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Economic valuation of water services related to protected forest management: a case of Bukit Batabuh in the RIMBA corridor, Central Sumatra, Indonesia

Barano Siswa Sulistyawan[1,2] · Budy P. Resosudarmo[3] · Rene W. Verburg[1] · Pita Verweij[1] · Mia Amalia[4] · Marija Bockarjova[5]

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Abstract

The context of daily household needs of rural communities, particularly the needs for water, often remains insufficiently considered in tropical forest management as it is facing an important decision-making trade-off between profit and preservation. We conducted a choice experiment study to elicit preferences of the rural community members in Central Sumatra, Indonesia, who perpetually depend on the ecosystem services of tropical forests. To inform a spatial planning policy for the protected forest, we focus on the valuation of water services in the protected forest area of Bukit Batabuh where the surrounding communities living rely on upstream watershed and water storage management. We find that those communities have a strict preference for improving forest water provisioning services, compared to the current situation (status quo), with the estimated aggregate benefit of non-commercial use ranging between USD 2.71 million and USD 2.47 million per year for each of the options of (1) maintaining and enhancing water storage, (2) rehabilitating forest in the upper watershed or (3) restoring the riparian forest. This study also identifies preference attributes, such as water storage capacity, water scarcity and water turbidity which can be used in other tropical landscape contexts in Indonesia and beyond.

Keywords Forest · Spatial planning · Economic valuation · Ecosystem services · Landscape

✉ Barano Siswa Sulistyawan
b.s.sulistyawan@uu.nl

1 Faculty of Geosciences, Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, The Netherlands

2 WWF Indonesia, Gedung Graha Simatupang, Tower 2nd unit C lt. 7 – 11, Jl. Letjen. TB. Simatupang, Jakarta Selatan 12540, Indonesia

3 Arndt-Corden Department of Economics, Crawford School of Public Policy, Australian National University, ANU College of Asia and the Pacific, Canberra, Australia

4 Ministry of National Development Planning and Development Planning Agency/Bappenas, Jakarta, Indonesia

5 Department of Urban and Regional Planning and Geo-Information Management, Faculty of Geo-Information Science and Earth Observation, University of Twente, Enschede, The Netherlands

1 Introduction

The United Nations have prioritised the conservation, restoration, and sustainable use of forests, such as the provisioning of clean water, non-timber forest products, and other ecosystem services, materialised in the Sustainable Development Goals (SDGs), i.e. SDG 6 (Improve Clean Water and Sanitation) and SDG 15 (Life on Land). However, a global forest assessment conducted by WWF indicates that at least 11 major regions worldwide are threatened by further deforestation (Taylor et al., 2015), among others in Sumatra, Kalimantan and Papua in Indonesia. In particular, over the past decade forest conversion and natural forest cover loss in Sumatra have affected an estimated 2.8 million hectares, which is the highest forest cover loss in Indonesia (Margono et al., 2014). Sustainable management of forests should, therefore, be based on well-informed decisions concerning the benefits of the services they provide for commercial and non-commercial uses.

One of the many ecosystem services provided by forests is water provisioning, which contributes to the livelihoods of surrounding communities (Rideout et al., 2014). Such non-commercial benefits derived from natural forests are crucial to local communities. Nevertheless, in most cases they are neither explicitly articulated, quantified, nor monetised. Timber production is commonly the highest commercial benefit derived from forests (Mogas et al., 2006). Ignoring non-commercial uses and benefits of natural ecosystems, like forests, too often leads to sub-optimal decisions and unsustainable natural resource management. Monetising the benefits of the non-commercial uses of forest ecosystem services such as water provisioning, food for subsistence, and other non-timber forest products provides an essential information for the decision-making process. In this case, by accounting for the total value of forest ecosystem services, including the non-commercial benefits, better decision making on sustainable use and conservation can be achieved accordingly (Kragt, 2013; Ojea et al., 2012).

As in the case of Sumatra Island, ten governors have conveyed their political will to maintain the forest stock, biodiversity, and the Sumatran ecosystems by including non-commercial benefits into decision making and land use planning processes. This commitment is embodied in the "Road Map for saving Sumatra Island Ecosystem 2020", which is used as an input for the Presidential Decree No. 13/ 2012 on the Sumatra Island Spatial Planning (Barano et al., 2010). This decree highlights five forest corridors on Sumatra Island, one of which is the RIMBA (RIau–JaMbi–Sumatra BArat) corridor. The government is committed to mitigate environmental degradation, halt deforestation of the tropical forest cover in Sumatra and address climate change issues by reducing greenhouse gas emissions from land use and land cover change (Roosita et al., 2010).

The RIMBA corridor comprises the upper catchment basin of the Indragiri and Batanghari rivers, which represents an important ecological corridor particularly for the migration of wildlife. Besides its importance for habitat connectivity, the catchment provides numerous ecosystem services to the area, which includes regulation of water yield and surface run-off (Bhagabati et al., 2014). These services prove even more crucial in the face of global climate change, which is expected to result in increased dynamics of surface temperatures of the Indian Ocean and the El Niño phenomenon, which in turn also causes below-average rainfall in Sumatra (Hermawan, 2011). The decline of forest cover in Bukit Batabuh area of the corridor RIMBA from 94,000 ha in 1985 to 45,000 ha in 2014 has already reduced water retention capacity, further reducing water availability and affecting the local micro-climate (Bhagabati et al., 2014). Stabilisation of land use in the RIMBA corridor through spatial planning regulation has therefore become an urgent issue.

However, there is a dispute on the impacts of forest restoration in an attempt to effectively improve water yields (Bezerra et al., 2017). Hence, such a policy requires a strong justification from various aspects to obtain political support for its implementation. In particular, aspects that involve trade-offs between restoration costs in the upper watershed and community benefits in the downstream should be taken into account (Ellison et al., 2017). Hence, obtaining the monetary value of both commercial and non-commercial benefits of forest uses such as water provisioning services in this study can strengthen the decision base for an environmentally sound, economically rigorous, and a socially fair planning policy.

With such consideration in mind, this research aims to assign monetary values to different water regulation services of the Bukit Batabuh protected forest in the RIMBA corridor landscape in Sumatra, in support of spatial planning policy. Quantitative methods to assign monetary values, such as choice modelling, have already been applied in Indonesia to facilitate decision making. Two examples of such application are the assessment of the health and air pollution impacts of the transport sector in Jakarta (Amalia, 2006; Amalia et al., 2016) and the estimation of the willingness to pay (WTP) for ecosystem services of the communities surrounding Lore Lindu National Park in Central Sulawesi (Glenk, 2011). This study focuses on the benefits obtained by the local communities from using water provisioning services in Bukit Batabuh Forest in the RIMBA corridor, a protected forest which deteriorates due to decreasing forest cover. The total population directly affected by the services provided by the forest comprises about 4,660 citizens out of a total population of 23,072 in the Kuantan Mudik Sub-district (Statistik, 2016).[1]

In this study, we used a choice experiment (CE) to reveal the individual preferences of local community residents surrounding the Bukit Batabuh protected forest. In particular, the CE method allows us to address the following research questions: (1) How do rural community members value the benefits of improving water services derived from the protected forest?; (2) which attributes determine community preferences for water resources?; and (3) what is the aggregate benefit of water provisioning services derived from the forest (to the community living within and around the protected area)?

The results of this study are therefore expected to inform and support the decision making of the Indonesia policy on Spatial Planning in support of forest protection, which can also be used to enhance habitat connectivity in the RIMBA corridor. A CE study like ours, can be of particular relevance to other tropical landscapes that face similar problems related to deforestation and the depletion of ecosystem services provided by tropical forests.

The rest of this paper is organised as follows. The methodology describes the study area, study design and statistical model. The results section presents respondent characteristics, mixed logit model results and the latent class logit model. The discussion section puts the findings into perspective, discusses research limitations and policy implications, which is then followed by the highlighted findings and the approach replicability to another landscape as conclusions.

[1] Statistical Agency of Kuantan Singingi District (2016).

2 Methodology

2.1 Study area

The RIMBA corridor landscape has three major clusters of programme interventions for improving habitat connectivity: Cluster I covering Bukit Batabuh Protected Forest, Cluster II which is a protected peatland forest ecosystem and Cluster III covering a highland production forest connecting with Kerinci National Park.

The Bukit Batabuh protected forest is located along the boundary of Kuansing District in Riau Province (Fig. 1). The Ministry of Forestry Decree No. 173/1986 designated the total area of the Bukit Batabuh protected area at 82,300 ha. However, the forest cover decreased by 45% between 1990 and 2014, with 45,456 ha remaining in 2014 (Uryu et al., 2010).[2] The area of Bukit Batabuh is part of the protected forest in the RIMBA corridor landscape that covers three provinces of Riau, Jambi, and West Sumatra in Central Sumatra.

According to Bhagabati et al. (2014), the forest loss has decreased the capacity of sub-watersheds to regulate water services in terms of the water yield distribution in the study area. Due to heavy degradation of the Bukit Batabuh Protected Forest as a result of encroachment by illegal agriculture activities and illegal logging, the main programme of the forest management authority (*Kesatuan Pengelolaan Hutan Lindung*) of the Bukit Batabuh Protected Forest is to restore forest cover and enhance the ecosystem services of Bukit Batabuh in order to benefit the environment, local communities, and regional development.

The forest of Bukit Batabuh has special status as a National Strategic Area (*Kawasan Strategis Nasional*), declared by the Central Government of Indonesia and recognised by the Presidential Decree on Sumatra Island spatial planning within the RIMBA corridor landscape. Its function is to act as a corridor to connect two protected areas: Rimbang Baling Wildlife Sanctuary and Bukit Tigapuluh National Park. Furthermore, this landscape is a habitat for endangered species, such as Sumatran tigers and other large cats, elephants, tapirs, and other local species of Sumatra (Ministry of Agrarian & Spatial Planning, 2013; Sulistyawan et al., 2017).

One of the priorities in implementing the Presidential Decree on Sumatra Island Spatial Planning is to develop a proper spatial planning policy that includes the Bukit Batabuh Protected Forest area. This spatial planning policy is a key instrument for delivering economic, social and environmental benefits (UNECEC, 2008). The Indonesian spatial planning regulation allocates land for both development and environmental protection. All natural resource-based sectors must use natural resources in accordance with this spatial planning policy. Significant efforts are required to enhance spatial planning policy towards sustainable landscape management in the RIMBA corridor (Sulistyawan et al., 2019). Spatial planning policy should, among others, consider the trade-offs in land use allocated between commercial and non-commercial use, including resource utilisation such as, mining, agriculture, plantation estate, and linear infrastructure (such as roads, powerlines and canals) and nature conservation (such as

[2] Forest cover mapping by WWF Indonesia based on Landsat images from 1990 to 2014 to update the previous mapping report of 2010.

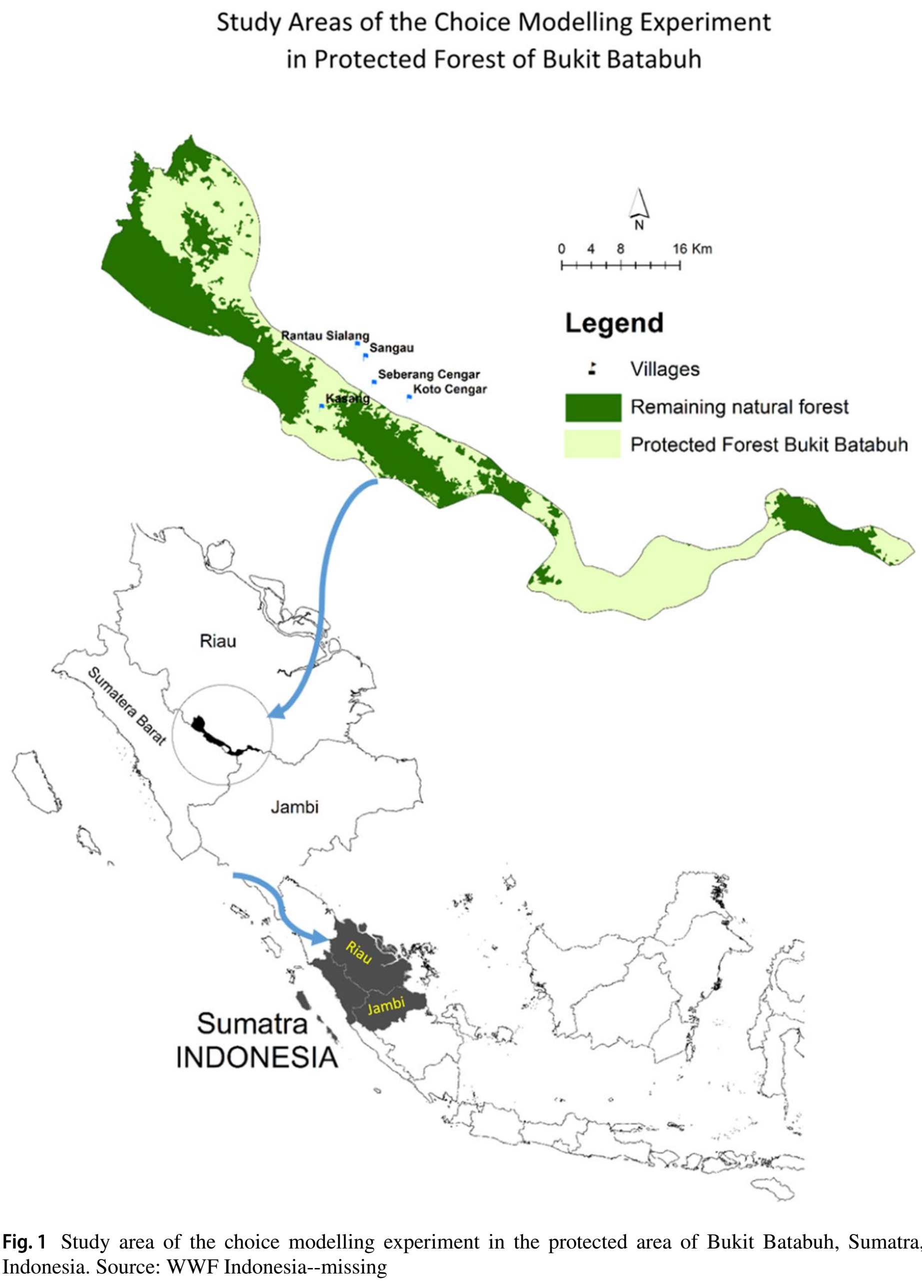

Fig. 1 Study area of the choice modelling experiment in the protected area of Bukit Batabuh, Sumatra, Indonesia. Source: WWF Indonesia--missing

maintaining the remaining tropical forest and other natural ecosystems, wildlife habitats, water springs, and catchment areas) (Bennett, 2005; Hudalah & Woltjer, 2007). For example, one of such trade-offs is between logging and extensive agriculture on the one hand and forest preservation in watersheds to maintain water supply on the other hand (Boithias et al., 2014; Perni et al., 2012; Wang et al., 2006).

2.2 Choice experiment design and data collection

To date, environmental economics includes well-developed concepts and methods for the valuation of non-market goods and services to integrate estimated welfare-compatible economic values in policy making (Bennett, 2005; Carson, 2000). Behavioural approaches are widely used in the valuation of environmental goods and services. In general, these methods can be grouped into revealed preference (Yusuf & Resosudarmo, 2009) and stated preference methods. Stated preference methods based on survey data are applied when data on such benefits is not readily available, in contrast to revealed preference methods which use market data of related goods and services, and by means of statistical inference estimate the value of environmental goods and services. Among stated preference methods, common survey-based economic techniques to determine the value of non-market services, such as environmental protection, are contingent valuation and choice modelling (Hanley et al., 2002).

Choice modelling is based on the theory and methods for discrete choice as described by McFadden (1974), who introduced conditional logit analysis and demonstrated that a mixed logit model is in line with random utility theory (McFadden, 2000). Choice modelling is widely used to reveal individual preferences for alternative actions or policies and is applied in many different sectors, including health, transportation, energy and environment (Birol & Koundouri, 1992; Hanley et al., 2002).

Based on the studies by Birol and Koundouri (1992) and Kragt (2013), Choice Modelling has established itself as a frequently used method for valuing specific attributes of policy options which are expected to change as a result of a new decision or policy. This modelling can be classified into four variants: discrete choice experiments, contingent ranking, contingent rating and paired comparisons (Hanley et al., 2002; Perni et al., 2012). In this study, we apply a discrete choice experiment (or CE for short) where survey respondents are asked to compare and report their preferred choice regarding a set of options (alternatives) that are described by a number of features or attributes with varying levels, often related to expected or envisaged policy interventions (Kragt, 2013). This can be related to different environmental states of natural resources, such as forests and respective costs related to implementation or maintenance of these options.

Typically, choice experiments can serve two purposes. First, they help elicit individual preferences of the local population for the important ecosystem services provided by the forest and, as a result, articulate these preferences in a quantified manner to inform spatial planning and decision making. Second, conveying the survey itself may help raise awareness among local communities about the meaning and importance of forest conservation for the provisioning of water services and their livelihoods, and to prevent illegal activities in the protected forest areas such as logging, hunting and encroachment.

Several stages are distinguished in implementing choice experiments, including formulating the problems and hypothesis, attribute selection and value assignment, choice of experimental design and choice sets, conducting the survey and data analysis (Hanley et al., 2002). Each of these stages is described below.

Based on current forest conditions and the main programme of the forest management authority, we have identified the following main areas of intervention aiming at improving specific environmental conditions: (1) restore and rehabilitate the riparian forest to reduce

Table 1 Attributes, unit, status quo, and attributes level used in the experimental design

Attributes	Unit	Status quo Level	Attribute levels
Water turbidity	NTU	250	100, 25, 10
Water scarcity	Number of dry water sources	50	20, 15, 10,5
Water storage capacity	Number of months	5	7, 8,10,11, 12
Annual cost	IDR (10,000)	0	15, 35, 40, 45, 50, 60, 80

Source: own elaboration

sediment transport into the river and improve water quality; (2) rehabilitate the upper catchment to improve the water yield of both spring and groundwater sources; and (3) improve water management to control surface water run-off and increase water storage. These areas of intervention are the starting point for the formulation of alternative policy options in comparison with the current situation (status quo) in our choice experiment.

To develop choice attributes relevant to respondents' choices and to test attribute levels for the three policy alternatives, focus group discussions with local communities were conducted and run alongside with literature review and discussions with peer economists. Focus group discussions were conducted in local communities from three villages nearby the Bukit Batabuh Forest, namely Rantau Sialang, Seberang Cengar, and Kasang villages (Fig. 1) and were attended by 30 individuals (both men and women). The respondents were selected based on consultation with the head of the village government, using criteria that included gender, jobs, role in society and their willingness to participate.

The focus group discussions revealed that, for the communities, decreased water provisioning from protected forests due to decreasing forest cover was among their most relevant environmental problems. Besides, most of the focus group participants mentioned the land use changes have impacted their clean water sources. In particular, participants indicated three main problems related to water provisioning that have emerged over the past 10 years due to forest cover loss: (1) increased turbidity due to high sedimentation; (2) reduced access to water sources such as wells, springs, rivers, rainwater harvesting, and the drinking water company services (*Perusahaan Daerah Air Minum*); and (3) insufficient water supplies.

Therefore, the following attributes for the stated choice experiment were defined, with assigned attribute levels (Table 1). The attribute levels for the status quo option were established during the focus group discussions and field observations:

- *Drinking water turbidity* attribute is stated in standardised NTU units (Nephelometric Turbidity Units) and qualitatively described as brown water (250 NTU, status quo), slightly turbid (100 NTU), slightly clean (25 NTU), and clean water (10 NTU). To explain water turbidity to the community we used a picture of water turbidity based on the level of NTU.[3]
- *Water scarcity* attribute describes the number of dry water sources (such as wells) within 5 km distance from the village of residence ranging between 50 (status quo) and 5.

[3] The water turbidity picture was produced by the NCSU Water Quality Group http://www.water.ncsu.edu/watershedss/info/turbid.html.

Table 2 An example of a choice card

CARD 1	Status Quo	Policy to restore the riparian forest	Policy to rehabilitate upper watersheds	Policy to improve water storage
Water turbidity	Brown water 250 NTU	Slightly turbid water 100 NTU	Slightly clean of water 25 NTU	Water clean 10 NTU
Water scarcity	Water sources dry in 50 locations in a year	Water sources dry in 20 locations in a year	Water sources dry in 15 locations in a year	Water sources dry in 15 locations in a year
Water storage capacity	Water supply for 5 months	Water supply for 7 months	Water supply for 11 months	Water supply for 12 months
Annual cost	Annual cost IDR 0	Annual cost IDR 150,000	Annual cost IDR 400,000	Annual cost IDR 500,000
Key question: What is your preference to choose the option from this card? There are three policy interventions to solve the environmental problems including the cost estimation. You feel free to choose without a correct or wrong answer.				

Source: own elaboration-missing

- *Water storage capacity* attribute describes the time in months that drinking water is available to the communities for their household use. The storage capacity used in the experiment ranges between 5 months (status quo) and 12 months.
- *Annual costs* The monetary attribute is stated as the costs in local currency IDR units per year associated with policy changes, ranging from IDR 0 for the status quo to IDR 800,000[4] for the highest cost per year; assuming the payment will be collected through annual payments similar to a water tax (see Table 1 for all attribute descriptions and levels).

A choice experiment was conducted using a fractional factorial design to define suitable and possible combinations of attributes and levels. For this, an orthogonal array (main effects) was used (Earnhart, 2001; IBM Corporation, 2013). Because the experiment was conducted in the rural context, we chose a reduced experimental design taking into account the education level of respondents while orthogonality was maintained (Wang et al., 2006). Therefore, we used four choice cards, each consisting of four alternatives (three policy options and the status quo), with varying levels of all attributes. An enumerator accompanied by a village facilitator helped explain the cards to the respondents. Also, because a relatively low number of respondents was expected, this would ensure enough response to

4 We converted the currency from IDR 800. 000 to USD 60.70 based on currency conversion during the research period 1 USD = IDR 13,180.00 (30 June 2016).

each choice card and thus a better statistical power for model estimation. A card example is shown in Table 2.

The survey that included the choice experiment was conducted in three villages (Seberang Cengar, Koto Cengar, and Sangau villages) near the Bukit Batabuh Protected Forest in Kuantan Singingi District of Riau Province (Fig. 1). A random sampling method based on household listings was used to select respondents for this survey. Each enumerator was trained according to the code of conduct of the survey to obtain informed consent through a voluntary respondent agreement form. Only if the respondent agreed, the interview was conducted. During the process of data collection, the main respondent could consult other family members when providing answers to the survey questions. The total number of respondents was 209 and of those, 178 completed the full questionnaire.

Beyond the choice experiment, other relevant information was collected from the respondents, such as socio-economic variables (main respondent's age, gender, education, income, and current expenditure to purchase drinking water), and information related to different sources of water and consumption patterns (Hanley et al., 1998; Kragt, 2013; Ojea et al., 2012). Through the focus group discussions, the team identified five sources of water for community water supply: (1) the Drinking Water Company; (2) rainwater harvesting; (3) river; (4) wells; and (5) purchased gallon jugs of drinking water from a refill storehouse or depot (see Sect. 3.1 for more detail).

2.3 Statistical model

The CE study on individual preferences of village residents for water provisioning from the Bukit Batabuh protected forest applies random utility theory (RUT). The RUT introduced by Lancaster in 1966 can be expressed as (Wang et al., 2006):

$$U_{an} = V_{an} + \varepsilon_{an} \tag{1}$$

where unobserved utility ***U*** represents individual preferences of respondent ***n*** for alternative ***a*** that consists of the observed utility ***V*** through the respondent's choice, and an unobserved random error component Ɛ, which is assumed to be independently and identically distributed across all observations (Amalia et al., 2016; Hole, 2007). Due to the presence of a random element, the probability of choice can be expressed as (Wang et al., 2006):

$$P\left(a/C_n\right) = P\left[\left(V_{an} + \varepsilon_{an}\right)\right] > \left[\left(V_{jn} + \varepsilon_{jn}\right)\right] \tag{2}$$

where ***P*** is a probability of choice ***a***, for all available ***j*** options in choice set ***Cn***. This probability of respondent ***n*** choosing the alternative ***a***on a choice occasion can be estimated by multinomial logit model formulated in Eq. 3 (Amalia, 2006; Wang et al., 2006).

$$P(a) = \frac{\exp_\mu V_a}{\sum_{j \in C_n} \exp_\mu V_j}. \tag{3}$$

A multinomial logit model assumes random error terms to obey the independence of irrelevant alternatives (IIA) property which is not affected by options outside the choice set (Birol & Koundouri, 1992; McFadden, 2000). The Hausman test is often used to test the IIA assumption (Amalia et al., 2016; Wang et al., 2006).

If the IIA assumption is violated, a mixed logit model must be utilised. The mixed logit model can help identify unobserved taste heterogeneity for choice attributes and alternative-specific constants (Hole, 2007). The model can be written as:

$$V_{an} = \beta_a + \sum_k \beta_k X_{km} \tag{4}$$

where $\boldsymbol{\beta_a}$ is a vector of alternative-specific constants for each alternative $1 \ldots a$, β_k is a vector of estimated coefficients for each choice attribute $1 \ldots k$, and $\boldsymbol{X_{km}}$ is a vector of choice attributes $1 \ldots k$, in each choice card $1 \ldots m$.

Note that when estimated coefficients β are assumed to be fixed, the model takes a closed form and is referred to as a multinomial logit model. When estimated coefficients β are allowed to vary, they are assumed to follow a distribution, and the model is referred to as a mixed logit model. A mixed logit model thus allows to test for taste heterogeneity and has another advantage of capturing the panel structure of the CE data.

According to Hanley et al. (2002) and Amalia (2006), to calculate the implicit price of the willingness of the respondent to pay for improving protected forest management to enhance the provision of water services, we applied the following formula (Eq. 5). The implicit price of an attribute of interest is obtained by dividing the estimated coefficient of this attribute, $\boldsymbol{\beta_{choice\ attr.}}$, by the estimated coefficient of the cost attribute, $\boldsymbol{\beta_{cost}}$:

$$\text{Implicit Price (IP)} = -\frac{\beta_{\text{choice attr.}}}{\beta_{\text{cost}}} \tag{5}$$

Furthermore, the compensating surplus (CS) measures the individual willingness to pay for alternative policy options captured by the alternative-specific attribute, such as in our case the proposed policy for enhancing water services provisioning. The CS can be calculated by Eq. 6, where $\boldsymbol{V_o}$ is total individual observed utility of the status quo option and $\boldsymbol{V_a}$ is the total individual observed utility of an alternative policy, and β_{cost} is the estimated coefficient of the cost attribute.

$$\text{CS} = -\frac{1}{\beta_{\text{cost}}}\left(V_0 - V_a\right). \tag{6}$$

To estimate the overall benefit of a particular alternative policy option to the affected population, the compensating surplus aggregate (CSA) is used as formulated in Eq. 7 (Amalia, 2006):

$$\text{CSA } = \text{CS} \times \text{RR} \cdot P \cdot t \cdot \frac{1}{(1+r)^t} \tag{7}$$

where ***CSA*** is the aggregate welfare estimate, ***CS*** is the compensating surplus as defined in Eq. 6, ***RR*** is the response rate, ***P*** is the population in the affected area, ***t*** is the time span in years of policy impact and ***r*** is the prevailing discount rate.

The multinomial and mixed logit models can be informative to understand overall patterns of preferences for alternative policies or policy attributes, as well as to derive compensating surpluses. Nonetheless, these models provide little information on the sources of unobserved taste heterogeneity. For policy implementation purposes, a better understanding of the underlying differences in preferences can be more than helpful to facilitate processes on the ground. In such cases, other statistical models, such as a latent class logit model, can be used to identify groups of individuals with similar patterns of preferences

Table 3 Descriptive statistics of variables, means, and standard deviations (SD)

Variables	Mean	SD
Education of respondent (years)	7.90	3.90
Age of respondent	50.48	12.69
Gender (male)	0.89	0.31
Income, Indonesia average (US$, per month)	182.17	42.20
Income, Indonesia average (IDR, per month)	2,401,048	556,256
Income, agriculture sector (US$, per month)	117.60	19.03
Income, agriculture sector (IDR, per month)	1,550,000	250,832
Number of family members	4.94	1.77
The cost of water gallon (US$, per month)	3.92	2.67
Number of consumed water gallon (19 L, per month)	13.27	11.59
Villages	N (per cent)	
Koto Cengar	62 (35.89%)	
Sangau	72 (35.41%)	
Seberang Cengar	75 (28.71%)	

Source: own elaboration

to design group-specific interventions (Hanley et al., 1998). The advantage of this model is that it does not only identify class-specific preferences for water provisioning services of a protected forest, but also estimates a probabilistic class membership model (estimated simultaneously with the choice model), which sheds more light on the expected group characteristics. A latent class logit model (LCL), according to Shen (2009), is formulated as follows:

$$P_{an} = \sum_{s=1}^{s} P_{an|s} H_{ns} \tag{8}$$

where the unconditional probability $\boldsymbol{P}$ of an individual $\boldsymbol{n}$ choosing alternative $\boldsymbol{a}$ is a sum of class-specific choice probabilities over all classes. $\boldsymbol{P}_{\boldsymbol{an|s}}$ is the class-specific choice probability and is defined as in Eq. 3. $\boldsymbol{H}_{\boldsymbol{ns}}$ denotes the prior probability that individual $\boldsymbol{n}$ belongs to class $\boldsymbol{s}$**,** for which a particularly convenient form is the multinomial logit with $\mathbf{z}_{\boldsymbol{i}}$ standing for a set of observable characteristics which enter the model for class membership:

$$H_{ns} = \frac{\exp\left(\mathcal{Z}_i\theta_q\right)}{\sum_q^{\mathcal{Q}} \exp\left(\mathcal{Z}_i\theta_q\right)}, \quad q = 1, \ldots, \mathcal{Q}, \ \theta q = 0. \tag{9}$$

In particular, the likelihood for individual $\boldsymbol{n}$ choosing alternative $\boldsymbol{a}$ is the expectation (over classes) of the class-specific contributions. The LCA model therefore simultaneously estimates Eqs. 3, 8, and 9. The choice of an appropriate number of classes is based on a number of criteria, including the Bayesian information criterion (BIC) and Akaike information criterion (AIC) (Pacifico & Yoo, 2003; Shen, 2009).

3 Results

3.1 Respondents' characteristics

The background characteristics of the respondents and descriptive statistics are found in Table 3. The age of respondents was between 22 and 87 years, with a sample average of 50.5 years. Most of the respondents (89.5%) were male because the target respondent was the household head who is usually male. The respondent's education level was mostly Elementary School (43.5%), Junior High School (23.4%), and Senior High School (29.7%). Respondents with below-average income make up 40% of the sample (IDR 1.55 million for the agricultural sector, equivalent to USD 117.60 per month),[5] with 10% below the income level of IDR 1 million. Besides, 25% of the respondents have an income of above IDR 2.75 million. Main sources of income for the population are derived from agriculture plantations, such as oil palm, rubber, and non-timber forest products such as fruits trees (durian, banana, and jack fruit).

For the survey respondents, the main water sources were wells, purchased gallon jugs, and river and rainwater harvesting. In general, wells are the main source of water for most of the respondents (81%), which are owned by individual households. Less than 5.5% constitute public wells. However, about half of the total wells lacked sufficient water during the dry season when the water level could drop by up to 10 m.

Nearly half of the respondents (47.7%) purchased gallon jugs of water from the public storehouse/ depot. The survey results showed that more than 51% of these buyers bought more than ten jugs of water per month with costs ranging from IDR 5000 to 160,000. The average cost of water purchased was IDR 52,000[6] per month (equivalent to USD 3.9 per month or USD 46.8 per year).

Furthermore, water from rivers was used by 40.6% of respondents. The water turbidity of the river water was higher (> 35 NTU) during the rainy season than in the dry season (< 5 NTU). The respondents had allocated their own means to cover the costs of a water jet pump and pipe installation for pumping water from the river.

Rainwater harvesting was used by 5.6% of respondents. This applied to respondents living in remote areas with very limited access to the river. The rainwater quantity was sufficient for only 4 to 8 weeks of the year, depending on the size of the water storage facility, such as a water tub (100 L), drum (200 L) and water tank (250 L) and rainfall frequency.

Lastly, none of the respondents reported any use of water from the drinking water company (PDAM), as the PDAM installation did not reach these villages to provide potable water services. Therefore, the community purchased water from an outside provider or private business if their wells did not provide potable water. Overall, the community used a mix of water sources to support various daily household needs.

[5] Indonesia Statistics Agency (BPS) data 2017 provide an average wage in agriculture, plantation, and forestry sectors.

[6] We converted the currency from IDR to USD based on currency conversion during the research period 1 USD = IDR13,180 (30 June 2016).

Table 4 Selected mixed logit model (MXL) and latent class logit model (LCL)

Variable	MODEL 1: mixed logit (MXL)		MODEL 2: latent class logit (LCL)			
			Class 1 (32.8%)		Class 2 (67.2%)	
Choice model						
Alternative-specific constants						
Policy 1: restore riparian forest	14.1398	***	−.3929		−2.5040	
Policy 2: rehabilitate upper water catchment	14.8885	***	3.2576		−3.3310	
Choice modelPolicy 3: improve water storage management	15.4634	***	3.1372		−2.9310	
Choice attributes;						
Choice modelAnnual cost (× 10,000IDR)	−.0752	***	−.0908	*	−.0491	*
Choice modelWater turbidity	−.0238	***	−.0393	***	−.0083	
Choice modelWater scarcity	−.1446	**	−.0707		−.0323	
Choice modelWater storage capacity	.4227	*	−1.4861	*	1.1700	***
Class membership model						
Education of respondents			−.0618			
Respondents income			−.3576	***		
Respondents age			−.0095			
Respondents gender (male)			2.0595	**		
Respondents village Sangau			−.0097	**		
Family members of respondents			−.2499	**		
Random parameters						
Water turbidity	−.0223	***				
Water scarcity	.3367	***				
Water storage capacity	1.0201	***				
Estimation statistics						
chi2	215					
N	2848		2848			
LL (model)	−664		−594			
Aic	1348		1229			
Bic	1407		1354			
Rank	10		21			

Source: own elaboration

3.2 Mixed logit model estimation results for policy choices

First, we present the estimation results of the mixed logit model with main effects only that accounted for heterogeneity in taste for the three choice parameters of water turbidity, water scarcity, and water storage capacity using 250 Halton draws and assuming normal mixing distribution (Table 4). Compared to the multinomial logit model (not reported here), the mixed logit model yielded a significantly better fit (respective log-likelihood statistics are − 1332.7 and − 663.8). The coefficients of all choice attributes as well as alternative-specific constants are statistically significant. The three constants for the three alternative policies are positive which means that each of the policies, i.e. to restore the riparian forest, to rehabilitate the upper water catchment, and to improve water storage management,

Table 5 Attribute (willingness to pay/ WTP), per household per year (all values expressed in 2016 IDR and USD)

	WTP(IDR)	WTP(USD)
Water turbidity (NTU), per 1 NTU	**−3157**	**−0.24**
Water turbidity (250–> 100NTU), decrease compared to SQ	473,536	35.93
Water turbidity (250–> 25NTU), decrease compared to SQ	710,304	53.89
Water turbidity (250–> 10NTU), decrease compared to SQ	757,658	57.49
Water scarcity (n sources), per 1 source	**−19,222**	**−1.46**
Water scarcity (50–> 20), decrease compared to SQ	576,666	43.75
Water scarcity (50–> 15), decrease compared to SQ	672,777	51.05
Water scarcity (50–> 10), decrease compared to SQ	768,888	58.34
Water scarcity (50–> 5), decrease compared to SQ	864,999	65.63
Water storage capacity (months), per 1-month	**56,184**	**4.26**
Water storage capacity (5–> 7 months), increase compared to SQ	112,368	8.53
Water storage capacity (5–> 8 months), increase compared to SQ	168,552	12.79
Water storage capacity (5–> 10 months), increase compared to SQ	280,921	21.31
Water storage capacity (5–> 11 months), increase compared to SQ	337,105	25.58
Water storage capacity (5–> 12 months), increase compared to SQ	393,289	29.84

Source: own elaboration

is preferred to the status quo option, which represents the current situation without policy intervention.

The annual cost attribute is negative and statistically significantly different from zero ($P < 0.001$) reflecting marginal disutility associated with costs, which is in line with expectation. The water turbidity coefficient is negative and statistically significant ($P < 0.001$) compared to zero, reflecting higher marginal disutility associated with higher water turbidity in water sources. The water scarcity coefficient is negative and statistically significant ($P < 0.05$) reflecting higher marginal disutility associated with a higher number of dry water sources within a 5 km range of the households. The water storage capacity coefficient is positive, reflecting higher marginal utility associated with longer time periods when drinking water is available to the households, yet, the P value is above 0.1, indicating no statistically significant association with the choice of intervention. The estimated model is tested for the presence of unobserved taste heterogeneity of the three choice attributes. The respective estimated standard deviations of the three choice attributes are all statistically different from zero signalling that households indeed differ in their preferences concerning water turbidity, water scarcity, and water storage capacity.

As explained in Sect. 2.3, the estimated choice in Eq. 1 allows to calculate various willingness to pay (WTP) indicators, such as the implicit prices of attributes of non-commercial water services provided by the Bukit Batabuh Forest to the local population (Eq. 5), as well as the compensating surplus and the aggregated benefits of various policies that can improve water provisioning services of the Bukit Batabuh Forest (Eqs. 6, 7, respectively). Obtained implicit prices (WTP) for the choice attributes are provided in Table 5. Local households were willing to pay for improved water quality in terms of decreasing "water turbidity" at IDR 3157 (corresponding to USD 0.24 per NTU per household per year). The implicit price of water scarcity, i.e. decreasing the number of "dry water sources" was

Table 6 Compensating surplus and aggregate benefit for the proposed alternative policies for forest management aimed at improved water provision (all values expressed in 2016 IDR and USD)

	Compensating surplus		Compensating surplus aggregate		
	IDR (per household, per year)	USD (per household, per year)	IDR (aggregate, per year, in billions)	USD (aggregate, per year)	USD (aggregate, for 5 years)*
Policy 1: restore riparian forest	1,879,237	142.58	32.61	2,473,851	10,948,765
Policy 2: rehabilitate upper water catchment	1,978,747	150.13	34.33	2,604,848	11,528,531
Policy 3: improve water storage management	2,055,141	155.93	35.66	2,705,413	11,973,611

*Assuming prevailing interest rate in Indonesia of 6.5%

Source: own elaboration

estimated at IDR 19,222 (USD 1.46 per water source, per household per year). The implicit price for water storage capacity, i.e. prolonging "water supply" in months was estimated at IDR 56,184 (USD 4.26 per each month, per household per year).

In addition, to obtain the range of WTP for the expected improvements in the water provision conditions, implicit prices were also calculated for the changes in attribute values compared to the status quo level presented in the choice experiment. In particular, for water turbidity, the proposed improvements in the conducted choice experiment ranged between 10 and 100 NTU compared to the status quo (current) condition of 250 NTU. These changes were valued at between USD 36 and USD 57 annually per household. For water scarcity, the proposed decrease in the number of "dry water sources" in the conducted choice experiment ranged between 5 and 20 water source locations compared to the status quo condition of 50 dry water sources. These changes would then be valued at between USD 44 and USD 66 annually per household.

For water storage capacity, the proposed improvement in the number of months of "water supplies" in the conducted choice experiment ranged between 7 and 12 months compared to the current condition of 5 months. These changes would then be valued between USD 9 and USD 30 annually per household. These numbers seem feasible given that the average actual annual cost of purchase of water gallon jugs per household is about USD 47.

Table 6 presents the valuation results for the three alternative policies aimed at the improvement of water provisioning services from the Bukit Batabuh Forest. The compensating surplus following Eq. 6 indicated the average household's willingness to pay for the improvement of water provisioning services of the Bukit Batabuh Forest for three policy options. First, the compensating surplus for the forestry Policy 1, i.e. to reduce sediment transport for improving water quality through "restoring riparian forest" was estimated at IDR 1.88 million (USD 143 per household per year). Second, the estimate of compensating surplus for Policy 2, i.e. to improve water recharge for maintaining the groundwater by "rehabilitating the upper catchment" was at IDR 1.98 million (USD 150 per household per year). Third, the compensating surplus for Policy 3, i.e. to capture water in reservoirs by "improving water storage management" was estimated at IDR 2.06 million (USD 156 per household per year). The obtained valuations for the alternative policies as described above are numerically close to each other and thus do not reflect substantial differences in average values attached to them by the households making use of water provisioning services of the Bukit Batabuh Forest.

Finally, the aggregated benefit of water provisioning services of the Bukit Batabuh Protected Forest was obtained by applying the compensating surplus aggregate equation as in Eq. 7 using a 85.17% response rate (178 usable questionnaires out of the distributed 209 ones), assuming a 6.5% official government discount rate,[7] a 5 years timespan for the governmental spatial planning policy review, and an estimated population of 23,072 people living in the immediate surroundings of the protected forest (see Table 6).

The compensating surpluses aggregate for Policy 1 ("restoring riparian forest"), for Policy 2 ("rehabilitation of the upper catchment"), and for Policy 3 ("improvement of water storage management") were estimated at IDR 32.6 billion per year or USD 2.47 million per year (USD 10.95 million on the 5 years basis), IDR 34.3 billion per year or USD 2.6 million per year (USD 11.53 million on a 5 years basis), and IDR 35.7 billion per year or USD

[7] Bank Indonesia rate: https://www.bi.go.id/id/ruang-media/siaran-pers/Pages/SP_185016.aspx.

Table 7 Latent class model (two classes) and WTP for selected attributes (per household per year) (all values expressed in 2016 IDR and USD)

Estimated class membership	Class 1 (32.8%)		Class 2 (67.2%)	
	WTP (IDR)	WTP (USD)	WTP (IDR)	WTP (USD)
Water turbidity (NTU), per 1 NTU	**−4335**	**−0.33**		
Water turbidity (250–> 100 NTU), decrease compared to SQ	650,197	49.33		
Water turbidity (250–> 25 NTU), decrease compared to SQ	975,296	74.00		
Water turbidity (250–> 10 NTU), decrease compared to SQ	1,040,316	78.93		
Water storage capacity (months), per 1-month			**238,429**	**18.09**
Water storage capacity (5–> 7 months), increase compared to SQ			476,857	36.18
Water storage capacity (5–> 8 months), increase compared to SQ			715,286	54.27
Water storage capacity (5–> 10 months), increase compared to SQ			1,192,143	90.45
Water storage capacity (5–> 11 months), increase compared to SQ			1,430,571	108.54
Water storage capacity (5–> 12 months), increase compared to SQ			1,669,000	126.63

Source: own elaboration

2.71 million per year (USD 11.97 million on a 5 years basis), respectively. These numbers reveal substantial value of benefits for local communities who depend on the water provisioning services from the Bukit Batabuh Forest for each policy option that is expected to result in improved water management.

3.3 Latent class logit model estimation results for policy implementation

For the next step, we estimated the latent class logit model (LCL) to test for the presence of subgroups within the sample population that would differ in their preferences for choice attributes or proposed policy options (see Table 4). Results of this model can be seen as complementary to the estimates of the mixed logit model as presented in Sect. 3.2. While the latter can be used to support decision making concerning the choice of the policy and the levels of water improvement attributes, the latent class model can potentially be useful for the implementation of the policies on the ground as it reveals more specific preferences

Table 8 Estimation statistics for the LCL model with 2, 3, and 4 classes

Model	Obs	ll(model)	*df*	CAIC	BIC	Model interpretability
2-class LCL	2848	−593.3	21	1228.5	1353.6	v
3-class LCL	2848	−544.8	33	1155.6	1352	x
4-class LCL	2848	−527.4	48	1150.9	1436.7	x

N = Obs. used in calculating BIC; see [R] BIC note

Source: own elaboration

of different groups within the population residing in the area surrounding the Bukit Batabuh Forest.

Because the number of subgroups with different preference patterns is unknown in advance, we estimated three models with different numbers of assumed latent classes, namely with 2, 3, and 4 classes. The choice of the final model is conventionally guided by a number of indicators, such as the model fit in terms of log-likelihood, information criterion (such as the Bayesian information criterion (BIC), the Akaike information criterion (AIC), or consistent Akaike information criterion (CAIC)), the interpretability of the results and the estimated class sizes. In our case, we have chosen the LCL model with two classes.

Table 8 provides estimation statistics for estimated LCL models with 2, 3, and 4 classes. While models of 3 and 4 classes were superior in terms of log-likelihood, we report the results of a two-class model as the most parsimonious following BIC, and the one that lent itself best for interpretation. Estimation statistics for the LCL model with 2 classes are found in Table 8. This LCL model provides an improved fit in terms of log-likelihood of − 593.3 compared to the mixed logit model discussed above. The probability of class membership for Class 1 is 32.8% and for Class 2 67.2% (see Eqs. 8, 9). The LCL model results indicated a stronger preference of respondents in Class 1 for improved water turbidity (negative and statistically significant coefficient) and a stronger preference of respondents in Class 2 for improved water storage capacity (positive and statistically significant coefficient). In both classes, respondents had significant preferences for either of the proposed policies compared to the status quo; all alternative-specific constants proved to be not statistically significant. These results may reflect the weak statistical power of the LCL model which may improve with larger samples.

The class membership model was tested for several specifications, which included socio-economic variables, as well as water acquisition variables. However, apart from the socio-economic variables, none of the other class membership determinants proved to be statistically significant. Therefore, we have chosen to report a latent class logit model where class membership is described by respondent education level (in years), age (in years), gender, monthly income, household size (number of family members that constitute a household), and place of residence.

Respondents in Class 1 are likely to have a lower income, be a female, have fewer family members and to reside in Seberang Cengar and Koto Cengar villages, compared to respondents of Class 2. Level of education and respondent age were not statistically significant determinants of class membership. In turn, membership in Class 2 is associated in a statistically significant way (at least at 5% level) with a higher level of income, with the majority of respondents being male and inhabitants of Sangau village and having a bigger household size. Table 7 shows the calculated implicit prices (WTP) of the choice attributes that determine the choices of the respondents in the two classes (Table 8).

Respondents in Class 1, i.e. the lower income, female class place a strong preference on water turbidity which is the only attribute for this class that is significant at least at 5% level. In particular, the implicit price of the improvement of water turbidity equals IDR 4334, equivalent to USD 0.33 per 1 NTU per year. This would translate into a range of USD 49.33–78.93 for improved water turbidity changes to 100 NTU and 10 NTU, compared to status quo (250 NTU), a range measured by this choice experiment. These amounts are higher compared to the sample average WTP for water turbidity reported in Table 5.

Meanwhile, the respondents of Class 2, i.e. the high-income male class in turn, place a strong preference on water storage capacity, which is the only attribute that is statistically significant (at least at 5% level) for this group. In particular, the implicit price that respondents of this class are willing to pay for the increase in the months of water supply is four times higher than the sample average as reported in Table 5 which equals IDR 238,429, equivalent to USD 18.09 per year per additional month that water storage capacity is increased. This would translate into a range of USD 36.18–126.63 for increased water storage from 5 months (of the current condition) to 7 and 12 months, as measured by this choice experiment.

4 Discussion

This study has elicited the preferences of local communities for three alternative forest preservation policies as an intervention to restore the water provisioning services of the Bukit Batabuh Forest. These policy scenarios included restoration of the riparian forest, rehabilitation of the upper water catchment area, and improvement of water storage management. The magnitude of the monetised values based on the willingness to pay estimates, hardly differed between the three policies with the aggregate surplus per year ranging between USD 2.47 million and USD 2.71 million annually. These findings revealed that local residents strictly prefer a change (i.e. policy intervention for forest preservation) compared to the status quo, but do not have an outspoken preference towards a specific type of forest preservation option.

When we divided the aggregate benefit by the intervention area of 37,035 ha, the monetised benefit was estimated at USD 66.79–73.05 per ha. In the USA, various types of choice experiments have been conducted to estimate WTP for forest ecosystem services and their results show large variation due to context, such as mandatory tax versus voluntary payments (Roesch-McNally & Rabotyagov, 2016), one-off payments versus recurrent payments (Mueller, 2014), or type of ecosystem service to be restored (Aguilar et al., 2018; Rosenberger et al., 2012). Due to large differences in income, the results of these studies cannot be used for direct comparison with our results.

We have therefore selected several studies with similar approaches limited to water services estimates from Costa Rica, Tanzania, Colombia, and China to compare those to the obtained monetised values for Bukit Batabuh Forest in this study. In a study from Costa Rica, the preferences of residents were assessed for water supply, recreation, and maintenance of biodiversity provided by forests (Bernard et al., 2009). The aggregate benefits of water-related services from Tapantí National Park, such as provisioning of potable water, regulation of water supply to the river, lake, pond, and artificial water storage for multiple uses was estimated at about USD 32.12 per ha per year, which corresponded to USD 1.84 million per year for the total intervention area. In this study, the avoided cost method was used, based on the costs associated with sediment removal, deforestation, and forest cover degradation. A study of the Tanzania Kilombero Wetlands and forest catchment area indicated a much lower WTP for forest conservation ranging between USD 8.98 per km^2 and USD 26.37 per km^2, which was only 2% of the rural populations revenues from charcoal (Mombo et al., 2014). In the Colombian Andes, both smallholders and recreational house-owners currently pay a flat fee for water use of USD 1.44 per month (Moreno-Sanchez et al., 2012). Smallholders were willing to pay an additional USD 0.41 per month and recreational house-owners USD 1.61 per month for improved water services from forested areas.

For the Heshui watershed in China, a contingent valuation method (stated preference approach) was used to estimate the farmers' willingness to pay for forest restoration and protection at USD 573 per ha per year; this value referred to various ecosystem services including watershed protection for water provisioning, forest carbon, biodiversity conservation and landscape cultural values (Tao et al., 2012). It is important to note that the case study in China valued multiple benefits of protected forest and therefore did not distinguish the economic benefit of the watershed for water protection only, which may explain the higher values in comparison with our case. These examples show that our current estimated values are plausible, provided the differences in method and valued benefits.

The attributes of water turbidity, water scarcity, and (temporal) water storage were found to significantly influence respondents' choices of forest preservation policies. Hence our results indicate that local residents attach a positive monetary value to these water provisioning attributes with the highest values attached to the improvement of water quality, i.e. a decrease in turbidity, and water availability, i.e. a decrease in the number of dry water sources, for the range of values considered in this experiment. The yearly amounts obtained in the current study for the three attributes ranged between USD 30 and USD 66 and were comparable in size to the factual average household expenditures for purchasing drinking water which were reported by respondents at USD 47 per year.

Although Payment for Ecosystem Services (PES) has been applied in Indonesia for more than two decades, it remains challenging to obtain data on the economic valuation of ecosystem services, such as water provisioning from protected areas (Heyde et al., 2012). The ultimate goal of this study was to support policymakers in spatial planning related to protected forest management. It therefore emphasised the estimation of the non-commercial benefits of alternative forest preservation policies as an intervention for the communities in the downstream catchment area who depend on the forest for water provisioning.

While protected forests deliver a broader variety of ecosystem services, current results can readily be used in policy making at different levels, such as at the national policy level concerning national protected areas including community forestry schemes, regional spatial planning, and local regulation of access permits to buffer zones of protected areas. A possible approach to implementing and financing a forest preservation policy, could be a market-based mechanism such as PES. This would require exploration of the potential for compensating current forest users, such as small-scale jungle rubber harvesters, as well as the potential for including a broader range of beneficiaries of water provisioning services such as local residents in the downstream of the catchment area.

Monetary valuation of both the demand and supply side of the water provisioning services has helped to establish and enact a mandatory PES scheme in Indonesia (Diswandi, 2017b). An example of a broad monetary valuation of ecosystem services used in protected area management in Indonesia is the case of Lombok (Diswandi, 2017a) where multiple institutions have been involved, including the Natural Resort Conservation Unit, Lombok Forestry Agency, and Mount Rinjani National Park Office in collaboration with WWF Indonesia.

A number of limitations of this study, however, need to be mentioned. First, this study was based on the hypothetical scenarios of forest preservation and restoration focusing on water provisioning services to the local population. The choice of the policies, as used in this study, was based on previous experiences and best practices of tropical forest preservation and restoration, however the precise magnitude of positive effects, which are specific to the context of the Bukit Batabuh Forest, has not been studied. While there is ample evidence of the beneficial impacts of interventions related to the restoration of the riparian forest, rehabilitation of the upper water catchment area, and improvement of water storage management, research should further quantify the expected effect of each intervention on the water provisioning services for this region.

Second, the hypothetical nature of the choice experimental setting imposes a cognitive burden on respondents (Hanley et al., 2002). Other case studies in developing countries show that it is important to address the cognitive burden during study design, while selecting the set of choice attributes relevant within the local context, in particular by reducing the complexity of the presented options (Bennett & Birol, 2010; Mangham et al., 2009; Mekonnen et al., 2010). We have attempted to address this issue by setting up a context of the choice experiment that was relevant to the survey respondents. In particular, the restoration policies for the protected forest of Bukit Batabuh were framed in the context of water provisioning services because this aspect was repeatedly mentioned in a pilot study among village residents living in the surrounding area of the forest as the most relevant one to their livelihoods.

In order to decrease the cognitive burden of choice, we conducted the focus group discussions to obtain inputs for improving the relevant attribute selection and opted for a simple design with only four choice cards per respondent. In spite of the relatively small sample size and simple design, the model estimation results obtained in this study were robust and the range of monetary values of choice attributes found was comparable to current household expenditures for purchasing drinking water. The use of a more extensive statistical design and a larger sample in the future should improve the possibilities for estimating more sophisticated models for an in-depth analysis of individual preferences.

Third, the current study has valued a single facet of multiple ecosystem services provided by a tropical forest: the non-commercial benefits of water provisioning services. Other benefits relevant to local populations may include community livelihoods derived from non-timber forest products such as durian fruit, rattan, jungle rubber, and dragon blood fruit, which can be derived from market values. The aggregated values obtained in this study therefore provide a conservative valuation of non-commercial benefits that local populations receive from the forest and can be used as lower bound estimates. We also note that established values are anthropocentric and capture predominantly use-values and may not take account of other important benefits from the Bukit Batabuh Protected Forest such as improving habitat preservation and connectivity for wildlife in the RIMBA corridor landscape.

5 Conclusion

This study uses a stated preference framework to value water services derived from forests, which supports land use allocation in spatial planning policy for the forestry sector in Indonesia. Particularly in the context of forest conservation efforts, it remains challenging in collective decision making on land use planning to convince the non-forestry sector to preserve forest areas compared to other cultivation options that bring commercial benefits. Hence, monetisation of the values of ecosystem services from the forest as performed in this study becomes necessary. It provides meaningful insights into the value of non-commercial benefits of forest protection to local communities whose livelihoods depend on the forest ecosystem services at the landscape scale. The method is applicable to other tropical landscapes under the condition that the communities benefit directly from water services derived from the forest.

Our results reveal a positive implicit price that local households place on the water provisioning services of the protected forest, in particular, decreased water turbidity, decreased number of dry water sources, and increased water storage capacity. Our results also reveal that local households place a positive value on the three proposed policies of restoring the riparian forest (Policy 1), restoring the upper catchment (Policy 2), and improvement of water storage management (Policy 3). Furthermore, we also found differences in preferences for water provisioning services between two subclasses of respondents. A majority group of respondents has a stronger preference for improving water storage capacity, while a minority group of respondents has a stronger preference for improving water quality. The design and implementation of appropriate policies can thus be informed by different preference patterns within the surveyed communities.

Summarising, our study provides important information on environmental benefits of water services that have not been articulated or quantified previously, in support of spatial planning policies and practices for tropical forests. The monetised values of water provisioning services can be used as the basis of policies for forest protection and spatial planning, to support community forest management, and to develop market-based mechanisms, such as PES schemes. Choice experiments can be replicated to similar contexts in relation to other Indonesian islands, or other tropical countries, in support of environmental and planning policies.

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