Benefit and perceptions of people towards karst in Pangkep District, South Sulawesi

N Hayati¹ and I N Dewi¹

Environment and Forestry Research and Development Institute of Makassar, Jl. Perintis Kemerdekaan Km. 16,5 Makassar, Sulawesi Selatan, 90243, Indonesia.

email: hytslo@yahoo.com

Abstract. Karst is very important because it has unique potential, diverse resource and has many benefits. Karst has a role in climate change, related to the provision of water resources and absorption of atmospheric carbon dioxide. For some people around karst, the benefits of karst are still unrecognized. This research aims to know the benefits of karst, level of perception and relationship of perceptions with the respondent characteristics to karst as water storage in Pangkep District. Data are collected by field observations, interviews, questionnaires and literature studies. Data are analyzed implementing descriptive analysis, Chi-Square, and Coefficients Correlation. The results of community perception show that karst function as a store of water (60%), tourism (10%), windbreaks (10%), land for farming (5%), mining (3%), microclimate regulators (3%) and others (9%). The level of public perception towards karst as water storage is moderate. There is a relationship between people's perceptions and their level of formal and informal education, water-sources uses and gender. The relationship between perceptions and the level of informal education is the strongest with a medium category. To improve perceptions of karst function, socialization is needed about the importance of maintaining karst existence for the community.

1. Introduction

Karst area is a unique ecosystem if it is compared to other ecosystem [1]. Karst area is an area that can capture and store rainwater, as a habitat for several species of living things, and potential mining because of hilly physiography that is formed from limestone [2]. Karst area has important potential for socio-economic, scientific, and water system that is also very important in supporting the survival of living things on it. Water is a basic need for living things to maintain their survival [3], and karst water is an important source of drinking water. According to some estimates, karst water supply almost a quarter of the world population [4]. Most important of all, karst has a role in climate change, related to the provision of water resources and absorption of atmospheric carbon dioxide [5, 6]. Karst area is one of the important chains in carbon cycle, so the loss of karst area will contribute to global warming and climate change [7, 8].

Karst area is very vulnerable and cannot avoid threats of climate change and environmental problems [9]. Flood events in the rainy season and a decrease in water flow in dry season are signs of climate change that is felt by people around the karst area [10, 11]. Climate change also has an impact on agricultural [12].

Karst in Indonesia spreads on most islands in Indonesia and consists of seventeen major karst regions. Of the seventeen areas, Maros-Pangkep karst is one of the two best besides Gunung Sewu.
karst and they are considered the prototype of karst in the tropics [13]. The existence of Maros-Pangkep area that cover an area of around 46,200 hectares [14], have a very strategic value. The community has utilized karst both directly and indirectly as a source of water, mining materials, tourism objects, flora and fauna habitat, food sources, climate regulators and other benefits. Community interaction with the karst region raises perceptions. Perception is essentially in activity sensing, integrating, and giving an assessment of physical and social objects, and sensing activities depend on physical and social stimulation in the environment [15]. Public perception is an opinion that directs people's respect in responding to events that occur around them [16].

Community perceptions of karst greatly determine the success of sustainable management of karst. The higher the community's perception, the better understanding of the people to the importance of preserving the karst area will increase. Preservation of karst as one of water source is very important, considering that there is a lot of damage to water resources today which causes the decrease in the quality, quantity and continuity of water resources availability [17].

People perception of karst will support karst conservation in Maros-Pangkep area. Individual karst perception is important because it will continue to be a response that determines individual's actions [18]. Public perception is related to the individual's knowledge. Knowledge is a basic concept and capital for the development of people's behaviour around the karst area [19].

Karst is useful as water storage, but karst existence can become threats as well because of other benefits. Some people consider that karst benefits as mining materials or other benefits are more economical than karst benefits as water storage. If this continues, there will be a change of function of the area, which causes a decrease in karst function as a water store. Community usually sell limestone at the price of Rp85,000 per ton.

The existence of water in the location of this research is very dependent on the karst area. Based on this, it is necessary to do a research about the function of karst region, level of perception and relationship of perceptions with the characteristics of respondents to karst as water storage in Pangkep District so that the conservation of the karst area can be carried out with the carrying capacity of the local community.

2. Methods
2.1. Time and Location
This research was conducted in February – March 2019 at Minasate'ne Sub-district, Pangkep District. This research was conducted on three water sources from karst namely Leang Kassi, Leang Londrong and Ulu Ere. We collected 60 respondents who were distributed proportionally to each water source.

2.2. Data collection
Data collected in the form of primary data and secondary data. Primary data that are collected are: socioeconomic characteristic, community perception, karst benefit for community, and water source used. Secondary data consist of water discharge data and regional minimum wage of Pangkep Regency. Primary data are obtained through observation and interviews using a questionnaire. Respondents are chosen randomly to people who live around the karst area. The total number of respondents are 60 people who spread proportionally to each water source. Secondary data are obtained from literatures, reports and other documents related to this study.

2.3. Data Analysis
Respondents' characteristics of data and the use of karst are analyzed descriptively. Likert scale method used to find out the level of people perception of the karst function as a store of water. Likert scale is a method for measuring the extent/depth of perceptions or opinions of respondents. Likert scale is used to measure perceptions, attitudes and opinions of a person or group of people about social phenomena [20, 21].

Respondents' perceptions are divided into 3 scoring categories: low, medium and high. The assessment of the three categories base on the results of scoring on four key questions as it follows:
Table 1. Question about perception and scoring

| No. | Description                                                                 | Score  | 1 | 2 | 3 |
|-----|-----------------------------------------------------------------------------|--------|---|---|---|
| 1.  | Limestone mountain is also known as "karst".                               |        |   |   |   |
| 2.  | Karst function as water storeir                                            |        |   |   |   |
| 3.  | The karst area needs to be protected                                       |        |   |   |   |
| 4.  | Community depends on the existence of karst                                |        |   |   |   |

The next step is to sum all the scores of each respondent. The categorization of perceptions was done by the formula from [22] as follows:

1. High perception if, \( x > \text{Mean} + \text{Standard deviation} \)
2. Moderate perception if, \( \text{Mean} - \text{standardization} \leq x \leq \text{Mean} + \text{Standard deviation} \)
3. Low perception if, \( x < \text{Mean} - \text{Standard deviation} \)

\( x \): summation of the scoring results of each respondent.

Chi-Square is implemented to test the significance of the relationship between people's perceptions around the karst region and socio-economic characteristics. Furthermore, the coefficients correlation is employed to know the degree of correlation among variables.

Chi-square and correlation analysis are processed using SPSS version 13. The classification of the coefficients correlation can be seen in Table 2.

Table 2. The Value of correlation coefficients and level of relationship

| No. | Rate Coefficient | Interval Relation |
|-----|------------------|-------------------|
| 1.  | 0.00 – 0.199     | very low          |
| 2.  | 0.20 – 0.399     | Low               |
| 3.  | 0.40 – 0.599     | Moderate          |
| 4.  | 0.60 – 0.799     | Strong            |
| 5.  | 0.80 – 1.00      | Very strong       |

Source: [23]

3. Result and discussion

3.1. Socio-economic characteristics of respondents

Community characteristics are points that can indirectly influence people's perceptions [24]. The following are presented in Table 3, the socio-economic characteristics of respondents who live around the karst area.

Most respondents who are people who live around the karst area are in productive age (90%). The respondents work variously in many areas from farmers, grain mill workers, village office staff, water entrepreneurs, and other small entrepreneurs such as workshops or small shops. Earnings obtained by 70% of respondents are still below the regional minimum wage of Pangkep Regency in 2019 of Rp2,941,000.00.

The number of female respondents are more than the male as many as 56.7%. Female respondents provide more detailed information because they are directly involved in the use of water from the karst area. Women also interact more with karst because they use food in the form of vegetables and tubers from the karst region. In various parts of the world and also in Indonesia, women are shown to be more concerned with the preservation of environment and water resources than men [25].

Most respondents (51.7%) have low formal education, which are equivalent to elementary school, and 85% of the respondents state that they have never attended informal education. As many as 15% of the respondents have attended informal education in the form of training related to karst
management, forestry socialization, and tour guide training. According to [26], formal and informal education is very influential on competence, namely ability to plan a series of activities to achieve target. Knowledge of karst obtained from formal and informal education will influence people's perceptions and decisions in managing karst, namely preserving it or, otherwise, exploiting it.

As many as 48.3% of the respondents have moderate family members which range from 4-6 people in one family. The number of family members will affect the amount of water consumption every day. Totaling of 70% of the respondents use water from karst to fulfil their daily needs, to irrigate rice fields, for fisheries and livestock. While the respondents who do not use water from karst obtain the water from wells, rainwater, and gallon water for various daily uses.

### Tabel 3. Respondent’s socioeconomic characteristic

| No. | Socioeconomic characteristics | Number of respondents (person) | Percentage (%) |
|-----|--------------------------------|--------------------------------|----------------|
| 1.  | Age                            |                                |                |
|     | productive (15-58 year)        | 54                             | 90             |
|     | not productive (>58 year)     | 6                              | 10             |
| 2.  | Sex                            |                                |                |
|     | Male                           | 26                             | 43.3           |
|     | Female                         | 34                             | 56.7           |
| 3.  | Formal education level         |                                |                |
|     | Low (Elementary school)        | 31                             | 51.7           |
|     | Medium (Highschool)            | 23                             | 38.3           |
|     | High (College)                 | 6                              | 10             |
| 4.  | Informal education             |                                |                |
|     | Joined                         | 9                              | 15             |
|     | Never joined                   | 51                             | 85             |
| 5.  | Number of family member        |                                |                |
|     | Low (1-3 person)               | 7                              | 11.7           |
|     | Medium (4-6 person)            | 29                             | 48.3           |
|     | High (>6 person)               | 24                             | 40             |
| 6.  | Income level                   |                                |                |
|     | Under regional minimum wage    | 42                             | 70             |
|     | Upper regional minimum wage    | 18                             | 30             |
| 7.  | Source of water                |                                |                |
|     | Karst                          | 42                             | 70             |
|     | Non-karst                      | 18                             | 30             |

Source: Primary data analysis, 2019

#### 3.2. Karst function for community

Karst for the surrounding community has various functions. The functions of the karst area for the community include water storage, tourism, windbreaks, land for farming, mining, microclimate regulators and others, as it is shown in Figure 1.
The following are the functions of the karst area according to the respondents in the research location:

- **Water store**
  All three springs at this research site are all included in the karst area in Bantimurung Bulusaraung National Park area (Babul NP). Leang Kassi is included in the religious/cultural/historical zone, with a water discharge of 0.1000 m³/second; Leang Londrong is included in the utilization zone, with water discharge of 17.17 m³/second; and Ulu Ere spring is included in the utilization zone, with a water discharge of 0.05 m³/second [27]. The water from the karst area is being utilised by the community, with the purposes below:
  - Fulfilling daily needs
    People who live in the three karst areas have used water from the karst area. People take water from springs or rivers that come from the karst using pumps that is flowed through hoses or pipes to their homes. This water is used to fulfil their daily needs, such as cooking, bathing and washing. The average community water demand per month is 2,072.5 litres per household head for the households that use water from karst, and 820 litres per household head who also uses water from other sources beside from the karst.
  - Agriculture, Fisheries, Livestock needs
    Utilization of water for agriculture have been used for wetland agriculture, namely rice fields, both with mechanical irrigation, half technical and village irrigation. According to [12], agricultural land in the study sites began to be affected by climate change, namely the emergence of pests and diseases; the difficulty of rice plants undergo fertilization; excess water in the rainy season; and lack of water in the dry season. The existence of this climate change has an impact on decreasing rice yields at the research sites.
    Water from the karst region have been used for fisheries activities. There are two types of fisheries activities, namely freshwater fish nurseries and fish therapy services for health. Freshwater fish nurseries are carried out along the river flow from Leang Kassi by using karamba. Fish therapy services are carried out by filling pond with hundreds of small fish. If we put our foot in the water, many small fish will bite our foot repeatedly. This fish therapy service is beneficial for foot skin health, exfoliating dead cells. Regular fish therapy services are crowded on Saturdays and Sundays. The tariff for this fish therapy services is IDR 10,000 per 30 minutes.
    Communities also need water to provide drinking and bathing livestock. Many people in the research locations raise livestock, such as cows, goats and chickens. There are several chicken farms around the research site.
  - Industry/small business
Water from karst is also used by surrounding communities and migrants to develop various businesses, both small scale and industrial scale. Various small-scale businesses include motorbike and car wash services, fish therapy businesses, and gallon water businesses. The business of gallon water and bottled mineral water utilizing water from Leang Kassi spring is "Zero" and the drinking water depot "Tirta Misten". Ulu Ere spring has also used by local people as a source of gallon water and bottled mineral water called "Qarinah". Leang Londrong spring have been used by "AAA" branded gallon water producers or commonly called "Triple A. Besides small businesses, water from karst, precisely from Leang Londrong, have been used by large companies, namely PT. Semen Tonasa since 1963. Initially, the water are used for the production of cement production. When the factory has not produce cement anymore, precisely start in the year of 1984, water from Leang Londrong is used to fulfil the daily needs of employees who live in the housing complex of PT. Semen Tonasa 1.

- Regional water company (PDAM)
Water from Leang Kassi and Ulu Ere, is also used by Regional Water Company (PDAM) as PDAM raw water. With the presence of PDAM, people who are registered as customers have no trouble obtaining clean water because the water flows throughout the year. Even though water flows throughout the year, there is a flow decrease in the dry season that is felt by the community. During the past five years, according to [12], there has been a long dry season which has caused the community in the study area experiencing water lack, due to seasonal shifts.

**Tourism**
Karst have been used as a valuable tourist attraction. Karst tourism consists of water tourism, cultural tourism and special interest tours. In the research location, water sources from Leang Kassi and Leang Londrong are used by the surrounding community as water tourism attractions. Around the water sources, a simple pond have been built for swimming. When swimming, visitors can also enjoy fresh air and views of the karst cliffs. Sometimes, it can also be seen a herd of monkeys swinging in the trees on the karst area near the water source. This water attraction in the karst area is visited every weekend and national holiday. The other potential of the area can still be explored, so the local government has many plans to develop Leang Londrong into a more commercial tourist attraction. Regarding cultural tourism, Maros-Pangkep karst area, in general, has historical caves that keep traces of ancient humans. At the location of Leang Kassi, there are also historical caves in which paintings could be found on stone walls. The condition of this cultural site is poorly maintained, and the condition of the painting has a medium level of damage. In addition to water tourism, cultural tourism and special interest tours in the form of exploring karst caves, people also travel in the karst area because of the beautiful scenery [28].

- **Windbreak**
People around the karst area also assume that karst can function as a windbreak. Areas protected by karstic cliffs have never experienced hurricanes, so people feel safe living around the area. This is because Maros-Pangkep karst is karst tower type. Karst hillside is like a tower that forms an almost vertical slope angle hill with the height of 200 m [29, 30, 31].

- **Land for farming**
Some people consider karst is useful place for farming. People plant bamboo and woody trees around the karst area, but because karst status have been protected as part of national park, timber products have not to be harvested by the community. Communities have been prohibited from cutting down trees in karst Leang Kassi, Leang Londrong, or Ulu Ere.

- **Mining**
Another function of karst is mining. Communities around the research site have already understood that karst mountains around their area are protected, so they could not be mined. However, the community is still mining karst mountains which are considered not functioning as storing water. In general, the karst mined by the community is not too large and it located on their land property. Although it does not interfere with the underground water system, mining by the community creates noise that disturbs other residents. In addition to noise, mining has caused changes in karst topography
from a mountain that is still overgrown with trees to a plain or even arid basin as it happens in the Gunung Sewu karst area, Gunungkidul [32].

- **Microclimate regulator**
  
  Some people assume that the existence of karst with trees that grow on it and the water it produces can provide coolness to balance the surrounding microclimate. According to [8], the karst area can act as a climate regulator, regard to the vegetation that grows on it. [33] Conducted studies on the effects of land coverage on microclimate and land with the cover in the form of trees produce the lowest air temperature and the highest humidity. The implication in the karst region is that wooded karsts are better than non-wooded karsts.

- **Others (habitat for flora and fauna, wood, food sources)**

  Maros-Pangkep karst area is known as a habitat for various endemic flora and fauna [14, 34]. The surrounding community still often sees various types of monkeys, birds and wild pigs in the karst area. Karst is also considered as a source of wood because people have planted a variety of woody plants in the karst area even though they are now unable to utilize the wood products. Besides wood, the community also uses plants that live in karst as a food source. In the rainy season, bamboo trees begin to sprout, and young bamboo shoots become ingredients for making vegetables. Besides bamboo, there are also forest mangoes and various types of tubers harvested by the community to add to the family consumption menu. The karst area in various parts of the world also has a similar function, it is used as a food source for local people [35].

  As various functions of karst have been previously explained, it could be stated that as many as 60% of respondents realize the most important function of the karst area is as a water storage. While 40% of the other respondents understands the function of the karst region as presented, in Figure 1. According to [13], the karst region is allegedly an aquifer which functions as the fourth largest reservoir after alluvial, volcanic, and coastal plains. The karst area as a store of underground springs is a water storage area [32] and karst is also one of the landscapes that has a large and significant hydrological value as a provider of water resources [5].

![Pie chart showing karst function according to respondent](image)

**Figure 2. Karst function according to respondent**

### 3.3. Level of Community Perception of Karst

Community perception is a way or process of a person to look at or to judge what he sees [36]. The level of community perception of karst as a store of water that have measured people's perception of knowledge about karst, karst benefits, people's willingness to protect karst and community dependence on karst.
People who do not understand the area will view that karst is an arid, barren, difficult area to obtain water and infrastructure that is inadequate and unattractive. But in reality, the karst area has a lot of potentials that is useful for the welfare of the community.

The majority of respondents in the study locations, there are 73% who do not understand the term karst. People commonly refer to karst as 'mountain' or 'bulu' (Bugis language). [16] It is also said that in Sambueja Village, Maros District, the majority of the people do not understand the term karst and call the karst area 'mountain rocks'. While 27% of respondents understand the term karst because they have attended training and socialization. Even if the term karst is not understood, people realise that 'mountain' or karst has a function as a water store in addition to other purposes.

![Figure 3. The level of community perception of karst as a water store](image)

From the calculation results it is obtained that most of the perceptions of respondents are moderate (68%) as it is presented in Figure 2. Respondents realize that they are dependent on water from the karst area but they do not understand the need for sustainable karst management. Respondents with high perceptions are amounted to 18%, it means that respondents understand well that their lives depend on water sourced from the karst region and want the karst area is managed to fulfil its sustainability. Respondents with low perceptions are 14% meaning that the respondents do not realize when they are dependent on water from the karst area, and they do not understand that the karst area needs to be preserved. The meaning of the level of public perception in this study refers to [37].

3.4. Relationship between community perceptions and socio-economic characteristics

High and low perceptions of the community are often influenced by socio-economic characteristics [38] or none at all [39]. A chi-square analysis have been carried out to find out whether or not the socio-economic characteristics of the people around the karst area are influenced or are related to perception; the results are presented in Table 4.

Table 4 shows that the seven points of socio-economic characters, there are four characteristics of respondents that are significantly related to perception. The four characters are gender, formal education, informal education, and water sources usage. The relationship between perception and gender, besides being indicated by the results of chi-square calculations, it us also shown by more female respondents who have a higher level of perception than male respondents to karst as a store of water. Women are family members who are most involved in daily water use [25].
Table 4. Chi-square analysis of socio-economic factors with respondents' perceptions of the existence of karst as a source of water at a 95% confidence level.

| No. | Socioeconomic characteristics    | Value Chi square | Df  | Asymp. Sig. (2-sided) |
|-----|----------------------------------|-----------------|-----|----------------------|
| 1.  | Age                              | 3.225           | 2   | 1.99                 |
| 2.  | Sex                              | 10.440          | 2   | 0.05*                |
| 3.  | Formal education level           | 25.343          | 4   | 0.00*                |
| 4.  | Informal education level         | 25.115          | 2   | 0.00*                |
| 5.  | Income level                     | 3.865           | 2   | 0.145                |
| 6.  | Water source used                | 6.324           | 2   | 0.042*               |
| 7.  | Number of family members         | 2.758           | 4   | 0.599                |

Remarks: * = Significant at the 95% confidence level

There is a relationship between the level of formal education and informal education with the level of perception. This is indicated by respondents who are highly educated and have attended informal education. They have better knowledge and understanding of karst as a source of water if it is compared to respondents who have low education. So, the higher formal and informal education a person has, the higher perception of karst as a store of water it is. [40] states that higher education implies a broader range of experience and a better ability to understand an object or phenomenon. Whereas [41] states that education is the basis of intellectual knowledge possessed by someone; the higher one's education, the greater ability to absorb and receive information it will be.

The source of water used by the community has a relationship with the level of perception. The majority of people who use water from the karst region understand and realize that the karst area must be protected and managed for its sustainability. Respondents who use water from the karst region have a high perception of karst as a store of water. They are very dependent on water sourced from the karst region to meet their daily needs and irrigate their agricultural land [11].

To see the strength of the relationship between socio-economic factors and the level of respondents' perceptions of the existence of karst as a water source, a correlation test analysis is carried out. The results are presented in Table 5.

Table 5. Test of correlation analysis of socio-economic factors with respondents' perceptions of the existence of karst as a source of water at a 95% confidence level.

| No. | Socioeconomic characteristics    | Correlation Coefficients | Asymp. Sig. (2-sided) |
|-----|----------------------------------|--------------------------|----------------------|
| 1.  | Age                              | 0.227                    | 0.081                |
| 2.  | Sex                              | 0.052                    | 0.693                |
| 3.  | Formal education level           | 0.527                    | 0.00*                |
| 4.  | Informal education level         | 0.554                    | 0.00*                |
| 5.  | Income level                     | 0.205                    | 0.116                |
| 6.  | Water source used                | 0.316                    | 0.014*               |
| 7.  | Number of family members         | 0.129                    | 0.327                |

Remarks: * = Significant at the 95% confidence level

If the value of the correlation coefficients is observed, then the seven characteristics, formal and informal education has a moderate correlation value. The correlation coefficients of each character are 0.527 and 0.554. Education is a learning process in developing a person's personality, and abilities in carrying out his activities. Formal and informal education affects people's perceptions where their education is high, both formal and informal, their level receive information from other people as well as from the mass media is also high. The higher their education, the higher their level of receiving information will be [42].
Relationship between the water source used with the community perception produces a low correlation, with a correlation coefficient of 0.316. This is because not all people use water directly from the area. Some people use water from wells or rainwater so that they do not experience karst benefits directly, this is the cause resulting different perceptions. Communities around the study site use water sourced from the karst area that flows into the river or the water is used as a raw water source for PDAM and wells. Usually, people use pipes or hoses to drain water from the karst area to the reservoir. People around the watery karst area also always interact and depend on the karst area. According to [43], the karst region is one of the best types of aquifers on earth in terms of storing rainwater that falls on it and then flowed to supply underground rivers or springs with drainage properties depending on the level of development of their porosity.

4. Conclusion and Recommendation

4.1. Conclusion
The function of the karst area for the community includes water storage, tourism, windbreaks, land for farming, mining, microclimate regulators and others. The level of respondents' perceptions of karst as storing water is 68% moderate, 18% high, and 14% low. There are four socio-economic characteristics of the community that have to do with the level of perception, namely gender, formal education, informal education, and water sources usage. Of the four socio-economic characters, formal and informal education with the level of community perception has a moderate correlation value. The source of water usage with the level of community perception produces a low correlation value.

4.2. Recommendation
Community perception is one of the information needed to support the success of efforts to preserve the karst area. From the results of the study, it is found the fact that most people (68%) have a moderate perception. The meaning of the medium perception is that respondents realize that they are dependent on water from the karst area but they do not understand the need for sustainable karst management. With moderate perceptions, this community perception still needs to be improved. The perception could be increased by developing socio-economic factors that have the most influence on the perceptions, namely education, both formal and informal education.

Some recommendations that can be given to improve people's perceptions including:

- Through formal education ways
  - Encouraging primary and secondary schools around the karst area to include discussion of karst in the school curriculum / local content.
  - Encouraging elementary and secondary schools around the karst area to collaborate with relevant agencies to carry out field study activities to the karst area and learn directly in nature by assisting experts from related agency.

- Through informal education ways
  - Encouraging relevant agencies (Babul NP or local government) to disseminate karst to the community.
  - Encouraging stakeholders to involve the community in managing the karst area.

By implementing the steps above, the community's perception of the karst area is expected to increase so that it can be even wiser in managing the karst area around their homes.

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