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Fertile soil retention strategy to maintain food security and conserve ecosystem in Tuban District, East Java province, Indonesia

Markus Patiung[1], Ismanto Hadi Santoso[2], Hary Sastrya Wanto[3] and Dwi Prasetyo Yudo[3]

[1] ***Faculty of Agrobusiness Agriculture, University of Wijaya Kusuma Surabaya Jl. Dukuh Kupang XXV/54 Surabaya, 60255, Indonesia***
[2] ***Faculty of Economy, University of Wijaya Kusuma Surabaya, Indonesia***
[3] ***Faculty of Agriculture, University of Wijaya Kusuma Surabaya, Indonesia***

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ABSTRACT

Land conversion to non-agriculture fields continues to occur, resulting in decreased food security stability and environmental degradation. The purpose of this study was to establish the wetland economic value as cultivation media, economic valuation of wetland as environmental, socio-culture functions as well as public awareness of wetland's multifunction. The method used in this research is the analysis of farming and economic valuation. The results showed that the average land conversion to non-agriculture field in Tuban District East Java Province Indonesia, covered an area of 338 ha / year or Rp. 44.27 billion / year in monetary value. Based on wetland economic value, 22.3% is utilized as cultivation media, 49.1% as environmental function and 28.6% as socio-cultural function. The public exhibits low awareness of wetland multifunction.

Key words : *Land Conversion, Field, Valuation, Food, Environment.*

Introduction

The Government currently endeavors to realize national sovereignty and food security, with efforts including the provision of production tools such as tractors, rice transplanter, cutting tools and procurement of rice seed and fertilizer. But one of the most fundamental things that have not been conducted is managing wetland conditions which are continuously converted to non-agriculture land. Efforts to maintain productive wetland by constructing upstream and downstream industries is the main asset of the nation's food supply stability and continue to conserve local resources in rural areas. Restoring farmers and change farmer behavior to maintain his farm is the character of the nation.

One of the main problems encountered in the agriculture development in Indonesia is realizing food security, especially rice products and preserving the environment due to reduction in productive land as they were converted to non-agriculture fields (industrial, housing, tourism, etc.). Land conversion into other non-agriculture field is driven by economic orientation that emphasizes short-term gains in the management of natural resources (*SDA or Sumber Daya Alam*), without taking into account benefit loss or losses arising from wetland environmental and socio-cultural functions loss. Land conversion into non-agriculture fields is not only a problem in the agriculture field but also economic and envi-

***Corresponding author's email:** markus_uwk@yahoo.co.id

ronmental issue.

Land conversion to non-agriculture fields continue to occur, causing increased poverty, unemployment and urbanization, decreasing food security stability, especially rice, and degrade ecosystem quality. Factors which cause land conversion to non-agriculture, one of which is the public's understanding of wetland that serves only as a cultivation medium which produces rice and *palawija* (non-rice yield), and if the understanding of wetland only to the extent it caused total wetland economic value is low. Despite having extraordinary socio-culture and environmental function, agriculture fields products / services do not possess economic value or do not have a market price (non-marketable good).

One factor of rampant wetland conversion into non-agriculture field is public awareness towards wetland multifunction. They assume that wetland's only function is to produce rice and *palawija* (non-rice yield) therefore assuming total wetland economic value is lower compared to when used as residential, industrial area, etc.

Cultivated rice fields not only produce rice and *palawija*, but also produce environment product / service as well as socio-cultural product that have no economic value or do not have market prices (non-marketable good). If the value of the products / services and socio-cultural environment of wetland rated economically, the wetland has total value which is far greater compared as rice or *palawija* producer.

Land conversion to non-agriculture fields continue to occur, may decrease the stability of food security, especially rice, and degrade the quality of the environment, which in turn cause production capacity loss from the fields and simultaneously eliminating employment opportunities for rural settlers, especially farmers, and damage the ecosystem.

The purpose of research conducted by universities in the first year of the five-year plan is as described below:

1. Establishing wetland economic value as agriculture media (rice).
2. Wetland economing valuation environmental value (flood control, natural nutrient providers, ground water supplier) and socio-cultural functions (employment).
3. Determining wetland economic value as cultivation media, environmental, and socio-culture function.
4. Determining public awareness towards wetland field multifunctional.

There are several ways that could be done to achieve food security and preserving the ecosystem. Strategy of maintaining wetland productivity, by assessing the total wetland economic value fields as cultivation media, environmental, and socio-culture function, which has no economic value or do not have a market price (non-marketable goods). This could be used as a foothold or the basis for determining the policy of the following issues:

1. Wetland conversion to non-agriculture field.
2. Establish standardized base value for unhulled rice.
3. Realizing food security
4. Preserving ecosystem.

Should Government apparatus and society have high understanding of wetland multifunction, it would become a motivation in maintaining the wetland, as a social intervention in improving the nation's character.

This research contributes to science and technology by proposing a new scientific approach to wetland. Wetland is only considered to possess agricultural or cultivation function which produces rice or *palawija*. This research proposes a new perspective (new paradigm) that the wetland not only produce rice or *palawija* (non-rice yield) but also produce environmental products / services and socio-culture function that has no economic value or do not have a market price (non-marketable goods).

Therefore, the contribution of this research to science and technology can provide new information and understanding (paradigm) in the field of agro-ecology (environment) and the agro-economic (economy), especially for wetlands. This is in line with *Universitas Wijaya Kusuma Surabaya*'s *RIP* (*Rencana Induk Pengembangan* or Development Plan).

Materials and Method

The research is conducted in Tuban District East Java province, Indonesia, on the basis that wetland conversion to non-agriculture fields in the region has been increasing, especially into residential and industrial areas (338 ha / yr). Four sub-districts were chosen from total sub-districts in the region. One village is selected in each sub-district, bringing the total village that became the object of study as much as 4 villages. The method used in determining the location of the research is multistage method.

In this study, the number of respondents is 60 people, consisting of 40 farmers, 10 beuraucrats, and 10 visitors who visit the village to observe agricultural fields every year. The method used in determining the respondents is random method.

The data used in this study are primary data and secondary data. Secondary data were obtained by recording data provided on the related institutions, and through the internet. Primary data were obtained through interviews, field observation, and Focus Group discution (FGD).

Economic valuation methods used in this research the method of replacement cost (Replacement Cost Method = RCM) and the contingency valuation method (Contingent Valuation Method = CVM). RCM methods used to assess wetland environmental and socio-cultural services, while the CVM is used to determine people's understanding of wetland multifunction.

Economic Value Wetland Function as Rice Production Producer or Source of Income or *Nilai Ekonomi Lahan Sawah sebagai Fungsi Penghasil Produksi Padi atau Sumber Pendapatan* (NELSsFPP).

$$NELSsFPP = \sum_{i=1}^{n} (A \times IP_i \times P_i \times H_i) \quad ..(1)$$

With values as follows:

A = total agricultural field converted into non-agricultural field (ha)

IP = Plantation index (%/yr)

P_i = Productivity(kg/ha)

H_i = Rice value (Rp/kg)

Economic value of Agrigultural Field as Employment Provider

$$NELSsFPLK = \sum_{i=1}^{n} (A \times IP_i \times T_i \times W_i) \quad ..(2)$$

A = total agricultural field converted into non-agricultural field (ha).

IP = Plantation Index (%/th)

T_i = Rice field agriculture labor demand (HKSP/ha)

W_i = Labor wages (RP/HKSP)

Economic Value of Field as Flood Control.

$$NLSsFPB = (D_p \times A \times \alpha \times P_d) \quad ..(3)$$

D_p = Water Withstanding Power of wetland (m^3/ha)

A = total agricultural field converted into non-agricultural field (ha/yr)

α = Capacity Coefficient wetland against rainwater (%)

P_d = Field dyke or embankment cost (Rp/m^3)

Wetland economic value as natural nutrient provider, could be estimated using Yoshida (2001) method with following formula:

$$NELSsFPUH = (U_n \times P_n + U_p \times P_p + U_k \times P_k)\ A \quad ..(4)$$

A = total agricultural field converted into non-agricultural field (ha)

U_n = N element contained in wetland (kg/ha)

U_p = P element contained in wetland (kg/ha)

U_k = K element contained in wetland (kg/ha)

P_n = Organic N Fertilizer cost (Rp/kg)

P_p = Organic P Fertilizer cost (Rp/kg)

P_k = Organic K Fertilizer cost (Rp/kg)

Wetland economic value as ground water provider (water preservation)

$$NELSsPAT = (RO + LSS) \times A \times (Dc + Mc) \quad ..(5)$$

NELSsPAT = Wetland economic value as ground water provider

(water preservation).

RO = the amount of the annual surface water flow coming from

wetland into reservoir (m^3/year).

LSS = Lateral underground water flow (assumed 75%) as

Wetland percolation part into reservoit

Through lateral flow (m^3/year).

A = total wetland area (m^2)

Dc = Depreciation costs for each water unit saved in reservoirs

(Rp/m^3/year).

Mc = Maintenance cost for each water unit saved in reservoirs

(Rp/m^3/year).

People's knowledge of wetland multifunction used descriptive analysis and multiple regressions.

$$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 \quad ..(6)$$

With values as follows :

Y = Scores knowledge of wetland multifunction ($0 < Y < 1$) where the value Y is calculated from the number multifunctional aspect is known by respondents divided by multifunctional aspects of the most widely known of all respondents. For example, the interviews shows there are eight multifunctional aspects of wetland known by a number of respondents and said 8 as divisor for calculating the Y's value

X_1 = respondent's education level (yr),

X_2 = respondent's age (yr)

D_1 = dummy : 1 for bureaucrat's, 0 for other respondents.

D_2 = dummy : 1 for visitors, 0 for other respondents

D_3 = dummy : 1 for rice farmers, 0 for other respondents

Results and Discussion

Wetland Economic Value as Production and Farmer Source of Income Function

Average area of wetland converted into non-agriculture field in Tuban districts is about 338 ha / yr. Cropping index of 300%. Average production of rice is 8,000 kg per hectare, with the rice production cost on average Rp. 3,600 per kilogram, the economic efficiency of 3.2 Based on the equation (1) the wetland economic value function as a medium for the rice cultivation reached Rp.29.203.200 / ha / yr. This value exhibits benefit loss if wetland were converted to non-agricultural field. The potential loss of wetland production value will be grow in line with nature and cumulative impact of the rate of land conversion to non agricultural fields that occur in subsequent years. Wetland that has been converted to non-agricultural fields will be difficult or impossible to be restored to its original form or irreversible. Cumulative amount of agricultural area which was converted in the next few years will follow the exponential function in accordance with the wetland conversion rate.

Based on the extensive wetland that converted to non-agricultural field during the last 10 years out of the study sites exhibits an average of 338 ha / year, in subsequent years assumed to be constant (0.6% / year), if there is no control efforts of land conversion, the magnitude of the potential loss in production value due to land conversion is estimated at Rp. 9.87 billion per year.

Wetland Economic Value as Employment Provider

Wetlands function as employment provider in cultivation (on-farm), post-harvest (off-farm), as well as trade and distribution (out of farm). Employment function is essential to employ labor at the sites.

Wetland employs their labor for 156 working days (HKSP) per hectare per year. According to recorded source, the workforce is made up of labor within the family as much as 88 HKSP (56.41%) and labor from outside the family or waged labor as much as 68 HKSP (43.59%). Labor in rice farming in the study site of 156 HKSP / ha is relatively lower than in the labor utilization in the rice farming in Markus' research results (2013) in Sidoarjo at 207.33 HKSP / ha.

Given wetland study site employ irrigation technique so it can be planted three times per year or cropping index (IP = 300%), with employment of 156 HKSP, and the wage rate of Rp. 80,000 / HKSP then by equation (2) the wetland economic value as a employment provider reached Rp 12.65 billion or Rp. 37.44 million / ha / year. Should the entire wetland were converted into non-agriculture field, the economic value loss as employment provider reached Rp.2,11 trillion. This exhibits that the wetland is very closely related to employment.

For the people in the study site, particularly the labor force due to job opportunities loss over the wetland conversion means they have no source of income. Based on the prevailing wage in the study site is about Rp. 80,000 / day, therefore potential wages calue loss due to land conversion reaches Rp. 12.65 billion or Rp. 37,440.000 / ha / yr. Should the rate of wetland conversion constantly continues will cause in decrease in employment. Especially labor force in other sectors or other unchanged conditions will raise unemployment as much as 156 people every year.

Wetland Economic Value as Flood Mitigator

Wetland as a wetland flood mitigator is the ability to hold rain water temporarily during and shortly after it rained. Wetland can serve as natural pools which form small dams that can hold or detain rainwater before it flows downstream through bodies of water, such as rivers, irrigation canals, etc. Wetland will work on areas that have high rainwater intensity, because it is able to withstand water runoff that could cause flooding.

The ability to support wetland or rainwater temporarily after rain occurs can be influenced by existing rice acreage, as well as high-margin and high dykes before the rain. Rice's leaf surface area is relatively small and relatively deep groundwater levels stable state so the canopy and soil absorption rice in paddy fields is very small in retaining rainwater. Thus playing an important role here is spacious and high rice fields.

High embankment at the study site ranged from 15-35 cm with an average of 27.63 cm. Puddles height in paddy fields before the rains ranging between 5 -10 cm with an average of 7.88 cm. Therefore the water buffering capacity in paddy fields ranging between 10 - 25 cm with an average of 19.75 cm. In one hectare of wetland can detain rain water amounted to 19.75 cm x 10.000 m^2 or a total of 1,975 m^3/ha. Therefore high dike is one factor that can be manipulated to increase the buffering capacity of rain water in rice fields. The higher the rice paddies will provide greater rainwater buffering capacity and vice versa. As there are a huge number of farmers in research location cultivate rice, dike's height does not matter. Fish cultivators are more concerned in higher dikes and likely would build taller dikes.

Considering the magnitude wetland role in rainwater mitigation before it flows downstream, then in the event of land conversion (into residential, industrial or otherwise) will result in agricultural field's ability in water mitigation is equivalent to the amount of water collected as much as 1,975 m^3/ha (19.75 cm x 10.000 m^2). When compared with the water buffering capacity in Sidoarjo, the amount of water buffering capacity of wetland study site is still higher (Sidoarjo water buffering capacity reaches 1,217 m^2/ha). Meanwhile, when compared with the water buffering capacity South Korea, the amount of water buffering capacity study site is considered lower. In South Korea the power of water mitigation reaches 2,376 m^3/ha (Eom and Kang, 2001). The high water wetland buffering capacity in South Korea because it has a higher embankment.

With wetland water capacity of 1,975 m^3/ha, while vast wetland is converted as much as 338 ha / yr, the capacity coefficient of wetland collecting rain water by 80%, and the cost of making the dike at the study site by creating mounds costs as much as Rp. 27,000/m^3. The cost of making this dike is a market price. Thus, to determine the wetland economic value as a flood control function can be calculated with reference to the equation (3), the wetland economic value as a function of flood control in the study area was Rp 14.42 billion / year (Rp. 42.66 million /ha/yr). If the land conversion in research area continues in the same proportion, the potential for water buffering capacity loss will be greater and this will result in higher cost of the necessary flood control.

Wetland Economic Value as Natural Nutrient Provider

From the calculation results in laboratory of soil science exhibits that the land or wetland study site in four villages : Bogorejo Village Merakurak Sub-district, Mulyoagung Village Singgahan Sub-district, Semanding Village Semanding Sub-district, and Sumberejo village Widang Sub-district Tuban East Java Province contains nutrients N , P, K naturally as exhibitted in table 1.

Results of laboratory analysis exhibits natural nutrient content in the soil, where analyzed soil has not been fertilized by farmers. To equalize the nutrient content of N, P, K based on laboratory analysis in hectares value in the field therefore

Table 2. N, P, K Natural Nutrient in Agricultural Field Tuban District.

No	Sub-district	N (kg/ha)	P (kg/ha)	K (kg/ha)
1	Merakurak	3.400	130,66	218,4
2	Singgahan	1.800	28,56	85,8
3	Semanding	3.200	58,76	234,0
4	Widang	3.600	31,90	538,2
	Average	3.000	62,47	269,1

Source: Primary Data Analysis

Table 1. Laboratory Analysis Result of N,P,K Element in Agricultural Field Tuban District, 2016.

Lab.No	Code	N.total(%)	P.Bray1 (mg kg^{-1})	K $NH_4OAC1NpH$:7 (me/100g)
TNH 446	Merakurak Sub-district	0,17	65,33	0,28
TNH 447	Singgahan Sub-district	0,09	14,28	0,11
TNH 448	Semanding Sub-district	0,16	29,38	0,30
TNH 449	Widang Sub-district	0,18	15,95	0,69

Source : Laboratory Analysis Result

milliequivalents unit were utilized.

To find out the N, P, and K fertilizer cost which are contained in the organic soil, first count N, P and K elements in 1 kg composite. Based on laboratory research result in PTP XI, that in 1 kg composite at a price of Rp. 950 / kg N elements contained is 0.8%, P amounts to 1.2% and K elements of 0.8%. Thereby, the ratio of N: P: K is: 8/10: 12/10: 8/10 (8: 12: 8 = 28). Therefore o rganic N fertilizer cost is 8/28 x Rp. 950 = Rp. 271.43 per kilogram. Organic P fertilizer costs about 12/28 x Rp. 950 = Rp. 407.14 per kilogram, as well as organic K fertilizer costs 8/28 x Rp. 950 = Rp. 271.43 per kilogram.

The wetland economic value as natural nutrient provider (N, P, K) is at study site can be calculated by equation (4). Agricultural area is converted into non-agriculture area as much as 338 ha / yr. The average content of N in the paddy field as much as 3,000 kg / ha, P element content of 62.47 kg / ha, K element content of 269.1 kg / ha. Then the wetland economic value natural nutrient provider is Rp. 308 514 854 or Rp. 912.765./ha/th. This value is the benefit loss should the wetland is converted into non-agroculture field.

Wetland Economic Value as Water Reservoir

Nine of the reservoirs have an average land area of 88.78 ha. Nine reservoirs have very important role for the rice fields as a source of water used in irrigation. Land use varies and is dominated by wetlands and dry land.

Irrigation water required for rice farming, calculated by Fagi and Sanusi (1983), amounts to an average of 13 mm/day. For irrigation purposes, Diidek (1998) measured amount of water used between 535.5 to 735.8 mm for approximately 70 days. With this assumption, the irrigation water is available for 120 days a year. It is calculated regarding water flowing into the wetland as rainfall amounts to 2,500 mm / yr.

Percolation water is water that infiltrated the soil and flow as seepage or underground water. The amount of percolation, according Fagi and Sanusi (1983), is 10.3 mm/hr. Whereas evapotranspiration amounts to 4 mm/hr. In Korea, evapotranspiration occurred as much as 3.35 mm/day (Eom and Kang, 2001) which is smaller than the evapotranspiration rate assumption for this calculation, equal to 4 mm / day.

Percolation duration in general is 110 days for each cultivation season, although there are some areas that rice could be harvested after less than 100 days of cultivation. Rice variety grown in Tuban district is known as *Ciherang* which grows between 118-125 days.

Eamount of water that infiltrated into groundwater through further percolation Kyun (2001) and Eom and Kang (2001) estimates that 45% of them becomes groundwater. For this calculation the water percentage that infiltrated assumed to be approximately 55% and the amount of water infiltrated from the bulk (75%) flows back into the river. The remaining 25% is the part that becomes groundwater.

Based on the foregoing assumptions for the water balance in the reservoir Tuban district are presented in Table 3.

Based on the equation 5, the wetland economic value as a water reservoir amounts to Rp. 6.95 billion or 20,556,315/ha.

If wetland economic value is only counted as cultivation media, then in the future should the wet-

Table 3. Water Balance on Wetland Rainfed Water Reservoir.

No	Item	Speed (mm/day)	Time (day/year)	Total (mm/year)
1	Input			
	a. Irrigation	13	120	1.560
	b. Rain			2.500
	Total			**4.060**
2	Output			
	a. Percolation	10,3	220	2.266
	b. Flows into river			1.700
	c. Ground water			567
	d. Evapotranspiration			1.460
	e. Run off			334

land economic value as an environmental services and socio-cultural needs to be internalized or taken into account, therefore when the government sets policies related to land use, establishing grain and rice price, etc. they need to consider the wetland economic value as a whole.

On the other hand that if wetland conversion continues without a solution, it will greatly affect the stability of food security especially rice and environmental damage.

Public Awareness Towards Wetland Multifunction

Model analysis functions alleged public awareness towards wetland multifunction as equation (6) models of these allegations could explain the diversity of the number multifunctional aspects of wetland known/understood by the respondent which amounted to 86.9%, the accuracy rate of 95% (a = 0.05%). At this accuracy level there are four variables of five independent variables (83.3%) in models that have an influence on the dependent variable diversity, which is the amount of known wetland multifunction to respondents. Based on the model, there are factors that influence the respondent status such as bureaucracy, visitors with differing value to zero (0), while the status of ce farmer respondents had no significant effect, meaning there is difference knowledge regarding wetland multifunction among farmers compared to visitors and bureaucracy.

The influence of education on wetland multifunction knowledge factor interpreted exhibits that the higher the education level means higher knowledge of the wetland multifunction. The statistical results are consistent with the descriptive analysis. Similarly, the age and sex of the respondents influence the multifunctional knowledge of wetland.

Table 4. Analysis Result Regression Model of Respondent Knowledge Regarding Multifunctioned Wetland.

Model	B	t	Sig
(Constant)	.522	4 .209	.000
X_1(education)	.007	.132	.046
X_2(age)	.002	.082	.012
D_1(beurocracy)	.215	.351	.023
D_2(visitor)	.111	.159	.023
D3(farmer)	.301	3.047	.004

Source : Primaru Data Analysis

Wetland Economic Value

The results showed that if the wetland is regarded as cultivation media (rice-cultivation), the wetland economic value only amounts to Rp. 29.2032 million /ha/year (22.3%). On the other hand, wetland economic value as environmental services (flood control, natural nutrient provider, and water reservoir) amounts to Rp. 64,129,071 / ha / yr (49%). Wetland economic value as a socio-cultural (employers) reached Rp. 37.44 million/ha/year (28.7%).

Average area of wetland that is converted into non agriculture fields in Tuban reached 338ha / yr. Calculated value of economic losses due to land conversion reached Rp. 130.772.217 ha/year or 44.27 billion/year. Noting the items above it if:

Should wetland converted into non-agriculture in Tuban District continue to occur then economic losses will rise to 44.27 billion year. Thus this issue is needed to become a consideration establishing land conversion policy.

At the time of the wetland economic value amounts to Rp. 29.203 million / ha / yr, wetland was regarded merely as a cultivation media (rice-cultivation). Grain farmers receive Rp. 3,600 / kg. By integrating the wetland economic value functions, such as environmental services (flood control, natural nutrient provider, and water reservoir), and socio-cultural (employers), wetland economic value amounts to Rp. 130 772 217 / ha / yr. Farmers should receive Rp. 15 692 / kg for grain (dry grain harvest). This issue could be used as consideration in establishing acceptable grain price.

If the land is converted to non-agricultural fields which reached 338 / ha / yr, the total rice production loss amounted to 8112 tons/year. This will affect the shortage of food, especially rice, which in turn affects the instability of food security.

Should the land is converted to non-agricultural fields which reached 338/ha/yr, it would cause environmental damage, but if wetland is maintained it can serve as a producer of environmental services (flood control, erosion control, landslide control, air pollution control, absorping organic waste, carbon sequestration (CO_2), oxygen (O_2), biodiversity, habitat conservation, rare species, and natural nutrient provider.

It can be concluded that the strategy in maintaining productive wetland should take into account the value of losses incurred in the event of land conversion. In other words, maintaining productive wetland can achieve food security, improve environmental quality in a sustainable manner and increase farmers' income.

Conclusion

1. Wetland economic value as agricultural field (rice) amounts to Rp.29.203.200/ha/yr. (22,3 %)
2. Wetland economic value as socio-culture function (employment provider) amounts to 157 HKSP/ha/th atau Rp. 37.440.000/yr (28,6 %)
3. Wetland economic value as environmental function (flood mitigation, natural N,P,K nutrient provider and water reservoir) amounts to Rp. 64.129.071/yr (49,1 %)
4. Wetland economic value as cultivation media, socio culture function (employment provider) and environmental service (flood mitigation, natural N,P,K nutrient provider and water reservoir) amounts to Rp. 130.772.217/yr.
5. Land conversion from agricultural field to non-agricultural in Tuban averaged about 338 ha/yr which cause benefit loss of Rp. 44,27 miliar/th.
6. Public awareness regarding wetland multifunction is low.

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