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THE ECONOMIC VALUE OF FOREST HYDROLOGICAL SERVICES: A CASE STUDY AT BUKIT SULIGI PROTECTED FOREST, THE UPPER PART OF SIAK WATERSHED, RIAU

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Abstract

Bukit Suligi Protected Forest (BSPF), situated in the headstream area of many rivers in Riau Province, plays an important role in providing hydrological services such as flood prevention in the rainy season and water supply in the dry season. Siak River is one of the rivers which runs from BSPF. The objectives of this study are to clarify the recent condition of BSPF and to estimate the economic value of BSPF's hydrological services. Contingent valuation method was employed to elicit people's willingness to pay (WTP) for the hydrological services. Interviews were carried out in Dayo Village, which is located in the upper part of Siak Watershed and adjacent to BSPF. The sampling rate of respondents was 8% of the total households in Dayo Village. The findings showed that an average WTP value of the respondents was 113,000 IDR per household per year. This value indicated the indirect benefit which people obtained from hydrological services of the BSPF area. Moreover, based on the calculation result of these values to the total amount of the household and forest area, the economic value of hydrological services of BSPF was 73,096 IDR per hectare per year.

Key words: Environmental Services; Protected Forest, Willingness to Pay, Contingent Valuation

Introduction

The natural environment provides various benefits for the natural world and mankind. In laying a foundation for the valuation of the natural environment, Pearce and Turner (1990) categorized the role of the natural

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environment into three groups: (1) as provider of input for production processes and direct consumption; (2) as an assimilator of waste which is produced by production processes and consumption; and (3) as a provider of environmental services, such as sequestrated carbon dioxide, oxygen production which are essential to life on this planet, and as a life-support system for living things.

In the traditional analysis of economic growth, there existed a trade-off among these roles of the natural environment (see Marta-Pedroso, *et al*., 2007; Cheung and Sumaila, 2008). In this situation, policy makers usually face two options: to utilize natural resources as source materials for production processes and direct consumption; or to conserve them for providing environmental services.

People have a need for cash income, and the propulsion to boost economic growth often drives policy makers to choose the first option as the main priority, overriding the role of environmental services. This situation could be observed in the economic development of Riau Province, Indonesia.

According to the Statistics Office of Indonesia (2009), the per capita gross domestic product (GDP) of Riau province is ranked the third highest in the country. However, the GDP of Riau province did not come from well managed environmental services. In the last two years, natural disasters such as floods and landslides took place in Riau province. In 2011, floods occurred in Rokan Hulu District (Riau Pos, 2011a) and Kampar District (Riau Pos, 2011b). These disasters damaged natural resources and destroyed man-made resources. However, the damage and losses were not taken into account in the GDP of Riau province, and therefore, while environmental degradation occurred in Riau Province, the GDP was still high.

In Riau Province, forest resource depletion and degradation also occurred in protected areas such as Bukit Suligi Protected Forest (BSPF). BSPF plays a role in providing environmental services such as water regulation, flood prevention, carbon sequestration and biodiversity conservation. However, due to the cash income motive, people have cut down trees in BSPF and converted the forest for agricultural cultivation.

Flooding or water shrinking in the upper part of rivers in the BSPF area (e.g. Dayo River, Tapung Kiri River of Siak Watershed) are indicators of the serious damage in the BSPF area. According to the Minister of Public Works (2005), fluctuation of water discharge of Siak River was very wide. Whereas the maximum flow rate reaches 1,700 m^3/second in the rainy season, the minimum is 45 m^3/second in the dry season. This condition causes flooding in the rainy season and water shrinking in the dry season. In order to deal with the problem, it is considered that conservation of BSPF area is the best choice. Therefore, estimation of the economic value of BSPF area is necessary to justify forest conservation policy. The objective of this paper is to describe

the recent condition of the BSPF area and to estimate the economic value of BSPF hydrological services in the Siak Watershed.

Research Method

Theoretical Framework

The economic value of hydrological services of BSPF was elicited by contingent valuation (CV) method. This method was initiated by Ciriacy-Wantrup (1947) and firstly empirically tested by Davis in 1963 to investigate the willingness-to-pay (WTP) for goose hunting in Maine Woods of the USA (see Venkatachalam, 2004; Verbic and Slabe-Erker, 2009).

The concept of WTP is based on classical economic theory of utility maximization. In the classical economic theory, as recalled by Nicholson and Snyder (2010), individuals maximize their utility by consuming some combination of goods under a constraint of limited income (Nicholson and Snyder 2010). This axiom of utility is expressed in the following function (Carson, Flores and Mitchell 2001):

$$\mathbf{U = f\ (X,\ Q).}$$

where: U = utility, X = market good, and Q = environmental good/services.

The formula for maximizing utility is presented in the following equation:

$$\mathbf{U : v\ (p,\ Q,\ y) = f\ [X(p,Q,y),\ Q]}$$

The increasing of willingness to pay for hydrological services from Q^0 to Q^1 is shown by the equation: $v(p,Q^0,y) = v(p,Q^1,y - WTP)$. Furthermore, Carson, Flores and Mitchell (2001) stated that WTP is the income that would be forgone in order to get improved environmental services to keep environmental services (Q) at the initial level (Q^0) with y income.

Mathematically, WTP equation is formulated as:

$$\mathbf{WTP = v\ (p,Q^1,y) - v(p,Q^0,y)}$$

Data Collection

General observation of the location (BSPF), watershed area and community livelihood were conducted at the beginning of this study. In addition, secondary data were collected, comprising data from government documents, research reports, statistics offices publications, and mass media news. Afterwards, interviews were conducted with key informants and selected respondents to reveal their WTP.

The WTP survey was conducted in Dayo Village, located in the flood risk area and shrinking in the Siak River Watershed and adjacent to BSPF area. This village is situated in Tandun Sub district, Rokan Hulu District, Riau Province.

The WTP survey put forward the scenario that reforestation and forest rehabilitation will be executed to improve hydrological services of the BSPF area. For such utilization, we used artists' images which showed how the reforestation and forest rehabilitation might contribute to improve hydrological service. The assumptions pointed out to the respondents were as follows: 1) reforestation activity would minimize flooding risk; and 2) reforestation activity would prevent shrinking in the dry season. Subsequently, we asked the respondents' WTP for the scenario presented to them. The respondents were the heads of households, usually men, and presumably they spoke on behalf of their household.

The respondents were randomly selected from the population of households in the village. The sampling intensity was 8%, which doubled the minimum sampling intensity recommended by Hufschmidt, *et al*. (1983). According to the Central Agency of Statistics (*BPS*) of Rokan Hulu District (2010), the total number of the household in Dayo Village is 843. Thus, the total number of the sample was 67 households. The sample included households in which the various household occupations of heads included farmers, unskilled labourers, private employees, government employees and others.

Data Analysis

Descriptive statistic analysis was carried out to reveal information on the respondents in connection with WTP. The economic value of BSPF hydrological services is an aggregate of the WTP value. It was derived by multiplying average household WTP by the total number of the households in the research site. The average economic value per hectare was obtained by dividing the aggregate WTP by the area of the total remaining forest stand of BSPF.

A Pearson Correlation Test and multiple regression analysis were executed to find out the correlation between socio-economic variables with WTP and to understand the influence of these variables on WTP. Based on the theoretical foundation of the WTP formula and the research findings by previous researchers (Amigues, *et al*., 2002; Baranzini, Faust and Huberman, 2010; Prasmatiwi, 2010; Purwawangsa, 2008; Sattout, Talhouk and Caligari, 2007), it was found that several socio-economic variables such as age, education, occupation, income and number of household members had an effect on WTP. Hence, in this study we examined these variables, which were stated in the following equation:

$$WTP = \beta_0 + \beta_1 A + \beta_2 E + \beta_3 O + \beta_4 I + \beta_5 H + \varepsilon i$$

where: WTP = the cash amount that people are willing to pay; β_0 - β_5 = the coefficients; A = age; E = education level; O = occupation; I = income; H = household member; and εi = error.

General Description of Bukit Suligi Protected Forest (BSPF)

BSPF Location

Bukit Suligi forest area was declared as protected forest in 1982 with a total area of 33,000 ha. Formerly, the area was dealt with under *HPH* (Forest Concession Right) PT. Tanjung Budi Sari. A tin mining company also operated in this area, but was closed in 1979.

In 1983, a part of the BSPF area was designated as an Education and Training Forest (ETF/*Hutan Diklat*) that was managed under the Forestry Education and Training Institute (FETI/*Balai Diklat Kehutanan*) of Pekanbaru. FETI is the institute under Ministry of Forestry which is located in Pekanbaru, Riau.The initial area of ETF was 1,950 ha, and in 1985, the area was expanded to 2,183 ha (BDK Pekanbaru, 2010).

BSPF is situated in Rokan Hulu and Kampar Districts in Riau Province on the island of Sumatera (see Figure 1). In Rokan Hulu District, the area is located in several Sub-districts, including Tandun, Kabun, Rokan IV Koto and Pendalian IV Koto. In Kampar District it is situated in the XIII Koto Kampar Sub-district.

Biophysical Condition

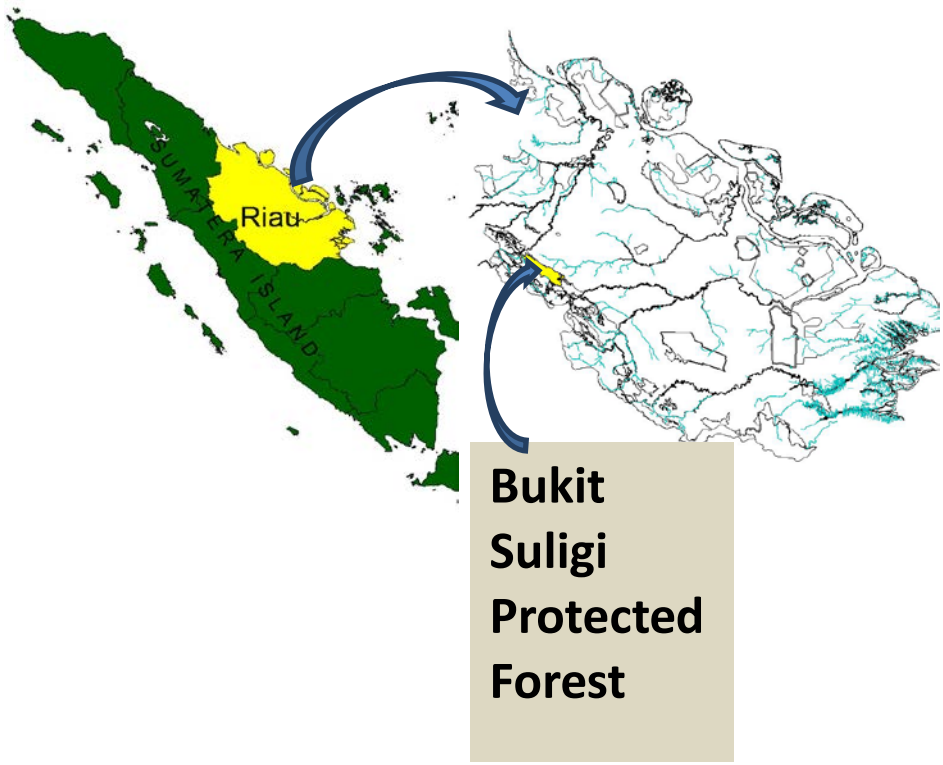
The flooding risk and erosion rate in BSPF area is affected by biophysical factors such as rate of the precipitation, vegetation type, soil type and topography. As a tropical area, the precipitation rate in BSPF area is high. The average precipitation rate is recorded at 2,280 mm per year (BDK Pekanbaru, 2010).

BSPF area is hilly, with slopes ranging from 0 to 27 percent, and the altitude between 100 – 250 meters above sea level. The land is dominated by two soil types, Podsol and Latosol. According to Hariyadi, Yahya and Anwar (nd), Yellow Red Podsol soil is physically poor due to the high clay content and bad water drainage capacity. Under extreme rainfall conditions, Yellow Red Podsol absorbs less rain water and is rapidly saturated. This condition can lead to flooding, especially in bare land.

BSPF has abundant biodiversity. According to BDK Pekanbaru (2010), forest vegetation in the BSPF area is dominated by *Dipterocarp*, such as *Shorea*, *Dipterocarpus* and *Anisoptera*. There are also *Palaquium*, *Litsea*, *Calophylum*, *Koompassia*, and *Scorodocarpus*, and scarce orchid species. Protected fauna have been detected in the BSPF area, namely elephant (*Elephas maximus*

sumatrensis), sumatran tiger (*Panthera tigris sumatrensis*), small antelope (*Muntiacus muntjak*), deer (*Cervus sp.*), malayan bear (*Helarctus malayanus*), monkey (*Macaca fascicularis*), sumatran siamang (*Symphalangus syndactylus*), tapir (*Tapirus indicus*), hornbill (*Buceros bicornis*), porcupine (*Hystrix brachyura*), anteater (*Manis javanica*), and junglefowl (*Gallus gallus*).

Figure1. The Map of BSPF Location



The Hydrological Services of BSPF Area

BSPF provides environmental services such as a hydrological regulatory system, carbon sequestration, biodiversity conservation and oxygen production. As a hydrological regulatory system, BSPF is very important because the area plays a role as the upper part of many rivers, including the Sei Asam River, Poimbaran River, Saiyus River, Dayo River, Meranti River and Tapung Kiri River. The latter five rivers mentioned flow to Tapung Kiri River and in turn, Tapung Kiri River is an upper part of the Siak River Watershed.

Result and Discussion

Deforestation and Forest Degradation of the BSPF Area

The BSPF area has been in a critical condition in recent years. Illegal logging, forest fires and land encroachment have occurred in this area. Illegal logging began in 1990 and reached a peak in 1998 at the end of the New Order Era. After 1998, illegal logging was on the decrease, but land occupation was on the increase.

According to an officer of the Forestry and Estate Crops Office (*Dinas Kehutanan dan Perkebunan*) of Rokan Hulu District (2011, personal communication), the forest stand in the BSPF area decreased drastically from 33,000 ha in 1983 to 9,900 ha at present. Most of the BSPF area has been changed into oil palm and rubber plantations and also bare land.

Most of the forest stand remaining in the BSPF area is now situated in ETF (*Hutan Diklat*), which is a part of BSPF. According to the ETF manager, the forest stand remaining in his territory (ETF area) is 600 ha. This area was distributed in the western part of the ETF area. The central part of the ETF has been cleared for oil palm crops, rubber plantation or secondary re-growth.

ETF Manager (2011, personal communication) has stated that the conversion of forest into oil palm plantations was started by illegal logging. After commercial wood had been fully extracted, small trees were felled and burnt together with shrubs to clear the land and prepare it for planting. This process involved the local people. However, land occupation was done both by local people and outsiders who came from other districts or even other provinces. Outsiders mostly obtained the land by purchasing it from the local people. For this transaction, "some unofficial services" of the village head (*Kepala Desa*) was required.

The prevalence of deforestation and forest degradation of the BSPF area affects soil erosion, sedimentation, flooding in the wet season and water shortage in the dry season. Dayo people complained about water scarcity in the dry season. They found a decline in production of palm oil fresh fruit in the dry season, and they thought that this was due to water shortage and a change in land use in the BSPF area. Furthermore, there were also occurrences of flash flooding in the Dayo River which flows through Dayo Village. According to Hamilton and King (1983) in Chandler (2006), this hydrological phenomenon is a common problem in humid tropical areas where forests lands have been converted to agriculture. This changed hydrological response is strongly influenced by rainfall intensity, soil bulk density, soil porosity and topography. Bruijnzeel (2004) found similar evidence in his research in South East Asia.

In response to this situation, FETI of Pekanbaru in collaboration with FECO of Rokan Hulu District worked out an agreement to work together to

conserve the BSPF area. They planned to conduct reforestation activity to restore BSPF by involving the local community.

Respondents' Characteristics

Most of respondents were senior high school and elementary school graduates (64%). The proportions of respondents with highest level of education for elementary school graduates, junior high school drop-outs, junior high school graduates, senior high school graduates, college graduates and master's degree holders were 36%, 3%, 22%, 36%, 3% and 1% respectively.

With regard to occupations, more than a half of the respondents were farmers and unskilled labourers. They worked for agricultural activities in oil palm culture. The unskilled labourers were engaged in planting, weeding and harvesting. Occupations of the others respondents were private company employees, government employees and also business men/women.

The respondents' annual incomes varied, ranging from 500,000 IDR to more than 4,000,000 IDR per month. The average income was 1,940,000 IDR, but the majority (59%) earned below average.

WTP and Socioeconomic Variables

The majority of respondents (94%) stated their agreement to pay for the improvement of the hydrological services of the BSPF area, whereas 6% of them rejected the idea of payment. WTP value analysis was carried with results from the respondents who agree to pay.

The results of analysis show that the average WTP value was 113,000 IDR per household per year, and the median was 60,000 IDR per household per year. These values indicate that if people were asked to pay for hydrological services of the BSPF area, they would agree to pay 113,000 IDR on average and more than half of them would be willing to pay 60,000 IDR per year. In reality they do not pay to get this benefit. Hence, it can be interpreted that people obtain benefits worth 113,000 IDR per household per year by consuming hydrological services provided by the BSPF area.

The result of the Pearson Correlation test indicated that there was no significant correlation between socio-economic variables and WTP except for the income rate. A significant correlation between two variables is indicated by a significance value under 0.05. As shown in Table 1, the significance value for the correlation between WTP and income was 0.005. The significance values of all other variables exceeded 0.05. This result means that the rise of income will increase WTP value. Furthermore, the increase of other variables did not increase WTP value. This result confirmed the theoretical foundation of WTP recalled by Carson, Flores and Mitchell (2001), where WTP was correlated with income.

Table 1. The Distribution and Correlation of WTP Value with Selected Socio-Economic Variables

Socio-economic variables	No. of respondents (%)	Average of WTP	Pearson Correlation significance (value)
Income			
500,001 – 750,000	2 (3.2)	90,000	
750,001 – 1,000,000	5 (7.9)	84,000	
1,000,001 – 1,250,000	17 (27.0)	78,352.9	
1,250,001 – 1,500,000	4 (6.3)	105,000	
1,500,001 – 1,750,000	10 (15.9)	60,000	0.344**
2,000,001 – 2,250,000	12 (19.0)	119,000	(0.005)
2,250,001 – 2,500,000	3 (4.8)	64,000	
2,500,001 – 2,750,000	2 (3.2)	420,000	
3,000,001 – 3,250,000	6 (9.5)	166,000	
3,250,001 – 3,500,000	1 (1.6)	60,000	
3,750,001 – 4,000,000	1 (1.6)	120,000	
Occupation			
Unskilled labourers	18 (28.6)	74,000	
Farmers	26 (41.3)	115,384	0.243
Private employees	8 (12.7)	127,500	(0.053)
Government employees	2 (3.2)	60,000	
Others	9 (14.3)	184,000	
Education			
Elementary graduates	24 (38.1)	91,500	
Junior High School drop-outs	2 (3.2)	120,000	
Junior High School graduates	13 (20.6)	78,461.5	0.130
Senior High School graduates	22 (34.9)	161,454.5	(0.307)
College graduates	1 (1.6)	60,000	
Master degree holders	1 (1.6)	60,000	

Source: Field research (2011)

Regression analysis was carried out and showed significance value (was under 0.05 according to F-test). This result indicated that the variables examined in this study explained the differences in WTP. However, the coefficient of determination value was low, (R^2 = 0.103). It can be interpreted that the socio-economic variables tested in this equation explain only 10.3 percent of the variation in WTP. Factors other than the socio-economic

variables tested in this equation affected the WTP up to 89.7 percent. The regression showed that the variables tested had relatively little explanatory power. According to this result, a similar study is necessary in the future to include other variables besides age, education, occupation, household members, and income.

The t-test on each socio-economic variable did not indicate a significant influence, except in the case of income. Income had a significant effect on WTP at the 0.05 level. The results of regression analysis and t-tests are presented in the Table 2. In this equation, it is shown that the coefficient of income was 0.004. This result can be interpreted as showing that an increase of 100 percent of income will affect on increase in the WTP value up to 0.4 percent.

Table 2. The Result of Regression Analysis and t-tests

Variables	Coefficients	t	Sig.
Constant	-12993.46	-1.185	0.241
Age	61.74	0.370	0.712
Education	837.21	0.809	0.422
Occupation	1109.96	0.975	0.333
Income	0.004	2.082	0.042*
Household member	1601.28	1.357	0.180

Source: Data processed (2011)

There are some differences in the results of this research and previous work by Amigues *et al*., 2002; Baranzini, Faust and Huberman, 2010; Prasmatiwi, 2010. This study confirms their research findings about the influence of income on WTP. However, other variables such as education and occupation showed no significant impact on WTP, in contrast to the findings of Amigues, *et al.* (2002), Baranzini, Faust and Huberman (2010) and also Prasmatiwi, (2010).

This finding also showed dissimilarity to the result presented by Purwawangsa (2008), as well as Sattout, Talhouk and Caligari (2007). In different research sites, these authors found that education was the single variable which influenced the WTP for environmental services.

The Economic Value of BSPF hydrological Services

This study was focused on finding out the economic value of hydrological services of the BSPF area, especially the benefit for the people residing in the upper part of Siak Watershed. The economic value of hydrological services is an aggregate value of the WTP of the people who live in the area at risk from flooding and shrinking of water flows. To calculate the aggregate value of

hydrological services, it would be best to use a map of the flooding risk area. However, such maps were not available (Antara News.com, 2012). Therefore, this study used the data of the flooding risk area presented by Meteorology, Climatology and Geophysics Agency (*BMKG*) as cited by Antara Riaunews.com (2012). According to this article, the area in the upper part of Siak Watershed which was vulnerable to the risk of flooding is Tandun Sub-dstrict. The aggregated value of the hydrological services of the BSPF area was therefore elicited by multiplying the average WTP by the total number of households in Tandun Sub-district.

The calculation process and the economic value are presented in Table 3. The economic value of hydrological services stated in per unit area (per hectare) was obtained by dividing the aggregate economic value by the remaining forest stand area (9,900 ha).

Table 3. Economic Value of Hydrological Services of BSPF Area

WTP Value (IDR per household per year)	Total number of household	Aggregate economic value of BSPF hydrological services (IDR per year)	Economic value of BSPF hydrological services (IDR per ha per year)
113,000	6,404	723,652,000	73,096*

* Obtained by dividing aggregate value by the remaining forest stand in BSPF area (9,900 Ha).
Source: Data analysis (2012)

Compared to the similar studies in African and Asian countries, this research finding was not greatly different. As cited by Ruitenbeek (2001), the study carried out by Ruitenbeck (1992) in the Korup, Cameroon also found the value which was not too different from our result if calculated in the present value. He found that the economic value of flood protection service of watershed was 3 USD per ha. At the present time, this value is equivalent to 8 USD (calculated at a 5% rate of inflation). It is equivalent to 72,000 IDR (on the assumption of the exchange rate of 9,000 IDR per USD).

Furthermore, Pearce also presented the research finding by Yaron (2001), which is also in line with our finding. Yaron (2001) has found that the flood protection value of forest in Mount Cameroun was within the range of 0 – 24 USD. At present, it is equivalent to range of 0 - 39 USD (on the assumption of an inflation rate of 5%) per ha. It is also similar to 0 - 351,000 IDR (exchange rate was assumed to be 9,000 IDR per USD).

Conclusion

This study has found that the average WTP for hydrological services of BSPF area was 113,000 IDR per household per year. This value indicated the economic value of hydrological services which equal to 5.8 percent of the household income.

Household income was the single variable which significantly influenced WTP. Increases in income will increase the WTP for environmental services.

In addition, this study also found that the economic value of hydrological services of BSPF was 73,096 IDR per ha per year. This value was regarded as an indirect benefit which people obtained from the hydrological services of BSPF.

Because of the role of the BSPF in the watershed system and high value of the economic benefits obtained from hydrological services, special efforts toward conserving the BSPF need to be made. Conservation activity can be carried out by preserving the remaining forest stand and restoring the degraded forest area.

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