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The Impact of Mining Activities on Ecology Condition and in the Marisa Watershed Pohuwato Regency, Gorontalo Province

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ABSTRACT

The Marisa watershed with an area of 248.43 km2 is one of the watersheds in the Paguyaman Watershed. The upstream area of the Marisa Taluduyunu River in Marisa District empties into the coastal waters of the south coast of Pohuwato Regency. Almost all the riverbanks are used by local communities for traditional gold mining. Some of these mining businesses are managed traditionally using mercury, and the waste produced without being managed is directly thrown into the environment. This research aims to analyze the impact of illegal mining on land and the Marisa watershed. The method used to analyze the data is descriptive qualitative based on field observation data and literature studies. Observations from various mining locations show that the removal of the topsoil causes the soil to be unproductive for plant growth around the mining location or site. River pollution is also one of the impacts that can be seen at mining locations. Gold ore processing, especially if the amalgamation process uses mercury, spreads mercury to environmental components, especially water quality and aquatic biota. The water quality that is most affected by mining and gold ore processing activities includes increased concentrations of suspended solids and mercury concentrations. The impact of traditional gold mining activities greatly affects the water quality components, namely, total suspended solids and dissolved mercury concentration. The concentration of total suspended solids poses a risk of harm to aquatic organisms. Concentrations of dissolved mercury metal have the potential to reduce the quality of fishery products.

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INTRODUCTION

The Gorontalo Province region has several locations for traditional gold mining activities carried out by the community. One of the gold mines that is currently still operating is gold mining in the Mount Pani area. The Pani mountain area is part of the upstream area of the Marisa watershed. Mining activities on Mount Pani have been going on for a long time. In fact, one proof of the existence of the Pohuwato mine has existed since colonial times, namely one of the provisions of the regulations of the Dutch colonial government as the ruler in Pagoeat (Pohuwato), was obliged to pay tribute in the form of gold to the Dutch rulers through the Controleur, Jogugu and Marsaoleh appointed by the Dutch government. Finally it was continued by the local community, so that a village was formed around the location of the Mount Pani area, namely Hulawa Village, Buntulia District, Pohuwato Regency, in the Gorontalo language, Hulawa means gold. Not only that, maintaining divisions between local communities, in the 1980s, the mining community formed the Dharma Tani Marisa Village Unit Cooperative (KUD). The gold content created in the Mount Pani area occurs due to the primary gold mineralization process in rhyodacite lava rock, breccia and other pyroclastic rocks, a type of deposit in the form of Au porphyry which occupies the hilly areas around Mount Pani. Primary gold ore contains not only silver, but also the metals Cu, Pb, Zn, Cd, As and Hg. Secondary gold deposits are found in residual soil, and as alluvial gold deposits that occupy the river valley around Mount Pani which flows continuously to the Marisa River (Suhandi, 2005).

Mining as an activity, technology and business related to the mining industry starting from prospecting, exploration, evaluation, mining, processing, refining, transportation, to marketing. Mining activity is an activity carried out by means of excavation, as well as processing of excavated materials and the sale of excavated materials for metal, coal, minerals, oil and gas and others (Article 1 point 6 of Law No. 4 of 2009 concerning Mineral and Coal Mining). The negative impact that occurs on illegal mining, Natural Resources (SDA) that are extracted illegally will experience severe degradation, especially since some illegal mining uses cyanide and mercury which damage the environment. Soil loses nutrients and minerals as a result of mining waste which damages the soil structure, as a result the land cannot be replanted by plants and plant productivity is hampered. The negative impact of illegal mining also affects the safety of mine workers, because they do not use SOPs. Apart from the negative impact, gold mining can have a positive impact. The positive impact of coal mining activities is that apart from being a source of original regional income and a source of foreign exchange, it also plays a role in developing regions in Indonesia, namely by opening roads in isolated areas due to mining activities. Apart from that, mining activities will open up employment opportunities for people in the mining area (Uyu Wahyudin, 2020).

From an economic perspective, mining can increase people's income, one example is nickel mining activities at the PT location. IMIP in Morowali Regency was able to change the income level of people who previously worked as fishermen with an income of only Rp. 500,000 when working in mining, the average income is IDR 7,500,000. Infrastructure built from CSR funds includes roads, schools and assistance with fishing equipment (Nurhayat. et al, 2023). Referring to the impact of mining in Morowali Regency, indirectly mining activities in Pohuwato Regency will also have a positive impact on the community's economy. *1) Based on the results of an interview with one of the elements of the mining company (Pani Gold Project) operating in Pohuwato Regency, it is known that the projected workforce for 2025 at the Pani Gold Project mining location will absorb as many as 2500 workers. By absorbing a large enough workforce, mining activities will have a positive impact, including increasing employment opportunities and increasing people's income from economic activities. Based on the explanation above, this research aims to determine the impact of gold mining activities on conditions of ecological change and economic change in the Marisa watershed area, Pohuwato Regency, Gorontalo Province.

METHOD

The research location is in the Marisa watershed which is administratively located in Pohuwato Regency. This research was conducted in March 2024. Geographically, the Marisa watershed is located between 121° 54' 0.00” – 122° 5' 45.60” E and 00° 26' 31.20” – 00° 41' 6.00” N, with an altitude of 0 - 1340 meters above sea level. The research population is the Marisa watershed and the research samples are Hulawa Village and Taluduyunu Village. The materials used in carrying out this research were the Marisa Watershed Map, the Indonesian Earth Map (RBI) scale 1: 50,000 in 2017, the Village Administrative Boundary Map in 2020 and the Land Cover Map from 2003 to 2023, while the tools used were a GPS Receiver, cameras, stationery and computer equipment equipped with supporting software including ArcGIS 10.8, Microsoft Excel and Microsoft Word as well as other equipment that supports research. Primary data or main data was collected by collecting spatial data from the Gorontalo XV Region Forest and Environmental Management Stabilization Center and water quality data from the Pohuwato Regency Environmental Service. Primary data collectors will focus on analyzing changes in forest cover over the last 20 years, namely 2003 to 2023, while secondary data is collected from various informants who are at gold mining locations. The focus of secondary data collection is to analyze the socio-economic conditions in the mining location area.

Interviews were conducted with the community around the mining location. The selection of this type of sampling was based on the community's willingness to talk to researchers. Data analysis was carried out in 2 stages, namely analysis of changes in forest land cover and socio-economic analysis. Forest land cover analysis was carried out by interpreting spatial data analysis by analyzing land use changes that occurred in the Marisa watershed in the period 2003 to 2023. The results of the interpretation of spatial analysis of land cover changes in the Marisa watershed were then analyzed using a pivot table in Microsoft Excel to group the data land cover that is undergoing changes in order to obtain the final results of land cover changes that occur in the Marisa watershed area.

Figure 1. Flow diagram for analysis of changes in land cover in the Marisa watershed area

RESULTS AND DISCUSSION

Description of Research Location

The Marisa Watershed with an area of ± 26,655 Ha is one of the watersheds in the Paguyaman Watershed. The upstream area of the Marisa Taluduyunu River in Marisa District empties into the coastal waters of the southern coast of Pohuwato Regency. Almost all the riverbanks are used by local communities for traditional gold mining. Some of these mining businesses are managed traditionally using mercury, and the waste produced without being managed is directly thrown into the environment.

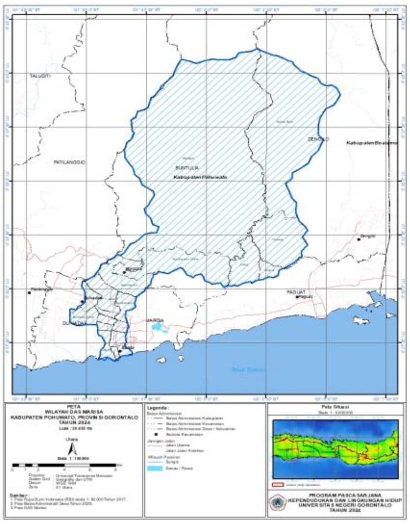

Figure 2. Map of the Marisa Watershed Area

The majority of the residents of Taluduyunu Village work as miners, dominated by middle-aged men of productive age. However, there are still those who work as farmers or agricultural laborers or in other jobs such as vegetable traders. People who choose jobs other than mining are people who are old and not physically strong enough to do mining. The methods used by miners based on the results of field observations are divided into two, namely the spray method and the drum method.

The most miners using the spray method are in Hulawa Village and Taluduyunu Village. People who do this work usually do mining for one day (leaving in the morning and returning in the afternoon or evening). This method generally applies to school dropouts and residents who want to try becoming miners. Based on the results of interviews, more and more people are mining gold because economic factors are becoming increasingly difficult and even getting worse.

In practice, mining using the spray method only uses simple equipment such as hoses, carpets, small water pumps, chisels, flashlights and sacks to contain the mining products. Processing to make gold pieces, by panning. Panning is the oldest method used by gold miners since ancient times. The tools used in panning are very simple, namely using a pan or other object with a pan-like shape. The cauldron was then filled with water and native rock which is thought to contain gold metal. In this traditional gold refining process, the precious metal is separated from a mixture of other minerals by shaking a cauldron filled with water and rocks so that the gold settles at the bottom of the cauldron.

Figure 3. Mining activities using the spray and pan method
(Source: Herlindah Documentation, 2023)

Apart from mining by panning, there is also the method of filling holes. Mining to get mining results takes 4 to 6 days a week. The results of field observations show that in the process of mining in groups. One group usually consists of 6 – 8 people who will carry out mining in very deep holes. This group is usually people who also have close kinship relationships or may come from other areas. In processing raw materials into gold using a tool commonly called a drum.

The rock is first ground, then an amalgamation process is carried out using mercury which is filled in a cylindrical coil. The cylinder, measuring 50 cm long, 32 cm in diameter, will be filled with fine rock (ore) in an amount of between 9 - 11 kg and approximately 20 liters of water. and added mercury according to the type of rock with the aim of binding the gold (amalgamation process), using less than one day depending on the hardness of the material obtained. Next, it is filtered and separated from mercury to obtain gold. After that, it is burned and placed in water, crushed (smashed) to obtain gold pieces which are then sold to gold collectors.

Figure 4. Mining Activities Using the Drum Method
(Source; Herlindah Documentation, 2023)

The Impact of Traditional Gold Mining Activities on Ecological Conditions

Traditional gold mining activities in the Taluduyunu River area generally fall into the category of open-pit mining which is mostly carried out on rivers or river borders. These activities cause potential damage to land, soil quality, water quality and the biota that live in it. The results of field observations found considerable environmental damage, especially in the Mount Pani area and Hulawa village. Large holes have been dug even to a depth of more than 500 meters into the bowels of the earth. After finishing mining, they did not re-cover the holes that had been made. Observations from various mining locations show that valuable layers of soil in various locations or places have been removed and piled on land that has not been mined. Generally, community activities that can disrupt the balance in the watershed are PETI, non-mineral rock mining, agricultural activities and household activities along the main river flow of the watershed (Salote, et al 2022; Cahyono, 2021). These activities have an impact on the quality of the environment in the watershed starting from pollution to erosion in the middle area of the watershed and downstream of the watershed (Lahili, et 2023; Desey et al, 2022)

Mining is an activity that carries the risk of pollution and/or environmental damage. There is no mining activity that does not have the potential to pollute and/or damage the environment, as stated by George W. (Rock) Pring. Removal of the topsoil causes the soil to be unproductive for plant growth around the mining location or area. The accumulation of topsoil has a negative impact on the culture of soil microorganisms, disrupts biological functions along with the nutrient cycle, and impacts the chemical and physical properties of the soil which results in the soil system not functioning. This condition is clearly visible in various abandoned mining locations. As part of the ecosystem, the upstream of each watershed actually plays a key role as a catchment area, while the distribution and utilization functions are in the middle and downstream areas of the watershed, so that any changes that occur in the watershed area will have a significant impact on the watershed ecosystem as a whole (Olii et al 2023).

Figure 5. Land Damage Due to Mining Excavations
(Source: Feri Novriyal Documentation, 2023)

Furthermore, river pollution is also one of the impacts that can be seen at mining locations. Gold ore processing, especially if the amalgamation process uses mercury, spreads mercury to environmental components, especially water quality and aquatic biota. The water quality that is most affected by mining and gold ore processing activities includes increased concentrations of suspended solids and mercury concentrations as shown in the picture below.

Figure 4. (a) The impact of traditional mining activities in the form of land damage on river borders, and (b) High sediment material turns the clear water of the Taluduyunu River into a mine waste canal.
(Source; Documentation by Herlindah, 2023)

An increase in the use of mercury, especially in the mining sector, can increase the amount of mercury in nature, so that it exceeds the specified quality standard limits. This increase in mercury levels can contaminate fish and other aquatic creatures, which can be eaten by larger fish or aquatic animals or can enter through the gills. Furthermore, these fish will be consumed by humans so that indirectly humans have accumulated mercury in their bodies.

In 2021, the Pohuwato Regency Environmental Service has carried out monitoring and examination of sediment in the Taluduyunu river. The results of data processing / laboratory samples are presented in Table 1.

Table 1. Sediment Examination Test Results for the Taluduyunu River Marisa Watershed

No	Test Description	UoM	Result	GRL	Method Reference	Rem Q
1	Copper (Cu)	mg/kg dry	4670	n/a	WI-(ID)-[EHS]-LA-070 (ICP-OES)	Q
2	Iron (Fe)	mg/kg dry	46200	n/a	WI-(ID)-[EHS]-LA-070 (ICP-OES)	Q
3	Manganese (Mn)	mg/kg dry	4230	n/a	WI-(ID)-[EHS]-LA-070 (ICP-OES)	Q
4	Zinc (Zn)	mg/kg dry	< 1	n/a	WI-(ID)-[EHS]-LA-070 (ICP-OES)	Q
5	Mercury(Hg)	mg/kg dry	0.22	n/a	WI-(ID)-[EHS]-LA-070 (CV-AFS)	Q

Source: Pohuwato Regency Environmental Service Laboratory Test Results, 2021

Based on the table of laboratory test results above, it is known that there is mercury content in the Taluduyunu River in the Marisa Watershed. The results of this laboratory test are in line with the results of a study by Barakati, Kevin Philips (2024) where in the results of his research regarding the quality status of surface water and groundwater around Unlicensed Gold Mining (PETI) it is known that the impact of unlicensed gold mining and processing activities that use water Mercury (Hg) as a filter causes environmental pollution with water quality status showing light to heavily polluted levels. According to Dunggio and Musa (2022), pollution activities that occur in main rivers not only damage the water body ecosystem, but have an impact on damage to the watershed environment, even though the damage occurs slowly.

Utina, Ramli, et al (2015) in their research results stated that traditional gold mining activities, especially panning and gold ore processing using mercury (Hg), have produced solid waste (tailings) which are then thrown into river waters until they reach estuaries and coastal waters. Pohuwato Regency. Palar (1994) stated that mercury enters the body of living organisms mainly through food. Because almost 90% of toxic substances or heavy metals (mercury) enter the body through food, the rest enters by diffusion or seepage through tissues and through respiratory events. In the food chain, methyl mercury ions which are easily consumed by organisms will dissolve in lipids and then be stored in the fatty tissue of fish, without showing any interference from mercury. Anonymous (1994) fish can store methyl mercury in fat tissue up to 3000 times the level in water without suffering from illness. Mercury that enters humans either through the food chain or through breathing can inhibit the enzymes Glutathione reductase and Seric phosphoglucose isomerase in serum by binding to –SH (sulfihydryl) groups and if it accumulates, it can damage the brain, kidneys and liver. Long-term damage can damage the central nervous system which can have very dangerous effects, besides that it can also result in chromosome damage which causes birth defects.

One indicator to know whether a watershed can carry out its function well can be seen from the carrying capacity of the watershed. Analysis of the carrying capacity of a watershed is important to determine whether watershed management has been carried out well. Analysis of the carrying capacity of the Marisa watershed in 2019 is presented in Table 2 below.

Table 2. Marisa Watershed Performance Values and Weights

CRITERIA/SUB CRITERIA	WEIGHT %	MARK	CLASS	SCORE	THE CALCULATION RESULTS 2 x 5
A. Land Conditions					
1. Percentage of critical land	20	8	low	0,75	15
2. Percentage of vegetation cover	10	90	Very low	0,50	5

3. Erosion index	10	0,1	Very low	0,50	5
B. Water Management Conditions					
1. Flow regime coefficient (KRA)	5	6	low	0,75	3,75
2. Annual Flow Coefficient	5	1,8	Very high	1,5	7,5
3. Sediment Load	4	2	Very low	0,5	2
4. Flood	2	1 x 2 Year	Currently	1	2
5. IWater Use index	4	1,14	Very high	1,50	6
C. Socioeconomic Conditions					
1. Population Pressure	10	3,5	low	0,75	7,5
2. Level of Population Welfare	7	9	low	0,75	5,25
3. Existence and enforcement of regulations	3	Practiced limited	low	0,75	2,25
D. Building Investment					
1. City classification	5	There is no city	Very low	0,5	2,5
2. Classification of the value of water structures	5	<15 Billion	Very low	0,50	2,5
E. Regional Space Utilization					
1. Protected area	5	100	Very low	0,50	2,5
2. Cultivation Area	5	153	Very low	0,5	2,5
Total Score Value					**71**
WATERSHED IS MAINTAINED					

Source: BPDASHL Bone Bolango, 2019

Based on the table above, it is known that the value and weight of the performance evaluation of the Marisa Watershed in 2019 is 71 so that it is concluded that the Marisa Watershed is maintained. The value and weight related to the performance evaluation of the Marisa watershed are obtained based on calculations of 5 (five) parameters, namely: land conditions, water system conditions, socio-economic conditions, building investment and regional space utilization. Wolok, Estefanus et al, (2014) revealed that the potential runoff that occurs in the Marisa watershed is 197,779 mm / year with a potential erosion rate of 14,114 mm / year and sedimentation potential of 125,299 tons / year. Seeing these conditions, it is necessary to maintain the condition of the Marisa watershed so that it can play a role as it functions. Efforts to maintain the condition of the Marisa watershed need serious attention from various parties by taking various actions, including: maintaining the area of forest cover, paying attention to and considering land capabilities and directions for space utilization based on the Regional Spatial Plan, making preventive efforts in watershed areas with critical and very critical conditions and carrying out mechanical control in the form of construction of sediment control buildings and other actions to maintain the continuity of the function of the Marisa watershed.

Analysis of Forest Land Cover Change Due to Gold Mining Activities

Analysis of land cover change in the Marisa watershed area was carried out using the method of overlapping (overlaying) spatial data for each period (2003, 2013 and 2023). The condition of Marisa watershed land cover in 2003 based on the results of spatial analysis found that the largest land cover was dominated by forest land cover successively, namely secondary dryland forest covering an area of 11,1117.92 Ha (41.71%), primary dryland forest covering an area of 10,891.64 Ha (40.86%) this forest land cover was in Buntulia District (Hulawa Village and North Taluduyunu Village), Dengilo District (Karya Baru Village and Popaya Village) and Paguat District (Libuo Village, Soginti Village). The smallest land cover in the Marisa watershed area in 2003 was in the form of rice fields with an area of 11.60 Ha (0.04%) located in Duhiadaa District (Duhiadaa Village and West Buntulia Village). In detail, the area of land cover of the Marisa watershed in 2003 is presented in the following table.

Table 3. Land Cover in the Marisa Watershed Area in 2003

Subdistrict	Village	Land Cover											Total (Ha)
		Aw	Hp	Hs	Sb	Pkb	Pmk	Tnh Tbk	Hms	Pt	Pc	Sw	
Buntulia		64,34	6704,55	7507,43	595,44	628,43	45,94	70,61		298,57	1432,08		17347,39
	Buntulia Tengah	5,11				147,50							152,60
	Buntulia Utara	2,70				236,39	3,72				42,04		284,84
	Hulawa	23,41	6704,55	6473,65	436,84			70,61		213,39	521,49		14443,93
	Karya Indah	1,43			1,29	16,20	16,96				153,64		189,52

	Sipatana	2,00				76,31							78,31
	Taluduyunu	9,43		0,39	5,17	151,13	15,24			47,19	357,98		586,54
	Taluduyunu Utara	20,27		1033,39	152,15	0,90	10,02			37,99	356,93		1611,65
Dengilo			4173,28	2741,91									6915,20
	Karya Baru		4173,28	1259,44									5432,72
	Popaya			1482,47									1482,47
Duhiadaa		16,36				761,01	14,87		33,11	3,24	8,02	11,60	848,22
	Bulili	13,44				113,03	14,87		33,11	3,24	8,02		185,71
	Buntulia Barat					272,14						1,29	273,43
	Buntulia Jaya	1,50				88,68							90,18
	Buntulia Selatan	1,42				70,15							71,57
	Duhiadaa					217,01						10,31	227,32
Marisa		2,06				413,07	11,01			0,99	201,22		628,35
	Batubilotahu	1,80				160,20					97,42		259,42
	Bulangita										0,28		0,28
	Marisa Selatan	0,20				135,66					13,85		149,71
	Marisa Utara	0,05				95,71							95,76
	Palopo					3,40							3,40
	Pohuwato	0,01				15,28	8,01			0,99	17,90		42,18
	Pohuwato Timur	0,01				0,28	2,99				71,27		74,55
	Teratai					2,55					0,49		3,05
Paguat		2,03		867,83						24,17			894,03
	Libuo	2,03		675,83						24,17			702,03
	Sipayo			0,18									0,18
	Soginti			191,82									191,82
Patilanggio			13,80	0,75		6,84					0,01		21,41
	Balayo		11,30	0,75		6,84					0,01		18,91
	Dudepo		2,50										2,50
Total (Ha)		*84,79*	*10891,64*	*11117,92*	*595,44*	*1809,36*	*71,82*	*70,61*	*33,11*	*326,98*	*1641,33*	*11,60*	*26654,60*

Information :
Aw = Clouds, Hp = Primary Forest, Hs = Secondary Forest, Sb = Shrubs, Pkb = Plantations, Pmk = Settlements, TnhTbk = Open Land, Hms = Secondary Mangrove Forest, Pt = Dry Land Agriculture, Pc = Mixed Dry Land Agriculture, Sw = Rice Fields
Source: Data processing results, 2024

Marisa watershed land cover in 2013 based on the results of spatial analysis shows that the largest land cover is dominated by primary dry land forest land cover covering an area of 10,885.39 Ha (40.84%), secondary dry land forest covering an area of 10,377.81 Ha (38.93 Ha). This % forest land cover is in Buntulia District (Hulawa Village and Taluduyunu Utara Village), Dengilo District (Karya Baru Village and Popaya Village) and Paguat District (Libuo Village, Soginti Village). The smallest land cover in the Marisa watershed area in 2013 was secondary mangrove forest with an area of 33.11 Ha (0.12%) located in Duhiadaa District (Bulili Village). In detail, the land cover area of the Marisa watershed in 2013 is presented in the following table.

Table 4. Land Cover in the Marisa Watershed Area in 2013

Subdistrict	**Village**	**Land Cover**												**Total (Ha)**
		Aw	**Hp**	**Hs**	**Sb**	**Ht**	**Pmk**	**Tnh Tbk**	**Hms**	**Pt**	**Pc**	**Sw**	**Tbk**	
Buntulia		64,34	6704,55	6791,36	1171,96	234,09	83,61	62,05		214,22	1769,53	251,68		17347,39
	Buntulia Tengah	5,11				128,73	18,08					0,69		152,60
	Buntulia Utara	2,70				44,18	8,16				79,94	149,86		284,84
	Hulawa	23,41	6704,55	6246,89	621,34			62,05		209,31	547,08	29,30		14443,93
	Karya Indah	1,43			1,29		16,96				169,84			189,52
	Sipatana	2,00				61,17	15,14							78,31

	Taluduyunu	9,43		0,38	5,19		15,24				485,35	70,95		586,54
	Taluduyunu Utara	20,27		544,09	544,15		10,02			4,92	487,31	0,89		1611,65
Dengilo			4167,04	2748,13	0,02									6915,20
	Karya Baru		4167,04	1265,68										5432,72
	Popaya			1482,45	0,02									1482,47
Duhiadaa		16,36				525,68	114,72		33,11	3,24	27,23	124,83	3,05	848,22
	Bulili	13,44				95,64	29,80		33,11	3,24	7,49		2,99	185,71
	Buntulia Barat					237,49	34,59					1,29	0,06	273,43
	Buntulia Jaya	1,50				58,78	29,90							90,18
	Buntulia Selatan	1,42				57,86	12,30							71,57
	Duhiadaa					75,91	8,13				19,74	123,54		227,32
Marisa		2,06				349,28	95,80			0,99	101,09		79,13	628,35
	Batubilotahu	1,80				140,29	19,91				97,42			259,42
	Bulangita										0,28			0,28
	Marisa Selatan	0,20				108,44	32,73						8,34	149,71
	Marisa Utara	0,05				65,50	30,21							95,76
	Palopo					1,46	1,94							3,40
	Pohuwato	0,01				29,36	8,01			0,99	2,82		1,00	42,18
	Pohuwato Timur	0,01				1,69	2,99				0,07		69,79	74,55
	Teratai					2,55					0,49			3,05
Paguat		2,03		836,94	30,38					24,68				894,03
	Libuo	2,03		644,94	30,38					24,68				702,03
	Sipayo			0,18										0,18
	Soginti			191,82										191,82
Patilanggio			13,80	0,75							6,86			21,41
	Balayo		11,30	0,75							6,86			18,91
	Dudepo		2,50											2,50
Total (Ha)		***84,79***	***10885,39***	***10377,18***	***1202,36***	***1109,05***	***294,13***	***62,05***	***33,11***	***243,13***	***1904,70***	***376,51***	***82,18***	***26654,60***

Information :
Aw = Clouds, Hp = Primary Forest, Hs = Secondary Forest, Sb = Shrub, Ht = Plantation Forest, Pkb = Plantation, Pmk = Settlement, TnhTbk = Open Land, Hms = Secondary Mangrove Forest, Pt = Dry Land Agriculture, Pc = Mixed Dry Land Agriculture, Sw = Rice Fields
Source: Data processing results, 2024

As time progresses, the need for land will increase, the condition of land cover in the Marisa watershed in 2023 based on the results of spatial analysis shows that the largest land cover is dominated by primary dry land forest land cover covering an area of 10,848.89 Ha (40.70%), secondary dry land forest covering an area of 10,069.51 Ha (37.78%) of this forest land cover is in Buntulia District (Hulawa Village and North Taluduyunu Village), Dengilo District (Karya Baru Village and Popaya Village) and Paguat District (Libuo Village, Soginti). The smallest land cover in the Marisa watershed area in 2023 is secondary mangrove forest with an area of 11.04 Ha (0.04%) located in Duhiadaa District (Bulili Village). Based on the results of observations, it is known that there is land cover in the form of mining covering an area of 338.18 Ha (1.27%). In detail, the land cover area of the Marisa watershed in 2023 is presented in the following table.

Table 5. Land Cover in the Marisa Watershed Area in 2023

Subdistrict	Village	Land Cover													Total (Ha)
		Hp	Hs	Sb	Ht	Pmk	Tnh Tbk	Tb Air	Hms	Pt	Pc	Sw	Tbk	Ptmbg	
Buntulia		6668,04	6541,95	645,64	233,86	111,03	33,37	83,23		1476,99	1019,00	213,21		321,08	17347,39
	Buntulia Tengah				128,73	18,08		5,11				0,69			152,60
	Buntulia Utara				50,56	20,05		2,70		63,23	0,36	147,94			284,84
	Hulawa	6668,04	6022,64	444,84			33,37	39,20		678,95	235,81			321,08	14443,93
	Karya Indah					16,96		1,43		169,84	1,29				189,52

	Sipatana				54,57	21,74		2,00							78,31
	Taluduyunu		0,38	0,25		24,17		9,43		221,87	266,76	63,70			586,54
	Taluduyunu Utara		518,94	200,55		10,02		23,37		343,09	514,79	0,89			1611,65
Dengilo		4167,04	2703,75	27,50										16,91	6915,20
	Karya Baru	4167,04	1258,69	6,99											5432,72
	Popaya		1445,06	20,50										16,91	1482,47
Duhiadaa					486,74	134,25	12,10	22,07	11,04	19,74		138,65	23,63		848,22
	Bulili				85,50	31,30	12,10	19,16	11,04			2,99	23,63		185,71
	Buntulia Barat				227,26	40,17						6,00			273,43
	Buntulia Jaya				56,38	32,30		1,50							90,18
	Buntulia Selatan				57,77	12,38		1,42							71,57
	Duhiadaa				59,82	18,10				19,74		129,65			227,32
Marisa					329,10	171,78		2,05		27,22	98,20				628,35
	Batubilotahu				133,02	27,18		1,80			97,42				259,42
	Bulangita										0,28				0,28
	Marisa Selatan				116,68	32,83		0,20							149,71
	Marisa Utara				47,42	48,29		0,05							95,76
	Palopo				1,46	1,94									3,40
	Pohuwato				23,20	18,98									42,18
	Pohuwato Timur				4,76	42,56				27,22					74,55
	Teratai				2,55						0,49				3,05
Paguat			823,06	23,55			3,99	2,03		41,21				0,19	894,03
	Libuo		631,74	22,88			3,99	2,03		41,21				0,19	702,03
	Sipayo		0,18	0,00											0,18
	Soginti		191,14	0,67											191,82
Patilanggio		13,80	0,75							6,86					21,41
	Balayo	11,30	0,75							6,86					18,91
	Dudepo	2,50													2,50
Total (Ha)		***10848,89***	***10069,51***	***696,69***	***1049,69***	***417,06***	***49,46***	***109,39***	***11,04***	***1572,02***	***1117,20***	***351,86***	***23,63***	***338,18***	***26654,60***

Information :
Hp = Primary Forest, Hs = Secondary Forest, Sb = Shrub, Ht = Plantation Forest, Pmk = Settlement, TnhTbk = Open Land, Tb Air = Body of Water, Hms = Secondary Mangrove Forest, Pt = Dry Land Agriculture, Pc = Agriculture Mixed Dry Land, Sw = Rice Fields, Tbk = Ponds, Ptmbg = Mining
Source: Data processing results, 2024

Based on the results of spatial analysis carried out on land cover in the Marisa watershed, it is known that there are 14 (fourteen) land cover classes, namely: Primary Dry Land Forest, Secondary Dry Land Forest, Secondary Mangrove Forest, Shrubs, Plantations, Settlements, Open Land , Dry Land Agriculture, Mixed Dry Land Agriculture, Rice Fields, Ponds, Clouds, Water Bodies and Mining. Calculations were carried out to determine the pattern of land use changes in the Marisa watershed obtained from the results of overlaying land cover maps in the periods used as sampling in this research, namely 2003, 2013 and 2023.

Changes in Marisa Watershed Land Cover for the 2003 - 2013 Period

Changes in land cover that occurred in the Marisa watershed area in the period 2003 - 2013 were changes from primary dry land forest land cover to secondary dry land forest covering an area of 6.24 Ha, changes from secondary dry land forest to several land covers, namely shrubs covering an area of 577.32 hectares. Ha, into agricultural land covering an area of 148.61 Ha. Detailed changes in land cover during this period can be seen in the following table.

Table 6. Transition Matrix for Changes in Marisa Watershed Land Cover 2003 – 2013

		Land Cover in 2013												**Amount (Ha)**
		Aw	**Hp**	**Hs**	**Sb**	**Pkb**	**Pmk**	**Tnh Tbk**	**Hms**	**Pt**	**Pc**	**Sw**	**Tbk**	
an Lah an	Cloud	**84,79**												**84,79**

Primary Dryland Forest		10885,39	6,24										10891,64
Secondary Dryland Forest			10370,94	577,32			21,05		22,06	97,25	29,30		11117,92
Shrubs				595,44									595,44
Plantation					1087,52	222,30				160,87	335,61	3,05	1809,36
Settlement						71,82							71,82
Open Land				29,60			41,01						70,61
Secondary Mangrove Forest								33,11					33,11
Dryland farming									221,07	105,91			326,98
Mixed Dry Land Agriculture					21,53					1540,67		79,13	1641,33
Ricefield											11,60		11,60
Pond													0,00
Jumlah	*84,79*	*10885,39*	*10377,18*	*1202,36*	*1109,05*	*294,13*	*62,05*	*33,11*	*243,13*	*1904,70*	*376,51*	*82,18*	*26654,60*

Source: Data Analysis Results, 2024

Changes in Marisa Watershed Land Cover for the 2013 – 2023 Period

Changes in land cover that occurred in the Marisa watershed area in the 2013 - 2023 period varied greatly, with many changes in land cover occurring, one of which was new land cover in the form of ponds and mining. The changes in land cover that occurred during this period included changes in land cover from primary dry land forest to secondary dry land forest covering an area of 22.68 Ha, to shrubs covering an area of 111.30 Ha and to mining covering an area of 2.52 Ha. Changes in land cover during this period that are quite visible are the existence of mines covering an area of 338.18 Ha and ponds covering an area of 23.63 Ha. Detailed changes in land cover during this period can be seen in the following table.

Table 7. Transition Matrix for Changes in Marisa Watershed Land Cover 2013 – 2023

	Land Cover in 2013														Julmah (Ha)
Land Cover in 2013	Aw	Hp	Hs	Sb	Pkb	Pmk	Tnh Tbk	Tbh Air	Hms	Pt	Pc	Sw	Tbk	Ptmbg	
Cloud			0,00			0,25		84,54	0,00						84,79
Primary Dryland Forest		10848,89	22,68	11,30										2,52	10885,39
Secondary Dryland Forest			10007,75	117,00			37,36			19,2:	69,3:			126,53	10377,18
Shrubs			39,08	550,33				4,88		333,45	171,16			103,47	1202,36
Plantation					1030,19	56,36	10,43	0,44				11,64			1109,05
Settlement						293,57						0,55			294,13
Open Land														62,05	62,05
build Water									9,48				23,63		33,11
Secondary Mangrove Forest				5,88	1,71			2,52		227,24	5,79				243,13
Dryland farming				5,33	6,37	15,79	1,67	17,01	1,56	964,89	870,93			21,16	1904,70
Mixed Dry Land Agriculture				6,85		10,60						336,62		22,45	376,51
Ricefield					11,41	40,50				27,22		3,05			82,18
Pond															0,00
Mining															0,00
Amount	0,00	10848,89	10069,51	696,69	1049,69	417,06	49,46	109,39	11,04	1572,02	1117,20	351,86	23,63	338,18	26654,60

Source: Data Analysis Results, 2024

CONCLUSION AND RECOMMENDATION

Illegal mining activities have a huge impact on the land and Marisa watershed, especially the river which is a place for waste from these activities. The impact of traditional gold mining activities greatly affects the water quality components, namely, total suspended solids and dissolved mercury concentration. The concentration of total suspended solids poses a risk of harm to aquatic organisms. Concentrations of dissolved mercury metal have the potential to reduce the quality of fishery products.

People's gold mining activities can be categorized as a risk of environmental damage which is a slow process and could potentially become an environmental disaster if not managed properly. The increase in the number of miners provides the potential for environmental damage in the future. Policies to prevent and reduce the risk of environmental damage have been implemented at various levels of provincial, national and regional authority. However, the most important issue is related to the enforcement of the legal product or policy.

Efforts to improve river ecosystems or public waters that are experiencing pollution can be carried out using bioremediation techniques involving various existing R&D research and universities. Efforts to reduce the risk of pollution or contamination of water resources, both public waters and marine waters, can also be carried out using various approaches, including, developing alternative livelihoods, improving technology that is more environmentally friendly, establishing wetland areas as buffers for damage to coastal ecosystems and establishing better spatial planning so that the natural condition of the public water environment is maintained. Determining mangrove forest ecozones and coastal areas as conservation areas or city parks will be very helpful in reducing the rate of spread of mercury and total suspended solids into aquatic ecosystems. Therefore, the role of regional governments at the provincial and district or city levels will determine the condition of aquatic biological resources.

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