The Economic Value of Environmental Services in the Karst Area of Jatijajar Village

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ABSTRACT

Jatijajar Village is included in the Gombong karst area based on the Minister of Energy and Mineral Resources Decree No. 3043 K/40/MEM/2014 and was confirmed by the Kebumen Regency Regional Regulation No. 23 of 2012 concerning RTRW of Kebumen Regency. It has the potential value of environmental and ecological services both in the karst area itself and in the non-karst area which is used as a buffer zone. The underground river system provides benefits to the environment around the karst area and even the community as a provider of clean water needs that are perennial/flowing throughout the season. The contingent valuation method is used as an approach in this research. Primary data obtained from field research is used as the main data. The analysis of environmental services used is the willingness to pay technique of individuals for environmental services or resources. Natural resources in the Karst Gombong area of Jatijajar Village have characteristics in the form of direct use, the value of water resources for lowland rice farming and Water resources from underground rivers in the karst area is 15 springs. The total economic value of the potential use of existing resources in the Gombong Karst Gombong area of Jatijajar Village is IDR 87,616,789,519 in one year. The magnitude of this value is the value of natural and environmental resources from the direct use of the availability of natural resources to the community. These values will be lost if the karst area is damaged either from mining activities or changes in environmental functions.

Keywords: Karst; Economic Valuation; Natural resource and environmental economics; Total Economic Value.

ABSTRAK

Desa Jatijajar termasuk dalam kawasan karst Gombong berdasarkan Keputusan Menteri ESDM Nomor 3043 K/40/MEM/2014 dan dikukuhkan dengan Peraturan Daerah Kabupaten Kebumen Nomor 23 Tahun 2012 tentang RTRW Kabupaten Kebumen. Memiliki nilai potensi jasa lingkungan dan ekologi baik di kawasan karst itu sendiri maupun di kawasan non-karst yang dijadikan sebagai buffer zone. Sistem sungai bawah tanah memberikan manfaat bagi lingkungan sekitar kawasan karst bahkan masyarakat sebagai penyedia kebutuhan air bersih yang bersifat abadi/mengalir sepanjang musim. Metode penilaian kontingen digunakan sebagai pendekatan dalam penelitian ini. Data primer yang diperoleh dari penelitian lapangan digunakan sebagai data utama. Analisis jasa lingkungan yang digunakan adalah teknik kesediaan membayar individu untuk jasa atau sumber daya lingkungan. Sumber daya alam di kawasan Karst Gombong Desa Jatijajar memiliki karakteristik berupa pemanfaatan langsung, nilai sumber daya air untuk pertanian padi sawah dan sumber air dari sungai bawah tanah di kawasan karst adalah 15 mata air. Total nilai ekonomi dari potensi pemanfaatan sumberdaya yang ada di kawasan Karst Gombong Desa Jatijajar adalah sebesar Rp87.616.789.519 dalam satu tahun. Besaran nilai ini merupakan nilai sumber daya alam dan lingkungan dari *pemanfaatan langsung ketersediaan sumber daya alam tersebut kepada masyarakat. Nilai-nilai tersebut akan hilang jika kawasan karst mengalami kerusakan baik akibat kegiatan penambangan maupun perubahan fungsi lingkungan.*

Kata Kunci: *Kawasan Karst, Valuasi Ekonomi, Ekonomi Sumber daya alam dan lingkungan, Nilai ekonomi total.*

INTRODUCTION

Jatijajar Village is one of the villages in Ayah Subdistrict, Kebumen Regency, which is included in the Gombong Karst area's landscape according to the karst area's delineation map through the Decree of the Minister of Energy and Mineral Resources No. 3043 K/40/MEM/2014. The definition of karst according to Hanang Samodra (2001) is a landscape that specifically develops in carbonate rocks due to the karstification process during the available geological space and time (Pramestyan, 2021). The karstification process begins with the dynamic movement of the earth's plates, these movements collide with each other and produce tectonic forces that push some of the earth upwards so that coral reefs that were previously located in shallow waters are also uplifted and sedimented into calcium carbonate (CaCo3). Ford and Williams (1989) stated that karst is plain with characteristic hydrological conditions resulting from easily soluble rock or limestone and has a well-developed secondary porosity.

Ordinary people understand that a karst area is a dry and unproductive area. This is due to the physical nature of limestone which is easily soluble and has secondary porosity, so it cannot store water for a long time. Rainwater that flushes the karst area immediately sinks to the bottom of the water-saturated zone and then flows through fractures and large passageways (caves) such as canals to the exit points of springs or is directly dumped into the sea, only a small amount flows on the surface (Fitri, 2017). Rainwater that inundates the karst area immediately seeps to the bottom of the water-saturated zone and then flows through cracks and alleys (caves) like canals to the exit point of the springs or directly discharged into the sea, only a small amount flows on the surface. This incident is the answer to why the karst area is identical to a dry and barren area, even though underneath it stores quite a lot of water and flows all the time with good quality and is used by the community as a clean water requirement.

The limestone area is known as an area for producing cement raw materials, bleaching agents, neutralizing soil acidity, ceramic raw materials, glass industry, paint industry, cosmetics, rubber mixtures, paper bleach, and as road hardener. In addition, in the cave which is the remnant of the smelting process of the karst area, phosphates can be found which settles at the bottom of the cave which is formed from the droppings of bats and birds dissolved in limestone. Phosphate is usually used as an organic fertilizer, while wet bat droppings are also used as guano fertilizer (Hidayat, 2016).

Not only as an extractive material, but the karst area also has the value of environmental and ecological services both in the karst area itself and in non-karst areas that are used as buffer zones (Akhmad, 2006). The underground river system formed in the karst area provides benefits to the environment around the karst area and even the community as a provider of clean water that is eternal or flows throughout the seasons so that the karst area is referred to as a "natural water tank" with varying discharges to supply 25 percent of the needs clean water for the world's population (DC. Ford et al, 1988), while in Java, according to BAPPENAS, 40 percent of clean water sources come from springs in karst areas.

In the Kebumen Regency Regulation Number 23 of 2012 concerning the RTRW of Kebumen Regency in 2011 – 2013, Jatijajar Village is included in the Karst Area and is also a water catchment area and the area around springs. By looking at development indicators which are usually measured based on real (measured) things, it is also one of the factors that result in the reduced value of the karst area. Meanwhile, intangibles (not measurable) are still very low (Wisnuaji, 2016). In the economics of environmental services, natural resources are not only assessed from the economic benefits generated, but this value consists of the benefits obtained by the people of Jatijajar Village on the karst area even though they are not directly affected (Jhon, 2004).

From this description, this research aims to:

1) Identify the characteristics of the natural resource potential of the karst area in Jatijajar Village.
2) Analyzing the economic value of environmental services from natural resources in the karst area and what are the uses of the karst area in Jatijajar Village.
3) Formulating a strategic direction for the preservation of the karst area in Jatijajar Village.

This study limits the calculation of the economics of environmental services to the level of calculating multiple effects and calculating comparisons with mining businesses as well as being cross-sectional or calculating data at the time of the study. This research refers to various previous studies. Research conducted in Sirau Village, Karangmoncol District, Purbalingga Regency (Pramestyan, 2021), and (Hidayat, 2016) in the Mahat Hulu watershead has the same theme even though the method is different. The Gombong Karst area has become the main topic of various scientific studies, however research using the Contingent valuation method approach which is specifically applied in the Jatijajar Village area is the main novelty in this research.

METHOD

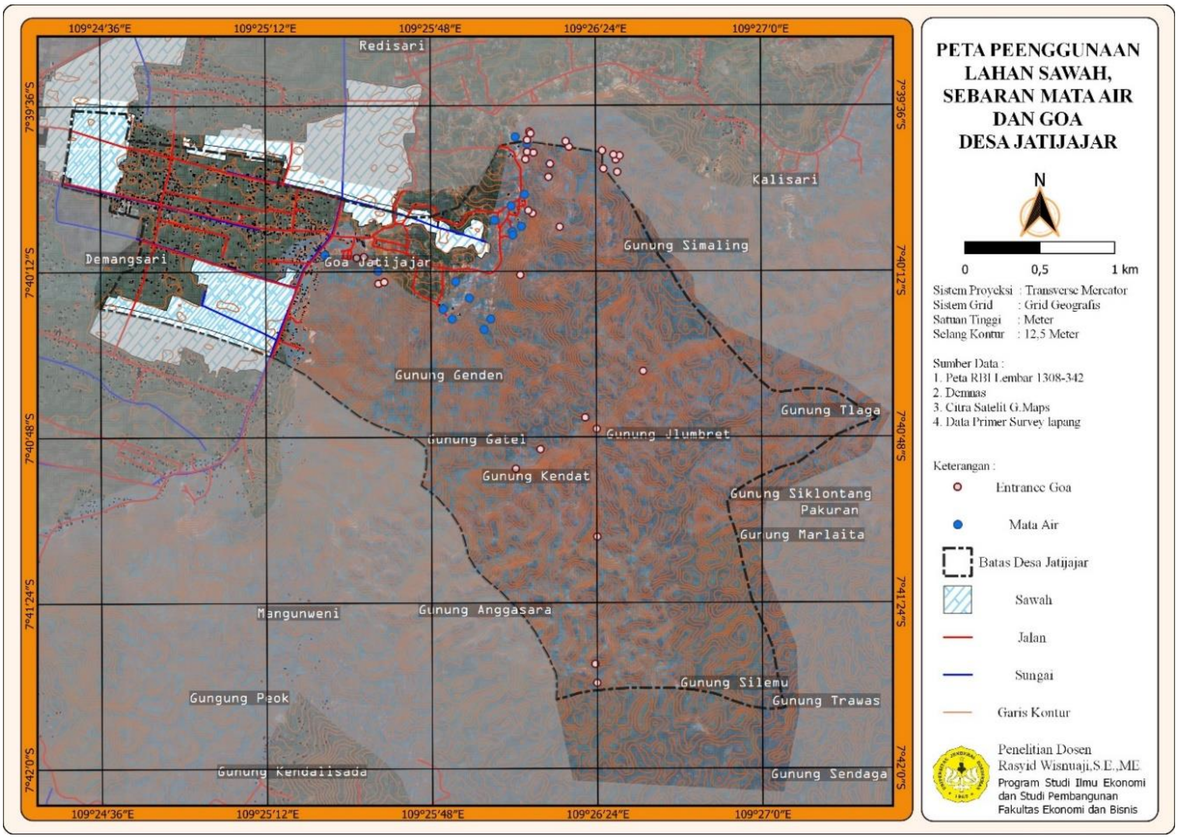
The research method used is primary data or field research with direct surveys both field orientation, cross-section data collection, structured interviews, and observations using contingent assessment methods and descriptive methods to determine the potential of resources and the economic value of environmental services and their utilization. The sampling method was carried out by purposive sampling, namely samples taken based on certain considerations and criteria.

Environmental service analysis analyzes potential characteristics using surveys either directly or indirectly. There are various techniques to quantify the concept of value, but the basic concept in economic valuation that underlies all techniques is the individual's willingness to pay for environmental services or resources (Munasinghe, 1993). The method used in this study is based on market prices (with a price tag) and non-market prices (no price tags). The method based on the price tag is the Market Price Approach, the Prevention Expenditure Approach, the Forgone/Loss of Earnings approach, and the Trended Historical Cost Approach. The non-market price method used is the Individual Travel Coast Method and the Contingent Valuation Method.

DUV = NArt + Napt + NAma
DUV = Direct use value (Rp/th)
NArt = Economic Value of Household Water Utilization
Napt = Economic value of water use for lowland rice farming
NAma = Economic value of the spring

RESULTS AND DISCUSSION

The data analyzed are data obtained in the field, both new findings and those that have been used by the community in the form of data on the distribution of caves and springs, measured discharge from springs, utilization of springs, and area of rice fields. rice fields, irrigation systems from springs to agricultural land, the number of residents and heads of families who use water from springs that are processed through spatial analysis in the form of digitization and geoprocessing to quantify the potential of karst areas which are then processed to determine the total economic value of natural resources from karst in the village of Jatijajar (Wijayanti, Solihin, Alikodra, & Maryanto, 2011).



Source: The results of the field survey processing and processed using QGIS 3.16

Figure 1. Map of Research Results in Jatijajar Village

Direct Use Value of Jatijajar Village Karst Area

Direct use value is the value given based on its existence from available natural resources. The Gombong Karst area of Jatijajar Village has the potential of abundant water resources due to the nature of the karst area which stores water and releases water at certain points. Therefore, the utilization of water resources in the karts area is very potential. The direct use value at the research location was obtained from the utilization of natural resources in the Gombong Karst area which consisted of the use of water to meet household needs, the use of water for lowland rice farming, and the potential value of groundwater resources from springs scattered in the karst area of Jatijajar Village which calculated using the Market Price Approach and Cost Prevention Expenditure.

The economic value of environmental services of water resources used to meet household needs

The karst area is a unique landscape because the groundwater system is very unique and different from other areas where underground rivers are more dominant than the surface (Putri, 2020). This water flow system is controlled by a system such as natural canals that eventually come out in springs and or caves that have underground rivers. The emergence of springs and the existence of underground rivers are utilized by the community in the karst area by connecting water pipes that flow from springs and or caves to the homes of their respective communities to meet their daily needs. Based on field surveys and open interviews with the people of Jatijajar Village, it is known that all residents of Jatijajar Village use water from the karst area, both managed through household groups and individuals, not through PDAM. Even the use of water from the springs in the two villages is also used by other village communities such as Redisari Village Rowokele District, Kalisari Village Rowokele District, Mangunweni Village, Ayah District, and Demangsari Village Ayah District. Even in the dry season, the people of Redisari and Kalisari villages will bring water jerrycans to springs, especially at Kalikarag springs to collect water directly.

Water needs cannot be separated from people's lives. Where the daily needs for drinking water, cooking, bathing, and latrines are basic so that in PERMENDAGRI No. 71 of 2016 it is explained that the standard for basic drinking water needs is 10 cubic meters of water/head of household/month. or 60 liters/individual/day (Kementerian Lingkungan Hidup, 2007). Even UNESCO in 2002 stipulates that the basic human right to water is 60 liters/individual/day for both consumption and sanitation needs. Meanwhile, the Directorate General of Human Settlements of the Ministry of Public Works defines and divides individual needs based on place of residence, where the individual water needs in one day in villages are 60 liters/day, small towns are 90 liters/day, medium. 110 liter/day city, 130 liter/day big city, and 150 liter/day metropolitan city. Jatijajar village which is included in the village category, the average individual water requirement is set at 60 liters/day.

The total population of Jatijajar Village is 7,044 people who are included in 2,151 families with an average of 3 people per family head. Determination of the direct use value of water resources used to meet household needs through a market-based pricing approach based on PDAM usage prices for group II households (direct connection) with a tariff of Rp. 2.750, per cubic meter where 1 cubic meter = 1,000 liters.

Then use the following formula:

$$Nart = JMrt \times Ja \times KArt \times HA$$
$$Nart = 2{,}151 \times 3 \times 4{,}228{,}005.6 \times 2{,}750$$

NArt = Economic Value of Household Water Utilization
JMrt = Number of households using water
Ja = Average number of family members
KArt = Average household water consumption (m^3/ year)
HA = PDAM water market price (Rp/m^3)

On average, each household uses 180 liters of water per day and in 1 month uses 5,400 liters of water or 5.4 cubic meters. So the economic value of household water use in one month in Jatijajar Village is Rp. 31,942,350,- in one month. So the total economic value of environmental services for household water use in one year in Jatijajar Village is Rp. 11,627,015,400,- a year.

The *economic* value of water resources environmental services for lowland rice farming

Jatijajar village is included in the village category where most of the land is in the karst mountains so very little land is used as agricultural land. Agricultural land in Jatijajar village is generally located in the lowlands which in the geological map is not included in the Kalipucang Limestone formation but is included in the alluvium formation (Wijayanti et al., 2011). Based on the results of spatial analysis by digitizing through satellite imagery and polygon surveys in the field, it can be seen that the area of agricultural land in Jatijajar Village is 68.62 hectares or 7.69 percent of the Jatijajar Village area with an average of 2 planting seasons in one year.

Lowland rice farming using water as a reservoir is one of the main production factors because the agro-climatic process in one rice season requires a lot of water use. So far, especially in karst areas, the use of water for rice farming has never been taken into account due to the perception of people who regard water as a public good, especially in karst areas that have long-lasting water, which is always available throughout the year (Wijayanti & Maryanto, 2017).

Rice fields use to water the most during the growth and maintenance period, where inundation is required for ±9-10 weeks with a water requirement of 1.7 liters/second/day/Ha, while at the tillage stage for ±5-6 weeks it requires water. mostly water namely 10.4 liters/second/day/Ha, at the nursery stage for ±2 weeks it requires 1.2 liters of water/second/day/Ha, and at the pre-harvest stage for ±2 weeks requires 0.2 liters of water/second/ day/ha. From the four stages, it can be said that the water requirement for rice fields in one growing season is 1,157 liters/second/day in one hectare. This means that the need for water to meet the needs of rice fields in Jatijajar Village is 163,296 liters/second/ in one growing season. This large water need has been met so far from runoff from springs in the Gombong karst area in Jatijajar Village, even this water is also used for rice farming in other villages following the direction of the water flow.

Based on research by Putu Angga Aditya et al in 2013 in Denpasar, it is known that the price of water is Rp. 358,515,-/Ha in one growing season. So to find out the economic value of water resources for lowland rice farming, you can use the following formula.

$$Napt = Lp \times BpA \times Mt$$

Napt = The economic value of using water for lowland rice farming (Rp/Th)
Lp = Agricultural area (Ha)
BpA = Water supply cost (Rp/Ha/season)
Mt = Average rice-growing season (planting season per year)

So the economic value of environmental services for the use of water for agricultural businesses in the village. Based on the spatial analysis, it can be seen that the area of rice fields planted with rice (Oryza sativa) with an area of 68.62 hectares of rice fields in 2 planting periods in a year is Rp. 49,202,599,- in one year.

The economic value of environmental services for water resources from underground rivers in karst areas

Limestone which is the main constituent of the karst area is a rock that is easy to undergo a karstification process which is strongly influenced by dissolution from water. With this dissolution, cavities are created in the limestone, and then surface water will enter through these cavities and create tunnels in the form of underground rivers and or cave systems (Aditya, Sudarma, & Djelantik, 2013).

Underground rivers that form grooves in the karst area usually always connect between underground rivers - caves - springs called karst aquifers. Karst aquifers consist of two basic principles, namely diffuse flow and channel (Wijayanti & Maryanto, 2017). The diffusion system is surface water that enters and seeps and is stored in the karst zone which will eventually form underground rivers. Diffuse flow characteristics are clear water throughout the year, less significant flow fluctuations between seasons so that they are available throughout the year and are not very sensitive to rain. While conduit flow is surface water that enters through water flow holes (ponor), filling underground rivers. The characteristics of conduit flow are that during the rainy season the water will be cloudy and in the dry season, no water will enter.

Based on field surveys, the underground river system in karst Gombong, especially in Jatijajar Village, is mixed, namely a mixture of diffuse and conduit, as evidenced by stable water discharge in the dry season and the rainy season, there are several springs. which will experience a significant increase in discharge (Milon & Alvarez, 2019). The distribution of springs outlets in Jatijajar Village is on the edge of the karst area which is usually in the form of layer springs and contact springs. While the upstream of the spring is in the karst mountains.

In order to determine the potential of springs and watery caves, it is necessary to know the discharge from springs and watery caves. The following are the results of the calculation of the average discharge using the velocity area method, both measured using a current meter and a buoy conducted in the research area for 5 months.

Table 1. Water Discharge Calculation Table

No	Name of spring	Type	X	Y	Z	Calculated Debit	Average discharge in 1 month	
						Liters / Second	Liter	M3
1	Ubalan 1	Water springs	327,366	9,152,306	51	24.2	62,726,400	62,726.4
2	Ubalan 2	Water springs	327,254	9,152,211	36	0.13	336,960	336.96
3	Ubalan 3	Water springs	327,435	9,152,170	66	29.8	77,241,600	77,241.6
4	Ubalan 4	Water springs	327,376	9,152,135	55	0.19	492,480	492.48
5	Ubalan 5	Water springs	327,378	9,152,112	56	1.4	3,628,800	3,628.8
6	Ubalan 6	Water springs	326,996	9,151,801	39	18.2	47,174,400	47,174.4
7	Ubalan 7	Water springs	327,088	9,151,690	56	27.5	71,280,000	71.280
8	Ubalan 8	Water springs	327,169	9,151,697	66	29.4	76,204,800	76,204,8
9	Ubalan 9	Water springs	326,123	9,151,975	17	35.8	92,793,600	92,793,6
10	Sirah 1	Water springs	327,231	9,151,552	98	17.6	45,619,200	45,619.2
11	Sirah 2	Water springs	327,186	9,151,481	107	32.9	85,276,800	85,276.8
12	Banyurata	Water springs	326,913	9,151,616	55	17.5	45,360,000	45.300
13	Jatijajar	Watery cave	327,169	9,151,697	66	198.8	515,289,600	515,289.6
14	Barat	Watery cave	327,470	9,152,326	73	208.8	541,209,600	541,209.6
15	Kalikarak	Watery cave	327,443	9,152,709	54	245.6	636,595,200	636,595.2

From table 1 above, it can be seen that Kalikarak Cave has the largest discharge because Kalikarak is a resuscitation of the West Goa underground river system which stretches for 9.8 Km originating from Purat Cave in Watukelir Village (Ening, 2015). Meanwhile, the springs with the smallest discharges are Ubalan 2 and Ubalan 4. In one month the springs in Jatijajar Village can produce an average of 2,301,229,440 liters or 2,301,229.44 cubic meters.

To determine the direct use-value of the economic value of water resources from underground rivers in the karst area of Jatijajar Village using a market-based price approach from the price of PDAM water for Rp. 2.750,-/M3. This approach is used because the value of water will be lost if there is damage and the community must replace water from springs with PDAM water. To simplify the calculation, the following formula can be used.

$$\mathrm{NAma} = (\mathrm{Vma}_1 \text{ x } \mathrm{HA}) + (\mathrm{Vma}_2 \text{ x } \mathrm{HA}) + (\mathrm{Vma}_3 \text{ x } \mathrm{HA}) + \cdots + (\mathrm{Vma}_z \text{ x } \mathrm{HA})$$

NAma = Economic value of springs (Rp/month)
Vma = Average water discharge from the spring (m^3/ month)
HA = PDAM water market price (Rp/m^3)

Based on the calculation using the above formula, the economic value of environmental services for water resources from underground rivers in the karst area of Jatijajar village which consists of 15 springs with a total discharge in one month of 2,301,229.44 cubic meters is Rp. 6,328,380,960,- per month and in one year of Rp. 75,940,571,520,-. The value of water resources from underground rivers in the karst area of Jatijajar Village will always exist as long as the function of the karst area as a natural regulator of the water system is not reduced or lost.

Based on the description of the economic valuation of the total economic value of resource use in the Jatijajar Karst Village, which consists of direct use value, indirect use-value, and option value. The characteristics of economic value can be seen as follows:

Table 2. Table of Economic Value of Resources for the Gombong Karst Area, Jatijajar Village.

To use	Value Name	Rupiah/ year
DUV 1	The economic value of household water use	11.627.015.400
DUV 2	The economic value of using water for lowland rice farming	49.202.599
DUV 3	The economic value of the spring	75.940.571.520
Total resource potential		87.616.789.519

The results showed that the Gombong Karst Area, Jatijajar Village, contributed significantly to the community's economy, especially through the use of water resources. This is in accordance with research conducted (Aditya et al., 2013) which shows that water contributes significantly to rice production. Meanwhile (Wijayanti et al., 2011) who conducted a study in the same location as this study focused more on the positive impact of a swarm of bats on the environment. Meanwhile, the results of this study indicate that the economic value generated from natural resources and the environment in the Gombong Karst Area of Jatijajar Village will be increasingly eroded when various environmental damages occur. This is in line with research conducted by (Putri, 2020) which shows the economic value of Mata Air Mudal.

CONCLUSION

Based on the results and discussions that have been described previously regarding the Study of Economic Assessment of the Gombong Karst Area in Jatijajar Village, Ayah District, Kebumen Regency, the following conclusions can be drawn:

a) Characteristics of natural resources in the Gombong Karst area, Jatijajar Village, have resource characteristics in the form of direct use, namely from the hydrological system of water from the karst area which consists of the value of water resource utilization used to meet household needs, the value of water resources for lowland rice farming, and the value of water resources for rice farming. source of water from underground rivers in karst areas.
b) The total economic value of using potential resources in the Gombong Karst Area, Jatijajar Village, is Rp. 87,616.789,519,- in one year. This value is the value of natural resources and the environment from the direct use of the availability of natural resources to the community. These valueswill be lost if the karst area is damaged either due to mining activities or changes in environmental functions. This value will be a value that must be issued by the community to compensate for the loss of potential natural resources in the karst area.

Based on the above findings, there is a need for directed planning in the use of karst areas, both by the central and local governments, rural communities around the karst areas, as well as the active role of academics, because karst areas are very vulnerable and sensitive to changes caused by the loss of one of the characteristics of the karst area, both from exokarst and endokarst. Utilizing one of these potentials will lead to a positive assessment (beneficial) but will also lead to a negative assessment (detrimental). This is due to the unique relationship between surface karst and subsurface karst and damaged karst areas are non-renewable.

REFERENCES

Aditya, P. A., Sudarma, I. M., & Djelantik, A. W. S. (2013). Analisis Harga Air untuk Irigasi Padi Sawah di Wilayah Perkotaan(Kasus Subak Pakel I dan Subak Pagutan Kota Denpasar). *E-Jurnal Agribisnis Dan Agrowisata*, *2*(2).

Akhmad, F. (2006). *Ekonomi Sumberdaya Alam dan Lingkungan: Teori danAplikasi*.

Ening, A. (2015). Optimalisasi Pemanfaatan Sumber Daya Genetik Padi Melalui Valuasi Ekonomi. Forum Penelitian Agro Ekonomi. *Forum Penelitian Agro Ekonomi*, *33*(2).

Fitri, D. R. K. (2017). VALUASI EKONOMI SUMBER DAYA ALAM DAN LINGKUNGAN. In *Proceeding IAIN Batusangkar*.

Hidayat, F. (2016). Valuasi Ekonomi Untuk Pengembangan Sumber Daya Air DAS Mahat Hulu. *Jurnal Agrium*, *12*(2).

Jhon, G. (2004). *Encyclopedia of caves and karst science*. New York.

Kementerian Lingkungan Hidup, R. (2007). *Panduan Valuasi Ekonomi Sumberdaya Alam danLingkungan.Kantor Menteri Negara Lingkungan Hidup*.

Milon, J. W., & Alvarez, S. (2019). *Coastal resources economics and ecosystem valuation*. Switzerland.

Pramestyan, A. (2021). Valuasi ekonomi sumber daya alam kawasan hutan lindung Siregol di Desa Sirau, Kecamatan Karangmoncol, Purbalingga. *E-Jurnal Ekonomi Sumberdaya Dan Lingkungan*, *10*(1).

Putri, A. (2020). Valuasi Ekonomi Mata Air Mudal, Bejiharjo, Karangmojo, Gunungkidul, Yogyakarta Dengan Metode Replacement Cost. *Jurnal Manajemen Keuangan Publik (PKN STAN)*, *4*(2).

Wijayanti, F., & Maryanto, I. (2017). Diversity and pattern of nest preference of bat species at bat-dwelling caves in Gombong Karst, Central Java, Indonesia. *Biodiversitas Journal of Biological Diversity*, *18*(3).

Wijayanti, F., Solihin, D. D., Alikodra, S. H., & Maryanto, I. (2011). Eritrosit dan Hemoglobin pada Kelelawar Gua di Kawasan Karst Gombong, Kebumen,Jawa Tengah. *Jurnal Biologi Indonesia (LIPI)*, *7*(1).

Wisnuaji, R. (2016). Tinjauan Ancaman Kelangsungan Dan Daya DukungEkosistem Essensial Karst Gombong Oleh Rencana Pendirian Pabrik Semen. *Masyarakat Spleologi Indonesia*.