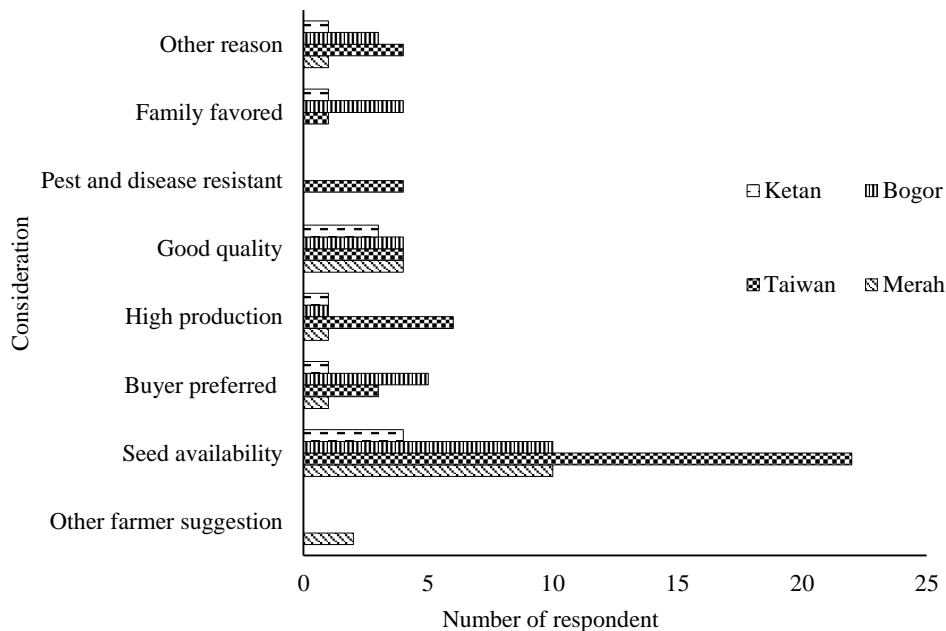
Table 3. Taro cultivars in Bogor.

	Category	Percentage
Number of farmers based on the total cultivars planted simultaneously on the same field	1 cultivar	20
	2 cultivars	46,7
	3 cultivars	26,7
	4 cultivars	-
	5 cultivars	6,7
Number of farmers base on the the type of cultivar* being planted during interview	Bogor	53
	Ketan	27
	Merah	43
	Taiwan	87
	Lampung	7
	Gambir	3
Population range of each cultivar* on farmer field during the interview	Pandan	3
	Bogor	500-1000
	Gambir	50
	Ketan	50-200
	Lampung	100-300
	Merah	500-1000
Pandan	50	
Taiwan	1000-5000	

*also known as: Bogor (=Bentul Bogor, Mentega), Ketan (=Hitam), Lampung (= Mentega Lampung), Merah (= Pontianak, Roma), Taiwan (= Sutra Baru, Pratama)



Figure 7. A few cultivars of taro planted simultaneously on the farmer’s field.



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Figure 8. Farmer consideration in cultivar selection.

Similarity analysis showed that the seven cultivars were divided into 3 major groups. The first group consisted of 3 cultivars i.e., Bogor, Lampung and Gambir, the second group also consisted of 3 cultivars i.e., of Taiwan, Merah and Ketan and the third group consisted only of Pandan cultivar (Figure 9). Characteristics that are easy to identify and distinguish directly on the field between these groups are plant stature and petiole color. Cultivars that were included in the first group looked smaller and shorter than cultivars in the second group. Petioles of cultivar Bogor, Lampung, and Gambir have green color with brown element forming lines or shading, cultivar Merah, Ketan and Taiwan have purple or green petiol with pink element meanwhile petiol of Pandan have a clear light green color (Figure 10). Another distinctive characteristic is the color of the corm cross-section. Cultivars in group one have a yellowish-white color corm while cultivars in group two have a white corm with a little bit of purple or pink element and cultivars in group three has a clear white color corm (Figure 11).

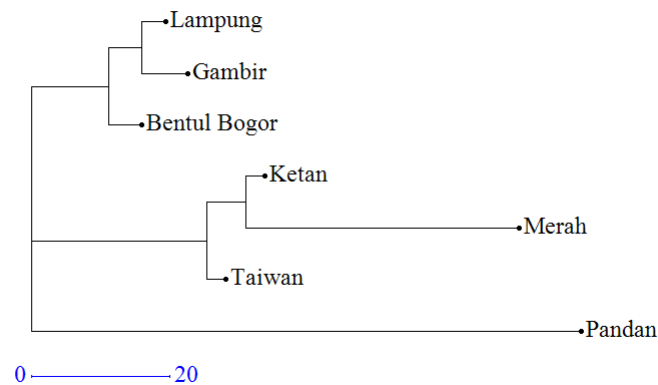


Figure 9. Similarity diagram of 7 cultivars in Bogor.

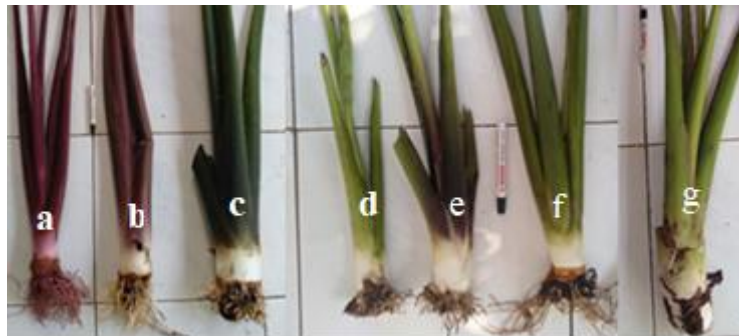


Figure 10. The appearance of the taro petiole; Merah (a); Ketan (b); Lampung (c); Pandan (d); Gambir (e); Bogor (f); Taiwan (g).



Figure 11. The cross section of taro corm; Merah (a); Ketan (b); Bogor (c); Lampung (d); Gambir (e); Pandan (f); Taiwan (g).

4. Conclusions

Taro cultivation has been going on for years in Bogor. This plant has provided economic benefits to farmers when grown in monoculture or intercropping but most farmers prefer to grow it in intercropping cultivation. The availability of seeds is a factor that determines the survival in cultivating of this plant for a long time. The traditional practices of exchanging seeds between farming communities have played a major role in the sustainability of taro cultivation. This exchange has also led to cultivars transmission and diversification of taro plants in Bogor. Taro varieties in Bogor can be divided into three similar groups. The diversity preserved in farmers' fields as positive impacts of seed transfers activities between farmers. This occurrence appeared traditionally and can be described as unplanned natural conservation.

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