

THE ECONOMIC VALUE OF PADDY FIELD BASED ON ITS FACULTIES TO SUPPORT LAND PRODUCTIVITY IN LOWOKWARU SUBDISTRICT, MALANG, EAST JAVA

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Abstract: Paddy fields commonly possesses intrinsic natural processes and external benefits that support land productivity. Soil fertility which shown by nutrient contents (Nitrogen, phosphorous, potassium and organic matters) gives evidence of the existence of natural processes that occur within the soil that will be lost when land conversion happens. Similarly the external benefit of paddy fields as container of domestic waste compost will be lost too due to the land conversion. These functions and benefits are very important but are not appreciated by society. Giving economic values to paddy fields based on these two faculties will inform the society how valuable paddy fields are as natural resources. The economic valuation method used in this research is the Replacement Cost Method (RCM) with mathematical formula as follows $NELSPK = (U_N \times P_n + U_P \times P_p + U_K \times P_k + U_{BO} \times P_{BO}) \times A$ for economic value of paddy field as provider of nutrients contents (N, P, K) and organic matters; and $NELSPK = (WK/KK) \times PK \times A$ for economic value of paddy field as compost container. The research was taken place in 6 sub-subdistricts in Lowokwaru Subdistrict with 205 hectares of paddy fields. The economic value of paddy field is about Rp 133,31 billions for economic value of paddy field as provider of nutrients contents (N, P, K) and organic matters; and Rp 7,76 billions for economic value of paddy field as compost container. For both faculties the average economic value Rp 688,18 million per hectare. Paddy fields in Lowokwaru Subdistricts are very feasible to be protected from conversion due to its satisfactory soil fertility and its potential to be increased, thus it is able to maintain land productivity. Therefore, it is very reasonable to call paddy fields as productive open green space in which economic and social activities can be developed.

Keywords : *Soil Nutrients, Domestic Waste Compost, Economic Value, Paddy Field.*

INTRODUCTION

Paddy field located in the urban area has been known to have a significant role in maintaining the environment quality through its external benefits that are produced indirectly (Yokohari *et al.*, 1997; Matsuno, Hatcho, dan Shindo, 2007). This role makes paddy fields can function as open green space in urban areas. Thus, it is very beneficial for the community when the remaining paddy fields are protected.

As open green spaces, the paddy field ecosystem will serve as conservation areas that sustain hydrological processes; as flood mitigation areas which provide retention basin; as biodiversity development areas; as areas that creates microclimate and pollutant reductions; as public recreation areas; as areas that protect natural,

artificial and historical resources; and as disaster mitigation / evacuation areas (Xiao *et al.*, 2005; Natuhara, Y. 2013; Meijide *et al.*, 2017). The paddy fields can function as provision of employment for marginal communities (farmers and farm labor) in urban areas and continue to generate economic benefit by producing food crops. (Iiyama, Kamada dan Nakagoshi, 2005; Frimawaty *et al.*, 2013; Ndiiri, *et al.*, 2013).

Paddy fields' productivity in urban areas is not secondary compared to productivity in other production areas. One determinant of paddy fields' productivity is soil fertility and its ability to continuously provide soil nutrients at certain rate and proportion to support growth and crop production (Poerwowidodo, 1992; Alam *et al.*, 2017). Soil nutrients and organic matter can be used as an

indicator of soil productivity and fertility that affect plant growth and crop production (Bauer dan Black, 1994; Carter, 2002; Brady dan Weil, 2004; Krull, Skjemstad dan Baldock, 2004)

Paddy fields' productivity can also be affected by application of agrotechnology conducted by farmers in managing their farms (Soemarno, Prasetya dan Kusuma, 2016). To increase paddy fields' productivities, additional organic matter can be given in the form of compost that will act as soil enhancer to improve soil structure as well as soil physical, chemical and biological properties (Ponnamperuma, 1984; Ladha et al., 2000; Dawe et al., 2003; Goyal, et al., 2009; Pambudi, Indrawan dan Soemarno, 2017). Compost can be produced from organic matters derived from domestic waste.

In big cities of most developing countries, large amounts of solid waste or liquid waste resulting from human activities are transported and disposed in landfills (Henry, Yongsheng dan Jun, 2006; Vidanaarachchi, Yuen dan Pilapitiya, 2006; Manga, Forton and Read, 2008; Lombrano, 2009; Guerrero, Maas and Hogland, 2013; Nurita dan Hassan, 2013). The management and disposal of urban solid waste often turn into the most common problem in major cities around the world (Shekdar, 2009; Ngoc dan Schnitzer, 2009; Bel and Fageda, 2010; Xudong, et al., 2010). However, in some major cities, the organic components of municipal waste are recycled and processed into fuel and compost that is used to increase agricultural productivity (Metin, Eröztürk, Neyim, 2003; Sæbø dan Ferrini, 2006; Wilson, Velis dan Cheeseman, 2006; Weber et al., 2007; Troschinetz dan Mihelcic, 2009; Al-Khatib et al., 2010; Himanen dan Hänninen, 2011; Komilis et al., 2012; Rogge dan deJaeger, 2012; Chen et al., 2016; Taeporamaysamai dan Ratanatamskul, 2016; Vigneswaran, Kandasamy dan Jahir, 2016). The application of compost processed from domestic waste to paddy fields not only will increase crop production and land productivity but also will exercise paddy fields as a municipal waste disposal (Levy dan Taylor, 2003; Zheljazkov and Warman, 2004; Hargreaves, Adl dan Warman, 2008; Farrell dan Jones, 2010; Wei et al., 2017).

The problem at hand in regard of protecting the remaining paddy fields is that their environmental services are under appreciated. The natural ability of paddy fields to provide nutrients and organic matters, as well as its potential ability to dispose domestic-waste-compost are very significant yet often underated. The purpose of this study is to measure the economic value of paddy fields as the provider of natural nutrients and as the disposal of domestic-waste-compost.

MATERIAL AND METHODS

The research was conducted in 205 hectares paddy fields areas of Lowokwaru Subdistrict, Malang City, East Java.

The research was conducted by using quantitative approach through survey method. Data used in this research are primary and secondary data. Primary data were collected by direct sampling in the field and tested in the soil laboratory; while the data related to the cultivation system is obtained through interview with farmers. Secondary data includes data of population, waste production, and spatial plan. Secondary data and information are obtained from various official documents issued by related institutions and various publications. Descriptive analysis is used to explain the ability of paddy field as a provider of natural nutrients and organic matters; and disposal of domestic-waste-compost.

The economic valuation method used in this research is Replacement Cost Method (RCM) with mathematical formula as follows:

- A. The Economic Value of Paddy Field as Provider of Natural Soil Nutrient (N, P, K) and Organic Matters (NELSPUH)

$$NELSsFPUH = (U_N \times P_n + U_P \times P_p + U_K \times P_k + U_{BO} \times P_{BO}) \times A \dots\dots\dots (1)$$

Where: NELSFPUH = Economic Value of Paddy Field as Provider of Natural Soil Nutrient (N, P, K) and Organic Matters (Rp); U_N = the quantity of Nitrogen contained in paddy field (kg/ha); P_N = Price of N-contained manufactured fertilizer (Rp/Kg); U_P = the quantity of Phosphor contained in paddy field (kg/ha); P_P = Price of P-contained manufactured fertilizer (Rp kg); U_K = the quantity of Potassium contained in paddy field (kg/ha); P_K = Price of K-contained manufactured fertilizer (Rp kg)); U_{BO} = the quantity of organic matter contained in paddy field (kg/ha); P_{BO} = Price of organic manufactured fertilizer (Rp/ha); A = the acreage of paddy field (ha)

To convert the quantity of soil nutrient (N,P,K) and organic matter from laboratory analysis results into field dimension he calculation is made as follows:

1. Nitrogen is expressed in terms of percentage (%) which means in every 100 grams of soil contains 1 gram of N-total. N in the soil consists of organic and inorganic N where the organic N is much greater (95%) than inorganic N (5%). According to Patrick and Reddy (1978)

about 2 - 5% organic-N is converted to inorganic-N annually.

2. Phosphorus is expressed in mg/kg unit which means in every 1 kg of soil contains 1 gram of P.
3. Potassium is expressed in me/100g which means in every 100 grams of soil contains 1 me of K, where 1 me equals to 39 mg K.
4. Organic matter (BO) expressed in percentage (%) which means in every 100 grams of soil contains 1 gram of organic matter.

The quantity of nutrients per hectare is calculated within 25-cm depth which is equivalent to 2,500,000 kg of soil.

The economic value of soil nutrients (N, P, K) and organic matters is calculated by converting the quantity of each soil nutrients and organic matter into the quantity of relevant manufactured fertilizers used by local farmers and hence their prices. The related conversion is shown at table 1 below:

Table 1. Conversion of soil nutrients into relevant manufactured fertilizers

No	Nutrient Substance	Name of Manufactured fertilizer	Active material composition	Fertilizer price per kg
1	N organic	Petroganik	12,30 % C, C/N ratio 15,19	IDR 1,500
	an-organic	Urea	46 % N	IDR 4,500
2	P	SP36	36 % P ₂ O ₅	IDR 5,850
3	K	KCl	60 % K ₂ O	IDR 6,000
4	Organic material	Organic fertilizer	-	IDR 1,000

Note :

Value of N in Petroganik 8 gr/kg

Conversion of P to P₂O₅ is 2.29

Conversion of K to K₂O is 1.2

B. The Economic Value of Paddy Field as Domestic Waste Disposal (NELSPK)

$$\text{NELSPK} = (\text{WK}/\text{KK}) \times \text{PK} \dots\dots\dots(2)$$

Where: NELSPK = Economic Value of Paddy Field as Domestic Waste Disposal (Rp); WK = The Capacity of Paddy Field to Contain Compost (ton/ha); KK = Coefficient of Domestic Waste turned into Compost (0,4); PK = The Cost of Domestic Waste Management (Rp/ton).

The cost of domestic waste management in the city of Malang is about Rp 9.386,- per ton. This cost is calculated based on: (the income from municipal retribution of domestic waste management per year + the Government fund of the city waste Management per year)/quantity of waste manage in the same year.

To calculate the potential of paddy field of receiving compost processed from domestic waste, the research used a corresponding the amount of compost apply on SRI (System of Rice Intensification) which is between 14,6 - 20,9 ton/ha/year or at 17,75 ton/ha/year average. Then, the potential compost that can be received by the paddy fields is calculated with the following mathematical formula:

$$\text{WK} = \text{PO} \times \text{A} \dots\dots\dots(3)$$

Where WK = The capacity of paddy field to receive compost (ton/year); PO = The quantity of compost apply in paddy field (ton/ha/year); A = the acreage of paddy field (ha)

To calculate the potential of domestic waste produced in one year (365 days) by communities in Lowokwaru Subdistrict, the research used the average amount of waste produced per person in a big city, which is about 0.5 kg/person/day, while the proportion of domestic waste in a municipal waste is calculated for the city of Malang at 0.7637. Thus, the mathematical formula for the potential amount of domestic waste produced is as follow:

$$\text{JSD} = (\text{P} \times \text{S} \times \text{KK} \times 365)/1000 \dots\dots\dots(4)$$

Where JSD = Potential of domestic waste produced (ton/year); P = Number of population (body); S = Waste Production (kg/person/day); KK = Proportion of Domestic Waste in Municipal Waste (0.7637).

RESULT AND DISCUSSION

Paddy Field As Provider of Natural Soil Nutrient (N, P, K) and Organic Matters

Soil nutrients are needed by plants to grow and mature in different forms and amounts at every phase of plant growth. There are no less than sixteen essential nutrients that must be sufficiently available for the plant to grow and develop well. Nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) are substances that are required by plants in large quantity, known as macro essential nutrients, while other nutrients are called micro essential nutrients because they are needed in small quantities (Zhang and Wang, 2005).

The presence of nutrients and organic matters in soil can occur naturally or unnaturally by adding fertilizer. Farmers apply manufactured fertilizers after considering that nutrients are not available for plants naturally. Three substances that are often given as fertilizers are N, P, and K to increase rice production (Hirzel and Rodríguez, 2013). The availability of nutrients in soil and plant tissue is also highly determined by the character and behavior of each nutrient.

Nitrogen is very significant for plant at growth stage. Nitrogen is known as the nutrient that often limits plants' production. (De Datta, Comez and Descalsota, 1988; Kim, 1991; Matsunami, Matsunami and Kokubun, 2009; Artacho, Bonomelli, and Meza, 2009; Hirzel, Pedreros, and Cordero, 2011). Plants suffering from N-deficiency will become dwarfed due to root growth inhibition, while plants with N-excessiveness will easily fall down or catch pest disease.

Another macro substance that can cause critical in growth stage is phosphorus (P). Lack of phosphorus will affect general plants growth because it cause inhibition to other substances (Saleque, et al., 1998a; Islam, Islam and Sarker, 2008). Phosphorus is very significant on the growth and production stage of paddy plants, especially for formation of flower and seed, maturing of grain, root development, and resistance to plant diseases.

Potassium (K) is required by plants as enzymes activator. Potassium involves in all the

biochemical reactions that take place in plants and thus is known as the most limiting substance. Potassium is not an integral component of a plant, but it is fundamentally required as catalyst of various essential physiological processes. The presence of sufficient available K in the soil will ensure the plant rigidity. Furthermore, Potassium affects plants to be more resistant to various diseases and stimulate root growth. K is known as the determinant of production quality. (Saleque et al., 1998b; Soepardi dan Ismunadji, 2007).

In addition to the above three substances, another important component of the soil that benefits to plant growth is the organic matter. This organic matter is a complex and dynamic system, which is materialized from the remains of living material (plants and/or animals) that constantly changing due to biological, physical, and chemical processes that occurs in soil. Organic matters (BO) possesses an important role in determining soil's ability to support crop production, so that when soil is lacking organic matter thus crop production will decrease. The low amount of organic matter in soil informed that the soil has been damaged. Healthy soil contains sufficient organic matters which is important to ensure agricultural productivity (Suriadi dan Nizam 2005).

The existence of nutrients in soil does not mean its continuous availability for plants, nevertheless it shows its potential availability. To determine the condition of nutrients in paddy field in Lowokwaru subdistrict, soil analysis was performed. The soil samples were taken when paddy field was at fallow state which were after harvesting of the first planting season and before the commencement of second planting season. At this state, it is assumed that the state of nutrient present in soil are residue from previous season that are not available to plants and not washed away. This condition is considered to be the most natural content of soil nutrients and organic matter at research area. The soil analysis results are listed in Table 2.

Tabel 2. Soil analysis results at Lowokwaru Subdistrict

No	village	N -Total %	P mg/kg	K me/100g	BO %	C/N
1	Tasik Madu	0.14	12.70	0.19	2.13	13
2	Tunggul Wulung	0.14	11.16	0.19	3.38	14
3	Mojolangu	0.12	4.49	0.29	3.08	15
4	Jati Mulyo	0.09	2.73	0.22	2.38	15
5	Merjosari	0.11	9.53	0.49	2.76	15
6	Tlogomas	0.10	11.21	0.03	2.65	15

Source : primary data analysis

Note : BO = Organic Matter

Based on the above soil analysis results, in general N and P substances are at low levels, while K and Organic Materials are at moderate level. This condition occurs because farmers at the research areas apply fertilizer only twice in one planting season. Firstly, at the 15 - 20 days after Planting and secondly, at 40 - 45 days after planting with small dosage of fertilizer. However, the N required by plants could be fulfilled from the microorganism composting process which occurs because the soils have C/N ratio of 13 - 15. Soils with C/N ratio between 10 - 15 have the ability to release N well so that the plant can grow normally (Syekhfani, 2010).

Another favorable quality of soil in research areas is that it contains sufficient organic matter. Healthy soil ideally contains > 5% organic matter while soil with < 2% of organic matter is classified as insufficient and considered unhealthy. Organic matter is an integral part of the soil that is very significant to changes in physical, chemical and biological properties of the soil so it becomes a very important indicator of soil qualities (Carter *et al*, 1997).

The existence of sufficient organic matter in soil can reduce the use of manufactured artificial fertilizers because the organic material is a source of nutrient reserves for plants. The advantage of the soil with sufficient organic matter is that it improves its physical condition thus the soil will be easily cultivated. Syekhfani (2010) explains the advantages of soil with rich humus and organic matters include the ability to promptly compost plant residues, the formation solid aggregate, the reduction of soil hardening and crusting, the increase internal drainage, the improvement of internal water flow and the increase in water and nutrient holding capacity. Thus, the rationale of why the paddy fields Lowokwaru subdistrict is still productive as agricultural land is because the soil is

very responsive fertilization and any other agri-technological engineering undertaken by the farmers.

To determine the nutrient content of N, P, K and Organic Matter within every hectare of paddy field, the calculation is shown in Table 3.

Most people are not aware about the benefits of soil's nutrient content in their lives. People should be informed that its is the presence of soil's nutrients that put food on the table via very long intricate processes and services produced by agricultura ecosystem. The Millenium Ecosystem Assessment acknowledged 4 type of services provided by an ecosystem, which are provision services, regulatory services, cultural services and support services. The first three services are directly contacted with human while the last mentioned is the type of service that maintains other services' sustainability. According to Rodriguez *et al*. (2006) the support services such as soil formation and nutrient cycles, often considered to be an aspect that is not taken into account by the community.

To raise community appreciation of paddy field, they should be introduced to the concept of economic value of paddy field based on its ability to provide natural soil nutrients and organic matter. The environmental and economic impacts of decreasing agricultural soil fertility, due to plant over-absorbtion, erosion, intensive cultivation, low organic matter content, and inadequate fertilization, are real and direct threat to food security and people's livelihoods (Bosede, 2010). The economic valuation of a natural resource is an effort to quantitatively calculate (monetary) the benefits of goods or services produced by that specific natural resource, which is based on market value if it exists or non-market value if it does not exist.

Tabel 3. Nutrient content of N, P, K and BO per hectare of Soil

No	Village	Nutrient Content (kg/ha)				
		N organic	N anorganic	Phosphor	Pottasium	BO
1	Tasik Madu	3,325	175	31.75	185.25	53,250
2	Tunggul Wulung	3,325	175	27.90	185.25	84,500
3	Mojolangu	2,850	150	11.23	282.75	77,000
4	Jati Mulyo	2,138	113	6.83	214.50	59,500
5	Merjosari	2,613	138	23.83	477.75	69,000
6	Tlogomas	2,375	125	28.03	29.25	66,250
Average		2,771	146	21.59	229.13	68,250

Source : primary data analysis

Note : BO = Organic Matter

The nutrient cycle is a type of ecosystem service that is difficult to impose monetary value (price) on because there is no market value that can be imposed on this process. This cycle is a manifestation of the existence of highly complex, efficient and sophisticated processes in soil that can not be matched by human fabricated processes, so that no human activity-based service activity can describe the processes occurring within the soil. However, in simple terms, the economic value of

the soil's ability to provide nutrients and organic materials is done by using the final product value of the cycle, ie manufactured fertilizer (petroganik, urea, SP36, KCl and organic fertilizer). The following is the calculation of the amount of nutrients in the soil, the conversion into manufactured fertilizers and the economic value of paddy fields based on their ability to provide natural soil nutrients and organic matter per village in Lowokwaru subdistrict (Table 4 - 9).

Tabel 4. Condition of soil nutrients and its conversion to manufactured fertilizers and its economic value per hectare in Tunggul Wulung

No	Nutrient content (kg/ha)		Artificial fertilizer (kg/ha)		Economic value (IDR/ha)
	Type	Amount	Name	Amount	
1	N organik	3,325	Petroganik	410,624	615,935,976
	an-organik	175	Urea	81	362,250
2	P	27.90	SP36	177	1,038,229
3	K	185.25	KCl	371	2,223,000
4	Organic material	84,500	Organic fertilizer	84,500	84,500,000
				Amount	704,059,454

Source : Primary data Analysis

Tabel 5. Condition of soil nutrients and its conversion to manufactured fertilizers and its economic value per hectare in Tasik Madu

No	Nutrient content (kg/ha)		Artificial fertilizer (kg/ha)		Economic value (IDR/ha)
	Type	Amount	Name	Amount	
1	N organik	3,325	Petroganik	410,624	615,935,976
	an-organik	175	Urea	81	362,250
2	P	31.75	SP36	202	1,181,497
3	K	185.25	KCl	371	2,223,000
4	Organic material	53,250	Organic fertilizer	53,250	53,250,000
				Amount	672,952,722

Source : Primary data Analysis

Tabel 6. Condition of soil nutrients and its conversion to manufactured fertilizers and its economic value per hectare in Mojolangu

No	Nutrient content (kg/ha)		Artificial fertilizer (kg/ha)		Economic value (IDR/ha)
	Type	Amount	Name	Amount	
1	N organik	2,850	Petroganik	351,963	527,945,122
	an-organik	150	Urea	69	310,500
2	P	11.23	SP36	71	417,710
3	K	282.75	KCl	566	3,393,000
4	Organic material	77,000	Organic fertilizer	77,000	77,000,000
				Amount	609,066,332

Source : Primary data Analysis

Tabel 7. Condition of soil nutrients and its conversion to manufactured fertilizers and its economic value per hectare in Merjosari

No	Nutrient content (kg/ha)		Artificial fertilizer (kg)		Economic value (IDR)
	Type	Amount	Name	Amount	
1	N	organik	Petroganik	322,633	483,949,695
		an-organik	Urea	63	284,625
2		P	SP36	152	886,588
3		K	KCl	956	5,733,000
4		Organic material	Organic fertilizer	69,000	69,000,000
				Amount	559,853,908

Source : Primary data Analysis

Tabel 8. Condition of soil nutrients and its conversion to manufactured fertilizers and its economic value per hectare in Tlogomas

No	Nutrient content (kg/ha)		Artificial fertilizer (kg/ha)		Economic value (IDR/ha)
	Type	Amount	Name	Amount	
1	N	organik	Petroganik	293,303	439,954,268
		an-organik	Urea	58	258,750
2		P	SP36	178	1,042,880
3		K	KCl	59	351,000
4		Organic material	Organic fertilizer	66,250	66,250,000
				Amount	507,856,899

Source : Primary data Analysis

Tabel 9. Condition of soil nutrients and its conversion to manufactured fertilizers and its economic value per hectare in Jati Mulyo

No	Nutrient content (kg/ha)		Artificial fertilizer (kg/ha)		Economic value (IDR/ha)
	Type	Amount	Name	Amount	
1	N	organik	Petroganik	263,973	395,958,841
		an-organik	Urea	52	232,875
2		P	SP36	43	253,975
3		K	KCl	429	2,574,000
4		Organic material	Organic fertilizer	59,500	59,500,000
				Amount	458,519,692

Source : Primary data Analysis

The economic value of paddy field in Tunggul Wulung sub-village is highest compared to the other five villages because it has the highest soil nutrient and organic matter content. In comparison to nutrient and organic matter conditions in Tasik Madu sub-village (the second highest), the difference lies in the content of organic matter. The average economic value of paddy field as a provider of natural soil nutrients and organic matter per hectare in Lowokwaru subdistrict is about Rp 585.38 million. This value indicates the economic loss per hectare of paddy fields converted to non-agricultural use. This is information is something that community, even farmers as the person responsible in the field, does not aware of.

The calculation of paddy field as the provider of natural soil nutrients and organic matter in Lowokwaru subdistrict was conducted in 6 villages with acreages approximately reached 205 hectares, which divided into 131 hectares in Tasik Madu, 32 hectares in Tunggul Wulung, 12 hectares in Mojolangu, 12 hectares in Merjosari, 11 hectares in Jatimulyo and 7 hectares in Tlogomas. The total economic value for each village is based on the area of paddy fields in corresponding village. The total economic value of paddy field in Tasik Madu is the highest, reaching up to Rp 88.16 billion because this village covers the most extensive paddy field area as (Figure 1).

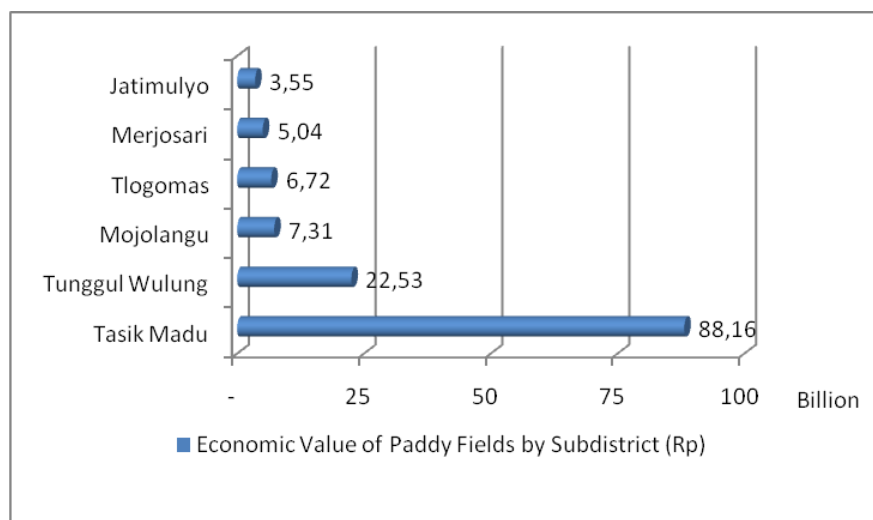


Figure 1. Economy value of paddy field as provider of natural soil nutrients (N, P, K) and organic matter in lowokwaru subdistrict

The ability of paddy fields to provide natural soil nutrients (N, P, K) and organic matter directly influences the condition of soil fertility and eventually determined its productivity. Hence, land conversion which disregards soil fertility will directly affects the condition of food production. Irawan (2008) explained about two type of impacts caused by paddy field conversion to food production. The first is that this impact is considered permanent because there is no turning back when paddy field is converted to non-agricultural use (irreversible); and then, it is considered to be progressive because it is harming the opportunity of production increase (due to new farming technology or farming efficiency) that can only be adopted if the paddy fields stays as productive agricultural land.

The Economic Value of Paddy Field as Disposal of Domestic Waste

The 205 hectares of paddy fields in Lowokwaru subdistrict when managed as System of Rice Intensification (SRI) cultivation system will provide a high potential for compost absorption. In some areas of Indonesia, SRI cultivation methods have shown to increase productivity compared to conventional rice cultivation. Sato (2007) stated that SRI cultivation method which developed in

eastern part of Indonesia could increase land productivity from 5.0 ton/ha to 7.4 ton/ha.

The Ministry of Agriculture (2013) defines SRI as an approach to rice cultivation practices that emphasizes on soil, crop and water management through group empowerment and local wisdom which is based on environmentally friendly activities. In SRI concept paddy crop is treated as living organism and not as a food-generating machine that can be manipulated. Anugrah et.al. (2008) stated general adoption of SRI undertaken by farmers of Ecological Rice Farming Community in Garut and Ciamis constituted these 3 essential elements: (1) healthy soil and organic matter management; (2) optimal management of crop potential; and (3) good and orderly water management.

Farmers in Lowokwaru subdistrict are still applying conventional rice cultivation with the use of inorganic fertilizers and minimum compost addition. If farmers in Kecamatan Lowokwaru apply SRI rice cultivation with compost volume of 14.6 - 20.9 tons per hectare per year (as applied by farmers of Ecological Rice Farming community in Garut and Ciamis). Thus, based on equation (3) the area of paddy field in research area will need compost as seen as Table 10.

Table 10. Compost Needs for Paddy Fields per Village

No	Village	Paddy Field area ha	Compost need (ton/ha/year)		
			14.6 (minimum)	20.9 (maximum)	Average
1	Tasik Madu	131.00	1,912.60	2,737.90	2,325.25
2	Tunggul Wulung	32.00	467.20	668.80	568.00
3	Jatimulyo	7.00	102.20	146.30	124.25
4	Tlogomas	12.00	175.20	250.80	213.00
5	Merjosari	12.00	175.20	250.80	213.00
6	Mojolangu	11.00	160.60	229.90	195.25
Average		34.17	498.83	714.08	606.46
Total		205.00	2,993.00	4,284.50	3,638.75

Source : Primary Data analysis

Based on quantity of compost needed per hectare paddy field, then the total compost need for the whole area of paddy fields and its economic

value in Lowokwaru subdistrict is shown in table 11. The economic value of paddy field based on its capability to receive compost is calculated using equation (2).

Table 11. Potential Compost Needs for All paddy Fields and Economic Value of Paddy Field as Compos Container in Kecamatan Lowokwaru

No	Village	Total compost need (000 ton/year)			Economic value (000.000 IDR)		
		Minimum*	Maximum**	Average	Minimum	Maximum	Average
1	Tasik Madu	250.55	358.66	304.61	5,879.17	8,416.07	7,147.62
2	Tunggul Wulung	14.95	21.40	18.18	350.81	502.19	426.50
3	Jatimulyo	0.72	1.02	0.87	16.79	24.03	20.41
4	Tlogomas	2.10	3.01	2.56	49.33	70.62	59.98
5	Merjosari	2.10	3.01	2.56	49.33	70.62	59.98
6	Mojolangu	1.77	2.53	2.15	41.45	59.34	50.40
Average		45.36	64.94	55.15	1,064.48	1,523.81	1,294.15
Total		272.19	389.64	330.91	6,386.89	9,142.87	7,764.88

Note : (*) Based on compost quantity of 14,6 ton/ha/year; (**) based on compost quantity of 20,9 ton/ha/year.

Paddy fields have the maximum potential to receive 389,640 tons of compost per year with economic value reaching Rp 9.14 trillion. This economic advantage can only be achieved if the Lowokwaru sub-subdistricts community are willing to select, sort and process domestic waste that they produce to turn them into compost. If the need for compost can be fulfilled from recycling local domestic waste, then paddy field within the area will be the solution to waste management problems in the city Malang.

The raw material for composting comes locally and is quite abundant and cheap (Sulistiyawati et al., 2009). The composting raw

material from domestic waste is highly dependent on the number of population and the rate of waste they generate. Damanhuri (2006) calculates the waste generation unit for a big city is about 2 – 2.5 litre/person/hari or 0.4 – 0.5 kg/person/day which become the basis of planning, design, and potential of waste management towards zero waste. Based on the above assumption, it is estimated that the waste generation at the research location is about 0.5 kg/person/day, the calculation of waste generation and the quantity of domestic waste is based on equation (4) in Lowokwaru Subdistrict are listed in Table 12.

Table 12. Waste Generation Rate and Estimated Quantity Domestic Waste Volume in Lowokwaru Subdistrict

No	Village	Number of population (body)	Rate of Waste Generation * (kg/day)	Quantity of Domestic waste * (kg/day)
1	Tasik Madu	6,281	3,141	2,398
2	Tunggul Wulung	6,701	3,351	2,559
3	Jatimulyo	20,332	10,166	7,764
4	Tlogomas	13,450	6,725	5,136
5	Merjosari	16,729	8,365	6,388
6	Mojolangu	24,481	12,241	9,348

Source : secondary data analysis.

Domestic waste into compost is a simple process that can be done on individual household scale or on communal scale. However, in order to assure that domestic waste is free from the harmful effects of chemicals, then compost quality testing is required (Domingo and Nadal, 2009; Smith, 2009; Sudrajat, 2015). The management of composting from domestic waste requires commitment and participation from surrounding community. Direct community participation will be presented by the amount of organic waste that is sorted and collected at collection point. The higher the level of community participation, the more organic waste

will be sorted and collected. Considering the level of community participation in the sorting and collection of organic waste, it is assumed that not all domestic waste can be processed into compost, thus in this research there 3 assumptions of community participation, which are 75%, 50% and 25% participation. The conversion rate of waste processed into compost is 0.4 which is based on the pilot project of market-waste management in Yogyakarta so that the potential quantity of compost that can be produced by the community in each subdistrict is shown in Table 13.

Tabel 13. Potential quantity of domestic waste and compost (ton/year)

SubDistrict	Domestic waste			Compost		
	75%	50%	25%	75%	50%	25%
Tasik Madu	656.56	437.71	218.85	262.62	175.08	87.54
Tunggul Wulung	700.47	466.98	233.49	280.19	186.79	93.40
Jatimulyo	2,125.33	1,416.89	708.44	850.13	566.76	283.38
Tlogomas	1,405.95	937.30	468.65	562.38	374.92	187.46
Merjosari	1,748.71	1,165.80	582.90	699.48	466.32	233.16
Mojolangu	2,559.03	1,706.02	853.01	1,023.61	682.41	341.20
Total	10,918.62	7,279.08	3,639.54	4,367.45	2,911.63	1,455.82

Source : secondary data analysis

More populated villages have the potential to produce more compost, in contrast they have relatively smaller area of paddy fields which resulting in compost overproduction. The

illustration of the ratio of compost needs (based on mean value) and compost production can be seen in Figure 2.

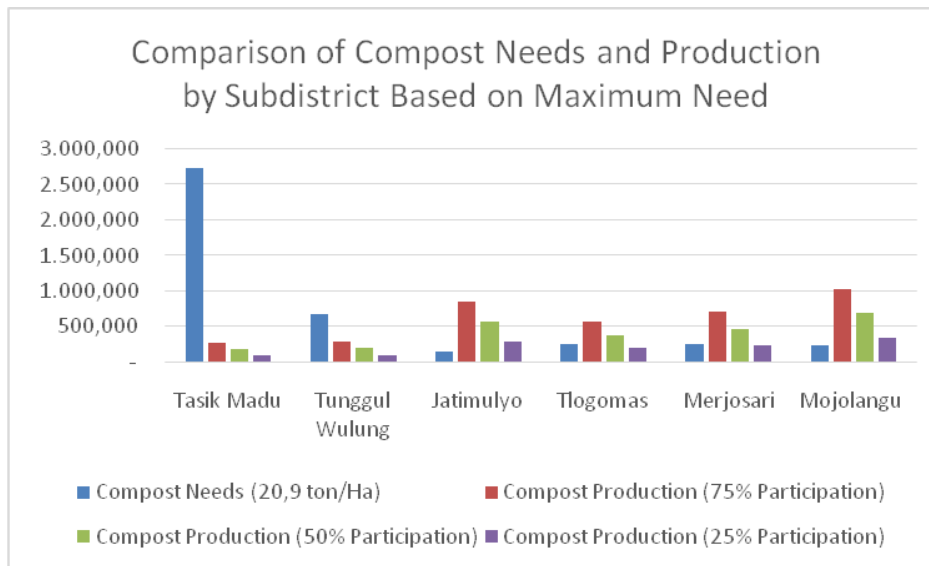


Figure 2. Comparison of Needs and Production of Compost per village

There are two types of situation in Lowokwaru subdistrict based on the ratio of compost needs and compost production, ie villages with insufficient compost production (Tasik Madu and Tunggul Wulung) and the other is villages with excess compost production (Jatimulyo, Tlogomas, Merjosari and Mojolangu). Under these circumstances, the sub-villages in the first situation will require additional compost, while other subdistrict in the second situation can send their compost production elsewhere. To bridge these two situations, there should be a compost management system in Lowokwaru that works across village with tasks includes waste collection, compost processing and distribution.

The total need of compost in Lowokwaru village reach to the quantity of 330,913.25 tons per year while local production only amounted to 75,722.82, 50,481.88 and 25,240.94 tons per year at community participation level 75%, 50% and 25 % respectively. To meet the needs of compost for the whole area of paddy field then additional compost

should comes from other villages that do not have paddy field. Thus, these village should be encourage to adopt composting programs as well.

In the end, the function of paddy field as disposal of domestic waste holds multi impacts to the community, socially it affects the society behavior to handling waste, economically it directly increases land production and profit of rice farming, and indirectly it reduces the budget for waste management Kota Malang.

The Total Economic Value of Paddy field as Provider of Natural Soil Nutrient and Organic Matter and Disposal of Domestic Waste

The total economic value calculated from two intrinsic functions of paddy fields based on its faculties to support land productivity (Table 14). Based on the calculation below, each hectare of paddy field in the research area has an average economic value of about Rp 688.18 million.

Table 14. The total economic value of paddy field in Lowokwaru subdistrict (Rp million)

NO	Village	NELSPUH	NELSPK*	TOTAL
1	Tasik Madu	88,156.81	7,147.62	95,304.43
2	Tunggul Wulung	22,529.90	426.50	22,956.40
3	Mojolangu	7,308.80	20.41	7,329.21
4	Merjosari	6,718.25	59.98	6,778.23
5	Jatimulyo	5,043.72	59.98	5,103.70
6	Tlogomas	3,555.00	50.40	3,605.40
7	Average	22,055.19	1,294.15	23,512.90
Total		133,312.48	7,764.88	141,077.37

Note :

* The average of economic value of paddy field as disposal of domestic waste

CONCLUSION

The existence of 205 hectares of paddy fields in Lowokwaru subdistrict holds the economic value of about Rp 688.18 million/ha based on its intrinsic benefit of provider natural soil nutrient and organic matter, and disposal of domestic waste.

The ability of paddy fields to provide natural soil nutrients and organic matter is only beneficial if the paddy fields are not converted into other land use.

The potential of paddy fields to receive compost processed from domestic waste is one solution to recurring urban problem of waste management.

Paddy fields in the city of Malang are feasible to be protected as agricultural land because of the current state of soil fertility which is potential to support high productivity.

Thus, with the existing environmental and economic benefits derived, paddy field in the city Malang can serve as productive open green space.

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