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REGULAR RESEARCH ARTICLE

Adaptation From Maladaptation: A Case study of Community-Based Initiatives of the Saddang Watershed

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ABSTRACT

Over the last few decades, numerous countries have invested vast sums of money and resources in addressing the effects of climate change through adaptation and mitigation measures. Part of these actions, however, resulted in maladaptation. This research investigates the adaptation response to climate change that (potentially) becomes maladaptation for both upstream and downstream watershed communities. This research uses a watershed approach located in the Saddang watershed, one of Indonesia's priority watersheds. The primary data were obtained from observation and in-depth interviews with villagers directly affected by extreme weather (droughts and floods) occurred between 2009 and 2020. The examination of satellite imagery yielded secondary data that revealed changes in land cover, sedimentation, and river flow. This study reveals that by applying a watershed approach, forms of maladaptation are found in the upstream area and have detrimental effects not only on the area itself, but also to the downstream. The upstream deforestation occurring in the period was closely related to the adaptation responses (maladaptation) to the effects of a long drought, which is likely to form a vicious circle between adaptation and exacerbating the impacts of climate change in the coming years. In addition, upstream maladaptations make downstream areas more vulnerable: they divert and create new hazards, and therefore vulnerability of other groups, although some positive examples of adaptation are also found downstream. Programs labeled "climate resilience" with increased food security are applied in both upstream and downstream regions, triggering maladaptation that has a wider impact and illustrating the non-consolidation of adaptation actions that take into account a watershed as a distinct landscape.

KEYWORDS
Maladaptation; Climate change adaptation; Watershed; Land use change; Deforestation; Spatial analysis.

1. INTRODUCTION

Climate change research has been a major topic of investigation in recent years, as the world continues to grapple with the impacts of a rapidly changing climate (Nalau & Verrall, 2021; Rogelj et al., 2016). Some of the most notable trends in climate change research are related to adaptation (Aguiar et al., 2018; Nalau & Verrall, 2021). Climate adaptation research has progressed on vulnerability, risks, and policy (Nalau & Verrall, 2021). However, learning from previous research, it is necessary to improve understanding of the potentially negative effects of adaptation responses, i.e., maladaptation (Barnett & O'Neill, 2010; Neset et al., 2019; Work et al., 2019). Maladaptation can occur when adaptation efforts are poorly designed, implemented, and evaluated, which threaten to waste the cost and effort of adaptation that are not only substantial but also are likely to increase over time as the impacts of climate change become more severe.

Indonesia, like other nations, has designed and implemented a national adaptation strategy (RAN API) (Biesbroek et al., 2010; Mullan et al., 2013). In the years 2016–2020, the Ministry of Finance of the Republic of Indonesia has invested over USD 5.4 billion on climate change adaptation initiatives. As a developing nation, this investment is not insignificant, and it is crucial for Indonesia to assure a lasting constructive impact on the future. Maintaining the quality and carrying capacity of watersheds is one of RAN API's primary objectives and focuses on reducing the risks of climate change consequences. Improving the quality of watershed is a way to increase socio-ecosystem resilience (Baird et al., 2016; Bottom et al., 2009; Dixon, 2000; Folke et al., 2002; Nemec et al., 2014). Watershed is a clear ecological category to look at the linkages in a single ecosystem or landscape (Li et al., 2021; Sivapalan et al., 2014). What happens downstream of a watershed can be seen as the impact of occurrences in the upstream areas. For instance, mining activities at the upstream area can generate detrimental effects on water quality downstream, or substantial land use change upstream would most likely increase erosion and cause sedimentation downstream.

This study will focus on the Saddang River watershed, South Sulawesi, Indonesia, which has experienced a climate-driven crisis mainly since 2009, in the form of extreme droughts and floods. The Saddang watershed ecosystem became one of Indonesia's priority watersheds, as it is one of the most severely degraded watersheds. At the same time, Indonesia government, provincial level, non-governmental organizations, and local community are striving to adapt to extreme drought upstream and flooding downstream in the Saddang watershed. In light of the parties' extensive efforts to promote climate change adaptation and the likelihood of maladaptation processes occurring, adaptation initiatives must prioritize the risk of maladaptation in their planning (Magnan et al., 2016).

In contrast, a variety of studies on maladaptation have not provided a comprehensive explanation of the watershed landscape. We believe that studies on maladaptation may be more thorough if the upstream and downstream linkages are examined. Thus, the objective of this research is to comprehend the adaptation response to climate change, particularly in relation to changes in land use and their effects both in upstream and downstream areas. In this way, also examine the background of maladaptation in a coherent landscape while regarding aspects that may not have been viewed as relevant or deemed connected in prior studies.

2. METHODOLOGY

2.1 Theoretical framework

This research focuses on the community's response to disasters in a single watershed. The calamities in concern are protracted droughts and floods stimulated by the impacts of climate change. Climate-driven and non-climate-driven elements are the primary determinants of the frequency or occurrence of these disasters (Huang et al., 2021; Linnenluecke & Griffiths, 2010; Zagefka et al., 2011). In this context, the crises might be determined by the severity and duration of the drought or the amount of precipitation over a given period (Huang et al., 2021; Zagefka et al., 2011). While activities and/or changes in land use, as well as topographical characteristics, will be assessed as non-climate driven (Dalu et al., 2018; Luo et al., 2019; Roy et al., 2020).

The concept of "adaptation" has appeared in several definitions, particularly with regard to ecological systems; this aspect of resilience is more process-oriented. Adaptation to climage change is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (McCarthy et al., 2001). Another perspective about climate change adaptation is the process, or outcome of a process, that leads to reduction in harm or risk of harm, or realisation of benefits, associated with climate variability and change (Willows et al., 2003). The two adaptation concepts illustrate that stimulus or factor stem from the impact of climate change encourages nature and humans to produce a response.

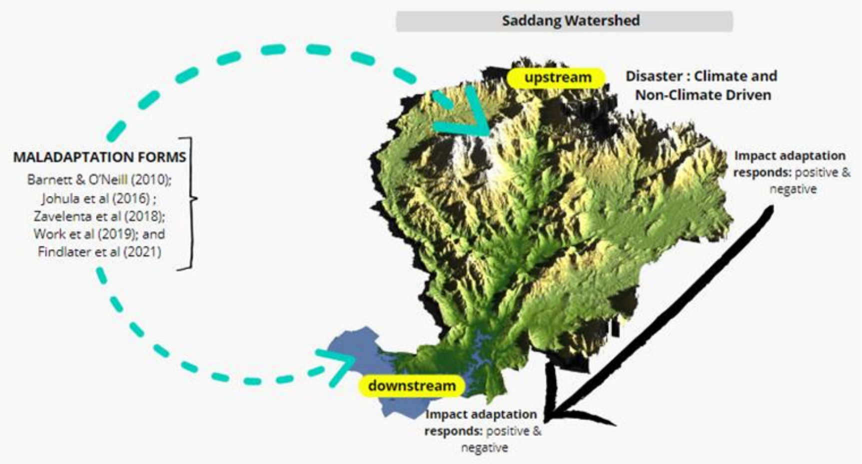


Figure 1. Theoretical Frameworks

In this regard, a theoretical framework is established to identify community's responses to the impacts of climate change and their relationship to watershed ecosystems, as watershed are areas that flow to the same place (Kerr, 2007). This could also be interpreted more widely to mean that, depending on what occurs upstream, watersheds can have positive or negative effects downstream. The purpose of watershed delineation is to strengthen the recognition of maladaptation that was absent or unexplored in earlier research, where the watershed landscape connects environmental/forest factors including water and human factors from upstream to downstream (Beasley et al., 1980; Kolok et al., 2009). The watershed approach is envisioned to provide a more comprehensive view of the effects of climate change adaptations, as it makes it simple to assess that the upstream adaptation response can have both positive and negative impacts on the region itself, as well as positive and negative impacts on the downstream region. The watershed affected by climate change encourages the community to adapt in their own way, both in the upstream and downstream areas. But apart from direct climate impacts, what happens in the downstream is also influenced by the accumulation of adaptation/maladaptation responses by the people in the upstream.

Furthermore, forms of maladaptation will be studied both in the upstream and downstream areas. Maladaptation is an action conducted with the intention of avoiding or reducing vulnerability to climate change that have negative effects on or enhance the vulnerability of community or in various aspect/sector (Barnett & O'Neill, 2010). The forms of maladaptation outcomes from several previous studies in 2003-2015 formulated in the form of rebounding vulnerability, shifting vulnerability, and eroding sustainability development (Juhola et al., 2016). The introduction of new tree species to combat climate change, which heightens susceptibility, exemplifies the concept of rebound vulnerability. One example of shifting vulnerability is the fact that new roads that can stand up to the effects of climate change will make new settlements more vulnerable in the future. Meanwhile, eroding sustainability development is exemplified by adaptation actions leading to increased GHG emissions and environmental degradation.

Several studies have pointed out examples of varied forms of maladaptation in several countries, such as Australia, in the form of increasing emissions of greenhouse gases, disproportionately burdening the most vulnerable, high opportunity cost, reduced incentive to adapt, and path dependency (Barnett & O'Neill, 2010; Neset et al., 2019). In the case of Melbourne's water, both the desalinisation and cross-basin water transfer plan projects will require a great deal of energy and generate a significant amount of greenhouse gas emissions. While, disproportionately burdening the most vulnerable is the pipeline project will impact disproportionally on poorer households in the form of higher water costs. High opportunity cost, as well as environmental and social impacts, on how Melbourne is resolving the water crisis at a lower cost, compared to planned pipeline and desalination projects. Whilst illustration for reduced incentive to adapt is by increasing unwarranted dependency on others, stimulating rent-seeking behavior, or penalizing early actors, then such practices are maladaptive. In the past, big infrastructure projects may have been successful, but in the future, relying on these methods could limit our ability to adapt to changes in climate, environment, economy, and society is an example of path dependent responses.

Maladaptation forms in Cambodia where conservation and reforestation programs are integral components of climate change policy in this nation, but fail to contribute in the slightest to climate change adaptation, and rather worsen problems in social and natural systems (Work et al., 2019). Maladaptation also will emerge from non-transformational adaptation initiatives that neglect to take into account the perspectives and priorities of indigenous peoples and how they might be included into national development policies included food interventions (Zavaleta et al., 2018).

A study in Malawi explained that rainfall projections used in plant growth models but not calibrated at the local scale will lead to reduced climate resilience, it demonstrates a type of technical failure of maladaptation (Findlater et al., 2022; Warnatzsch & Reay, 2020). Another instance of technical failure in the Republic of Kiribati, where they critiqued seawall building, particularly outside metropolitan areas, as an instance of maladaptation (Nunn et al., 2021). Furthermore, the most recent research also attempts to examine the sort of maladaptnation at British Columbia and Canada in forms of too-narrow framing of adaptation (Findlater et al., 2022), in which the adaptation framework is simplified to only one interest (forest). In contrary, adaptation entails safeguarding and enhancing essential forest values, such as the economic benefits of the forestry sector or the aesthetically, recreational, and spiritual benefits of the forest, which cannot be reduced to a single purpose.

To summarize, we will explore responses to climate change which is characterized by extreme weather in each village, upstream and downstream. The results of the identification will then be examined to establish whether there are positive or negative effects (maladaptation) generated from the responses, especially those related to land. These effects may cause further impacts, either on the upstream communities or on the downstream.

2.2 Methods

This research was conducted for six months, from July to December 2021, in the Saddang watershed which administratively covers four regencies. These regencies (in order from upstream to downstream) are North Toraja, Toraja, Enrekang and Pinrang Regencies. We focus on five villages that have experienced droughts and floods. In addition, these villages represent the upstream and downstream areas of the Saddang watershed, including Paku, Bokin, Randan Batu, Ranga, Paria, and Bababinanga (see in fig. 2). The upstream watershed is an area characterized by a sloping and hilly topography, a high density of tributaries and a source of water and erosion that flows into the main river. The downstream area of the watershed is an area characterized by a flatter topography and or slightly sloping, which is also a place for sediment deposits. The primary data of this study were obtained from observation and in-depth interviews. The in-depth interviews were conducted with 39 farmers, who are directly affected by drought and floods. The interview guide focused on two main topics, namely the identification of adaptation forms/efforts that have been/are being undertaken and the effects/changes these adaptation responses have had on the surrounding environment. The interview process was noted and recorded, and each question asked is an open question type about the main topic that occurred between 2009 and 2020. While observations are made to review land use conditions and topography including verifying data/information that has been collected previously, either from interviews or observations using satellite imagery and drones to see details of land cover (Naufal et al., 2022).

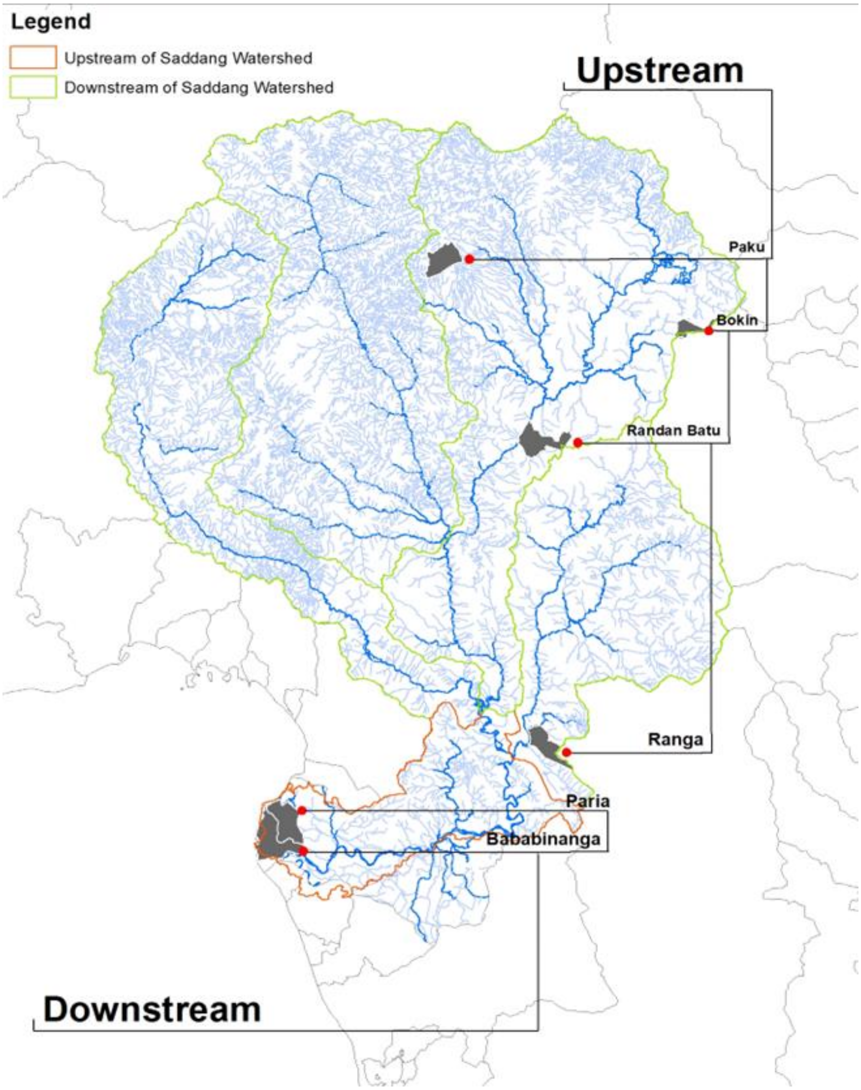


Figure 2. Villages of research location

Secondary data was obtained from analysis of satellite imagery to examine land cover changes as well as literature studies especially related to research on deforestation and climate change in the Saddang watershed. The spatial analysis on the medium and high-resolution images was carried out by digitizing their respective land uses change and shifts in river patterns caused by sedimentation, in 2009 and 2020. Furthermore, spatial analysis was also carried out by overlaying the land cover change with the slope level derived from DEMNAS (https://tanahair.indonesia.go.id/demnas).

3. RESULTS

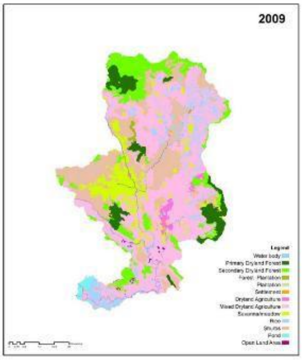
3.1 Condition of Saddang watershed

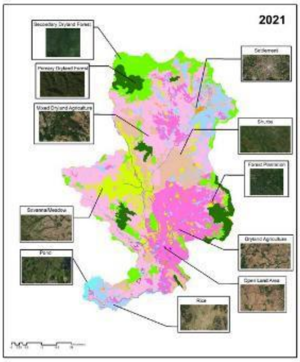
3.1.1 Non-climate driven

Land use is one of the factors that greatly affects the condition of a watershed, including the size of erosion in the area (Ristic et al., 2013). Because land use change that causes deforestation can produce and/or accelerate sedimentation downstream (Gharibreza et al., 2021; Kaushal & Binford, 1999; Restrepo et al., 2015). By analyzing the Landsat 7 & 8 images from 2009 to 2021, we found that land use change in the Saddang watershed have cause erosion and accelerate sedimentation especially in downstream areas.

Table 1. Landuse change on Saddang Watershed 2009 and 2021

SADDANG WATERSHED	2009	2021		Deviation (ha)
Downstream				
Water body	1458.45	1461.12	↑	2.67
Primary Dryland Forest	560.47	560.47	↑	0.004
Secondary Dryland Forest	6391.45	4374.99	↓	-2016.46
Plantation		220.28	↑	220.28
Settlement	224.04	816.77	↑	592.73
Dryland Agriculture	49.95	8170.09	↑	8120.14
Mixed Dryland Agriculture	25636.17	17514.78	↓	-8121.38
Savanna/meadow	82.04	242.74	↑	160.70
Rice	9291.78	9625.70	↑	333.92
Shrubs	5991.77	6659.00	↑	667.24
Pond	3506.33	3501.29	↓	-5.04
Open Land Area	452.70	497.91	↑	45.21
Upstream				
Water body	1444.70	1474.20	↑	29.50
Swamp Scrub		35.39	↑	35.39
Primary Dryland Forest	30471.55	29965.71	↓	-505.85
Secondary Dryland Forest	51624.62	54332.82	↑	2708.19
Forest Plantation	1467.23	104.68	↓	-1362.55
Plantation	401.63	401.63	↓	-0.001
Settlement	571.83	3170.60	↑	2598.77
Dryland Agriculture	5792.77	83629.96	↑	77837.18
Mixed Dryland Agriculture	173021.25	120926.35	↓	-52094.91
Savanna/meadow	41285.22	40555.06	↓	-730.16
Rice	21841.13	36948.78	↑	15107.65
Shrubs	103579.89	59650.87	↓	-43929.03
Open Land Area	474.51	780.31	↑	305.80





[Source: Image analysis results in 2009 and 2021]

From 2009 to 2021, the upstream areas experienced significant changes in land use. Mixed dry land agriculture areas dropped by 52,094 hectares, or 30.1%. Shrubs coverage decreased by 43,929 hectares, or 42.4%, and the forest plantings shrinked by 1,362 hectares, or 92.8%. Dry land farming is the small-scale agricultural practices that is typically conducted in the form of intercropping with several crops such as coffee, cocoa, shade trees, candlenut, sweet potato, cloves, peanuts and corn.

The decrease in this figure was converted into Dry Land Agriculture with a fantastic number, an increase of 13 times or an increase of 77,837 ha in 2021. Similarly, rice field areas also increased by 15,107 ha (69%) in 2021. This increase in dry land is dominated by corn which is still being cultivated to downstream areas. Meanwhile, the increase in rice fields in the upstream area is due to the construction of new irrigation networks, which are generally located near the main river network that flows downstream. Since the 2010's long drought in Ranga Village, an upstream village, rice fields have been completely abandoned due to the climate crisis, and all rice fields at that time were rainfed.

In the upstream Saddang watershed stated that between 1990-2000 the area did not experience deforestation (Putri, 2019). In the subsequent period of 2000-2010, however, the area experienced a significant deforestation increase of 3,413 ha. Meanwhile, in the 2010-2019 period, deforestation occurred around the area that was deforested in the previous period and expanded to a new upstream area on a flat to steep slope, which amount to 1,562 ha. The deforestation pattern illustrates the increasing level of connectedness in the period 2000-2010 and 2010-2019 (Putri, 2019). This incident is generally caused by forest land encroachment activities carried out for agriculture (Putri, 2019).

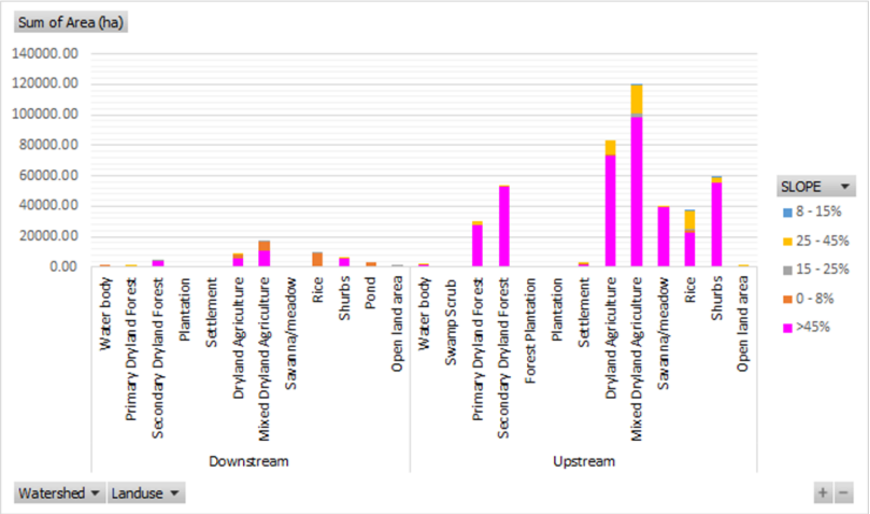


Figure 3. Land Use Comparison of slope class in 2021

Each land use in the slope class shows land conversion into dryland agriculture, which has a high erosion rate since the agricultural land is cultivated as monoculture and does not have shade plants (Rijal et al., 2021). This erosion is more severe because the conversion occurs in the upstream area which has a relatively steep topography. Land use in each slope class in the upstream area (figure 3) shows the dominance of dryland agriculture and mixed dryland agriculture on very steep slopes (>45%). With a total land use of 171,258 ha or covering 42.7% of the upstream area of the Saddang watershed, the topography is very steep. In addition to topographic conditions, we can also investigate climatic conditions to explain the sedimentation rate that occurs in the area (Jansen & Painter, 1974; Vanmaercke et al., 2011).

3.1.2 Climate driven

If we look at the graph below (see fig. 4), especially in the period between 2009 and 2010 there has been an increase in the average rainfall, to >300mm in 2010. This illustrates an increase in the average annual rainfall of above 50%. This condition had occurred 12 years earlier, namely in 1997 to 1998. The document also states that the average change in rainfall is in line with an increase in river discharge during the rainy season, by 8.56% in 2004 – 2013, indicating an increase in the potential for disasters due to surface runoff. While the decrease in river discharge in the dry season by 12.74% causes drought in the watershed, this is also stated by a male informant, Irawan (47). This is another climate driven hazard for the upstream villagers.

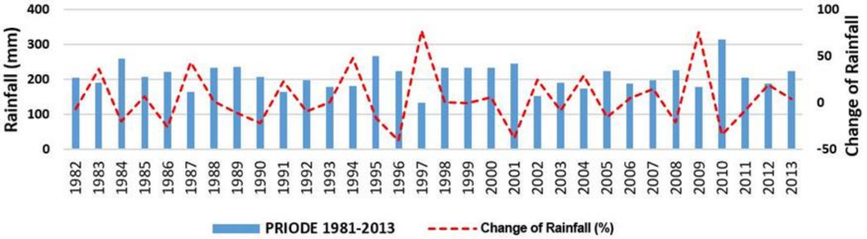


Figure 4. Change of Rainfall 1981-2013 at Saddang Watershed
[Source: Document Community Adaptation for Forest-Food Based Management in Saddang Watershed Ecosystem in https://www.adaptation-fund.org]

3.2 How maladaptation is formed on upstream Saddang watershed

3.2.1 The impact of climate change on upstream watershed coffee farmers

In 2009, almost all villages in the upstream of Saddang Watershed were affected by extreme weather, specifically the long dry season. The residents in the villages of Ranga, Randan Batu, Bokin, and Paku greatly felt this disturbance. This long drought has caused a widespread coffee crop failure. Apart from that, the rivers in the upstream area have become dry. This condition felt most severely dy the village of Rangga.

Table 2. Adaptation pattern on upstream watershed

No.	Villages	Adaptation Pattern	
		Before extreme condition	After extreme condition
1	Ranga	Coffee & Cocoa (mixed)	• Become migrant workers in Malaysia • Convert coffee groves to corn, cassava and cloves
2	Paku	Coffee	• Convert coffee fields to corn, cassava and vegetables • Clear new lands for coffee
3	Bokin	Coffee	• Convert to clove • Keep working on coffee
4	Randan Batu	Coffee	• Build houses using materials available around the village • Buy and raise goats

[Source: primary data analysis (2021)]

The crisis got worse when the long dry season triggered a large forest and land fire in Paku Village. As many as 4,900 coffee plants ready for harvest were burned to the ground along with a resident's house in Paku village. In addition, Irawan (47) also felt that during this period (2009), monkey and wild boar attacks increased drastically, invading the community's croplands. This illustrates how severe the impact of the drought was at that time. This crisis then encourages coffee farmers to adapt in various ways, especially by switching to drought-resistant commodities. The following is the adaptation response to the impact of the drought that occurred in four villages that are located in the upstream of the Saddang Watershed.

Although some of the farmers interviewed in Ranga Village have tried other alternatives, such as Baharuddin (50) and Abd Hamid (36) who migrated to Malaysia, more people were converting their coffee and cocoa crops into corn, cassava, cloves and vegetables. However, conversion to corn is the most massively developed because the seeds are easily accessible, and farmer obtained a lot of information that cultivating corn is quite easy and profitable. More importantly, corn is considered to be more drought-resistant than other commodities and can be harvested within 3-4 months. The easy access to information related to corn also greatly facilitated by the government's corn development program in the form of seed and fertilizer assistance starting in 2010 and is still running today. The Regulation of the Minister of Agriculture No. 15/Permentan/Rc.110/1/2010 stated that for the next five years (2010-2014), Indonesia should achieve sustainable self-sufficiency in corn production, targeting a production of 29 million tons in 2014, which means the target is to increase production by an average of 10% per year. Ironically, the vast majority of maize that is now being planted in the Saddang watershed is for livestock feed, meaning it cannot be used as an alternative food source during economic crises or natural catastrophes.

A small number of farmers are sticking to the remaining coffee, such as Kawa (50) and Komba (41). As a response to the drought, farmers who still depend on coffee do so by clearing new lands which are considered suitable for coffee. Although the clearing is very closely related to previous theories which explain that shifting cultivation occurs due to reduced soil nutrients, traditional systems, land scarcity and topographical factors (Angelsen, 1995; Kuotsuo et al., 2014; Mertz, 2009), we see that in this case it occurred due to a response to the impacts of climate change and the shift is not cyclical but permanent. The response is also strongly influenced by the remaining capital resources (savings, land), and external influences that came at that time such as the corn seed assistance program for national food security, however, it as one of the underlying reasons of maladaptation (Zavaleta et al., 2018).

This massive adaptation response to the effects of drought has become one of the main factors triggering quite drastic changes in land use or deforestation in the period between 2009 to 2020. Interestingly, the upstream farmers' timing in adapting came together with the incessant government and private sectors' efforts in the development of corn cultivation. As a result, the economy has thrived to date with seed assistance, processing factories, fertilizers, and collecting traders. However, the massive commodity shift from coffee to maize has a greater detrimental impact on the environment since it requires more chemical fertilizer input and less able to prevent erosion relative to coffee groves, which historically grown without fertilizer and require shade trees.

The adaptation response of seeking alternative to drought-resistant crops, combined with the government and private sector's massive promotion of corn cultivation, has push for changes in land use (non-climate driven), which trigger additional impacts because corn is planted in steep hill areas. In 2020, three consecutive days of severe rainfall prompted landslides in Putu hamlet in Randan Batu Village. In addition to destroying three houses and croplands, the landslide also claimed the life of a 45-year-old homeowner. The three families of the landslide victims escaped to the school while others constructed makeshift shelters. The family then constructed a habitable home within four to six months using wood gathered from the surrounding area. Agustina Dudung (49), a member of one of three families, was compelled to build her home near the landslide site since she possessed no other land.

3.2.2 Maladaptation effect in the downstream

After a long drought in the upstream in 2009, farmers slowly stopped growing coffee and instead started growing corn, and this drastically changing mixed farming practices to monoculture. This also slowly increases the occurrence of erosion and increases the sedimentation in downstream areas. Sedimentation, which increased dramatically after 2009 through the Saddang tributary that flows into Paria village, has continued to the present day, with the river flow completely diverted in 2020 as the sedimentation grew to form new land (see fig. 5). In fact, if we look at the river areas close to the coast, there is still stream, but the it is no longer connected to the main river, which drains water from the upstream. The stream water comes from incoming sea water because there is no more upstream water flow due to sedimentation.

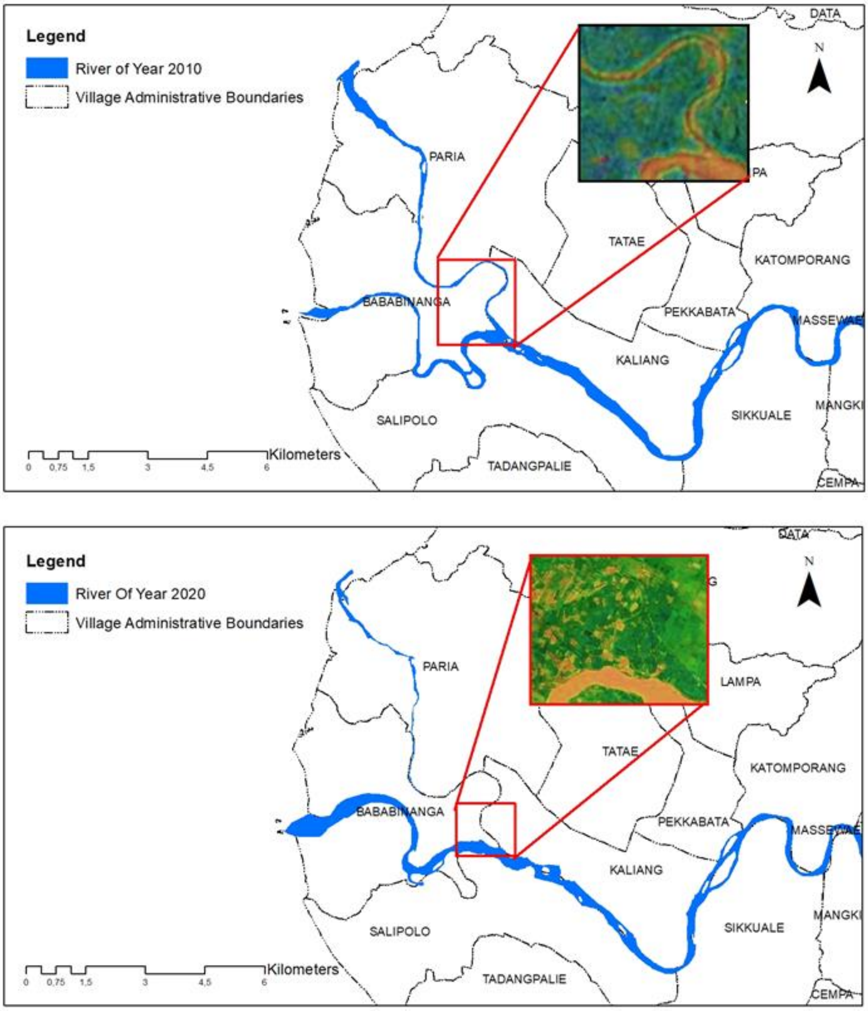


Figure 5. Comparison of rivers in Paria and Bababinanga villages in 2009 and 2020 at the Downstream Saddang River Basin

The closure of the river that flow to Paria village makes the river flow to Bababinanga village bigger than in previous years. In addition, with increasing rainfall that falls on the Saddang River Basin (see fig. 5) increase the incoming water discharge, with the increased sedimentation, the river become wider in Bababinanga. In 2010 the worst flood occurred in Bababinanga and Paria villages, the flood came from the overflowing water discharge from the Saddang River. Regional Disaster Management Agency of Pinrang Regency (2011) noted that there were 105 families affected by the flood that occurred at that time. In addition, 233 houses were submerged, 600 ha of croplands and 400 ha of ponds were damaged due to flooding. Already in this period, the impact of the flood to Bababinanga village is felt more severely than the Paria village, since the tributaries that flow into Paria village have started to narrow due to sedimentation.

The sedimentation process that has been going on for a long time has develop floodplains, raises bars in the middle of the river and formed natural levees that completely block the stream that flow to Paria. Although the 'emerged land' from the deposit that form the floodplains has the potential to cause land conflict, the local tradition has established that the 'emerged land' will be owned by the land owner adjacent to it. In addition to local knowledge, a decree of the Minister of State for Agrarian Affairs/National Land Agency in 1996 regarding controlling the status of 'emerged land' and land reclamation also confirmed this.

The adaptation pattern of most residents in Babinanga who experienced damage to their ponds was dominated by those who changed professions to become a fisherman for cathing baby shrimp 'rebon', and a small number became farmers working in other villages. Meanwhile, residents who have sufficient capital at the time of the flood have moved and live in the city. The structure of houses and schools (on stilts) in Bababingga is also a form of adaptation to flooding, which indicate that this is not the first time a flood has occurred in Bababinga. When the river water flows very fast and erodes the soil along the riverbanks, the houses in the area are moved by simply lifting them up to safer locations. However, the locals revealed that the 2010's flood was the worst have ever experienced.

Policy advocacy conducted in 2011 by the affected villages demanded the members of the regency parliament that a post-flood rehabilitation program should be carried out. This effort bore fruit in 2013, the government started to build embankment construction and the installation of elephant stones on the banks of the river to prevent flooding. But the infrastructure has started to break down two years after (2015). This case represents another form of maladaptation, namely technical failure (Findlater et al., 2022; Nunn et al., 2021; Warnatzsch & Reay, 2020).

Meanwhile, in Paria Village, those who were used to be fishermen, due to the availability of land that recently emerged from the floodplains, are now cultivating corn and bananas in their new croplands. Bananas are considered to be able to survive quite well in water, and corn is seen as a good source of income. In addition, if there is a flood, corn can still be harvested because "they can still standing" at the time of the flood, which is different from rice that are common crops in the surrounding areas.

The change from pond farmers to fishermen in Bababinanga and from fishermen to farmers in Paria illustrate adaptation responses to shifting flood disasters. The shifting of the flood location is caused by accumulation of sedimentation, a negative impact brought by the maladaptation in the upstream areas. Each of these regions has a different way of adapting, and further study needs to be conducted to establish wether the adaptation in downstream villages will have a negative impact on themselves or other places.

4. DISCUSSION

Applying a watershed approach, the forms of maladaptation as rebounding and shifting vulnerabilities, as well as degrading sustainable development (Juhola et al., 2016) become more comprehensive and complex. We find that the adaptive response to extreme droughts in upstream villages makes the area more vulnerable to other hazards, such as landslides, which can be described as an example of rebounding vulnerability and eroding sustainable development. However, we found that this response also causes an increase in vulnerability downstream from the shift in flood susceptibility. Due to an increase in the rate of erosion from changes in land cover, it has triggered an increase in sedimentation downstream which has closed one of the river basins. This moved the flooded area to another village. In short, this research reveals a layered and simultaneous impact from upstream to downstream, which may also help it to evaluate whether maladaptation results from an adaptation activity or a maladaptive process.

The drought that occurred in the Upper Saddang Watershed area caused crop failures, triggered forest fires, and prompting people to switch to other commodities. The commodity that is available to the upland farmers, such as corn, is both economically promising and capable of surviving in dry conditions. Although there were several alternatives at that time, such as sweet potatoes, they were shortlived due to pests. Corn continues to grow because the private sector plays an active role in providing the seeds, industry as well as the market channels. Additionally, the government support the corn through food security programs, including the expansion of food crops in forest areas (Zakaria A, 2011). Corn is currently very popular among the farmers, upstream and downstream of Saddang watershed, and cultivated solely for industrial poultry farms. This case shows a combination of maladaptation forms, namely the inability of persons and communities to adjust to environmental or economic instability (Work et al., 2019) and deepened deforestation by governmental social and food interventions (Zavaleta et al., 2018).

Findlater et al (2021) describe examples of technical failures in their research where efforts by governments, scientists and private sectors that are difficult or fail to predict climatic conditions for certain types of seeds and specific planting locations can cause greater losses. It is the crossroads between scientific uncertainty and overconfidence. Meanwhile, our finding may be more technical, where adaptation responses in the upstream villages with steep slopes is done by converting a mixture of coffee and cocoa groves into large tracts of corn monoculture farms. We notice that while farmers are attempting to escape the problems caused by climate change, the government and private sector have played a significant role in this corn expansion. This demonstrates a lack of understanding of distinctions in geographical settings: simplifying the adaptation framework by looking only at one goal that will have an impact on deforestation of natural resources and an increase in greenhouse gases (Barnett & O'Neill, 2010; Findlater et al., 2022; Zavaleta et al., 2018). This can be seen from the massive food related state programs, which in this case ironically supporting the corn production mainly for poultry farms. Regardless of topography and watershed conditions coffee agroforestry cover in the upstream areas quickly turned into corn farms. Moreover, while the previous coffee plantations were cultivated without fertilizers, the current corn farms are depended on chemical fertilizers.

Furthermore, the farmers depend on the crop since they are considered more adaptive to drought conditions. When crop failures are repeated and last for a long time, farmers are encouraged to look for alternative crops that are more drought-resistant, provide fast return, easier to work with and comparably profitable. At the same time, easy access to state subsidized seeds and relatively stable commodity markets for the harvest help to support the trend. As a result, dominating monocrop on steep lands create croplands that are more vulnerable to the impacts of climate change, which then results in extreme sedimentation downstream. The increase in greenhouse gases does not only come from land clearing through burning, but also from the use of fertilizers that are increasing massively compared to the previous periods when they cultivate coffee. This response is also a form of inability to adapt to environmental or economic instability (Work et al., 2019). Changes in land use during the drought period increased significantly on a broad scale, and accordingly in recent past years, an increase in sedimentation in the area downstream altered the river's flow, which among others resulted in the relocation of villages that are frequently impacted by flooding.

In addition, the adaptation that occurs in the downstream is a response to floodings caused by growing sedimentation that create 'emerged land' and completely diminish important stream (i.e., deverting the river flow). These are closely related to maladaptation in the upper watershed areas. The adaptation process in the upstream indirectly increases the vulnerability of the people in the downstream areas due to high sedimentation which then creates a shifting vulnerability, namely by moving flood-prone areas from one village to another.

However, maladaptation also has a positive follow-up impact from an economic perspective, for example the formation of 'emerged land' which is then used as productive cropland by the local farmers, and sand mining activities in the Saddang River. The downstream adaptation response comes from the accumulation of maladaptation and the direct impacts of climate change.

5. CONCLUSION

Deforestation can occur as a form of adaptation climate change outcome. This is illustrated by the adaptation response in the upstream of the Sadang watershed which was affected by a long drought. Along with the need of the farmers to deal with the drought that created a crisis for the coffee as their main cash crop, the government and the private sector came up with the corn as a solution, which has become a catalyst for major changes in land use during the period after 2009. Hence proved a massive maladaptation has taken place in the Saddang upstream, facilitated by the food security program. A large-scale corn production is applied uniformly to all sites, it has a negligible effect on watershed sustainability, and even worse, makes upstream regions more vulnerable and causes new problems downstream.

Moreover, these conditions impair the upstream region and promote vulnerability, particularly for those who cultivate on steep areas (rebound vulnerability). This also makes downstream areas more susceptible to flooding owing to deposit accumulation and heavy precipitation (increased vulnerability). The impact of upstream maladaptation has prompted downstream communities to adjust to the shifting flooding locations, because sedimentation alters the river flow and bring potential hazards to more villages. From flood-prone places near the river in Paria village, currently relocating to Bababinanga village (shifting vulnerability).

We believe that, when compared to other forms of maladaptation, using the watershed approach will allow to more conveniently explain and check forms of maladaptation such as shifting vulnerability, increased vulnerability, rebound vulnerability, eroding sustainable development, and technical failure, because there are upstream and downstream connections. Although it may require a while to observe the impact, it is cumulative.

There are positive impacts downstream due to maladaptation in the upstream such as the emergence of floodplains which is used for farming, and increasing mutual cooperation in moving residents' houses along the river banks. Unfortunately, even though the emerged land appeared to be turned into cropland, policy instruments and local tradition did not accommodate the people who actually lost their land/houses as a result of this newly emerged land. Therefore, further study is needed to investigate more deeply into the potential of downstream maladaptation. Furthermore, based on this research process, the researcher also believes that further research related to maladaptation identification using remote sensing should be developed.

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