Potential development of mangosteen (*Garcinia mangostana L.*) through optimizing land use in Pati, Central Java, Indonesia

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Abstract. Preservation of local genetic resources through exploration and conservation along with inventory and characterization are efforts to maintain food resources. Optimizing land use is very potential in the development of local genetic resources. Objective of the research was to characterize local mangosteen from Pati and to optimize the land use. The primary data was derived from the mangosteen characterization results. Information for the secondary data was derived from various sources relevant to the research. The data includes: land potential, climatology, and agroecosystems. Characterization was conducted on a cultivar of Gunungsari mangosteen as the parent plant used in this research. Format of the mangosteen description has been arranged in the form of standard blanks. Results of the research showed that the public yards are potential to develop local mangosteen of Gunungsari. Morphological characters of the Gunungsari mangosteen are red petals (44 A Red Group), circular shape p-1, average weight of the fruit ranges 119.22 g-180.53 g, yellowish white aril (NN 155 A yellowish white) and the taste is sweet and slightly sour. The specific characteristics of Gunungsari mangosteen are soft seeds, the aril tastes sweet and slightly sour, fine fibrous textures, delicate aroma, and high production. The residents' yards in Gunungsari Village are potential for the development of local fruits commodities especially mangosteen. In order to keep up the local genetic resources and to increase the economic value, Gunungsari mangosteen must be registered immediately to acquire the Certificate of Registration of Plant Varieties.

1 Introduction

The rich diversity of fruit species needs to utilized in order to meet the needs for foods, especially fruits [1]. The existence and sustainability of the local commodity diversities,

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including mangosteen, have still largely unexplored due to a lack of understanding and concern among the community. There are large number of local mangosteen commodities that spread across Indonesia are needed to be concerned due to recognition of ownership has not optimal.

Mangosteen is a tropical fruit which also known as the "queen of fruits" and belongs to the Clusiacea genus [2] which has large market share in the world [3] Mangosteen belongs to Guttiferae family originating from Southeast Asia including Indonesia, Thailand, and Malaysia [4,5]. The Indonesian Ministry of Agriculture has released 13 superior varieties of mangosteen as a result of selection by local residents in several regions in Indonesia [6].

The spread of mangosteen plants in Indonesia is, of course, inseparable from the existence of productive and unproductive plants. In 2021, there were 2,705,421 productive plants, 27,054 ha areas of harvest, 303,934 tons production, with average yield of 11.23 tons/ha and 112.34 kg/plant. In Central Java, out of 108,220 mangosteen plants, they resulted 1,082 ha areas of harvest that produced 8,784 tons/ha and average yield of 81.17 kg/plant [7].

The mangosteen productions in Pati Regency in 2019 (3,775 quintal), 2020 (5,640 quintal), and 2021 (10,377 quintal) [8]. The productivities have increased but they must be developed by optimizing the land use of the residents' yards. The potential development of mangosteen through appropriate land use will increase the economy of a region, create new jobs, and increase the people's income. In order to be utilized productively, the potential land use is affected by physical, social, economic, and environmental factors. Optimizing the potential land use in accordance to the land availability and suitability to avoid any damage to the ecosystem [9].

To optimize the land yard used, the assistance from the community is required. Based on research [10]. Increasing awareness of the potential of small plots of land to produce fruit for selfconsumption and finansial benefits can achieved through community service and empowerment.

An important factor that still needs attention in developing local commodities is characterization and registration for ownership recognition. Ownership certificate might increase sales value to increase farmer income and to protect genetic resouces.

In order to support the success and prospect of the agricultural products development, it requires the management of land, plants, and water. The horticultural commodity is the source of growth for the agricultural industry due to the inelastic feature of demand and income [11]. But today, mangosteen cultivation has still faced some obstacles, for instance, non-standard or uniform fruit quality, erroneous rooting system, long harvest period due to the seedling derived from seeds [12].

Identifying the available potency and applying the sustainable technology will increase the plant productivity to develop local genetic resources including plant breeding. Land identification and commodity characterization are required to preserve the local genetic resources. Furthermore, results of the characterization can be used as a requirement for registration of local varieties in order to acquire the acknowledgement of ownership, so that they would be potential to be developed. Objective of the research was to optimize the land use for mangosteen development from Pati.

2 Materials and methods

2.1 Location and time

The research was conducted from March 2019 to May 2020 at the residents' yards in Gunungsari Village of Telogowungu Subdistrict, Pati Regency.

2.2 Tools and materials

Stationery, color charts, scales, cloth mats, measuring tape, sample plants (stems, leaves, flowers, fruit, seeds).

2.3 Data collection

2.3.1 The primary data

The data was derived from the mangosteen characterization and the climate data from the Meteorological and Geophysical Agency (BMKG).

2.3.2 The secondary data

The data was derived from various resources relevant to the research. The data includes: land potential, climatology, and agroecosystems.

2.3.3 Plant characterization

Characterization was conducted on a cultivar of Gunungsari mangosteen as the parent plant used in this research. 10 samples of fresh fruits and leaves were examined. Various characters of the mangosteen were observed. Format of the mangosteen description has been arranged in the form of standard blanks [13].

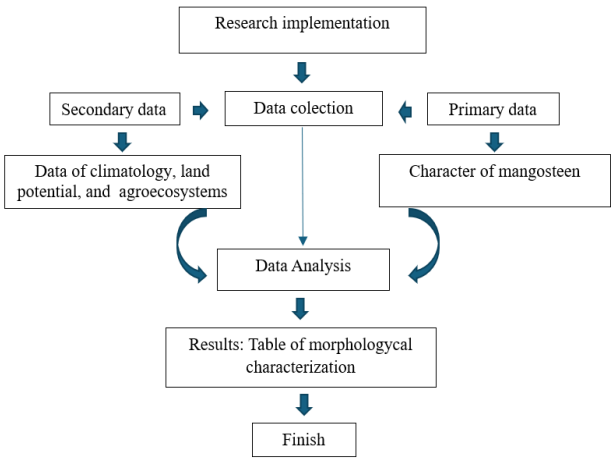


Fig. 1. Flowchart of research method.

The observed characters include external appearances of the tree (height and trunk circumference, canopy, branches, texture, and color of the trunk).

Leaves (shape, leaf edge, incision characteristic, leaf tip, color, direction, petiole length, length and width of the leaf, shape of the leaf base, and numbers of leaf/stalk, as well as space among leaves).

Flowers (color, position, petal color, and numbers of flower/bunch, number of stamens and pistils).

Fruits (type, shape, rind texture, length and width, weight, color of the aril (flesh), aril thickness, taste, texture, aroma, weight without aril, stalk, shape and base, color and rind, cross-section cutting, number of segments). Other character that was observed on fruit is seed (shape, color, numbers of seed/fruit, and seed size).

Morphological characterization of plant is also functioned to determine Genus, Species, Local name, Indonesian name, and Latin name.

2.4 Data analysis

Data of the results was analyzed descriptively and comparatively.

3 Result and discussions

3.1 Characteristics and geographical condition of the location

Total area of Tlogowungu Subdistrict is 94.46 km2/sq. It locates at the altitude of 172,87 masl. In 2020, the average temperature was 29.52 °C, humidity 79.09%, rainfall 208.98 mm, sun radiation 81.18% [14]. Telogowungu Subdistrict has latosol soil dan red yellow mediteran [15].

Based on data from the Meteorology Climatology and Geophysics Council, which was taken from the closest station in Jollong area of Pati Regency, it showed heavy rainfalls, 218 mm, during November – December 2019 which took place in December 2019. While rainfall during January – April 2020 was 651 mm which took place in January 2020.

Gunungsari Village is a part of Tlogowungu Subdistrict. The areas include rice field: 82.72 Ha; upland farm: 398.55 Ha; yards: 132.41 Ha. Topography of the Gunungsari Village is hilly with a slope of 15-35º. The altitude is 810 masl and average temperature is 30º C. it has moderate drainage and soil pH 6-7.5. Average rainfall in the last 10 years was 201 mm with a total of 121 rainy days [16].

3.2 Potential land and mangosteen development

Utilizing the yards has the potential to increase income so that it will support the family's economy [17]. Efforts to optimize the land use for the potential superior commodity development must be arranged according to the potential land and commodity production. Condition of the land use affect the water infiltration especially that depend on components and types of the vegetations [18,19]

There are many mangosteen plants in the residents' yards and even they have the largest planting area compared to the other fruit commodities. The planting area for mangosteen commodity in Gunungsari Village is: 1,685 ha with average production is 120 kg/plant and the potential production is 2 quintal/plant. Based on the planting area, 3% of the farmers have utilized the yards intensively for horticultural plants [16]. As the use of the yard has not been optimal yet, an appropriate technology is needed to increase production and income of the local community.

The productions of mangosteen in Gunungsari Village, Pati Regency and Central Java in the last four years are presented in Table 1.

Table 1. Production of Mangosteen [14,15]

Year	Gunungsari Village*) (quintal)	Pati Regency **) (quintal)
2018	32,506	2,433.00
2019	44,515	3,775
2020	52,569	5,640
2021	-	10,377.3

Based on Table 2, productivities of the mangosteen in Gunungsari Village and Pati Regency have increased year by year. The plant development in many places and the increase of productivity are due to the appropriate land suitability. Mangosteen will grow well at the altitude of 0-600 m asl, temperature 20–30 °C, soil pH 5-7, and rainfall 1500-3000 mm per year that fall evenly throughout the year [20]. The agroclimate condition in Pati particularly in Gunungsari Village has higher altitude and soil pH for the growing requirements of the mangosteen plants. Nevertheless, the potential development can be carried out by optimizing the land. Adaptability of the mangosteen to certain micro climate will create specific and unique properties, both in anatomical and morphological structures, which support its physiological functions [21]. Sari [22] Reported that the increase in temperature will directly affect on physiology of the plant.

Based on production and productive plants of mangosteen commodity in Pati Regency, there are still many plants which are not producing and there is a decline in production (Table 2).

Table 2. Production and mangosteen plants in Pati Regency [14].

Year	Productive Plant		Production (quintal)
	Producing	Not producing	
2014	1,706	24,585	6,327
2017	22,849	104,587	54,774
2018	2,846	26,146	2,433

It was presumed that such decline in production was due to the climate shift. The climate change will affect the yield and quality of the mangosteen [23]. A strong correlation was found between variations of the mangosteen harvests, which was thought to be due to the microclimate (agroclimate) dynamics around the cultivation, even the seasonal shifts result in a mangosteen exporting country experiencing a decline in production and even crop failure [24]. It is allegedly that lack of nutrients in the soil needed by the plants, so fertilization is necessary.

The chemical properties of the soil relate to the speed of flowering and fruiting, although this correlation requires further verification [24]. However, the application of P fertilizer may affect the growth of mangosteen seeds particularly the plant height, branch length, numbers of branches and leaves [25]. Martias [26] Reported that excessive micro nutrient of Mangan in the soil will influence on the yellow sap contamination that can be overcome by providing sufficient Ca and ensuring sufficient sunlight during the fruiting period [27,28].

In order to optimize the land use for mangosteen development, it requires an evaluation on physical, chemical, and biological properties of the soil. Characterization is required for preservation of the local commodities that being developed with the hope that it can be used for registration requirements in order to acquire some protection, utilization, and commercialization as a state asset.

3.3 Characterization of Gunungsari Mongosteen

Pati Regency has high diversities for local fruits, but only few that have certificates of Registration of Plant Varieties from the Ministry of Agriculture, namely Lumut rose apple and Pamelo orange. In order to protect local varieties which have not been registered, an identification and characterization must be conducted as requirement of registration to the Ministry of Agriculture through the Centre for Plant Variety Protection and Agricultural Licensing (PVTPP). Characterization of mangosteen was performed both qualitatively and quantitatively [29]. Gunungsari mangosteen is local fruit from Pati Regency that has been characterized and ready to be registered to PVTPP to acquire an acknowledgement as the property of Pati Regency. The morphological characterization results of Gunungsari mangosteen are presented in Table 3.

Table 3. Characteristics of plant and leaves of Gunungsari mangosteen from Pati

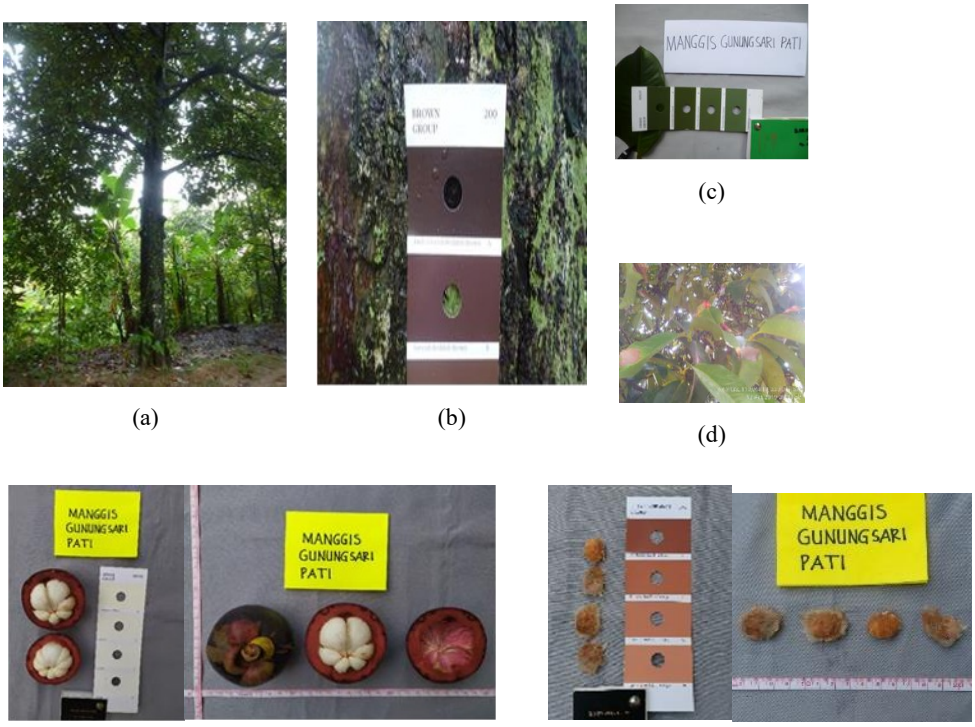
Plant		
Height	:	17 m
Trunk circumference	:	150 cm
Canopy shape	:	Circular/Umbrella
Canopy condition	:	Dense
Canopy width	:	9 m (W-E) 12 m (N-S)
Trunk shape	:	cylindrical
Branching	:	Curving upright
Position of the lowest branch	:	1-5 m
Trunk texture	:	Rough
Color of the bark	:	Dark brown, Dark Greyish Reddish Brown (200 A)
Leaf		
Shape	:	Ovoid
Edge	:	Flat (smooth)
Incision characteristic	:	Flat
Leaf tip	:	Tapered
Color of young leaves	:	Yellowish green (144 B0 Yellow Green)
Color of old leaves	:	Yellowish green (144 B0 Yellow Green)
Color of the lower leaves	:	Yellowish green (144 B0 Yellow Green)
Color of the upper leaves	:	Green (141 A Green Group)
Type	:	Ellipse
Direction	:	Sideways and upward
Petiole length	:	1.5-2.5 cm
Number of leaves/stalk	:	22-24 blades
Space among leaves	:	3.5-6.5 cm
Leaf size (p x l)	:	(15.5-20)x(8-10) cm
Shape of the leaf base	:	Obtuse

Gunungsari mangosteen tree grows at the yard owned by Mrs. Marfuah in Gunungsari Village, Telogowungu Subdistrict, Pati Regency, at the altitude (172.87 m asl) [14]. Morphological characterization results of mangosteen on the plant parts showed that height of the tree is 17 m, and the trunk circumference is 150 cm. The condition indicates that Gunungsari mangosteen has excellent performance. Agus Santini [20] reported that mangosteen trees which grow naturally in tropical forests have a height of up to 25 m and trunk diameter of 45 cm. An important factor that affects the plant growth is the environment,

which influence the physiological and morphological characteristics of the plant populations even though they are similar [30].

The mangosteen plant has circular/umbrella and dense canopy. The widths are 9 m (W-E) 12 m (N-S). Even though the plant has dense canopy, but it does not affect the moisture which influence the fruit quality. Moisture is a significant risk that affects the growth of thrips population [31]. The trunk has cylindrical shape with a curved upright branching. Position of the lowest branch: 1-5 m. Trink texture: rough. Color of the bark: Dark Greyish Reddish Brown (200 A). As reported by Rugayah et al. [32] a factor that affects the roughness of the mangosteen bark is light intensity interception, and based on several studies, high level of the bark surface roughness on mangosteen plant is due to the shade from other plants.

Mangosteen leaves are ovoid. The leaf edge is flat (smooth) with flat incision. The leaf tip is tapered. Color of the young leaves: Yellowish green (144 B0). While the old leaves: Yellowish green (144 B0). Color of the lower leaves: Yellowish green (144 B0). Color of the upper leaves: Green (141 A). Leaf type: Ellipse that directed to sideways and upward. Petiole length: 1.5-2.5 cm and number of leaves/stalk: 22-24 blades. Space among leaves: 3.5-6.5 cm. Leaf size (p x l): (15.5-20) x (8-10) cm. Shape of the leaf base is obtuse. Characterization of Gunungsari mangosteen is presented in Figure 2.



(a) (b) (c) (d) (e) (f)

Fig. 2. Gunungsari mangosteen: (a) tree, (b) trunk, (c) leaf, (d) flower, (e) fruit, (f) seeds

Characterization results for flowers, fruits, and seeds are presented in Table 4 below:

Table 4. Characterization of flowers, fruits, and seeds of Gunungsari Pati mangosteen

Flower		
Flower stem	:	Yellowish green, N144 C (Yellow Green Group)
Position of flower	:	Axil
Number of flowers/bunch	:	1
Sepal	:	Red 44 A (Red Group)
Number of stamens	:	25-30
Number of pistils	:	4- 7
Petal	:	Red, 44 A (Red Group)
Stamen	:	Yellow
Pistil	:	Red, 44 A (Red Group)
Fruit		
Fruit type	:	Even
Fruit shape	:	Spherical P-1
Rind texture	:	Smooth
Fruit length	:	4.3-6 cm
Fruit width	:	5.5-6.7 cm
Fruit weight	:	119.22-180.53 gram
Color of aril (flesh)	:	White, NN 155 A (Yellowish White)
Aril thickness	:	0.7-1 cm
Aril taste	:	Sweet and slightly sour
Aril texture	:	Fine fibrous
Aroma	:	Delicate
Weight without aril	:	70.29-12.,87 gram
Pedicle	:	Yellowish green, N 144 C (Yellow Green Group)
Fruit base	:	Flat-shouldered
Shape of the fruit base	:	Concave
Rind of the young fruit	:	Light green, 150 C Brilliant Yellow Green (Yellow Green Group)
Rind of the ripe fruit	:	Purple, N.186 B (Dark Greyish Purple B)
Rind thickness	:	0.9-1.2 cm
Cross-sectional of the fruit	:	Circular
Number of segments	:	5 - 8
Fruiting schedule	:	November-April
Production/Tree/Year	:	3 quintals
Resistance in Shipping	:	Resistant
Seed		
Seed shape	:	Flat
Color of the seeds	:	Brown, 174 B (Greyish Reddish Orange)
Number of seeds/fruit	:	1 - 3
Seed size (p x l)	:	(1.9-2.6 cm) x (1. 4-1.8 cm)
Weight/seed	:	1.91-2.85 gram
Specific characteristics	:	Sweet and slightly sour, less seed and the seed is soft

The mangosteen flower is yellowish green, N144 C (Yellow Green Group). Position of the flower is at the leaf axil on the twig. Number of flower/bunch is 1 (one). The petals are red 44 A (Red Group). Number of stamens: 25-30 and number of pistils: 4-7. Color of the petal: Red 44 A (Red Group).

Mangosteen has even type with spherical shape P-1. The rind texture is smooth. Not all of the mangosteens look smooth, but there are some that have "dotted" rinds. Most of mangosteen fruits, which are cultivated in the lowland < 500 m asl, have dotted rinds [33]. However, contamination of the yellow sap found in mangosteen fruit causes low export quality of the mangosteen, and it is presumed that it contributes to induction, one of which is an excess of manganese [34].

Economically, the price of mangosteen is relatively expensive because it has many benefits, for example, the rind is useful as the source of natural antioxidants, anti-inflammation, antihistamines, and antibacterial which included in xanthone group [3]. The smooth rinds, which have no puncture scars from the thrips, are potential to be developed to meet the market demand. Smooth rinds of the mangosteen are considered as high-quality fruit [35]. Fruit length: 4.3-6 cm and fruit width: 5.5-6.7 cm.

Fruit measurement is a procedure for measuring the parameters of pointed and round fruit based on their diameter and weight [36]. Mangosteens have diverse weights (Tabel 3). Mangosteen diversities, both quality and quantity, are not only affected by genetic factor, but also climate. It causes local climate plays strong role in the formation of local varieties. The average weight ranges 119.22-180.53 gram. According to Standard Codex Stan 204-1997.3 (Tabel 6). Weight of the mangosteen is included in the classification D (101-125 gram) and E (>125 gram) [37].

Table 5. Classification of mangosteen fruits by size according to the Standard Codex Stan 204-1997 [37].

Size Code	Weight (g)	Diameter (mm)
A	30 - 50	38 - 45
B	51 - 75	46 – 52
C	76 - 100	53 - 58
D	101 - 125	59 - 62
E	> 125	> 62.4

The aril (fruit flesh) color of Gunungsari mangosteen is NN 155 A (Yellowish White). Thickness: 0.7-1 cm. Taste: sweet and slightly sour. Texture: fine fibrous. Aroma: delicate. Weight without aril: 70.29-129.87 gram. Color of the pedicle (fruit stem) is N 144 C (Yellow Green Group). Fruit base: flat and concave. The rind color of the young fruit: Brilliant Yellow Green (150 C Yellow Green Group) and the rind color of the old fruit: Brilliant Yellow Green (150 C Yellow Green Group). The rind thickness: 0.9-1.2 cm. the epidermis character: none.

Cross section of the fruit: Round. Number of segments: 5-8. Pedicle resistance is an important morphological character because it could maintain quality of the fruit which will affect the selling price of the fruit. As reported by [38]. the best characteristic of the fruit quality is the intact stem. Therefore, the morphological characters that relate to fruit storability must be concerned.

Mangosteen bears fruits in November – April. It bears fruits in rainy season. The period of bearing fruits: on season. At the eastern areas, on season period starts from September and harvest time starts from April to June [39] Fruit production: 300 kg/tree/year. Productivity of Gunungsari mangosteen is higher than the average productivity of mangosteen in Indonesia in 2021 about 112. 34 kg/tree [7]. When compared with mangosteen production in the off season, breeding mangosteen in the off-season produced heavier fruits [39]

The main characteristic of Gunungsari mangosteen is the seed which soft or tender. Moreover, the seeds are flat-shaped and there are not even seeds inside the aril (flesh of fruit). Colors of the seeds: 174 B (Greyish Reddish Orange). Number of seeds/fruit: 1-2 seeds. Seed size (pxl): Length (1.9-2.6) x (1.4-1.8) cm. Seed weight: 1.91-2.85 gram.

4 Conclusions

The residents' yards in Gunungsari Village are potential for the development of local fruits commodities especially mangosteen. Gunungsari mangosteen has specific characteristics such as soft seeds, sweet and slightly sour tastes, fine fibrous textures, delicate aroma, and high production. In order to keep up the local genetic resources and to increase the economic value, Gunungsari mangosteen must be registered immediately to acquire the Certificate of Registration of Plant Varieties.

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