International Journal of Environmental Impacts
Vol. 7, No. 4, December, 2024, pp. 769-780
Journal homepage: http://iieta.org/journals/ijei

Policy Analysis for Handling Environmental Damage based on Disaster Mitigation in Nagari Air Dingin, Solok Regency

Zikri Alhadi*, Agid Rahman, Rahmadani Yusran, Yuliarti

Department of Public Administration & Research Center for Policy, Governance, Development & Empowerment, Universitas Negeri Padang, Padang 25132, Indonesia

Corresponding Author Email: zikrialhadi@fis.unp.ac.id

https://doi.org/10.18280/ijei.070417

Received: 17 October 2024
Revised: 1 December 2024
Accepted: 9 December 2024
Available online: 31 December 2024

Keywords:
environmental damage, disaster mitigation, policy analysis, Indonesia

ABSTRACT

This research is motivated by seeing that mining activities in Nagari Air Dingin, Solok Regency, Indonesia, have increased the risk of floods and landslides, causing deforestation, thereby eliminating the function of forests in preventing disasters. For this reason, the research aims to explain the dynamics of disaster management policies for environmental damage that results in disasters in the region. This research uses a qualitative approach with descriptive methods, and data collection is carried out through interviews, observation and documentation studies. The main findings of this research explain that environmental damage management policies in the area have been carried out by related parties, including rehabilitation and preservation of forest vegetation, as well as community participation through village "restoration" through coffee plants. Second, supervision of land use for mining: supervision of environmental permits for mining activities and regulation of illegal mining. Furthermore, the findings of this research also explain policy obstacles that focus on three aspects, namely weak law enforcement regarding land used for mining. Second, there is a lack of knowledge and community apathy regarding environmental management that has not been implemented, as well as the rehabilitation of forests and land whose functions have been damaged. Meanwhile, the significance of this research is that it provides benefits in environmental management policies to prevent disasters both theoretically and practically.

1. INTRODUCTION

Community involvement in forest vegetation rehabilitation and conservation not only increases the effectiveness of forest conservation [1-3] but also strengthens the relationship between humans and the environment, ensures good forest function [4-6], and maintains forests as valuable resources for future generations [7-9]. Sustainable forest rehabilitation helps repair environmental damage and reduce disaster risks [10-13]. The focus of rehabilitation is to restore forest ecosystems damaged by human activities [14-16], such as land clearing and uncontrolled logging, by planting various plants to restore their ecological functions. Meanwhile, conservation focuses on protecting and maintaining ecosystem functions that are still good or have been rehabilitated [17-19], including monitoring illegal logging through regulations and law enforcement.

Nagari Air Dingin, which has critical forest land due to utilisation for plantations and mining, is a crucial area. Local communities have shown environmental concern by initiating rehabilitation by planting Arabica coffee, a hereditary tradition and by land conditions (altitude 1500 masl). Coffee cultivation, driven by market demand and its impact on the local economy, uses an agroforestry system that integrates ground support trees with cultivated plants.

The results of interviews with informants regarding human factors influencing disasters in Nagari Air Dingin indicate that several problems related to irresponsible land use for plantations and agriculture exist in the community. Based on informants' statements, local people often ignore land suitability for irresponsible use for plantations. Examples include farming on steep slopes (45-60 degrees), changing land without rehabilitation, and changing land use from rice fields to commodity plantations such as onions and chilies. However, the plantation sector remains important to the local economy and livelihoods. Human activities that influence the potential for flooding and landslides in Nagari Air Dingin, Solok Regency, include uncontrolled C mining. Mining in this area includes taking rocks, gravel, and sand.

Mining activities in Nagari Air Dingin increase the risk of flooding and landslides. Mining activities cause deforestation, which eliminates the function of the forest in preventing disasters. The West Sumatra Environmental Forum also linked the flood and landslide disasters in Nagari Air Dingin, Solok Regency, to C Mining activities, especially in Jorong Kayu Aro. Mining by a company is in a steep, hilly area, only 100 meters from residential areas. This exacerbates the risk of disasters threatening life and damaging homes and public facilities such as roads.

Figure 1. One of the open mines in the Nagari Air Dining area

Figure 1 shows open-pit mining activities in the Air Dingin hilly area, located on the edge of the national highway connecting West Sumatra Province and Jambi Province. Previous studies have shown that open-pit mining can damage the environment, including losing vegetation, flora, fauna, and soil layers. In fact, in May 2021, a landslide hit Nagari Air Dingin due to heavy rain, especially at five points near the C Mining location. The landslide completely closed the national highway, cutting off access to the road. There are so many losses due to environmental damage that result in disasters and disrupt the socio-economic activities of the community. For the reasons above, this study aims to explain the policy for handling environmental damage that impacts disasters in Nagari Air Dingin, Solok Regency, Indonesia. The study will assess the implementation of relevant policies and make recommendations for improvement. The study results will provide decision support to policymakers to reduce future disaster risks and promote sustainable development

2. LITERATURE REVIEW

The analysis reveals that fragmented policy and regulatory frameworks in Japan hinder effective disaster risk reduction and management, particularly in the context of unsustainable development practices. The 2021 Atami mudslide disaster exemplifies how inadequate oversight of land use and construction practices can exacerbate environmental hazards, leading to significant displacement. The legacy of post-war developmentalism contributes to these governance challenges, highlighting the need for integrated approaches that align territorial development with disaster risk management to mitigate future environmental damage and displacement risks [20]. This paper provides conceptual reinforcement for this research, especially how effective disaster risk reduction and management policies must be followed by good supervision in their implementation.

The review highlights the urgent need for effective hazard management strategies to mitigate the adverse impacts of hazardous wastes, which can lead to environmental disasters. It emphasizes that government and individual-level policies are crucial in addressing the causes and effects of waste production. Various countries are implementing tailored management approaches based on their resources, aiming to prevent the depletion of natural resources while ensuring environmental sustainability. The paper underscores the importance of knowledge and awareness in developing these policies to combat the escalating pollution and its detrimental effects on living organisms [21]. This paper contributes to this research by stating that sustainable environmental management policies require resources that are appropriate to the impacts to be faced.

The paper highlights the significant relationship between disaster events and the management of waste generated, emphasising that inadequate handling policies can exacerbate environmental injustice. It reveals that the spatial distribution of landfills is disproportionately concentrated in economically disadvantaged areas, particularly affecting minority populations and families led by women. This inequitable distribution suggests that existing policies may fail to address the needs of vulnerable communities, leading to increased environmental damage and challenges in recovery following disasters. The findings advocate for improved policy frameworks considering spatial inequalities in waste management and disaster response [22]. These findings illustrate that inadequate policies for dealing with environmental damage can lead to injustice both socially, economically and environmentally.

The study highlights the need for improved disaster risk management policies in Balikpapan, particularly regarding hazardous materials. It emphasises the importance of educating competent hazmat responders, ensuring adequate spill response equipment, and implementing extensive environmental monitoring. The analysis indicates that the mining, energy, and oil and gas sectors contribute significantly to disaster risks, necessitating targeted policies to mitigate environmental damage. Effective communication and coordination among industries and government are crucial for handling disasters and minimising their impact on public health and ecosystems [23]. These findings provide conceptual reinforcement that disaster management policies require effective communication and coordination between all stakeholders.

The paper emphasises the need for policymakers to consider long-term consequences when addressing environmental crises, as urgent decisions can lead to policy errors that exacerbate disasters. It advocates for a decision platform that includes diverse stakeholders to enhance critical questioning and avoid defensive heuristics. By structuring decision-making around future scenarios, the platform encourages innovative framing of problems, which can mitigate the risk of repeating past mistakes and improve the handling of environmental damage. This approach is rooted in urban experimentation, suggesting a low barrier to implementation in various contexts [24]. This article explains that innovation is needed to reduce the risk of disasters and prevent past mistakes from happening again in the future.

The paper identifies a gap in policies addressing mobility related to climate change, particularly in the context of slow-onset environmental degradation. It highlights that existing policies often overlook the need for proactive measures to facilitate migration as an adaptation strategy, viewing it instead as a last resort. This lack of comprehensive policy can exacerbate vulnerabilities, especially in regions facing severe environmental threats, leading to inadequate responses to disasters. The analysis suggests that effectively handling environmental damage requires integrating mobility into policy frameworks to enhance resilience and reduce disaster risks [25]. These findings contribute to the importance of proactive actions and policies in preventing environmental damage.

The article discusses how disasters can catalyse transformative policy changes, particularly in the context of environmental damage. It highlights the dynamics of institutional crises, policy subsystems, and governance capacity that influence how societies respond to disasters. By examining the interplay between agenda-setting, issue salience, and policy-oriented learning, the paper suggests that effective handling of environmental damage can lead to significant shifts in policy aimed at sustainability and resilience. Future research priorities are identified further to explore these relationships in disaster contexts [26]. This paper illustrates the importance of encouraging transformative policies in overcoming environmental damage.

The paper emphasises the necessity for structured damage and loss data management systems to enhance disaster risk reduction and climate change adaptation policies. Effective environmental damage handling requires accurate, comparable, and consistent data across different regions and timeframes. The LODE project aims to address these needs by developing an Information System that facilitates multisectoral damage estimation, ensuring that environmental impacts are systematically recorded and analysed. This will ultimately inform better policy decisions and improve resilience against future disasters [27]. This article contributes to strengthening accurate data-based disaster management policies to reduce environmental damage more effectively.

3. METHODS

This study uses a qualitative approach with a descriptive method. The research location is where the research was conducted and the main data source was obtained. This study uses primary and secondary data. Data was collected in various ways that were adjusted to the desired information, using data collection techniques through interviews, observations, and document studies.

Observations are made on research objects related to data needs to provide comparisons to research findings. Observations are made by the researcher himself by visiting the locus of the research object.

The determination of informants in this study used a purposive sampling technique. This technique is expected to produce the right informants to make the data obtained credible. Interviews with informants were conducted in a semi-structured format.

Based on the description above, the informants in this study included officials or functional staff from the Regional Disaster Management Agency of Solok Regency, as well as representatives from several related agencies responsible for disaster management. Additionally, disaster experts, activists, the Nagari Air Dingin apparatus, and members of the Nagari Air Dingin community were also involved as informants. Table 1 provides a detailed list of the informants in this study.

Table 1. Research informants

No.	Institution
1	Regional Disaster Management Agency of Solok Regency
2	Environmental Service of Solok Regency
3	Public Works Service of Solok Regency
4	Disaster Expert
5	Mining Company
6	Local Government Apparatus
7	Publics

Source triangulation and method triangulation were used to test the validity of the data in this study and can be scientifically justified.

4. RESULTS AND DISCUSSION

4.1 Rehabilitation and conservation of forest vegetation through community participation

One of the causes of floods and landslides in Nagari Air Dingin, Solok Regency, is the loss of forest land function, allegedly due to irresponsible use by the community for the development of passion fruit commodities. As a result, forest land becomes bare and dry. To overcome this problem, mitigation efforts were made in the form of forest function rehabilitation initiated by some local communities. Based on the results of observations and documentation studies, some residents have begun environmental rehabilitation by planting and developing Arabica coffee cultivation. This hereditary tradition is driven by land conditions (altitude 1500 meters above sea level) and increasing market demand, which also affects the community's economy. Efforts to rehabilitate forest land through planting coffee with an agroforestry system (integrating soil support trees with cultivated plants) are led by a native resident and Chairman of the Solok Radjo Cooperative in Lembah Gumanti District, as a response to the threat of disaster due to environmental damage. Then, to expand efforts to restore damaged forests and support the local economy, most coffee farmers who are members of the Solok Radjo Cooperative have applied for permits to manage customary forests and Nagari forests. The Ministry of Environment and Forestry has handed over the management rights for 3,200 hectares of customary forests in Lembah Gumanti. At the same time, local customary leaders have also granted management rights for Nagari forests. These efforts to restore nature have finally yielded positive results.

Efforts to improve forest function with (rehabilitation) are very important to be carried out to reduce the potential for flooding and landslides in Nagari Air Dingin, Lembah Gumanti District, considering that much of the land in the area is already critical because it has been used irresponsibly after being unproductive, especially in the plantation and mining sectors. Seeing the portrait of the development of coffee cultivation with an agroforestry system in the Air Dingin area, precisely in Solok Radjo, it is hoped that there will be environmental changes for the better, the return of forest functions to reduce the potential for disasters.

Regarding the extent of the development of coffee cultivation in Nagari Air Dingin and its influence on land improvement, coffee plant cultivation is only carried out by the community in Solok Radjo, part of Nagari Air Dingin, which is a highland area. Meanwhile, the area has varied topography, and the community in the lowlands uses the land for mining and plantations, even in sloping areas, and carries out land conversion (not paying attention to land suitability). In addition, coffee cultivation will continue to develop according to market demand. Its influence on land improvement is not too great because the rehabilitated land is still smaller than the critical land in the area.

Therefore, it can be concluded that a small part of the local community has shown concern for the environment by taking the initiative to cultivate coffee to rehabilitate the forest and as an economic supporter. Researchers assume that the

involvement of the community or community in the process of rehabilitating and conserving forest vegetation increases the effectiveness of these conservation efforts and strengthens the relationship between humans and the environment. This ensures that forests that continue to function well will help prevent disasters [28-33] and maintain forests as valuable resources for future generations [34-38].

4.2 Supervision of land use and environmental permits for class C mining

Based on data from the Central Statistics Agency in the Solok Regency Document in Figures 2023, The mining and quarrying sector is one of the business fields that contributes greatly to the Gross Regional Domestic Product **(**GRDP) of Solok Regency and has developed from year to year. In 2021, this sector contributed 5.20% to the GRDP, increasing to 5.40% in 2022 and reaching 5.55% in 2023. One of the areas with great mining potential is Nagari Air Dingin, Lembah Gumanti District. The following presents data on the Mining Business Permit Areas of legal mining companies operating in the Nagari Air Dingin area, which can be seen in the Table 2.

Based on Table 2, it is known that several Jurong areas in Nagari Air Dingin, namely Jorong Data, Cubadak, and Kayu Aro, have content of rock commodities such as sandstone (situ), gravel, and limestone (type C excavation). 5 (five) companies have the right to use mining business permit land, with different areas, the highest reaching tens of hectares. On the other hand, the cause of the massive flood and landslide disasters in the Nagari Air Dingin area of Solok Regency cannot be separated from the increasingly rampant C mining activities. In addition, mining activities in the region are indicated to be carrying out illegal mining and have negative implications for the environment. Mining activities that exist, whether they have permits or not, in Nagari Air Dingin are the main cause of floods and landslides. Large-scale clearing of forest land has resulted in the loss of forest function, contributing to the disaster. Then, illegal mining activities in Nagari Air Dingin, carried out by some local people, impact environmental damage. An Environmental Service of Solok Regency audit revealed that mining was carried out using methods that did not meet standards; the community utilised river water flow, causing river water pollution and damage to its ecosystem. The illegal mining community digs sand or rocks by taking water from the river using tools. The water is directed (at a certain speed) to the cliff wall of the sand excavation. The sand (excavation results) that falls in the tamping and is washed in a box near the river, then the washing water from the excavation is thrown away and flows back into the river water so that it pollutes the water or pollutes the river water. In addition, illegal mining activities are often carried out around mining areas with IUPs, giving the impression that companies with these permits do not make adequate environmental management efforts.

Table 2. Data on mining business permit areas of mining companies (legal) in Nagari Air Dingin, Lembah Gumanti District, Solok Regency

No.	Company Name	Mine Location	Commodity	Area (Ha)	No WIUP
1	Zila Jaya Nusantara	Jorong Data	Rock (Limestone)	10	1113025442021002
2	Damiri	Jorong Data	Rock (Limestone)	118	2113025442020220
3	Kuansing Mineral Sejahtera	Air Dingin	Rocks (sand and stones)	-	1113025402021002
4	Lembah Jaya	Jorong Cubadak	Batuan Rocks (Natural Large Gravel)	5	1113025402021003
5	YELM	Jorong Kayu Aro	Rock (Limestone)	5	2113025442020015

Source: Ministry of energy and minerals, 2023

Documentation studies show that many parties are concerned about the negative impacts of mining activities in Nagari Air Dingin, which is also a public concern. In addition to endangering people's lives when a disaster occurs, severe damage to the national highway connecting the provinces of West Sumatra and Jambi also occurs. The flow of mine water that leads to the road increases the risk for drivers. Researchers assess that the threat of floods, landslides, and damage to the national highway in the Air Dingin area, Solok Regency, requires serious attention from the West Sumatra Provincial Government, Solok Regency Government, and related agencies and law enforcement officers (according to their authority). The handling includes monitoring mining activities in Nagari Air Dingin as a disaster mitigation measure and repairing badly damaged roads.

Based on the documentation study, the Padang Legal Aid Institute assessed that the response of the West Sumatra Provincial Government, Solok Regency, and law enforcement officers was still not firm enough in enforcing the law against Galian C mining activities that allegedly triggered disasters and damaged the National Road in Nagari Air Dingin, Solok Regency. Following public complaints and inadequate actions by the local government, the Padang Legal Aid Institute warned relevant officials, including the Governor of West Sumatra, the Head of the National Road Management Agency, and the Regent of Solok, to take legal enforcement steps. The warning requested the revocation of permits for mining companies that did not meet environmental management standards and coordination with the West Sumatra Regional Police to handle damage caused by illegal mining. In addition, NGO WALHI, together with environmental activists, academics, and several other parties, urged the local government and national institutions to permanently stop all mining activities in Air Dingin, demand accountability for mining actors for environmental restoration, and enforce the law related to environmental violations (crimes), mining, and disasters. The actions that they are taking are that the government has the authority to take firm steps in addressing environmental problems that have the potential to cause disasters due to mining activities. For legal mining activities, the government must conduct a comprehensive evaluation of the licensing administration, including environmental documents, and revoke permits if necessary. Meanwhile, law enforcement officers can follow up on illegal mining activities by Law Number 32 of 2009 concerning the Environment, Article 1, paragraph 2, which regulates systematic efforts to preserve environmental functions and prevent pollution.

In addition, Law Number 3 of 2020 concerning Mineral and Coal Mining, Article 158, threatens those who mine without a permit with a sentence of 5 years in prison and a fine of IDR 100,000,000,000 (one hundred billion rupiah). Therefore,

strict action against illegal mining actors should be implemented. Seeing the efforts or actions that the local government has taken regarding handling mining problems in Nagari Air Dingin, efforts to supervise mining activities/businesses in Nagari Air Dingin, the Solok Regency Environmental Service in 2021 had disciplined mining, one of which was the Abdel Hanif Company because community reports and audit results showed that mining activities were damaging the environment and threatening the safety of the surrounding community. Miners did not fulfill their commitments in environmental documents. However, after the transfer of authority to the West Sumatra Provincial Government, the Environmental Service of Solok Regency can now only report (convey, voice) community complaints to relevant agencies at the provincial level regarding environmental damage due to mining activities.

In the implementation of the regulation above, it can be explained that there are obstacles to this policy because of the transfer of authority from the Solok Regency Government to the West Sumatra Provincial Government. When there is a report from the community regarding illegal mining activities that damage the environment, the local government does not have the authority to follow up with law enforcement efforts. Local institutions can only forward the report to the provincial government for follow-up. In practice, good governance will lengthen the bureaucratic chain in public services, especially in the environmental sector. So, the effectiveness of this policy will be difficult to achieve.

Based on a documentation study, the West Sumatra Provincial Government in April 2024 closed the operations of three mining companies in Air Dingin, Solok Regency, which is close to the national highway. The three companies, including the Bukit Villa Putri Company, the Sirtu Air Dingin Company, and the Putra YLM Company, were closed because they did not fulfill their environmental management obligations. This closure was carried out based on the recommendation of the West Sumatra Regional Mining Inspector after a coordination meeting on March 28, 2024, involving various agencies, including the Energy and Mineral Resources Service, the Environmental Service, the Capital Investment Service, the Public Works Service, the Ministry of Energy, and the National Road Management Agency. This step was also taken after the Governor of West Sumatra and the National Road Management Agency conducted a survey and found illegal mining activities in Nagari Air Dingin. The Solok Regency Government, supported by the West Sumatra Provincial Government, agreed to handle illegal mining managed by the local community. Then, the Solok Regency Government, together with the police, conducted an inspection in Nagari Air Dingin to handle community complaints about the negative impacts of mining activities, such as the risk of disasters and damage to the national highway. The Solok Regency Environmental Agency audit showed that four mining companies did not comply with recommendations regarding the construction of drainage and control tanks to regulate water flow to the road. Therefore, the Solok Regency Government is committed to conducting a comprehensive evaluation of the mine owners in the area.

The Solok Regency government apparatus will temporarily close all mining activities (both from official companies and illegal mining) in Nagari Air Dingin, Solok Regency until environmental problems are resolved through deliberations by related parties. This step was taken to protect the local community's economy, which depends on mining. The local government is committed to protecting residents and addressing the negative impacts of mining activities. The conclusion from the situation in Nagari Air Dingin shows that the large mining potential in the area has negative impacts, such as environmental damage, increased risk of flooding and landslides, and damage to the national highway. These impacts have caused anxiety and unrest among the local community (mostly) and road users. Various non-governmental organisations, including the Padang Legal Aid Institute and civil society groups, have urged stakeholders to address mining issues through the media and legal channels. In response, the West Sumatra Provincial Government, the Solok Regency Government, and other stakeholders have identified the main problems of non-compliance by companies that own mining licenses and illegal mining. Follow-up steps include controlling illegal mining, evaluating environmental administration and documents, and possibly revoking permits for companies that violate. The Solok Regency Government plans to meet with related parties, including the West Sumatra Provincial Government and the Minister of Public Works, to discuss handling the problem in Nagari Air Dingin. This effort aims to mitigate flooding and landslides and ensure the community's and road users' safety.

4.3 Policy constraints

4.3.1 The weak law enforcement related to land utilization for mining

Exploration and exploitation activities of Class C mining (sand, stone and gravel) in Nagari Air Dingin, Solok Regency, have a high risk of causing disasters. The data collection results by researchers also support this statement, where mining has a major influence on disasters, and weak law enforcement is the main obstacle. Several sources, such as the Regional Disaster Management Agency of Solok Regency, stated that the main cause of floods and landslides in Nagari Air Dingin, Lembah Gumanti District, is related to the way the community utilises the land and the weak enforcement of land use regulations. The majority of the community uses the land for agriculture or plantations, while a small number do mining. These activities damage the environment and increase the risk of disasters, especially by mining actors. Although the Regional Disaster Management Agency is aware of the need for education regarding land management that considers environmental stability, weak enforcement of regulations, especially in mining activities, is still the main obstacle in preventing disasters in the area. Based on informants' statements, mining operations in Nagari Air Dingin, Solok Regency, show that the local government does not continuously supervise and evaluate mining companies' compliance with environmental management commitments.

Supervision from the local government is limited to the initial permit issuance process without any further audits or evaluations. Interview results show that most of the people of Nagari Air Dingin reject mining activities in their area. The local village government cannot fully coordinate community rejection because the authority for mining permits lies at a higher level of government. They were responding to the mining issue that is suspected of increasing the potential for flooding and landslides in Nagari Air Dingin, Lembah Gumanti District, the Solok Regency Environmental Service, which previously had the authority to issue environmental permits for mining businesses at the district/city level, previously carried out direct supervision of the mining

location. They gave administrative sanctions in the form of written warnings, government coercion, recommendations for temporary suspension, and freezing of environmental permits if the company was proven to have damaged the environment or failed to fulfill environmental management commitments. However, with the latest regulation that transfers full authority to the provincial government, the Solok Regency Environmental Service can no longer act as before.

Based on interviews with various informants, it was concluded that many parties, including environmental experts, NGO WALHI, the Regional Disaster Management Agency, the village government, and the community, are aware of the weak enforcement of regulations related to mining activities that damage the environment and increase the potential for disasters in Nagari Air Dingin. This threatens the safety of lives, property, and the psychological well-being of the local community. However, the Solok Regency Government faces obstacles because the limits of its authority are not yet adequate to handle this problem.

Information from informants shows that the West Sumatra Provincial Government, the mining licensing authority, must closely monitor mining activities in Nagari Air Dingin. The permit must be reviewed or revoked if environmental problems are found due to mining activities. EveryA mining actor must report their activities to the local government per the applicable Environmental Impact Analysis, and the local government must ensure that this obligation is complied with. To handle illegal mining, law enforcement officers must act firmly. In addition, the community's active role also greatly influences handling environmental impact problems due to mining, such as by questioning or voicing complaints to related parties about the environmental damage that occurs in the area where they live.

It can be concluded that the weak enforcement of regulations related to land use for mining is still a major obstacle in mitigating flood and landslide disasters in Nagari Air Dingin, Solok Regency. This problem is caused by the lack of consistency of the local government in supervising and evaluating mining activities and the lack of attention of law enforcement to illegal mining. The effectiveness of law enforcement is highly dependent on consistent supervision and effective monitoring. Therefore, the government must ensure that law enforcement is carried out consistently. In addition, the community, especially those living around the mine and feeling its negative impacts, also needs to play an active role by reporting and questioning adverse conditions to policymakers, especially those related to environmental damage and disaster threats. Considering that the Nagari Air Dingin area is geologically prone to disasters, such as landslides, floods, and earthquakes, due to the presence of the Semangko Sumatra Caesar fault that crosses it (Regional Regulation Number 1 of 2013 concerning the Solok Regency Spatial Planning Plan), researchers argue that consistency in law enforcement is very important for mitigating flood and landslide disasters, especially related to land use for mining. Weaknesses in law enforcement or land use regulations can cause environmental damage [39-42], such as development in water catchment areas or on hillsides prone to landslides, as seen in the case of mining activities. Related to the use of space and land use by the rules that explain the principles of control in Law No. 26 of 2007 concerning Spatial Planning are: (1) control of the use of landslide-prone zones is carried out by observing the consistency of suitability between the use of space and the spatial plan of the district/city/province area; (2) in the use of landslide-prone zones, the level of vulnerability/risk level of landslides and the carrying capacity of the land/soil must be taken into account; (3) activities that disrupt the protective function of landslide-prone areas with a high level of danger are not permitted or stopped: areas prone to landslides must be protected and maintained and even their protective function must be increased, and (4) areas whose protective function is not disturbed can be designated for space utilisation activities with strict requirements.

4.3.2 Lack of knowledge and community apathy in environmental management

To effectively implement disaster mitigation, the community must have knowledge and awareness supporting government efforts [43-45]. Communities, especially those living in disaster-prone areas and those utilising forest land for agriculture, plantations, or mining, must actively participate in mitigation activities. This includes participating in socialisation on the causes and reduction of disaster risks and rehabilitating damaged forest land. Nagari Air Dingin, Solok Regency, requires immediate handling due to the reduction in forest areas, production forests, protected forests in the Kerinci Seblat National Park area, and the expansion of critical land.

The extent of critical land is suspected to be due to mining activities in Nagari Air Dingin, which impacts the damage to forest function due to deforestation that removes vegetation. In addition, the community carries out agriculture or plantations irresponsibly, such as not rehabilitating land after it is unproductive. As a result of these activities, soil humus erosion occurs, which makes the land critical, especially regarding mining. In addition to the issue of the mining as the cause of the critical land in Nagari Air Dingin, there are several bad portraits of community activities, where some people in Nagari Air Dingin have converted rice fields into onion, tomato, and chili plantations because they are considered more economically profitable. However, the impact of this change is not considered, resulting in changes in water flow and increasing the risk of flooding in residential areas during heavy rain. Researchers assess that critical land in Nagari Air Dingin is caused by irresponsible land use by the community, such as for agriculture, plantations, and mining. This shows an indifferent attitude and a lack of community concern for the environment. The lack of community knowledge about the causes of disasters and steps to mitigate flooding and landslides also impacts their attitude of not caring. The reason is that the level of knowledge and attitudes the community holds influence the implementation of disaster mitigation activities [46, 47]. On the other hand, researchers see that the agricultural/plantation sector, as a non-natural factor that can affect the potential for disasters (floods and landslides) in Nagari Air Dingin, is a big dilemma. The community may be more focused on daily needs and short-term economic problems than long-term disaster mitigation because plantations are their main source of livelihood. Therefore, seeing the lack of community concern for rehabilitating critical land, efforts must be made to increase community knowledge and concern. The Solok Regency Government, through the Solok Regency Regional Disaster Management Agency, reminded the community, including Nagari Air Dingin, about the importance of rehabilitating critical land. They conducted socialisation to encourage tree planting as a buffer for forest functions and the application of terracing methods on sloping land. Meanwhile, the Environmental Service of Solok Regency encouraged the improvement of

forest functions by providing free plant seeds. The success of this effort requires initiative and active participation from the local community.

It can be concluded that flood and landslide disaster mitigation efforts in Nagari Air Dingin, Solok Regency, are hampered by the lack of knowledge and non-compliance of the community with activities that can trigger disasters, such as farming on steep slopes and land conversion, as well as low awareness of the importance of environmental management, including land rehabilitation. As a result, the land becomes critical. The local government, through related stakeholders, continues to strive to increase knowledge, awareness, and community involvement, although it is still limited. The government and related institutions need to increase community understanding and encourage a proactive attitude because the community is an important actor besides the government so that the purpose of mitigation as an effort to reduce disaster risk can run well, as mandated in Government Regulation Number 21 of 2008 concerning Disaster Management, in Article 9 letter 4, that disaster management activities are the responsibility of the government, local governments, and the community. This means that there is an acknowledgement that community participation is important in disaster management, including disaster mitigation. Therefore, the community is advised to carry out land rehabilitation and conservation programs, and agricultural land development should be carried out in areas that are relatively safe from the dangers of erosion.

The challenge of implementing this policy is how to design and implement environmental damage prevention programs that involve the community consistently. In addition, the Government must provide alternative welfare improvement programs for the community so that the community shifts from their activities that have not maintained environmental sustainability to prevent disasters. If this is done consistently and can raise public awareness, then this goal can be achieved effectively.

4.4 Policy analysis

4.4.1 Supervision of land utilization for mining

Nagari Air Dingin has great mining potential, which is currently being enhanced by various mining activities. However, these activities have negative impacts, such as environmental damage, increased risk of flooding and landslides, and damage to national highways. This has caused anxiety among the community and road users. Various non-governmental organisations, including the Padang Legal Aid Institute and activists, have fought through the media and legal channels to urge a resolution of the problem.

In response, the Sumatra Provincial Government, the Solok Regency Government, and stakeholders have conducted inspections and found major problems in non-compliance by IUP companies and illegal mining. Follow-up steps include controlling illegal mining, evaluating administration and environmental documents, and enforcing operational bans or revoking permits for Mining License companies. The Solok Regency Government also plans to meet with related parties, including the West Sumatra Provincial Government and the Ministry of Public Works, to discuss handling the problem in Nagari Air Dingin. This is part of a disaster mitigation effort to protect the safety of the lives of the community and road users, considering the potential for disasters.

Effective landslide disaster mitigation measures involve hard engineering methods [48, 49], such as constructing retaining walls to reduce soil erosion in slope areas bordering roads [39]. The findings in this study indicate that the Solok Regency Government, through coordination with the PUPR Service and the Regional Disaster Management Agency of Solok Regency, has made efforts to prevent and reduce the risk of flooding and landslides in Nagari Air Dingin by building a Retaining Wall to maintain slope stability and implementing a river normalisation program by building a barrier on the Batang Kapalo Koto River in Jorong Koto, Nagari Air Dingin. Constructing retaining walls and strong foundations is crucial to stabilise slopes and prevent landslides due to heavy rain.

In addition, the construction of river barriers controls river flow, reduces the risk of flooding, and prevents waterlogging that can loosen the soil and trigger landslides. For this reason, the Regional Disaster Management Agency of Solok Regency is working with the South Solok Public Works Agency Service to increase public awareness of the dangers of disasters. They created and installed landslide warning signs at vulnerable points, including lowland residential areas and along the national highway connecting West Sumatra and Jambi Provinces, especially in the Nagari Air Dining area. The placement of these warning signs is based on the results of the Regional Disaster Management Agency of Solok Regency mapping. It is part of a disaster mitigation strategy to increase public awareness and preparedness.

Regional Disaster Management Agency of Solok Regency, as the disaster management command, conducts monitoring to minimise risks or impacts. They continue to monitor vulnerable areas such as Nagari Air Dingin, especially during heavy rains that can trigger hydrometeorological disasters such as floods and landslides. Monitoring is carried out by the Regional Disaster Management Agency of Solok Regency Quick Reaction Team and the village government and local communities by checking the condition of slopes and rivers, providing information related to the situation in the field, and appealing to the community to remain vigilant. Increasing community knowledge, awareness, and capacity regarding disaster risks and how to handle them is the key to disaster mitigation [50]. This aims to build community resilience and readiness, especially in understanding disaster risks in their area. A basic understanding of disasters is very important so that the community can act calmly and effectively when a disaster occurs. Efforts are made through socialisation, education, and training by Law Number 24 of 2007. Through the Regional Disaster Management Agency of Solok Regency, the local government plays an important role in disaster prevention and mitigation. Regional Disaster Management Agency of Solok Regency programs include Socialization, Communication, Information, and Education, which is carried out annually and training for the formation of a Disaster Preparedness Community in each Nagari. In addition, the Regional Disaster Management Agency of Solok Regency conducts outreach in schools, participates in coordination meetings, and utilises digital media for disaster education. The materials presented include first aid techniques, evacuation, and disaster simulations. However, the Regional Disaster Management Agency of Solok Regency faces obstacles such as a lack of community participation in outreach activities, which hinders disaster preparedness. Active community participation is important for managing risks and reducing disaster damage. Regional Disaster Management Agency of Solok Regency also faces challenges in improving the quality of the apparatus's human resources with the annual Technical

Guidance program and routine directions in morning assemblies to improve the quality of internal human resources.

Furthermore, community involvement in the rehabilitation and conservation of forest vegetation increases the effectiveness of forest conservation. It strengthens the relationship between humans and the environment, ensures good forest function, and maintains forests as valuable resources for future generations. Sustainable forest rehabilitation helps repair environmental damage and reduces the risk of flooding and landslides. The focus of rehabilitation is to restore forest ecosystems damaged by human activities, such as land clearing and uncontrolled logging, by planting various plants to restore their ecological function.

Nagari Air Dingin, which has critical forest land due to its use for plantations and mining, is a crucial area. Local communities have shown environmental concern by initiating rehabilitation by planting Arabica coffee, a hereditary tradition that is in accordance with land conditions (altitude 1500 masl). Coffee planting, driven by market demand and its impact on the local economy, uses an agroforestry system that integrates soil-support trees with cultivated plants.

Research findings show that environmental damage in this area began with the development of passion fruit farming, which resulted in the forest in the hills becoming bare and dry. After the passion fruit price crisis caused farmers to abandon their land, rehabilitation efforts were carried out by cultivating Arabica coffee, which is suitable for an altitude of 1500 meters above sea level, such as in Nagari Air Dingin. This coffee cultivation is a hereditary tradition and has received new impetus due to increasing market demand. To ensure that natural recovery goes hand in hand with coffee cultivation, agroforestry methods are applied, integrating trees and shrubs into the agricultural system, thus bringing environmental, social, and economic benefits.

Then, in order to expand efforts to restore damaged forests and support the local economy, most of the coffee farmers who are members of the Solok Radjo Cooperative have applied for permits to manage customary forests and nagari forests. The Ministry of Environment and Forestry has handed over the management rights for 3,200 hectares of customary forests in Lembah Gumanti. At the same time, local customary leaders have also granted management rights for nagari forests. These natural recovery efforts have finally yielded positive results.

The process of improving forest function with (rehabilitation) is very important to be carried out to reduce the potential for flooding and landslides in Nagari Air Dingin, Lembah Gumanti District, considering that much of the land in the area is already critical because it has been used irresponsibly after being unproductive, especially in the plantation and mining sectors. Seeing the portrait of the development of coffee cultivation with an agroforestry system in the Air Dingin area, precisely in Solok Radjo, it is hoped that there will be environmental changes for the better, the return of forest functions to reduce the potential for disasters.

Regarding the extent of the development of coffee cultivation in Nagari Air Dingin and its influence on land improvement, coffee plant cultivation is only carried out by the community in Solok Radjo, part of Nagari Air Dingin, whose area is a highland. Meanwhile, the area has varied topography, and the community in the lowlands uses the land for mining and plantations, even in sloping areas, and carries out land conversion (not paying attention to land suitability). In addition, coffee cultivation will certainly continue to develop according to market demand. Its influence on land improvement is not too great because the land that has been rehabilitated is still smaller than the critical land in the area. The community that plants coffee is only in Solok Radjo, which is a highland area suitable for the land. At the same time, this area varies and is quite large, not only in Solok Radjo. In the lowlands, it has different uses. Indeed, there has not been much improvement in the function of forest land because the critical land is more than that which has been rehabilitated. It can be explained that a small part of the local community has shown concern for the environment by taking the initiative to cultivate coffee as an effort to rehabilitate the forest and also as an economic support. Researchers believe that community involvement in the process of forest vegetation rehabilitation and conservation not only increases the effectiveness of conservation efforts but also strengthens the relationship between humans and the environment. This ensures that forests continue to function well, helps prevent disasters, and maintains forests as valuable resources for future generations.

According to reference [39], it is important to identify and mark locations at high risk of flooding and landslides. This step is crucial for planning and implementing appropriate and effective mitigation. Based on the findings, the Regional Disaster Management Agency of Solok Regency has mapped the area's distribution of flood and landslide disasters. The resulting map shows the level of disaster hazard from low to high, with Nagari Air Dingin, Lembah Gumanti District, being at a high level of vulnerability for both types of disasters. Floods can potentially threaten residential areas in the lowlands, while landslides are a risk along the national highway in Nagari Air Dingin. Therefore, it is hoped that the government and related institutions will prioritise mitigation efforts in this area.

Furthermore, cross-sector coordination is very important in disaster mitigation because it requires collaboration between various government agencies to produce an effective and efficient response [39, 51, 52]. In Solok Regency, the Disaster Risk Reduction Forum, chaired by the Chairman of the Regional People's Representative Council of Solok Regency, with members from the Regional Disaster Management Agency, the Environmental Service, the Public Works Department, the Social Service, the Health Service, and National/Regional owned enterprises such as Telkom, State Electricity Company, and Clean Water Company, acts as a forum for coordination between stakeholders. The Disaster Risk Reduction Forum facilitates regional disaster coordination and mitigation, including those of Nagari Air Dingin and Lembah Gumanti District. The Disaster Risk Reduction Forum also allows for the formulation of regional policies and action plans related to disaster risk reduction so that the resulting policies are more comprehensive and to local needs.

In this aspect, all stakeholders must synergize and collaborate to control environmental damage to prevent disasters. Efforts that can be made include further activating the Disaster Risk Reduction Forum at the Regency and Provincial levels with assistance from the National Government. This forum should also be given relevant authority and budget as a central coordination and synergy between stakeholders. Recommendations and advice from this Disaster Risk Reduction Forum should be implemented by related parties to follow up on environmental damage mitigation policies to mitigate worse disasters and restore environmental damage itself.

4.5 Policy constraints

There are significant constraints in disaster services in Solok Regency, especially policies for handling environmental damage resulting in disasters in Nagari Air Dingin, Solok Regency. This study will discuss classifying constraints into two types: internal and external.

4.6 Internal constraints

Research findings in Nagari Air Dingin, Solok Regency, identified several internal constraints in mitigating flood and landslide disasters, as follows:

Inadequate quantity of human resources: Research findings show that the Regional Disaster Management Agency of Solok Regency and the Solok Regency Environmental Service of Solok Regency face constraints in disaster management, especially mitigation, due to limited personnel. The Regional Disaster Management Agency of Solok Regency only has 52 human resources, including 36 honorary workers, 21 of whom are Rapid Reaction Team members. This limitation makes it difficult for the Regional Disaster Management Agency of Solok Regency to carry out disaster service tasks in large areas with high disaster potential. Meanwhile, the Environmental Service of Solok Regency, which is responsible for disaster mitigation and supervision of activities that have an impact on the environment, only has two officers to monitor environmental management compliance throughout the district, which is quite large in number.

Lack of competence in disaster mitigation personnel: Based on research findings, the lack of human resource competence is the main obstacle to disaster mitigation by the Regional Disaster Management Agency of Solok Regency. Many employees come from structural backgrounds, even though they should have special competence and experience in the field of disasters. Many disaster mitigation officers do not yet have adequate practical experience, especially because some employees come from transfers from other organisations with non-disaster backgrounds. In addition, not all officers have the required expertise certificates related to functional disaster rescue personnel. This can potentially cause malpractice, which can worsen the disaster situation.

Weak budget support: The study results showed that the Regional Disaster Management Agency of Solok Regency and the South Solok Public Works Agency experienced obstacles in disaster mitigation efforts due to limited budgets. Regional Disaster Management Agency of Solok Regency assessed the need for more massive disaster socialisation and education due to the high potential for disasters in Solok Regency. Still, the existing budget is not yet adequate for these activities. In addition, a sufficient budget is also needed for the costs of honorary officers and disaster mitigation programs such as early warning systems. Meanwhile, the Solok Regency Environmental Agency also experiences minimal budget constraints, so it can only supervise ten activity/business units in 2023. With an adequate budget, the Environmental Agency can increase supervision of more activities/businesses, reducing negative environmental impacts and disaster risks.

Weak law enforcement in land use for mining: Research shows that weak enforcement of regulations related to land use for mining is still an obstacle to mitigating flood and landslide disasters in Nagari Air Dingin, Solok Regency. This is due to the lack of consistency of the local government in supervising and evaluating mining activities in the area, as well as the minimal attention of law enforcement to prosecute illegal miners. Uncontrolled mining activities have a major impact on the environment and increase the risk of disasters, especially floods and landslides, considering the hilly and undulating land conditions in Nagari Air Dingin and the presence of the Sumatran fault that crosses the area.

Inadequate drainage system: This study shows that the drainage system that has received less attention is an obstacle to mitigating flood and landslide disasters in Nagari Air Dingin, Solok Regency. One example is the non-compliance of mining business actors who did not build an adequate drainage system, causing water to flow onto the road (based on the results of the South Solok Public Works Agency audit). In addition, the absence of drainage along the Nagari Air Dingin National Highway caused water to overflow onto the road and caused the road to collapse. The government needs to pay serious attention to the construction of drainage on the national highway and take firm action against mining actors who do not comply with the regulations.

4.7 External constraints

The findings show that external constraints hampering flood and landslide disaster mitigation efforts in Nagari Air Dingin, Solok Regency, are the community's lack of knowledge and apathy towards environmental management, especially in the rehabilitation of damaged forests and land. The community is often unaware that their activities, such as farming on steep slopes and land conversion, can cause disasters. Non-compliance with the importance of critical land rehabilitation is also a problem, with much land left unproductive after use.

The local government and related stakeholders continue to strive to increase community knowledge and awareness and encourage their involvement in disaster mitigation. However, these activities are still minimal. Community understanding of the causes of disasters and mitigation measures is essential to reducing disaster risk. The community is an important actor besides the government's ineffective mitigation efforts.

5. CONCLUSIONS

From the results of the research and discussion, it can be concluded that the large mining potential in the Nagari Air Dingin area of Solok Regency has negative impacts, such as environmental damage, increased risk of flooding and landslides, and damage to national roads. These impacts have caused unrest and anxiety among the local community (most) and road users. Several points of conclusion of this research can be explained as follows:

1. Various non-governmental organizations, including the Legal Aid Institute and civil society groups, have urged stakeholders to address mining issues through the media and legal channels. The weak enforcement of regulations related to land use for mining is still a major obstacle to overcoming floods and landslides in Nagari Air Dingin, Solok Regency. This problem is caused by the lack of consistency of the local government in supervising and evaluating mining activities and the minimal attention from law enforcement officers to illegal mining.

2. Efforts to overcome floods and landslides are hampered by the lack of knowledge and non-compliance of the community with activities that can trigger disasters. Therefore, in its implementation, it is recommended that efforts be made

to increase community knowledge, awareness, and capacity regarding the prevention of environmental damage in order to reduce the risk of disasters and determine how to handle them, which are the keys to disaster mitigation.

3. Community involvement in the rehabilitation and conservation of forest vegetation not only increases the effectiveness of forest conservation but also strengthens the relationship between humans and the environment, ensures good forest function, and maintains forests as valuable resources for future generations. Sustainable forest rehabilitation helps repair environmental damage and reduces the risk of flooding and landslides. Furthermore, the role of the government, together with the community, is important, as it consistently monitors and supervises illegal activities that damage the environment.

Conceptually, this research is recommended to be followed up through research that focuses on designing environmental damage prevention policies based on synergy between stakeholders as part of disaster mitigation efforts.

ACKNOWLEDGEMENT

The research team appreciates and thanks the Research Center for Policy Governance Development and Empowerment Universitas Negeri Padang for conducting this research.

REFERENCES

[1] Arts, B., Behagel, J., de Koning, J., Zon, M.V.D. (2023). Community forest management: weak states or strong communities? Politics and Governance, 11(2): 336-345. https://doi.org/10.17645/pag.v11i2.6325

[2] Herbohn, J., Ota, L., Gregorio, N., Chazdon, R., Fisher, R., Baynes, J., Applegate, J., Page, T., Carias, D., Romero, C., Putz, F.e., Firn, J. (2023). The community capacity curve applied to reforestation: A framework to support success. Philosophical Transactions of the Royal Society B, 378(1867): 20210079. https://doi.org/10.1098/rstb.2021.0079

[3] Fariss, B., DeMello, N., Powlen, K.A., Latimer, C.E., Masuda, Y., Kennedy, C. M. (2023). Catalyzing success in community based conservation. Conservation Biology, 37(1): e13973. https://doi.org/10.1111/cobi.13973

[4] Paluš, H., Krahulcová, M., Parobek, J. (2021). Assessment of forest certification as a tool to support forest ecosystem services. Forests, 12(3): 300. https://doi.org/10.3390/f12030300

[5] Austen, G.E., Dallimer, M., Irvine, K.N., Fisher, J.C., Fish, R.D., Davies, Z.G. (2023). The diversity of people's relationships with biodiversity should inform forest restoration and creation. Conservation Letters, 16(1): e12930. https://doi.org/10.1111/conl.12930

[6] Löf, M., Madsen, P., Metslaid, M., Witzell, J., Jacobs, D.F. (2019). Restoring forests: Regeneration and ecosystem function for the future. New Forests, 50(2): 139-151. https://doi.org/10.1007/s11056-019-09713-0

[7] D'Amato, A.W., Orwig, D.A., Siegert, N.W., Mahaffey, A., Benedict, L., Everett, T., Daigle, J., Johnson, L., Johnson, P., Cusack, C. (2023). Species preservation in the face of novel threats: Cultural, ecological, and operational considerations for preserving tree species in the context of non-indigenous insects and pathogens. Journal of Forestry, 121(5-6): 470-479. https://doi.org/10.1093/jofore/fvad024

[8] Arroyo-Rodríguez, V., Fahrig, L., Watling, J. I., Nowakowski, J., Tabarelli, M., Tischendorf, L., Melo, F.P.L., Santos, B.A., Benchimol, M., Morante-Filho, J.C., Ferry Slik, J.W., Vieira, I.C.G., Tscharntke, T. (2021). Preserving 40% forest cover is a valuable and well-supported conservation guideline: Reply to Banks-Leite et al. Ecology Letters, 24(5): 1114-1116. https://doi.org/10.1111/ele.13689

[9] Duncanson, L., Liang, M., Leitold, V., Armston, J., Krishna Moorthy, S.M., Dubayah, R., Costedoat, S., Enquist, B. J., Fatoyinbo, L., Goetz, S. J., Gonzalez-Roglich, M., Merow, C., Roehrdanz, P.R., Tabor, K., Zvoleff, A. (2023). The effectiveness of global protected areas for climate change mitigation. Nature Communications, 14(1): 2908. https://doi.org/10.1038/s41467-023-38073-9

[10] Paudel, P.K., Lamichhane, A., Acharya, K.P., Bastola, R. (2023). Ecosystem restoration reduces community vulnerability to water-induced disasters: Need to rethink Chure conservation in Nepal. International Journal of Disaster Risk Reduction, 90: 103647. https://doi.org/10.1016/j.ijdrr.2023.103647

[11] Chabba, M., Bhat, M.G., Sarmiento, J.P. (2022). Risk-based benefit-cost analysis of ecosystem-based disaster risk reduction with considerations of co-benefits, equity, and sustainability. Ecological Economics, 198: 107462. https://doi.org/10.1016/j.ecolecon.2022.107462

[12] Mohan, M., Saritha, V.N.K., Rameshan, M., Chacko, A., Gopikrishna, V.G. (2021). Restoring degraded riparian forest ecosystems of the Western Ghats for ecological sustainability. Restoration Ecology, 29(4): e13254. https://doi.org/10.1111/rec.13254

[13] Alayan, R., Rotich, B., Lakner, Z. (2022). A comprehensive framework for forest restoration after forest fires in theory and practice: A systematic review. Forests, 13(9): 1354. https://doi.org/10.3390/f13091354

[14] da Silva, C.M., Elias, F., do Nascimento, R.O., Ferreira, J. (2023). The potential for forest landscape restoration in the Amazon: State of the art of restoration strategies. Restoration Ecology, 31(5): e13955. https://doi.org/10.1111/rec.13955

[15] Hojjati, S.M., Darzi, A., Asadi, H., Tafazoli, M. (2021). Changes in soil properties and plant biodiversity after 12 years of rehabilitating livestock farms in the Hyrcanian Forests. Agroforestry Systems, 95: 1493-1503. https://doi.org/10.1007/s10457-021-00658-y

[16] Kassa, K., Gebeyehu, G., Bekele, T., Abebe, S. (2023). Rehabilitation options for degraded secondary forests in Adiyo district of Kaffa zone, Southwest Ethiopia. Trees, Forests and People, 12: 100394. https://doi.org/10.1016/j.tfp.2023.100394

[17] Zhang, Z., Li, T., Li, L., Li, S., Rong, Y., Bao, R., Fu, X., Tang, M., Wu, G. (2023). Integrating ecosystem service importance and ecological sensitivity to identify priority areas for ecological conservation and restoration in Miyun Reservoir Basin. International Journal of Sustainable Development & World Ecology, 30(8): 925-937. https://doi.org/10.1080/13504509.2023.2230168

[18] Zhou, S., Peng, L. (2022). Integrating a mixed‐cell cellular automata model and Bayesian belief network for

ecosystem services optimization to guide ecological restoration and conservation. Land Degradation & Development, 33(10): 1579-1595. https://doi.org/10.1002/ldr.4218
[19] He, J., Chen, J., Xiao, J., Zhao, T., Cao, P. (2023). Defining important areas for ecosystem conservation in Qinghai province under the policy of ecological red line. Sustainability, 15(6): 5524. https://doi.org/10.3390/su15065524
[20] Mosneaga, A. (2022). Unsustainable development, disasters and displacement: Revisiting the governance challenge. International Journal of Disaster Risk Reduction, 79: 103172. https://doi.org/10.1016/j.ijdrr.2022.103172
[21] Qian, G., Duanmu, C., Ali, N., Khan, A., Malik, S., Yang, Y., Bilal, M. (2021). Hazardous wastes, adverse impacts, and management strategies: A way forward to environmental sustainability. Environment, Development and Sustainability, 24: 9731-9756. https://doi.org/10.1007/s10668-021-01867-2
[22] McKinney, L., Thomson, R. (2022). Landfills and disasters: A geospatial analysis of environmental injustice across the Southern United States. Environmental Sociology, 8(2): 173-186. https://doi.org/10.1080/23251042.2021.2004497
[23] Lestari, F., Setyowati, D.L., Muzanni, A., et al. (2023). Industrial and environmental disaster risk assessment for hazardous materials in Balikpapan City, East Kalimantan, Indonesia. Sustainability, 15(12): 9430. https://doi.org/10.3390/su15129430
[24] Hukkinen, J.I., Eronen, J.T., Janasik, N., Järvensivu, P., Kaaronen, R.O. (2022). Coping with policy errors in an era of chronic socio-environmental crises. Ecological Economics, 199: 107489. https://doi.org/10.1016/j.ecolecon.2022.107489
[25] Kaenzig, R., Piguet, E. (2021). Toward a typology of displacements in the context of slow-onset environmental degradation. An analysis of hazards, policies, and mobility patterns. Sustainability, 13(18): 10235. https://doi.org/10.3390/su131810235
[26] Nohrstedt, D. (2022). When do disasters spark transformative policy change and why? Policy & Politics, 50(3): 425-441. https://doi.org/10.1332/030557321X16508834302815
[27] Faiella, A., Menoni, S., Boni, M.P., Panoutsopoulou, M., Thoma, T., Salari, S., Rueda, N. (2022). Enabling knowledge through structured disaster damage & loss data management system. Sustainability, 14(10): 6187. https://doi.org/10.3390/su14106187
[28] Haq, S.M., Waheed, M., Khoja, A.A., Amjad, M.S., Bussmann, R.W., Ali, K., Jones, D.A. (2023). Measuring forest health at stand level: A multi-indicator evaluation for use in adaptive management and policy. Ecological Indicators, 150: 110225. https://doi.org/10.1016/j.ecolind.2023.110225
[29] Thom, D., Taylor, A.R., Seidl, R., Thuiller, W., Wang, J., Robideau, M., Keeton, W.S. (2021). Forest structure, not climate, is the primary driver of functional diversity in northeastern North America. Science of the Total Environment, 762: 143070. https://doi.org/10.1016/j.scitotenv.2020.143070
[30] Funk, J.M., Aguilar-Amuchastegui, N., Baldwin-Cantello, W., Busch, J., Chuvasov, E., Evans, T., Griffin, B., Harris, N., Ferreira, M.N., Petersen, K., Phillips, O., Soares, J., van der Hoff, R.J. (2019). Securing the climate benefits of stable forests. Climate Policy, 19(7): 845-860. https://doi.org/10.1080/14693062.2019.1598838
[31] Guerrero-Ramírez, N.R. (2021). Functional forest restoration. Nature Ecology & Evolution, 5(12): 1572-1573. https://doi.org/10.1038/s41559-021-01575-0
[32] Hu, Y., Xiang, W., Schäfer, K.V., Lei, P., Deng, X., Forrester, D.I., Fang,, X., Zeng, Y., Ouyang, S., Chen, L., Peng, C. (2022). Photosynthetic and hydraulic traits influence forest resistance and resilience to drought stress across different biomes. Science of the Total Environment, 828: 154517. https://doi.org/10.1016/j.scitotenv.2022.154517
[33] Morel, L., Dujol, B., Courtial, C., Vasseur, M., Leroy, B., Ysnel, F. (2019). Spontaneous recovery of functional diversity and rarity of ground-living spiders shed light on the conservation importance of recent woodlands. Biodiversity and Conservation, 28: 687-709. https://doi.org/10.1007/s10531-018-01687-3
[34] Östlund, L., Norstedt, G. (2021). Preservation of the cultural legacy of the indigenous Sami in northern forest reserves–Present shortcomings and future possibilities. Forest Ecology and Management, 502: 119726. https://doi.org/10.1016/j.foreco.2021.119726
[35] Litaor, M.I., Israeli, A. (2023). A new precision soil sampling approach in support of reforestation experiment in dry Mediterranean ecosystem. In Precision Agriculture'23, pp. 587-593. https://doi.org/10.3920/978-90-8686-947-3_74
[36] Lo Monaco, A., Macinnis-Ng, C., Rajora, O.P. (2022). Forests for a Better Future: Sustainability, Innovation and Interdisciplinarity. Forests, 13(6): 941. https://doi.org/10.3390/f13060941
[37] Huo, L., Strengbom, J., Lundmark, T., Westerfelt, P., Lindberg, E. (2023). Estimating the conservation value of boreal forests using airborne laser scanning. Ecological Indicators, 147: 109946. https://doi.org/10.1016/j.ecolind.2023.109946
[38] Moor, H., Eggers, J., Fabritius, H., Forsell, N., Henckel, L., Bradter, U., Mazziotta, A., Nordér, J., Snäll, T. (2022). Rebuilding green infrastructure in boreal production forest given future global wood demand. Journal of Applied Ecology, 59(6): 1659-1669. https://doi.org/10.1111/1365-2664.14175
[39] Hermon, D. (2012). Hydrometeorological Disaster Mitigation. UNP Press.
[40] Blum, D., Aguiar, S., Sun, Z., Müller, D., Alvarez, A., Aguirre, I., Domingo, S., Mastrangelo, M. (2022). Subnational institutions and power of landholders drive illegal deforestation in a major commodity production frontier. Global Environmental Change, 74: 102511. https://doi.org/10.1016/j.gloenvcha.2022.102511
[41] Roy, P., Pal, S.C., Chakrabortty, R., Islam, A.R.M.T., Chowdhuri, I., Saha, A. (2022). Impact of ineffective measures on the increasing land degradation in a monsoon-dominated region of India: Issues and policy implications. Land Degradation & Development, 33(16): 3174-3185. https://doi.org/10.1002/ldr.4380
[42] Andrade, M.B., Ferrante, L., Fearnside, P.M. (2021). Brazil's Highway BR-319 demonstrates a crucial lack of environmental governance in Amazonia. Environmental Conservation, 48(3): 161-164. https://doi.org/10.1017/S0376892921000084
[43] Gouda, M., Yang, Y. (2023). Investigating the impact of

a community disaster awareness training on subjective disaster preparedness: The case of Myanmar's Ayeyarwaddy region. Disasters, 47(4): 1047-1068. https://doi.org/10.1111/disa.12575

[44] Hadlos, A., Opdyke, A., Hadigheh, S.A. (2022). Where does local and indigenous knowledge in disaster risk reduction go from here? A systematic literature review. International Journal of Disaster Risk Reduction, 79: 103160. https://doi.org/10.1016/j.ijdrr.2022.103160

[45] Oktari, R.S., Latuamury, B., Idroes, R., Sofyan, H., Munadi, K. (2022). Validating knowledge creation factors for community resilience to disaster using structural equation modelling. International Journal of Disaster Risk Reduction, 81: 103290. https://doi.org/10.1016/j.ijdrr.2022.103290

[46] Jiang, R., Wang, Z., Tao, Y., Yang, C., Song, X., Shibasaki, R., Chen, S., Shyu, M.L. (2023). Learning social meta-knowledge for nowcasting human mobility in disaster. In Proceedings of the ACM Web Conference 2023, Austin, USA, pp. 2655-2665. https://doi.org/10.1145/3543507.3583991

[47] Fu, X., Yuan, T., Wang, W., Wölk, F., Strunz, G. (2022). Towards Exploiting Stakeholder Resources for Data-Driven Resilient Hazard Management. In 2022 IEEE 42nd International Conference on Distributed Computing Systems Workshops, Bologna, Italy, pp. 254-259. https://doi.org/10.1109/ICDCSW56584.2022.00055

[48] Baek, J., Schlinkman, R.T., Beckwith, F.N., Chen, J.S. (2022). A deformation-dependent coupled Lagrangian/semi-Lagrangian meshfree hydromechanical formulation for landslide modeling. Advanced Modeling and Simulation in Engineering Sciences, 9(1): 20. https://doi.org/10.1186/s40323-022-00233-9

[49] Cheung, R.W. (2021). Landslide risk management in Hong Kong. Landslides, 18(10): 3457-3473. https://doi.org/10.1007/s10346-020-01587-0

[50] Graveline, M.H., Germain, D. (2022). Disaster risk resilience: Conceptual evolution, key issues, and opportunities. International Journal of Disaster Risk Science, 13(3): 330-341. https://doi.org/10.1007/s13753-022-00419-0

[51] Liu, C., Shi, Q., Xiao, C., Zhou, Y., Han, Y. (2022). Optimal relationship patterns in disaster response project organizing: An interorganizational network model. Journal of Management in Engineering, 38(6): 04022063. https://doi.org/10.1061/(ASCE)ME.1943-5479.0001094

[52] Bodin, Ö., Guerrero, A.M., Nohrstedt, D., Baird, J., Summers, R., Plummer, R., Jasny, L. (2022). Choose your collaborators wisely: Addressing interdependent tasks through collaboration in responding to wildfire disasters. Public Administration Review, 82(6): 1154-1167. https://doi.org/10.1111/puar.13518