SSRG International Journal of Recent Engineering Science
ISSN: 2349–7157 / https://doi.org/10.14445/23497157/IJRES-V10I5P103

Volume 10 Issue 5, 24-29, Sep-Oct 2023

Original Article

Monitoring of River Water Discharge Volume in the Konaweha Watershed, Southeast Sulawesi Province, Indonesia

Eva Safitri Maladeni[1], Haydir[2], Hasddin[3], Jasman[4], Osu Oheoputra Husen[5]

[1,4]*Department of Civil Engineering, Faculty of Engineering, Halu Oleo University, Kendari, Indonesia*.
[2,3,5]*Department of Urban and Regional Planning Engineering, Faculty of Engineering, Halu Oleo University, Kendari, Indonesia.*

Received: 30 July 2023 Revised: 07 August 2023 Accepted: 30 August 2023 Published: 22 September 2023

Abstract - *Watersheds provide many resources (goods and services) that are important for human survival (such as agriculture, forestry, plantations, animal husbandry, industry and others) because watersheds are the choice to bring closer access to these resources. Along with population growth followed by increased space requirements, it will have negative implications for watershed sustainability. One of the indicators to assess the quality of the watershed is the water discharge. The study aims to monitor water discharge in order to provide data that has not been provided by previous researchers in the Konaweha Watershed, Konawe Regency, Southeast Sulawesi Province, Indonesia. Research data were obtained from secondary sources and field visits (primary) to ensure field conditions and secondary data confirmation. Using data for the 2014-2021 period. The analysis results show that during this period, there was a decrease in discharge; an extreme decrease occurred in 2017 and 2021.*

Keywords - *Monitoring, Volume, Water discharge, Watershed, River.*

1. Introduction

Population growth has implications for using space to target protected areas as water catchment areas, namely watersheds. Some researchers say that watersheds provide many essential resources (goods and services) for human survival (such as agriculture, forestry, plantations, animal husbandry, industry, and others) because watersheds are the choice to get closer to accessing these resources [1–4].

Watersheds as a limited resource, if used excessively, will cause a problem of decreasing the quantity (volume) of water discharge as a source of irrigation. Several researchers report that the watershed is currently under pressure and uncertainty [5], all of which lead to reduced availability of discharge [7-10]. Pressure on the watershed as a provider of water discharge (for irrigation) will continue to occur if there are no efforts to protect and control specific changes in decreasing forest area [11-17]. This indicates that watershed protection is important in order to maintain food availability because food productivity is primarily determined by water availability (irrigation) [18, 19].

The same phenomenon occurs in the Konaweha watershed in Southeast Sulawesi Province, Indonesia. Summarized several studies, it was found that changes in land cover that occurred in the Konaweha watershed have indicated changes in hydrological conditions, which were marked by a decrease in discharge. Andono [20] reported that the water discharge in the Konaweha watershed between 2000-2010 decreased by around 82 m3/s, and 40% of rainwater turned into surface runoff.

Indications of a decrease in the water discharge of the Konawe watershed can be seen from the increase in the flow coefficient increasing from 31.40% to 36.30%, resulting in an increase in the maximum discharge (Qmax) from 246 m3/s to 252 82 m3/s and the minimum discharge (Qmin) from 40 82 m3/s to 36 82 m3/s [21]. Then, the study of Baco [22] showed that the flow coefficient was from 28.50% to 45.50%.

Pressure on the watershed due to population growth continues to occur; in fact, several studies have found implications for changes in land cover [23] and decreased water discharge. On this basis, it is necessary to present the latest data to monitor water discharge in the Konaweha watershed. Until now, there have been no recent studies, especially the 2014 to 2021 timeframe in Konaweha. On this basis (state of the art), this study analyzes the development of river water discharge in the Konaweha watershed so that there is a pattern of change, whether it has decreased or is relatively stable.

2. Materials and Methods

This research will be carried out in Konawe Regency, Southeast Sulawesi Province. The reason is that the source of agricultural irrigation in Konawe Regency comes from the Konaweha Watershed, so it is necessary to present the latest data for future planning purposes.

This research uses a quantitative approach. Research data were obtained from secondary sources and field visits (primary) to ensure field conditions and confirmation of secondary data. Secondary data for water discharge were obtained from the Southeast Sulawesi River Basin IV Office, as well as the Southeast Sulawesi Watershed and Protected Forest Management Agency (BPDASHIL). The data it needs is time series or path data between 2014-2021. Data with this time span is needed as a basis for the strength of the interpretation of the results of the analysis so that it is more logical so that the results of this study are worthy of being used as the basis or basis for parties who need them for the benefit of special development planning related to the management and conservation of water resources and land in the Konaweha Watershed.

The average discharge is carried out using the arithmetic mean approach with the equation [24]:

$$Q \text{ average} = Q1 + Q2 + Q3 + \ldots Qn / n \qquad (1)$$

Q-average: monthly average discharge in a given month
Q1, Q2,…Qn is the monthly average discharge in the 1st, 2nd, and nth years.

n = number of years of observation (data).

3. Results and Discussion

The flow rate data used is the result of daily observations and recordings using weekly Automatic Planes throughout 2014-2021 on the Konaweha River with observation points on the flow of the Konaweha River in Asolu. The results of measuring the flow rate of the Konaweha watershed are presented in Table 1.

Table 1. Average River Flow for Irrigation Sources in the Konaweha Watershed in 2014-2021

Year	Daily/Monthly Water Debit (m^3/S)												Average
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2014	116	76,55	126,60	193	170,60	458	145,60	96,53	42,54	22,86	21,16	66,76	128,02
2015	29,61	116,60	114,80	160,40	182,30	240	75,51	48,61	24,68	38,04	30,55	49,65	92,56
2016	28,85	79,80	172	199,60	95,34	144,60	110,10	82,46	68,17	61,32	54,46	42,95	94,97
2017	-	-	-	-	93,01	191,80	92,36	41,76	23,50	51,68	124,70	79,22	87,25
2018	72,02	42,02	66,03	38,66	141,10	275	317,30	83,82	56,77	38,41	48,71	-	107,26
2019	52,08	110,40	56,28	108,70	76,89	565	102,20	57,33	49,37	38,31	36,31	51,24	108,68
2020	67,52	130,40	138	161	103,70	209,50	478	59,50	62,67	28,99	8,81	3,213	121
2021	74,29	40,52	60,11	38,45	59,19	37,48	129,50	142,50	229,10	93,83	164,60	116,70	98,86

Source: Center for Hydrology, Center for Research and Development of Water Resources, Center for River Region IV Southeast Sulawesi, Ministry of PUPR (2022).

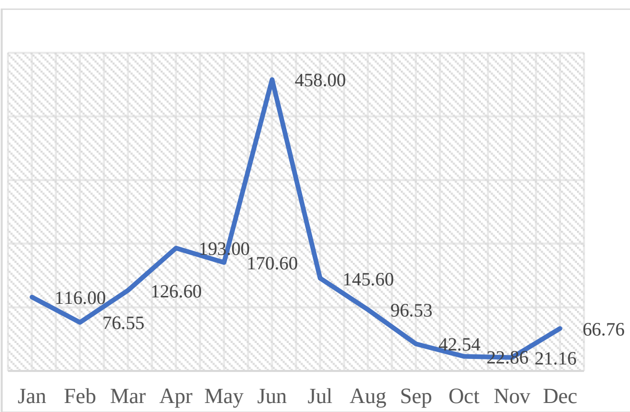

Fig. 1 Water discharge hydrograph (Asolu River) konaweha watershed, 2014

Table 1 above shows that the annual average discharge of the Konaweha watershed during observations shows a decreasing trend. The flow rate in 2014 was 128.02 m3/s; in 2021, it decreased to 98.86 m^3/s. An extreme decrease in debit occurred in 2017. The highest monthly debit in 2014 occurred from March to July. Among these periods, the highest discharge occurred in June, namely 458 m^3/s. The lowest discharge occurred in October (22.86 m^3/s) and November (21.16 m^3/s). As seen from the daily discharge in November, the lowest was 9.23 m^3/s, and the highest was 48.60 m^3/s. The highest discharge in June was 707.50 m^3/s, and the lowest occurred at the end of the month, namely 182.50 m^3/s. River water discharge in the Konaweha watershed in 2014 by day and month in full is presented in the hydrograph in Figure 1.

The highest monthly water discharge in 2015 occurred between February and June. Likewise, in 2014, the water discharge in June was the highest among other months, namely 240 m^3/s. The lowest monthly discharge in 2015 occurred in September, 24.68 m3/s, and in January, 29.61 m^3/s. The highest daily debits in June occurred on the eleventh and twelfth days (11th and 12th), namely 576.40 m^3/s and 396.20 m^3/s. The highest discharge occurred in September at the beginning of the month between 32.55-34.05 m^3/s, while the lowest occurred at the end of the month, namely 15.87 m^3/s. The hydrograph of the Asolu River water discharge in the Konaweha watershed in 2015 in days and months is shown in Figure 2.

Fig. 2 Water discharge hydrograph (Asolu River) konaweha watershed, 2015

The highest monthly debits 2016 occurred in March, April, June, and July. The peak occurred in April, namely 199.60 m^3/s. The lowest discharge occurred in October until the peak in January, namely 28.85 m^3/s. The highest daily discharge occurred at the beginning of April (1st), namely 696.90 m^3/s and the lowest daily discharge occurred in mid-April (16th), namely 9.00 m^3/s. The hydrograph of the Asolu River water discharge in the Konaweha watershed in 2016 in days and months is shown in Figure 3.

Fig 3. Water discharge hydrograph (Asolu River) konaweha watershed, 2016

Observation of discharge in 2017 was only carried out in May-December. During this period, it is known that the highest monthly debit data occurred in June, which was 191.80 m^3/s, as happened in 2014 and 2015. The lowest monthly discharge occurred in September and peaked at the month's end, namely 16.89 m^3/s. The highest daily discharge in June occurred at the beginning of the month (363.50 m^3/s), and the lowest occurred in the middle of the month (19th), namely 68.45 m^3/s. The development of debit data for 2017 is presented in Figure 4.

The water discharge (average) of the Asolu River DAS Konaweha in 2018 was 107.90 m^3/s. This amount has increased compared to the debits in 2015, 2016, and 2017. The highest monthly discharge (>100 m^3/s) occurred in May and June; the peak was in July, namely 317.30 m^3/s. The lowest discharge occurred in November, and the lowest peak occurred in October, namely 38.41 m^3/s. The highest daily discharge (July) reached 918.30 m^3/s, and the lowest daily discharge was 108.60 m^3/s. The highest daily discharge in October (lowest monthly discharge) occurred in the middle of the month (14th), namely 44.44 m^3/s, while the lowest daily discharge occurred at the end of the month, namely 33.38 m^3/s (daily and monthly debit data attached). Hydrographs of daily and monthly discharge during 2018 are shown in Figure 5.

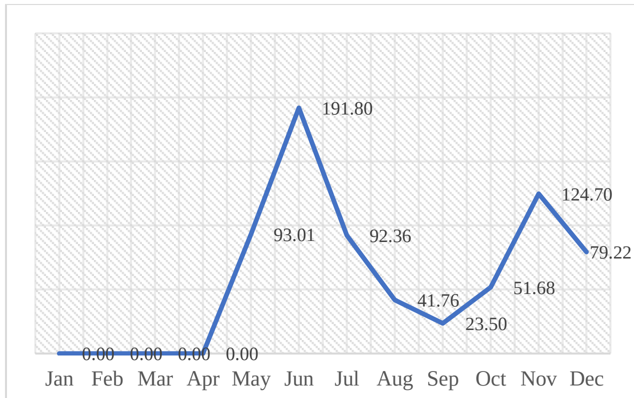

Fig. 4 Water discharge hydrograph (Asolu River) konaweha watershed, 2017

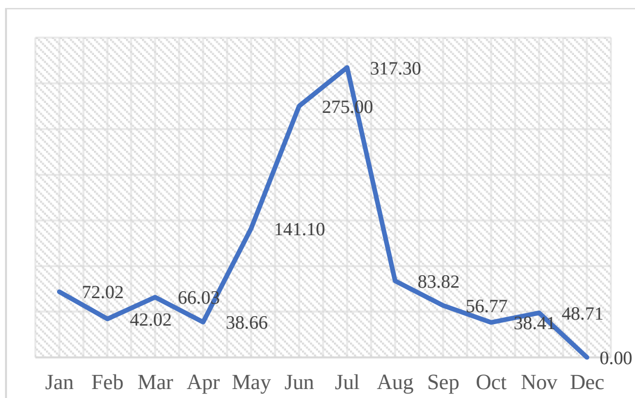

Fig. 5 Water discharge hydrograph (Asolu River) konaweha watershed, 2018

The total (average) discharge in 2019 was 108.68 m^3/s, higher than in 2018-2015 but still lower than the average discharge in 2014. The highest monthly discharge in 2019 occurred in June, namely 565 m^3/s. The same thing was also found in the 2017, 2015, and 2014 observation periods. Furthermore, the lowest monthly discharge occurred in November, namely 36.31 m^3/s (daily and monthly discharge data for 2019 are attached). Judging from the highest daily discharge, it occurred in the middle of June, namely 908.80 m3/s, while the lowest daily discharge occurred towards the end of November (26th), namely 26.96 m^3/s. The development of river water discharge during 2019 is shown in Figure 6.

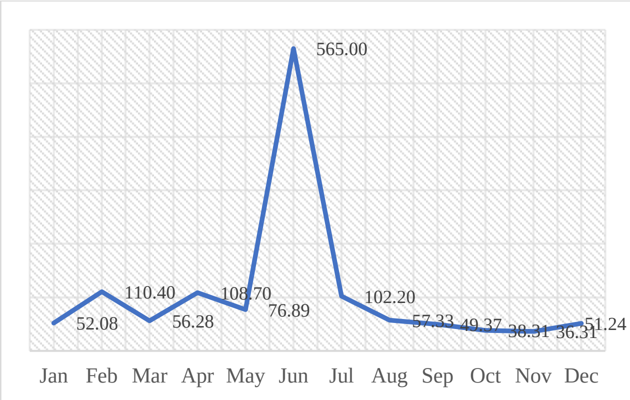

Fig. 6 Water discharge hydrograph (Asolu River) konaweha watershed, 2019

The average discharge of the Asolu River, Konawe watershed in 2020 was 121 m^3/s. This amount is higher than the discharges from 2019 to 2015 but still lower than the discharges in 2014. The highest discharges (>100 m^3/s) occurred in February, March, April, May, June, and July. During this period, the highest discharge occurred in July, namely 478 m^3/s. This fact also occurred in 2018, when the maximum discharge occurred in July. The lowest monthly discharge occurred in November and December, respectively 8.81 m^3/s and 3.21 m^3/s. This figure is the lowest among the minimum debits in other observation years. River water discharge data according to observation time during 2020 is shown in Figure 7.

Fig. 7 Water discharge hydrograph (Asolu River) konaweha watershed, 2020

The highest daily discharge in 2020 occurred in the middle of July (14th, 15th, and 16th), namely > 1,017 m^3/s, and the highest during the observation period. Another fact was revealed that there were zero (0) daily debits occurring in November and December as the lowest from other observation periods (discharge data is attached).

The debit in 2021 was 98.86 m^3/s, a significant decrease compared to the discharge in the previous three years (2020, 2019, and 2018). The highest monthly discharge in 2021 differs from other observation years, namely in July, August, September, November, and December. During this period, the highest discharge occurred in September, namely 229.10 m^3/s. The lowest monthly debit occurred in June, namely 37.48 m^3/s.

The highest daily discharge (September) occurred at the beginning of the month (6th), namely 472.90 m3/s, while the lowest daily discharge occurred at the end of June, namely 25.33 m^3/s (discharge data from observations attached). River water discharge for 2021, according to observation time, is presented in Figure 8.

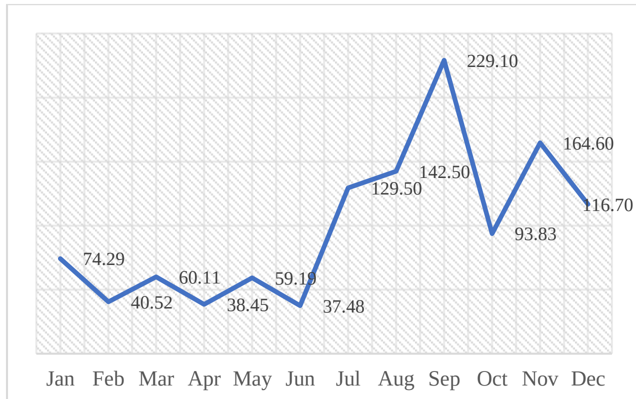

Fig. 8 Water discharge hydrograph (Asolu River) konaweha watershed, 2021

The above data (highest and lowest discharge) indicate quite extreme hydrological disturbance (highest and lowest discharge during observation). The disturbance indicates changes in land use and rainfall (the highest discharge) [25].

In general, between 2014 and 2021 shows, the dynamics of changes in discharge indicate that the Konaweha watershed is currently under pressure. When viewed from the amount of change in discharge, it can be said that it is still in a reasonable stage so that the function of water (discharge) as a processor is still functioning properly. This is based on the opinion of Asdak [25] that if the amount of average flow rate each year is not much different (during the observation period), this indicates that the DAS as a processor is functioning well, or in other words, the characteristics of the DAS or the health of the DAS are still maintained.

4. Conclusion

Several things differentiate the 2021 debit observation from the previous year. First, the highest discharge occurs in September, which in other observation years generally occurs in the middle of the year, meaning that this is the first time this has occurred during the observation period from 2014-2021. Second, the high debit data in November and December only occurred in 2017 observations. Third, in the previous year (2020), in December, it was found that there was a zero (0) daily discharge, while in 2021, the discharge was relatively stable. Third, the lowest debit observation in 2021 occurred in June; in the previous year, it actually showed a different (highest). The amount of discharge in the 2014-2021 period has indeed decreased; it is just not that significant or provides a far enough differentiator. In 2015, 2016, and 2017 experienced a significant decrease, but then in 2018, 2019, and 2020 showed an increase comparable to 2015-2017 and decreased again in 2021. The dynamics of changes in discharge are still at a reasonable stage so that the function of water (discharge) as processor still works fine.

Conflicts of Interest

Each author has contributed to preparing the contents of this manuscript. Before submission for publication, each author agrees with the manuscript's contents. This research is purely based on the author's ideas and ideas, so it can be emphasized that the entire contents of this manuscript are free from conflicts of interest.

Funding Statement and Acknowledgments

We would like to thank the Ministry of Education, Culture, Research and Technology for providing research assistance for the 2023 fiscal year. On this occasion, we would like to thank the Chancellor of Lakidende University for entrusting us as the University's research team. Lastly, thanks to the head of the Sulawesi River Region IV Office in Kendari City, who has provided permission and data support during the research.

References

[1] Farida Farida, Dasrizal Dasrizal, and Trina Febriani, "Review: Water Productivity in Agricultural Water Resources Management in Indonesia," *Jurnal Spasial*, vol. 5, no. 3, pp. 65–72, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[2] Waluyo Hatmoko et al., "Irrigation Water Security in River Areas in Indonesia," *Jurnal Irigasi*, vol. 12, no. 2, pp. 65-76, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[3] Jeffry S. F. Sumarauw, Sisca V. Pandey, and Hanny Tangkudung, "Analysis of Water Level of Binjeita River for Several Return Periods of Flood," *SSRG International Journal of Civil Engineering*, vol. 9, no. 11, pp. 33-42, 2022. [CrossRef] [Publisher Link]

[4] H. Hasddin, "Economic Valuation of Natural Resources in the Tiworo Watershed, West Muna District," *Jurnal Akran Juara*, vol. 4, no. 2, pp. 115-125, 2019. [Publisher Link]

[5] Alexander J. Horton et al., "The Cambodian Mekong Floodplain under Future Development Plans and Climate Change," *Natural Hazards and Earth System Science*, vol. 22, no. 3, pp. 967–83, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[6] Feri Fadlin et al., "Spatial Modeling for Flood Risk Reduction in Wanggu Watershed, Kendari," *International Journal of Engineering Trends and Technology*, vol. 70, no. 12, pp. 219-226, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[7] N'da Jocelyne Maryse Christine Amichiatchi et al., "Evaluation of Potential Changes in Extreme Discharges over Some Watersheds in Côte d'Ivoire," *Hydrology*, vol. 10, no. 1, p. 6, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[8] Shamira Nathania, Endrawati Fatimah, and Benny B Suharto, "Efforts to Reduce River Water Discharge through Land Use Control (Case Study: Upstream Ciliwung Watershed, Indonesia)," *Journal of Applied Geospatial Information (JAGI)*, vol. 6, no. 2, pp. 674–80, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[9] Muhammad Moazzam Ali, and Mashal Jabeen, "IoT Based Monitoring and Control of Water Parameters," *SSRG International Journal of Electrical and Electronics Engineering*, vol. 7, no. 8, pp. 1-3, 2020. [CrossRef] [Publisher Link]

[10] Nani Heryani et al., "Analysis of Climate Change Impacts on Agricultural Water Availability in Cimanuk Watershed, Indonesia," *Sustainability*, vol. 14, no. 23, p. 16236, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[11] Buddhi Gyawali et al., "Assessing the Effect of Land-Use and Land-Cover Changes on Discharge and Sediment Yield in a Rural Coal-Mine Dominated Watershed in Kentucky, USA," *Water*, vol. 14, no. 4, p. 516, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[12] Ifeanyi Chukwudi Achugbu et al., "Potential Effects of Land Use Land Cover Change on Streamflow over the Sokoto Rima River Basin," *Heliyon*, vol. 8, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[13] Eng. Omar Khaleefa, and Ammar Hatem Kamel, "Effects of Flow Rate in Euphrates River on Salinity Concentrations," *SSRG International Journal of Civil Engineering*, vol. 8, no. 6, pp. 1-7, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[14] Mateso Said et al., "Evaluation and Prediction of the Impacts of Land Cover Changes on Hydrological Processes in Data Constrained Southern Slopes of Kilimanjaro, Tanzania," *Earth*, vol. 2, no. 2, pp. 225–47, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[15] Jiahao Zhai et al., "Spatio-Temporal Patterns of Land-Use Changes and Conflicts between Cropland and Forest in the Mekong River Basin during 1990–2020," *Land*, vol. 11, no. 6, p. 927, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[16] Xuan Guo, Junzhi Ye, and Yunfeng Hu, "Analysis of Land Use Change and Driving Mechanisms in Vietnam during the Period 2000–2020,"*Remote Sensing*, vol. 14, no. 7, p. 1600, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[17] Hero Marhaento, Martijn J. Booij, and Arjen Y. Hoekstra, "Hydrological Response to Future Land-Use Change and Climate Change in A Tropical Catchment," *Hydrological Sciences Journal*, vol. 63, no. 9, pp. 1368–1385, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[18] Mateso Said et al., "Predicting Land Use/Cover Changes and its Association to Agricultural Production on the Slopes of Mount Kilimanjaro, Tanzania," *Annals of GIS*, vol. 27, no. 2, pp. 189–209, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[19] Zinabu Wolde et al., "Understanding the Impact of Land Use and Land Cover Change on Water–Energy–Food Nexus in the Gidabo Watershed, East African Rift Valley," *Natural Resources Research*, vol. 30, pp. 2687–702, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[20] Riwin Andono, Lily Montarcih Limantara, and Pitojo Tri Juwono, "Assessment Study of Konaweha Watershed Performance Indicators due to Land Use Changes Based on Hydrological Criteria," *Jurnal Teknik Pengairan: Journal of Water Resources Engineering*, vol. 5, no. 1, pp. 54-60, 2014. [Google Scholar] [Publisher Link]

[21] Sitti Marwah, "Analysis of Changes in Land Use and Availability of Water Resources in the Konaweha Watershed, Southeast Sulawesi Province," *Jurnal Agroteknos*, vol. 4, no. 3, pp. 208-218, 2014. [Google Scholar] [Publisher Link]

[22] S. La Baco et al., "The Effect of Land Use Changes on the Hydrological Conditions of the Upper Konaweha Watershed, Southeast Sulawesi Province," *Jurnal Agroteknos,* vol. 1, no. 3, pp. 163-172, 2011. [Publisher Link]

[23] T. Taufik, J. Mukaddas, and H. Hasddin, "Level of Land Cover Change (Deforestation) in the Tiworo Watershed, West Muna Regency," *Sang Pencerah: Jurnal Ilmiah Universitas Muhammadiyah Buton*, vol. 7, no. 2, pp. 260–269, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[24] L. A. Bruijnzeel, "Hydrological Functions of Tropical Forests: Not Seeing the Soil for the Trees?," *Agriculture, Ecosystems and Environment*, vol. 104, no. 1, pp. 185-228, 2004. [CrossRef] [Google Scholar] [Publisher Link]

[25] Chay Asdak, *Hydrology and Watershed Management*, Gadjah Mada University Press Yogyakarta. 2014. [Google Scholar] [Publisher Link]