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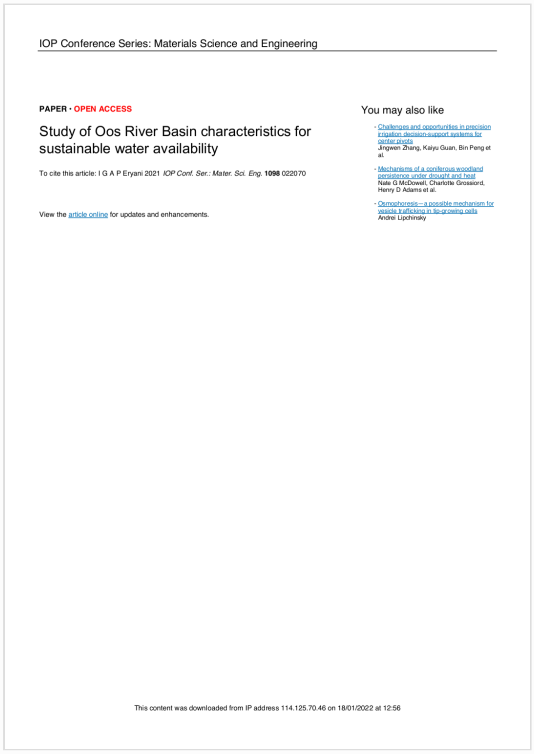

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Study of Oos River Basin characteristics for sustainable water availability

Study of Oos River Basin characteristics for sustainable water availability

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Abstract. Oos River Basin is one of the perennial river basin in Bali, whose water potential is widely used as raw water and irrigation water mainly for the Gianyar Regency. Even though it has great water potential, according to the BWS Bali-Penida (2012), 18.84% of its area is classified as critical land and 81.16% is classified as very critical. If it is not managed in an integrated manner, then this will have an impact on the sustainability of existing water availability. This study will examine the characteristics of river basins that are very important to be used to determine the condition of the river basin and how to maintain the sustainability of the existing water potential. The data needed in this research is Oos river basin boundary map data, Oos river basin river network map, topographic data, land use and maps of soil types. The results of this study will be in the form of Oos River Basin characteristics and river basin management recommendations for the sustainability of its water potential.

1. Introduction

In Bali Province there are 391 river basins which are part of the Bali - Penida River Basin Unit. There are 401 rivers with 66 potential rivers. Gianyar Regency is one of the regencies in Bali Province which has 31 rivers which all flow to the South. Of all the rivers that flow in Gianyar, only 4 rivers have potential water as a source of raw water, that are Oos, Pekerisan, Sangsang and Petanu Rivers [1]. The potential of water resources in the Oos river basin is 2.77 m^3/ sec (87.47 million m^3) consisting of ground water 0.12 m^3/ sec (3.78 million m^3), return flow of 0.78 m^3/ sec (24.66 million m^3) and water district 1.82 m^3/ sec (57.67 million m^3). Even though it has a large enough water potential, according to the analysis of land criticality [2], the area of the Oos River basin is 23.31 km^2 (18.84%) and very critical is 100.43 km^2 (81.16%).

Critical land is land that is not able to be effectively used for agricultural land, as a medium for regulating water systems, as well as protecting the natural environment. It can also be defined as land that is incompatible between the ability of the land and its use due to physical, chemical and biological damage that endangers hydrological, socio-economic, agricultural production or settlement functions. This can lead to erosion and landslides in the upstream area and sedimentation and flooding in the downstream area [3].

To maintain the sustainability of the existing potential based on existing conditions, it is necessary to have a sustainable management of the river basin [4-7]. As a unified ecosystem, river basins must be managed based on the characteristics and interrelations between ecosystem components from upstream to downstream in an integrated manner [8].

This research will examine the characteristics of river basins and integrated and sustainable river basin management in the Oos river basin. River basin characteristics that will be reviewed only morphometric and morphological characteristics.

2. Research methods

2.1. Research location

This research took place in the Oos River Basin. The topographical conditions of the Oos river basin are sourced in springs in Lake Batur which have steep cliffs with an average height difference between the riverbed and the flat area above it ± 50 to 75 meters [9].

Oos River Basin has an area of 119.95 km² with a river length of 51,963 km [10]. Oos River basin through two districts that are Bangli and Gianyar and through several sub-districts including Kintamani, Tegalalang, Payangan, Tampak Siring and empties into Sukawati.

According to Raka the most developed area of the tourism sector is Ubud and Sukawati sub-districts, where the most dominant land conversion takes place is the change of agricultural land to tourism land such as for the construction of hotels, resorts, restaurants, cafes or villas [11]. Oos River itself is a type of Perennial River with potential water every year. Because of this potential, the Oos River Basin is also used as a source of raw water and irrigation water for the Gianyar region.

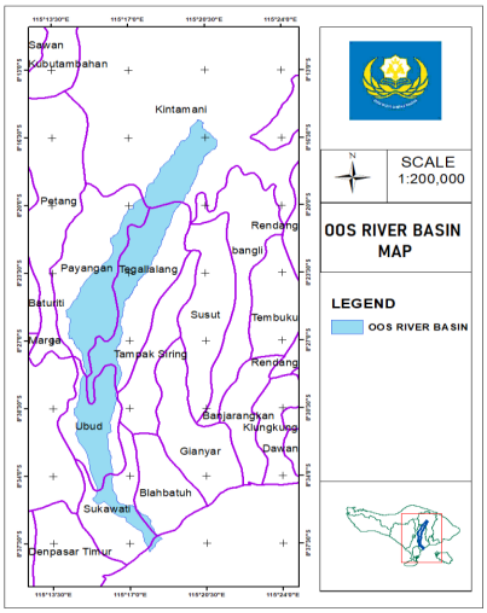

Figure 1. Oos river basin.

2.2. Research tools and materials

2.2.1. Research tools. The tool used in processing data in this research is a laptop with software: QGIS 3.1, Microsoft Office (Excel and Word).

2.2.2. Research material. The data needed in this research is Oos river basin boundary map data, Oos river basin river network map obtained from BWS-Bali Penida. Topographic data were obtained from

DEM SRTM map classified using the QGIS 3.1 application, land use maps were obtained from the Directorate General of Forestry Planning, the Ministry of Forestry of the Republic of Indonesia and maps of soil types obtained from the Centre for Environmental Research at Udayana University.

2.3. Data analysis technique

This study will analyze the characteristics of the Oos river basin, which includes morphometric, morphological and hydrological characteristics. The collected data is then analyzed quantitatively and qualitatively using descriptive methods. After obtaining the characteristics of the Oos river basin, then proceed with analyzing the integrated and sustainable river basin management methods that can be applied in the Oos river basin.

3. Results and discussion

3.1. Morphometric characteristics of Oos river basin

3.1.1. Area of Oos river basin. Based on the river basin boundary map of the Bali-Penida BWS, the area of the Oos river basin is 12401,425 ha or around 124.01 km^2. Oos river basin if classified according to area, Oos river basin is classified as a small river basin with an area range of 10,000 - <100,000 Ha river basins.

Table 1. River basin classification based on area (Ha).

No	River Basin Area (Ha)	River Basin Classification
1	Above 1.500.000	Very large river basin
2	500.000 - <1.500.000	Large river basin
3	100.000 - <500.000	Medium river basin
4	10.000 - <100.000	Small river basin
5	<10.000	Very small river basin

Source: Regulation of the Directorate General of River basin Management and Social Forestry [12]

3.1.2. The length of Oos river. Based on the Environment Status of Bali Province [13], the length of the Oos River Basin is 45.5 km.

3.1.3. The shape of river basin. The shape of a river basin can be divided into four forms: bird feathers-shaped, radial, parallel and complex. Based on the Oos river basin map, it is classified in the form of a bird feather type river basin with characteristic tributary lines on either side of the main river flowing towards the main river, the flood discharge is small because the time of flooding for the tributaries varies. The flood lasted a bit longer.

3.1.4. Bifurcation ratio (Br). The composition of the river can affect the efficiency of the drainage system as well as hydrographic characteristics and flow patterns for river basin managers. Sriyana states that determining the river order can use the Strahler method, namely the most upstream river channel that has no branches is called the first order (first order), the meeting between the first order is called the second order (second order), and so on until the main river is marked with the largest order number [14].

River order is a branching position of a river channel in which there is a sequence of the main river in a river basin. As well as the number of river flows of an order determined from the ratio of the river branching ratio (bifurcation ratio) with the equation (1).

$$Br = \frac{N_u}{N_{u+1}} \quad (1)$$

Where:
Br : river branching index level
N_u : number of river flows for the u-order
N_{u+1} : number of river flows for order to (u + 1)

Based on the results of the equation above, the classification can be as follows:

- Br <3 : river channel has a rapid rise in flood level, while the decline is slow
- Br 3-5 : the river channel has an increase and decrease in the flood water level not too fast or not too slow
- Br> 5 : the river channel has a rapid rise in the flood level, so the decrease goes quickly.

Table 2. Bifurcation ratio.

No	River Basin Order	Total
1	Order 1	69
2	Order 2	18
	Bifurcation Ratio (Br)	3.83

Based on Table 2, the value of Br (the number of comparisons between first order of the rivers and second order of the rivers) is 3.83, then the Oos river basin has the characteristics where the river channel has an increase and decrease in flood water level not too fast or not too slow.

3.1.5. Density / Drainage Density (Dd). The River basin Characteristics Identification Guidelines [14] explain the flow density is the length of river flow per square kilometre of river basin area:

$$Dd = \Sigma Ln/A \quad (2)$$

Where:
Dd : flow density (km/km^2)
Ln : river length (km)
A : river basin area (km^2)

If the Dd value is large, the better the drainage system in the area, the greater the total amount of surface water (causing a small infiltration), the smaller the groundwater stored in the area.

Linsley in the Regulation of the Directorate General of River basin Management and Social Forestry [14] states that if the value of flow density is less than 1 mile/mile^2 (0.62 km/km^2), the river basin will experience flooding, whereas if the value of flow density greater than 5 mile/mile^2 (3.10 km/km^2), river basins often experience drought.

Based on the width and length of the Oos river basin, the Dd value is 0.367 km/km^{2}and is classified as having a moderate density, which means groundwater storage in the moderate Oos river basin. And because the value of flow density is less than 1 mile/mile^2 (0.62 km/km^2), the river basin will often experience flooding.

3.2. Morphological characteristics of oos river basin

3.2.1. Soil type of Oos river basin. Based on Table 3, in general the Oos River Basin is dominated by Regosol soil types. Regosol soil is land formed by weathering rocks containing volcanic ash, beach sand and naphtha. Is the result of a volcanic eruption, soil type is still young, has not experienced the differentiation of the horizon, is fertile, coarse-grained, gray in color, rich in nutrients, pH 6-7, tends to loose, high water absorbing ability, and easily eroded. Widely used for agricultural land. Regosol soil is also suitable for crops, tobacco and fruits. This land is also of moderate temperature because it is part of volcanic soil of moderate temperature.

Table 3. Soil types of Oos river basin.

No	Soil Types	Area (km^2)	Percentage
1	Gray Regosol	2.213	1.78%
2	Yellowish Brown Regosol	74.784	60.30%
3	Humus Regosol	46.229	37.28%
4	Brown Gray Regosol	0.788	0.64%
	Total	124.014	100%

3.2.2. Topography of Oos river basin. In general, the height of the Oos River Basin ranges from 0-1500 m with the dominant height ranging from 0-300 m at 30.75% of the Oos river basin area. Significant height differences from upstream to downstream and easily eroded soil types cause a fairly large level of erosion in the Oos river basin with an erosion rate of 37,256.70 tons/ ha/year [2].

Table 4. Topography of Oos river basin.

Elevation	Area (km^2)	Percentage
0-300 m	38.13	30.75%
301-600 m	37.80	30.48%
601-900 m	23.67	19.09%
901-1200 m	19.61	15.81%
1201-1500 m	4.80	3.87%
Total	124.01	100.00%

3.2.3. Land use of Oos river basin. The land use of the Oos river basin is dominated by plantations with a percentage of 35.03%, followed by irrigated area and grassland of 24.97% and 18.43%.

Table 5. Topography of Oos river basin.

Land Use	Area (km^2)	Percentage
Sand beach	0.07	0.06%
Bush	0.41	0.33%
Building	0.00	0.00%
Plantation	43.45	35.03%
Settlement	19.16	15.45%
Grass	0.05	0.04%
Irrigated Area	30.96	24.97%
Rain-Filled Fields	7.04	5.68%
Grassland	22.86	18.43%
Total	124.01	100.00%

3.3. Integrated river basin management policy for sustainable water availability

Sustainability (sustainable) water availability can be done by making policies in the management of water resources, especially in its natural resource management system and water distribution in meeting water needs in the Oos River Basin. Technically for the short term it can be done by making infiltration wells, reservoirs, and check-ins. Activities for the long term can be done in a vegetative way by carrying out reforestation and reforestation activities as a water conservation act. Integrating water infrastructure planning with water conservation programming is critical to meeting potential increases in water demands due to population growth while ensuring a sustainable water supply [15].

Conclusion

Based on the explanation above, it can be concluded that Oos river basin is classified into small river basins with an area range of 10,000 - <100,000 Ha. The length of the Oos River Basin is 45.5 km, based

on the shape, the Oos river basin is classified in the form of bird feather type river basins with dendritic flow pattern. Based on the results of the analysis, the value of Br (the number of comparisons between first order of the rivers and second order of the rivers) is 3.83, with a flow density value (Dd) of 0.367 km/km^2 and classified as having a moderate density. In general Oos river basin is dominated by Regosol soil types. With the topography of the Oos River Basin dominant height is ranging from 0-300 m (30.75% of the area of the Oos River Basin). The land use of the Oos river basin is dominated by plantations with a percentage of 35.03%, followed by irrigated area and grassland of 24.97% and 18.43%. Water resource management policies that are needed primarily in the system of natural resource management and water distribution in meeting water needs in the Oos River Basin. Technically for the short term it can be done by making infiltration wells, reservoirs, and check-ins. Activities for the long term can be done in a vegetative way by carrying out reforestation and reforestation activities.

Acknowledgments

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