JOURNAL OF GEOSCIENCES INSIGHTS
Jan-Mar 2024, VOL. 2, ISSUE 1, pp. 20-24
https://doi.org/10.61577/jgi.2024.100004

RESEAPRO JOURNALS

REVIEW

OPEN ACCESS

# Impact of urbanization on landslide incidences in the Indian Himalayan region

Supriya Mohanty[1], Mainak Biswas[2] and Swati Suman Mishra[3]

[1]Department of Agriculture, Agropolytechnic Centre - OUAT, Rourkela, Odisha, India
[2] Department of Zoology, Scottish Church College, University of Calcutta, India
[3]Department of Biotechnology, MITS School of Biotechnology, Odisha, India

## ABSTRACT

Urbanization in the Indian Himalayan region has intensified in recent decades, driven by population growth, economic development, and tourism, leading to significant changes in land use and increased landslide risks. This review examines the intricate relationship between urbanization and landslide occurrences, highlighting key factors such as deforestation, unplanned construction, and altered drainage patterns. Deforestation weakens soil stability, while unplanned infrastructure development disrupts natural landforms and drainage systems, exacerbating slope instability. Effective mitigation strategies are crucial for managing these risks. Government policies must enforce strict zoning laws, mandatory environmental impact assessments, and resilient construction practices. Community-based approaches, including education and participatory planning, empower local communities to engage in sustainable practices. Technological innovations such as remote sensing, drones, and advanced monitoring systems offer real-time data for better risk assessment and early warning systems. Additionally, ecosystem restoration and resilient infrastructure development are vital for maintaining long-term slope stability. Future research should focus on updating landslide inventories, conducting comprehensive geological and hydrological studies, and understanding the impact of climate change on landslide dynamics. Integrating interdisciplinary insights and fostering collaborative research among academic institutions, government agencies, and local communities is essential. By adopting these comprehensive measures, it is possible to balance development needs with environmental conservation, ensuring the safety and sustainability of the Indian Himalayan region. This review underscores the urgency of a holistic approach to urban planning that prioritizes environmental stability and risk mitigation.

KEYWORDS

Urbanization; Landslides; Indian Himalayas; Sustainable development

ARTICLE HISTORY

Received 13 January 2024; Revised 16 February 2024; Accepted 27 February 2024

## Introduction

Urbanization in the Indian Himalayan region has surged in recent decades, driven by population growth, economic development, and increasing tourism [1,2]. This mountainous area, known for its diverse ecosystems and fragile geology, is now experiencing significant land use and cover changes [3,4]. Historically, the Indian Himalayas have been sparsely populated with communities that adapted their lifestyles to the challenging terrain and climate [5,6]. However, the recent influx of people and infrastructure expansion have disrupted this delicate balance [5].

The Himalayas are inherently prone to landslides due to their steep slopes, complex geological structures, and heavy monsoon rains [7,8]. Landslides in this region are not new; they have been recorded throughout history, causing substantial loss of life and property [8]. However, the frequency and intensity of landslides have increased in recent years, raising concerns among scientists, policymakers, and local communities. This review explores the relationship between rapid urbanization and the rising incidence of landslides in the Indian Himalayan region.

Several factors link urbanization to increased landslide risk. Deforestation and vegetation loss due to urban expansion reduce the natural stability of slopes, making them more susceptible to failure [9,10]. Unplanned construction and infrastructure development, such as roads and buildings, further exacerbate the problem by altering the natural topography and drainage patterns [11,12]. These changes disrupt the delicate equilibrium of the landscape, often leading to catastrophic landslides [11,12].

This review will analyze various case studies from different parts of the Indian Himalayas to provide a comprehensive understanding of how urbanization affects landslide dynamics. The paper will also discuss the effectiveness of current mitigation strategies and the need for sustainable urban planning practices. By highlighting the critical link between urban expansion and landslide risk, this review underscores the urgency of adopting a balanced approach to development that prioritizes environmental conservation and safety.

## Factors Linking Urbanization and Landslides

Urbanization in the Indian Himalayan region has introduced several factors contributing to landslides' increased frequency and severity. The interplay between deforestation, unplanned construction, and altered drainage patterns creates a scenario where natural and anthropogenic factors combine to destabilize slopes.

*Correspondence: Ms. Supriya Mohanty, Department of Agriculture Agropolytechnic Centre – OUAT, Rourkela, India, 769001, e-mail: supriyam7437@gmail.com

## Deforestation and vegetation Loss

One of the primary consequences of urbanization is deforestation, which significantly impacts soil stability [13,14]. Forests play a crucial role in maintaining the integrity of slopes through root systems that bind the soil together, reducing erosion and absorbing excess water [14]. Removing vegetation for urban development weakens these natural supports, making slopes more prone to landslides. Studies have shown that areas with reduced forest cover are more susceptible to soil erosion and landslides, especially during heavy rainfall. The loss of vegetation also disrupts the local hydrological cycle, leading to increased surface runoff and reduced water absorption, further destabilizing slopes [15].

## Unplanned construction and infrastructure development

Unplanned construction and rapid infrastructure development are major contributors to landslide risk in the Himalayas [16 – 18]. Roads, buildings, and other infrastructure projects often involve extensive excavation and alteration of natural landforms [16 – 18]. This can create unstable slopes and increase the likelihood of landslides. For instance, road construction in hilly areas involves cutting into slopes, which can disrupt the natural equilibrium and lead to slope failure. Additionally, improper construction practices, such as inadequate drainage systems and poor-quality retaining walls, can exacerbate the problem [19]. Construction activities are often carried out without proper geological assessments, increasing the risk of triggering landslides.

## Changes in drainage patterns

Urban development significantly alters natural drainage patterns, contributing to landslide risk [11, 12, 20]. The construction of roads, buildings, and other infrastructure often involves changes to the natural water flow [11, 12]. Impermeable surfaces, such as asphalt and concrete, prevent water from infiltrating the ground, increasing surface runoff. This runoff can erode slopes and cause landslides, particularly during heavy rainfall. Moreover, inadequate drainage systems in urban areas can result in water accumulation and saturation of the soil, which reduces its stability and increases the likelihood of landslides. Improperly managed drainage systems can also lead to waterlogging, further weakening the soil and making slopes more prone to failure.

## Case Studies from the Indian Himalayan Region

### Uttarakhand

Uttarakhand, a state in the northern part of India, has experienced significant urban expansion, particularly in the aftermath of the 2013 Kedarnath disaster. This tragic event, triggered by a cloudburst and exacerbated by extensive deforestation and unplanned construction, caused massive landslides and flooding, resulting in substantial loss of life and property [21]. The disaster highlighted the dire consequences of ignoring environmental sustainability in urban development. Post-disaster investigations revealed that deforestation for roads and buildings had destabilized slopes, and the lack of adequate drainage systems further aggravated the situation. The increased runoff from impermeable surfaces overwhelmed the natural drainage capacity, leading to catastrophic landslides.

In recent years, cities like Dehradun and Nainital have witnessed rapid urbanization, contributing to frequent landslides [22]. Unregulated construction on steep slopes, inadequate retaining structures, and poor drainage systems are common issues. For instance, Nainital has seen numerous landslides that have damaged roads, homes, and infrastructure, primarily due to the lack of proper urban planning and land use management.

### Himachal Pradesh

Himachal Pradesh is another state significantly affected by landslides, driven largely by rapid urbanization and infrastructure projects [23]. Road, hydroelectric, and building construction often occur without thorough geological assessments, leading to frequent slope failures. The 2017 landslide in Mandi district, which resulted in over 40 fatalities, was attributed to unplanned road construction and deforestation [24]. Similarly, the Kullu-Manali region, a major tourist destination, faces regular landslides due to the haphazard construction of hotels and resorts on unstable slopes [25].

The state government's efforts to promote hydroelectric projects have also increased landslide risk. These projects involve extensive excavation and tunneling, which disturb the region's geological stability. The Kinnaur district, for example, has witnessed multiple landslides linked to such developments, affecting local communities and infrastructure [26]. Despite these challenges, Himachal Pradesh has begun implementing stricter regulations and better land use planning to mitigate landslide risks.

### Sikkim and Arunachal Pradesh

Urbanization and infrastructure development have also led to increased landslide occurrences in the northeastern states of Sikkim and Arunachal Pradesh [27]. Sikkim is particularly vulnerable with its fragile geology and high seismic activity [28]. The expansion of roads and hydroelectric projects has triggered landslides, disrupting local communities and transportation networks. The 2011 Sikkim earthquake further destabilized the region, causing numerous landslides and highlighting the need for resilient infrastructure [29].

Arunachal Pradesh, characterized by its rugged terrain and heavy monsoon rains, faces similar issues [30]. The construction of roads and infrastructure without proper environmental assessments has led to frequent landslides. For instance, the Trans-Arunachal Highway project has been associated with several landslides, affecting the environment and local livelihoods.

These case studies from the Indian Himalayan region underscore the critical link between urbanization and increased landslide risk. They highlight the need for sustainable urban planning, proper land use management, and the implementation of effective mitigation strategies. By learning from these examples, policymakers and planners can develop more resilient and environmentally sound approaches to urbanization in mountainous regions.

## Mitigation Strategies and Sustainable Urban Planning

Mitigating the impact of urbanization on landslide risk in the Indian Himalayan region requires a multi-faceted approach that



https://doi.org/10.61577/jgi.2024.100004

includes government policies, community-based initiatives, and technological interventions. Sustainable urban planning is crucial to balance development needs with environmental conservation, ensuring long-term stability and safety.

## Role of government policies and regulations

Effective government policies and regulations are essential for managing urbanization and reducing landslide risk. Several measures that can be adopted to achieve this are summarized in Table 1.

**Table 1.** Role of government in sustainable urban programs.

| Strategy | Implementation and Outcome | References |
|---|---|---|
| Strict Zoning Laws | Implementing strict zoning laws can prevent construction in high-risk areas. These laws should be based on detailed geological and hydrological assessments to identify vulnerable zones. | 31 |
| Environmental Impact Assessments (EIAs) | Mandatory EIAs for all major construction projects can ensure that potential environmental risks, including landslides, are identified and mitigated before project approval. | 32 |
| Enforcement of Building Codes | Adhering to rigorous building codes that consider the unique topography and geology of the Himalayas can reduce the likelihood of landslides. These codes should mandate appropriate construction techniques and materials that enhance slope stability. | 33 |
| Afforestation Programs | Government-led afforestation programs can help restore vegetation cover, vital for maintaining soil stability and preventing erosion. These programs should focus on planting native species well-adapted to the local environment. | 34 |

## Community-based approaches

Community involvement is crucial for the success of any landslide mitigation strategy. Local communities possess valuable environmental knowledge, which can be leveraged to develop effective solutions, summarized in Table 2.

## Technological interventions

Advances in technology provide powerful tools for predicting, monitoring, and mitigating landslides. Table 3 summarizes some of the potential technological interventions.

**Table 2.** Community-based approaches in sustainable urban programs

| Strategy | Implementation and Outcome | References |
|---|---|---|
| Community Education and Awareness | Educating communities about the risks of unplanned urbanization and landslides can encourage more sustainable practices. Awareness programs can highlight the importance of maintaining vegetation cover and following safe construction practices. | 35 |
| Participatory Planning | Involving local communities in the planning and decision-making ensures that their needs and knowledge are considered. This can lead to more effective and culturally appropriate mitigation strategies. | 36 |
| Community-Led Afforestation | Engaging local communities in afforestation and reforestation efforts can enhance the success of these programs. Communities can take ownership of maintaining vegetation cover, which is critical for slope stability. | 36, 37 |

**Table 3.** Technological interventional approaches in sustainable urban programs.

| Strategy | Implementation and Outcome | References |
|---|---|---|
| Remote Sensing and GIS | Remote sensing and Geographic Information Systems (GIS) can map landslide-prone areas, monitor changes in land use, and assess slope stability. These technologies enable early warning systems that alert communities to imminent landslide threats. | 38, 39 |
| Slope Stabilization Techniques | Innovative construction techniques, such as soil nailing, retaining walls, and terracing, can significantly enhance slope stability. These methods should be integrated into building codes and applied in high-risk areas. | 40 |
| Drainage Management | Proper drainage systems are essential to managing surface runoff and preventing waterlogging, which can trigger landslides. Implementing advanced drainage solutions, such as subsurface drainage networks and rainwater harvesting systems, can reduce the risk of landslides. | 41, 42 |



https://doi.org/10.61577/jgi.2024.100004

Mitigating urbanization's impact on landslides in the Indian Himalayan region requires a comprehensive approach that combines government policies, community involvement, and technological advancements. By adopting sustainable urban planning practices and leveraging local knowledge and modern technology, it is possible to balance development needs with environmental conservation, ensuring the safety and stability of the region for future generations.

## Future Directions and Research Needs

Addressing urbanization and landslide risks in the Indian Himalayan region necessitates ongoing research and innovative approaches to identify knowledge gaps and develop comprehensive strategies for sustainable urban development. Essential steps include updating landslide inventories to document past events and triggers, conducting in-depth geological and hydrological studies to understand soil composition, slope angles, and rainfall patterns, and examining the impact of climate change on landslide frequency and intensity. Integrating interdisciplinary insights from geology, hydrology, urban planning, and social sciences is critical, as is fostering collaborative research among academic institutions, government agencies, and local communities. Effective policies must promote sustainable urban planning by enforcing zoning laws, mandating environmental impact assessments, and ensuring resilient construction techniques. Encouraging community participation in decision-making processes ensures that mitigation strategies are culturally appropriate and widely accepted. Strengthening disaster preparedness through early warning systems, regular disaster drills, and efficient evacuation plans can significantly reduce the impacts of landslides. Technological innovations such as remote sensing, drones, and ground-based sensors offer advanced monitoring capabilities, providing real-time data on slope stability. Employing big data and machine learning techniques can also enhance risk assessment models and prediction accuracy. Focusing on ecosystem restoration, such as reforestation and soil conservation programs, is vital for maintaining slope stability. Adopting resilient infrastructure development practices ensures that future projects are designed to withstand environmental stresses. These multifaceted efforts aim to balance development needs with environmental conservation, ensuring the long-term safety and stability of the Indian Himalayan region. By addressing these future directions and research needs, it is possible to mitigate the impact of urbanization on landslides and promote sustainable development in this vulnerable region.

## Conclusions

In conclusion, rapid urbanization in the Indian Himalayan region has heightened landslide risks, demanding sustainable development strategies. Deforestation, unplanned construction, and altered drainage patterns destabilize slopes, necessitating comprehensive approaches. Updated landslide inventories and geological studies are essential, alongside policies enforcing strict zoning laws and environmental impact assessments. Community involvement ensures culturally appropriate mitigation strategies, while technological advancements in remote sensing, drones, and sensors offer real-time monitoring data. Big data and machine learning enhance risk assessments, prioritizing ecosystem restoration and resilient infrastructure development to ensure long-term stability. Collaborative efforts among academic institutions, government agencies, and local communities are crucial for effectively mitigating landslide risks. Integrating these measures makes it possible to balance development needs with environmental conservation, ensuring the region's safety and sustainability.

## Disclosure statement

No potential conflict of interest was reported by the authors.

## References

1. Ishtiaque A, Shrestha M, Chhetri N. Rapid urban growth in the Kathmandu Valley, Nepal: Monitoring land use land cover dynamics of a himalayan city with landsat imageries. Environments. 2017;4(4):72. https://doi.org/10.3390/environments4040072
2. Pandit MK, Manish K, Koh LP. Dancing on the roof of the world: ecological transformation of the Himalayan landscape. BioScience. 2014;64(11):980-992. https://doi.org/10.1093/biosci/biu152
3. Tse-Ring K, Sharma E, Chettri N, Shrestha AB. Climate change vulnerability of mountain ecosystems in the Eastern Himalayas. International centre for integrated mountain development (ICIMOD); 2010.
4. Chamling M, Bera B. Spatio-temporal patterns of land use/land cover change in the Bhutan–Bengal foothill region between 1987 and 2019: study towards geospatial applications and policy making. Earth Syst Environ. 2020;4(1):117-130. https://doi.org/10.1007/s41748-020-00150-0
5. Bhatta LD, Shrestha A, Neupane N, Jodha NS, Wu N. Shifting dynamics of nature, society and agriculture in the Hindu Kush Himalayas: Perspectives for future mountain development. J Mt Sci. 2019;16(5):1133-1149. https://doi.org/10.1007/s11629-018-5146-4
6. Lokgariwar C. Changing with the seasons: how Himalayan communities cope with climate change. InEcocultures. Routledge; 2014. 97-112p.
7. Das S, Sarkar S, Kanungo DP. A critical review on landslide susceptibility zonation: recent trends, techniques, and practices in Indian Himalaya. Nat Hazards. 2023;115(1):23-72. https://doi.org/10.1007/s11069-022-05554-x
8. Dubey S, Sattar A, Goyal MK, Allen S, Frey H, Haritashya UK, Huggel C. Mass movement hazard and exposure in the Himalaya. Earth's futur. 2023;11(9):e2022EF003253. https://doi.org/10.1029/2022EF003253
9. Bozzolan E, Holcombe EA, Pianosi F, Marchesini I, Alvioli M, Wagener T. A mechanistic approach to include climate change and unplanned urban sprawl in landslide susceptibility maps. Sci Total Environ. 2023;858:159412. https://doi.org/10.1016/j.scitotenv.2022.159412
10. Pacheco Quevedo R, Velastegui-Montoya A, Montalván-Burbano N, Morante-Carballo F, Korup O, Daleles Rennó C. Land use and land cover as a conditioning factor in landslide susceptibility: a literature review. Landslides. 2023;20(5):967-982. https://doi.org/10.1007/s10346-022-02020-4
11. Roy S. Role of transportation infrastructures on the alteration of hillslope and fluvial geomorphology. Anthr Rev. 2022;9(3):344-378. https://doi.org/10.1177/20530196221128371
12. Thapa A. Factors Shaping the Landslide Trend in Nepal and their Impact on Human Lives and the Economy. Journey Sust Dev Peace J. 2023;1(02):113-131. https://doi.org/10.3126/jsdpj.v1i02.58265
13. Lehmann P, von Ruette J, Or D. Deforestation effects on rainfall-induced shallow landslides: Remote sensing and physically-based modelling. Water Resour Res. 2019;55(11):9962-9976. https://doi.org/10.1029/2019WR025233
14. Ram AS. A Review on Effects of Deforestation on Landslide: Hill Areas. Int J Sci Res Dev. 2014;2(07).
15. Lann T, Bao H, Lan H, Zheng H, Yan C. Hydro-mechanical effects of vegetation on slope stability: A review. Sci Total Environ. 2024:171691. https://doi.org/10.1016/j.scitotenv.2024.171691
16. Singh A, Pal S, Kanungo DP. An integrated approach for landslide



https://doi.org/10.61577/jgi.2024.100004

susceptibility–vulnerability–risk assessment of building infrastructures in hilly regions of India. Environ Dev Sustain. 2021; 23(4):5058-5095. https://doi.org/10.1007/s10668-020-00804-z
17. McAdoo BG, Quak M, Gnyawali KR, Adhikari BR, Devkota S, Rajbhandari PL, et al. Roads and landslides in Nepal: how development affects environmental risk. Nat Hazards Earth Syst Sci. 2018;18(12):3203-3210. https://doi.org/10.5194/nhess-18-3203-2018
18. Tiwari PC, Joshi B. Challenges of urban growth in Himalaya with reference to climate change and disaster risk mitigation: a case of Nainital Town in Kumaon Middle Himalaya, India. Himalayan Weather and Climate and their Impact on the Environment. 2020:473-491. https://doi.org/10.1007/978-3-030-29684-1_23
19. Chourasia A, Dalbehera MM, Kapoor A, Kulkarni KS, Gaurav G, Singh S, et al. Damage assessment of buildings due to land subsidence in Joshimath town of Northwestern Himalaya, India. Nat Hazards. 2024:1-8. https://doi.org/10.1007/s11069-024-06625-x
20. Bozzolan E, Holcombe EA, Pianosi F, Marchesini I, Alvioli M, Wagener T. A mechanistic approach to include climate change and unplanned urban sprawl in landslide susceptibility maps. Sci Total Environ. 2023;858:159412. https://doi.org/10.1016/j.scitotenv.2022.159412
21. Sharma V, Joshi KK, Agrawal R. Mitigating Disasters Through Community Involvement and Righteous Practices in Himalayan Region of Uttarakhand, India. In: Ha, H., Fernando, R., Mahmood, A. (eds) Strategic Disaster Risk Management in Asia. Springer; 2015.
22. Yadav S. (2022). Risk evaluation and its prioritization in the lesser himalaya city, nainital (Doctoral dissertation, Forest research institute); 2022.
23. Ratha KC. Development of india's mountainous regions revisited: re-assessing the present, re-imagining the future. Himalayan and Central Asian Studies. 2023;27(2):1-17.
24. Chand K, Sharma DD. Causes, Consequences, and Mitigation of Landslides in the Himalayas: A Case Study of District Mandi, Himachal Pradesh. InGeospatial Modeling for Environmental Management. CRC Press; 2022;127-156.
25. Chakravorty SP. Collective Sustenance and the Environment: A Political Economy Analysis of Tourism in Himachal Pradesh, India (Doctoral dissertation, SOAS University of London). https://doi.org/10.25501/SOAS.00036989
26. LATA R, SRishi MA, Herojeet R, Dolma K. Socio-economic Vulnerability and Environmental Implications of Major Hydropower Projects in District Kinnaur, Himachal Pradesh, India. Int J Earth Sci Engg. 2017;10(04):826-832. https://doi.org/10.21276/ijee.2017.10.0414
27. Bhusan K, Pande T, Kayal JR. Landslide affected areas and challenges imposed in North Eastern Region of India: an appraisal. Aust J Eng Innov Technol. 2022;4(2):32-44. https://doi.org/10.34104/ajeit.022.032044
28. Joshi M. Co-seismic landslides in the Sikkim Himalaya during the 2011 Sikkim Earthquake: Lesson learned from the past and inference for the future. Geol J. 2022;57(12):5039-5060. https://doi.org/10.1002/gj.4416
29. Kumar S, Sengupta A. Physical Model-Based Landslide Susceptibility Mapping of Himalayan Highways Considering the Coupled Effect of Rainfall and Earthquake. Nat Hazards Rev. 2024; 25(3):04024013. https://doi.org/10.1061/NHREFO.NHENG-1997
30. Kalita A, Baruah S, Omo Y. Arunachal Pradesh. InGeotechnical Characteristics of Soils and Rocks of India. CRC Press. 2021;37-55.
31. Deyle RE, French SP, Olshansky RB, Paterson RG. Hazard assessment: The factual basis for planning and mitigation. Cooperating with nature: confronting natural hazards and land use planning for sustainable communities; 1998;119-166.
32. Hapuarachchi AB, Hughey K, Rennie H. Effectiveness of Environmental Impact Assessment (EIA) in addressing development-induced disasters: a comparison of the EIA processes of Sri Lanka and New Zealand. Nat Hazards. 2016;81:423-445. https://doi.org/10.1007/s11069-015-2089-8
33. Mandal S, Maiti R. Semi-quantitative approaches for landslide assessment and prediction. Singapore: Springer. 2015.
34. Stanturf JA, Kleine M, Mansourian S, Parrotta J, Madsen P, Kant P, et al. Implementing forest landscape restoration under the Bonn Challenge: a systematic approach. Ann For Sci. 2019;76:1-21. https://doi.org/10.1007/s13595-019-0833-z
35. Puente-Sotomayor F, Egas A, Teller J. Land policies for landslide risk reduction in Andean cities. Habitat Int. 2021;107:102298. https://doi.org/10.1016/j.habitatint.2020.102298
36. Anderson MG, Holcombe E. Community-based landslide risk reduction: managing disasters in small steps. World Bank Publications; 2013.
37. Phillips C, Marden M. Reforestation schemes to manage regional landslide risk. Landslide hazard and risk. 2005;517-547. https://doi.org/10.1002/9780470012659
38. Zulhaidi Mohd Shafri H, Mohd Zahidi I, Abu Bakar S. Development of landslide susceptibility map utilizing remote sensing and Geographic Information Systems (GIS). Disaster Prev Manage. 2010;19(1):59-69. https://doi.org/10.1108/09653561011022144
39. Rai PK, Mohan K, Kumra VK. Landslide hazard and its mapping using remote sensing and GIS. J Sci Res. 2014;58(1):1-3.
40. Gue SS. Landslides: How, Why and the Way Forward. The Journal of The Institution of Engineers Malaysia. 2023;84(2). https://doi.org/10.54552/v84i2.220
41. Sarwar GM. Landslide tragedy of Bangladesh. In The First World Landslide Forum. United Nations University (UNU), Tokyo, Japan. 2008;11.
42. Priyono P, Maulida EI. Mitigation of area prone to landslide in anticipating the impact of climate change. ASEANA Sci Educ J. 2021;1(1):17-26. https://doi.org/10.53797/aseana.v1i1.3.2021



https://doi.org/10.61577/jgi.2024.100004