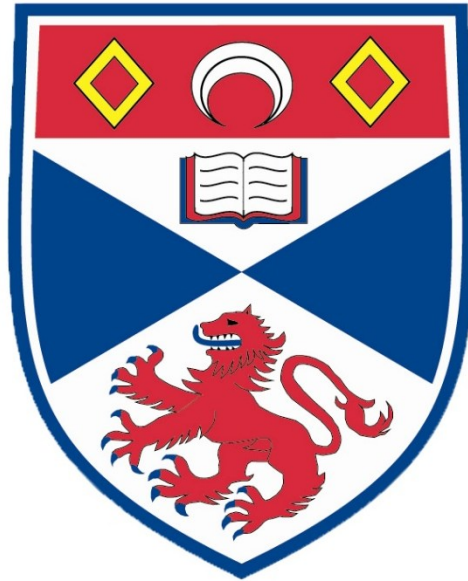


GG4399: Research Dissertation in Geography

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University
of
St Andrews

Changing with the Climate: Extreme Rainfall and Tribal Violence in
Papua New Guinea

220000270

Supervised by Dr Antje Brown (School of Geography and Sustainable
Development)

Declarations

Submitted as an integral part of the MA Joint Honours Degree in Geography, University of St Andrews, April 2026.

I declare that this dissertation is 9,592 words in length, excluding appendices, bibliography and figures.

I declare that the School of Geography and Sustainable Development informed me of, and that I have agreed to abide by, the Ethics, Risk Assessment, and Local Health and Safety rules, codes and procedures associated with this part of my degree; that I have completed and signed the relevant Ethics Self-Assessment and Risk Assessment forms and that I have obtained appropriate Ethics Approval for this project

I certify that I have read the University's policy on Academic Misconduct; that the following work is my own work; and that significant academic debts and borrowings have been properly acknowledged and referenced.

Signature

A handwritten signature in black ink, appearing to read 'E. J. O'Regan', written over a horizontal line.

Date 21/04/2026

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Abstract

Papua New Guinea (PNG) is an ethnically diverse country that finds itself at the epicentre of the multifaceted effects of climate change, namely extreme rainfall. Its complex tribal politics often result in intense disputes over land rights, accusations of sorcery and electoral corruption. This dissertation analyses the relationship between extreme precipitation and tribal violence rates to see if there is a direct causality. It carries out a spatial analysis of annual precipitation against violence rates on a national scale before presenting a district-level analysis of incidents of violence and extreme rainfall events in Enga province, the primary exhibitor of a positive relationship in the national analysis. The results uncovered a lack of a deterministic relationship between the two, but the possibility that precipitation acts as an environmental stressor to worsen already fractious relations. These findings were then compared with an analysis of the government's Sustainable Development Roadmap alongside NGO recommendations to uncover the reasons for the high violence rates. Current policies were found to be economically and logistically unrealistic, failing to consider the importance of the community systems that are at the base of Papua New Guinean societal structures. As such, this research recommended a focus on a church-led community education plan to help the youth unlearn behaviours that lead to incidents of mass violence, especially in a world where volatile weather events can threaten social stability.

Contents

Declarations	ii
Acknowledgements.....	iii
Abstract.....	iv
Contents.....	v
Abbreviations	vii
Figures and Tables	viii
Appendices.....	ix
Map of Papua New Guinea	x
1. Introduction	1
1.1. The Problem	1
1.2. Research Gap.....	2
1.3. Original Contribution.....	2
1.4. Objectives.....	3
1.5. Dissertation Overview	4
2. Literature Review	5
2.1. Climate Change.....	5
2.2. Global Climate-Conflict Linkages	5
2.3. PNG Rainfall Vulnerabilities	7
2.4. Displacement Pathways in PNG.....	8
2.5. Tribal Structures in PNG	8
3. Methodology.....	11
3.1. Research Design.....	11
3.2. Topic Selection.....	11
3.3. Data Collection and Processing	12
3.3.1. Climate.....	12
3.3.2. Violence	12
3.3.3 Population.....	13
3.4. GIS Analysis	13
3.4.1. Precipitation and Rainfall	13
3.4.2. Bivariate Mapping	14
3.4.3. Statistical Analysis	14

3.4.4. Enga Province	14
3.5. Policy Analysis Framework.....	15
3.6. Limitations.....	15
3.7. Ethics.....	16
4. Results.....	17
4.1. Rainfall Patterns.....	17
4.2. Violence Patterns	20
4.3. Spatial Overlap.....	23
4.4. Temporal Trends.....	25
4.5. Enga Province Analysis	26
5. Discussion	29
5.1. Analysis and Implications.....	29
5.2. Research Question 1 – To what extent is extreme rainfall associated with increased tribal violence rates in PNG?	29
5.3. Research Question 2 – Have current climate policies and proposals effectively addressed rainfall-induced inter-tribal tensions in PNG?	31
5.4. Research Question 3 – What solutions could be introduced to reduce the level of violence?.....	34
5.5. Theoretical Synthesis.....	35
6. Conclusion	36
6.1. Summary of Key Findings.....	36
6.2. Theoretical Contributions	36
6.3. Implications for Environmental Security	37
6.4. Representativeness and Case Study Value	37
6.5. Research Gaps	38
6.6. From Analysis to Action – Future Policies to Integrate.....	38
Bibliography	39
Appendices.....	47

Abbreviations

By order of appearance in text:

PNG – Papua New Guinea

ENSO – El Niño Southern Oscillation

SARV – Sorcery Accusation Related Violence

ACLED – Armed Conflict Location and Event Data

ANU – Australian National University

IOM – International Organisation for Migration

IDP – Internally Displaced Person

Figures and Tables

Figure 1: Map of PNG, p.8

Figure 2: The conceptual pathway of climate-related violence in PNG, p.11

Figure 3: A topographic map of PNG, p.26

Figure 4: Decadal mean precipitation, p.28

Figure 5: Annual violence rates, p.31

Figure 6: A bivariate overlay of precipitation and violence, p.33

Figure 7: A province-level scatter plot comparing precipitation and tribal violence, p.35

Figure 8: Violence and precipitation incidents in Enga Province, p.37

Figure 9: The PNG government's Sustainable Development Roadmap, p.43

Figure 10: PNG's progress towards achieving its SDG goals, as of 2024, p.43

Table 1: Location of tribal violence incidents in PNG between 2018-22, p.10

Appendices

Appendix 1: Decadal precipitation averages (mm), p.47

Appendix 2: Tribal violence annual data (incidents/10,000 people/year), p.48

Appendix 3: Provincial violence and precipitation data, p.49

Appendix 4: Ethics self-assessment form, p.50

Map of Papua New Guinea



Figure 1: Provincial map of PNG (World Atlas, 2026)

1. Introduction

1.1. The Problem

In 2024, Enga Province was struck by a devastating landslide that buried over 2,000 people and caused immense infrastructural damage (IFRC, 2025). It was later revealed that the land surface had been weakened by intense rainfall that had infiltrated the surface for several weeks previously, as stated by both the PNG Prime Minister James Marape, and the Red Cross (Jose and Needham, 2024; Le Monde with AFP, 2024). The landslide displaced an estimated 1,680 individuals (IFRC, 2025), who were forced to move to surrounding areas. Such migration is particularly problematic in PNG's unique sociopolitical context, where contentious land ownership laws and complex inter-tribal relations mean that sudden mass migration can ignite disputes over territories and resources. Indeed, the continuing tribal violence in the area, exacerbated by forced migration after the landslide, was so disruptive that rescue efforts from NGOs like the Red Cross were restricted from accessing the area to provide aid (IFRC, 2025). This restriction of humanitarian NGOs both exacerbated the death toll and deepened the relationship of mistrust between tribal authorities and external organisations.

This dissertation aims to examine PNG's dual vulnerability to high precipitation and internal conflict by assessing possible associations between the two. Understanding this relationship is vital given that climatological factors, particularly extreme rainfall events such as the El Niño Southern Oscillation (ENSO), are becoming more unpredictable (NOAA, 2020). They are also projected to increase in both frequency and intensity under climate change scenario RCP 8.5 (Meinshausen et al., 2011). Therefore, this study explores the unique social situation in PNG, where the presence of over 250 tribes speaking over 800 languages creates a fractious environment where seemingly minor disputes often break out into violence (Paget, 2020). In addition to large-scale tribal clashes over land, tribal violence also includes sorcery accusation-related violence (SARV), where natural disasters are attributed to acts of sorcery and can trigger targeted attacks against women, as well as violence over electoral corruption (Rüttinger et al., 2025, p.3; Wood et al., 2023). The different pathways to violence are

outlined in Figure 2, highlighting that PNG is a country characterised by fragile sociopolitical structures that can easily topple into unrestricted conflict.

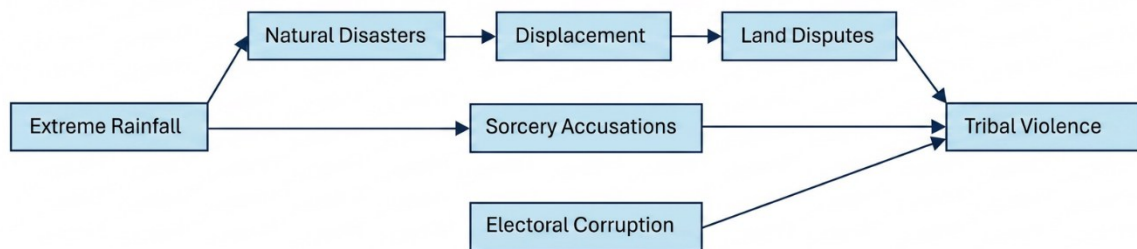


Figure 2: A flowchart showing the conceptual pathway of climate-related violence in PNG

1.2. Research Gap

Existing global climate-conflict studies suggest that extreme rainfall events can intensify such tensions by provoking displacement and weakening fragile state influence in remote regions (Hendrix and Salehyan, 2010). However, much of the existing research concerns the Middle East and North Africa (Petrova, 2022) with little empirical work in the South Pacific. Although PNG offers a unique case study, there is a notable lack of place-specific, quantitative research on climate-conflict mechanisms there due to data collection difficulties and limited international attention (IOM, 2024).

1.3. Original Contribution

In order to address the identified research gap, this study undertakes a province-level, quantitative analysis of the relationship between rainfall and tribal violence in PNG. It uses secondary data on precipitation to demonstrate the change in average rainfall received in the decades between 1980 and 2024. It then carries out a spatial analysis of this rainfall data against incidents of tribal violence, collated from the Armed Conflict Location and Event Data (ACLED) site and data provided by previous analyses of violence from academics at Australian National University (ANU). It uses choropleth maps to visualise the overlap between rainfall and violence hotspots in different provinces in an attempt to identify a link. The analysis then continues on a multi-scale level by comparing the location of individual

incidents of violence in Enga province with the location of the 2024 landslide. This approach, from national choropleths to district-level point mapping, represents a methodological first in PNG climate-conflict research as previous studies have not employed such a spatial analysis (Forsyth, 2024; Rüttinger et al., 2025). Building on this empirical foundation, the study then evaluates existing policies designed to mitigate the impacts of both extreme rainfall and violence. It then draws on observations gained from the spatial and policy analyses to propose solutions specific to PNG and its provinces in an attempt to reduce tribal violence.

1.4. Objectives

Guided by this aim, this dissertation is directed by the following three research questions:

RQ1 – To what extent is extreme rainfall associated with increased tribal violence rates in PNG?

RQ2 – Have current climate policies and proposals effectively addressed rainfall-induced inter-tribal tensions in PNG?

RQ3 – What solutions could be introduced to reduce the level of violence?

The first research question was tested with the hypothesis that prolonged periods of high precipitation, inclusive of precipitation anomalies, might provoke displacement of people fearing for their livelihoods and then contribute to tribal violence through increased land disputes (Figure 1). The research uses a Geographic Information System (GIS) analysis with bivariate mapping techniques to reveal co-occurrence patterns across multiple different scales in a systematic attempt to prove an association between the two factors.

The second research question was answered with a detailed policy analysis of the current PNG '30 by 30 Sustainable Development Roadmap' and potential policies proposed by Rüttinger et al. (2025) through Adelphi Research. They were evaluated against feasibility criteria including budgeting and local agency to determine the actual viability of their solutions being achieved.

The third research question is informed by a detailed judgement derived from the information provided by RQ1 and RQ2. A response to this seeks to fill in the blanks left by the current policies. It aims to tailor climate-conflict solutions to the unique Papua New Guinean context with the same feasibility criteria as the policy analysis used with RQ2.

These research questions present a nuanced consideration of the climate-conflict relationship in PNG with the aim that conclusions drawn from each question can be used to reduce preventable loss of life by informing more context-specific policy responses.

1.5. Dissertation Overview

Chapter 2 provides a comprehensive review of relevant literature, starting from an overview of climate change and violence on a global scale before focusing on the situation in PNG specifically. Chapter 3 reviews the methodology of the dissertation, focusing on research design and then delving deeper into data collection and how it was processed to be mapped using GIS software. It also includes a framework for responses to the three research questions and how they were affected by data limitations. Chapter 4 uses GIS to present five separate figures displaying a multi-scale analysis of the relationship between extreme rainfall and violence in PNG. Chapter 5 uses the findings from the GIS analysis to answer the three research questions. Chapter 6 concludes the dissertation by summarising the findings, emphasising the research's contribution to broader academia and outlining recommendations for future research and policy.

2. Literature Review

2.1. Climate Change

International climate change policy, driven by the Intergovernmental Panel on Climate Change (IPCC), has often been critiqued for its Eurocentric perspective (Wagner and Hornidge, 2025). Wagner and Hornidge posit the idea of ‘unlearning Eurocentric modernity’ in academic research in order to better incorporate the work of marginalised scientists from marginalised countries. Although such ‘grey literature’ (Ibid.) does not garner the peer reviews that mainstream scientists attract, it remains methodologically valuable. This study aims to integrate both peer-reviewed and grey literature from a range of sources to provide a nuanced viewpoint on the effect of extreme rainfall on tribal violence in PNG.

Moreover, less economically developed countries like PNG bear a disproportionate amount of the impacts of climate change, caused by increased emissions from more economically developed countries. Indeed, the 10 highest emitting countries account for 60% of global GHG emissions (Filonchyk et al., 2024). This is combined with the current lack of success of international agreements to slow global warming, with the 1.5°C maximum temperature increase proposed in the 2015 Paris Agreement now thought to be increasingly unattainable (King, 2025). However, while Filonchyk et al. provide some effective global warming mitigation strategies for high GDP countries, their conclusions support Wagner and Hornidge’s view that academia experiences a heightened Eurocentric bias. This is due to Filonchyk et al.’s failure to demonstrate how such strategies could be transferred to lower income countries without significant financial aid. The impacts of global warming have been felt particularly hard in the Southwest Pacific as the extreme rainfall events caused by ENSO have been occurring more frequently and with greater intensity, placing countries like PNG at an elevated risk (SPREP, 2023). This creates conditions well suited for empirical testing of the climate-conflict hypothesis.

2.2. Global Climate-Conflict Linkages

While this research localises the effects of extreme rainfall on intergroup violence in PNG, it is first important to analyse the concept on a holistic, global scale. This is reflected in Xie et

al.'s 2024 meta-analysis of literature concerning a potential link between the two identifying migration as a primary climate-conflict pathway in areas receiving migrants. They describe how the likelihood of terrorist attacks resulting from extreme weather events increases when the natural disaster significantly weakens one of the parties involved, causing them to rebel to try and achieve parity (*Ibid.*). This is compounded by Petrova's (2022) research highlighting that conflict can occur as a result of ineffective disaster relief on the part of the government. However, Xie et al. overlook the critical feedback loop that pre-existing conflict can amplify disaster impacts by preventing the effective delivery of relief and aid, as evidenced in the 2024 Enga landslide (IFRC, 2025). The study actively states that potential links between climate change and conflict have been identified, but that more place-specific focus is needed, especially in regions that are vulnerable to climate change. This underlines the research gap that this dissertation aims to fill as it provides a localised focus to connect rainfall, migration and violence.

While the gap in research is evident, filling it is made more complex by the difficulty of accurately predicting migration and the complexity of climate change projections, particularly in remote areas (Burrows and Kinney, 2016). As such, it is challenging to comment on a global trend due to the place-specific nature of the debate. That being said, Reuveny (2007) qualifies Xie et al.'s claim by showing that areas that depend more on the natural environment for their livelihood will experience more environmental migration. He also states that conflict results from migration due to immigrants being viewed as the 'other' and that the perceived risk of immigrants to socioeconomic security can be enough to provoke violence even if the actual risk is low. Slettebak (2012) also supports this theory and adds that violence in the wake of natural disasters generally occurs in highly politically unstable countries that lack sufficient governmental power to maintain peace. This is relevant to PNG, where the decentralised government has increasingly less influence in maintaining peace between tribes in remote highland areas (Lakhani and Willman, 2014, pp.7-8).

2.3. PNG Rainfall Vulnerabilities

PNG therefore emerges as high-risk for both extreme precipitation and conflict, yet quantitative research there remains scarce, making it an ideal focus for this study. Rainfall anomalies trigger a cascade of impacts, such as landslides and flooding, that pose a threat to life and infrastructure whilst degrading water quality, decreasing agricultural productivity and increasing the risk of waterborne disease (Papua New Guinea Red Cross, 2024). Inland river flooding in PNG affects 22-26,000 people annually and costs the country between \$8-12 million USD in damages (PNG Office of Climate Change and Development, 2014). Moreover, as 85% of the population live in rural areas (World Bank Group, 2024a) and 85% of that rural population depend on subsistence agriculture for food and income (USA International Trade Administration, 2024), the wellbeing of the vast majority of Papua New Guineans depends on a stable climate to support agricultural production.

The World Bank Group's 2021 climate risk assessment confirms PNG's acute rainfall vulnerability, stating that 18% of its landmass is either permanently or regularly inundated. This biophysical situation is verified by PNG's ND-GAIN index of 166 (of 186 countries ranked by climate change vulnerability and resilience (University of Notre Dame, 2023)) and its poverty rate of 52.21% (World Bank, 2009) alongside the government's narrowing sphere of influence. The report reveals PNG's unique vulnerability to the effects of climate change but acknowledges that there is a significant lack of reliable data on social vulnerability. It also recognises that models normally used to predict annual precipitation fail to account for the increase in climate variability caused by ENSO, which has an intense effect in PNG. Its recognition that long-term prediction is difficult ensured that this dissertation only used existing precipitation data so as not to base any proposed solutions on unreliable future climate projections.

This paper was expanded on by Ashton et al.'s 2024 study which highlighted how political instability can exacerbate climate change vulnerability, particularly in the South Pacific. It describes the ingrained history of conflict in the area, stemming from years of colonial discontent. It underlines how extreme rainfall and sea level rise have blurred boundaries between different tribes, causing more land disputes and worsening violence in the Enga province. This in turn leads to emigration from areas perceived to be dangerous.

2.4. Displacement Pathways in PNG

Rainfall contributes towards migration out of high-risk areas in PNG, causing friction in the host areas they move to, which in turn causes intergroup violence. The International Organisation for Migration's (IOM) 2024 Displacement Overview recorded a total of 30,970 Internally Displaced Persons (IDPs), 71% of which were from natural hazards (38% from flooding) and the remaining 29% from conflict (IOM, 2024). However, as the IOM has to rely on testimonies from people, their results are limited by 'social desirability bias' as respondents may have altered their replies to try and solicit humanitarian aid. Moreover, infrastructural damage from both flooding and violence restricted access to data collection in some areas.

Perhaps the most illuminating paper on climate change and violence in the country is Adelphi Research's 2025 Climate Peace and Security Assessment. While it identifies six pathways which link climate change to insecurity, this study focuses specifically on displacement as the primary mechanism linking extreme precipitation to tribal violence. As a result of the country's enduring colonial legacy, 97% of land is under customary tenure, meaning that people lack formal land ownership titles and can lay claims to other land (Antonio and Griffith-Charles, 2019). This is compounded by heavy rains erasing traditional boundary markers, so people often settle on land claimed by others without realising. The assessment provides an insightful look into the culture around migration in PNG. It underlines that not only is there a lack of available land for resettlement, but also a lack of acceptance of IDPs from host areas as they are often refused access to education and healthcare. From a financial perspective, the state consistently finds itself in debt caused by disasters as any (limited) money available for resettlement is used up on initial recovery costs from disasters. Evidently, the country finds itself in an inescapable cycle of natural disasters and debt such that it does not have the financial capability to manage the resulting displacement on a local level.

2.5. Tribal Structures in PNG

PNG's immense social diversity comes with its own complexities as tribes frequently interact, which often results in intergroup violence over land disputes. The aim of such violence is to

‘physically and mentally destroy the enemy’ and has been exacerbated by the modernisation of war and the proliferation of automatic firearms throughout the country (Kobylinski, 2022).

Papua New Guinean culture is governed by a social structure known as the ‘Wantok system’ (Rüttinger et al., 2025, p.18). This refers to how people from the same community support and protect each other, meaning that political allegiance follows kinship and communal ties and elected officials allocate resources exclusively to those who voted for them. This can cause unrest as people feel they have been unjustly treated by their so-called democracy. Furthermore, tribal violence statistics often go under-reported in the press as the state position often differs from the reality. In an example of grey literature vs government propaganda, local scholar Michael Kabuni (2024) reported on violence around the Porgera Mine in Enga Province. He contrasts the police viewpoint that the 2024 conflicts, which resulted in 30 dead, stem from illegal miners’ aggressive behaviour to landowners to the local perspective that violence is complex and can be attributed to land disputes, revenge killings and other misunderstandings. While Kabuni’s language is vague at points, his underlying message that the Papua New Guinean government is not doing enough to tackle the problem rings true. He cites the lack of investment in law and order which is highlighted in PNG’s police to citizen ratio being 1:1,845, well below the UN’s recommended 1:450, although he does not go as far as providing solutions to the problem.

Additionally, to fully comprehend the multifaceted nature of violence in PNG, it is important to touch on the concept of SARV in relation to climate change. The Adelphi Research Assessment (2025) demonstrates that natives seek to find explanation for natural disasters and blame them on sorcery, leading to targeted violence against women. While it is rooted in the traditional belief that misfortune is rarely random, it is exacerbated by a lack of climate awareness stemming from underinvestment in the education system. That being said, the study does note that attempts to educate on SARV have been ineffective due to traditional beliefs. However, it does not take into account the need for educational reforms and a shift in beliefs to be instigated by members of the community, due to the suspicion remote tribes hold for outsiders.

Indeed, the problem of actually reporting on violence is explained in Forsyth et al.'s 2024 research on attributing data to the problem (Table 1). Similarly to this paper, they analysed newspaper reports between 2018 and 2022 to collect their data. They considered data to be the foundation of the solution to the problem, stating the need to develop 'more robust and long-term systems for generating, analysing, and publicly sharing violence-related data.' However, that is much easier said than done due to a reported lack of trustworthiness in journalism in the nation (UNDP, 2025), particularly regarding reporting on SARV. It also provokes the question as to whether data is really the basis of the solution given the cost of sourcing it and if such money could be better invested into community-based initiatives.

Thus, despite increasing recognition of the relationship between climate change and conflict, existing literature is often focused on the global picture and relies on incomplete data in remote areas. Few studies attempt to quantitatively examine the relationship between rainfall and intergroup violence within Papua New Guinea specifically. This dissertation seeks to address this gap by analysing precipitation data alongside recorded incidents of tribal violence to assess whether extreme rainfall events cause conflict.

PROVINCE	NUMBER OF VIOLENT INCIDENT	PERCENTAGE
Enga	79	28.2
Westen Highlands	53	18.9
Hela	50	1.8
Jiwaka	32	11.4
Southern Highlands	31	11
Eastern Highlands	25	8.9
Chimbu	10	3.6
National Capital District	1	0.4
Total	281	100.0

Table 1: Location of tribal violence incidents in PNG between 2018-22 (Forsyth et al., 2024)

3. Methodology

3.1. Research Design

This study adopts a quantitative, secondary-data methodology using a multi-scale GIS approach to provide a spatial analysis of the relationship between extreme rainfall and tribal violence in PNG. An online qualitative approach was considered, with the potential for approaching local actors for interviews, but this would have presented safety risks for those involved. Moreover, it was deemed unnecessary as qualitative data from interviews would have distracted from the main findings behind the spatial GIS analysis. The multi-scale analysis (from national to provincial to district) offered different perspectives to the testing of the hypothesised link between rainfall and violence across different geographic contexts. This arose as Xie et al.'s paper underscored the need for more province-specific analysis to accompany a national perspective. Thus, this research was split into three methodological pillars structured around three research questions in order to present the situation (RQ1), analyse the policies surrounding it (RQ2) and offer a pragmatic solution design to suitably resolve the problem (RQ3).

3.2. Topic Selection

The selection of PNG as a case study emerged from a systematic literature review of the wider debate about a potential relationship between climate change and conflict. This uncovered that most of the research centred around conflicts influencing high-GDP countries in the Western world (Reuveny, 2007) and that there was a significant gap in research regarding Pacific Island Nations where climate change poses a very real threat given their geography (Xie et al.). Particularly within the Melanesian context, where its many different languages and tribal groups create an unparalleled ethnic diversity, PNG offered a unique template for testing climate-conflict dynamics outside of the highly researched Middle Eastern and African countries. PNG's weak governmental infrastructure combined with societal structures rooted in the centuries-old Wantok system (Arua and Eka, 2002) that provide deterministic factors that cause violent disputes as well as potentially interacting with extreme rainfall as an environmental stressor to provoke conflict. Therefore, PNG

represented an ideal case study of an interaction between rainfall and violence especially given the abundance of data and literature to consider in an analysis. Furthermore, a preliminary review of news articles and data identified Enga province as a consistent vulnerability hotspot in both reports of natural disasters from high precipitation and extreme tribal violence.

3.3. Data Collection and Processing

3.3.1. Climate

The data collection process relied on the collation of a number of different secondary sources, with the help of academics from the field to supplement existing data. Firstly, the provincial and district shapefiles of PNG were taken from the Pacific Data Hub. The precipitation CRU data was collected from the World Bank Climate Change Knowledge Portal with the help of researchers from the Pacific Data Hub, who were contacted to determine which would be the most reliable source of data (Appendix 1). It contained a range of both precipitation and temperature data but unfortunately as it lacked sufficient data on rainfall anomalies, only the annual precipitation means were used. These were then converted into decadal averages for ease of analysis. However, whilst the data initially appeared complete, upon closer investigation it was revealed that the precipitation values for 14 provinces were exactly the same from 1999 onwards, suggesting a data quality issue. Thus, it was decided to remove them to ensure statistical reliability and avoid misleading comparisons between provinces.

3.3.2. Violence

Data on tribal violence proved more difficult to collect than precipitation data. From a literature review on how previous data was collected, it was decided that a detailed analysis of local newspapers '*The Courier*' and '*The National*' (the only major daily publications in the country) would be the best method of aggregating the location of violence incidents. However, this approach was abandoned due to the fact that the newspapers did not contain geolocational data of the incidents of violence and the immense difficulties in determining the cause of different incidents from very informal reporting. Thus, the decision was made to contact Dr Miranda Forsyth, an academic from ANU who has extensively researched tribal

violence in PNG, who provided links to the ACLED data as well as sharing her own data from 2020 on locations of violence in PNG. This data was then filtered to isolate general violence to only select reports that referred to intergroup disputes, electoral violence and SARV. It was then recorded according to ACLED protocol as individual incidents, as opposed to fatalities per incident (apart from data in the Enga province). While the ACLED data, supplemented with ANU data, only dates back to 2020, it nevertheless allowed a comparison to precipitation values from the same years. However, as the ACLED data summarises journalistic reports, it must also be noted that differing journalistic presence between provinces can lead to under-reporting of incidents in certain regions.

3.3.3 Population

This violence data was then used in combination with population data to create a standardised metric to compare tribal violence rates between years – incidents/10,000 people/year (Appendix 2). The population data was derived from the 2024 National Census to serve as the most accurate and up-to-date statistics. Attempts were made to adjust the population figures to conform to the same year as the violence statistics, but accurate year-by-year data was not readily accessible, and the census was deemed to be the most accurate population record. As such, the raw data required extensive processing so it could be prepared for spatial analysis.

3.4. GIS Analysis

3.4.1. Precipitation and Rainfall

Having assembled the raw data, data processing and GIS analysis focused on classifying precipitation and violence metrics for choropleth mapping and implementing a multi-scale GIS workflow to test the spatial relationship between extreme rainfall and tribal violence. Indeed, precipitation means (mm) were classified using 5-class quantiles (in addition to provinces with no data being shown by a white shading) while violence rates employed 5-class equal intervals to highlight Enga as an outlying province. The red and blue colours were chosen to reflect the respective variables and provide an easily differentiable spatial comparison. In the same vein, a choropleth was used to analyse the violence metric instead of a point map, which would have been overly complex to view on a national scale.

3.4.2. Bivariate Mapping

Figure 6 involved the bivariate mapping of the precipitation data against violence data for the years 2020-24. This was achieved using the bivariate mapping tool in QGIS whereby a positive relationship between the two factors would be seen with a purple colouration. This bivariate overlay was also displayed with a 3x3 classification, simplified from a 6x6, in order to improve legibility. It also aided in clearly outlining Enga province as the primary area of positive association in the overlay.

3.4.3. Statistical Analysis

A simple statistical analysis was then carried out to test the relationship between provincial rainfall and tribal violence rates across PNG. This involved plotting annual average precipitation against violence incidents/10,000 people/year for certain provinces (that had both sets of data for 2020-2024) and fitting a linear regression line to analyse a potential trend in results (Appendix 3). The analysis was useful at drawing a broad conclusion on the relationship as well as for analysing the deviation of the data from a linear pattern. However, it is important to note that this approach was limited by the use of annual averages rather than short-term rainfall anomalies, meaning that localised extremes may have been masked. The fact that it is a statistical instead of spatial analysis also may conceal variation on a smaller, district-level scale. Therefore, it was also necessary to undertake a district-level analysis of Enga province itself.

3.4.4. Enga Province

A point-based analysis of Enga province, the national precipitation and violence hotspot, was conducted using ACLED event data from 2021-2024 as the 2020 data lacked geographic coordinates. Violence incidents were geolocated and classified by fatality count, shown in the different sizes of the red spots marking each incident, to display a visualisation of clustering patterns. A second map was then created, marking the May 2024 landslide as a blue spot and only marking the violence incidents that occurred after the event to assess a temporal and spatial proximity. This more localised mapping allowed the pinpointing of individual violence events in relation to rainfall anomalies on a much smaller scale, feeding into the policy evaluation framework.

3.5. Policy Analysis Framework

A systematic policy analysis framework was deployed in order to provide a well-rounded response to RQ2 and determine if PNG's current climate strategies could effectively mitigate rainfall-induced climate tensions. As such, the government's '30 by 30 Sustainable Development Goal Roadmap' was analysed alongside the policies proposed by Adelphi Research to simultaneously tackle climate change and violence. These two documents were specifically selected as they provided the most comprehensive examples of official national policy and NGO climate-conflict analysis that related to both variables.

Indeed, these two documents were extensively evaluated across five dimensions. These included economic feasibility, social structure sensitivity, community agency of decision-making, local rather than national applicability and integration of the empirical findings from RQ1. This evaluation identified notable implementation barriers, providing a baseline to develop a response to RQ3.

3.6. Limitations

This study has several limitations that should be acknowledged. Firstly, no in-person fieldwork or interviews could be conducted due to the significant safety risks associated with data collection. As a result, the quantitative spatial analysis in this paper depends on secondary sources rather than primary qualitative evidence. Additionally, the remoteness of the highland areas in the country means that data is limited and as the tribal violence data is derived from newspaper sources, it is possible that greater journalistic presence in certain areas skews the data to increase the violence rates in some provinces more than others. However, from the fact that the ACLED data has become more comprehensive and available from 2021 onwards, the ease of data collection appears to be on an upwards trajectory for the future. Furthermore, the GIS approach (despite some precipitation data gaps) provides a never-before undertaken spatial analysis of the relationship between violence and rainfall across multiple scales. While it cannot provide accounts of the lived experience that qualitative data may have offered, it helps identify broader patterns across PNG and its provinces to provide detailed responses to the research questions.

3.7. Ethics

Ethical approval was not required for this project (confirmed after consultation with several members of the University of St Andrews Geography department) due to its sole use of secondary, quantitative data. No interviews were conducted and as such no personal data was used. See Appendix 4 for an ethics self-assessment.

4. Results

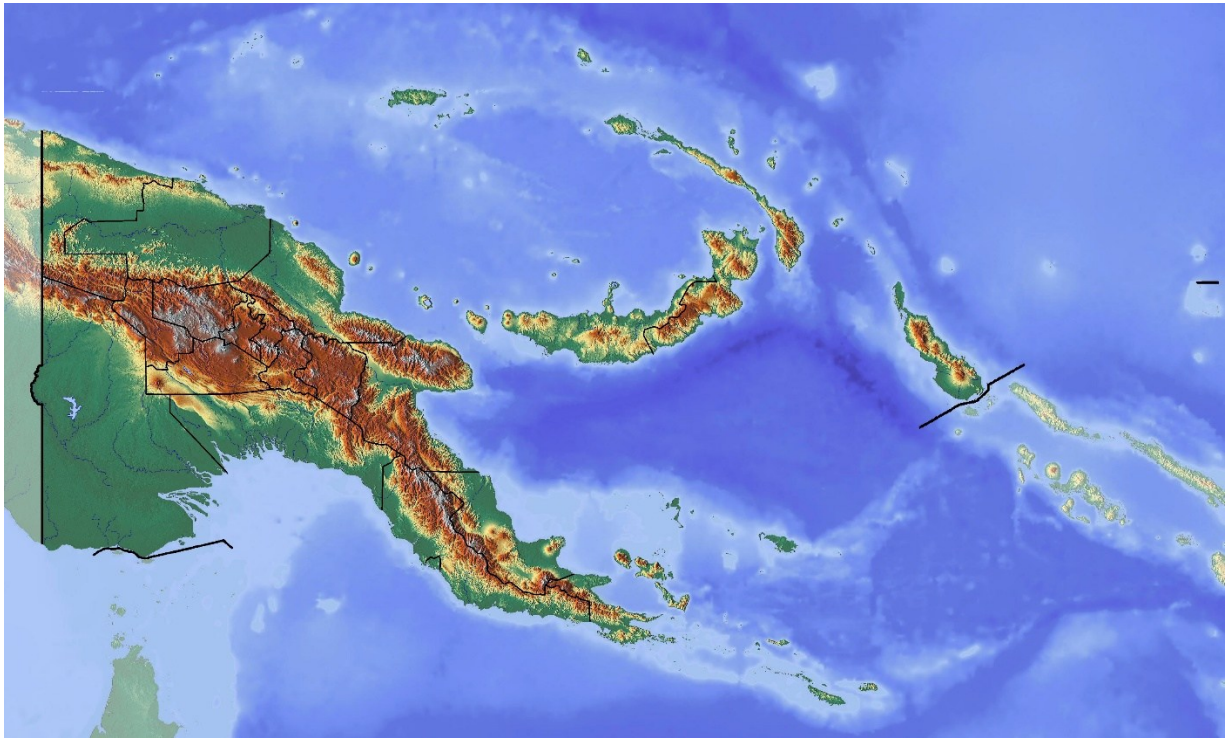


Figure 3: A topographic map of PNG (Mapsland, 2019)

4.1. Rainfall Patterns

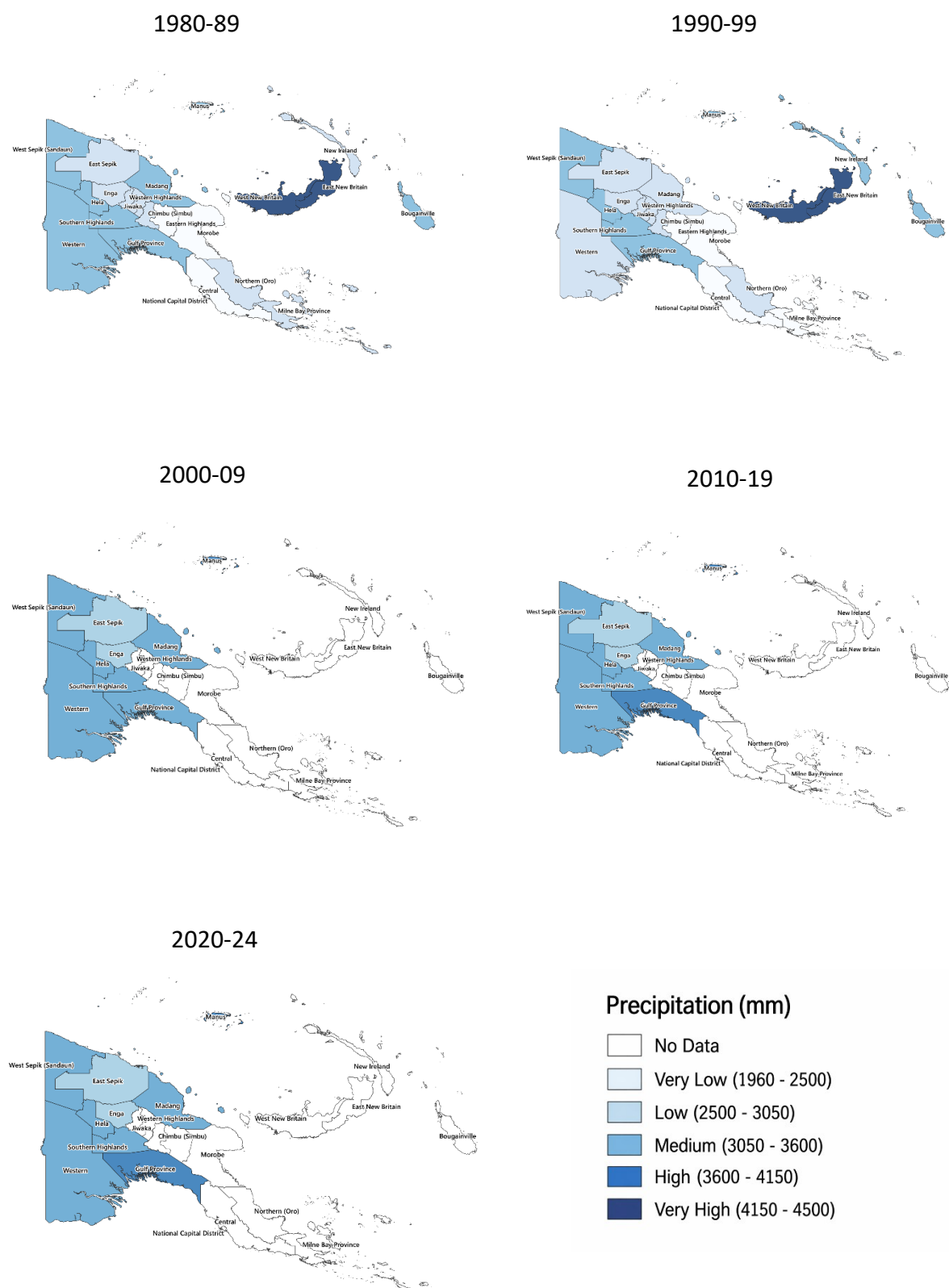
Figure 4 presents a time-series choropleth map of average decadal precipitation on a provincial level in Papua New Guinea for the five decades between 1980 and 2024 (the largest range available). The data was taken from the Climate Change Knowledge Portal after consultation with a member of the Pacific Data Hub support team. However, due to identical values in Southeastern provinces post-2000—likely data quality issues—these areas are mapped as white ('No Data') to maintain analytical integrity. The valid data was classified using a five-class quantile scheme from light blue (lowest precipitation) to dark blue (highest).

The maps reveal a general trend of a countrywide increase in precipitation, while there is a pronounced west-east disparity as the highland provinces receive a far greater amount of rainfall than the rest. Hela, Southern Highlands and Madang regularly receive over 3,100mm of rainfall annually due to their high-altitude geography and the resulting orographic lift that

occurs as moist equatorial air rises over mountainous terrain (Hossain and Pielke, 2019). This can be seen when comparing the precipitation choropleths (Figure 4) with the topographic map of the country (Figure 3). Additionally, this is contrasted with the coastal provinces, such as Milne Bay and the National Capital District, which often receive less than 2,500mm per year. This can be attributed to the rain-shadow effect as heavy precipitation occurs on the windward side of the mountains, meaning areas on the leeward side remain dry (Wee, 2017).

Furthermore, a clear intensification of rainfall emerges in the 21st century. The 1980s and 90s demonstrate that higher rainfall is confined to the mountainous spine of the country and the island of New Britain, while from 2000 onwards, larger portions of Enga, Hela and neighbouring provinces shift to the darker classes. National mean precipitation rises by 3.08%, from 3,089.41 in 2000 to 3,184.69 in 2024. This coincides with documented wetter conditions and a 'triple-dip' La Niña event as the weather system occurred three years in a row from 2020-22 (SPREP, 2023).

Figure 4: Decadal Mean Precipitation (mm) in PNG



4.2. Violence Patterns

The spatial distribution and intensity of incidents of tribal violence between 2020-2024 is presented in Figure 5, standardised in the metric of incidents/10,000 people/year to give a reliable method of comparative analysis regardless of differing population size (National Statistical Office of Papua New Guinea, 2024). These were the only five years analysed, due to difficulty in collecting data as ACLED (Armed Conflict Location and Event Data) only analyses news articles in PNG from 2021 onwards (supplemented with 2020 ANU data). The choropleth uses five classes with equal interval breaks (0, 0.08, 0.15, 0.25, >0.25) to highlight extreme outliers, like Enga province, whilst maintaining a basis of comparability between years. Provinces with no incidents of violence are shaded as white, while an increasingly darker colour red indicates higher rates of violence.

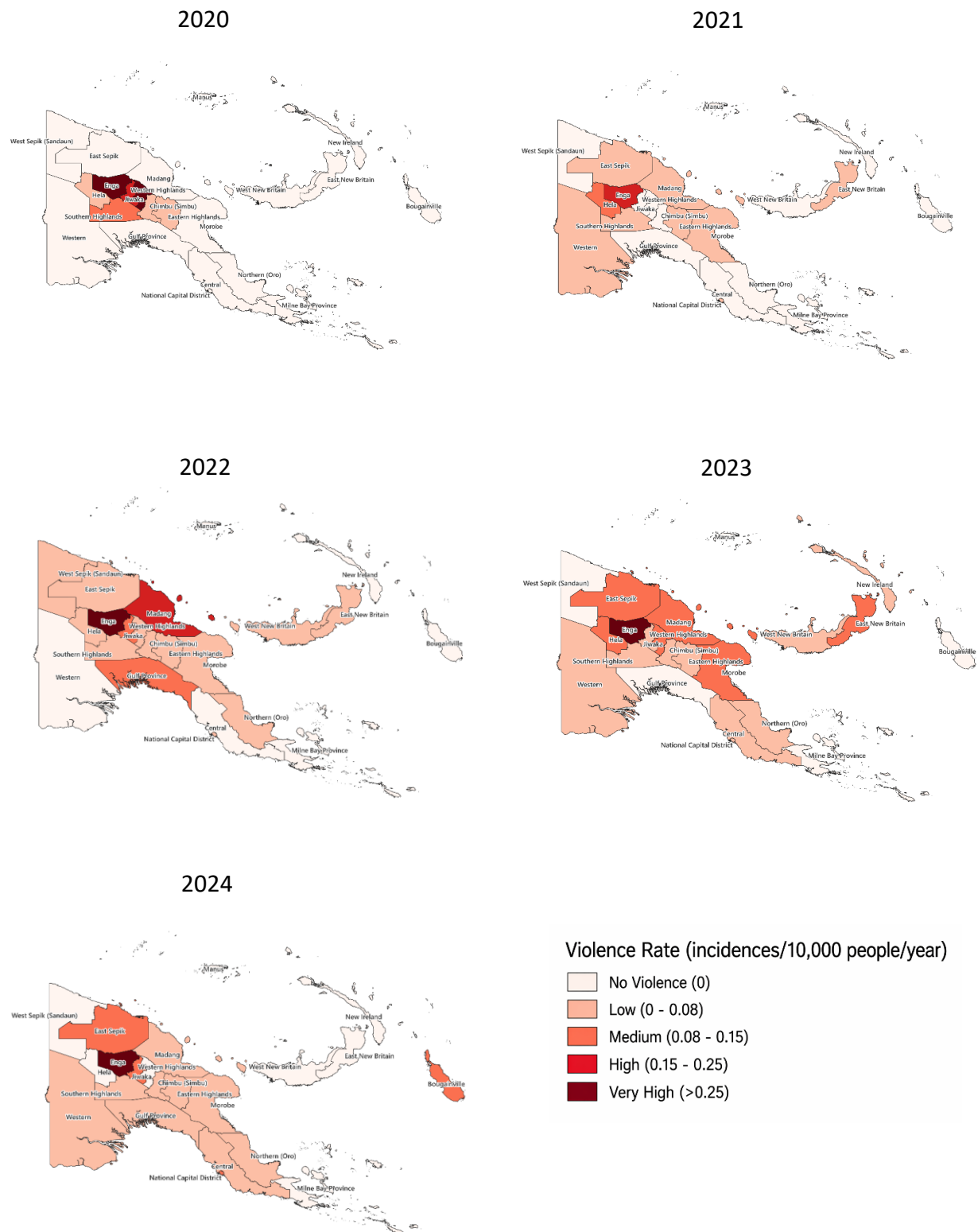
Across all four years, the pattern of violence is highly uneven apart from a hotspot in the highland areas. Enga consistently ranks as the province with the highest rate of violence, being the only province where the rate exceeds 0.25 incidents/10,000 people/year.

Moreover, the adjacent highland provinces of Madang, Western Highlands and East Sepik also experience an elevation in rates of violence over the years, indicating a widening zone of high violence rates around Enga. This is contrasted to the coastal and island provinces, such as Milne Bay, remaining in the 'No Violence' or 'Low Violence' categories. It is also important to note that there are several incidents of violence between tribes from a single province spilling over into other provinces (notably into the National Capital District). Therefore, such incidents are recorded where the violence takes place as opposed to the origin of the parties involved.

Temporally, the maps suggest a sharp escalation between 2020 and 2022, followed by sustained elevated levels. In 2020 and 2021, only Enga and a small number of neighbouring provinces register medium or high rates; by 2022 and 2023 a broad swathe of the northern highlands falls into the upper classes, before a slight contraction in 2024. These patterns support newspaper reports from *'The Courier'* and *'The National'* of intensifying tribal conflict in Enga and spillover into neighbouring provinces, while also highlighting the relative stability of coastal regions. However, it must be said that such maps do not capture outbursts of violence on a district or village level. This compelling evidence of a clustering of violence in the highland regions can be attributed to localised drivers explored in the articles

from which this data is derived, namely land disputes, local elections and SARV. It is also true that such violence interacts with high precipitation rates, something that is exemplified with bivariate analysis.

Figure 5: Tribal Violence Rates in PNG



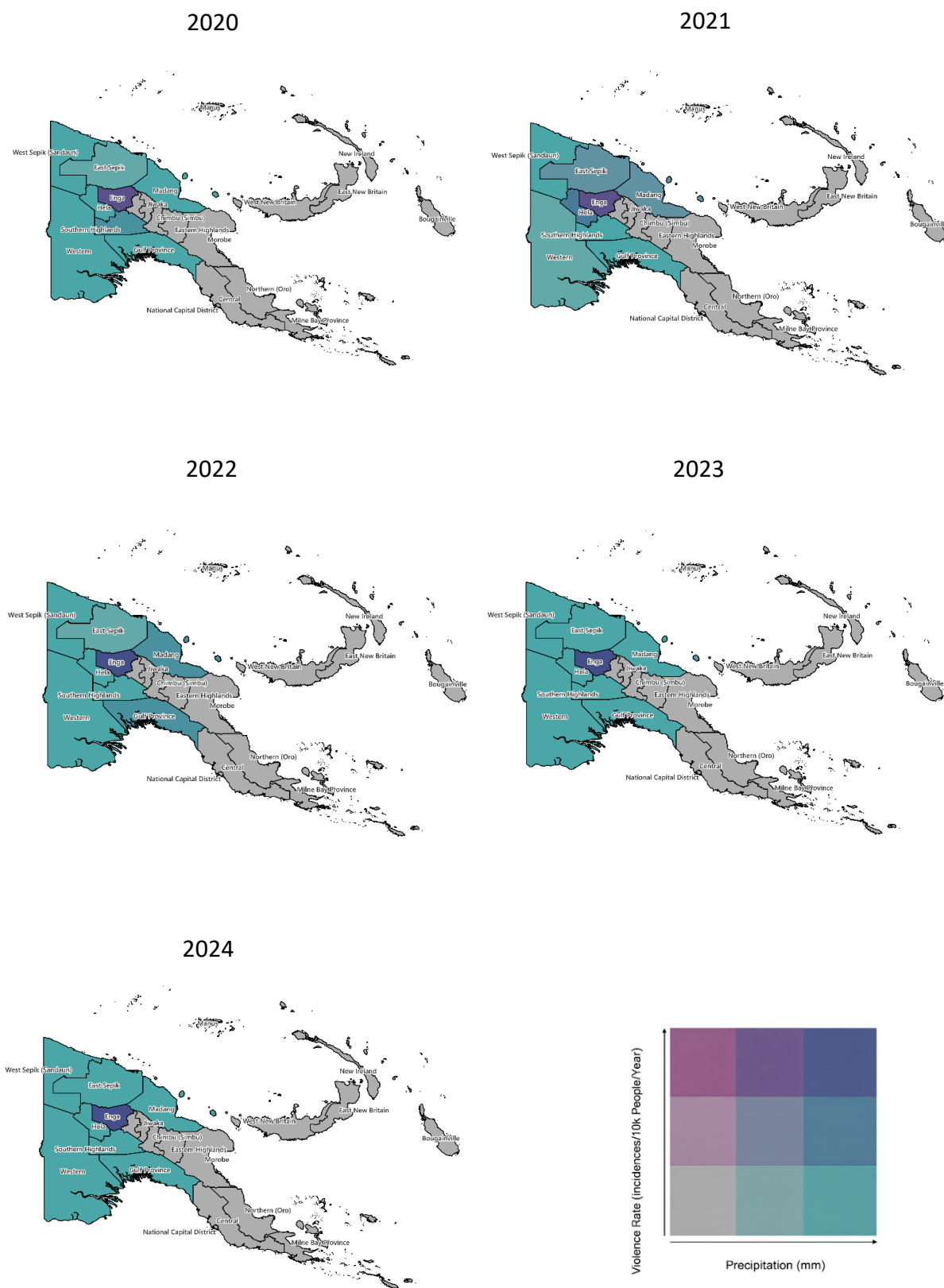
4.3. Spatial Overlap

Figure 6 advances the analysis of the first research question, regarding the exploration of a link between rainfall and violence. Thus, the violence maps in Figure 5 were overlaid with rainfall data (again taken from World Bank, 2024) from 2020-24. This allows a visual analysis of how the patterns in both datasets correspond to each other. The two variables were overlaid using a bivariate tool in GIS, with a light blue colour indicating high precipitation, purple indicating high levels of violence and a shift towards a dark blue showing where the two positively interact and both are high. In this case, only three classes of data were used instead of six in previous maps. This was done to minimise confusion between excessively similar colours. The data again excludes Southeastern provinces, where there is violence data but no rainfall data, to ensure a reliable basis of comparison.

Across all five years, Enga province appears as the most significant area of interaction between violence and rainfall, indicating that violence is not just randomly spread across the country but centred in certain high-risk provinces. The spatial trend of the highland areas being affected by both violence and rainfall is furthered to a lesser extent by the correlation shown in provinces surrounding Enga, namely Gulf Province. In contrast, coastal and island provinces remain largely unchanged and are mostly represented in the same neutral colours throughout the series, showing comparatively lower levels of violence.

Again, while this map only highlights average annual rainfall instead of short-term anomalies, the sustained presence of Enga as a province that ranks highly in both factors is important as it underlines a persistent problem. It could indicate that continued heavy rainfall exacerbates local disputes and causes tension to rise over a longer period of time. This supports the argument that violence in the region is deeply rooted in social and political structures, rather than being caused by one-off extreme weather events alone. Thus, this figure suggests that while rainfall may not be the sole driver of violence, it may act as an important amplifying factor in already fragile conflict zones such as Enga, where environmental stress and existing social tensions intersect.

Figure 6: A Bivariate Overlay of Precipitation and Tribal Violence in PNG



4.4. Temporal Trends

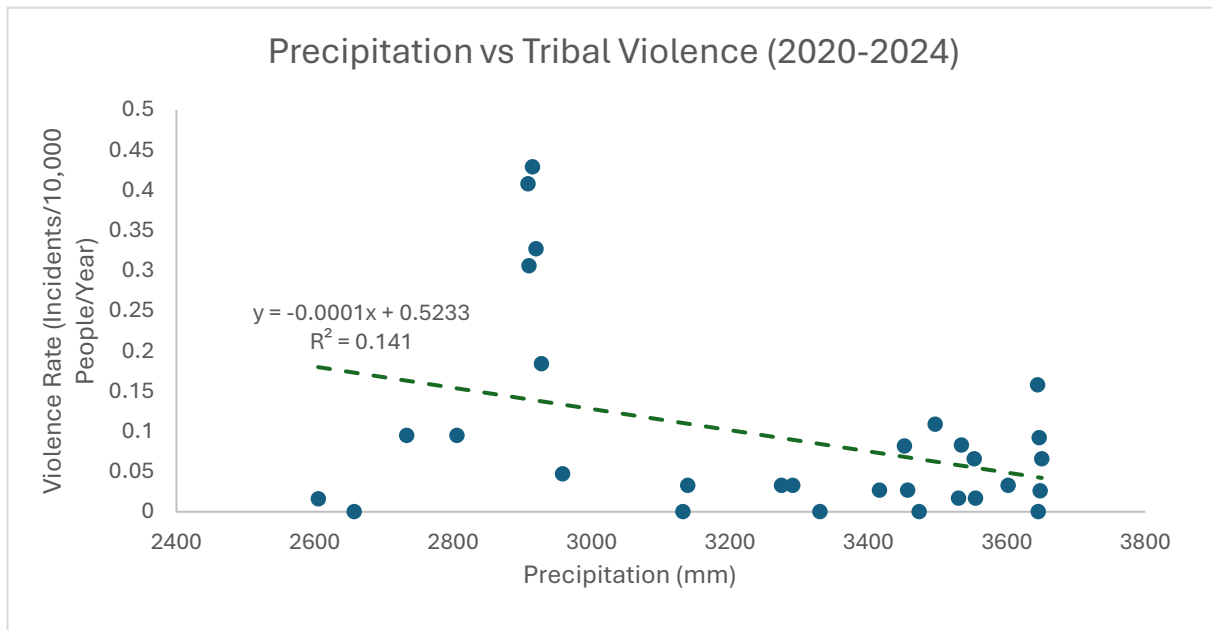
The relationship between extreme rainfall and tribal violence is further explored in Figure 7, which displays a scatter plot of provincial violence rates against annual precipitation between 2020-2024. Each point represents the provincial rainfall-violence situation in a given year, with the x-axis showing the annual precipitation in mm and the y-axis recording the violence incidents/10,000 people/year. This allows a visual assessment of RQ1 analysing the extent of the association between the two factors. Furthermore, provinces with invalid precipitation data and/or no recorded incidents of violence were excluded to avoid distorting the results.

The scatter plot shows a wide range of values, with no evident trend to be easily drawn. There is a large cluster of observations close to the vertical axis, across a range of precipitation values. Several provinces experience rainfall classified as Medium – High on Figure 4 (greater than 3050mm per year) while recording less than 0.05 incidents/10,000 people/year, thus indicating that precipitation alone is not a significant enough driver to cause elevated levels of violence. Moreover, as violence rates increase beyond 0.15 (classified as Medium – Very High on Figure 5), rainfall values remain constant between 2900-3100mm and do not reach precipitation levels classified above Medium.

The regression line slopes slightly downwards, with a regression equation $y = -0.0001x + 0.5233$ with an R^2 value of 0.141. While statistically significant ($p=0.041$), the low R^2 value of 0.141 indicates only a weak linear association between annual precipitation and recorded violence rates, and the wide scatter of points around the line confirms the weakness of this relationship.

Thus, the scatter plot supports an interpretation in which extreme rainfall interacts with, but does not directly drive, tribal violence. Moreover, this scatter plot analyses overall average precipitation, rather than individual anomalies and so only comments on a general trend. Therefore, while more localised patterns of rainfall and violence may exist, a provincial-level analysis is still too large-scale, and it is instead necessary to zoom in to individual events of extreme rainfall and violence on a district level to prove a link. This is particularly relevant in the Enga province, where violence rates are the highest in the country.

Figure 7: A Province-Level Scatter Plot Comparing Precipitation and Tribal Violence

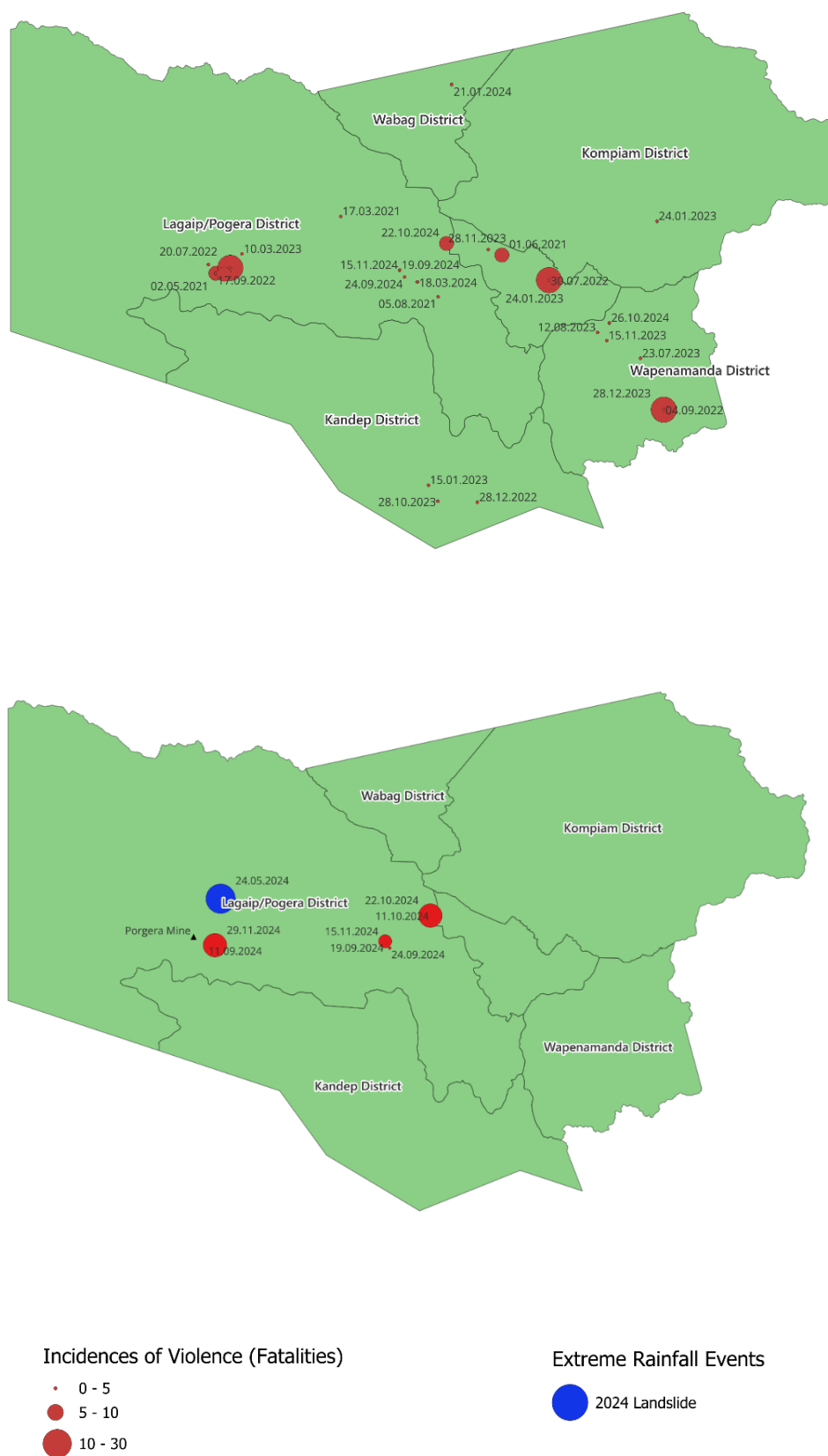


4.5. Enga Province Analysis

Therefore, a district-level analysis of the Enga province was undertaken in an attempt to provide the answers that a country-level perspective could not. From the national analysis (Figure 6), it is clear that Enga is the province most vulnerable to both violence and rainfall. As a result, Figure 8 analyses the Enga province and its districts in greater detail using two separate maps. The upper map displays individual incidents of violence across Enga province between 2021 and 2024 (2020 was excluded in this case due to a lack of geographic coordinates for the incidents of violence collated). It reveals a clear concentration in the Wabag and Lagaip-Porgera districts, with a range of incidents taking place there across the years. The size of the red spot denoting each incident corresponds to the fatalities that occurred, with the largest spots representing up to 30 fatalities. Indeed, the spots are clustered around villages and other infrastructure hubs, notably the Porgera gold mine, which highlights how disputes over land can play out over several years. Moreover, many of the clusters of smaller spots with fewer fatalities also occur within a month of each other. This underlines the cultural obligation of revenge killings, whether the original incident was due to SARV, land disputes or electoral violence.

In order to try and respond to RQ1, the bottom map tries to actively link incidents of extreme rainfall to tribal violence. It zooms in further on the Lagaip-Porgera district alone to plot the landslide of May 2024, caused by ground made unstable by weeks of heavy rain (Le Monde with AFP, 2024). The landslide is presented as a blue spot, among the red spots of violence incidents that occurred after the date of the landslide. However, the map presents no clear spatial-temporal relationship between the blue and red spots due to the physical distance between them and the gap in time between events. This underlines the results from Figure 7 that imply that extreme rainfall (whether that be anomalies or annual mean) is not the principal cause of tribal violence. The fact that so many of the incidents are clustered around land dispute hotspots like the Porgera gold mine implies that societal structures (derived from the Wantok system) are a greater cause of violence, although it is again true that such tensions could be exacerbated by environmental stressors. Moreover, data limitations do persist due to the remoteness of the Highlands and the danger of collecting data. That being said, this mapping does set the stage for the discussion, where these rainfall and violence patterns are contextualised against policy analyses to try and provide an adequate solution to the problem.

Figure 8: Violence and Precipitation Incidents in Enga Province (2021-24)



5. Discussion

5.1. Analysis and Implications

The GIS analysis undertaken has pointed to the likelihood that extreme rainfall cannot be isolated as the definitive cause of tribal violence in PNG. While there were some issues in interpreting the data due to inaccuracies, the overall trends remain evident, and the spatial analysis was not dramatically affected by the missing data values. The overlaid maps (Figure 6) did display a positive spatial association in certain provinces. However, Figure 7 results, while statistically significant ($p=0.041$), show a weak R^2 value of 0.141 that suggests annual precipitation explains only 14.1% of violence rate variation. This indicates that rainfall acts primarily as an amplifier of pre-existing social tensions rather than a primary driver. This could be attributed to unreliable data, but the fact that no strong relation was found over four different types of mapping implies that rainfall alone insufficiently explains tribal violence patterns. Indeed, the district-level analysis of Enga province showed a lack of association between the 2024 landslide and violence incidents later in the year. Perhaps what was more revealing was the violence clusters from land disputes around the Porgera mine, which compounded the findings from the literature review (Kabuni, 2024) that unpoliced territorial disputes often spiral out of control into escalating numbers of revenge killings. These findings illuminate the structurally ingrained and multifaceted problem that the PNG government has to tackle. Indeed, both NGOs (Rüttinger et al., 2025) and the government itself, with its '30 by 30' Climate Change Roadmap, have attempted to introduce policies to mitigate the impacts of both violence and climate change. However, these plans have been met with varying degrees of success and frequently overlook PNG's highly unique sociopolitical context. As such, a response to RQ3 aims to propose novel solutions to effectively combat the dual climate-conflict challenge that the country is fighting.

5.2. Research Question 1 – To what extent is extreme rainfall associated with increased tribal violence rates in PNG?

RQ1, covered extensively in Chapter 4, attempts to formulate a conclusive answer in the search for a link between elevated precipitation and high tribal violence rates in PNG.

However, it is difficult to give a simple response to a question connoted with the deep complexities of Papua New Guinean society. The findings demonstrate that it is challenging to draw a conclusion on the relationship from a national-level analysis due to the unpredictability of local situations. However, this study provides a nuanced multi-scale GIS spatial analysis of the problem that previous papers have not (Rüttinger et al., 2025; Forsyth et al., 2024). While Figures 4 and 5 did highlight that Enga is the best localised case study of a potential causality between the two, a scatter plot (Figure 7) and a close-up spatial analysis (Figure 8) of individual violence and rainfall incidents again did not provide any clear linkages. This implies that extreme rainfall in general, and indeed localised rainfall anomalies, do not solely cause tribal violence. It therefore does not support the hypothesis of a deterministic relationship between rainfall and violence. Indeed, Enga Province's high level of violence stems from a combination of land disputes, political conflict, gender conflict, revenge killings and alcohol (Philips, 2024). This is exacerbated not by rainfall, but by the deterioration of the decentralised government in remote provinces. The ethnically elected local governments lack the funds and willingness to intervene in tribal disputes, while the traditional Wantok system has not been able to effectively manage land disputes created from foreign direct investment in the Porgera mine (Mako, 2023; Swanston and Gunga, 2023). These disputes then spill into violent atrocities due to easily accessible modern firearms with the capability of facilitating genocide (Forsyth, 2024, pp.9-12).

However, the consistent factor in extreme rainfall events is the theme of displacement. This is a metric that is inherently difficult to map in the remote highlands of PNG as people diffuse from one epicentre to all areas of the country (Wiseman, 2025). It can be seen where events of violence between two tribes from one province spill over into a separate province, which skews the mapping of violence statistics away from the origin of the dispute. Thus, while the 2024 Enga landslide, which displaced 1,680 people (IFRC, 2025), could have acted as a stressor for violence as tribes were forced closer together, merging land borders and increasing resource competition, there is no empirical evidence to substantiate this relationship. Additionally, ACLED's data records incidents of violence by location rather than perpetrator origin, which systematically obscures how rainfall-induced migration transfers conflict from rural highlands to urban centres like Port Moresby. This methodological constraint reinforces the finding that while displacement is theoretically plausible as a

transmission mechanism, spatial data limitations prevent empirical confirmation of rainfall as a direct violence trigger. Attempts were made to use the IOM Displacement Tracking Matrix to try and trace displacement pathways across the country, but it lacked detailed location data. As such, this multi-scale GIS analysis shows no direct causal association between extreme rainfall and increased tribal violence rates. Instead, it functions as an amplifier of displacement, which places tension on fractious societal structures created through centuries of internal violence. These findings imply that climate adaptation policy must target a change in attitude towards using violence as the standard form of resolving disputes, instead of targeting climate change policies or land reform.

5.3. Research Question 2 – Have current climate policies and proposals effectively addressed rainfall-induced inter-tribal tensions in PNG?

RQ2 deals with a policy analysis of the existing solutions implemented by the government alongside proposals put forward by NGOs to improve the situation. The policies were evaluated against a feasibility criteria of economic cost, manpower and the realistic chances of success. Several papers considered in the literature review (World Bank, 2021; Rüttinger et al., 2025) underline the unique sociopolitical context of PNG and that a blanket imposition of traditional climate-conflict solutions used in other countries would not translate to PNG. This policy analysis primarily refers to the government's '30 by 30' Sustainable Development Roadmap, initiated in 2020 in collaboration with the UNDP, to deliver 30 solutions to improve responses to climate change from a Papua New Guinean standpoint by 2030 (Figure 9). It emphasises the need to 'unlock climate finance and investment' from foreign investors otherwise there is no hope to actualising proposed frameworks and developing in accordance with the 2015 Sustainable Development Goals (United Nations, 2015). It aims to reduce emissions by 50% and increase rural electrification to 100% of the population, important as the country became a net GHG emitter in 2015 (Government of Papua New Guinea, 2018, p8). However, PNG has actually experienced a regression in terms of their progress towards achieving their 2030 progress goal regarding the SDGs (Figure 10). That being said, this has negligible global impact on climate change with PNG only accounting for 0.02% of global carbon emissions (Ritchie and Rosado, 2025). Moreover, a national

restriction of its approach to mitigate climate change impacts would likely not have a dramatic effect on the elevated rates of tribal violence. In this respect, Adelphi Research's 2025 Climate, Peace and Security Assessment provides an insightful perspective on the usefulness of infrastructural overhaul compared to the community-based approach that the analysis points to.

It provides 21 solutions in total to address the situation, divided between 8 subtopics, but primarily focusing on 'Disaster Risk Management and Displacement Responses', SARV, and what it labels 'Integrated Approaches'. Its plans are extensive and include a step-by-step methodology on how its approaches might be implemented in a clear and concise way, such as educating community leaders and teachers on how to explain climate change in local languages. However, it provides no budget on how such goals might be achieved, while the sheer number of goals and people potentially involved in actualising them appears unrealistic. The thought process of a community-based solution is correct in theory, however achieving all 21 goals would require an immense infrastructural overhaul of the education, housing, law enforcement and data collection sectors and the report fails to clarify who has the agency, manpower or money to carry them out. Evidently, current legislation and proposals have had a negligible impact on climate change and tribal violence rates as the government and NGO's idealistic, underfunded recommendations fail to bridge the gap between national aspirations and the reality of a fragmented social system. Therefore, it is necessary to propose conflict resolutions more tailored to the sociopolitical realities of PNG.

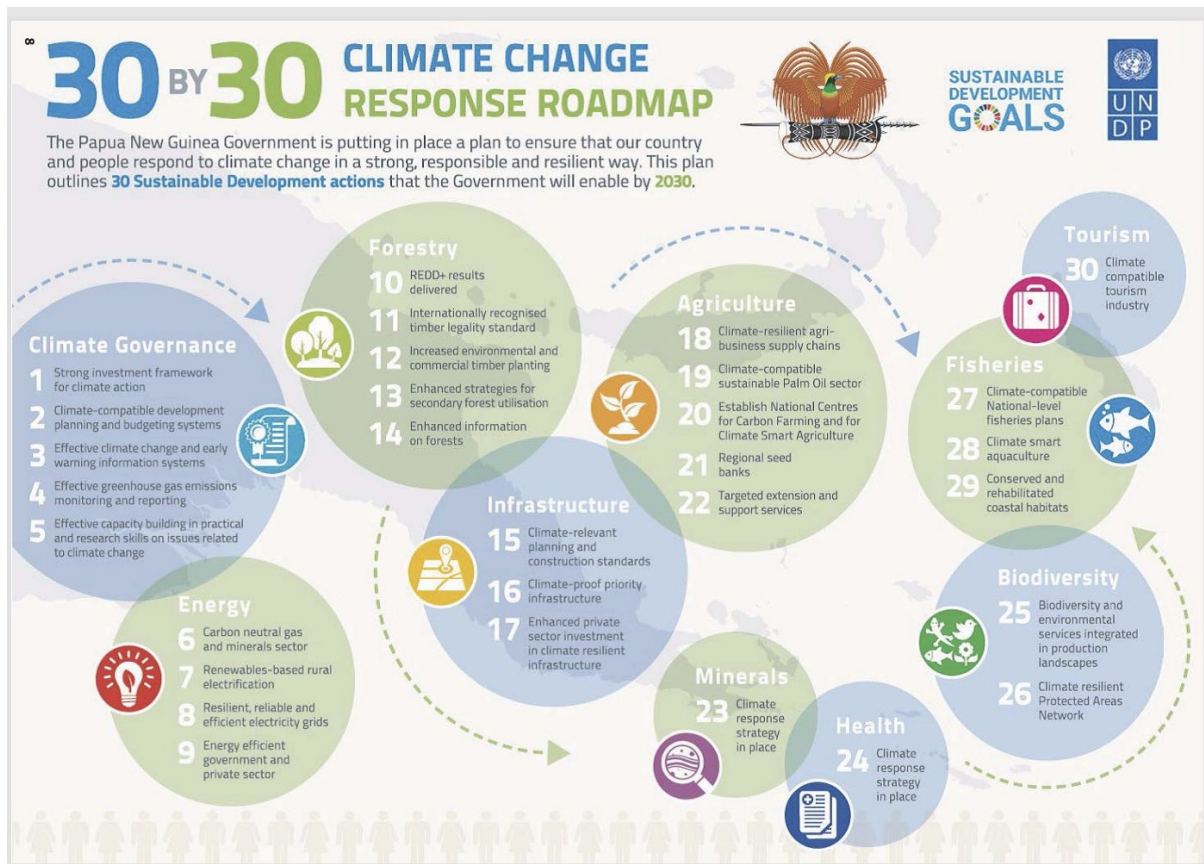


Figure 9: The 30 actions in PNG's climate roadmap to progress towards achieving the SDGs (Government of Papua New Guinea, 2018, p.8)

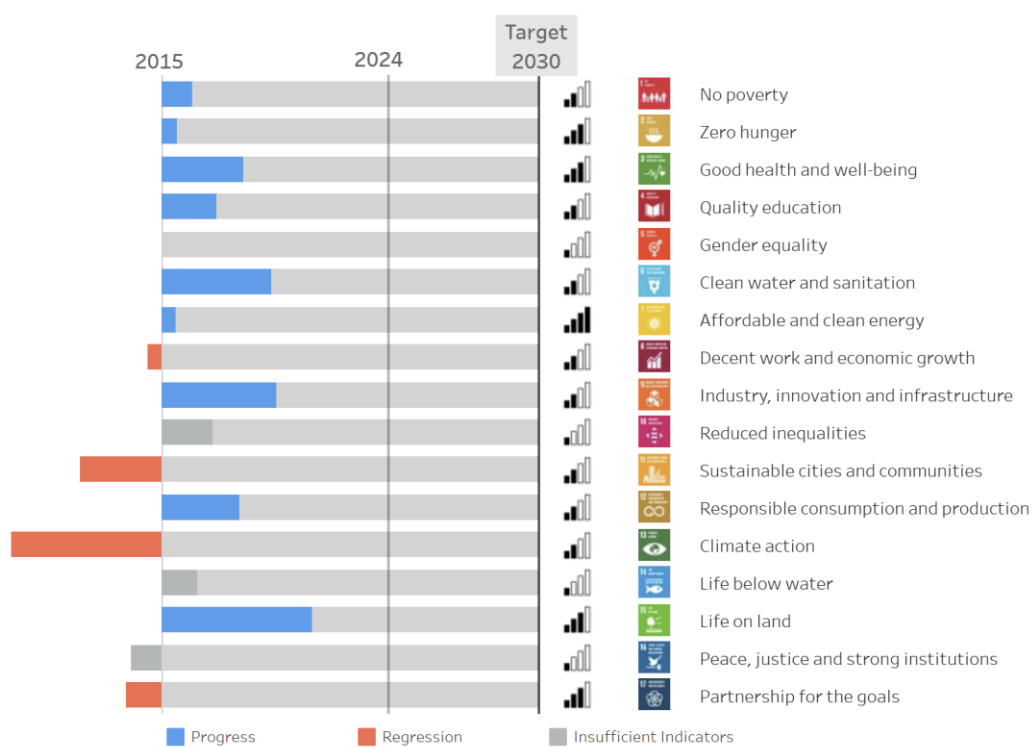


Figure 10: PNG's current progress towards its SDGs (UNESCAP Statistics Division, 2024)

5.4. Research Question 3 – What solutions could be introduced to reduce the level of violence?

RQ3 addresses the significant gaps in the current attempts to solve tribal violence in PNG, whether driven by extreme rainfall or not. It proposes community-led, inexpensive solutions that seek to effect change on the smallest scales in a country where systemic trust of outsiders necessitates local ownership of violence reduction strategies. This was demonstrated in 2021, when mobs attacked health workers trying to disseminate the coronavirus vaccine, as they believed it to have untoward side effects (ACLED, 2021). Due to the corruption and extremely low police to citizen ratio (Kabuni, 2024), especially in remote areas like Enga, it is clear that communities themselves are responsible for changing the situation. The Wantok system has been integral in Papua New Guinean society for hundreds of years and there is no point trying to force change upon it (Arua and Eka, 2002). Instead, the focus should be on tackling the main drivers of violence (namely SARV and land disputes) as well as improving data collection to gain a better spatial understanding of the problem.

Accordingly, the most effective solutions are small-scale and community driven. Moreover, it is necessary to prioritise tackling the drivers of violence that will actualise real change. Indeed, it is evident that tackling SARV and discouraging the use of high-powered firearms would lower violence rates more effectively than introducing land reforms and trying to overturn centuries of legislation and tradition. That being said, the PNG government has recently proposed 'The Customary Land Tenure Act 2026' to safeguard the rights of customary landowners who hold over 97% of the country's land (United Nations Papua New Guinea, 2026; Antonio and Griffith-Charles, 2019). It proposes introducing legislation systems around resolving land disputes and strengthening landowner authority. However, in order to actually enforce legislation, there has to be a government or police presence in the area. As has been repeatedly evidenced, there is very little presence in Enga province and as such the responsibility for enacting change falls to those within the community themselves.

Therefore, due to the institutional distrust in foreigners instilled in Papua New Guinean communities (Diamond and Paulson, 2018), peacebuilding workshops on dismantling myths like SARV would need to be delivered by trusted community leaders. In fact, the Christian

Church is perfectly placed to spearhead such an initiative given it is responsible for 40% of the country's education and 50% of its healthcare facilities (Hauck et al., 2005). It has already been successful in mediating land disputes in Simbu province, where a Catholic priest was initiated into the Nauro tribe and helped negotiate a peace over the disputed Gor mountain (Witne, 2025). Additionally, as it trains many of the country's teachers, educational reform to unlearn SARV can be passed down through the church to the teachers and then to the country's youth. This is especially important given PNG's demographic, where 44% of the population is under 20 (World Population Review, 2024), and the fact that the youth are increasingly responsible for elevated rates of tribal violence due to their tendency to use modern weaponry and disregard of traditional, peaceful methods of solving disputes (Forsyth, 2024). The future of the country's stability rests in the hands of the youth and it is essential that the church and other community leaders interact to help the next generation unlearn antiquated and unjust practices like SARV, particularly in highland areas where violence rates are particularly high.

5.5. Theoretical Synthesis

Overall, this study reveals that extreme rainfall amplifies, rather than causes PNG's tribal violence (RQ1), current climate policies remain disconnected from local realities (RQ2) and community-led interventions offer the only feasible path forward (RQ3). By combining a multi-scale GIS analysis with a place-specific policy review, this paper provides holistic and novel research that demonstrates that extreme rainfall is not the primary cause of tribal violence, which is instead rooted in structural dynamics. Ultimately, reduction of tribal violence requires positive use of integral institutional structures for education, instead of foreign agencies trying to impose thoughtless solutions on an already fragmented government system.

6. Conclusion

6.1. Summary of Key Findings

This dissertation has systematically investigated the presence of a rainfall-violence causal relationship across PNG's 22 provinces revealing spatially heterogeneous patterns that diverge from simple determinism. RQ1 established the spatial distribution of periods of extreme rainfall across the country, identifying Enga as the main co-occurrence between violence and rainfall. However, the district-level analysis rejects a causal relationship between the two factors (Figures 7 and 8). RQ2's policy analysis exposed systemic flaws in both the government's current climate strategies and proposals put forward by academic research. They emphasise unfeasible socio-economic structural overhaul, representing solutions proposed for the sake of proposal instead of realistic, community-based strategies that are needed to suit the highly place-specific needs of the climate-conflict context of PNG. RQ3 posited ways to fill the gaps left by current policy by prioritising the Christian Church to lead a community-based education programme on SARV and the dangers of modern weaponry to aid peacebuilding efforts on a local level. On a macro level, this dissertation finds that extreme rainfall represents an exacerbating factor of tribal violence in PNG, not a deterministic cause.

6.2. Theoretical Contributions

This study makes a novel contribution to the wider field of research around the climate-conflict nexus. It adds to Xie et al.'s (2024) theory that climate change causes migration and then violence against incoming migrants by placing the onus for violence on the social systems of the areas receiving violence as the main trigger, rather than solely blaming climate. It provides a spatial nuance to environmental security theory using a multi-scale analysis that adds to existing research (Gelvez and Bauer, 2025), which only considers the national picture. It calls for such analyses to become the norm in order to avoid national assumptions that are not valid on a regional level, as was demonstrated in Enga Province's position as an outlier in Figure 6 whilst showing a weak relationship in Figure 7.

6.3. Implications for Environmental Security

Climate change under RCP 8.5 (Meinshausen et al., 2011) is predicted to increase the likelihood of rainfall anomalies and extended periods of extreme rainfall, especially given the escalating unpredictability and frequency of ENSO events. This research provides an early warning for other Pacific Island nations of the multifaceted impact that climate change can have on national security. This warning extends beyond the threat of extreme rainfall to sea-level rise, ocean acidification and increased incidents of typhoons – all of which are caused by greenhouse gas emissions to which they contribute a mere 0.02% (World Meteorological Organization, 2024). The growing threat of such events will only act as multipliers to compound existing inter-tribal tension.

It is a very real threat that many nations do not consider in their climate change adaptation plans, as shown in the Papua New Guinean government's policies. Moreover, violence mitigation strategies take decades to unlearn negative behaviours (Schultze-Kraft and Hinkle, 2014) and so there should be a global emphasis on the necessity of a rapid introduction of such initiatives.

6.4. Representativeness and Case Study Value

As previously mentioned, PNG defies a generalisation of conflict-climate mechanisms elsewhere in the world (Rüttinger et al., 2025, p.12). As a result of its unique sociopolitical environment, it challenges conventional perceptions that extreme rainfall causes migration and then conflict. However, the concept of rainfall acting as a conflict stressor is a crucial factor that is representative of the global situation. Similar systems involving environmental conflict stressors do exist elsewhere in the world, such as in Colombia (Gelvez and Bauer, 2025) or Sub-Saharan Africa (Petrova, 2022). As such, PNG remains a valuable case study in a wider context because it helps identify how climate stressors interact with local vulnerability, offering broader lessons for understanding climate-conflict dynamics in other socially fragile contexts.

6.5. Research Gaps

It is true that this research requires further methodological evolution in a way that only primary data collected on the ground could provide. This refers to independent, unbiased actors surveying remote districts to collect accurate data on the causes and dates of violence incidents to aid in the clarification and classification of violence. This would also help to identify the different ethnic groups involved in the case of violence spilling out into other provinces and allow a better analysis of violence incidents clustering around specific sites (such as Porgera Mine).

This reliable violence data would work in combination with district-level satellite data to replace the World Bank provincial aggregates, as well as housing surveys to capture individual displacement pathways and more accurately track the hypothesised natural disaster – displacement – violence mechanism.

6.6. From Analysis to Action – Future Policies to Integrate

Data-wise this research advises the installation of a multipurpose weather station in each district in PNG, to be monitored by trained community leaders, at a relatively modest cost of \$5-10,000 USD per unit (NiuBol, 2026). As such, improved data on both fronts combined with the policy improvement recommendations outlined in the response to RQ3 would greatly ameliorate the socio-political landscape for years to come, especially in the face of the growing threat of climate change.

It is imperative that the government transform this spatial intelligence and theoretical approaches into practical action before effective policies become lost in bureaucratic chaos. Moreover, this dissertation underlines that internal conflict cannot be ignored as an impact of climate change, but that countries require a plan of action tailored to their individual situations to stop an escalation of violence as intensifying climatic events threaten social stability worldwide.

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Appendices

Appendix 1: Decadal precipitation averages (mm) (World Bank Group, 2024b)

Province	Rainfall_1980s	Rainfall_1990s	Rainfall_2000s	Rainfall_2010s	Rainfall_2020s
Papua New Guinea	3039.409	2983.884	3120.121	3137.808	3156.89
Bougainville	3308.51	3416.837	0	0	0
Central	2182.913	2180.571	0	0	0
Chimbu (Simbu)	2808.876	2669.197	0	0	0
East New Britain	4392.265	4670.956	0	0	0
East Sepik	2674.163	2524.002	2727.129	2700.424	2751.426
Eastern Highlands	2237.326	2162.042			
Enga	2928.103	2736.469	2913.551	2912.497	2915.716
Gulf Province	3559.459	3468.163	3591.848	3601.909	3601.926
Hela	3435.765	3211.084	3436.928	3445.034	3458.676
Jiwaka	2662.994	2507.656	0	0	0
Madang	3054.404	2914.69	3104.667	3104.96	3104.96
Manus	3572.124	3355.191	3645.156	3646.134	3646.99
Milne Bay Province	2691.318	2410.475	0	0	0
Morobe	2403.855	2368.999	0	0	0
National Capital District	1962.487	1975.564	0	0	0
New Ireland	3037.255	3120.715	0	0	0
Northern (Oro)	2827.154	2815.601	0	0	0
West Sepik (Sandaun)	3227.742	3057.852	3404.133	3323.651	3480.458
Southern Highlands	3541.303	3365.175	3533.338	3554.671	3554.658
West New Britain	4535.021	4663.893	0	0	0
Western	3103.562	2994.941	3109.452	3225.45	3232.944
Western Highlands	2796.116	2584.086	0	0	0

Appendix 2: Tribal violence annual data (incidents/10,000 people/year) (ACLED, 2025; Forsyth, 2020)

Province	Violence_2020	Violence_2021	Violence_2022	Violence_2023	Violence_2024
Papua New Guinea	0	0	0	0	0
Bougainville	0	0	0	0	0
Central	0	0	0	0.027	0.08
Chimbu (Simbu)	0.044	0	0.044	0.022	0.022
East New Britain	0	0.023	0.046	0.092	0
East Sepik	0	0.047	0.016	0.095	0.095
Eastern Highlands	0.062	0.012	0.063	0.025	0.013
Enga	0.306	0.184	0.408	0.429	0.327
Gulf Province	0	0	0.147	0	0.049
Hela	0.027	0.109	0.027	0.082	0
Jiwaka	0.264	0	0.022	0.088	0
Madang	0	0.066	0.158	0.092	0.026
Manus	0	0	0	0	0
Milne Bay Province	0	0	0	0	0
Morobe	0	0.06	0.08	0.11	0.04
National Capital District	0	0.013	0.053	0.053	0.093
New Ireland	0	0	0	0.042	0
Northern (Oro)	0	0	0.037	0.037	0.073
West Sepik (Sandaun)	0	0	0.028	0	0
Southern Highlands	0.083	0.017	0.033	0.017	0.066
West New Britain	0	0	0.027	0.027	0
Western	0	0.033	0	0.033	0.033
Western Highlands	0.238	0	0.087	0.065	0.108

Appendix 3: Provincial violence and precipitation data used in Figure 7

Province	Year	Violence Rate (Incidents/10,000 People/Year)	Rainfall (mm)
East Sepik	2020	0	2656.82
East Sepik	2021	0.047	2957.84
East Sepik	2022	0.016	2604.81
East Sepik	2023	0.095	2732.44
East Sepik	2024	0.095	2805.22
Enga	2020	0.306	2,909.21
Enga	2021	0.184	2,927.43
Enga	2022	0.408	2,908.14
Enga	2023	0.429	2,914.28
Enga	2024	0.327	2,919.52
Hela	2020	0.027	3415.75
Hela	2021	0.109	3496.25
Hela	2022	0.027	3456.42
Hela	2023	0.082	3451.8
Hela	2024	0	3473.16
Manus	2020	0	3645.34
Manus	2021	0.066	3650.49
Manus	2022	0.158	3644.43
Manus	2023	0.092	3646.69
Manus	2024	0.026	3648
Southern Highlands	2020	0.083	3534.34
Southern Highlands	2021	0.017	3530.24
Southern Highlands	2022	0.033	3601.66
Southern Highlands	2023	0.017	3554.39
Southern Highlands	2024	0.066	3552.66
Western	2020	0	3131.83
Western	2021	0.033	3138.54
Western	2022	0	3329.93
Western	2023	0.033	3290.3
Western	2024	0.033	3274.12

Appendix 4: Ethics self-assessment form

**UNIVERSITY OF ST ANDREWS
TEACHING AND RESEARCH ETHICS COMMITTEE (UTREC)**

**SCHOOL OF GEOGRAPHY & SUSTAINABLE
DEVELOPMENT PRELIMINARY ETHICS SELF-
ASSESSMENT FORM**

This Preliminary Ethics Self-Assessment Form is to be conducted by the researcher and, where applicable, the supervisor and should be completed in conjunction with the Guidelines for Ethical Research Practice. All staff and students of the School of Geography & Sustainable Development must complete it prior to commencing research.

This Form will act as a formal record of your ethical considerations.

Tick one of the following:

UNDERGRADUATE project

Title of project: Changing with the Climate: Extreme Rainfall and Tribal Violence in Papua New Guinea

Name of researcher(s): Cian O'Regan

Name of supervisor (for student research): Dr Antje Brown

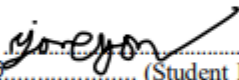
OVERALL ASSESSMENT (to be signed after questions, overleaf, have been completed)

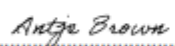
Self audit has been conducted

YES

Please tick one of the following:

*There are **no ethical issues** raised by this project*

Signed  Print Name CIAN O'REGAN Date 21/4/26
(Student Researcher(s), if applicable)

Signed  Print Name Antje Brown
Date 21/4/26 (Lead Researcher or Supervisor)

This form must be held in the files of the Lead Researcher or Supervisor. If fieldwork is required, a copy must also be lodged with appropriate Risk Assessment forms. A copy of this signed form should be included in the final research document (e.g. Dissertation).

**Geography & Sustainable Development
Preliminary Ethics Self-Assessment Form**

Before answering the following questions, you should familiarise yourself with the UTREC website
<https://www.st-andrews.ac.uk/research/environment/committees/utrec/>

1A. Research with human subjects

If your research involves human subjects, are you using secondary data (e.g. survey, administrative data) that is fully and robustly anonymised?

NO

If you answer YES to the last question, full ethics review is NOT required

If NO please continue

1B. Research with human subjects

If you are NOT using fully anonymised secondary data, will you be surveying, observing, interviewing human beings? Might your secondary analysis affect human subjects or might your research have the potential to significantly affect people in your study area?

NO

If you answer YES to any of the above questions, full ethics review is required

2. Confidentiality and data sharing

Will the data that you collect affect individuals' data protection rights? Might the collection, use, and sharing of data have the potential to compromise the confidentiality of human subjects? Will your research include the collection of personal data (e.g. age, gender) and data listed under *special category* (e.g. race, ethnic origin, sexual orientation)? Are you planning to work with *vulnerable groups* (children and protected adults)?

NO

If you answer YES to any of the above questions, full ethics review is definitely required.

3. Potential physical or psychological harm, discomfort or stress

Are there any foreseeable risks to the researcher, or to any participants in this research? For instance, is there a potential that you or your participants might be affected (physically or psychologically) by the research process?

NO

If you answer YES to the above, full ethics review is an absolute must.

4. Potential Conflicts of interest

Can you foresee any conflicts of interest with your project? For instance, might your research objectivity be compromised by sponsorship or other dependencies? Might issues of intellectual property or research collaboration arise?

NO

If you answer YES, full ethics review is required

5. Funding

Is your research funded externally?

NO

If YES, does the funder appear on the 'currently automatically approved' list on the UTREC website?

~~YES/NO~~ N/A

*If NO, you will need to submit a Funding Approval Application as per instructions on the UTREC website.
<https://www.st-andrews.ac.uk/research/integrity-ethics/humans/applications/ethical-funder-application/>*

6. Does your project involve clinical research, research or other projects involving the NHS, MOD or health and social care services?

NO

If YES, you will need to email the University's Research Governance team to check whether additional approvals or documentation is required: researchgovernance@st-andrews.ac.uk

7. Does your project focus on security-sensitive or extremism-related material?

NO

If YES, you will not only require ethical approval but also an SSER declaration. See <https://www.st-andrews.ac.uk/research/integrity-ethics/humans/applications/ethical-review/appendable-documents/> for further information.

8. Research with human tissue, samples, cell lines, or living animals

Does your research involve any of the above?

NO

If YES to human tissue, samples, and cell lines – you may need ethical approval, see <https://www.st-andrews.ac.uk/research/integrity-ethics/humans/applications/ethical-review/tissue/> for guidance.

If YES to living animals - your proposal must be referred to The University's Animal Welfare and Ethics Review Body (AWERB).

Last but not least, by ticking the following, you acknowledge that you are familiar with the current rules regarding Covid restrictions. See <https://www.st-andrews.ac.uk/research/integrity-ethics/humans/interim-guide-humans/> for further details. ✓