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Analysis of the Impact of Land Cover Change in 2010-2024 on the Potential of Water Catchment Areas in the Arau Watershed

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Abstract: The purpose of this research is to analyse the potential of water catchment areas and the impact of land cover change from 2010 to 2024. The research method used is quantitative research, with a descriptive approach. The analysis technique in this study uses the maximum likelihood analysis method, in analysing the classification of land cover in 2010 and 2024, and overlay analysis in analysing the potential of natural water catchment areas, land cover changes in 2010-2024, and the index of potential water catchment areas. Based on the results of the study, it can be concluded that the Batang Arau watershed has experienced a decrease in the area of potential water catchment areas, covering an area of 1057.80 hectares with a percentage of 5.94%, although it has increased the potential of water catchment areas covering an area of 238 hectares with a percentage of 1.34%, but the increase is not proportional to the decrease that has occurred. This decrease is due to land cover change from 2010-2024, with a reduction in forest area of 5.93%, wetland agriculture 2.49%, water bodies 0.02%, and grass 0.53%. This was accompanied by an increase in built-up areas of 7.94%, mixed gardens 0.73%, fields 0.10%, natural open land 0.002%, and shrubs 0.11%, So it can be concluded that the decrease in water catchment area is due to the reduction of forest area (natural vegetation), accompanied by an increase in built-up area

Keywords: Arau Watershed; Catchment area; Land Cover; Watershed

Introduction

Watershed is a unit of territory located on land, which is bounded by a ridge of hills or mountains that play a role in draining, storing, and storing water (Asdak, 2014). Iswandi & Indang (2020); Kadir et al. (2020), added that watersheds play a major role as a driver of the hydrological cycle in renewing water resources, water catchment areas and water storage. Stored water is water that comes from the absorption of rainwater and surface water, or called infiltration, in the end the water is in saturated soil (Putri & Gunawan, 2016). Based on PP No. 32 of 1990, areas that experience high water absorption capacity are called water catchment areas, which play a major role in supplying water into the soil, which is one of the most important components in fulfilling supplies and maintaining supplies of groundwater resources (Moeck et al., 2017; Nemaxwi et al., 2019). The need for groundwater resources for living things is very large, especially for humans, so that the use of groundwater from year to year is increasing. so this has a big influence on groundwater reduction (Nurkhotiah, 2023). With the increasing need for water, it is necessary to pay attention to groundwater supply. Land cover plays an important role in determining the potential level of water catchment areas (S. A. Putri et al., 2024) **Simanjutak et al., 2022)**.

Sitanggang et al. (2024) added that if a water catchment area, which has a high infiltration ability, will

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become low, if land cover conditions do not support the area. Ratag et al. (2018) mentioned that the increasing number of plants in the water catchment area will affect the level of water absorption value in the area. Dar et al. (2021); Rodríguez-Huerta et al. (2020) explained that vacant land cover and built-up land cover do not support water infiltration because these areas are impermeable to water. Ferede et al. (2020) added that land cover can control the level of water infiltration and soil moisture and atmospheric demand. In accommodating rainwater that falls in the area. Increasingly, the need for land for the population is increasing with the increase in population every year, which will have an impact on increasing land needs (Sugiarto, 2017). Kholis & Rendra (2022) explained that population activities to manage land to meet their needs will trigger land cover changes, due to the encouragement of economic, social, physical, policy and spatial factors. The development of an area will have an impact on the socio-economy of the region, triggering an increase in area management (Setyawan Alfandhani et al., 2021). Land cover change will affect the condition of water infiltration in the area (Kholis & Rendra, 2022).

The influence caused by land cover change is closely related to the reduction of potential infiltration areas, due to the conversion of vegetated areas as water infiltration, into agricultural and residential areas (Putri et al., 2024). Reduced water catchment area due to land cover change causes, increased surface flow to the river with a short travel time, thus increasing the discharge of watershed surface storage, so that it will cause floods and erosion disasters (Ikhsan, 2023; Iskandar et al., 2023; Jinno et al., 2009; Nasrah & D., 2022). The reduction of water catchment areas will cause a narrowing of the water catchment pedestal area, so that an increase in the potential for soil erosion with the help of surface flow will cause siltation of river flow in the area (Hastono et al., 2013). Fadil et al. (2011) added that excessive land cover change will increase the risk of drought. Hastono et al. (2013) explained that the greater the level of water infiltration, the smaller the surface runoff water so that the smaller the water discharge on the surface so that the water catchment area can prevent floods, erosion, landslides and drought.

The Arau watershed is one of the watershed areas of Padang City that has experienced an increase in population from year to year. This is because this area is the center of the government, the city's economy, which triggers the surrounding community to move and live in the area, so that with the increasing number of residents of the Arau watershed, this will have an impact on land cover changes to meet the needs of an increasing population. Based on the previous explanation, this land cover change will have an impact on the decline in the quality of water catchment areas in the Arau watershed, resulting in a decrease in the level of water infiltration and an increase in surface flow, so that this will cause potential floods and droughts. Based on this explanation, it can be proven by the BPS data report for 2020-2024 that the Arau watershed is one of the watershed areas with the most flood disasters in the Padang city area, namely 21 incidents in the last five years. In addition, based on the Antara news report in 2024, there were three sub-districts in the Arau watershed area that experienced drought during the dry season. Based on these events and phenomena is one of the symptoms that show the characteristics of the beginning of the decline in the quality of water infiltration in the Batang Arau watershed area, hence the need for this study with the aim of research in analysing the potential of water catchment areas and the impact of land cover changes on the potential of water catchment areas in the Arau watershed. It is hoped that this study can provide a descriptive picture of the potential of water catchment areas and the impact of land cover change on the potential of water catchment areas over the past fifteen years (2010-2024).

Therefore, this research is expected to provide an understanding of the potential of water catchment areas, as well as the impact of land cover change and this research can be used as a reference, in establishing sustainable regional management policies, in order to maintain groundwater resources through the protection of water catchment areas. The reason this research is considered important is because, this study clarifies the condition of the potential water catchment area of the Arau watershed area, as well as the impact of human activities in land management in the past fifteen years, and the results of this study can be a solution, in overcoming and prevent the potential for floods and drought disasters in the Arau watershed area.

Method

Types of Research

This research is included in quantitative research using a descriptive approach, aiming to describe a characteristic, or variable nature in a sample or population.

Location and Time of Research

This research was conducted in the Arau watershed area, with the research time lasting for three months starting from March 2025 to April 2025.

Research data and analysis techniques

This research consists of two types of research data, namely secondary data in the form of soil type data, rainfall data, obtained from the Padang City BAPPEDA office. Landsat 8 satellite images in 2010 and 2024, obtained from the official USGS website owned by the United States and DEM data obtained from the official BIG website owned by Indonesia. Primary research data obtained from the results of field surveys, with the aim of comparing the accuracy between the results of the analysis with the conditions in the field.

The analysis technique in this study uses spatial analysis techniques, using the maximum likelihood analysis method, in analysing the classification of land cover in 2010 and 2024, and overlay analysis is used in analysing the potential of natural water catchment areas, land cover changes in 2010-2024, and the index of potential water catchment areas.

Result and Discussion

Result

Potential Natural Infiltration Areas of Batang Arau Watershed

Potential natural water infiltration areas are infiltration areas formed without the influence of land cover. consists of the results of overlay analysis of slope, rainfall and soil type data for more details can be seen in Table 1 and Figure 1.

Table 1. Potential Natural Water Infiltration Area of Batang Arau Watershed

Potential natural water catchment areas	Extensive (ha)	Percentage (%)
Primary catchment area	1809.90	10.16
High catchment area	7753.08	43.53
Low catchment area	11.50	0.06
Non-Infiltration Area	8236.22	46.24
Total	17810.70	100.00

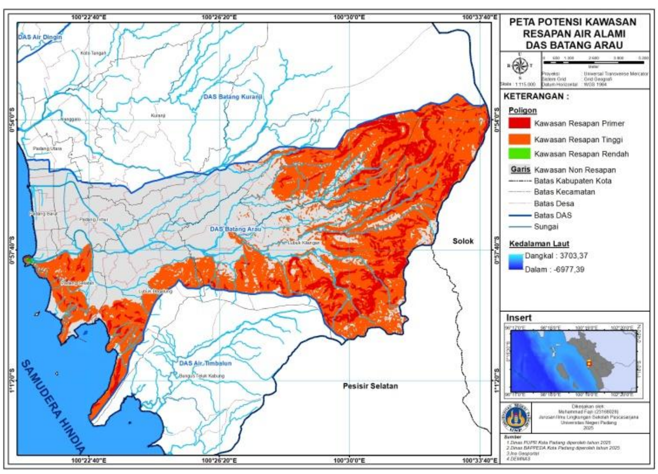

Figure 1. Map of Potential Natural Water Infiltration Areas of Batang Arau Watershed

Land Cover of Batang Arau Watershed in 2010-2024

Based on the year the land cover classification is divided into two parts in 2010 and 2024 for more details can be seen.

Land Cover of Batang Arau Watershed in 2010

Land cover in 2010 is the result of land cover classification using Landsat 7 satellite imagery in 2010, so that the area and description of land cover conditions in 2010 can be seen in Table 2 and Figure 2.

Table 2. Land Cover of Batang Arau Watershed in 2010

Land Cover Classification in 2010	Extensive (ha)	Percentage (%)
Forests	7615.82	42.76
Mixed farm	4540.87	25.50
landBuilt-up area	3126.96	17.56
Agriculture wetland	1556.95	8.74
Shrub bush	453.29	2.55
Water body	231.26	1.30
Grassland	220.62	1.24
Field	61.22	0.34
Natural open land	3.70	0.02
Total	17810.70	100.00

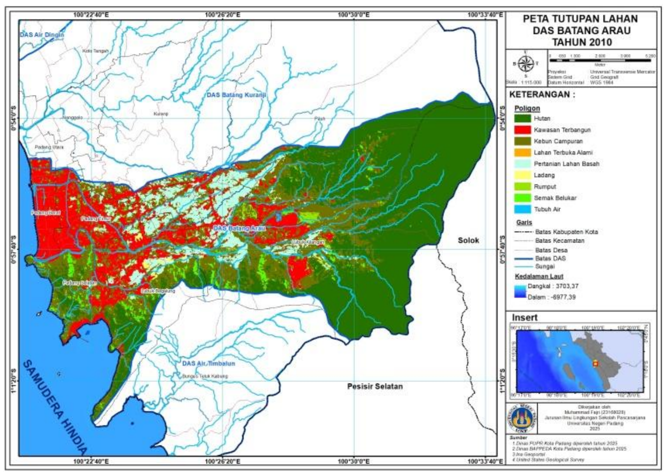

Figure 2. Land Cover Map of Batang Arau Watershed in 2010

Land Cover of Batang Arau Watershed in 2024

Land cover in 2024 is the result of land cover classification using Landsat 8 satellite images in 2024, so that the area and description of land cover conditions in 2024 can be seen in Table 3 and Figure 3.

Table 3. Land Cover of Batang Arau Watershed in 2024

Land Cover Classification in 2024	Extensive (ha)	Percentage (%)
Forests	6558.86	36.83
Mixed farm	4671.30	26.23
landBuilt-up area	4541.49	25.50
Agriculture wetland	1129.67	6.34
Shrub bush	473.45	2.66
Water body	227.19	1.28

Land Cover Classification in 2024	Extensive (ha)	Percentage (%)
Grassland	125.53	0.70
Field	79.83	0.45
Natural Open Land	3.38	0.02
Total	17810.70	100.00

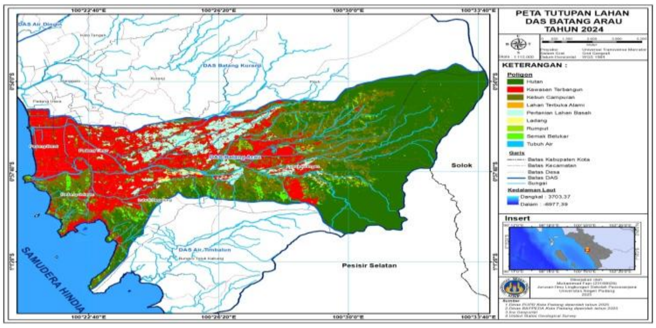

Figure 3. Land Cover Map of Batang Arau Watershed in 2024

Land Cover Change of Batang Arau Watershed in 2010-2024

Land cover change is an analysis of the condition of land cover change from the last year to the latest year. This analysis is generated by overlay analysis between land cover classification data in 2010 and 2024 so that the area and description of land cover change conditions in 2010-2024 can be seen in Table 4 and Figure 4.

Table 4. Land Cover Change of Batang Arau Watershed in 2010-2024

Land Cover Classification	year 2024 (ha)	2010 (ha)	Changes (ha)	Percentage (%)
Forest	6558.86	7615.82	-1.056.96	-5.93
Built-up area	4541.49	3126.96	1.414.53	7.94
Mixed farm	4671.30	4540.87	130.43	0.73
Field	79.83	61.22	18.61	0.10
Natural open land	3.38	3.70	-0.32	0.002
Wetland farm	1129.67	1.556.95	-427.28	-2.40
Grass	125.53	220.62	-95.10	-0.53
Scrub	473.45	453.29	20.16	0.11
Water body	227.19	231.26	-4.07	-0.02

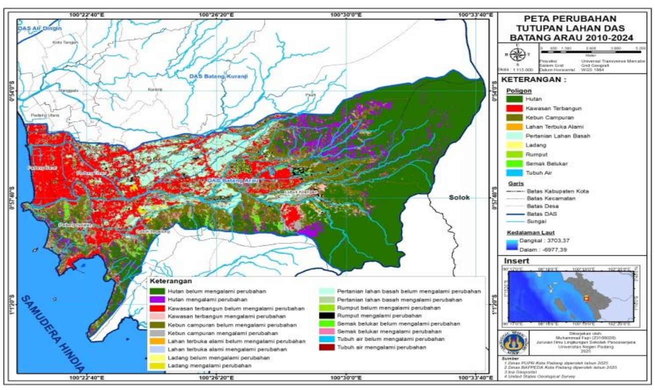

Figure 4. Land Cover Change Map of Batang Arau Watershed 2010-2024

Water catchment area potential index of Batang Arau watershed in 2010-2024

Based on the year, the index of potential water catchment areas is divided into two parts, namely 2010 and 2024, for more details can be seen below:

Water catchment area potential index of Batang Arau watershed in 2010

The index of potential water catchment areas in the Batang Arau watershed in 2010 is the result of an overlay analysis between data on the potential of natural water catchment areas and land cover classification in 2010 so that the area and description of the index of potential water catchment areas in 2010 can be seen in Table 5 and Figure 5.

Table 5. Water catchment area potential index of Batang Arau watershed in 2010

Water catchment Area Potential Index in 2010	Extensive (ha)	Percentage (%)
Primary catchment area	1809.90	10.16%
Very High catchment Area	5649.66	31.72%
High catchment Area	1879.46	10.55%
Medium catchment Area	225.45	1.27%
Low catchment Area	8.55	0.05%
Very low catchment Area	1.46	0.01%
Non-Infiltration Area	8236.22	46.24%
Total	17810.70	100.00%

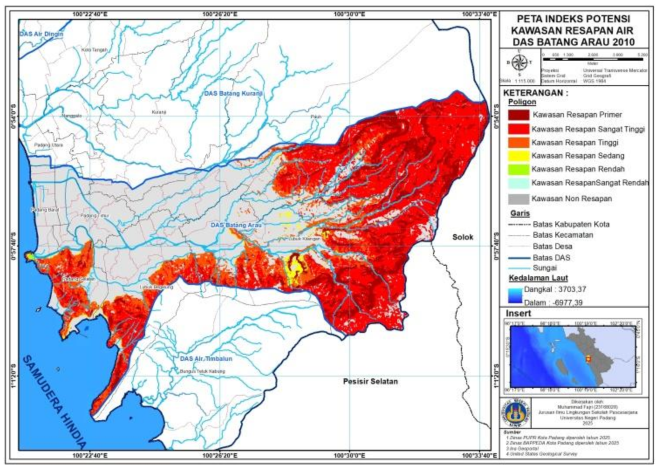

Figure 5. Index Map of Potential Natural Water Infiltration Areas of Batang Arau Watershed in 2010

Water catchment area potential index of Batang Arau watershed in 2024

The index of potential water catchment areas in the Batang Arau watershed in 2010 is the result of an overlay analysis between data on the potential of natural water catchment areas and land cover classification in 2010 so that the area and description of the index of potential water catchment areas in 2010 can be seen in Table 6 and Figure 6.

Table 6. Water catchment area potential index of Batang Arau watershed in 2024

Water catchment Area Potential Index in 2024	Extensive (ha)	Percentage (%)
Primary catchment area	1809.90	10.16
Very high catchment Area	4927.41	27.67
High catchment Area	2463.70	13.83
Medium catchment Area	365.00	2.05
Low catchment Area	5.07	0.03
Very Low catchment Area	3.40	0.02
Non-Infiltration Area	8236.22	46.24
Total	17810.70	100.00

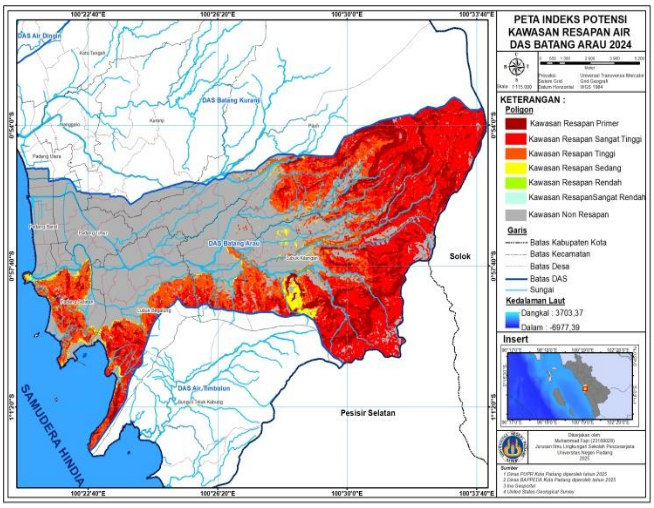

Figure 6. Index Map of Potential Natural Water Infiltration Areas of Batang Arau Watershed in 2024

Condition of Potential Water Infiltration Area of Batang Arau Watershed in 2010-2024

The condition of the potential water catchment area of the batang arau watershed in 2010-2024 is the result of an overlay analysis between the data of the potential water catchment area index in 2010 and 2024 so that the area and description of the condition of the potential water catchment area of the batang arau watershed in 2010-2024 can be seen, in Table 7 and Figure 7 below:

Table 7. Condition of Potential Water Infiltration Area of Batang Arau Watershed in 2010-2024

Condition of Potential Water Infiltration Areas 2010-2024	Extensive (ha)	Percentage (%)
Has increased	238.00	1.34
Has decreased	1057.80	5.94
Has not change	16514.9	92.72
Total	17810.70	100.00

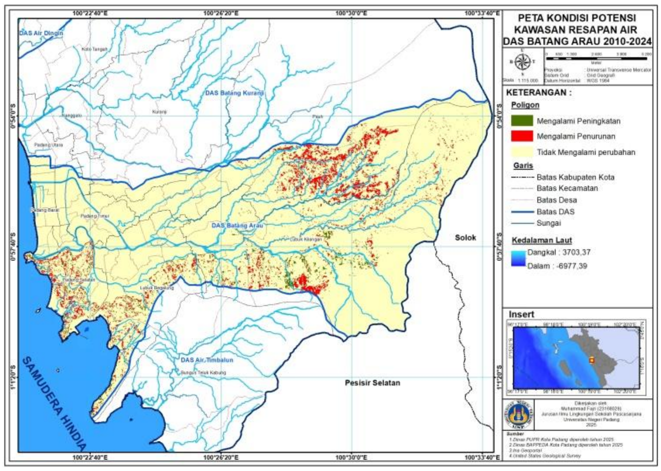

Figure 7. Condition Map of Potential Water Infiltration Area Index of Batang Arau Watershed in 2010-2024

Discussion

Potential Natural Infiltration Areas of Batang Arau Watershed

Based on Table 1 and Figure 2 above, the potential natural water catchment area of the Batang Arau watershed is divided into 4 classifications, namely primary, high, low, and non-infiltration areas. Based on the results of the data above, it can be seen that the non-infiltration area is the largest area in the Batang Arau watershed, the topography in the area is dominated by slopes of 0-8%, followed by a potential high water catchment area of 7,753.08 hectares with a percentage of 43.53%, a primary catchment area of 1,809.90 hectares with a percentage of 10.16%, and a low catchment area of 11.50 hectares with a percentage of 0.06%.

Land Cover of Batang Arau Watershed in 2010-2024

Based on Table 2, Table 3 Figure 2 and Figure 3 above that the Batang Arau watershed from 2010 to 2024 has a classification of forest areas, mixed gardens, wetland agriculture, shrubs, water bodies, grass, fields, and natural open land. Each of these areas has a diverse area but, based on monitoring over the past fifteen years, it turns out that the area has undergone significant changes, some land cover areas have decreased and some have increased, which can be seen in Table 4 above. The area that experienced the largest reduction in land cover is the forest area, which is 1056.96 hectares with a percentage of 5.93%, followed by wetland agriculture with a reduction in land cover of 427.28 hectares with a percentage of 2.40%, grass with a reduction in land cover of 20.16 hectares with a percentage of 0.53%, water bodies with a reduction in land cover of 4.07 hectares with a percentage of 0.02%, and natural open land with a reduction in land cover of 0.32 hectares with a percentage of 0.002%. The area that experienced the largest increase in land cover was the built-up area with an area of 1414.53 hectares with a percentage of 7.94%, followed by mixed gardens with an increase in land cover of 130.43 hectares with a percentage of 0.73%, shrubs with an increase in land cover of 20.16 hectares with a percentage of 0.11%, and fields with an increase in land cover of 18.61 hectares with a percentage of 0.10%. Based on the explanation above, it can be concluded that the dominant land cover change occurred in the reduction of forest areas with an increase in built-up areas. For more details can be seen in Figures 8.

(a) (b) (c)

Figure 8. Land cover change: (a) Forest to built-up area (mining); (b) Forest to mixed farm; and (c) from mixed farm to built-up areas (settlements)

Putra et al. (2021) explained that this land cover change was caused by economic, social and political factors, because the arau watershed area is the centre of the industrial area, the West Sumatra provincial government area, and the education area. This causes people from rural areas to migrate to cities with the aim of getting better jobs and education, in order to improve their quality of life (Şen, 2025). Andriani et al. (2022); Ophiyandri et al. (2021) added that this land cover change was also caused by the trauma of the people of Padang City due to the earthquake disaster, 30 September 2009 and the issue of tsunamis that continued to haunt the community, so this spurred people's desire to move to higher areas, namely upstream areas. As the population increases every year in the area, land cover change will increase every year (Junianto et al., 2023). This can be proven from BPPS data from 2010 to 2024 that the population of the Arau watershed area continues to increase in population every year, resulting in increased land cover changes, especially built-up areas for their residence (Khodaei et al., 2025).

Water catchment area potential index of Batang Arau watershed in 2010-2024

Based on Table 1 and Figure 2 above, the potential natural water catchment area of the Batang Arau watershed is divided into four classifications namely primary, high, low, and non infiltration areas when the map of potential water catchment areas is overlaid with the land cover map which can be seen in Table 5, Figure 5, Table 6, and Figure 6 so that the classification of the area has changed previously there were four classifications now there are seven classification areas namely primary, very high, high, medium, low, very low and non infiltration areas based on Table 5, Figure 5, Table 6, and Figure 6, it can be seen that the potential index of the Batang Arau watershed water catchment area in 2010 and 2024 has a different area and percentage in each classification of the potential index of the water catchment area, this can explain that the area has undergone a change in the area of the potential index of the water catchment area and this can be explained from Table 7 and Figure 6 that the potential index of the Batang Arau watershed water catchment area from 2010 to 2024 has decreased in the area of classification Based on Table 7, it explains that the area of the decrease in the classification of potential water catchment area index reached 5.94% with an area of 1057.80 hectares, although there was an increase of 1.34% with an area of 238 hectares, but it was not proportional to the reduction that occurred. This reduction is caused by the change in land cover from high land cover areas such as forests to built-up areas or land cover that is lower than forest land cover, this will be inversely proportional to the area that has increased the classification of the potential index of water catchment areas. If the decrease in the classification of potential water catchment areas due to the impact of land cover change continues to occur, the potential for flooding, erosion and drought disasters will become more frequent and increase, because land cover can reduce water catchment areas, and accompanied by an increase in impermeable areas, this will cause an increase in surface flow or flooding, especially urban areas (Morillyn et al., 2024; Purwanto & Paiman, 2023; Rahman et al., 2021). The reduction of natural vegetation areas (forests) with an increase in built-up areas due to land cover change will have an impact on increasing surface temperatures and encouraging climate change that causes extreme weather (Guo et al., 2018; Safitri et al., 2022). Bikis et al. (2025); Findell et al. (2017) added that this temperature increase occurs when there is a change in land cover due to deforestation, the addition of built-up areas and the expansion of agricultural areas so that it will have an impact on reducing the ability of ecosystems to absorb and store carbon, causing increased global warming so that it has an impact on increasing surface temperatures and extreme weather. Climate change due to global warming will have a significant impact on the availability and can reduce groundwater supply resulting in drought (Paule-Mercado et al., 2024; Tang et al., 2025). When hot weather shines on open areas without vegetation that protects, especially in forest areas, and the condition of clay soil when it rains will have an impact on erosion of the land surface by surface flow, due to the absence of vegetation that plays a role in inhibiting water so that the reduced ability of the watershed to withstand surface flow, this will cause erosion to cause siltation in the river, due to the increase in the volume of sedimentation in the river body, when there is an increase in rainfall with high intensity, this will cause river overflow which causes flooding (Eri et al., 2025; Mardyansyah et al., 2024; Sari & Hermon, 2025; Supiyati et al., 2024; Tamin et al., 2024; Virgota et al., 2024; Wijayanti et al., 2025).

Therefore, it is necessary to increase the forest area by reforesting in order to reduce the decrease in water catchment areas and the impact of climate change which can exacerbate the occurrence of floods, erosion, and drought (Gao et al., 2025). Xie et al. (2024) added the need to establish a buffer zone area with a certain distance in order to maintain and increase the water catchment area.

Conclusion

Based on the results of the study, it can be concluded that the Batang Arau watershed has experienced a decrease in the potential area of water catchment areas, covering an area of 1057.80 hectares with a percentage of 5.94%, although it has increased the potential of water catchment areas covering an area of 238 hectares with a percentage of 1.34%, but the increase is not comparable to the decrease that has occurred. This decrease was caused by changes in land cover in 2010-2024, with a reduction in forest areas of 5.93%, wetland agriculture 2.49%, water bodies 0.02%, and grass 0.53%. Accompanied by an increase in built-up area of 7.94%, mixed gardens 0.73%, fields 0.10%, natural open land 0.002%, and shrubs 0.11%, so it can be underlined that the decrease in water catchment area is caused by a reduction in forest land cover area (natural vegetation), accompanied by an increase in built-up area land cover.

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Author Contributions
M.F: preparation of initial draft, results, discussion, methodology, conclusions; I.U, E.B, N.S, T.H.A; review of analyses, proofreading and editing.

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