ANALYSING THE EXTREME ENVIRONMENTAL EVENTS IN THE NEPAL HIMALAYAS AND ENVIRONMENTAL ATTITUDE OF THE DOWNSTREAM CHILDREN

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Interest and willingness to seek on nature led to environmental engineering for my bachelors. Need to connect technology in the social sphere led to education for environment and sustainable development for my masters. The existence of both these aspects as a whole led to this research which tries to bridge the natural and social sphere of the human dimension.

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Abstract

The precipitation weather system in South Asia is dominated by the summer monsoon. The monsoon is mainly northwards directed humid vortex from the Bay of Bengal and the Arabian sea. The rising Himalayan peaks modulate the monsoon and cause shallow convection in the southern foothills of the Himalayas. Although sparsely, the westerly fed winter precipitation also contributes to the Himalayan region. Along with the orographic (elevation and topography) influence, the southern oscillation also has a salient impact on the monsoon. Moreover, the synoptic-scale and shallow convective nature of monsoonal depression and its interaction with the ubiquitous protruding topographies of the Himalayan belt is known to bring extreme precipitation events. Such extreme events are omnipresent in the southern slopes of the Himalayas, but there is an indication of its increasing trend, which is often attributed to the increasing trend of temperature.

There is a direct relationship between precipitation and river runoff in the Himalayan region. Thus, the extreme river runoff events are also part of the monsoonal circulation. The extreme precipitation and river runoff triggers landslides and floods. However, their status has received less attention in Nepal. In order to adapt to and tackle such an environmental crisis, the Government of Nepal focuses on education as one of the primary tools. However, the education content is criticised for being uniform in all parts of Nepal. Although limited in numbers, the literature shows that this uniformity has led students to identify common urban environmental problems but not their local issues in rural Nepal. Moreover, environmental attitude, which is known to direct environmental education to pro-environment and adaptive behaviour, has received no attention in Nepal.

Against these backgrounds, this research focuses on: the analysis of the pattern of extreme (above 90^{th} percentile) precipitation and river runoff events in Nepal and their inter-relationship, the impact of southern oscillation (using the BEST index) in these extreme events and, the status of environmental attitude and environmental education content (from school textbooks) of the vulnerable children. An existing tool which measures environmental attitude, the Two-Dimensional Model of Ecological Values (2-MEV), was modified to use in rural Nepal. The previous 2-MEV tool's items mostly from Germany and the USA were adopted, developed, and translated, followed by two surveys (n=200 & n=201) and validated using principal component analysis and confirmatory factor analysis method.

The two dimensions of environmental attitude are Preservation and Utilisation with a correlation of -0.93, which have attitudes as sub-scales under them, and items (questionnaires) under the sub-scales with Likert type responses. Likewise, the extreme precipitation status of whole Nepal was analysed. However, the extreme river runoff was analysed on the Koshi River basin of Nepal because the sample vulnerable children reside near the bank of the Koshi River

in the village of Chakraghatti. Thus, the environmental attitude and education content were also analysed of the school-going children of Chakraghatti.

The 204 quality-controlled precipitation stations of Nepal show the total, and extreme precipitation intensity (frequency) decreases (increases) with increasing elevation, but intensity increases with the sudden rise of the topography. Interestingly, both intensity and frequency of total and extreme precipitation are high in the eastern part of Nepal during the entire year and High Precipitation Months Period (HPM), i.e., May-October. In addition, the extreme precipitation threshold is high (>300m) in the plains and decreases with the increase of elevation, while all the events during the Low Precipitation Months Period (LPM), i.e., November-April, are high in the hills than the plains.

Furthermore, the mid-central part and the north-eastern corner of Nepal shows high extreme events during both HPM and LPM. Likewise, extreme river runoff intensity depends on the size of the river (based on 14 quality-controlled stations), but the frequency is almost uniform and independent from the size of the river in the Koshi River Basin (KRB). Furthermore, there are more stations in the KRB with a decreasing trend of extreme precipitation and river runoff events than the increasing, and there is no observable relationship between them. Finally, the total precipitation intensity and frequency, and extreme precipitation intensity during the HPM increase towards La Niña while total precipitation intensity and frequency during the LPM increase towards El Niño.

The validated 2-MEV tool shows the bi-dimensional construct of environmental attitude prevails in rural Nepal, too, with a strong negative correlation of -0.93. Out of the total sample of children (n=379), 298 are inclined (mean value higher than 3 in Likert scale) towards the preservation values. Likewise, 374, 300, and 367 are inclined towards the attitude of the intent of support, protection of nature, and enjoyment of nature, respectively. In contrast, only 96 and 92 are inclined towards the attitude to pollute and alter nature, respectively. Furthermore, the preservation (utilisation) values and attitudes show increasing (decreasing) tendency with the grade but not with age and gender. Lastly, the findings indicate that the content of the textbooks is well linked to the research site, which increases its complexity and details with grades. Thus, it enables a more detail structure of positive attitude, with an increment of grade, towards the environment by having a stronger – but not tested statistically – mean value in the answers to the 2-MEV questionnaires.

The findings of this research reveal important information about the pattern of extreme events and their inter-relationship along with their relationship with the southern oscillation. Moreover, the findings also assert 2-MEV as a standard tool; however, by considering the local aspects. Likewise, the children's environmental attitude shows to which direction they are heading towards in terms of pro-environmental and adaptive behaviour. Finally, the content of environmental education shows progressiveness with the inclusion of regional issues.

Zusammenfassung

Das Niederschlagswettersystem in Südasien wird vom Sommermonsun dominiert. Der Monsun ist hauptsächlich eine aus dem Golf von Bengalen und dem Arabischen Meer stammende und nach Norden gerichtete feuchte Luftzirkulation. Die aufsteigenden Himalaya-Gipfel verändern die Zirkulation und verursachen eine flache Konvektion in den südlichen Gebirgsausläufen des Himalayas. Die von Westen stammende Winterregen tragen – trotz spärlich – ebenfalls zu den Niederschlägen in der Himalaya-Region bei.

Neben dem orographischen, also aus der Höhe und Topografie herrührendem Einfluss, hat die südliche Oszillation ebenfalls einen starken Einfluss auf den Monsun. Darüber hinaus ist es bekannt, dass die großräumige Zirkulation an den hoch emporragenden Gipfeln des Himalaya-Gürtels extreme Niederschlagsereignisse hervorruft. Solche extremen Ereignisse sind allgegenwärtig an den Südhängen des Himalayas, aber es gibt Hinweise darauf, dass sich dieser Trend verstärkt, was oft wiederum mit der stetigen Temperaturerhöhung im Zusammenhang gebracht wird.

In der Himalaya-Region besteht ein direkter Zusammenhang zwischen Niederschlag und Flussabfluss: extreme Flussabflüsse sind Teile des Monsunzyklus. Solche extremen Niederschläge und Flussabflüsse lösen Erdrutsche und Überschwemmungen aus. In Nepal hat dieser Zusammenhang jedoch bisher wenig Beachtung gefunden.

Obwohl die nepalesische Regierung auf Bildung als das wichtigste Instrument zur Anpassung und Bewältigung solcher Umweltkrisen setzt, bleibt es kritisch anzumerken, dass die Bildungsinhalte in allen Teilen Nepals einheitlich sind und auf regionale Besonderheiten keine Rücksicht nehmen. Die relevante Literatur zu diesem Thema ist begrenzt, zeigt aber, dass der einheitliche Schulunterricht auf die städtische Umweltprobleme fokussiert, aber nicht die Probleme im ländlichen Nepal. Insgesamt spielen Umwelterziehung und umweltfreundliches Verhalten in Nepals Bildungspolitik ohnehin nur eine untergeordnete Rolle.

Vor diesem Hintergrund konzentriert sich die vorliegende Arbeit auf die Analyse des Musters von extremen (über dem 90-ten Perzentil liegenden) Niederschlägen und Flussabflüssen in Nepal und deren Beziehung zueinander. Auch diskutiert werden die Auswirkungen der Süd-Oszillation (unter Verwendung des BEST-Indexes) bei Extremereignissen. Daneben werden die Umwelteinstellungen sowie die Inhalte der Umweltbildung der Schülerinnen und Schüler in den gefährdeten Gebieten umfasst.

"Als Instrument zur Messung der Umwelteinstellung wurde das modifizierte Two-Dimensional Model of Ecological Values (2-MEV-Model) verwendet. Die Items des bisherigen 2-MEV-Instruments, die vor allem aus Deutschland und den USA stammen, wurden für den Einsatz im ländlichen Nepal angepasst und übersetzt, gefolgt von Validierungsstudien (n=200) und

(n=201) mittels erklärender und bestätigender Faktorenanalyse. Die beiden in das Modell einbezogenen Werte sind „Erhaltung“ und „Nutzung“, welche zu -0.93 korrelieren."

Ebenso wurde der extreme Niederschlagsstatus ganzes Nepals analysiert. Der extreme Flussabfluss wurde im Einzugsgebiet des Koshi-Flusses in Nepal analysiert, da die untersuchten Schülerinnen und Schüler nahe dem Ufer des Koshi-Flusses im Dorf Chakraghatti leben. In diesem Gebiet wurden auch die Einstellungen “Erhaltung“, sowie die „Nutzung“ der Schülerinnen und Schüler analysiert.

Die Ergebnisse der Niederschlagsanalyse zeigen, dass die 204 qualitätskontrollierten Niederschlagsstationen Nepals mit zunehmender Höhe eine Abnahme der Häufigkeit extremer Niederschläge, aber eine Zunahme der Intensität messen. Interessanterweise sind sowohl die Intensität als auch die Häufigkeit der Gesamt- und Extremniederschläge gazn hoch im östlichen Teil Nepals während des ganzen Jahres und der hohe Niederschlagsperiode – High Precipitation Months Period – (HPM), d.h. in den Monaten Mai bis Oktober. Darüber hinaus ist die Extremniederschlagsschwelle in den Ebenen hoch (>300m) und nimmt mit zunehmender Höhe ab, während alle Wetterereignisse während der Low Precipitation Months Period (LPM), d.h. November bis April höher in den Hügeln als in den Ebenen liegen. Außerdem zeigen der mittlere zentrale Teil sowie der nordöstliche Teil Nepals hohe Extremereignisse im gesamten Jahr.

Im Zusammenhang damit steht die Abflussintensität, die von der Größe der Flüsse abhängig ist (basierend auf 14 qualitätskontrollierten Stationen). Für das untersuchte Koshi River Basin (KRB) ist die Häufigkeit jedoch gleichbleibend und unabhängig von der Größe der Flüsse. Darüber hinaus gibt es mehrere Stationen in der KRB mit einem abnehmenden Trend der Extremniederschläge und Flussabflüsse als mit einem Anstieg und es besteht kein Zusammenhang zwischen ihnen. Schließlich steigt die Gesamtniederschlagsintensität und -frequenz sowie die extreme Niederschlagsintensität während des HPM in Richtung La Niña, während die Gesamtniederschlagsintensität und -frequenz während des LPM in Richtung El Niño steigen.

Die Analyse der Umwelteinstellung mit Hilfe der Daten aus dem 2-MEV-Tool zeigt, dass auch im ländlichen Nepal das aus der Literatur bekannte zweidimensionale Konstrukt der Umwelteinstellung mit einer starken negativen Korrelation von -0,93 feststellbar ist. Von der Gesamtstichprobe der Schülerinnen und Schüler (n=379) geben 298 eine Einstellung zur Erhaltung der Umwelt an. Im Detail geben 374 auf Unterstützung, 300 auf Schutz und 367 auf Freude an der Natur eine abzielende Einstellung an. Im Gegensatz dazu haben nur 96 Personen eine Verschmutzung und 92 eine Veränderung der Natur tolerierende Einstellung an.

Darüber hinaus zeigt sich mit zunehmender Klassenstufe ein Anstieg der Zustimmung zum Schutz der Natur und eine Abnahme der Zustimmung zur Nutzung der Natur, dies korreliert jedoch nicht mit Alter und Geschlecht. Auch deuten die Ergebnisse darauf hin, dass die mit zunehmender Klassenstufe komplexeren und detaillierteren Lehrbücher eine Umwelteinstellung fördern, die sich in den höheren – aber nicht statistisch getesteten – Mittelwerten in den Antworten auf die 2-MEV-Fragebögen zeigt.

Die Ergebnisse dieser Forschung zeigen wichtige Informationen über das Muster von Extremereignissen und deren Wechselbeziehungen sowie deren Beziehung zur Südoszillation. Darüber hinaus belegen die Ergebnisse, dass der 2-MEV-Fragebogen als Standardinstrument funktioniert, allerdings erst nach Anpassung an den lokalen Kontext. Ebenso zeigt die Analyse der Umwelteinstellung der Schülerinnen und Schüler, in welche Richtung sie sich in Bezug auf umweltfreundliches und an die Umwelt angepasstes Verhalten entwickeln. Schließlich zeigt sich auch, dass sich durch die Einbeziehung regionaler Themen eine Verbesserung des Unterrichts erreichen lässt.

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1 Introduction

This research takes place in an alpine and rural region of Nepal. There are two focal points in this research. First, the analysis of extreme precipitation and river discharge (runoff), which often leads to water related disasters. Second, the status of environmental education and environmental attitude of the children who are prone to water related disasters.

The Palaeocene era collision between the Indian and the Eurasian tectonic plate triggered crustal shortening absorbing a significant fraction of plate convergence (Molnar & Tapponnier, 1975). Subsequently, this led to the first development of the Himalayan orography (Hidges, Hurtado, & Whipple, 2001). The Himalayan range stretches from Nanga Parbat (Jammu and Kashmir) in the West to the Tsangpo-Dibang (Arunachal Pradesh) bend in the East, spanning almost 2,400 km (Nandargi & Dhar, 2011). This range has the highest mountains in the world and functions as a natural barrier between the mid-latitudes and the tropics. This positioning of the Himalayas modulates the atmospheric circulation in South Asia leading to summer monsoon and winter precipitation events (Barros, Kim, Williams, & Nesbitt, 2004; Anders et al., 2006; Dimri, 2012).

Comparatively, summer monsoon dominates the amount of precipitation in the region. Approximately 70%-80% of total annual precipitation occurs during the summer monsoon season (Singh & Kumar, 1997; Wulf, Bookhagen, & Scherler, 2015). Also, precipitation influences the water balance of the region (Hannah, Kansakar, Gerrard, & Rees, 2005). Primarily, one-sixth of the world's population relies on precipitation fed rivers of the Himalayas as their principal source of water (Nandargi & Dhar, 2011). This reliance demonstrates the importance of comprehending water balance of the region.

The research on precipitation and river runoff in the Himalayan region is thus increasing since last four decades (e.g., Hahn & Manabe, 1975; Webster, 1987; Burbank et al., 2003; Barros et al., 2004; Wulf, Bookhagen, & Scherler, 2010; Karki, Hasson, Schickhoff, Scholten, & Bohner, 2017, etc.). However, the complex arrangement of protruding ridges and deep gorges along with the paucity of the data is hindering the understanding of the precipitation and river runoff system (Barros, Joshi, Putkonen, & Burbank, 2000; Barros & Lang, 2001; Wulf et al., 2010). To date, researchers have identified the arrival of onset, location as well as the formation of terrain and convection as significant issues responsible for precipitation in the Himalayas (e.g., Barros et al., 2000; Barros & Lang 2003; Anders et al., 2006; Wulf et al., 2010; Bookhagen, 2010). Hence, the precipitation pattern is intricate in spatial and temporal scale (Bookhagen, Thiede, & Strecker, 2005). Moreover, the regional climatic phenomenon in the tropical Pacific, such as the southern oscillation also influences the precipitation regime of the Himalayan region (Shrestha, 2000). Overall, the precipitation pattern in the Himalayan region is intricate.

The recent research developments indicate an increase in extreme precipitation events over the Himalayas (Chalise & Khanal 2002; Nandargi & Dhar 2011; Karki et al., 2017). The extreme precipitation event is a low frequency/high-intensity rain/snowfall (Wulf et al., 2010; Nandargi & Dhar 2011). Although the documentation of such events in South Asia is not rare, it is scarce in the context of Nepal (Karki et al., 2017). The extreme precipitation occurs due to many interrelated reasons such as synoptic scale rainstorms, sudden cloudbursts, high winds, snowstorms (Barros et al., 2004; Nandargi & Dhar, 2011). As a result, it applies to control of mass transport of water and sediment discharge (Thiede, Bookhagen, Arrowsmith, Sober, & Strecker, 2004; Wulf et al., 2010; Bookhagen, 2010). In the same way, extreme precipitation has first-order control on the high rate of denudation, too (Gabet, Burbank, Pratt-Sitaula, Putkonen, & Bookhagen, 2008). A research conducted on the 47 catchments of the Andes demonstrates the positive correlation between the erosion rate with average slope and relief of the basin (Aalto, Dunne, & Guyot, 2006). In comparison, Nepal also has a steep river basin with headwaters at more than 8000 m and flood plains at a lower elevation of around 60 m within a distance of 100 km (Nandargi & Dhar 2011). Thus, the risk of extreme precipitation induced landslide, erosion and flood are relatively high in Nepal (Karki et al., 2017).

A recent water related disaster in southern Nepal during the monsoon of 2017 further emphasises the necessity to explore extreme events. An extreme precipitation event occurred in the mid-hills and plains of Nepal beginning on 11 August 2017 until 14 August 2017 and continued with moderate to heavy precipitation until 17 August 2017 (Bhandari et al., 2018). During this period 65,000 houses in southern Nepal drowned while 461,000 people were temporarily displaced and 143 lost their lives. A total of 1.7 million people were affected in Nepal. Furthermore, the dominant role of precipitation in influencing the river runoff is a fact (Shrestha & Aryal, 2011; Ménégoz, Gallée, & Jacobi, 2013; Shea, Immerzeel, Wagnon, Vincent, & Bajracharya, 2015). For example, river discharge is high during the monsoon period in Nepal (Hannah et al., 2005; Wulf et al., 2010; Nepal, 2016).

Chalise and Khanal (2002) outline the importance of comprehending extreme river discharge events to reduce the risks associated with it. They also point out observing precipitation events to understand extreme river discharge behaviour. However, the research related to extreme precipitation in overall Nepal is scarce and limited either on the representation of up to date data or juxtaposed with generalised findings. Similarly, the relationship between precipitation as well as other environmental factors such as glacial melt and river runoff is well documented in Nepal. However, the analysis of the status/occurrence of extreme river runoff events on a spatial scale in Nepal faces a dearth of research. Downstream river discharge shapes up valleys and forms alluvial fans in an alpine landscape (Miller & Spoolman, 2009). Such valleys and alluvial fans provide an opportunity for a livelihood and economic development in the region (Chalise & Khanal, 2002).

On the other hand, Chalise and Khanal (2002) also point the risk of losing life and property associated with these opportunities. For instance, the landslide and flood of August 2014 in the Western hills of Nepal displaced about 30,000 people from their damaged homes (International Federation of Red Cross, 2014). Likewise, communities residing near the alluvial fan of the Koshi River in Eastern Nepal have already experienced destructive floods in the past. In 2008, the extreme sediment flux in the Koshi River, leading to a breach of the embankment caused havoc in the region (Reddy, Kumar, Saha, & Mandal, 2008).

These recent episodes, along with extreme precipitation events, suggest that Nepal is highly susceptible to water related disasters. Various researchers and organisations also agree on this fact (e.g., United Nations Development Programme [UNDP], 2004; Eriksson et al., 2009; Agarwal, Babel, & Maskey, 2014; Karki et al., 2017). Consequently, the vulnerability of the people living near the Koshi River is also high. Notably, the children and adults of this region are likely to be the most affected group (UNDP 2004, Adhikari 2013). The vulnerability "is the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt" (Adger, 2006, p. 268).

Moreover, the capacity and scale of adaptation to environmental stress are related to the vulnerability of the society (Gentle & Maraseni, 2012). For instance, Taylor, Bruin, and Dessai (2014) in the UK and Pyhälä et al. (2016) in their meta-analysis, of 124 articles categorised according to different regions of the world, report people willing to adapt to potential environmental threats only if it is going to harm them. Furthermore, adaptation is an ability of the society to deal with the adjustment to the socioeconomic and ecological system about climate change and its consequences (Smit, Burton, Klein, & Street 1999; Gallopín, 2006; Adger, 2006). Therefore, adaptation to the environmental crisis is crucial for the livelihood of the vulnerable community living near the Koshi River. In general terms, livelihood is defined as a means of making a living (International Federation of Red Cross, 2014).

Education is considered as one of the primary tool in Nepal to address and adapt to the long-term environmental crisis (Adhikari, 2013). Correspondingly, the content of environmental education addresses this aim (Karki, 2000). However, the environmental education curriculum followed in the schools of Nepal has faced criticism for not including local environmental concerns (Pande & Karki 1998; Pande, Thapa, & Karki 2001; Keinath 2004). Nepal uses a centralised curriculum system where all the regions of the country follow the same educational content (Curriculum Development Centre of Nepal, 2007). The environmental problems in textbooks are more about the urban scenario (such as air or waste pollution) in contrast to that of the rural situation (Keinath, 2004). Hence, students from the rural areas of Nepal, where most vulnerable communities reside, are not able to understand their local environment and associated problems (Keinath, 2004).

Predominantly, there are two sources of knowledge in Nepal: Indigenous Traditional Knowledge (ITK) and modern school education (Sharma, Bajracharya, & Sitaula, 2009). The ITK is "knowledge, innovations and practices of local communities developed from experience gained over the centuries and adapted to the local culture and environment which is transmitted orally from generation to generation" (United Nations, 2014, p. 3). However, in the prejudice of ITK being unscientific, the Government of Nepal (GoN) has not shown any interest in documenting it, and its presence in the modern-day school education is negligible (Sharma, 2004; Sharma et al., 2009). Thus, the GoN started to focus on school education since the 1950s, making it the primary source of knowledge and understanding (Sharma et al., 2009).

The knowledge and understanding are the acknowledged cognitive component of environmental attitude (Rokeach, 1973; Fishbein & Ajzen, 1974; Gray, 1985; Hines, Hungerford, & Tomera, 1986). Consequently, environmental education affects environmental attitude (Ajzen & Fishbein, 1977; Bogner & Wiseman, 1997; Clery & Rhead, 2013; Kibbe, Bogner, & Kaiser, 2014). Likewise, environmental attitude and perception influence adaptive and pro-environmental behaviour (Lynne, Shonkwiler, & Rola, 1988; Stern, 2000; Meinhold & Malkus, 2005; Vignola, Koellner, Scholzb, & McDaniels, 2010; Johnson & Činčera, 2015; Pyhälä et al., 2016; Mutahara, Warner, Wals, Khan, & Wester, 2018). For example, Vignola et al. (2010) report the environmental perception exerting control on adaptive behaviour in Costa Rica while Pyhälä et al. (2016) reviewed 124 peer-reviewed articles about the relationship between locals' perception and their understandings of environmental change and report the same. Although environmental education is in use in Nepal to develop adaptive capacity, the role of environmental attitude which will boost the adaptive and pro-environmental behaviour is unexplored (Pande & Karki, 1998; Pande et al., 2001). However, the relationship between environmental attitude and pro-environmental behaviour is not a universally accepted fact. The strength of this relationship ranges from low to moderate (Grob, 1995; Kaiser, Ranney, Hartig, & Bowler, 1999; Bamberg & Möser, 2007).

Milfont and Duckitt (2004) questioned this uncertain relationship between attitude and behaviour with a hypothesis that the construct of environmental attitude needs an adequate clarification. Till early 2000, the environmental attitude consisted of a single dimensional construct where the attitude ranged on a continuum from a biocentric (pro-environment) to an anthropocentric (anti-environment) worldview (for example the New Environmental Paradigm) (Dunlap, Van Liere, Mertig, & Jones, 2000). Milfont and Duckitt explored onto the multi-dimensional orthogonal construct of environmental attitude, the two-dimensional model of ecological values (2-MEV), proposed by Bogner and colleagues (Bogner & Wiseman 1997; 1999; Wiseman & Bogner, 2003). In line with Bogner and colleagues' findings, they also independently verified the two-dimensional construct (Preservation and Utilisation) of environmental attitude. The development and verification of these two-dimensions gave environmental attitude a strong base to cover multiple viewpoints of behaviour (Van Petegem

& Blieck, 2006; Boeve-de Pauw & Van Petegem, 2010; 2013). However, all these studies exist only in the developed and industrialised countries. Milfont and Duckitt pointed out in the limitation of their research, the bi-dimensionality of environmental attitude might not be as distinct in developing countries as observed because the macro-social and macro-economic variables can influence the psychological constructs. Corral-Verdugo and Armendáriz's (2000) findings support this argument with high covariance between the pro-human exception and the pro-environmental exception in Mexico. Based on their finding, Corral-Verdugo and Armendáriz argue that there is a dualism in the belief of industrialised countries while it can be plausible to hold both pro-human and pro-environmental value in the non-industrialised countries. Nepal is a least-developed country with negligible research and discussion about the environmental attitude. Hence, exploring the construct of environmental attitude in Nepal based on the proposal of 2-MEV will help to understand the variability of the construct of environmental attitude on a different geographical and socioeconomic setting.

Against these backgrounds, this research focuses on the exploration of two parts: extreme environmental events (precipitation and river runoff), and the status of the downstream children's environmental attitude and school education content. The first research focus will base on the analysis of extreme precipitation and extreme river runoff in Nepal, their inter-relationship, and their relationship with the southern oscillation. Similarly, the second research focus will base on the exploration of the environmental education content followed by the school and the environmental attitude of the school going children. The findings from the first research focus will complement the existing literature on the Himalayan geomorphology system. Likewise, the second research focus serves both purposes to analyse the bi-dimensional construct of environmental attitude in a least-developed society of Nepal by using 2-MEV as a tool and using the same tool to explore whether the environmental education status corresponds to the environmental attitude of the students or not. Moreover, comprehending the environmental attitude of the students will help to elucidate in which direction they are heading to regarding pro-environmental and adaptive behaviour. Thus, the knowledge generated from this research aims to be valuable for the scientific community as well as for the regional planners and policymakers.

1.1 Overview of the Dissertation

This dissertation consists of eight chapters. The first chapter presents the background and motivation to conduct this research. The first part of second chapter provides a detailed state-of-the-art review of precipitation system, pattern, and its linkage with the southern oscillation system along with the existing knowledge on downstream river flow in the Himalayan region. Then, the second part of chapter two presents the review of environmental attitude construct, the environmental attitude tool, 2-MEV, and environmental education and environmental attitude of Nepal. Based on the literature review, the third chapter focuses on the need for research by elaborating the research objective and the method used to address the objectives. Furthermore, chapter four describes the research area of both precipitation and river runoff, and environmental attitude analysis part.

Moving on to the finding section, chapter five presents the data analysis result of the extreme precipitation, extreme river runoff part, and their relationship with the southern oscillation. Likewise, chapter six begins by presenting the validation of the environmental attitude assessment tool for rural Nepal. Followed by the children's environmental attitude status by using this validated 2-MEV tool and the environmental education status by analysing the course content followed by the school going children. Furthermore, chapter six presents the exploration of the construct of environmental attitude in rural Nepal. Finally, chapter seven focuses on discussing the results obtained in chapter five and six. It discusses the findings of this research based on the connection between extreme precipitation events, extreme river runoff events, environmental education course content, the state of environmental attitude and its construct. Lastly, chapter eight presents the conclusion, summary of findings and recommendations for future research.

1.2 Limitation of the Research

Nepal has a complex arrangement of the Himalayan orography limiting the setup of rain/snowfall monitoring stations in all parts of the country, usually in the high elevations (>4000 m). Thus, the analysis of the precipitation does not include the data from the high Himalayas. Although factors such as precipitation, soil-erosion, land-cover change, snowmelt, and glacial melt influence the downstream river runoff, these factors are not explored while analysing the extreme river runoff events. This is due to the lack of available data and these analyses being beyond the scope of this research. Nonetheless, a brief theoretical review of these factors is conducted in this research. Similarly, the environmental attitude part focuses on the school going children from grade 8 till 10. However, due to the lack of data, access to school education for all the children of the research site is not explored. Also, the socio-economic situation of the sample students is not explored in this research. Moreover, the relationship between environmental knowledge and environmental education content followed by the school going children of the research site is not explored due to the scope of the research which is focused on the current status of environmental education content and attitude of the children.

2 Literature Review

Based on the subjects to review, this chapter consists of two parts. The first part of this chapter presents a broad overview of the status of knowledge on the precipitation and river runoff system in the Himalayas and the water related risks associated with it, with a focus on Nepal. Likewise, the second part of this chapter presents an extensive review of the relationship between environmental education and environmental attitude, along with their status regarding the situation in Nepal.

2.1 Review of Precipitation and Downstream River Runoff

This subchapter provides an in-depth review of the precipitation system in the Himalayas. It includes the topics of summer and winter precipitation, the influence of orography and, southern oscillation. Secondly, the review of the precipitation pattern includes seasonal as well as extreme trends and status of precipitation. Finally, the review of downstream river runoff includes its status and its relationship with natural and human-made effects. These reviews are then finally followed by the identification of deficiencies and future research needs, respectively.

2.1.1 Precipitation System in the Himalayas

The various research going on since last four decades platitude the active role played by the Himalayas to modulate the regional precipitation system (Hahn & Manabe, 1975; Webster, 1987; Burbank et al., 2003; Barros et al., 2004; Wulf et al., 2010; Karki et al., 2017, etc.). The southern slopes of the Himalayas lie in the windward side. The windward side of the Himalayas receives more precipitation than the leeward side (Singh & Kumar, 1997; Anders et al., 2006; Wulf et al., 2010). Likewise, the Himalayas receive precipitation during the summer from monsoonal depression and during the winter from westerly wind (Barros et al., 2004; Dimri, Mohanty, Azadi, & Rathore, 2006). The following sections provide a more elaborative detail about the precipitation system.

2.1.1.1 The Indian Summer Monsoon

The Low-Level Westerly Jet (LLJ) from the Arabian Sea and a large-scale cyclonic vortex from the north of the Bay of Bengal to mainland India forms the Indian Summer Monsoon (ISM) trough (Ding & Sikka, 2006). The word monsoon comes from the Arabic language, meaning season (Goswami, 2005). The ISM over South Asia is a part of InterTropical Convergence Zone (ITCZ) which drifts the east-west oriented precipitation belt from the southern hemisphere during winter to the northern hemisphere during summer (Goswami, 2005; Bookhagen et al., 2005). In general, the ITCZ is the temperature and pressure differences between the northern and southern hemispheres. Moreover, there is interlink between the LLJ variation over India, East Asia and the western North Pacific.

The summer monsoon over Indian sub-continent and the East Asian summer monsoon share significant exchange and transport of moisture and heat between them (Ding & Sikka, 2006). Likewise, a coupling exists between the East Asian summer monsoon and the western North Pacific summer monsoon. Interlink of these three variations suggest ISM is a part of a larger climatic scenario. The Asian landmass faces rapid warming compared to the surrounding oceans due to the elevated topography of the Tibetan plateau (average elevation of 4,000 m) and releases latent heat as a by-product of condensation of moist air. This thermal gradient helps to ensconce the ISM circulation as well as derives the interannual variability based on the anomaly of sea-surface temperature (Bookhagen et al., 2005).

However, Liu and Dong (2013)'s argument based on their numerical model analysis to examine the impact of the Tibetan Plateau over the ISM is in contrast with Bookhagen et al. (2005)'s justification. They find that even without the elevated Tibetan Plateau, the ISM and large-scale atmospheric circulation structures show similar variability as observed currently. Furthermore, they report that the Himalayan topography is much more critical for the generation of ISM circulation than the location and elevation of the Tibetan Plateau. Likewise, their study highlights the Himalayas as a thermal insulator in the formation of ISM and challenges the accepted view of the Tibetan Plateau influencing the ISM due to the thermal gradient. Since this relationship does not exist in other parts of monsoonal Asia, Liu and Dong also challenge the coining of the word "monsoon" in other parts of Asia, i.e. East Asian summer monsoon and western North Pacific summer monsoon.

Nonetheless, multiple previous research reports the ISM circulation is regulated by the pressure difference between the Tibetan Plateau (low) and the surrounding oceans (high) due to the rate of thermal divergence (Barros et al., 2004; Bookhagen et al., 2005). This circulation produces north to northwest directed humid vortex from the proximate Bay of Bengal. Likewise, this vortex enters Nepal through the eastern side and exits through the west, leading to comparatively less monsoonal precipitation in the western part of the country. Furthermore, this circulation along with the vortex originating from the Arabian Sea gets deflected northwards and organise shallow convection at the foothills of south-facing slopes and valleys of the Himalayas to bring heavy summer monsoon precipitation (Barros & Lang, 2003; Bookhagen et al., 2005). The ISM often has an active and break period, during which the active period leads to excess storm events and break periods lead to draughts in the region (Goswami, 2005). Predominantly the prevailing wind direction and speed guide the moisture transport of the ISM in small regions (10^2-10^4 km^2) while the local topography influences the moisture transport into deep valleys and gorges (Bookhagen et al., 2005).

As explained earlier, the positioning of the Himalayas is crucial for the development of the ISM. The moist air elevates along the orography and decreases in pressure and temperature with an increase in volume. This interrelation of the physical components leads to the condensation of moist air which can no longer cross the orographic barrier and accounts for the distribution of the ISM precipitation along the Himalayan stretch (Bookhagen et al., 2005). Moreover, the existence of internal dynamics of the monsoon also generates unstable convections, for example, when the mid-latitude westerlies interact with the monsoonal trough (Malik, Bookhagen, & Marwan, 2012). Likewise, a timeseries analysis of the precipitation over India, from 1871-1990, elucidates a three decadal above normal (mean of the entire time-series) and below normal oscillating behaviour of the ISM (Krishnamurthy & Goswami, 2000). The behaviour of ISM is although well documented its nature is not fully understood and is also deemed to be almost impossible to understand (Bookhagen, 2010).

2.1.1.2 Westerly fed Winter Precipitation

The western region of the Himalayas receives precipitation during the winter (December-March), which also spreads through the central part of the Himalayas, over Nepal (Dimri et al., 2006). The western precipitation occurs due to the western disturbances which are low-pressure systems in the mid-latitudes with wind trails moving from the west to east (westerly) towards the subtropical region of Asia (Dimri et al., 2006). These mid-latitude trails are westerly upper tropospheric synoptic-scale waves (Barros, 2004). The moist air coming with these western disturbances get captured in the Himalayan orography and undergoes intensification until the moisture content condenses and falls as precipitation (Barros, 2004). Moreover, the winter precipitation is also termed as the Indian Winter Monsoon (IWM) (Dimri et al., 2013).

The extended mid and high-level clouds in the subtropical jet over Asia create interaction between the tropics and the mid-latitudes. Furthermore, these mobile cloud systems amplify the long wave troughs leading significant influence of mid-latitude westerlies over the subtropics (Dimri et al., 2006). Moreover, the tropical air mass and the topography of the Himalayas control the western disturbance in the mid-latitudes (Dimri et al., 2006). Likewise, Dimri et al. (2006) also point out the association of the western disturbance with the southern oscillation system in the tropical Pacific region but stresses on the dearth of research in understanding the IWM. Till date, there is minimal research on the topic of IWM of which Dimri and colleagues have the most numbers of the available literature.

Additionally, their research outlines the essential aspects of the IWM. For example, the active phase of IWM sees westerly and south-westerly jet leading to convective activity with enhanced moisture flux increasing precipitation in the region. Such convection is always present in a circulation of cyclonic-anti-cyclonic-cyclonic series. The interannual variability of the IWM shows southward shift, demonstrating the strong influence of the north-westerly incoming flow over the north Indian regions.

According to Dimri et al. (2006 & 2013), the increased convection over the central equatorial Pacific region and asymmetric upper tropospheric flow over the meridian from the southern to northern hemisphere intensifies the western disturbance corresponding to higher precipitation over the Western Himalayas. Likewise, the bi-monthly oscillations also occur prevalently during the IWM. Specifically, the increment in equatorial Indian Ocean surface temperature enhances the middle tropospheric anticyclone with the increased northerly wind to the east resulting in higher precipitation in contrast to the period with average temperature. In phase with the ISM, the IWM is also a complicated process, but with a dearth of research to understand it, deeming its nature as still unclear.

2.1.1.3 Orography Influenced Precipitation

The windward side of the orography receives more precipitation but in addition to that the probability of blockade in air and diversion, excitement of internal waves due to vertical density stratification, warming of air above the mountain drawing air up from low levels and triggering condensation or convection on the slopes are also part of the orography-precipitation interactions (Anders et al., 2006). Anders et al. (2006) also verify from their ad-hoc model that decrease in temperature and saturation of the vapour pressure with height in the atmosphere and the direct forcing of air upslope, especially at low elevations, are vital controls on precipitation in the Himalayas at scales greater than ten kilometres. A series of research carried out during the early 2000s (Barros & Lang, 2003; Barros et al., 2004) tries to clarify the spatial distribution of precipitation in the southern slope of the Himalayas located in Nepal. They report five significant factors:

1) Continuous and gradual increase of the atmospheric column consisting of moist air causing unstable convection during the weak middle and upper tropospheric westerly wind;
2) The effect of the upslope flow of air in the mountain and its convergence to cloud leading to precipitation;
3) Orographic air flow waves induced by the effect of gravity;
4) Convective weather system; and
5) The difference in precipitation pattern based on altitude.

Precipitation in the tropical region results from a cloud system known as the Mesoscale Convective System (MCS). The length of these cloud systems varies from 100-1000 km, with a lifetime ranging from several hours to a day (Houze, 2018). Within the MCS system, there are usually two types of precipitation: convective and stratiform. The convective precipitation occurs from active convection. The convection is a process where the surface of the earth warms the air above it. This process decreases the density of the air molecules and makes the air lighter. The light air rises rapidly and cools off forming the cloud hence resulting in convective precipitation, which is dominated by the condensation-deposition process (Tao, Chen, Li, Wang, & Zhang, 2012).

In contrast to convective precipitation, the stratiform precipitation is older and less active. The updraft magnitude of the stratiform cloud is less than 1 m/s, and cloud particle grows through the process of gradual deposition. The stratiform cloud is arranged in layers and forms a thick uniform grey layer at the low altitude. Likewise, the stratiform precipitation usually occurs without any thunder or lightning.

The Tropical Rainfall Monitoring Mission (TRMM) revealed an unprecedented relationship between the topography and precipitation system with continuous rainfall maxima observed in the frontal part of the Himalayas, where the average elevation is approximately 1 km, and in the inner rainfall belt which rises until an average elevation of approximately 2 km (Bookhagen & Burbank, 2006). Furthermore, the convective cloud plays an active role to form precipitation in the southern slopes of the Himalayas (Barros & Lang, 2003; Barros et al., 2004; Anders et al., 2006). The convection of cloud can occur in the flat land too, but in the Himalayan region, convection occurs due to the interaction with the mountainous terrain. Thus, convection is also part of the orographic precipitation. The orographic precipitation enhancement factors in Nepal ranges from 200% up to 300% (Barros et al., 2004). This phenomenon suggests the precipitation induced due to the orography-cloud interaction is spatiotemporal at different topographical gradients. Observation from Barros et al. (2000) found that not only elevation but the spatial arrangement of topographic gradients is detrimental to precipitation system. The main findings from Barros et al. are listed below.

1) Weak altitudinal gradients of annual rainfall exist between 1000 and about 4500 m;
2) Strong ridge-to-ridge zonal (east-west) gradients of monsoon rainfall (1500 mm/5 km);
3) Strong ridge-valley gradients during rainstorms, especially in the case of deep valleys (elevation differences ≥ 1000 m) and steep slopes (70%); and
4) Strong altitudinal gradients in rainfall intensity and duration (convective versus stratiform), with longer (shorter) durations and lower (higher) intensities at high (low) elevations along the ridges.

Likewise, Barros et al. (2004) report two distinct types of orographic controls at different spatial scales after comparative analysis between the collocated variability of topography and the overlying cloud cover; they are:

1) A synoptic mode (~300 km) associated with the overall terrain envelop and the major river valleys that cut through the mountains connecting the Indian subcontinent and the Tibetan Plateau; and
2) A quasi-periodic succession of ridges and valleys that constitute the Himalayan range (5-150 km).

Furthermore, Barros et al. (2004) also report three primary modes of spatial variability related to orographic land-atmosphere interaction. First, a synoptic scale mode linked to global climate controls; second, a synoptic scale mode linked to regional climate controls such as monsoon intensity and land-form; and third, a mesoscale mode linked to local orography. Moreover, based on the actual complexity of the terrain within different regions in the Himalayan range, Barros et al. report the variance of cloudiness and its scaling behaviour reflects the ridge density as well as its altitudinal range.

2.1.1.4 Southern Oscillation and Himalayan Precipitation

The southern oscillation variability occurs in every ten years and is well-known to influence the ISM (Krishnamurthy & Goswami, 2000; Shrestha, 2000). Shrestha studied the precipitation system of the Nepal Himalayan region from a broader perspective and found an active role of southern oscillation in the Himalayan precipitation. The World Meteorological Organization (WMO) categorises the variations of southern oscillation as neutral, El Niño and La Niña. Furthermore, Kripalani and Kulkarni (1997) show an increase in El Niño related drought in the below normal monsoon in India, compared to above normal monsoon. In addition to agreeing with Kripalani and Kulkarni's finding, Krishnamurthy and Goswami (2000) show La Niña events do not have a significant impact on monsoonal droughts throughout India. However, the relationship between the La Niña events and monsoon floods are firm, but the relationship between ISM and El Niño is weak (Krishnamurthy & Goswami, 2000). Likewise, Krishnamurthy and Goswami also suggest a coupled relationship between the interdecadal oscillation of ISM and southern oscillation. Moreover, they also report that during the interdecadal mode of warm Pacific and below-normal ISM, the interannual variance of ISM and southern oscillation is high, and in the opposite phase, the variance is low.

The southern oscillation is an atmospheric event which occurs in the form of change in trade wind, air pressure and temperature (World Meteorological Organization [WMO], 2014). The variations of southern oscillations are the oceanic components which occur through the change and transfer of water temperature in the Pacific Ocean (WMO, 2014). Out of the three variations, during the neutral variation of southern oscillation, the trade winds in the central Pacific region direct towards Australasia and East Asia from South America. During this process, the trade wind blows the warm air towards the west (Australasia and East Asia) in turn, pushing the warmer water also in the same direction. In the South American side, a process known as upwelling happens where the cold water comes to the surface of the ocean. With warm water in the west, the tropical Pacific region experiences warm atmosphere resulting in a rapid rise of air leading to extreme rainfalls and weather events. The rise in the air due to this effect creates an atmospheric circulation of the easterly wind in the Pacific region. The warm moist air rises in the western side, and cooler but dry air descends on the eastern side of the Pacific near South America.

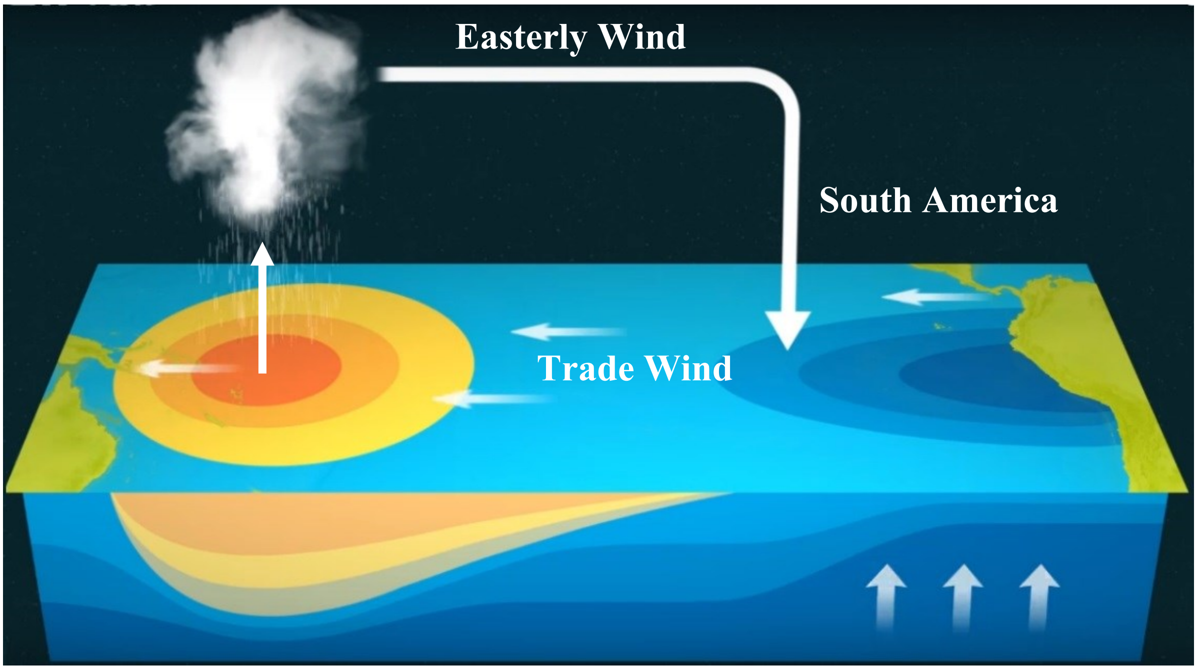

Figure 2.1. The neutral state of the weather at tropical Pacific region with trade wind blowing from east to west, warm water in the west, cold water in the east, extreme rainfall events in the west and generation of easterly wind. Red and yellow represent the warmth of the water, while dark blue represents coolness. (modified from Met Office UK, 2014)

El Niño, the second variation of southern oscillation occurs every three to seven years, and its acute phase usually lasts about a year. The unexpected warm water during the Christmas period observed off the coast of Peru was termed as El Niño. Niño is a Spanish word for 'the boy Christ' and the term El Niño only recently became a common word for this phenomenon. The fluctuation in ocean system around the equator and changes in tropical Pacific weather system can create a chain of events which leads to weakening of trade wind blowing from the eastern side of the Pacific to the west. The weakened push of the trade wind and less upwelling of the cold water allows the warm water to come closer to the eastern side near South America; this process fluctuates the temperature of an area with warm water.

Since the area of warm water moves east, the associated moist air and unsettled weather phenomenon also follow. Thus, a change in temperature and wind pattern in the tropical region occurs, leading to extreme precipitation and floods in Peru and drought in East Asia and India. However, El Niño has known impact everywhere in the weather system of the world. For example, El Niño releases a high amount of energy into the atmosphere and increases the global average temperature. This fact cannot generalise the impact of El Niño because every El Niño event is unique and has different impacts around the world.

The third variation of southern oscillation is La Niña and is precisely opposite to that of El Niño. The oscillation changes during La Niña from moderate trade wind of El Niño to strong trade wind pushing all warm water to the far western region of tropical Pacific. Usually, El Niño dies after its occurrence or flips to La Niña. La Niña is 'the girl' in Spanish, representing the opposite of 'the boy'. During La Niña, the upwelling of cold water increases in the eastern side of the tropical Pacific and spreads further towards the middle part of the ocean. Generally, La Niña has opposite effects on El Niño by increasing precipitation and extreme weather events in parts of Asia. The Southern Oscillation Index (SOI) measures the rate of oscillation between these three variations. Southern oscillation is a fluctuation in atmospheric sea level pressure which involves the exchange of air between the eastern and western part of the tropical Pacific region.

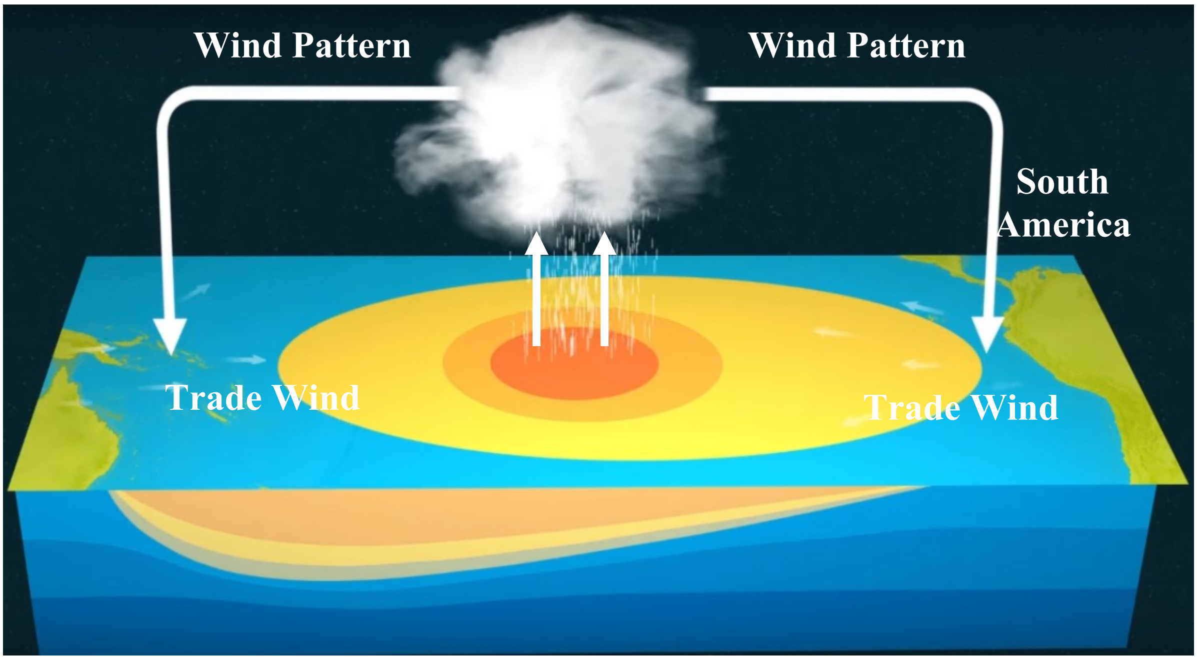

Figure 2.2. The El Niño state of the weather in the tropical Pacific region with weakened/flipped trade wind, warm water and extreme rainfall events in the central and eastern part and generation of new wind pattern. Red and yellow represent the warmth of the water, while dark blue represents coolness. (modified from Met Office UK, 2014)

The annual mean atmospheric sea level pressure of Darwin (in northern Australia) and Tahiti (in South Pacific Ocean) are significantly but oppositely correlated. Thus, the difference of fluctuation of atmospheric sea level pressure between Darwin and Tahiti (Tahiti – Darwin) is the SOI. A condition having higher atmospheric sea level pressure than average indicates dryness, and a lower atmospheric sea level pressure than average indicates excess rainfall and storminess. If atmospheric sea level pressure is lower in the east (Tahiti), then it will be higher in the west (Darwin). Thus, the negative SOI which is an El Niño year leads to wetness in the east and dryness in the west and opposite to that is La Niña year with positive SOI (Ranasinghe, McLoughlin, Short, & Symonds, 2004).

Shrestha (2000) reports in most cases of El Niño years the monsoon rainfall in Nepal was below average. However, Shrestha also suggests that the relation of SOI to monsoon rainfall in Nepal has interannual variation. The correlation between SOI and rainfall in Nepal from 1962 to 1983 was weak in the early sixties, which eventually became significant at 99% confidence from

1969 to 1980 and again decreased later. This observation shows an active role of southern oscillation in the precipitation system of Nepal.

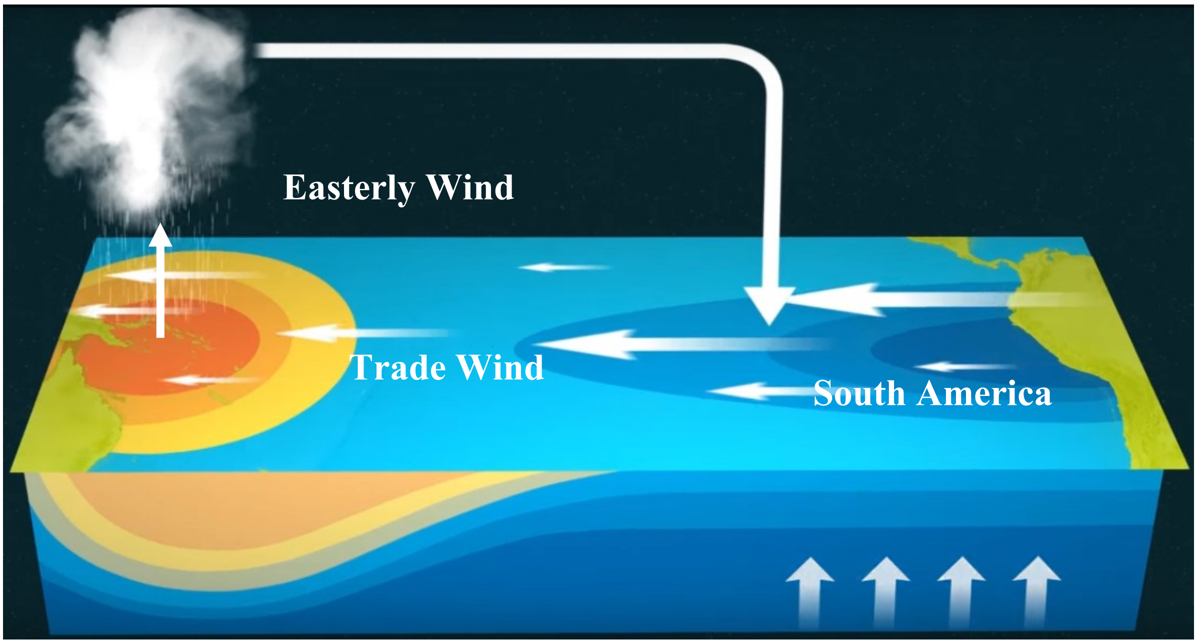

Figure 2.3. The La Niña state of the weather at tropical Pacific region with strong trade wind blowing from east to west, warm water in the tropical west, cold water in the central and eastern part of the ocean, extreme rainfall events in the tropical west and generation of easterly wind. Red and yellow represent the warmth of the water, while dark blue represents coolness. (modified from Met Office UK, 2014)

Furthermore, Zhu, Böthe and Fraedrich (2011) found the relation of North Atlantic Oscillation (NAO) in summer monsoon precipitation in regions surrounding north India. The NAO is an oscillation of atmospheric pressure at sea level of the Atlantic Ocean between subtropical (Azores) high and subpolar low. The NAO index is the observed fluctuation of atmospheric sea level pressure over a broad range of longitudes 80˚W-30˚E (Jianping & Wang, 2003). Zhu et al. found that the wave generated by the North Atlantic storm travel towards Asia via Scandinavia-Tibetan Plateau bridge or the Mediterranean-East Asia bridge.

Consequently, the North Atlantic storm created due to low-pressure anomalies in Iceland and high-pressure anomalies in the Scandinavia travels south and stops the depression coming from the Bay of Bengal, the Arabian Sea and the South China Sea to reach the Tibetan plateau (leeward side of the Himalayas) resulting in droughts. Moreover, the storm created due to NAO also plays a vital role to transport the moisture arising from the Arabian Sea and the South China Sea to the Tibetan plateau. The long-distance atmospheric bridges form a storm track for storms arising from various phenomena such as the southern oscillation or NAO provide the connection to influence the precipitation system of the Himalayas which is dominated by the summer monsoon.

2.1.2 Precipitation Pattern in the Himalayas

The summer monsoon and westerly govern the precipitation pattern in the Himalayas (Barros et al., 2004; Zhu et al., 2011). The studies related to precipitation in the Himalayas until now are not able to instigate any pattern. The underlying cause of this situation is often attributed to the paucity of precipitation measurement data, reduced accessibility of the field, lack of proper rain gauge network and sampling error ranging from 15-50% (Barros & Lang, 2003; Anders et al., 2006; Bookhagen & Burbank, 2006; Wulf et al., 2010; Nandargi & Dhar, 2011; Nepal, 2016; Panthi, Dahal, Shrestha, Aryal, & Krakauer, 2015; Ragettli et al., 2015). Furthermore, the research related to precipitation pattern in the Himalayas are not older than four decades and are in part (Barros & Lang, 2003; Anders et al., 2006; Bookhagen & Burbank, 2006; Wulf et al., 2010; Panthi et al., 2015). The difficulty in measuring and analysing precipitation over a specific or essential part of the region in both spatial and temporal scale is one primary reason for related research to be in part. Moreover, rain gauges which provide precise information about the precipitation in the region are loosely dense and are not located in the high Himalayas, resulting in the under-sampling of high-altitude areas.

2.1.2.1 Seasonal Precipitation Pattern

The summer monsoon varies in the Himalayan region based on the distance from the Bay of Bengal (Bookhagen et al., 2005). The hydrometeor originating from the summer monsoon in the Eastern Himalayas lasts four to five months from June to October, June to September in the Central Himalayas and hardly two months (July to August) in the Western Himalayas (Nandargi & Dhar, 2011). However, Nandargi and Dhar (2011) do not provide any precise information about the division of the Himalayas in the East and Central zone. They delineate that Ladakh region, which is in the south-eastern part of Jammu and Kashmir, as a part of the Western Himalayas. A thorough review of related articles (Thakur, 1992; Singh, Ramasastri, & Kumar, 1995; Singh & Kumar, 1997; Dimri & Dash, 2012) also delineates region from Western Pakistan to Jammu and Kashmir and the Punjab region as the Western Himalayas.

The National Disaster Risk Reduction Portal of Jammu and Kashmir state the monsoon to be spanning from mid-July until early September. Correspondingly, the monsoon in the Himalayan region of Pakistan spans from July till August (Imran, Zaman, Rasul, & Mahmood, 2014). Likewise, the Central Ground Water Board of Uttaranchal Region of India in 2016 report the monsoon of Uttaranchal region of India spans from July to August. These timeframes suggest that Uttaranchal also falls under the two months monsoon category of the Western Himalayas, as stated by Nandargi and Dhar (2011). According to these reviews, the Western Himalayas span along the Western border of Nepal. Likewise, Dhar and Rakhecha (1981), Shrestha (2000), and Lang and Barros (2004) identify Nepal as the central Himalayas. Moreover, Eriksson et al. (2009) from International Centre for Integrated Mountain Development (ICIMOD), a regional intergovernmental organisation working on different aspects of the Himalayas, and Barros and

Lang (2003) identify the monsoon of Nepal spanning from June to September. This period of monsoon activity is in line with Nandargi and Dhar's zoning of the central Himalayas.

Similarly, the National Disaster Risk Reduction Portal of Sikkim, which lies in the Eastern border of Nepal, state the monsoon of Sikkim spans from June till October. Likewise, on the east of Sikkim the summer monsoon ranges from June till September in Bhutan (Tamang, 2014) and further east the monsoon ranges from June till October in Arunachal Pradesh of India (GTZ, 2011). According to the monsoonal zoning of the Himalayas by Nandargi and Dhar (2011), and monsoonal activity in different regions of the Himalayas ranging from West of Pakistan to Arunachal Pradesh in the East, the Himalayas can be zoned as Western, Central and Eastern Himalayas. However, Karan (1966) tried to categorise the geographic regions of the Himalayas based on human occupancy, societal features and terrain. The zoning of the Himalayas based on the monsoonal activity as posited above slightly differs with Karan's version. The only noticeable difference is the central Himalayas spans from Uttaranchal till the eastern border of Nepal.

The rain gauges in the Himalayan region are loosely dense and do not represent every area of the uneven terrain. Thus, finding satellite data as best alternate option Anders et al. (2006) published the precipitation pattern of the Himalayas at a high spatial resolution of 10 km scale. They report substantial variability across, along with and within the Himalayan range but consistent spatial pattern during their sampling period (1998-2001). Similarly, long-term paleo-climatic study shows both wet and dry period in the last millennium (Eriksson et al., 2009). Furthermore, Eriksson et al. (2009) report, during the last few decades, the trend of precipitation is increasing in the Tibetan Plateau, eastern and central Himalayas while it is decreasing over the western Himalayas. However, Nepal Himalayas show no long-term trend in precipitation between 1948 and 1994.

In line with Bookhagen and Burbank (2006)'s finding, Anders et al. (2006) also report steep gradient in precipitation pattern from the wet foreland in the east to the arid Tibetan Plateau in the north and west. Likewise, Anders et al. define the valley of the Tsangpo/Brahmaputra River in the north of Bay of Bengal as a zone of high precipitation and north to that as dry Higher Himalaya in southern Tibet. The variation in precipitation is high between the ridges and valleys along the strike of the range. A broad double-band of high precipitation exists in the southern slopes of central and western Himalayas with the first and second rise in topography (Anders et al., 2006). There is a clear indication in the literature that precipitation pattern in the entire Himalayan region is actively controlled by topography but not by elevation (Barros & Lang, 2003; Barros, 2004).

Moreover, Anders et al. (2006) verify this fact with their theoretical model and Barros et al. (2004) verify with remote sensing method and modelling of the cloud patterns in the central Himalaya. However, Nandargi and Dhar (2011) state that maximum rainfall occurs in the foothills of the Himalaya (also agreed by Anders et al.), second maximum near 2400 m altitude and rainfall decreases when proceeded north. This decrease of rainfall might be due to the leeward side in the north and can also be a case of under-representation of precipitation measurement due to lack of required gauges. Furthermore, Barros et al. (2000), Lang and Barros (2002) and, Barros and Lang (2003) reveal noticeable variation in total seasonal precipitation over the spatial scale of 4 km to 10 km.

The summer monsoon precipitation accounts for ~80% of the mean annual precipitation in the frontal Himalayan stretch and the plains (Shrestha, 2000; Wulf et al., 2010; Panthi et al., 2015). The Cherapunji in India, which lies at the foot of Eastern Himalayas, is the wettest place on the Earth with more than 12,000 mm rainfall per year (Eriksson et al., 2009). In contrast, the winter precipitation from November to April varies drastically and are difficult to predict (Barros, 2004). Wulf et al. report winter precipitation to be approximately 60% of the total annual rainfall in the Western Himalayas and the central Himalayas. Likewise, Panthi et al. (2015) report it to be 26% of the annual precipitation. The winter precipitation occurs on the leeward side of the Western and Central Himalayas.

Moreover, precipitation over the Western Himalayas shows an average cycle of 10-12 days of evolution and decay (Dimri, Yasunari, Kotlia, Mohanty, & Sikka, 2016). Likewise, in the central Himalayas, the monsoon precipitation ranges between 350-450 cm with a variability of larger than 100 cm over short distances of ~10 km (Barros et al., 2000; Shrestha, 2000; Lang & Barros, 2002). Significantly, about 40% of summer precipitation falls during 4-6 storm events in both the frontal Himalayan stretch and the high Himalayas (Wulf et al., 2010). The plains and lesser Himalayas have the highest number of rainy days while in the high Himalayas the number of rainy days is low, but the trend of intense precipitation is increasing (Panthi et al., 2015).

The onset of monsoon originating from the Bay of Bengal in eastern and central Himalayas are equally strong up to 5000 m but timing and phase of precipitation changes above 3000 m (Barros, 2004). The onset of monsoon in the central Himalayas show no variation, but the withdrawal of monsoon shift by half a day per year (Panthi et al., 2015). Barros and Lang (2003) report a new pattern of precipitation where the monsoon rainfall intensifies during the night-time in high altitudes (≥2000 m). They suggest that during the day there is a low convergence of monsoonal flow due to slope up-flow and high conversion during the night due to the absence of slope up-flow leading to nocturnal peaks. Except for monsoon, the rainfall peak is during the afternoon. Barros (2004) report snowfall contributing 40% of annual precipitation in high elevations of the Himalayas. This percentage increases with altitude and is strongly modulated by inter-annual variations ranging from 20-30% of annual totals. Barros also reports all precipitation below 3000 m is in a liquid form and Lang and Barros (2004) report snow accounts for 17±11% of annual precipitation while increasing with elevation. Major snowfall events in the central Himalayas arrives with western disturbances (Lang & Barros, 2004). Likewise, Barros finds snow on the windward side of central Himalayas but also on the leeward side suggesting the transport of snow due to its lightweight. Moreover, Barros also reports insignificance of rain shadow during the winter as it is during the summer period.

Various research related to precipitation pattern focuses only on certain parts of the Himalayas, which are entirely different from other parts. The limited focus of research area generates a different result of the region with a standard answer; the precipitation pattern varies seasonally. Moreover, there is no observable trend in previous research to justify the use of either satellite data such as the TRMM or the rain gauge data. Although research shows about 85 to 90% coefficient of determination between the TRMM and rain gauge data, the sampling error of satellite data is as high as 60% (Anders et al., 2006; Bookhagen & Burbank, 2006). Thus, the usage of rain gauge data is efficient to explore ground reality. When combining all the findings as discussed above the distribution of precipitation, the intra-seasonal variation of monsoon and westerly onset, the variability of convective activity and the terrain are intricately interlinked to control the pattern and events of precipitation.

2.1.2.2 Extreme Precipitation Pattern

Nandargi and Dhar in 2011 analysed extreme rainfall event from 1871 to 2007 over the Himalayan stretch. With data of 137 years (1921-1990 in case of Nepal), they report the lowest category (≥250<300 mm) of one-day extreme rainfall events has the highest frequency in each decade compared with other three categories (≥300<400 mm, ≥400<500 mm and ≥500 mm). Furthermore, they report one-day extreme rainfall occurs mostly between the Siwalik and the Great Himalayan range. The extreme events of precipitation also occur during the El Niño year, in wet as well as during dry years. However, Bohlinger and Sorteberg (2018) mention no linear correlation between the El Niño Southern Oscillation (ENSO) and the extreme events above the 99^{th} percentile, while the seasonal rainfall correlates with ENSO but extreme daily precipitation does not in Nepal.

There is an increasing trend of extreme precipitation in Nepal from 1971 to 1990 with specific extreme events recorded in 1981, 1993, 1996 and 1998 (Chalise & Khanal, 2002). Likewise, Baidya, Shrestha, and Sheikh (2008) report an increasing trend of extreme precipitation events for the period of 1961-2006 in 26 rainfall monitoring stations of Nepal. Furthermore, Shrestha, Bajracharya, Sharma, Duo, and Kulkarni (2017) report increase in precipitation intensity over the Koshi River basin from 1975-2010; however, the trend is statistically insignificant. Similarly, Karki et al. (2017) report increase of extreme precipitation in southern plains of Nepal, middle mountains of western Nepal and high mountains of central Nepal along with an increase of dry days over central and eastern middle mountains of Nepal from 1970-2012 based on the data of selected 76 stations. Furthermore, Bookhagen (2005) reports twofold extreme precipitation events in the high Himalayas compared to the plains and the Tibetan plateau.

Likewise, Bookhagen (2005) also finds more extreme events in the arid interior part of the Himalayas compared to the wet orogeny. Moreover, Nandargi and Dhar (2011) and Malik et al. (2012) notice prominent peaks of one-day extreme precipitation from 1951 to 2000 over the Himalayan range. However, this can also be due to an increase in the rain-gauge network. Additionally, Bookhagen et al. (2005) also report abnormal monsoon years in Baspa Valley during 1957, 1968, 1978, 1990 and 2002.

The abnormal monsoon years are related to the onset of monsoon. Later the onset, violent the monsoon. However, this phenomenon was not vivid in the Himalayan fronts during the decade of 1992-2002 but was intricate and unstable (Bookhagen et al., 2005; Malik et al., 2012). The extreme rainfall events occur during the active monsoon period (Malik et al., 2012) but are decoupled from annual or seasonal rainfall distribution (Bookhagen, 2005). Likewise, the extreme precipitation events occur during the synoptic scale rainstorms, which are quite different from the local convective events (Barros et al., 2004). Furthermore, Chalise and Khanal (2002) and Nandargi and Dhar (2011) explored extreme precipitation based on four categories, as mentioned above. However, extreme precipitation events are also explored by using the above 90th percentile index (Bookhagen, 2010; Malik et al., 2012).

The extreme events during the winter period arrive with westerly disturbances and vary inter-annually and seasonally (Lang & Barros, 2004). Out of the total annual precipitation, 50% is often recorded within ten days of the arrival of the monsoon period in Nepal (Dahal & Hasagawa, 2008). Furthermore, Chaulagain (2006) report trend of faster increase of temperature in high altitude compared to plains and, increase in days with intense precipitation (>50 mm) while the decrease in that of less intense precipitation (<25 mm). Due to the climate variation and widening of temperature, extreme events such as droughts and flash floods are observed along with increasing glacier retreat rate (Eriksson et al., 2009). In general, the extreme precipitation study and its relationship with the ENSO in Nepal has not received much attention, while its status is still unexplored, and most of the research is only focused on specific places or present only generalised findings (e.g., Barros & Lang, 2003; Lang & Barros, 2004; Wulf et al., 2010; Karki et al., 2017, etc.). Intricate, unstable, complex and dynamic are the common words associated with studies related to extreme precipitation pattern in the Himalayas.

2.1.3 Upstream-Downstream Linkage in the Himalayas

The increasing trend of extreme precipitation events and fluctuating precipitation pattern impacts the runoff of a river within the catchment area (Wulf et al., 2015). Moreover, the theoretical concept of river runoff was traditionally static but recent research development focus more on the inter-annual variability of the river discharge (Harris, Gurnell, Hannah, & Petts, 2000; Bower, Hannah, & McGregor, 2004). The upstream-downstream relation asserts the complex relation of the natural environment and human activity. Such complexity escalates with anomalies of quasi-periodic synoptic features of the elevated Himalayan swath related to inaccessibility, fragility and heterogeneity in the environment. The climate in the Himalayas varies with elevation and in times is unpredictable, too (Nandargi & Dhar, 2011). Within a distance of 90-120 km, Nepal varies from 60 m in the south to 8848 m in the north. Moreover, the temperature decreases by 6˚C with an increase in 1 km elevation (Mani, 1981). This elevation gradient results in the climate to change quickly in different regions of the Himalayas, resulting in sudden cloudbursts, high winds, or snowstorms, leading to quick floods and landslides suggesting the unpredictability and dangerousness of the Himalayan climate. With such sudden damages, the denizens downstream are also affected by various physical and social activities conducted in the headwaters. This complex linkage of upstream-downstream relation is presented in Figure 2.4 below and reviewed in this section.

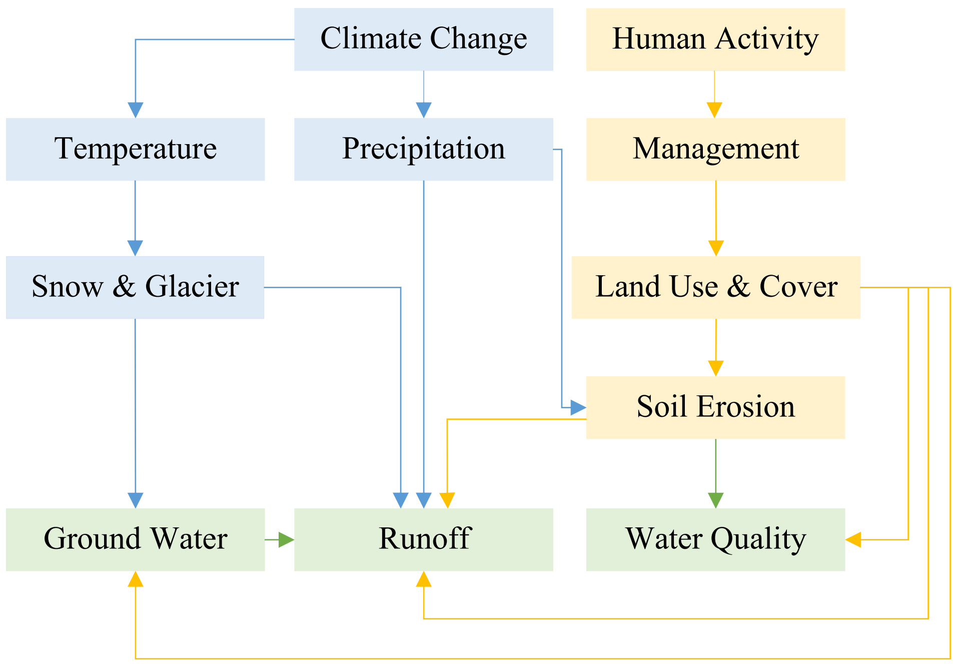

Figure 2.4. Upstream-Downstream linkages considering natural and human activity aspect (adapted and modified from Nepal, 2012, and based on literature review as elaborated below).

2.1.3.1 Natural and Humanmade Impact of Land-Use

The vegetation, deforestation and terrace farming are the most influential human-made triggers of variation in downstream river flow (Bronstert, Niehoff, & Bürger, 2002). Likewise, the increase in forest cover is associated with a decrease in river runoff (Nepal, 2012). Significantly, the forest plays an essential role in evapotranspiration where water is lost through transpiration of trees, leading to less runoff. In contrast, the conversion of forest to agricultural land responds with increased runoff (Wilk, 2002). Moreover, the reduced infiltration capacity of the soil impacts the downstream runoff. Similarly, the permeation of liquid into the soil by filtration occurs during the infiltration process. This process occurs through soil compaction, erosion, or increase in drainage capacity. However, generalising the relation of forest and soil with downstream runoff can be misleading (Bruijnzeel, 1990; Food and Agriculture Organization of the United Nations and Center for International Forestry Research [FAO CIFOR], 2005). The strong relation of forest and soil in reducing or increasing the runoff exists only in small basins, on a local scale. This interrelation of human activity and natural phenomenon is still not clear, but precipitation is the most important activity to shape the downstream river runoff (Brooks, Folliott, Gregersen, & Thames, 1991; Bruijnzeel, 1990, Hannah et al., 2005).

Wulf et al. (2015) found in the western Himalayas that 55% of rainfall, 35% snow melt and 10% glacier melt were responsible for the downstream river discharge. Similarly, Nepal (2012) found in the Koshi river basin that 72% precipitation and 20% evapotranspiration are responsible for downstream river flow. Likewise, Nepal (2012) also reports around 17% impact of the glacier melts in the Koshi River basin. Moreover, Ragettli et al. (2015) report the dominating influence of snowmelt during the winter and that of rainfall during the summer in the Langtang valley of Nepal. Correspondingly, the pre-existing saturated soil, precipitation lasting for several days in the catchment area along with the melting of snow or ice develop the long-lasting floods (Bronstert et al., 2002). Similarly, localised intense precipitation develops flash floods. The former situation occurs in the plains of the Himalayas while the latter in the hills and mountains.

Furthermore, Gaume and Payrastre (2018) state rainfall intensity measured based on its concentration over time in the watershed is directly related to the river discharge. Likewise, Milliman (2001) states river discharge as a function of meteorological runoff (precipitation minus evaporation), and area of the drainage or catchment basin. Moreover, Milliman reports existence of some rivers such as the Lena and Yenisei rivers of Russia with low meteorological runoff but high river discharge due their large catchment areas. Although, the impact of precipitation on river discharge is well studied in Nepal, the relationship between size of the catchment area and river runoff intensity and frequency is still an issue to explore.

A general concept which prevails in the Himalayan region about mitigating inundate events by afforesting might not be enough, due to stormy situations and saturation of soil due to too much water leading to reduced infiltration (FAO CIFOR, 2005). However, afforestation is improving and maintaining soil fertility with an increase in infiltration capacity, which is beneficial for the upstream environment (Bruijnzeel & Bremmer, 1989). Likewise, soil erosion, as well as the forest cover and land-use impact the runoff. Thus, denser forests in plains as well as in the hills keep the soil intact while reducing the risk of soil erosion (Shrestha, 1997). Primarily, the river discharge rises during the monsoon from June and peaks during August and decreases gradually till February in Nepal (Hannah et al., 2005).

The higher Himalayas with steep gradients have steady erosion rate directly related to the precipitation rate (Gabet et al., 2008). The inverse ratio between sediment delivery and basin size exists, making it challenging to notice the effect of erosion in large basins in short time lag (Bruijnzeel, 1990). In the Himalayan region, the intense rainfall and high stream flow rate reduce the opportunity to store sediment, thus making the process difficult to understand (Wasson, 2003). Furthermore, the higher Himalayas are the dominant source of sediment (80% of total suspended sediment) in the downstream rivers, increasing the difficulty to understand the role of human activity in the generation of sediment runoff (Wasson et al., 2008). The alluvial fan of the Koshi River suggests that during the last 220 years the river has shifted laterally about 115 km as a result of sediment deposition (due to active upstream denudation) and aggradation (Sinha, Bapalu, Singh, & Rath, 2008). Likewise, Bookhagen et al. (2005) also report high denudation rate in low to medium elevation (3000 m) mountains of the orogeny during abnormal climatic variation and such variation possess risk of channel erosion and sediment transport which plays a fundamental role in shaping arid mountainous landscapes and fluctuates the downstream flow of the rivers. The high amount of precipitation during monsoon over a short period in a concentrated area creates erosion, flash floods, denudation, sedimentation and runoff (Ives & Misserli, 1989; Gabet et al., 2008). However, research related to the spatial distribution of extreme river runoff events is negligible in Nepal. Furthermore, Eckholm (1976) claims environmental degradation, such as loss of forest, biodiversity and soil erosion, the dominant problem leading to flooding in the Himalayan region.

2.1.3.2 Other Linkages

Temperature is increasing in Nepal, with an alarming rate of 0.6˚C per decade (1977-2000), and the entire region of South Asia is expected to heat even more (Eriksson et al., 2009). The Himalayan glaciers, which is the enormous ice mass outside the polar caps cover about 17% out of the total landmass of the Himalayan region, are in high risk due to this warming trend (Intergovernmental Panel on Climate Change [IPCC], 2007). Furthermore, Nepal (2012) reports the trend of increase of maximum temperature is faster than that of minimum temperature in Eastern Nepal with the increase in evapotranspiration and snowmelt to disturb the hydrological regime of the same area. Likewise, Nepal also reports the increase in hydrological flow in glacier-fed and precipitation dominated river basins.

Furthermore, Eriksson et al. (2009) confirm snowfall precipitation turning into rainfall due to increase in temperature and faster formation of Glacier Lake increasing its risk of the outburst. The glacier shrinkage and formation of glacial lakes are highest here compared to anywhere in the world. Thus, leading to an increase in short-term river flow, which in the long-term, will gradually decrease (Eriksson et al., 2009). In combination with intense precipitation, which is also in an increasing trend, the glacial melting is triggering flash floods and debris flows (Hewitt, 2005). However, this phenomenon has not been quantified yet while considering the physical interaction involved in melting process affecting stream flows and several runoff components (Singh & Jain, 2006; Immerzeel, Beek, Konz, Shrestha, & Bierkens, 2012). The melted form of water is essential in the western Himalayans more than the East because there is less monsoon precipitation in the west but has comparatively higher winter precipitation in the form of snow (Immerzeel et al., 2012).

The socio-economic activities such as migration and development also impact the upstream-downstream discharge linkage. Primarily, commodity transfer and utilisation of available natural resources for production and exchange are the primary result of migration, which creates change in the land-use system (Ives, 2004). Similarly, infrastructure development, which generates development opportunities, also affect natural systems, but due to inaccessibility, these activities are limited in many parts of the Himalayan range. Furthermore, economic development influences the consumption of more products such as agricultural, and the magnitude and process of their flow impact the sustainability of the region (Jodha, 1997). The upstream and downstream communities are related by trade where the upstream community provides ecological services to the downstream community while the latter provides trade opportunity to the former creating a vital link between physical and socio-economic aspects (Jodha, 2000).

2.1.4 Flow Chart of Precipitation and Upstream-Downstream Linkage Review

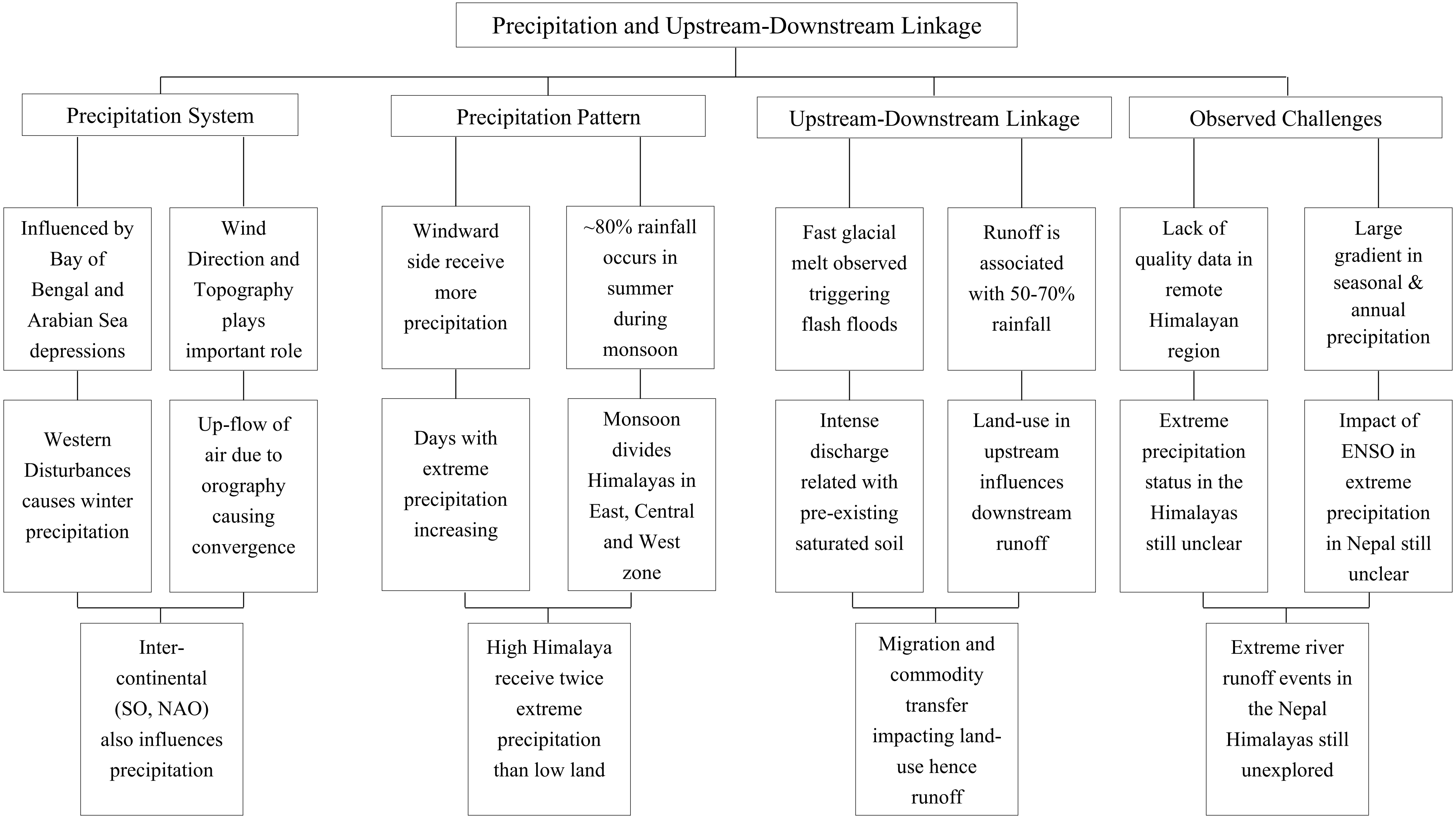

Figure 2.5. Summarised literature review map of precipitation and downstream run-off.

2.2 Review of Environmental Education and Attitude

Environmental education affects the environmental attitude and environmental attitude influences pro-environmental/adaptive behaviour (Meinhold & Malkus 2005; Johnson & Činčera, 2015). Thus, exploring both education and attitude is essential to comprehend in which direction the population is heading towards. Since this research takes place in rural Nepal, this review explores the existing literature on the state of environmental education content in Nepal and the environmental attitude of the Nepalese children. Moreover, the relationship between attitude and behaviour ranges from low to moderate (Hines et al., 1986/87). A prevailing hypothesis suggests that the single dimensional construct of the attitude is responsible for the low to moderate relationship (Milfont & Duckitt, 2004). Therefore, against this knowledge, this subchapter also reviews the existing literature on the construct of attitude and its relationship with education and behaviour. Furthermore, this review also explores a tool to analyse the environmental attitude of the children, the 2-MEV. Finally, this subchapter outlines the observed deficiencies and future research needs.

2.2.1 Education in Nepal

Durbar High School was the first formal school of Nepal established in 1892 (Wood, 1959). It was open only for the ruling elites, the Rana family of Nepal. Before 1892, the Gurukul was the dominating education system in Nepal. The Gurukul is a South Asian or Hindu residential schooling system where a student lives with the Guru (teacher) for education (Kachappilly, 2003). Furthermore, education during this period was mainly about the Hindu way of life, following the scriptures of the Hinduism. The terms "education" and "schooling" elucidates what a child learns to ascertain different ways for future living. For this research, the term "education" refers to the knowledge gained through a formal school system which includes primary, secondary and higher education. Likewise, the term "school" implies the state-controlled public (government funded) and private schools.

2.2.1.1 History of School Education in Nepal

In 1951 the Rana regime was dethroned from Nepal. With the regime's departure, their idea of blocking access to education for the citizens of Nepal also departed. Before that, there were six high schools in Nepal, out of which four were inside the Kathmandu Valley and one college (Koirala, 1996). Great thirst for knowledge was observed by 1954 as 1200 primary schools, 83 high schools and 14 new colleges came into operation (Wood, 1959). In 1954 the National Education Planning Commission was formed in Nepal, which developed the first education development plan and was implemented in 1956. This plan focuses on the central purpose to raise production, employment, standards of living and general well-being throughout the country, thus opening out to the opportunities for a richer and more satisfying life (Ministry of

Education of Nepal, 1956). There was an existing idea to catch-up the industrialised countries through education. However, the traditional knowledge base was rejected by saying it was not appropriate for growth and development (Nepal National Educational Planning Commission, 1956).

The 1956 first plan of education in Nepal, had a clear message to move forward towards technology and modern education. From 1956 till date, there have been fourteen periodic plans by the National Planning Commission of Nepal (NPC). The general message regarding the education of all these plans is, the key to development is education. The education plans of 1971, the tenth plan (2002-07) and twelfth plan (2010-12) emphasise education as a means for all-round development, economic and social transformation of the country (Parajuli, 2014). Furthermore, primary education (grade 1-5) was available for free and was compulsory in 1975, while by 1991, this facility was increased until grade 6 (Keinath, 2004).

Table 2.1. Increment in schools from 1991 to 2013/14 (Central Bureau of Statistics of Nepal, 1991 and 2014).

Type of Schools	**1991**	**2013/2014**
Primary Schools	14,500	34,743
Lower Secondary Schools	3,964	14,867
Upper Secondary Schools (Secondary Schools + Higher Secondary School)	1,953	12,322

The schools started to increase after the 1980s when new education plans focused on meeting the basic needs of the people, thus allowing private schools to open (Keinath, 2004). The new education plans (twelfth, thirteenth and fourteenth) focuses on the enrolment of students in each grade, literacy rate (able to read and write), inclusion, opportunity and rate of graduation (NPC, 2012; 2017). The fourteenth (current) national plan for education sets three goals and three objectives (NPC, 2017).

Goals:

- To provide the necessary education, vocational education for all and develop practical teaching methodology.
- To provide education according to the need of the country.
- To increase vocational education for employment and self-employment opportunities.

Objectives:

- To make education affordable, skilful, contemporary and high quality for all.
- To reach all the citizens, if necessary, by using the alternative education system to provide education and vocational education.
- To improve and instigate educational administration.

It is clear from these goals and objectives that the plan is to provide education for all in any form available. The fourteenth national plan for education is in line with the Sustainable Development Goals (SDGs) 2015 (NPC, 2017). There are 17 SDGs out of which one is about education (United Nations, 2017). The SDG 4 ensures inclusive and equitable quality education and promotes lifelong learning opportunities for all. Its main goals are:

- Ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and useful learning outcomes.
- Ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.
- Increase the number of adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.
- Ensure that all learners acquire the knowledge through education for sustainable development and lifestyles, human rights, promotion of peace, global citizenship and cultural diversity.

Table 2.2. The chronological highlight of inception of major educational activities in Nepal (modified from Aditya, 2003).

Year	**Established or Incepted Activity**
1918	Tri-Chandra College Established
1930	Ayurveda College Established
1942	Technical Training School Established
1948	Bachelor of Science course started
1952	Central Library
1954	National Education Planning Commission
1956	Multipurpose Vocational Education and First Curriculum Programme Starts
1957	College of Education
1959	Tribhuvan University Founded and First Post-Graduate Classes Start
1962	UN Report on Education in Nepal
1964	Nursery Classes Start
1967	National Education Advisory Council
1971	Curriculum Development Centre and New Education Act
1976	PhD in Science and Technology Starts
1978	B.Sc. in Agriculture, Engineering and Medicine
1978	National Literacy Programme Starts
1979-80	Private Schools and Campuses are Permitted to Operate
1986	Mahendra Sanskrit University Established
1991	Kathmandu University Established
1992	National Education Commission’s Report
1993	Purbanchal University Established
1996	Policy on Special Education
1996	Pokhara University Established
2004	Lumbini Buddhist University Established
2010	Agriculture and Forestry University Established

2010	Far-Western University Established
2010	Mid-Western University Established

Table 2.2 shows the brief history of major educational activities in Nepal. In 2009, School Sector Reform Programme (SSRP: 2009-2015) was initiated by the Government of Nepal (GoN) to restructure school education by integrating different levels into primary education and secondary education along with one year of early childhood education and development at the age of 4 as seen in Table 2.3 (Ministry of Education of Nepal, 2009). The main aim is to increase the retaining rate of students and overall enrolments. There was no vocational education option at the school level before, but now there is an option to enter the vocational stream at grade 9. This new education system allows the student to enter tertiary education after one year of bridge education.

Table 2.3. Comparison of old school structure and new school structure.

<table>
<tr><th>Age</th><th>Grade</th><th>Old System</th><th>New System</th></tr>
<tr><td>16</td><td>12</td><td rowspan="2">Higher Secondary Education</td><td rowspan="4">Secondary Education</td></tr>
<tr><td>15</td><td>11</td></tr>
<tr><td>14</td><td>10</td><td rowspan="2">Secondary Education</td></tr>
<tr><td>13</td><td>9</td></tr>
<tr><td>12</td><td>8</td><td rowspan="3">Lower Secondary Education</td><td rowspan="8">Basic Education</td></tr>
<tr><td>11</td><td>7</td></tr>
<tr><td>10</td><td>6</td></tr>
<tr><td>9</td><td>5</td><td rowspan="5">Primary Education</td></tr>
<tr><td>8</td><td>4</td></tr>
<tr><td>7</td><td>3</td></tr>
<tr><td>6</td><td>2</td></tr>
<tr><td>5</td><td>1</td></tr>
<tr><td>4</td><td colspan="3">Pre-Primary Education / Early Childhood Development</td></tr>
</table>

In recent years the enrolment rate in schools and tertiary education are increasing (NPC, 2017) but there is still 60% drop-out in primary schools as of 2000 (Onta, 2000). Likewise, the gender disparity also exists with 75.1% male being literate compared to 57.4% female in 2011 (Central Bureau of Statistics of Nepal [CBS], 2014). Moreover, the geographical disparity of literacy in 2011 between urban (82.2%) and rural (62.5%) areas is also evident (CBS, 2014). The literacy rate was 65.9% out of the total population in 2011 (CBS, 2014). Keinath (2004) considers household duties, teaching method, training of teachers, sparsely located schools in rural areas, and malnutrition as major hurdles towards school attendance.

There are private and public funded schools in Nepal. The private schools are self-funded, usually from the students' tuition and other fees, and have more resources compared to public school, creating a disparity between different school goers (Keinath, 2004). Thus, limiting quality education to wealthy students (Shrestha, 2002). However, there is also an opportunity to attend non-formal education, such as out of school programme for those who cannot attend primary school. Different non-formal education centre organises such programmes and provides equivalency to school education up to grade 10. In 2011, the non-formal education programme benefitted 4.15% of Nepalese citizens (UNESCO, 2015).

2.2.1.2 The Curriculum of School Education and its Development in Nepal

The Curriculum Development Centre of Nepal (CDC) develops the curriculum followed in the schools of Nepal. According to CDC (2012) curriculum is revised every five years and updated every ten years. The National Curriculum Development and Assessment Council formulates the curricular policies while the CDC implements it (CDC, 2007). The CDC collects recommendations and suggestions from the curriculum development committee, the curriculum users, related workshops and the civil societies for the development of the curriculum (CDC, 2007). The structure of the curriculum development committee varies on the subject being either compulsory or optional. The curriculum development committee to validate the curriculum of compulsory subjects include (CDC, 2012):

1. Specific expert of the subject or head of CDC as the chairperson of the committee.
2. Education expert of the subject from a university as a member of the committee.
3. CDC's head of the department of the related subject as a member of the committee.
4. Two experts on curriculum development or authorised personnel from CDC as a member of the committee.
5. Three teachers of the related subject (including at least one-woman teacher) as a member of the committee.
6. Authorised personnel related to the subject from the CDC as a member secretary of the committee.
7. Based on the nature of the subject, three more related experts can be invited by the committee.

The Nepali and English language, social studies, mathematics, science and environment, health and physical education, Sanskrit language and moral education are the compulsory subjects. However, there are optional parts within these subjects, and the same committee provides recommendations and validity. Likewise, social science, mother tongue languages, vocational education and religious education are optional subjects in the school curriculum of Nepal. Similar to the curriculum development committee of compulsory subjects, there is a curriculum development committee of optional subjects, and it includes (CDC, 2012):

1. Specific expert of the subject or head of CDC as the chairperson of the committee.
2. Teacher of the related subject from a university's related department as a member of the committee.

3. Two teachers of the related subject (including at least one-woman teacher) as a member of the committee.
4. CDC's head of the department of the related subject as a member of the committee.
5. Expert of the related subject or authorised personnel of CDC as a member of the committee.
6. Authorised personnel related to the subject from the CDC as a member secretary of the committee.
7. Based on the nature of the subject, three more related experts can be invited by the committee.

The CDC (2012) explains the basis, source and process of curriculum development in Nepal. The moral basis and source of curriculum development are constitution and law, history, eastern philosophy, psychology, social and geographical factors. The law and order, need of student and society, binding national and international treaties, political situation, recommendations from various stakeholders and experts, recommendations from district curriculum committees, conventional need, innovations, findings and reports on students', teachers', educational programmes' and curriculums' performance throughout the year is the basis to develop curriculum. Likewise, study and research, continuous development of the curriculum and its evaluation are the three significant steps in the development of the curriculum, which incorporates eight critical points as mentioned below.

1. Identifying the need for curriculum.
2. Objective.
3. Selection of topics and sub-topics of the subject.
4. Organisation of topics.
5. Selection of teaching method.
6. Organising teaching method.
7. Analysing student's progress.
8. Improving the curriculum by revision.

The developed or updated curriculum is sent for pre-evaluation to selected regions/schools, and the feedbacks are incorporated in the final curriculum of the subject. The local need-based education is also acknowledged by the national curriculum framework of Nepal (CDC, 2007). It stresses on developing a guiding principle to incorporate local contents of the region, selecting subjects and its contents, localise centrally prescribed subjects using instructional activities and develop and manage a curriculum at the local level to address relevant issues. Furthermore, a committee can also be formed in the district level or regional level to recommend local contents for a subject (CDC, 2012).

Moreover, there is also a provision to add 20% local contents in social studies, creative arts and physical education and as well as an entirely new subject, however only in primary level (CDC, 2007). The CDC (2007) admits several challenges such as human resources, training, conducive environment and institutional mechanism to develop and implement local contents in the curriculum. Likewise, CDC also admits that the process above of curriculum development in Nepal is not based on educational research and stresses the need for more educational research for capacity building to develop a viable curriculum. The outline of curriculum structure based on subject areas for schools of Nepal is presented in Table 2.4 below.

Table 2.4. The current curriculum structure of Nepal as adopted from CDC (2007).

Level	Stage/Stream	Major Learning Area	Subject
Basic Education (Grade 1-8)	First Stage (Grade 1-3).	Language, Mathematics, Social Studies, Creative Arts and Local need-based education.	Integrated curriculum with an activity book covering major areas of learning.
	Second Stage (Grade 4-5).	Nepali, English, Mathematics and Social Studies.	Compulsory: Nepali, English, Mathematics and Social Studies. School can select two local need-based subjects. Note: Social Studies should be local need-based and should be integrated with Science and Health and Physical Education.
	Third Stage (Grade 6-8).	Language, Mathematics, Social Studies, Science and Local Subject.	Compulsory: Nepali, English, Mathematics, Social Studies and Science. Optional first: Language / Others. Optional second: Local subject.
Secondary Education (Grade 9-12)	General Stream (Grade 9-12).	Language, Science, Mathematics, Social Studies and Local Subject.	
	Vocational Stream (Grade 9-12).	Agriculture, Forestry, Medical, Engineering, etc.	

As mentioned above, there are several challenges to develop and implement a viable need-based curriculum in the current scenario of Nepal. Due to such limitations, limited subjects without many choices of optional and local subjects/contents are followed throughout the schools (public and private) of Nepal. From 2000 to 2017 the subjects taught to students of grade nine and ten has not changed and can be seen in Table 2.5 below. One exception between the exam mark sheet of 2000 and 2017 is the change in grading system from numerical marks to grades (A+ to E), in 2016, after the eighth amendment of the Educational Act (Government of Nepal, 2016).

Table 2.5. Subjects taught to school children of grade 9 and 10 in Nepal.

Subjects	Weightage	Full Marks	Highest Grade
1. Nepali	5	100	A+
2. English	5	100	A+
3. Mathematics	5	100	A+
4. Science	5	100	A+
5. Social Studies	5	100	A+
6. Health, Population and Environment	4	100	A+
7. Optional I	5	100	A+
8. Optional II	5	100	A+
Total	**39**	**800**	**-**

2.2.1.3 Environmental Education in Nepal

As stated by the World Commission on Environment Development (WCED), the environment does not exist as a sphere separate from human actions, ambitions, and needs and is where we all live (WCED, 1987). The deteriorating environments, as seen today, are due to the exploitative utilisation of the natural resources by the humans. This situation is common in Nepal too. Jha (2007) reports the loss of forest, loss of biodiversity, soil erosion, air pollution, water pollution and solid waste as common environmental problems of Nepal. Researchers believe environmental education is the most viable tool to tackle environmental degradation (Alerby, 2000; Sudarmadi et al., 2001; Loughland, Reid, & Petocz, 2002). The term environmental education is widely used since the late sixties. Furthermore, the earth summit in 1992 ratified Agenda 21, which is the guideline for sustainable development in the 21st century.

The United Nations Conference on Environment and Development (UNCED) states education as, "critical for promoting sustainable development and improving the capacity of people to address environment and development issues" (UNCED, 1992). Chapter 36 of Agenda 21 appeals to the countries around the world to incorporate environment and development issues in their education system (UNCED, 1992). Following this development, the concept of environmental education took off in Nepalese education. Environmental education in Nepal aims to make individuals aware of their environment and its problems and helps them to understand the effect that human choices have on the environment (Karki, 2000). Environmental education has been part of the national curriculum in Nepal since its instigation after Agenda 21 in 1992.

The United Nations Education, Scientific and Cultural Organisation (UNESCO) and United Nations Environment Programme (UNEP), (1994) regards environmental literacy as the goal of environmental education. The goal of environmental education is further elaborated as, "aiding learners in becoming environmentally knowledgeable and, above all, skilled and dedicated human beings who are wiping to work, individually and collectively, toward achieving and/or maintaining a dynamic equilibrium between the quality of life and quality of the environment" (UNESCO-UNEP, 1994, p.1). Likewise, the official announcement of the United Nations Decade of Education for Sustainable Development (2005-2014) focuses on holistic and interdisciplinary methods to develop the knowledge and skills needed for a sustainable future to address required changes in human values, behaviour, and lifestyle instead of a universal model of environmental education (Zandvlet & Fisher, 2007). Furthermore, the government of British Columba from Canada, based on consultation with their stakeholders, suggest principles for organising and conceptualising environmental education. These principles facilitate students' understandings of responsible action towards the environment, which is influenced by their belief system and personal limitations, by encouraging students to understand the issue, their personal values and conflicting values of the community members (British Columbia Ministry of Education, 2007). Moreover, Kathmandu University School of Education from Nepal (KUSOED) also recommends these principles as the framework for environmental education or sustainable development education (Pokhrel, 2014). These principles of environmental education are a combination of complexity, aesthetics, responsibility, and ethics.

The complexity addresses interrelatedness of natural systems, and human interaction to affect those systems. In general, it addresses that life on earth depends on, and is part of, complex systems. Moreover, the relationship between culture, social values and nature are also part of this principle. Likewise, aesthetics focuses on environmental awareness and development of an aesthetic sense of respect and appreciation of the natural environment. Thus, environmental awareness leading to aesthetic appreciation relates to environmental issues and motivates students to express their appreciation through various mediums. The third principle, responsibility, includes issues regarding the impact of human decisions and actions on the environment. These issues not only discuss the limitations of natural resources but also the responsible role of legal aspects such as law and governments. Lastly, the principle of ethics addresses taking responsible action with positive environmental values. In general, the ethics part covers issues of crisis arising from personal or communal value systems, how the attitude and perception are influenced by the society, the formation of values, and need to question values for the benefit of the environment.

Furthermore, the UNESCO-UNEP (1994) has set goals of environmental education, which are derived from the objectives included in the Tbilisi Conference Report of 1977 and presented in Table 2.6 below. The Tbilisi Conference was the first-ever intergovernmental conference on environmental education organised by the UNESCO and UNEP in 1977. Likewise, along with the principles of environmental education, the KUSOED also recommends these four goals for

Nepal's environmental and sustainable development education (Pokhrel, 2014). These four goals consist of the aspects of cognitive knowledge and skills within the scope of environmental literacy. Out of the four goals, the first is the ecological foundation level. Alike the first principle of environmental education, this goal also covers the issues of interrelationship in nature along with the major concepts of ecology.

Likewise, the second goal is the conceptual awareness level. The understanding and awareness regarding the impact of humans' activities, culture, and beliefs on the environment, including environmental issues and solutions along with alternative solutions, are part of the second goal. The conceptualisation of awareness is also identical in both the principles and goals of environmental education. Similarly, the third goal is the investigation and evaluation level. The instructions related to the third goal address issues of knowledge and skill application for the identification, investigation, and solution, including the alternative solution of the environmental issues. Finally, the fourth goal environmental action skill level focuses on citizenship action such as consumerism, politics, legal action, and cultural implication to resolve environmental issues.

Table 2.6. Objectives of Environmental Education recommended by the Tbilisi Conference on Environmental Education in 1977 (adapted from Pokhrel, 2014).

Objectives	**Actions**
Awareness	To help society and individuals acquire an awareness of and sensitivity to the total environment and its allied problems.
Knowledge	To help society and individuals gain a variety of experience in, and acquire a basic understanding of, the environment and its associated problems.
Attitudes	To help society and individuals acquire a set of values and feelings of concern for the environment and the motivation for actively participating in environmental improvement and protection.
Skills	To help society and individuals acquire the skills for identifying and solving environmental problems.
Participation	To Provide society and individuals with an opportunity to be actively involved at all levels in working towards the resolution of environmental problems.

According to the CDC (2011), education related to the environment and local surroundings start from the basic level and are part of the compulsory subjects. Likewise, the related contents of the environment are integrated into the core subjects of science and social studies. The environmental knowledge, degradation, and conservation methods are the focus area of environmental education in Nepal. Environment education is part of social studies until grade 8. Specifically, the diurnal cycle, coordinate systems, natural resources, geography of Nepal, the geography of other continents, mapping, global warming, and disaster management are the content of environment-related subjects till grade 8. Likewise, from grade nine till ten, the environment related contents are part of health, population and environment subject. The students are made familiar with the environmental resources of Nepal, the geography of Nepal in detail, conservation of the planet earth, biodiversity, and environmental health. However, an optional subject named environmental science can also be chosen by the student at the secondary level based on her or his interest and based on the availability of the course in the respective school. In this subject, students are made familiar with the physical, chemical, biological, natural, socio-economic, and health aspect of the environment. The inclusion of environmental education contents in different subjects and levels indicate an interdisciplinary and holistic approach to address environmental literacy in Nepal.

However, as aforementioned, the centrally organised curriculum development and its evaluation have uniform characteristics throughout the country (CDC, 2012). Keinath (2004) reports the impact of such a curriculum, which happens to be one of the few available research in the context of students' perception of the environment in Nepal. She reports no connection between the students' environment and environmental problems stated by the students. Keinath explores environmental perception only in the context of knowledge about the environmental problems. However, there is no research in Nepal till date, which explores the inclusive approach of perception, such as the willingness to manage the available resources to maintain a balance in nature. Since this is the fundamental idea of sustainable development, and as we have entered the SDG era (2015-2030), focusing on the students' holistic perception or attitude is essential. Even with a regular curriculum's content, a student will gain environmental knowledge. The impact of this content to affect the students' attitude towards the environment in general needs further exploration.

Moreover, notable Non-Governmental Organisations (NGO) are working to incorporate environmental education in the non-formal education programme. The Nepal Forum of Environmental Journalists (NEFEJ) is one such NGO which produces media materials for the children and adults related to the environment. Likewise, the Environmental Camps for Conservation Awareness (ECCA) holds day camps for school children specifically focused on environmental education. These, however, is not available throughout the country.

2.2.2 Relation of Environmental Attitude, Education and Behaviour

The environmental attitude is a psychological index and covers most research in the field of environmental psychology and perception (Milfont & Duckitt, 2004). Schultz, Shriver, Tabanico, and Khazian (2004, p.31) define environmental attitude as "the collection of beliefs, affect, and behavioural intentions a person holds regarding environmentally related activities or issues." Likewise, Milfont and Duckitt (2010) define environmental attitude as a psychological tendency expressed by evaluating the natural environment with some degree of favour or disfavour. Hines et al. (1986/87) in their meta-analysis analysed and synthesised the identified variables in various environmental psychology research ($n = 128$) from 1971 to 1987. They report attitude as a psycho-social variable of pro-environmental behaviour. Furthermore, they conclude that attitude is the third most crucial variable of behaviour ($r = 0.35$) compared to verbal commitment ($r = 0.49$).

Moreover, out of the various models proposed to explore the relation of environmental attitude and behaviour, Bamberg and Möser (2007) discuss norm-activation model (Schwartz, 1977) and theory of planned behaviour (Ajzen, 1991). The former postulates pro-social motive while the latter suggests self-interest to influence pro-environmental behaviour. Furthermore, Bamberg and Möser extend the meta-analysis of Hines et al. (1986/97) by focusing on environmental psychology research from 1995 to 2006 (n = 46) and conclude that pro-environmental behaviour is a mixture of self-interest and pro-social motives. Likewise, they report a complex arrangement of self-interest and pro-social factors (problem awareness, internal attribution, social norm, feelings of guilt, perceived behavioural control, attitude, moral norm and, intention) responsible for predicting pro-environmental behaviour. Similarly, various research indicates a significant relationship between attitude and behaviour. For example, Meinhold and Malkus (2005), and Johnson and Činčera (2015) report pro-environmental attitude moderated by environmental knowledge can effectively predict pro-environmental behaviour.

Furthermore, Kaiser et al. (1999) report the environmental attitude as a construct of environmental knowledge (factual knowledge), environmental values (normative knowledge), environmental behaviour intention, and responsibility feelings. These constructs can predict ecological behaviour. Likewise, after a review of 109 studies, Ajzen and Fishbein (1977) find closer the target, action and reference components are, the more likely attitude will predict behaviour. Moreover, Kibbe et al. (2014) report a positive attitude of the population towards nature influencing their pro-environmental behaviour. Similarly, Milfont and Duckitt (2010) refer to various contemporary environmental perception theorist observing environmental behaviour interacting with environmental attitude. Likewise, an opinion survey by the European Commission in 2008 show a positive correlation between the European publics' attitude to the environment and extent of education. In addition to that, the level of education has repeatedly shown to be a good predictor of environmental attitude in Western Europe (Bogner & Wilhelm, 1996; Bogner & Wiseman, 1997).

The research above explores attitude as a one-dimensional construct while a new theoretical construct of a multi-dimensional view of environmental attitude has emerged (Blaikie, 1992). Blaikie (1992) uses established item scales, and factor analysed them to come up with seven first-order factors which represent the general ecological viewpoints. Based on this development, Bogner and colleagues in the late 90s and early 2000 extend the concept of multi-dimensional view of environmental attitude (Bogner & Wiseman, 1997; 1999; Wiseman & Bogner, 2003). There experimentation on the Western European population (11-16 years old) throughout their series of research led to the development of Two-Dimensional Model of Ecological Values (2-MEV). The 2-MEV has two higher order orthogonal factors, each based on biocentric and anthropocentric worldview, respectively. The higher order factors include the sets of primary factors. Furthermore, the two higher order factors were negatively correlated with each other and were named as Preservation and Utilisation. The higher order factors were referred to as values under which the sets of attitudes were considered as primary factors. The attitudes were considered traits while values as types of traits (Wiseman & Bogner, 2003). Likewise, the negative correlation between these two values means that a person can hold both values; this was quite different from earlier constructs of environmental attitude.

Since its development, the 2-MEV has been successfully used by various researchers to explore the link between education and attitude. Till date, as aforementioned, most research has found that education can influence attitude. However, these researchers have explored the relationship between education and attitude based on either a short-term environmental education programme or an extra curriculum educational programme. For example, Johnson and Manoli (2008) explore this relationship based on an education programme of five days while Johnson and Manoli (2011) explore it based on two educational programmes, one was a three days programme while the other was a five days programme. Similarly, Schneller, Johnson, & Bogner (2013) had a treatment group of students who met weekly to attend an extracurricular course over one year. Likewise, Bogner, Johnson, Buxner, and Felix (2015) explore this link based on a multi-day educational programme. Thus, exploring this relationship based on long-term environmental education content, usually followed at schools over a semester or a whole year, is essential to analyse the accessibility of the 2-MEV tool.

Although Bogner and colleagues cross-validated the construct of environmental attitude proposed by 2-MEV (Bogner et al., 2015) Milfont and Duckitt (2004) question the theoretical construct of two orthogonal dimensions based on the reported significant correlation, five primary factors under two higher order factors suggesting unbalanced attitudinal subscale, biased trait of items under primary factors including discriminant validity of higher order factors, using eight primary factors to come up with two higher order factors and later limiting to five primary factors in the proposed model, and using less adequate statistical test. However, Milfont and Duckitt successfully conduct experimental analysis and theoretical discussion to validate the two-dimensional construct of environmental attitude, thus strengthening the new construct of environmental attitude (cf. Bogner et al., 2015). Nonetheless, they question the bi-dimensionality of environmental attitude to be consistent all over the world, specifically the non-industrialised countries, while referring to Corral-Verdugo and Armendáriz's (2000) findings which support their argument with a high positive correlation between the pro-human order and the pro-environmental order in Mexico. These findings stress that 2-MEV can be a standard tool for the whole world, but local factors should be considered before using it (Schneller et al., 2013). Thus, analysing the environmental attitude of Nepalese children using the localised and verified 2-MEV is essential to understand the variation of the construct of environmental attitude in different parts of the world with different social, economic and environmental structure. Along with Milfont and Duckitt in New Zealand, Johnson and Manoli (2008) in the USA, and Boeve-de Pauw and Van Petegem (2010) in Belgium also individually validate the new construct of environmental attitude proposed by the 2-MEV model. Lately, after the longitudinal (8 years) validation of the 2-MEV in the USA, the multi-dimensional construct of environmental attitude is well founded (Bogner et al., 2015).

2.2.2.1 A Tool to Analyse Environmental Attitude: 2-MEV

The research on understanding environmental attitude and value is going on over the last four decades (Ajzen & Fishbein, 1977; Hines et al., 1986/87, Bogner & Wilhelm, 1996; Johnson & Manoli, 2011; Bogner et al., 2015). A common problem with these research was the lack of standard, psychometrically-sound measurement tools. Most researchers developed instruments specific for their study but not a general measure of environmental perceptions (Johnson & Manoli, 2008). To address this issue, Bogner and Wilhelm (1996) developed the Environmental Perception (ENV) Scale in 1996, leading to the identification of two dimensions, 'preservation' and 'utilisation', and the Two-Dimensional Model of Ecological Values (2-MEV) (Bogner & Wiseman, 1999; 2002; 2006).

Bogner & Wilhelm in 1996 gathered and integrated as many items as possible from earlier studies in their analysis. A psychometric technique by using factor analysis was developed to analyse the items. The items were then summarised under two dimensions, which had different factors under them, and each factor was an attitude. The principal component analysis was used during the factor analysis process to sort the items as the attitudes (Bogner et al., 2015). Attitudes were named according to the type or theme of items. The obtained items under themed attitudes were developed based on meaningful discussions covering the aspects of ecological and environmental attitude (Wiseman & Bogner, 2003). During their research, the items were updated and verified by Bogner and colleagues to reach a reliable stage (Schneller et al., 2013; Bogner et al., 2015). Based on the response of sample population, children between 11 and 16 years old, the first scale describing environmental attitudes and its contribution to environmental values of the sample population were published (Bogner & Wiseman, 1999; 2002; 2006).

The items were subsequently modified then adjusted and tested for use in other parts of the world, including New Zealand, Mexico and the United States. In some cases, the scale was translated into other languages, with careful attention given to its transferability into other languages without losing its validity as well as reliability (Schneller et al., 2013). The attitudes were the primary factors and values were higher-order factors. Two orthogonal higher order factors which encapsulated set of the attitudes namely: Preservation (P): a biocentric dimension, and Utilisation (U): an anthropocentric dimension, elicited from Bogner and colleague's studies. The 2-MEV Scale is specially designed to understand the environmental attitudes and values of children 11-16 years of age (Schneller et al., 2013).

The dichotomous biocentric and anthropocentric dimension reflects conservation/protection of the environment and utilisation of natural resources, respectively. In 2003, Wiseman and Bogner report the P and U were uncorrelated. This means that a person could have a high preservation value of the environment and at the same time can have a high utilisation value to make use of natural resources too. This point is a primary advantage of the 2-MEV over other psychometric tools as remarked by Boeve-de Pauw, Van Petegem and colleagues (2006, 2010, 2013). In most studies using the 2-MEV Scale, the P value consists of three attitudes: Intent of Support, Care with Resources, and Enjoyment of Nature. The U value consists of two attitudes: Altering Nature and Human Dominance.

Each attitude has 3-4 items, and each item has a 5-point Likert type response scale ranging from 1 (strongly disagree) to 5 (strongly agree), with 3 (not sure) representing a neutral position. In preservation, a mean above 3 is a positive value towards the preservation of nature; likewise, a mean above 3 in utilisation is a positive value towards utilisation of the natural resources. This relationship between P and U in the 2-MEV is shown in Figure 2.6. The 2-MEV model is independently verified by Milfont and Duckitt (2004) in New Zealand, Johnson and Manoli (2008, 2011) in the USA, Van Petegem and colleagues in Belgium (see above), and successfully used in Mexico by Schneller et al. in 2013 confirming the initiative of the structure of 2-MEV model.

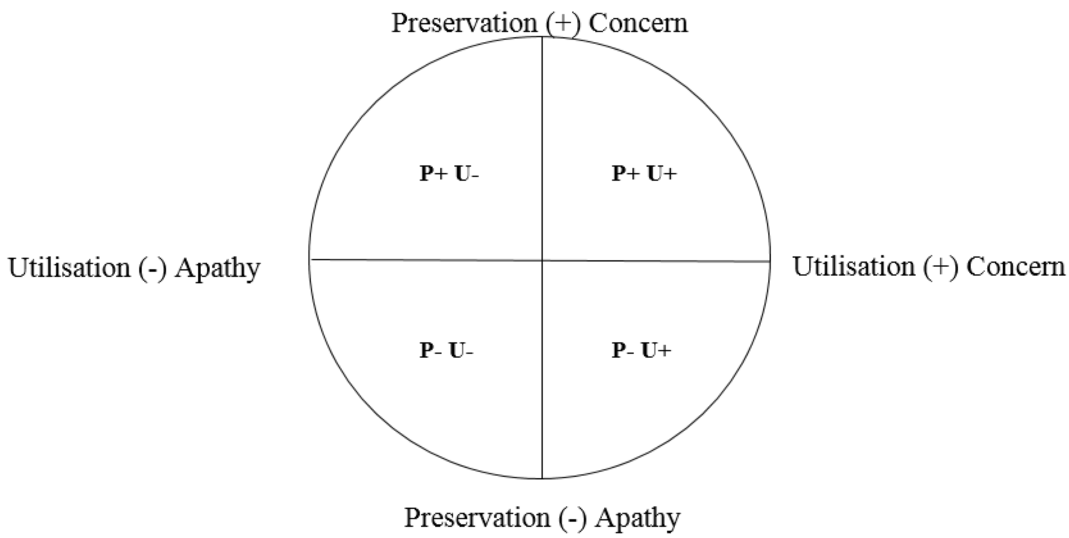

Figure 2.6. Two-dimensional model of ecological values (2-MEV) (Wiseman & Bogner, 2003).

2.2.2.2 Environmental Attitude of Nepalese Students

The school curriculum of Nepal elucidates primacy on the content rather than the need of the students (Keinath, 2004). Keinath, in her master’s thesis, reports the impact of centralised and uniform curriculum on the environmental perception of children. She reports no connection between the students’ environment and environmental problems stated by the students in

Eastern Nepal. The environmental problems in students' minds were referred to urban pollution even when they were living in rural areas. As the textbooks are the product of a centralised curriculum development system, they depict urban but not local environmental problems. Thus, she finds students' lack of understanding of their local environment. Keinath also mentions the textbooks of environmental education focus more on the problems rather than solutions and students should understand the solution so that they can act better towards the solutions. Moreover, she identifies the theoretical orientation of the content in the classroom and lack of training for the teachers to conduct the curriculum in the classroom effectively and understandably.

Keinath refers to various researchers about the students' retention of information in Nepal and state that little to no attention given to the perception of the students about how they see their environment and what they understand as their place in it (Pande & Karki, 1998; Hikawa, 1999; Pande et al., 2001). The rural students in Nepal are living and working closely with nature, indulging in activities such as agriculture, seasonal farming, forest fodder/fuelwood collection and using water bodies for day-to-day activity thus the way students understand this relationship with nature needs more exploration (Keinath, 2004). Bogner (1998) states that emotional principles and outdoor nature experience should be considered to promote environmental action. The only study to date on the environmental attitude of Nepalese adults (university students) reveals low environmental attitude. However, the author implies low environmental attitudes in Nepalese adults (urban-based) were influenced by lack of scientific education, weak individualism, and weak public criticism about the ongoing environmental scenario (Ohnisi, Khadka, Sánchez, & Dhamala, 2013). The author adopts the description of weak individualism from Dhungana (2008) and Bista (2008) as behaviour when someone obeys the group's rule and amalgamates their identity to the group's one.

2.2.3 Flow Chart of Environmental Education and Attitude Review

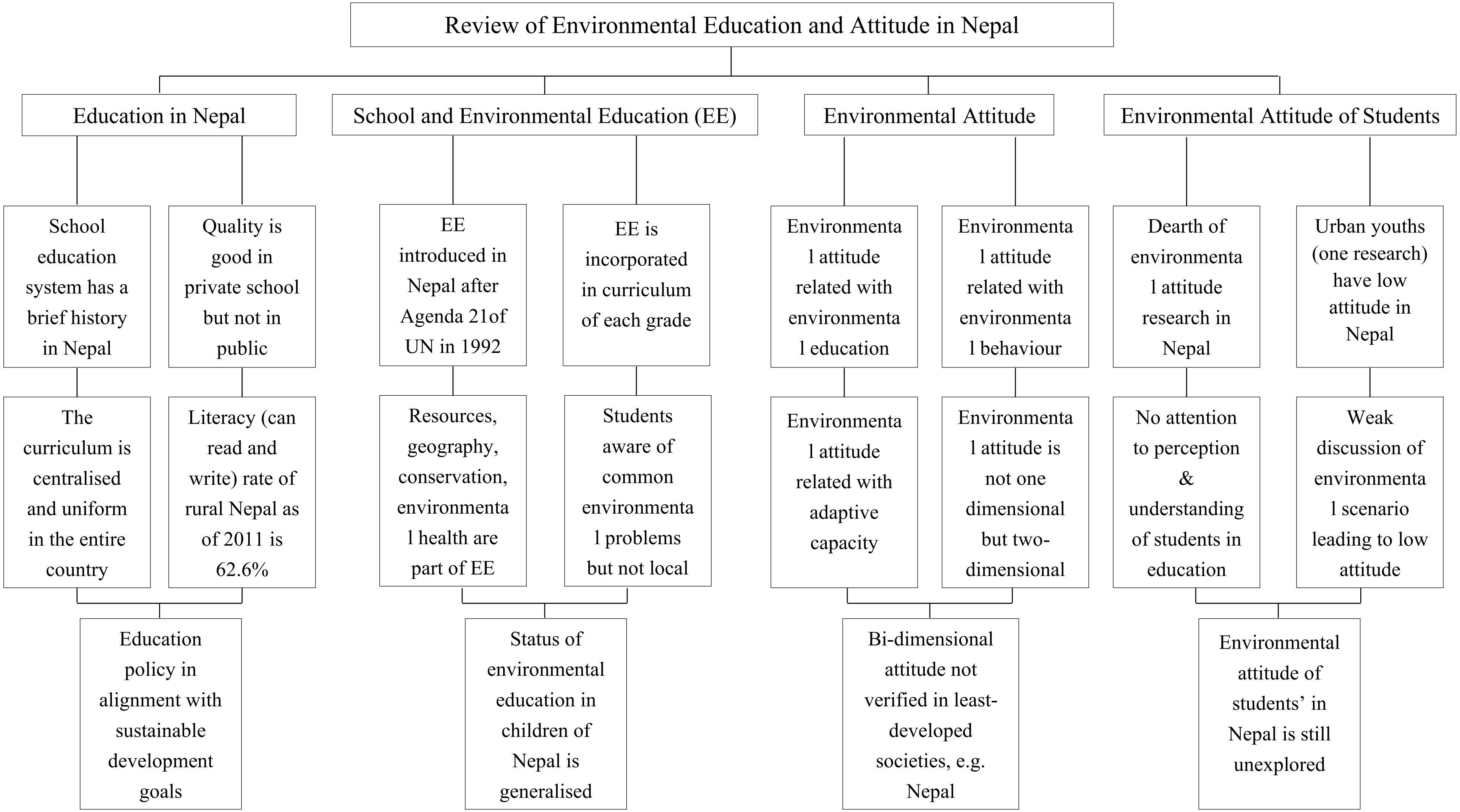

Figure 2.7. Summarised literature review map of livelihood, environmental education and attitude in rural Nepal.

3 Research Objectives and Methodological Approach

Chapter two elucidates the research deficits on extreme precipitation and extreme river runoff events in Nepal. Likewise, the literature review also highlights the absence of research on the environmental attitude of the school going children and its relationship with their education content in Nepal. Based on this review, the research objectives, research questions and research hypothesis were derived and proposed as below. Furthermore, this chapter also presents the methodological approach formulated to explore the research questions.

3.1 Research Objectives

The literature review chapter highlights the importance of local and regional factors to elucidate the pattern of precipitation in Nepal. Likewise, the review also clearly suggests the dominant role of rainfall in Nepal to influence the downstream river runoff. As a result, extreme events, both precipitation and river runoff, have led to natural disasters hampering the livelihood of the vulnerable communities in Nepal. However, research on the status of extreme precipitation and extreme river runoff is scarce in Nepal. Knowing the status of extreme events of any place will help to clarify the level of risk associated with it. Moreover, the influence of southern oscillation in the precipitation regime of Nepal is discussed but its impact on extreme precipitation is still not an elaborated issue. This lack of attention conceals the level of vulnerability of the downstream communities against such extreme disasters. Environmental attitude, as well as environmental education, are basic constructs to tackle and adapt to such catastrophes. Although the research on environmental education exists in Nepal, however, in limited numbers, the investigation of environmental education content and environmental attitude has received scant attention. Moreover, the already realised relationship between environmental education and environmental attitude is unexplored in Nepal.

The usage of psychometric tools to explore the environmental attitude is very common. Recently, 2-MEV has become a reliable psychometric tool based on a bi-dimensional construct of the environmental attitude. Moreover, the development of 2-MEV, its usage and verification materialised in the industrialised countries and lacked enough applied verification in a different geographical and socioeconomic setting. Thus, exploring the 2-MEV in an unindustrialised country like Nepal while regarding the impact of the educational content to influence the proposed bi-dimensional construct of attitude will ascertain its reliability in other parts of the world too. Based on these research deficiencies, the objectives of this research are pointed out as below:

1. Analysing the status of extreme precipitation events in the Nepal Himalayas;
2. Analysing the status of extreme river runoff events in the Koshi River basin;

3. Observing the relationship between the trend of extreme river runoff events with the trend of extreme precipitation events in the Koshi River basin;
4. Exploring the impact of southern oscillation on the extreme precipitation and river runoff events;
5. Exploring the bi-dimensional construct of environmental attitude, by using 2-MEV, in an unindustrialised society of Nepal;
6. Analysing the environmental attitude, using 2-MEV, of the children living near the Saptakoshi (Koshi) River; and
7. Exploring the status of environmental education content and its relationship with the environmental attitude of the school going children near the Koshi River.

3.2 Research Questions

The research questions are formulated by elaborating the research objectives mentioned above. Research questions, as mentioned below, will be investigated in this research.

1. What is the status of precipitation intensity and frequency along the Nepal Himalayas?
2. What is the status of extreme river runoff intensity and frequency in the Koshi River basin?
3. Is there any relationship between the trend of extreme river runoff events and the trend of extreme precipitation events in the Koshi River basin?
4. What is the impact of southern oscillation on extreme precipitation and river runoff events?
5. Does the bi-dimensional construct of environmental attitude prevail in an unindustrialised society of rural Nepal?
6. What is the status of the environmental attitude of the children living near the Koshi River?
7. What is the status of environmental education content, followed by the school going children, and does it correspond to their environmental attitude?

3.3 Research Hypothesis

Research objectives derived the research questions and based on the current state of knowledge, the hypothesis for this research are:

1. Status of precipitation intensity and duration depends upon the distance from the onset of monsoonal depression and the westerly wind as well as the orographic barrier.
2. The status of extreme river runoff intensity and duration in the Koshi River basin depends on the size of the catchment area.

3. Trend of extreme river runoff in the Koshi River basin is related with the trend of extreme precipitation events of the related stations.
4. Southern oscillation causes a scant change in total rainfall amount but influences the storm and runoff intensity, and storm and runoff duration significantly.
5. The construct of environmental attitude (Preservation and Utilisation) in rural Nepal represents bi-dimensionality.
6. There is no indication from previous research regarding the status of environmental attitude of the children living near the Koshi River basin or in a similar environment, thus, both the hypotheses are tested that the children have positive environmental attitude or they have negative environmental attitude.
7. There is an observable relationship between the environmental education content followed by the school going children with their environmental attitude.

3.4 Methodological Approach

The observation and analysis of extreme events and environmental education as well as attitude requires different methodological approaches. The methodology used in this research combines the study of historical data with survey and content analysis. The methodology section consists of two parts based on the analysis of natural events and the status of education/attitude.

3.4.1 Analysing Extreme Events

The precipitation events in the Himalayan front are almost impossible to predict (Bookhagen, 2010). Thus, analysing historical dataset is an efficient method to understand extreme events (Bookhagen et al., 2005; Nandargi & Dhar, 2011; Malik et al., 2012). In this research, the available data of precipitation and river runoff was analysed to analyse the status of extreme events on a spatial scale. The Department of Hydrology and Meteorology of Nepal (DHM) provided the data. There are 274 precipitation recording stations with available data (from 1970s to 2014) throughout Nepal. These stations are controlled and maintained by the DHM. The obtained data consisted of daily precipitation information in millimetre (mm). Likewise, the obtained daily river runoff data from the Koshi River basin was also from the DHM. The river runoff data were from 27 stations. These 27 stations represent all the tributary of the Koshi River including the *Sapta* Koshi River. The *Sapta* Koshi River is the confluence of all its tributaries from the basin. The detail of the Koshi River basin is in Chapter 4.2.

Moreover, the data source of southern oscillation was the Earth System Research Laboratory website for free of charge (Sardeshmukh & Smith, 2000). The data is available as the Bivariate ENSO Timeseries (BEST) index. The BEST index provides long-term El Niño Southern Oscillation (ENSO) data for each month from 1871-2018. The details of quality control and selection of all the obtained data for this research is in Chapter 5.

The precipitation stations have multiple years of daily data. The daily data was calculated from each station according to the need of selected parameters in the analysis. Likewise, the parameters used in this research to analyse the extreme precipitation events were adapted from The Expert Team on Climate Change Detection Monitoring and Indices (ETCCDMI) (Zhang & Yang, 2004). These parameters take account of the frequency and intensity of an event to analyse the extremity. The 90^{th} percentile threshold categorised the extreme events in this research, and the same was incorporated in these parameters (Bookhagen, 2010; Croitoru, Piticar, & Burada, 2016). The detail of data processing and parameter selection/development is in Chapter 5.2. Finally, based on the obtained value for each parameter of each station, the spatial distribution of extreme precipitation events throughout Nepal was obtained and analysed.

Similar to the precipitation analysis part, the 90^{th} percentile was taken as a threshold in river runoff analysis to compare the findings of extreme events. The parameters were adapted from the precipitation analysis method for calculation, spatial representation, and analysis. Likewise, the ENSO events and its comparison with extreme precipitation and river runoff events in Nepal were analysed based on the methodology used by Krishnamurthy and Goswami (2000), and Shrestha (2000). The yearly values of extreme events in Nepal from each stations were combinedly calculated as a mean value. It was then compared with the yearly BEST index. This comparison indicates the variation of ENSO events with extreme precipitation and river runoff events in Nepal. This finding further elucidates the relationship of southern oscillation with monsoonal activities in Nepal. The detail on the BEST index and its comparison with the extreme (above 90^{th} percentile) events are in Chapter 5.5.

Furthermore, the related precipitation stations and river runoff stations were analysed to explore any observable relationship of trend between the extreme precipitation and extreme river runoff events. This trend analysis was performed using the Mann-Kendall's methodology from the XLSTAT programme in MS Excel. Further details of data quality and parameters used in river runoff analysis are elaborated in Chapter 5.3. All the findings of this section are presented in the graphical or tabular form.

The Mann-Kendall trend test is extensively used by researchers to analyse the trend of extreme and normal climatic parameters (e.g., Hamed & Rao, 1998; Partal & Kahya, 2006; Zhai & Feng, 2009). Furthermore, the Mann-Kendall test is a nonparametric and statistic distribution test, which also works on non-linear trends and turning points (Croitoru et al., 2016). Moreover, the main advantage of the Mann-Kendall test is that it can cope with missing or negligible values and operates based on two hypotheses (Partal & Kahya, 2006). The null hypothesis and the alternative hypothesis: which means either there is no trend in the time-series or there is a trend in the time-series, respectively. The hypotheses are tested based on the determined level of significance, usually at 95% also noted as $\alpha=5\%$. If the obtained p-value after the analysis is lower than the significance level (e.g., <0.05 in case of $\alpha=5\%$), then the null hypothesis is rejected, and the alternative hypothesis is accepted. The positive or negative value of Kendall's tau determines the negative or positive trend of the time-series. Furthermore, the significance level can be changed, and the time-series can be tested accordingly. However, a significance level of 95% was taken as the standard value in this study. The significance level of 95% means that the positive, negative, or no trend in the time-series is correct with 95% confidence.

3.4.2 Analysis of Environmental Attitude and Education

The environmental attitude was analysed by using the psychometric tool 2-MEV. Bogner and colleagues developed the 2-MEV in the late 90s and early 2000s (Bogner & Wiseman, 1997, 1999; Wiseman & Bogner, 2003). The details of 2-MEV tool and its application are in Chapter 2.2.2. The 2-MEV was developed in Western Europe and later verified in different industrialised countries (Milfont & Duckitt, 2004; Johnson & Manoli, 2008; Boeve-de Pauw & Van Petegem, 2010; Bogner et al., 2015). Thus, the version for non-industrialised countries and more specifically, the Nepali version of the 2-MEV is not available. The first step was thus to create a verified version of the 2-MEV for the research site, which is in the rural part of Eastern Nepal. The detail description of the research site is provided in Chapter 4.3, while the sample population was selected by following the Arkin and Colton (1963)'s sample size formula.

$$n = \frac{NZ^2 * p * (1-p)}{Nd^2 + Z^2 * p\ (1-p)}$$

Here,

n = required sample size
N = total number of children
Z = confidence level (at 95% level Z = 1.96)
p = estimated population proportion (0.5, this maximizes the sample size)
d = error limit of 4.15% (0.0415)

There is no standard with a set value of confidence level and error limit – however, most research use 95% confidence level and 5% error limit. Anything above 95% and below 5% is considered a good statistical representation (Bhandari & Grant, 2007). The details of the population and sample size are in Chapter 6.2.

The 2-MEV is a set of questionnaire/items which reflect cognitive, affective, enactive and behavioural values with a focus on the action, target, context and phase of the respondents (Ajzen & Fishbein, 1977; Bogner & Wilhelm, 1996). Traditionally, the 2-MEV Scale uses a Likert-type response scale. After discussing the survey method with local experts, teachers and students, the children did not prefer the Likert-type scale. Thus, to address this issue, a worded rating scale which represented the Likert-type scale, was used, as recommended by Powell (2008).

Very satisfied (5)
Somewhat satisfied (4)

Neither satisfied nor dissatisfied	(3)
Somewhat dissatisfied	(2)
Very dissatisfied	(1)
Do not know / No opinion	(6)

Items followed by the options of worded rating scale was comfortable for the students to comprehend. To address the local context of rural Nepal, previously used items from other studies were modified along with the development of new items. As suggested by Bogner and Wilhelm (1996), great attention was paid to the item relevance of the students' world by addressing actions that are real to them. The items reflect ideas they encounter and are concrete rather than abstract. Items with multiple actions or that might only affect others were avoided. The details of selected, modified and developed items are in Chapter 6.1.1.

Likewise, the second step was translating the items to the Nepali language. The Nepali language is written in Devanagari script. According to Steiner (1998), translation is a transfer of meaning between languages. Thus, a literal translation of words was not enough in this study to create a valid instrument, but there is also no such thing as a correct translation. Moreover, Temple and Young (2004) suggest that the translator always makes his or her mark on the research, whether it is acknowledged or not. Birbili (2000) points out linguistic competence of the translators' knowledge of the people under study and the circumstances in which the translation takes place to be important factors for any valid research. For example, there was a conflict between the word nature and environment during the translation. In the Nepalese context, the usage of word nature and environment can have a different meaning in a specific situation. Thus, translating the item, *I prefer natural setting more than the urban setting* to the Nepali language became *I prefer the environment of village compared to that of a city*. This translation includes not only the aspect of translation but also the cultural aspect. The term natural setting is unclear, and villages are natural rather than urban areas; thus, it was easy for the respondents to understand this translation rather than using the word natural setting and urban setting.

Instead of literal translation, the focus was on the intended meaning of the item. Working with two languages can create confusion. Thus, Birbili (2000) suggests where lexical equivalence is not possible a 'conceptual equivalence' is to be sought. Moreover, Hanna, Hunt and Bhopal (2008) state that a view exists about the suitability of a native English validated study for other cultural groups with minimum adaptation. This attitude might emanate cultural hegemony, lack of salience of content, non-equivalence of concepts, and ensuring the interest present in the target group by the researcher (Kirkpatrick & Teijlingen, 2009). To avoid these confrontations in this research, conceptual equivalence as suggested by Birbili (2000) was achieved rather than equivalence of word form.

The conventional procedure of translation, as explained by Schneller et al. (2013), was followed. The process included translation and back-translation of the items by native Nepali speakers.

First, the native Nepali speaking author of this thesis translated all the 27 items to Nepali. Then, another native Nepali speaker with academic knowledge of English language back-translated the items to English. The differences between two English versions were noted, then re-translated to the Nepali language. This version of the translation was discussed with the experts who produced several modifications in the item battery. The experts had scientific background and knowledge about the research site, environmental issues, and survey battery tools. Finally, the items were taken to the research site, where the language, dialect and regional words were discussed with local teachers and students. No flaws were detected by the teachers and students in the set of items.

Following this development, the items were tested in two rounds with students of the research area. The Principal Component Analysis (PCA), and Confirmatory Factor Analysis (CFA) were conducted to obtain the final list of items and the bi-dimensional model of environmental attitude for rural Nepal. The PCA and CFA were conducted using SPSS software and its Analysis of Moment Structures (AMOS) package, respectively. Based on the obtained model, the construct of environmental attitude for rural Nepal was defined. Likewise, based on the finalised items, the final survey to analyse the environmental attitude of the students was conducted. The details used to conduct PCA, CFA, analysis of the construct of the environmental attitude and the final survey are in Chapter 6.1.2, 6.1.3, 6.1.4, and 6.2.

Furthermore, the environmental education status of the students was explored by analysing the environmental education textbooks followed in the schools of the research area. The textbooks of the sample population were analysed using the deductive content analysis method. Finally, the status of environmental education and environmental attitude of the sample students were observed together to point out any noticeable relationship. The details of the textbook analysis are in Chapter 6.3. Likewise, the detailed concept map of methodology to address the research objective is presented below in Figure 3.1.

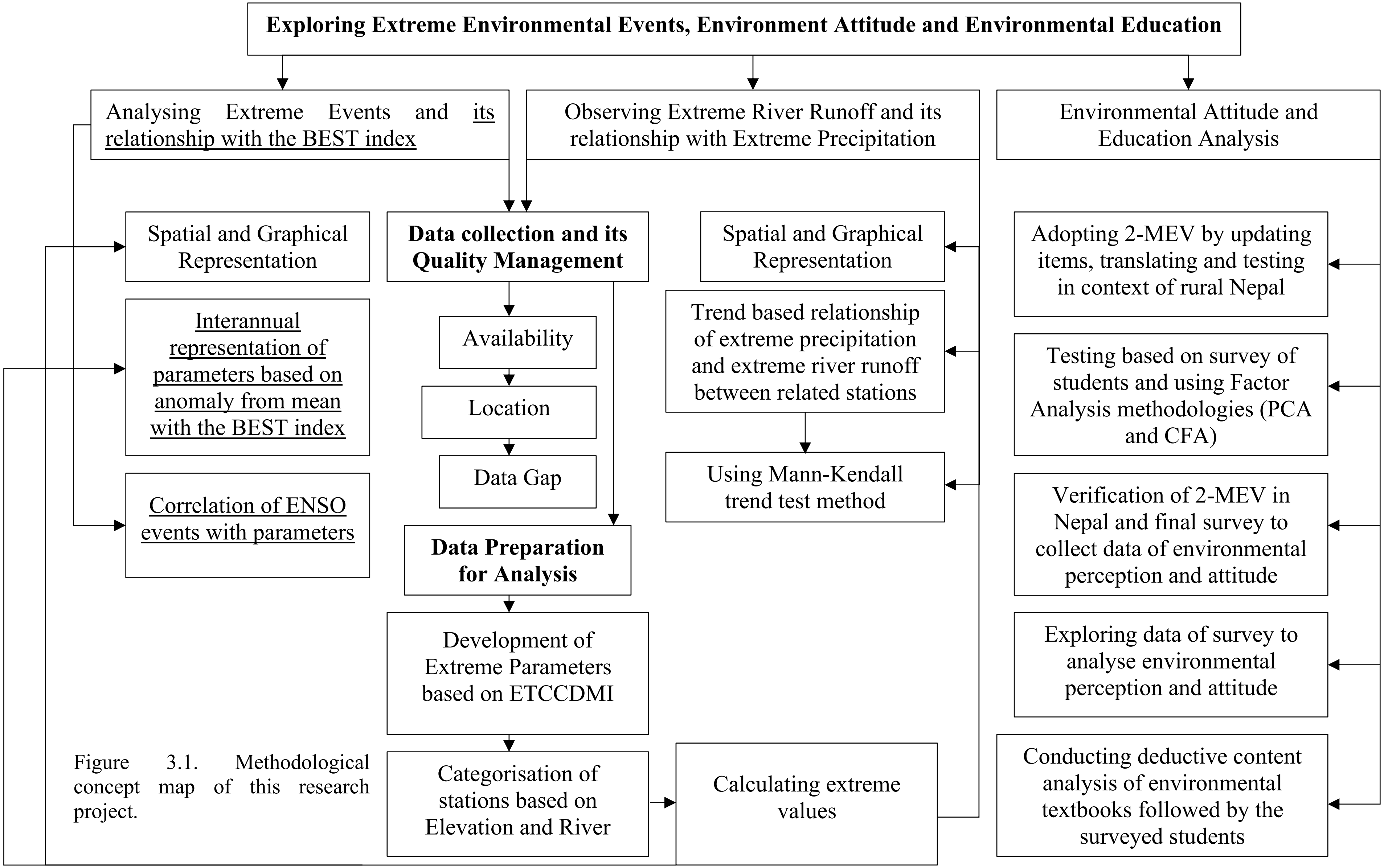

Figure 3.1. Methodological concept map of this research project.

4 Research Area

The research objective chapter outlines the need to explore extreme events in Nepal. Thus, to address this need, the extreme precipitation event was observed in the entire Nepal Himalayas. Likewise, for the exploration of the environmental attitude and education, a vulnerable community was selected due to their location in the bank of the volatile Saptakoshi (Koshi) River. Thus, the Koshi River basin was also selected to analyse the extreme events of river runoff (discharge). This chapter describes the characteristic features of the selected research area: the Nepal Himalayas, the Koshi River and its basin, and the community nearby the Koshi River (in Chakraghatti). This chapter consists of three parts. The first part describes the characteristics of the Himalayan range and the Nepal Himalayas. Likewise, the second part outlines the features of the Koshi River and its basin. Finally, the third part elaborates the population, education, environmental features/threats and the need to adapt, of the community living nearby the Koshi River.

4.1 The Himalayan Range

During the Palaeocene era, the Indian tectonic plate collided with the Eurasian tectonic plate exhorting crustal thickening in the land to rise and later develop as the parts of the Himalayas (Molnar & Tapponnier, 1975). When the crustal thickening reached compressive stress, the thrust resulted in horizontal shortening, creating faults (Searle, Simpson, Law, Parrish, & Waters, 2003). Figure 4.1 presents an example of the fault line.

Figure 4.1. Fault line (white line) in the Dhaulagiri peak in the Central Himalayas of Nepal (Astbury, 2009).

Searle et al. (2003) explained the process and the role of faulting, which led to the formation of the Himalayan orogeny. When faulting occurs, it puts different types of rocks one over another. During this process, one part of the surface rises higher while the other descends deep inside the earth, melting the rock. This ductile flow of the molten rock actively extruded southward from underneath the southern part of the Tibetan plateau. As a result, a process of metamorphosis occurred, forcing the molten rock up along the converging plate and cooling to take the form of solid granite. This conveyer belt system of the molten rock in the Indian tectonic plate continuously pushed the Himalayas higher. Moreover, this process of the Himalayan uplift is still active today at an estimated rate of 11-18 mm per year. Thus, the crown, the middle part, and the base of the Himalayas show three distinct types of rocks supporting this Palaeocene event (Searle et al., 2003).

The word Himalaya came from two Sanskrit words: Himal (snow) and Alaya (abode) (Zurick, Pacheco, Shrestha, & Bajracharya, 2005). The Great Himalayan Region extends from Afghanistan to Myanmar spanning up till 3500 km (Karan, 1966). Likewise, the Himalayan range extends from Nanga Parbat (Jammu and Kashmir) in the West to the Tsangpo-Dibang (Arunachal Pradesh) bend in the East (Nandargi & Dhar, 2011). The Himalayan range is part of the Great Himalayan Region and forms an arc of approximately 2,400 km (Figure 4.2) separating the Indian sub-continent from Asia (Nandargi & Dhar, 2011). The Himalayan range, located at the southern edge of the Tibetan Plateau, comprises of a complex chain of high mountains, elevated plateaus, deep gorges, and extended valleys (Barros et al., 2004). The width of the Himalayan range varies from 150-400 km north to south (Nandargi & Dhar, 2011).

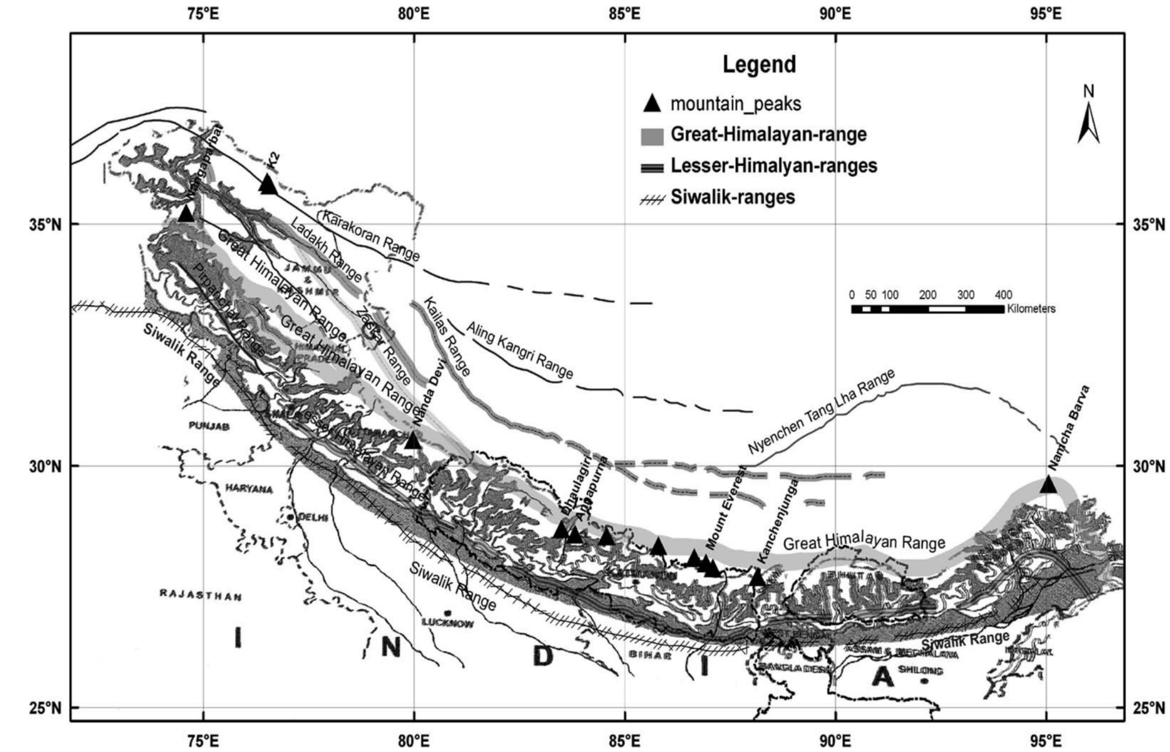

Figure 4.2. Map of the Himalayan stretch based on different ranges (Nandargi & Dhar, 2011).

Out of the fourteen peaks higher than 8,000 metre above the sea level (m), the Himalayan range consists of ten (Nandargi & Dhar, 2011). The rest four are in the Karakoram Range, which is a part of the Great Himalayan Region (Karan, 1966). Moreover, the Himalayas are headwaters of the ten largest rivers of Asia (Eriksson et al., 2009). As a result, these rivers flowing from trans-Himalayan region erode and shape high mountains producing deep valleys and gorges (Nandargi & Dhar, 2011).

4.1.1 Division of the Himalayan Range

The different fault thrusts accentuated varied topographical orography of the Himalayas during its formation. These variations characterise the Himalayas' structure and vary on three major thrusts: The Main Frontal Thrust (MFT), the Main Boundary Thrust (MBT) and the Main Central Thrust (MCT) (Nepal, 2016). The MFT and MBT have thrust dip approximately northeast from its fault zone (Nepal, 2012). Likewise, the MCT has inverted metamorphism and top-to-south break of the rock fabric dipping towards the northeast (Searle et al., 2003).

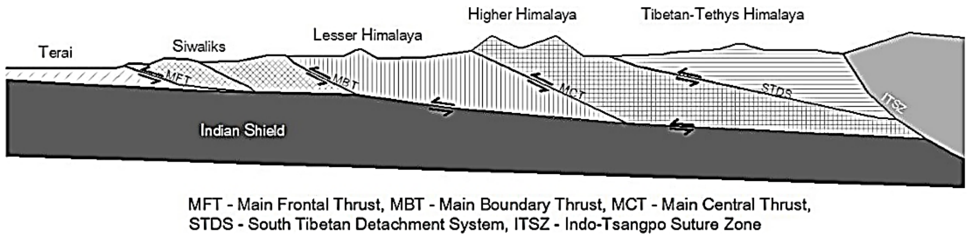

Figure 4.3. The generalised cross section of Himalayan geology (Dahal, 2006).

As seen in Figure 4.3, the Gangetic plain or the Terai lies southward of the MFT. Likewise, the Siwalik or the Sub-Himalayan zone lies in between the MFT and MBT. Similarly, the Lesser Himalayan zone lies between the MBT and MCT. Lastly, the Higher Himalayan zone lies north of the MCT. Moreover, to the north of the Higher Himalayan zone lies the Tibetan-Tethyan Himalayan zone separated by the South Tibet Detachment System (STDS) (Parsons, Law, Searle, Phillips, & Lloyd, 2016). The STDS normal fault lies along the top of the Higher Himalaya with flat fault line and down-to-north fault extension. The MCT and STDS act simultaneously extruding the southern edge of crustal rocks and have intense strain zones responsible for condensing the metamorphic isograds (Searle et al., 2003).

Based on the general topographical gradient Nandargi and Dhar (2011) divided the Himalayan range into three groups (Figure 4.2): Outer Siwalik range, Lesser Himalayas, and The Great Himalayan range. The Outer Siwalik lies between the Gangetic plain and the Lesser Himalayas with an average elevation of 900-1,200 m. Likewise, the Lesser Himalayas lies to the north of the Siwalik range with a mean elevation of 3,700-4,500 m. The Mahabharat range and the Pir Panjal range fall under the Lesser Himalayas. Lastly, the Great Himalayan range consists of the highest range of the Himalayas with an elevation ranging from approximately 5,000-8,848 m. The Tibetan Himalayas and the Tibetan Plateau lie to the north of this range.

4.1.2 The Nepal Himalayas

The entire landmass of Nepal which stretches ~885 km East to West and ~193 km North to South falls under the central Himalayan range. Out of 147,181 km^2, about 83% of the country's land are hills and mountains (Dahal & Hasegawa, 2008).

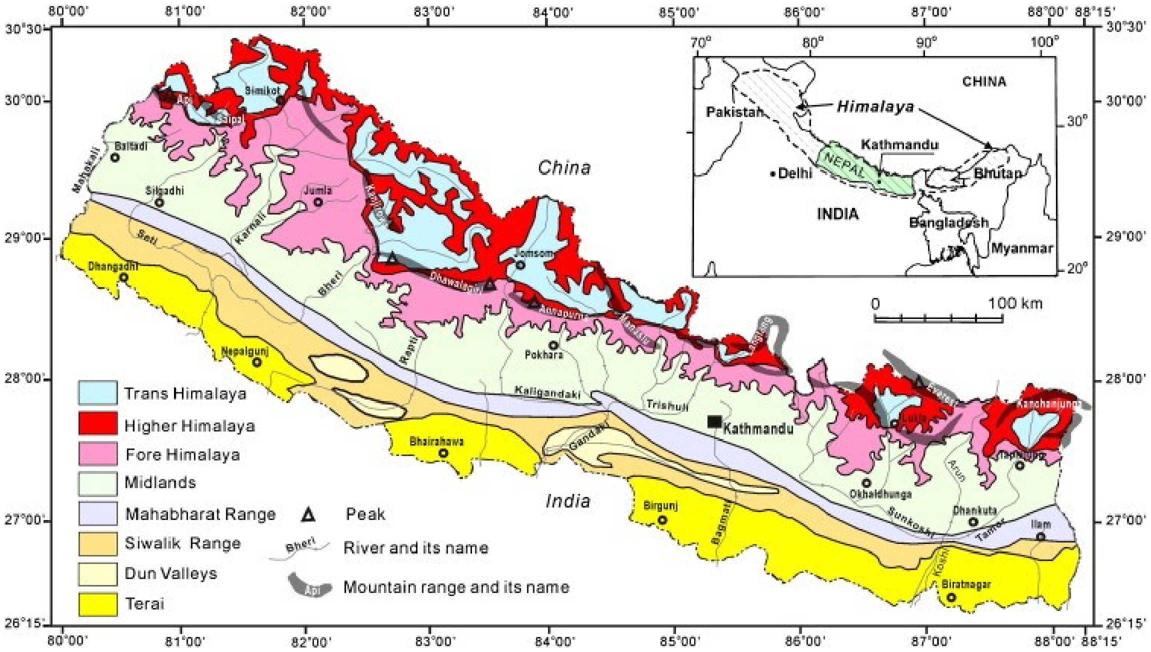

Figure 4.4. Geomorphic map of Nepal. Inset: Nepal in the Himalaya (Dahal and Hasegawa, 2008).

Based on the topographical gradient ranging from 60 m in the south to 8,848 m in the north the geomorphology of Nepal consists of five zones: Terai, Siwalik, Lesser Himalaya, Higher Himalaya and Trans (Tibetan) Himalaya (Figure 4.4) (Dahal & Hasegawa, 2008).

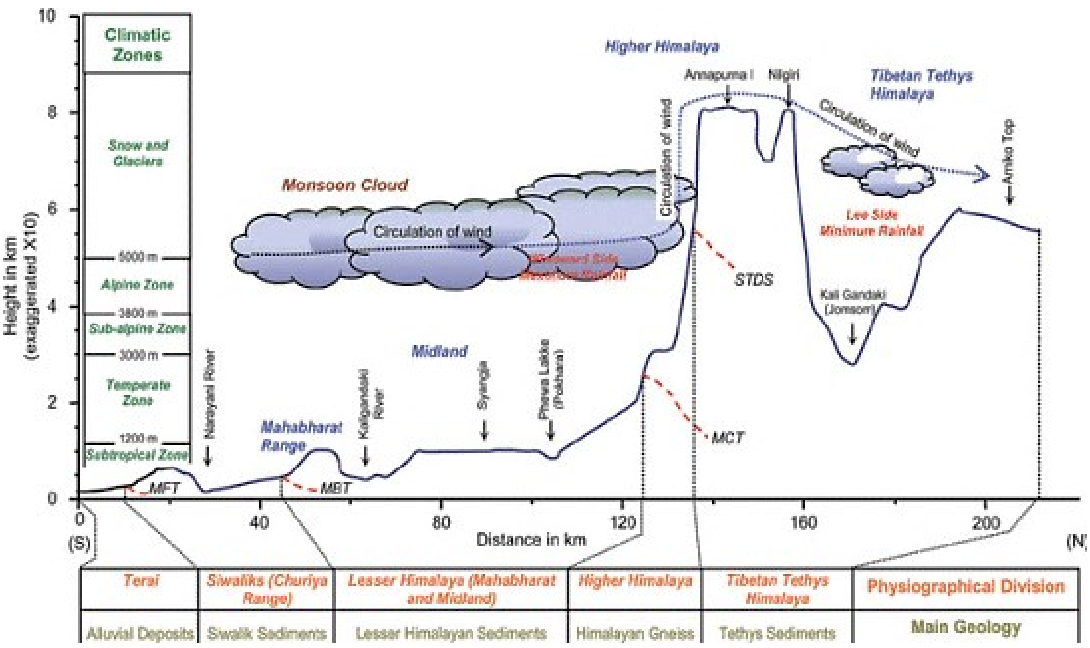

Figure 4.5. The generally conceptualised cross-section of the Nepal Himalayas (Dahal, 2006).

Dahal and Hasegawa (2008) elaborate on the elevation features of the Nepal Himalayas. The Terai is the south most of the Nepal Himalayas. Its altitude ranges from 60-330 m and covers 14% landmass of the country. Likewise, The Siwalik range is the Himalaya's starting point of uplift ranging from 200-1,500 m. The Dun valleys are part of the Siwalik range. Similarly, the Lesser Himalaya, which lies to the north of the Siwalik range consists of the Mahabharat range and the Midlands ranging from 500-3,000 m. Kathmandu, the capital city of Nepal, which is in the Kathmandu Valley, lies in the Lesser Himalayan zone.

Furthermore, the Higher Himalayas consists of a steep gradient rise of the topography forming the peaks of the Himalayas. The Higher Himalayas extends from the Fore Himalayas (2000-5,000 m) and elevates above 5,000 m reaching till 8,848 m. Lastly, the Trans Himalaya is in the north of the Higher Himalaya and ranges from 2,500-4,500 m. It is on the leeward side of the Himalayan range. Figure 4.5 presents the conceptualised cross-section of the Nepal Himalayas.

4.2 The Koshi River Basin

The Koshi River flows through Tibet and Nepal to India. In Nepal, this river is spelt as Koshi River while in India it is spelt as Kosi River. Thus, in relation to the research area, which is the Koshi River from the Nepalese side, this research uses the term "Koshi River". The Koshi River is one of the major constituents of the Ganges River basin in the Himalayan region.

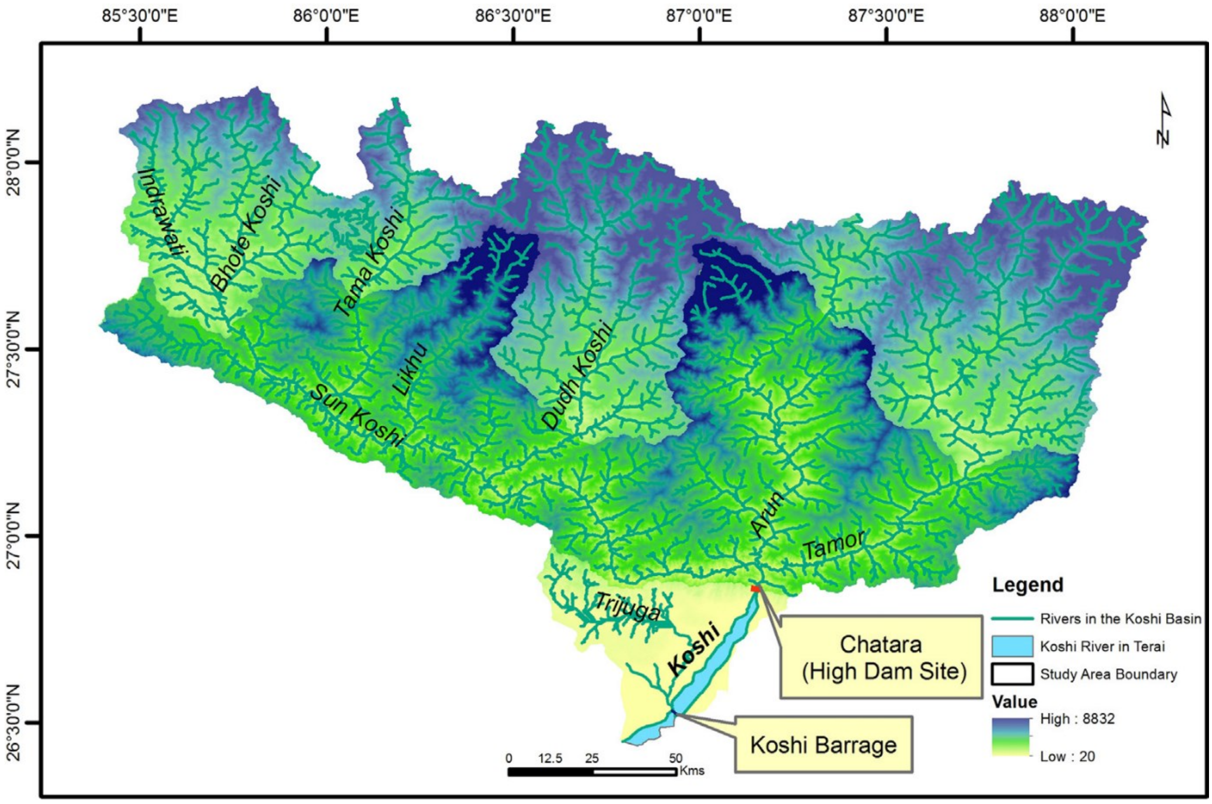

Figure 4.6. The Koshi river basin and its tributaries (Adapted from Devkota & Gyawali, 2015).

Correspondingly, the Koshi River originates in Tibet, near the Mount Everest, continues in Nepal and flows through India before mixing to the Ganges River in Kursela (India) (Singh, Parkash, & Gohain, 1993). From its origin to mixing in the Ganges River, the Koshi River travels about 200 km and cascades down by decreasing its elevation by nearly 9 km (Sinha et al., 2008). Primarily, this decline is steeper in the north (55-75 cm/km) and flatter in the south (6cm/km) (Sinha et al., 2008). Likewise, the elevation of the Koshi River basin ranges between 95 m and >8,000 m (Devkota & Gyawali, 2015). Figure 4.6 and 4.7 shows the geographical location of the Koshi River basin.

The total area of the basin, upstream of Chatara, is about 57,700 km^2 (Nepal, 2012). The basin lies within the latitudes 26˚51'0" 29˚79'0" and longitudes 85˚24'0" 88˚57'0" (Agarwal, Babel, & Masket, 2014). Geddes (1960) conducted one of the first geomorphological studies of the Koshi River basin and used the term "cone" to describe the form of the basin (see Figure 4.6).

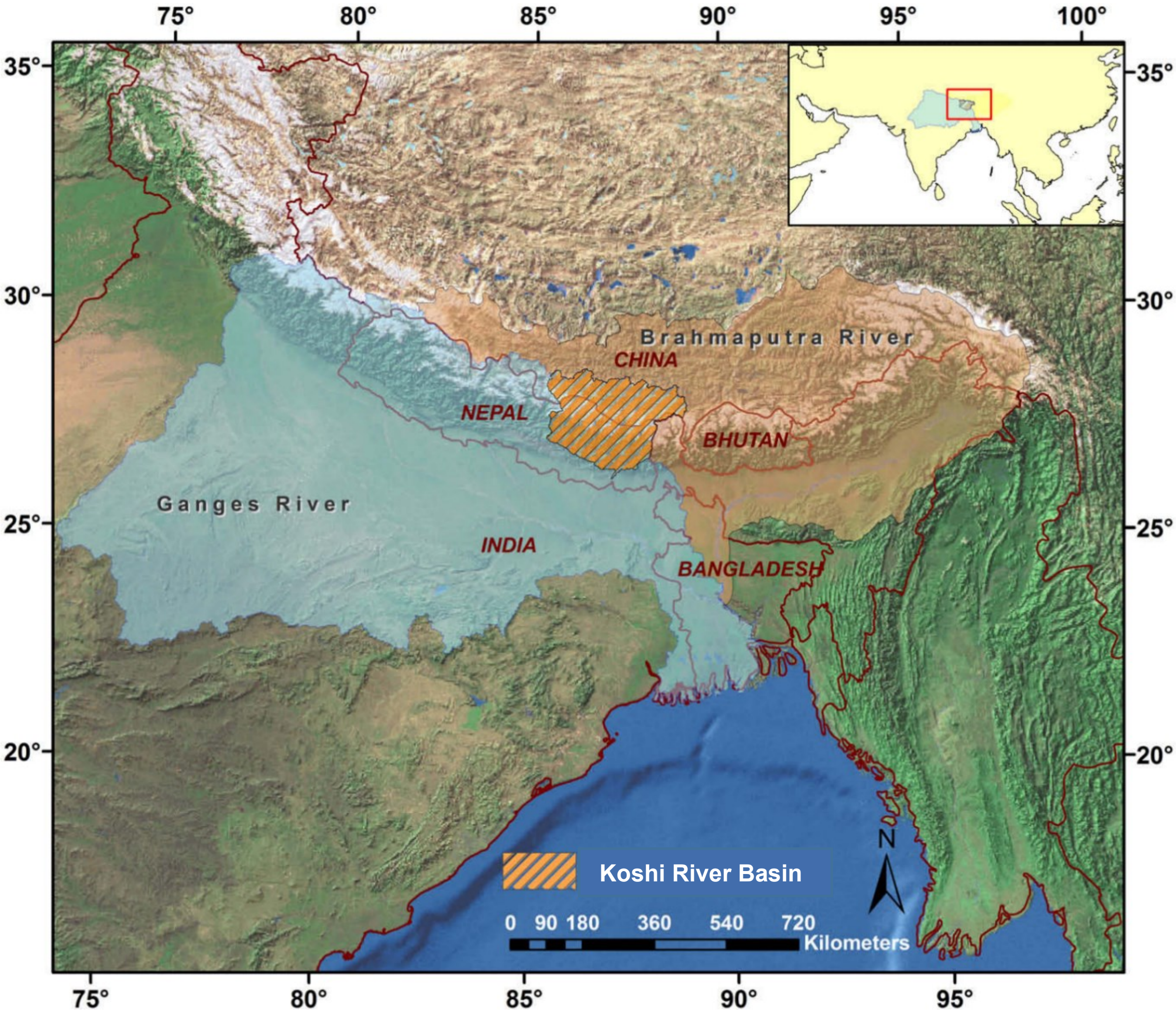

Figure 4.7. Location of the Koshi River Basin about the Ganges and the Brahmaputra river basin (Modified from Nepal, 2012).

The Indrawati, Likhu Khola, Dudh Koshi, Tamor and Sun Koshi lie in Nepal while the Bhote Koshi, Tama Koshi, and Arun lie in both Tibet and Nepal (Nepal, 2012). Out of the total basin area, 46% lie in Nepal while the remaining lie in Tibet (Nepal 2016). This research explores the part of the basin which lies in Nepal.

4.2.1 Climatic Condition

The summer monsoon enters Nepal from the eastern side at the location of the Koshi River basin. The monsoon spans from June to September in the Koshi River basin. Mean annual precipitation in the Koshi river basin ranges from 1,865-2,000 mm/year based on the elevation (Agarwal et al., 2014). In the Koshi river basin, monsoonal precipitation during the summer (June-September) accounts for 75%, spring (March-May) accounts for 15%, and winter (December-February) and autumn (October-November) accounts for around 10% of the total annual precipitation (Agarwal et al., 2014).

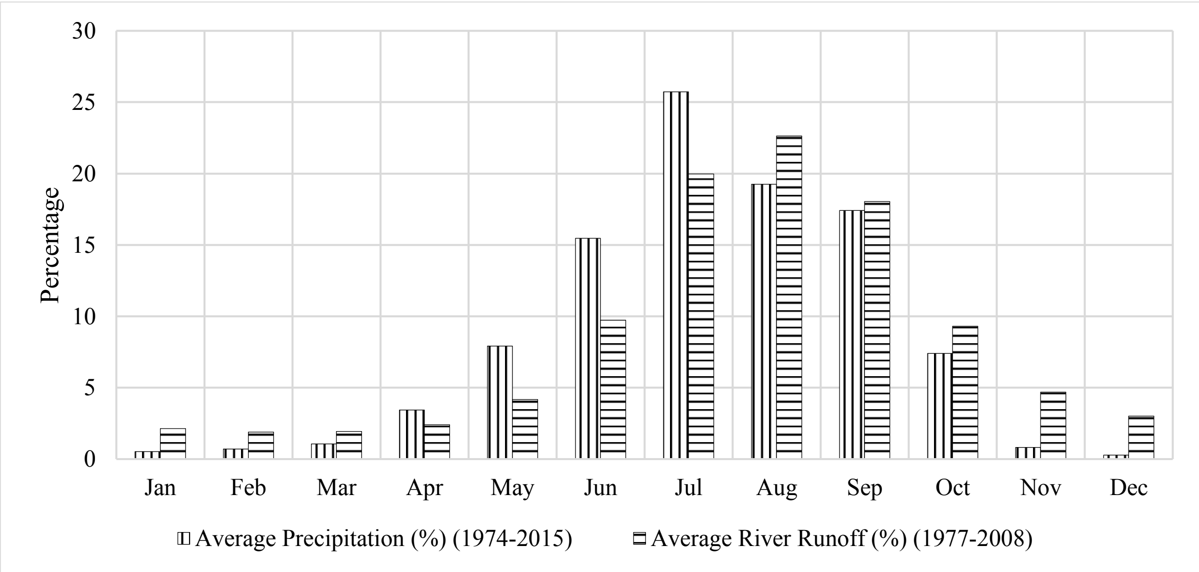

Figure 4.8. Average precipitation and river runoff percentage in the Saptakoshi River (Chatara station).

Department of Hydrology and Meteorology of the Government of Nepal (2015) reports detailed information about the climatic condition of the research site. Generally, December to February is the winter season with the lowest temperature in Nepal. During the spring (pre-monsoon), from March to May, the temperature increases steadily and the hottest period is from June to September as the monsoon arrives in the summer. The temperature starts decreasing in autumn from October to November, which is also known as the post-monsoon season (Shrestha, Wake, Mayewski, & Dibb, 1999). In the lower altitude of Terai and Siwalik region, the climate is tropical and sub-tropical respectively. This climate is characterised by hot, humid and wet summer with mild and dry winters. In the Lesser Himalayas, the climate changes to warm temperate. As the elevation increases, the climate changes, with a decrease in temperature, from sub-alpine to alpine zone (4,800 m).

Further, increase of the elevation till the High Himalayas exhibit a cold climatic condition where glaciers exist. The monthly temperature average during each season varies over the region. The temperature during the summer and winter period in plains is about 28˚C-32˚C and 16˚C-20˚C respectively. Likewise, the temperature during summer and winter in the mid-hills is about 16˚C-28˚C and 8˚C-16˚C respectively. In the high Himalayas, the temperature ranges from less than 0˚C-16˚C in the summer and less than -8˚C-8˚C during the winter period.

4.2.2 Discharge and Flooding

The discharge (runoff) in rivers of the Koshi basin is mainly fed by rainfall and glacier/snow melt. Nepal (2016) elaborates these facts and are briefly outlined in this subchapter. In correspondence with the monsoon, the river discharge peaks from May till June with a sudden rise in July, gradual decline in September till December and steadies till April then continues the cycle. The monthly average river runoff (in %) of the Koshi River at Chatara station from 1977-2008 is shown in Figure 4.8 above. Less monthly discharge in dry seasons (winter) compared to that of monsoon (summer) suggests an active role of monsoonal precipitation and glacial melt during warm summer. From 1985-2006 the mean monthly discharge of the Koshi River (Chatara station) in February was 352 m^3/sec compared to 4,488 m^3/sec in August. The maximum discharge observed during this period was 9,610 m^3/sec on 11th August 1987. Likewise, the maximum discharge recorded till date was about 25,878 m^3/sec in August 1968. Seasonal variation in flow and sediment discharge is observed in the Koshi River.

The part of the Koshi river basin on the southern part of the Himalayas (Nepal) is four times wetter than the northern half (Sharma, Moore, & Vorosmarty, 2000). The Koshi River is known to bring floods in the lowland area of Nepal and India during the monsoon. The significant difference of discharge during dry and monsoon season increases the vulnerability of the river associated with the flood. The high discharge values of 24,000-25,000 m^3/s in 1954 and 1968 are known to be the two most severe flooding events in the Koshi River. As a precaution against flood, embankments and barrage are also constructed in the river. However, embankment breaching by the river has also created havoc in the region. The flood of 2008 is one example when the Koshi river breached the embankment and started to flow on a new yet its old path, causing numerous casualties and damages (Reddy et al., 2008).

Water from the Koshi River is also used for irrigation purposes in Eastern part of Nepal and parts of Bihar (India). The canal in Chatara irrigates 66,000 hectares in Eastern Nepal while the Koshi barrage system irrigates 969,110 hectares in India. Impact of embankment and canal for irrigation in the Koshi River has been observed by Sinha et al. (2008). The downstream station in India records less discharge compared to that of Chatara station. This situation makes the Saptakoshi River in Chatara, Nepal an ideal area to explore the relation of precipitation events and downstream river discharge.

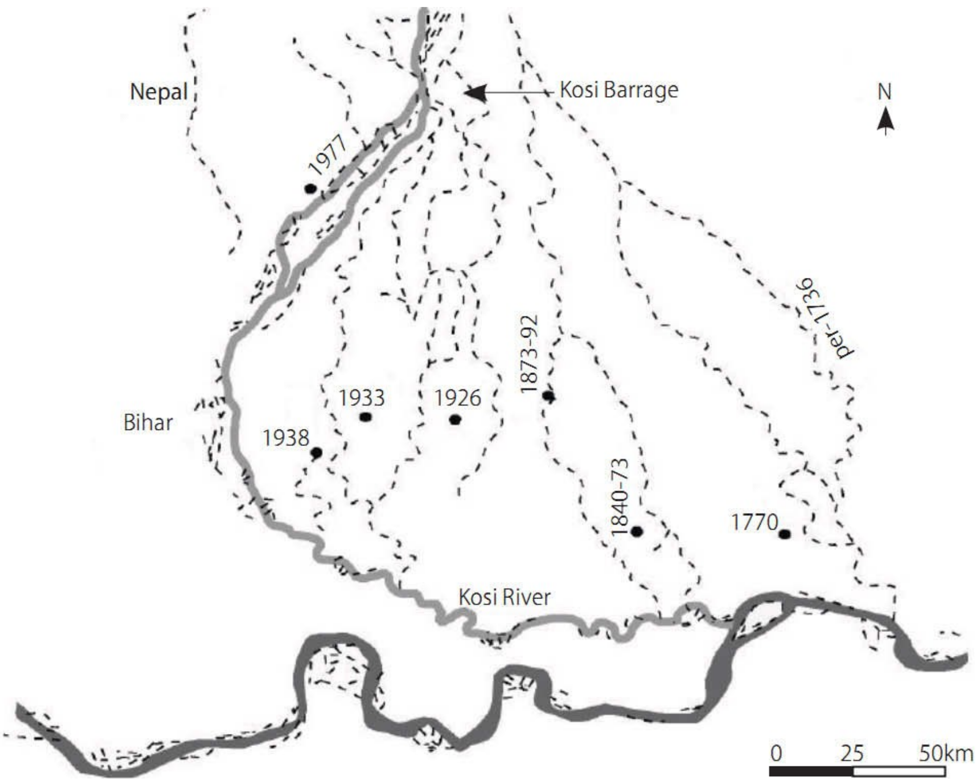

Figure 4.9. Alluvial fan of the Koshi River in lowlands of Nepal and India (Bihar) showing its westward movement throughout the last decades (Gole & Chitale, 1966).

The catchment area of the Koshi River basin starts from the Tethys till southern plains. As the river flows downstream in the gradient Himalayas with high velocity, the rate of denudation is also high. The sediment transport in the Ganges river system is highest amongst the world. The Koshi river basin represents 5% of the Ganges river system but contributes about 25% of total sediment transport to the Ganges. Compared to other river systems the Koshi River has very high sediment yield reported to be around 2,500 tonnes/km^2/year (For example Ganges: 491, Brahmaputra: 578. Amazon: 207 and Nile 40 tonnes/km^2/year). 2 mm topsoil is estimated to be denudated in the Koshi river basin each year, which is approximately equivalent to 118 million tonnes per year.

However, sediment load transport of such large river basin cannot be estimated accurately with the current state of knowledge. With very high sediment carrying capacity, the eroded sediments are transported and deposited in the plains of Nepal, downstream of Chatara. This deposition has created a riverbed, and over time, the main channel of the river aggraded to shift its course (Figure 4.9). This shifting of the river also creates flood which has had serious negative implications to the nearby communities. Significant floods in the region were recorded on July 1993, 1999 and August 2002 with an estimated loss of about 20% out of the total gross domestic product of Nepal (Pradhan, Dangol, & Adhikari, 2004).

4.3 Community on Focus

Chakraghatti is the selected research site for the exploration of environmental education and attitude of the local children. Chakraghatti is located 13 km downstream of Chatara. Written history about Chakraghatti is scarce but based on the community members' anecdotes Chakraghatti is supposed to be an old settlement dating back at least a century (Y Koirala, & S Baral, personal communication, September 17, 2016). Until 2015, Chakraghatti was officially known as Mahendranagar village development committee (VDC). However, in 2016 the status of Mahendranagar VDC was upgraded to the municipality by combining the adjoining VDCs. Chatara VDC, Bharaul VDC, Mahendranagar VDC, Prakashpur VDC and Madhuwan VDC were combined to form Barah Municipality. Chakraghatti lies in the ward 6, 7 and 8 of Barah Municipality, Sunsari district, Province 1 of Nepal. The Government of Nepal has a set of standards to determine if a place is either a rural or an urban area (CBS, 2014). The rural areas are labelled as VDCs, while the urban areas are labelled as municipality/metropolitan city. However, a specific area such as Chakraghatti, when considered individually, qualifies only as a VDC. Moreover, Chakraghatti was a VDC when this research was initiated in 2015. Thus, it is regarded as a rural area in this research.

Chakraghatti is located at 26°44'47.6"N 87°08'01.4"E and lies in the bank of the Koshi River. It is situated at ~110 m above the sea level and falls under the Terai region of Nepal. The high aggradation of river sediments occurs in the Terai region, forming alluvial flood plains (Reddy et al., 2008). The Koshi River has one of the most extensive alluvial flood plains in the world, which allows the river to change its path, causing a flood in the region (Reddy et al., 2008). The alluvial flood plain of the Koshi river in Nepal starts to deposit downstream of Chatara (Devkota & Gyawali, 2015).

Figure 4.10. The map of Nepal with the location of Chakraghatti (red point) (Google Maps, 2018).

Moreover, except for the flood caused due to the lateral movement of the river, high water discharge also has a long history of flooding in the region (Nepal, 2016). Location of Chakraghatti and its map can be seen in Figure 4.10 and Figure 4.11, respectively.

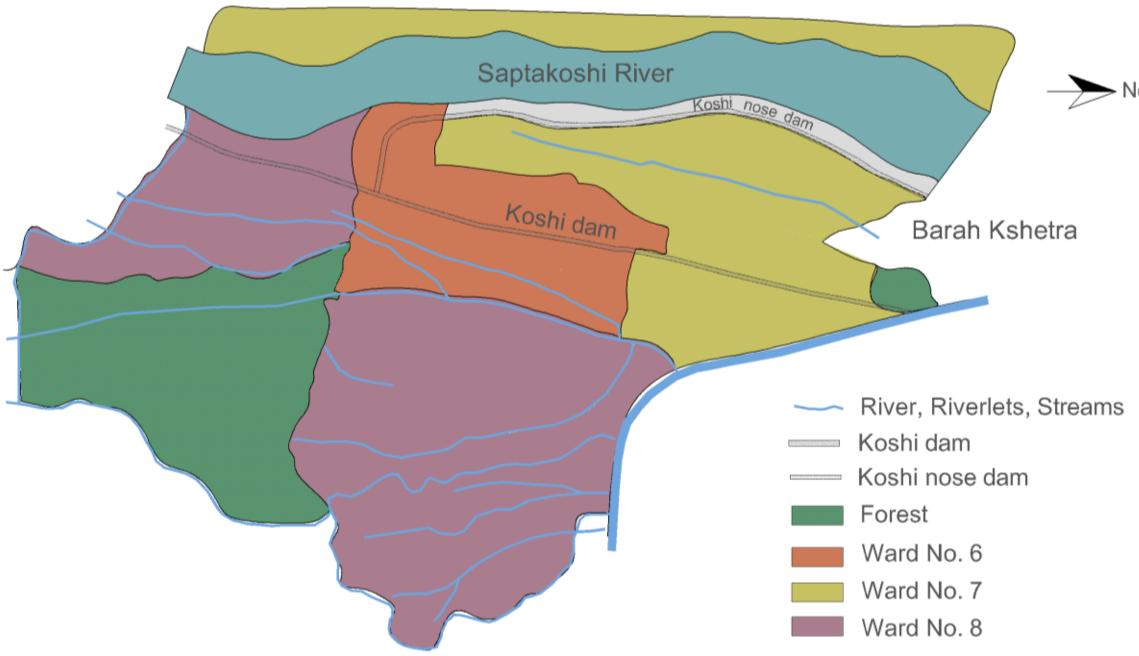

Figure 4.11. Map of Chakraghatti showing its three wards, dams and location of the Koshi River. (Adapted and Modified from the office of Mahendranagar VDC).

4.3.1 Population

According to the 2011 census of Nepal, there are 5,431 households in Chakraghatti. The total population is 23,631 out of which 45.6% are male (CBS, 2012). However, the CBS (2014a) reports there were 2,317 absentees during the 2011 census. Table 4.1 presents the population description of Chakraghatti.

Table 4.1. Population demographics of Chakraghatti. (CBS, 2012).

New Ward Number	Old Ward Number	Number of Households	Female Population	Male Population	Total
6	1	516	1095	939	2034
	2	477	1079	924	2003
	3	428	1041	853	1894
7	4	2018	4791	3946	8737
	5	259	681	668	1349
	6	181	464	397	861
8	7	509	1190	1057	2247
	8	427	1016	821	1837
	9	616	1491	1178	2669
Total		5431	12848 (54.4%)	10783 (45.6%)	23631

In 2001, there were 4,580 households with a total population of 22,195, where 48.5% of the population were male (CBS, 2001). As a result, the population in Chakraghatti, from 2001 to 2011, is growing at a rate of 0.65%, while the population growth rate in Sunsari district, from 2001 to 2011, is 2.2% (CBS, 2001; 2012). Since the population density is growing, the need to adapt to extreme environmental situations also increases.

Furthermore, there are 10,276 children (0-19 years) in Chakraghatti (CBS, 2014a). Here, the children represent 43.5% of the total population, out of which 49.8% are male. To illustrate, Figure 4.12 presents the population percentage of Chakraghatti based on the age group.

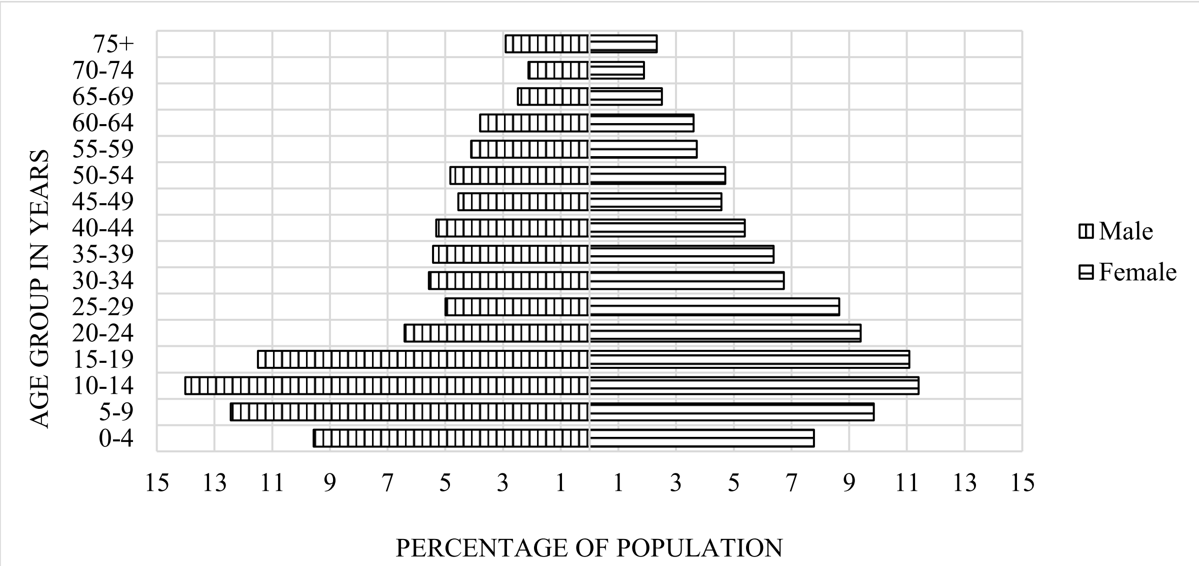

Figure 4.12. Population percentage by age group of Chakraghatti (CBS, 2014a).

4.3.2 Knowledge and Education

The Nepalese communities have used Indigenous Traditional Knowledge (ITK) since time immemorial (Sharma, Bajracharya & Sitaula, 2009). Sharma et al. (2009) highlight the importance and disuse of ITK in the Nepalese community. The Nepalese communities have sustained their lives in the various geographical conditions using their ITK. ITK is socially accepted, technically verified, and environmentally friendly practice suitable in a specific location.

Nonetheless, in the prejudice of it being unscientific, its presence in modern-day applications are negligible in Nepal. Moreover, the ITK is in the danger of becoming forgotten due to the lack of the government's interest in documenting it. However, many researchers and organisations are documenting ITK of Nepal, most commonly in the context of agriculture, such as water resources management, soil fertility management, pest management, bio-fencing and biodiversity. In line with the government's disregard, the presence of ITK is almost null in the school education system of Nepal (Sharma, 2004). Thus, in today's context, school education is the principal source of knowledge. A similar situation was observed in Chakraghatti, during an interaction with two community members, who stated:

"The common tradition is changing because the level of communication between the elder and younger members of this community has almost disappeared. Our only remaining indigenous knowledge is afforestation. The children are already studying the importance of afforestation in school. Thus, there is a need for school education to increase the safety of this place. However, the negative point is that the children do not use their school education outside of the school. They are seen planting trees only when instructed by the school teachers." (R.B.R. Chhetri, personal communication, April 20, 2017)

"Yes, we know about afforestation, but our surrounding environment of the riverbank will not allow us to succeed. Even if we see soil nearby the riverbed, there is sand beneath it. Thus, if we try to plant trees near the river to create a barrier, the river will cut-off the trees easily. We have land and ideal condition to plant bamboo trees which can act as a barrier, but our local community and government cannot afford its costs. Hence, gaining school education is the only way to use modern technology and find solutions to our problems" (D. R. Regmi, personal communication, April 21, 2017)

Moreover, the other community members echoed that they were reliant on modern technology to tackle the river's potential threats. For example, cross-pillar nose shaped dams are constructed along the edge of the river to stop the land cut-off (Figure 4.14 & 4.15). Likewise, the community members are relying on the irrigation canal coming from the Chatara dam for their agriculture. Thus, demonstrating their inclination towards modern technology.

Furthermore, the last two generations were exposed more to school education than ITK, causing the fading of ITK. Based on the comprehension of this discussion, school education is considered as the sole source of knowledge in this research. Hence, this research explores the contents of environmental education and the environmental attitude of the children.

There are twelve schools in Chakraghatti, and all of them include environmental education in their curriculum (CDC, 2011; Mahendranagar VDC, 2011/12). As of 2011, there were 6,710 school going students between the age of 5-25 in Chakraghatti, out of which 50.5% were male (CBS, 2014a). Out of the twelve schools, only five of them offer classes until the 10th grade, while one school offers classes until the 12th grade (Mahendranagar VDC, 2011/12).

However, Koshi School is also planning to offer classes until grade 12 from 2017 (Y. Koirala, personal communication, September 17, 2016). Table 4.2 provides the detail description of school and location by ward in Chakraghatti as of 2011/12.

Table 4.2. Description of school and students in Chakraghatti in 2011/12. (Source: Mahendranagar VDC, 2011/12).

S.N.	Name of School	Highest Grade	Location in Old Ward	Location in New Ward
1	Bhanu	8	1	6
2	Mahendra	12	2	6
3	Mahendranagar	5	4	7
4	Mahendra	10	4	7
5	Basantaritu	10	4	7
6	Balsewa	5	5	7
7	Sapta Koshi	5	6	7
8	Sunsari	8	7	8
9	Ramdhuni	5	8	8
10	Koshi	10	8	8
11	Janak	10	9	8
12	Sishu Jyoti	8	9	8

Moreover, 15,970 (50.7% male) people in Chakraghatti, who are more than five years old, have completed some form of school education by 2011 (Figure 4.13) (CBS, 2014a). The survey is done with the students from grade 8, 9 and 10 from the research site. The details of students from each of these three grades are in Chapter 6.2.

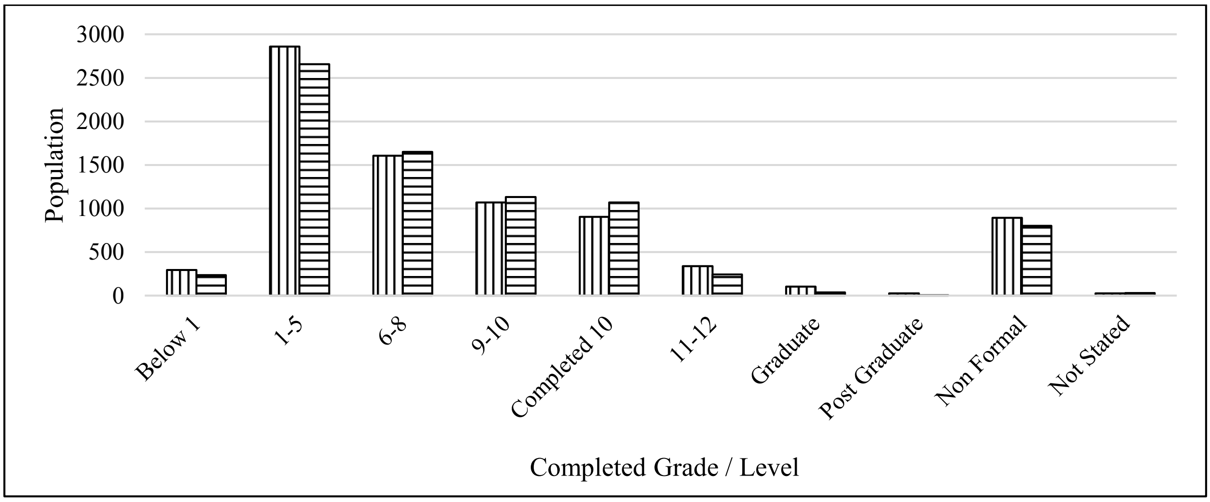

Figure 4.13. Population above five years who have completed some form of school education in Chakraghatti as of 2011 (CBS, 2014a).

4.3.3 Climate and Flood

Chakraghatti lies in the plains of the Nepal Himalayas. According to the VDC profile (2012), there is sub-tropical climate with six seasons in this region: spring (March-April), summer (May-June), monsoon (July-August), autumn (September-October), pre-winter (November-December) and winter (January-February). During the spring, the temperature ranges from 25-30˚C. Likewise, in summer, the temperature reaches up to 40˚C. During the monsoon, the humid weather dominates the region with rainfall and summer like temperature. Furthermore, in autumn the temperature is mild while in pre-winter, the temperature usually stays around 20˚C. Lastly, the winter is the coldest season with the temperature getting as low as 10˚C.

The most documented flood event in the Koshi River is the 2008 flood (Reddy et al., 2008; Sinha et al., 2008). The breaching of an embankment by the Koshi River near Kusaha, Sunsari district of Nepal led to the flood of 2008 (Reddy et al., 2008). As a result, about 90% of the discharge started to flow on the old (nearly 100 years) path of the river. However, being upstream of the breaching point, this flooding event did not affect Chakraghatti.

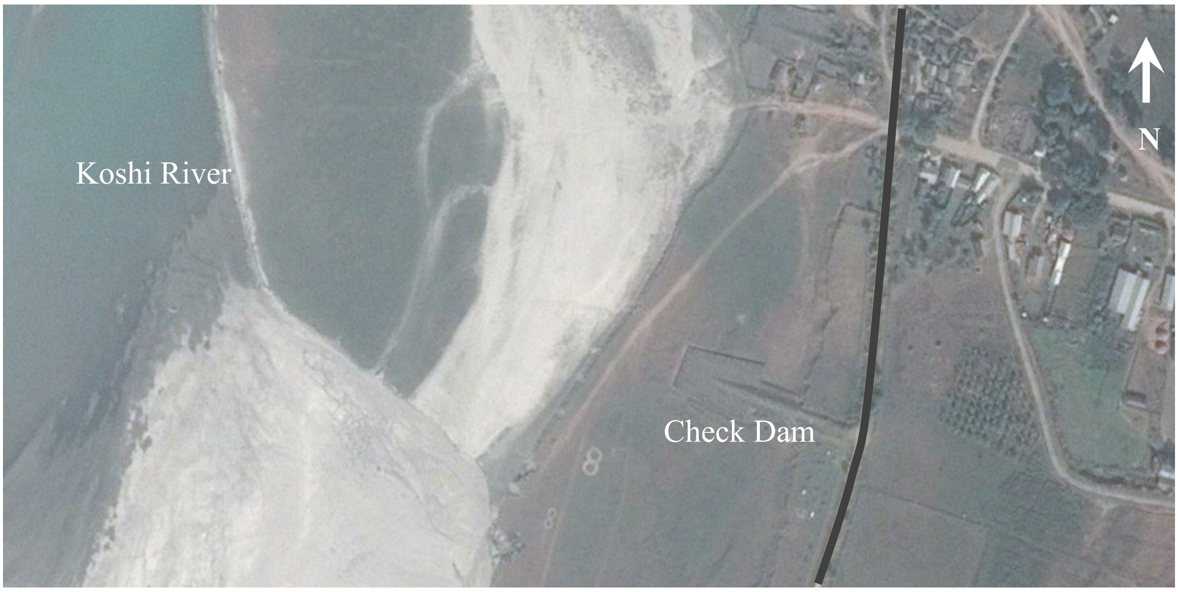

Figure 4.14. Satellite image of the Koshi Riverbank of Chakraghatti showing the check dam and the embankment represented by black line along with part of the flood plain (Google Maps, 2018a).

Instead, the recent and most disastrous flood in Chakraghatti was in 1984. Although the official documentation of this event is tenuous, the discussion with locals discloses the information about this event (M. Dahal, personal communication, April 21, 2017; S. Mishra & R. B. R. Chhetri, personal communication, April 20, 2017).

During this event, the Koshi River flowing in the western part of its alluvial fan started to divert towards the east. As Chakraghatti is on the eastern bank of the Koshi River, this event led to the destruction of more than 2,200 households, leaving numerous people homeless. Most importantly, the diversion process of the river channel was slow and lasted about a week. Thus, there was no human casualty, but this event damaged vast area of farming lands and swept away livestock of the community. Besides this event, numerous small-scale flooding events occur in this area and is a common phenomenon observed by the locals (R. B. R. Chhetri, personal communication, April 20, 2017).

Figure 4.15. (1) People starting to live in flood plain; (2) Flood plain with check dam to control potential flood; (3) Vast stretch of flood plain; and (4) Sediment left by the Koshi river.

Furthermore, after the sudden change of the river path in 1984 the Koshi River in Chakraghatti is again moving westwards (Figure 4.14 & 4.15) (Sinha et al., 2008; D. R. Regmi & M. Dahal, personal communication, April 21, 2017). Correspondingly, the sediment brought by the river tends to support different crops, as per their depth and characteristics (Kafle, Khanal, & Dahal, 2017). Hence, it can attract people to start farming and live nearby the riverbed but with an ever-prevailing risk of flood. Mostly, floods in the Koshi River occur due to the lateral movement of the river, but high-water discharge also has a long history of flooding in the region (Devkota & Gyawali, 2015; Nepal, 2016). Thus, with ever-occurring extreme conditions and high risk of floods parallel to increasing population, the role of education and attitude becomes ever crucial in this region to sustain a healthy livelihood. All these reasons make Chakraghatti an ideal place to explore the children’s attitude and their educational content as they are the most vulnerable group in their fluctuating environment.

5 Analysis of Extreme Environmental Events

Precipitation influences river runoff especially in the alpine environment of the Nepal Himalayas (Shrestha & Aryal, 2011; Bookhagen & Burbank, 2006; Ménégoz et al., 2013; Shea et al., 2015). Analysing extreme events of precipitation and river runoff provides an opportunity to explore its status. Such an exploration is vital because it can lead to proper disaster management strategies (Chalise & Khanal, 2002; Nepal, 2012). This chapter presents the spatial distribution of extreme precipitation events in Nepal along with extreme river runoff events in the Koshi River basin of eastern Nepal. Moreover, this chapter covers more contents, elaborated in different segments described below.

- The availability and selection of timeseries data and quality control of the data.
- Analysis of extreme precipitation events in Nepal.
- Analysis of extreme river runoff in the Koshi river basin and its relationship with the extreme precipitation events.
- Relationship between extreme events of precipitation and river runoff, with the southern oscillation events, i.e. El Niño and La Niña.

5.1 Data Availability and Selection

Observing and analysing extreme hydrometeorological events needs a thorough exploration of long timeseries data. For this research, the daily precipitation and river runoff data were obtained from the department of hydrology and meteorology of Nepal. Manually recorded data from ground stations were obtained and filtered to finalise the stations' list for the analysis. Likewise, the Bivariate ENSO Time-series (BEST) index was obtained for the analysis of southern oscillation data from the National Oceanic & Atmospheric Administration of the US Government (NOAA).

5.1.1 Precipitation Data

The Department of Hydrology and Meteorology of Nepal (DHM) controls 282 precipitation recording stations across Nepal (DHM, 2016). However, data of only 274 stations were available at the time (29.05.2016) of data collection. The precipitation data consists of daily (24 hours) observed precipitation (starting from 9 am the previous day) in millimetre. The DHM uses a US-standard 8-inch (20.32 cm) diameter manual precipitation gauge. In the case of snowfall, the snow water equivalent is measured by melting the collected snow and then measuring it as a standard rainfall measurement. Thus, the total precipitation per day discussed in this research is both rainfall and snow water equivalent recorded at the respective stations.

Moreover, the DHM controls the quality of the data by removing outliers and negative values (Bohlinger & Sorteberg, 2018).

Most of the daily precipitation data is available from the 1970s while some stations came into operation in the recent decades of 90s and 2000s only. Due to the increase of stations in recent years, there is a lack of consistency in the data. Thus, to have a consistent set of data, stations having data from the 1970s until 2014 were selected. Data from most of the stations start from 1974 while some others start from the late 1970s. In order to include all these stations with different but nearby starting date, stations with data from 1974 until the late 1970s were included. Finally, the concluding selection of stations was conducted by observing the years of data gap per station. Any stations with multiple years of data gap leading to less than 36 years of data were omitted to obtain the final list of the stations. These filtration processes led to the removal of 70 stations. While the selected 204 stations have an almost consistent 36-41 years of available data per each station from 1974 to 2014, as seen in Figure 5.1 below.

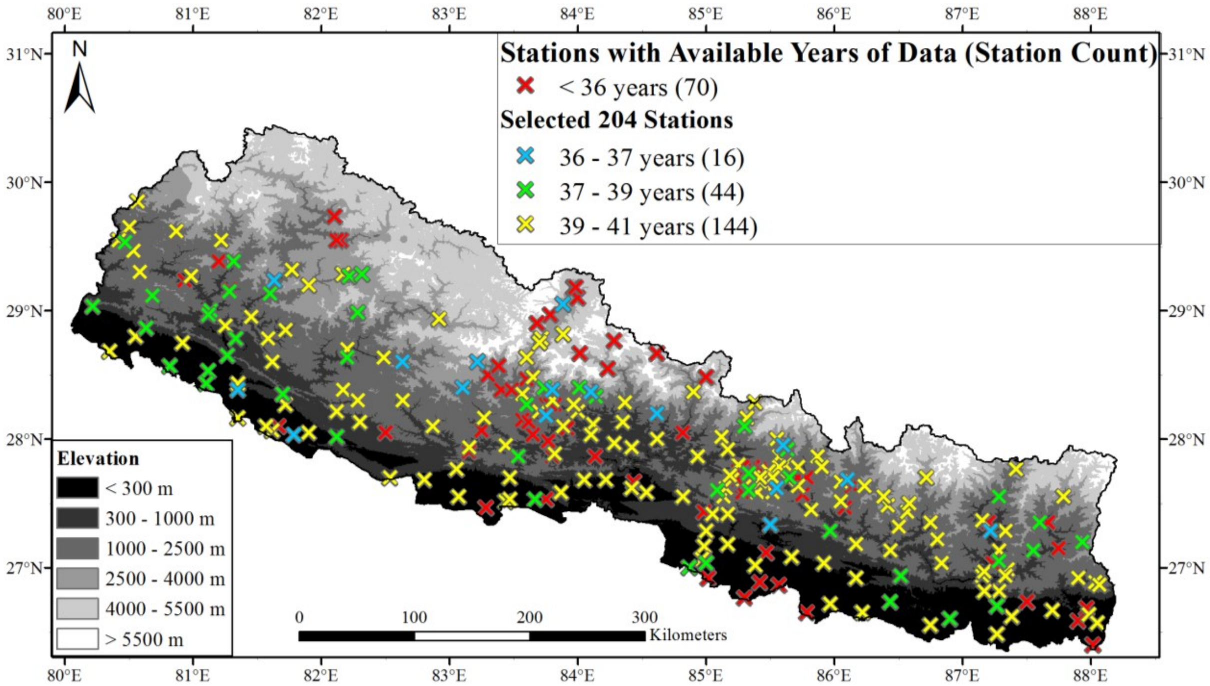

Figure 5.1. The location of the 274 stations with available years of data and the finalised 204 stations, to analyse, with at least more than 36 years of available data.

5.1.2 River Runoff Data

The river runoff data was obtained from the DHM in May 2016. The DHM controls 51 hydrological stations in Nepal (DHM, 2016a). The DHM mainly uses the cableway system to measure the daily (24 hours) runoff in cubic metre per second (m^3/s). The current meter of the cableway system is controlled from the bank of the river by an operator using the cableway cable. When the current meter is submerged into the moving water body, the operator can safely read the velocity of water and other required information from the bank.

The river runoff analysis was conducted in the Koshi River Basin (KRB) of Nepal. The KRB is located in 27 districts of Nepal, as seen in Figure 5.2 below (Hussain, Rasul, Mahapatra, Wahid, & Tuladhar, 2018). During the time of data collection in 29.05.2016, the DHM had data of 27 river runoff stations from the KRB districts. Out of these 27 stations, the final stations for analysis were selected based on the location, tributary of the main Koshi River known as the Saptakoshi, and the amount of daily data available, as seen in Figure 5.3.

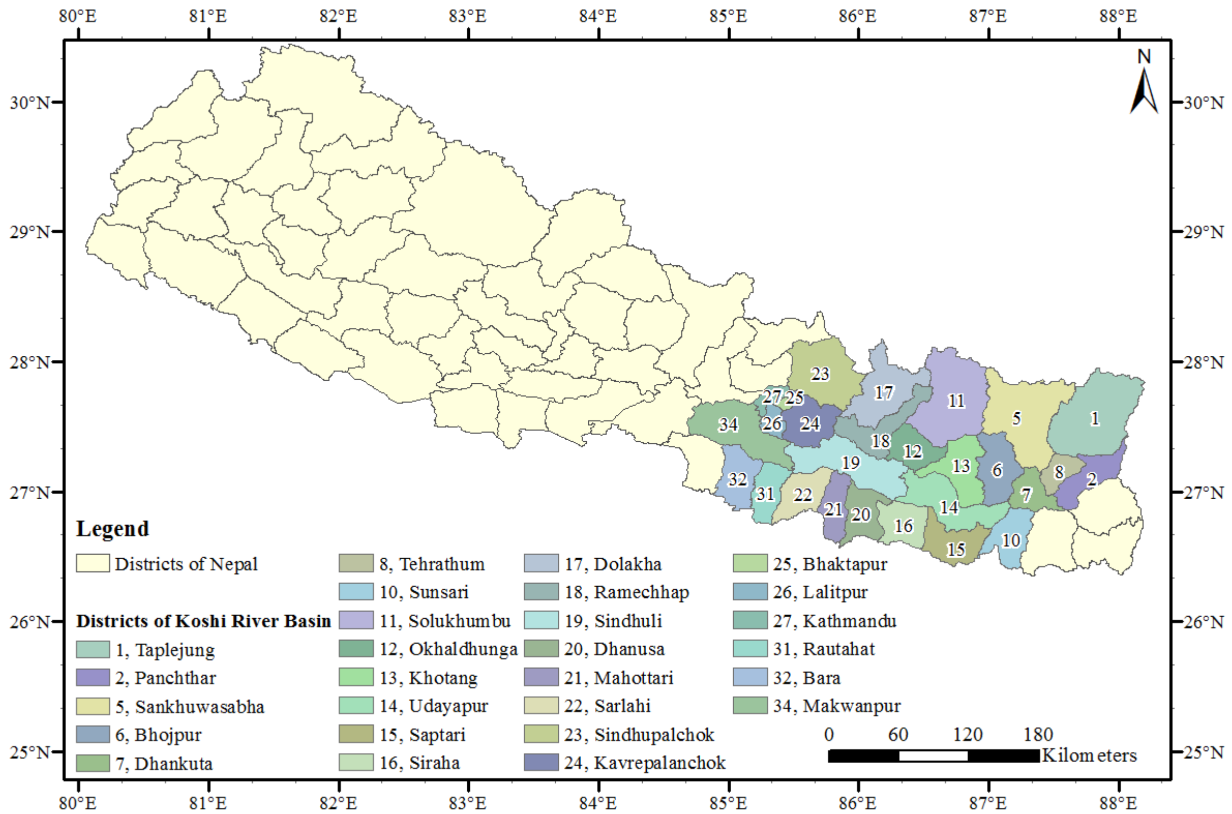

Figure 5.2. The location of Koshi River Basin districts in Nepal.

Firstly, stations 1 to 5 were removed from the final set of the stations to analyse. Although these five stations are in the districts of KRB the tributary rivers do not belong to the Saptakoshi river. The river with station code 1 and 2 belongs to the Karnali River basin while station code 3 to 5 belong to the Bagmati River basin which eventually mixes in the Karnali river in India. Furthermore, to compare the extreme river runoff events with extreme precipitation events, the river runoff stations with data from the early 1970s were preferred. Since the number of stations is few, river runoff stations at major eight tributary rivers of the Saptakoshi were considered even from the 1980s while tributary of these eight rivers was considered only if the data started from the early 1970s. Following this procedure further eight stations were removed to finalise the list of stations to analyse.

From the finalised 14 stations, 11 stations are in the major tributary rivers of the KRB including the Saptakoshi river. All but one major tributary river, Indrawati, is not included in the final set of the stations due to the unavailability of the data. Furthermore, data from station 6 and 10 located in the Arun river starts in 1985 and 1986 respectively. In contrast, data of all the other stations start from 1974, except station 9 and 27, which starts from 1976 and 1977 respectively. Likewise, the data of all the stations end in 2008 except station 12's in 2006.

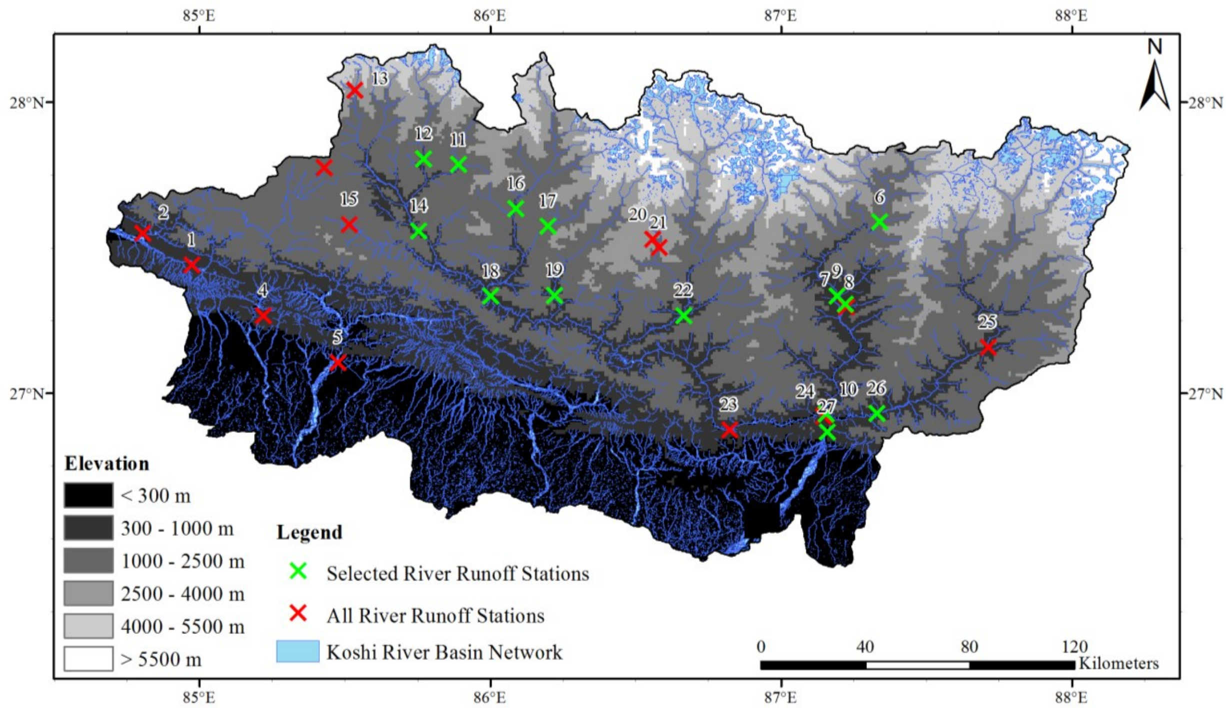

Figure 5.3. The location of all the 27 river runoff stations from the Koshi River basin districts along with the finalised 14 river runoff stations in the green cross, labelled as per the given station code.

5.1.3 Southern Oscillation Data

The southern oscillation data was acquired from the U.S. Department of Commerce's National Oceanic & Atmospheric Administration (NOAA) developed by Sardeshmukh and Smith (2000). The Southern Oscillation (SO) is analysed using the bivariate El Niño Southern Oscillation timeseries (BEST) index. The BEST index, also known as El Niño southern oscillation (ENSO) index, provides a long timeseries for research purposes. The BEST index is a combination of Southern Oscillation Index (SOI), elaborated in Chapter 2, and Sea Surface Temperature (SST) also known as Nino 3.4 over 5N to 5S and 170W to 120W region.

Previously, ENSO was analysed based on the SST anomaly only. The SST is partially recreated and not measured explicitly. Thus, including the aspect of air pressure through SOI reduced the probable biases in the Nino 3.4 (Sardeshmukh & Smith, 2000). Hence, finally adopting a balanced method to use both variables corresponding to high SST and low SOI values or vice-versa for each month of a year. The BEST index provides a reliable and more concrete index to explore the southern oscillation. According to Sardeshmukh and Smith (2000), the mean climatology from 1898-2000 was removed followed by the standardisation of the values by month to attain mean of 0 and a standard deviation of 1 for each month. Finally, the resulting SST and SOI were averaged for each month of the timeseries to produce the BEST index. Unlike the SOI, in the BEST index the El Niño is represented with positive value (>1), La Niña with negative (<-1), 0 for other and -9 for the missing data. The BEST index for one-month running mean timeseries is used in this analysis and is currently available from January 1870 to May 2018.

5.2 The Pattern of Precipitation Events

A regular precipitation event in the tropical environment might be an extreme event for a region with a moderate climate (Alexander et al., 2006). Moreover, an extreme event for the dry season can be a regular event for a rainy season. Thus, a station and season relative threshold are needed to define the extreme events (Croitoru et al., 2016). In this research, extreme events of the 12 months and extreme events of the high precipitation months (May-October), and low precipitation months (November-April) were analysed separately. Indices exploring intensity and frequency of the events were used to analyse the extreme precipitation. A station specific threshold, the 90th percentile index (R90) was used to analyse the intensity threshold of extreme events. Using percentile is a standard method to determine and observe the extreme values of precipitation (Bookhagen, 2010; Croitoru et al., 2016).

The R90 is objective, site-specific and facilitates comparison between different stations or regions (Haylock & Goodess, 2004). Likewise, R90 index is associated with the extreme precipitation events at the Himalayan region (Krishnamurthy, Lall, & Kwon, 2009; Bookhagen, 2010). The R90 (for days with >0.1mm of precipitation) was used to analyse the variation of selected stations around the country. Similarly, precipitation days and precipitation amount were also analysed.

Likewise, the frequency was analysed by observing days with a fixed threshold of more than 90th percentile of precipitation. Moreover, three or more consecutive days of precipitation over the 90th percentile threshold was also explored to analyse the storm frequency of extreme events. These precipitation frequency indices explore the changes in a number of days while providing a clear picture of the spatial pattern; however, only for a given region (Croitoru et al., 2016). The Expert Team on Climate Change Detection Monitoring and Indices (ETCCDMI) established a list of indices to analyse precipitation events (Zhang & Yang, 2004). ETCCDMI indices are widely used by researchers (Croitoru et al., 2016).

The indices used in this research were modified from the original list to address the objective of this research, similar to Croitoru et al. (2016). Furthermore, to include all extreme values, further removal of any outliers was not performed, as the DHM already controls the data quality. Table 5.1 presents the detail of modified indices for this research compared to the original indices. In contrast to the original indices, the indices used in this research were used for the entire timeseries of a given station in order to comprehend the impact of extreme events over the available years but not only the average of each year.

Table 5.1. List of modified versions of extreme precipitation analysis indices used in this research in contrast to the original version from ETCCDMI (Zhang & Yang, 2004; Croitoru et al., 2016).

Original Indices			**Indices for this Research**		
Acronym	Name	Description	Acronym	Name	Description
R0.1	Precipitation Days	Annual number of days with more than 0.1mm.	R0.1	Precipitation Days	A number of days with more than 0.1mm of precipitation.
			R90	Extremely heavy precipitation threshold	90^{th} percentile value of precipitation.
R30	Extremely heavy precipitation days	Annual number of days when precipitation ≥ 30mm	R90d	Extremely heavy precipitation days	A number of days when precipitation ≥ R90.
R99p	Extremely wet days	Annual total precipitation when rainfall > 99^{th} percentile	R90p	Extreme precipitation total	Total precipitation when rainfall > 90^{th} percentile threshold or during R90d.
PRCPTOT	Annual total wet-day precipitation	Annual total amount of precipitation cumulated in wet days	PRCPTOT	Total precipitation	The total amount of cumulated precipitation.
Rx5days	Max 5-day precipitation amount	Monthly maximum consecutive 5-day precipitation	Rx3days	Consecutive 3-day extreme precipitation	Consecutive 3 or more days of precipitation above R90.

Intensity-based index R0.1 is used to calculate the number of days with more than 0.1 mm of precipitation. There was no need to modify this index. Likewise, R90 was not included in the original list of indices. As 90th percentile threshold is used in this research as extreme precipitation, observing R90 for different stations was important. Likewise, R99p was modified to R90p because the original list considers 99th percentile as an extremely wet threshold in contrast to 90th percentile threshold. Furthermore, the modified version of PRCPTOT calculates total precipitation in contrast to the original version, which only calculates the total precipitation of wet days (>1 mm/day) in a year.

Similarly, R30 was modified to R90d. The 30 mm value was defined by the user, Croitoru et al. (2016), as per the need of their research. As 90th percentile threshold is considered as an extreme event in this research, the number of precipitation days with more than 90th percentile value was analysed. Likewise, Rx5days index observes monthly maximum 5-days of consecutive precipitation. However, the dry months in Nepal may not experience any precipitation event above the R90 value. Thus, to observe the frequency of storms, which are extreme events, Rx3days events from the entire timeseries were analysed in this research.

The data was firstly managed by calculating the value of the respective parameter (indices) from the entire timeseries. Except, R90 and Rx3days, these values were then normalised by the years with available data per station and represented on a spatial scale. The same method was conducted during the high and low precipitation months too. The high precipitation months included months (May-October) from the same year, while the low precipitation months included months (November-April) from the consecutive years. The distribution of data classes in spatial representation was determined by using the Jenks Natural Break methodology from ArcMap software. The Jenks Natural Break method identifies classes within data and accurately represents the trends in the data (Dent, Torguson, & Hodler, 1999).

Moreover, the R90 is the 90th percentile value of the entire timeseries, thus, represents the danger level associated with an extreme event in a given station throughout the timeseries. Likewise, the Rx3days without normalisation represents how many such events occurred during the timeseries in each station. As a result, this calculation gave a single value of a respective parameter for each station, which was then analysed and interpreted based on elevation, direction and topographical barrier. Regarding the data quality, the outliers were not removed because first, the DHM controls them and second, not to miss the extreme events. Likewise, days with data gap (3.05% out of the total data days) were left as blank during the calculation.

5.2.1 Total and Extreme Events during All Months

This sub-chapter presents the findings of total and extreme precipitation events during the 12 months period. The events are presented based on the calculations of six parameters, as explained above. The total precipitation amount ranges from 146.7 mm/year to 5386.2 mm/year while the total precipitation day ranges from 21 days/year to 190 days/year throughout Nepal.

Figure 5.4 presents the spatial distribution of total precipitation amount and total precipitation days during the 12 months period throughout the selected stations in Nepal.

The total precipitation amount (PRCPTOT) shows no significant relationship with elevation while total precipitation days (R0.1) shows an increment of events with increasing elevation with a significant (at 95%) coefficient of correlation (linear) of 0.44. Interestingly, both parameters PRCPTOT and R0.1 show an increment of events towards the east with a significant correlation of 0.15 and 0.3, respectively. Furthermore, these significant relationships can be verified by observing the Figure 5.4 below.

As seen in Figure 5.4, the R0.1 stations in the southern part of Nepal have comparatively low values than the PRCPTOT stations in the south. This indicates intense precipitation events in the southern part of Nepal compared to the other parts. This observation is further validated by the significant correlation of -0.58 between elevation and PRCPTOT per R0.1. In general, this means the southern parts or low elevation parts of Nepal receive more precipitation in fewer days, but as the elevation increases the intensity of precipitation per wet days decreases.

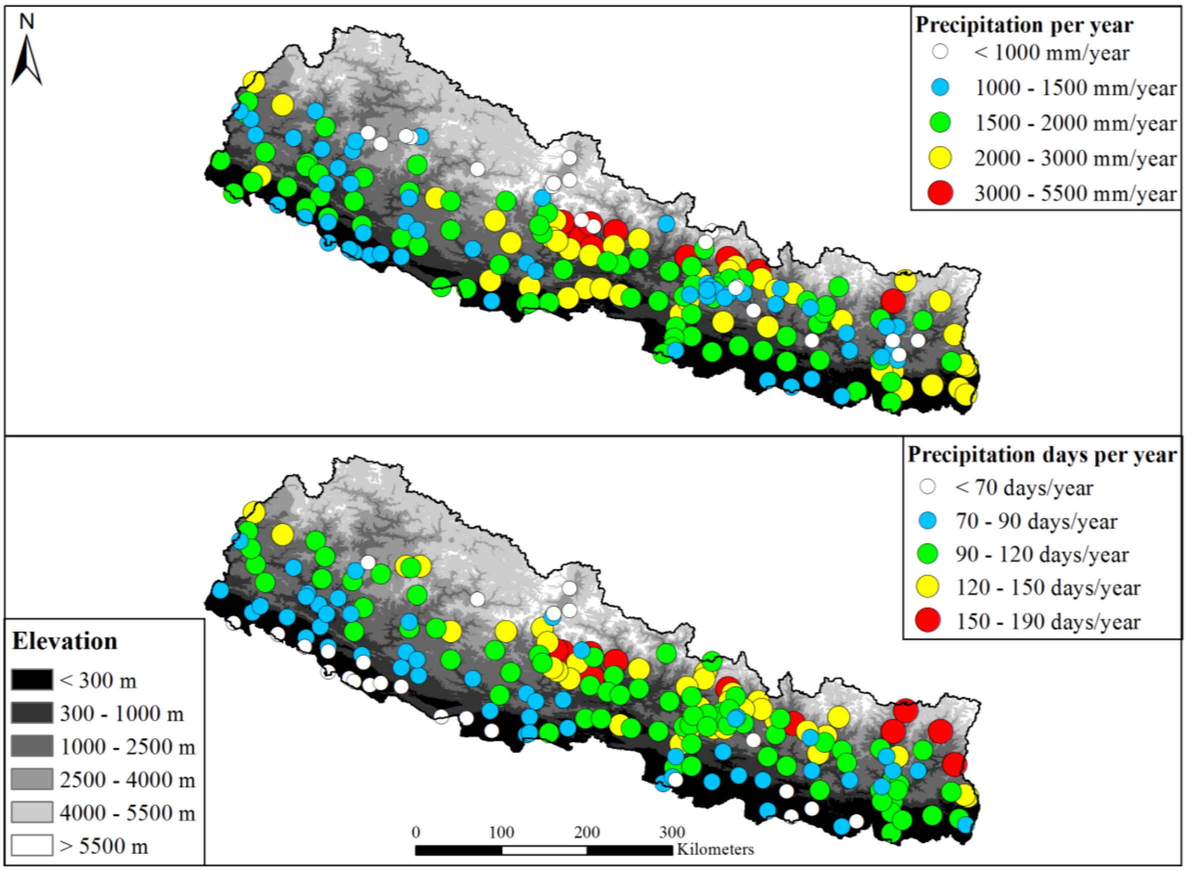

Figure 5.4. Total precipitation per year and total precipitation days per year in Nepal.

Likewise, the R90 or 90th percentile value of the precipitation events from the entire timeseries which is the threshold of extreme precipitation also decreases with the increase of the elevation as seen in Figure 5.5 below with a significant coefficient of correlation of -0.61.

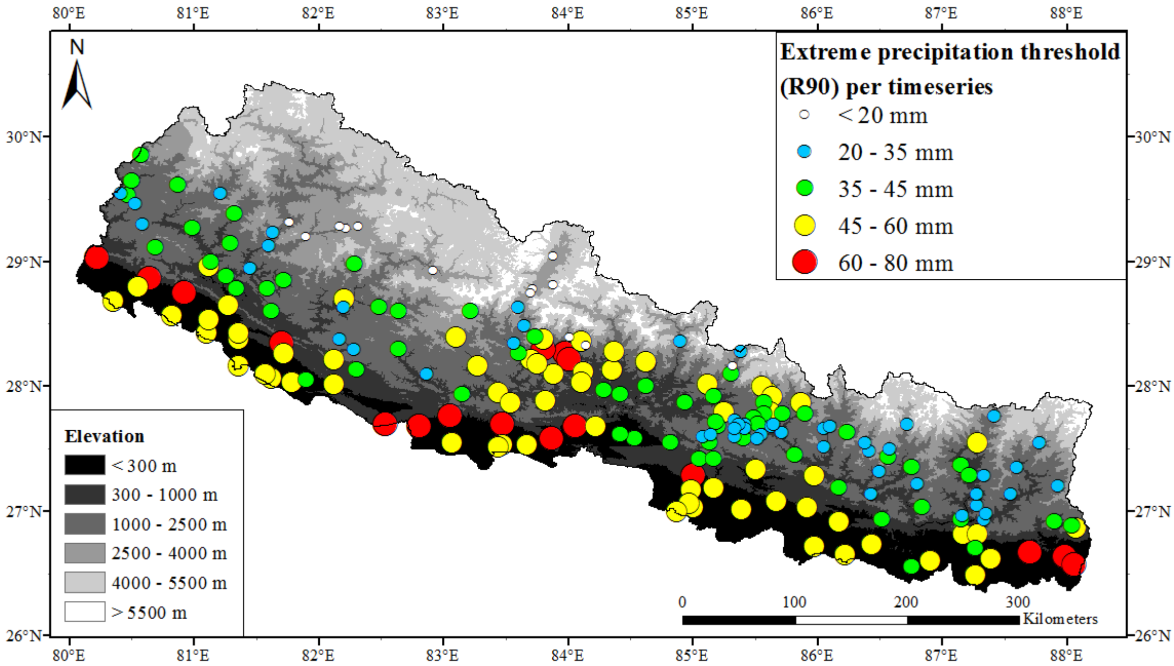

Figure 5.5. The extreme precipitation threshold (R90) throughout Nepal.

The R90 ranges from 10.4mm to 78.5mm throughout Nepal with highest concentrations in the southern plains but shows no trend dependent on the direction. In contrast, R90d or extreme precipitation days increases with elevation and towards the east with significant correlation coefficients of 0.44 and 0.33, respectively. Likewise, the R90d ranges from 2 days/year to 19 days/year.

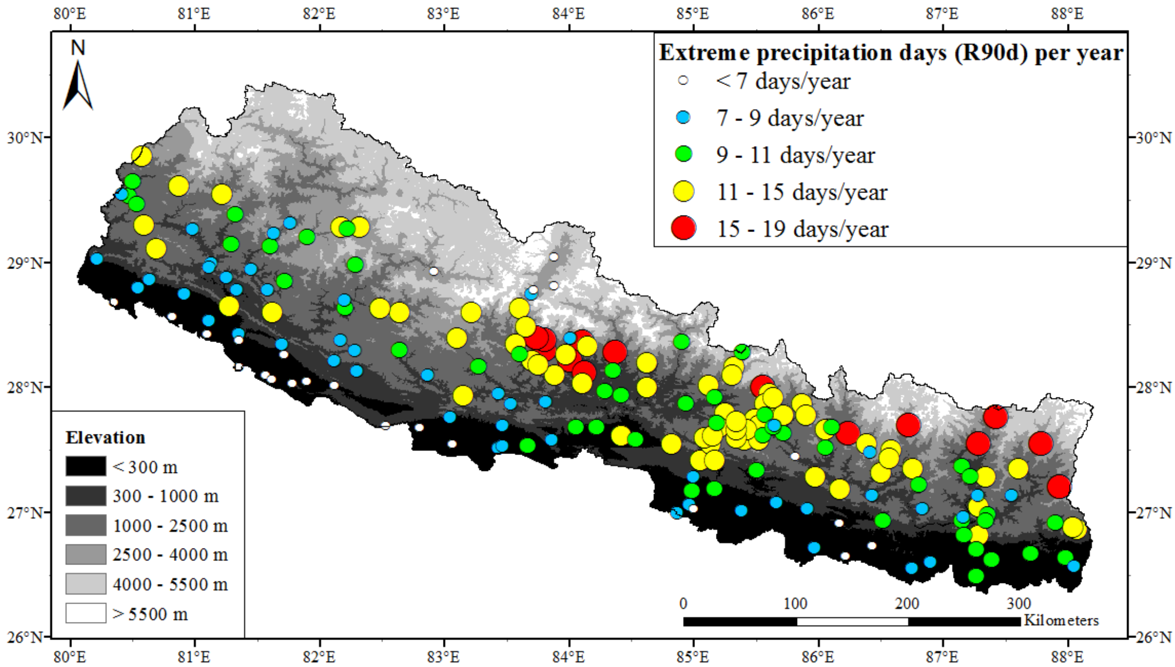

Figure 5.6. Extreme precipitation days throughout Nepal.

Interestingly, as seen in Figure 5.6, the highest R90d stations are located in the mid-central and north-east parts of Nepal. The north-east parts with highest R90d stations are located close to the orography barriers indicating vulnerability in the high Himalayas.

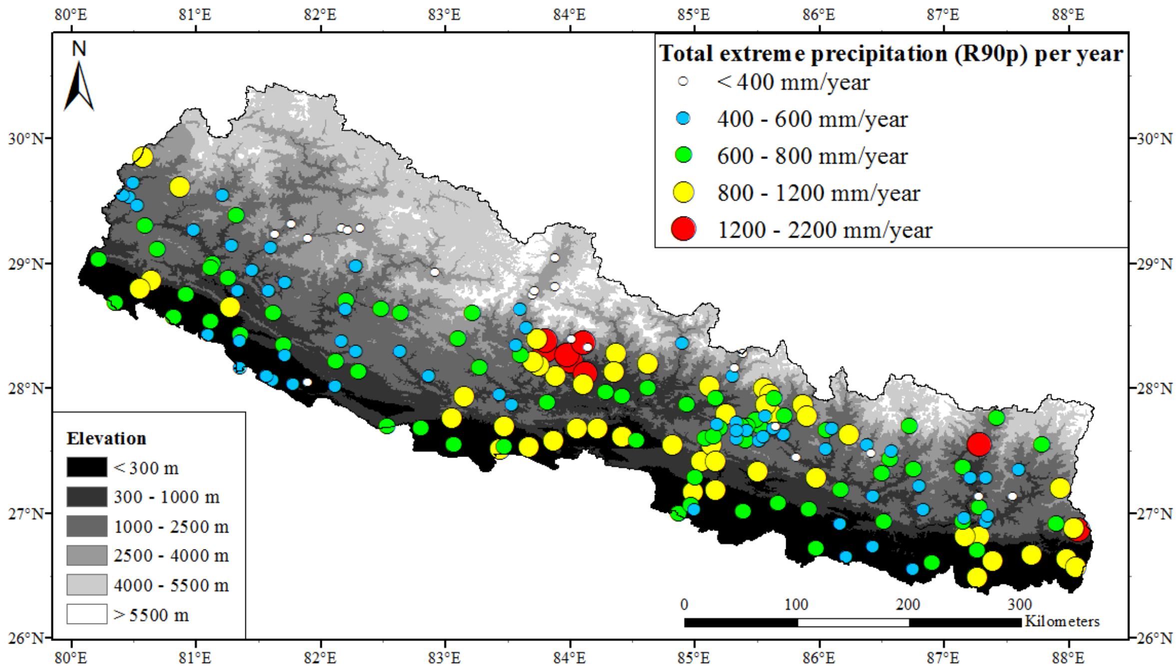

Figure 5.7. Total extreme precipitation throughout Nepal.

However, R90p or total extreme precipitation amount shows opposite characteristics in regards to the relationship with elevation compared to R90d. The R90p, although not strongly but significantly, decreases with elevation but increases its concentration towards the east. This observation, as seen in Figure 5.7, is supported by testing R90p per R90d for each station. This analysis shows higher R90p per R90d in the southern stations of Nepal, which decreases significantly with the increase of elevation with a correlation of -0.69. In general, the R90d values are comparatively lower in the plains of Nepal, but the higher R90p in the plains means more extreme precipitation amount in less time compared to the hills or the high Himalayas.

In contrast, the relationship with elevation and direction is not a smooth continuum, as indicated by the coefficient of correlation values. Precisely, the mid-central part of Nepal, which is the wettest region, shows the highest events even in parameters decreasing their concentration with increasing elevation such as, R90 and R90p. In general, R90p per R90d analysis shows less amount of R90p in the hills during more R90d.

However, the R90p shows a double band of concentration, as seen in Figure 5.7, the first increment in the second rise of elevation and second increment after the third group of elevation. These findings suggest high R90p amount during high R90d events in the higher hills. Thus, the plains and hills both show vulnerability associated with extreme events; however, their dynamics are different but not negligible. Additionally, the R90d and R90p events are highly concentrated on the eastern side of Nepal. Thus, these observations are more representative of the central and eastern parts of Nepal compared to the western parts.

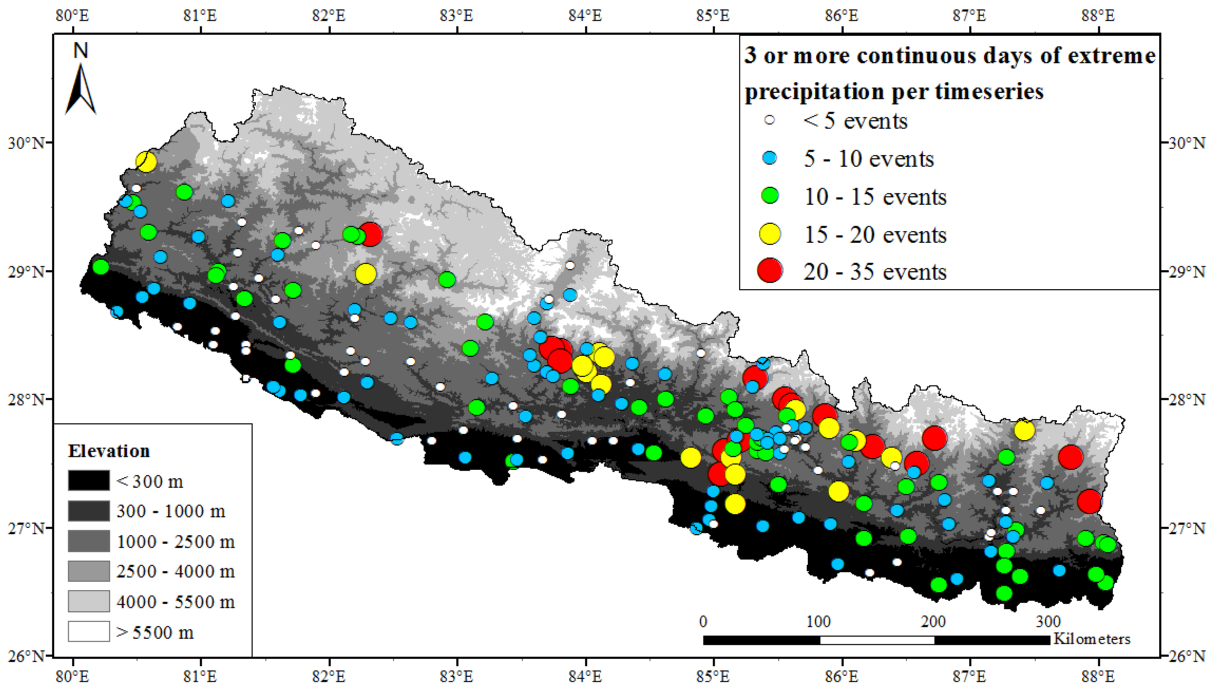

Figure 5.8. Three of more continuous days of extreme precipitation events throughout Nepal.

Likewise, the three or more consecutive days of extreme precipitation (Rx3days) events also follow the same pattern as the R90d with a significant increase of concentration towards the east and with the rise of elevation. The Rx3days events range from 0 to 33 events per timeseries throughout Nepal. As seen in Figure 5.8, the highest events occur in the mid-central, and north-east belt of high Himalayas of Nepal. This indicates a higher vulnerability of the high hills and the high Himalayas.

Moreover, except total precipitation amount, the intensity-based parameters R90 and R90p show a significant inverse relationship with increasing elevation while, frequency-based parameters R0.1, R90d, and Rx3days show a significant direct relationship with the increasing elevation. Likewise, all the parameters, except R90, show significant direct relationship towards the east. This shows the increasing concentration of events towards the east where the onset of monsoon arrives.

5.2.2 Seasonal Total and Extreme Events

This sub-chapter presents the findings of total and extreme precipitation events during High Precipitation Months (HPM), i.e. May-October, and Low Precipitation Months (LPM), i.e. November-April. The all or 12 months duration analysis of events is dominated by monsoon events which occur within the HPM. Thus, there are similarities between the findings of all months and HPM duration. The striking similarity is the pattern of a significant relationship between the events of each parameter with elevation and direction.

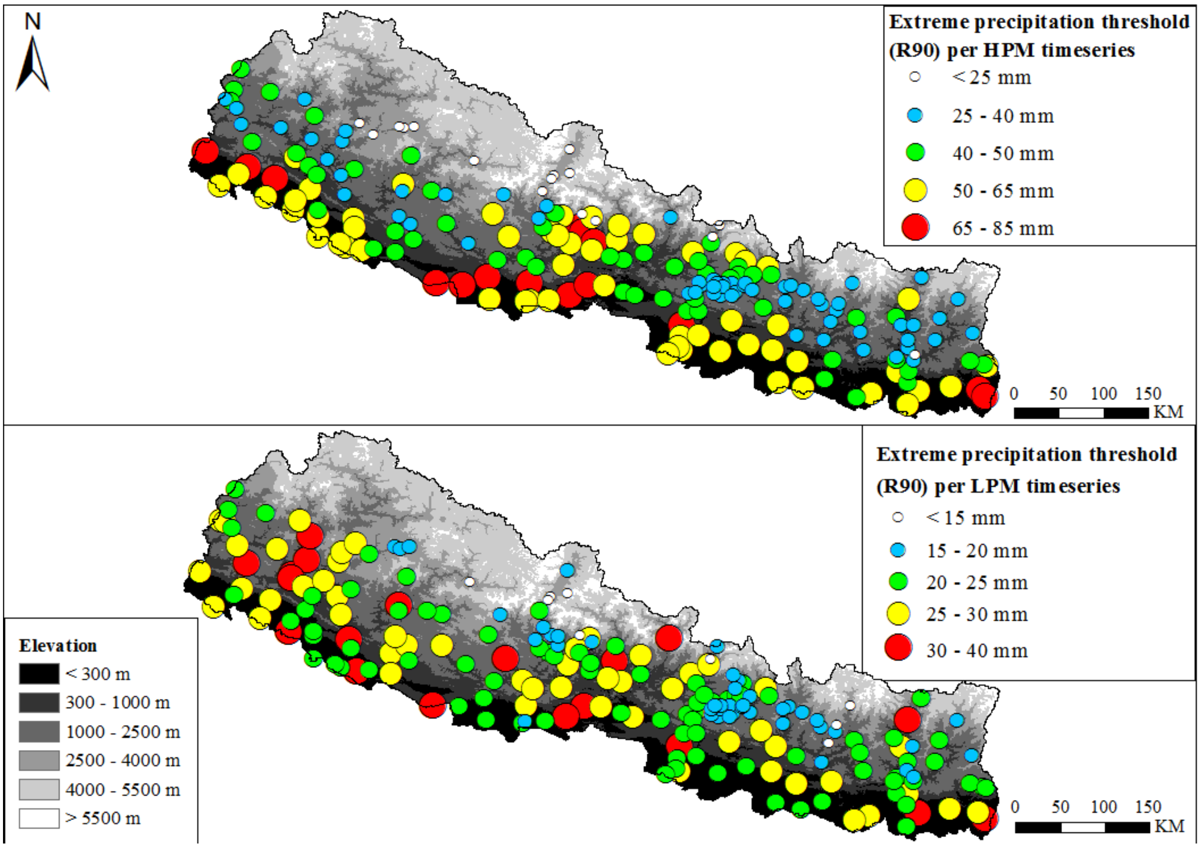

Figure 5.9. Extreme precipitation threshold (R90) during entire high precipitation months (HPM) and low precipitation months (LPM) in Nepal.

The total precipitation amount during HPM and LPM range from 107.4 mm to 5090.4 mm per HPM of each year, and 39.3 mm to 527.4 mm per LPM of each consecutive years. The difference of range indicates the polarity of the strength of events between HPM and LPM. Alike the events of all months, the PRCPTOT during HPM also shows a non-significant relationship with elevation, while R0.1 shows a significant positive relationship. However, the concentration of both PRCPTOT and R0.1 increases with the increase of the elevation during the LPM period with a significant coefficient of correlation of 0.37 and 0.57, respectively.

These observations indicate the impact of winter precipitation in the higher parts of Nepal compared to the plains. In contrast, the R90 shows a strong presence in the plains than the hills during both HPM and LPM, but it also increases towards the west during the LPM, while during the HPM the strength of R90 is spread throughout the southern part of Nepal (Figure 5.9).

The significant increment of R90 during the entire LPM period towards the west with a correlation of -0.24 further establishes the role of westerly during the winter period in Nepal. In contrast, the other three parameters, R90d, R90p, and Rx3days during the LPM, show a significant direct relationship with increasing elevation suggesting the impact of westerly induced winter precipitation in the hills of Nepal.

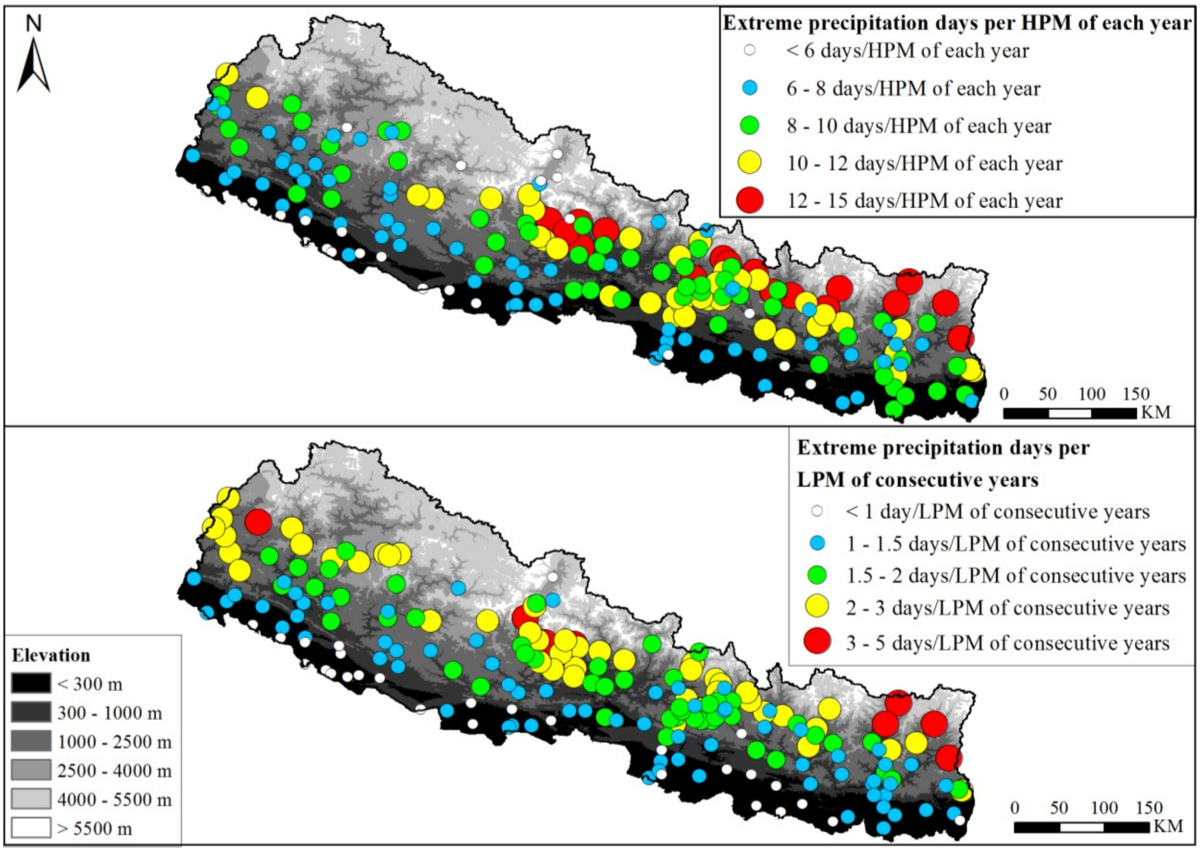

Figure 5.10. Extreme precipitation days (R90d) during high precipitation months (HPM) and low precipitation months (LPM) of each year in Nepal.

However, there is no observed significant relationship between these three parameters with the direction during the LPM. Although, this relationship is not significant, but as mentioned above the relationship with elevation and direction is not a smooth continuum. Figure 5.10 and 5.11 shows increase (decrease) of events in the western (eastern) side (above 300m) during the LPM period compared to the HPM.

Interestingly, during all months and HPM, the R90p decreases with the increase of elevation while R90d increases with the increase of elevation, but during LPM, both R90d and R90p increase with the increase of the elevation. However, the difference between their increment shows R90p per R90d during LPM has high concentration in lower to mid (1500 m) elevation compared to the higher ones. In general, these comparisons suggest the low impact of extreme precipitation in higher elevation stations.

However, in both Figures 5.10 and 5.11, the presence of highest concentration events in the north-east corner of Nepal during LPM suggests pressure of precipitation events in this high region of the Himalayas. Moreover, the mid-central part of Nepal shows high activity during both HPM and LPM. Furthermore, the three or more continuous days of extreme precipitation events (Rx3days) during HPM and LPM both show a positive yet significant relationship with the elevation. Moreover, the Rx3days during the HPM period shows similarity with that of all month's events. However, the Rx3days during the LPM period ranges only from 0 to 3 events. Thus, there is no major significant pattern observed in its findings.

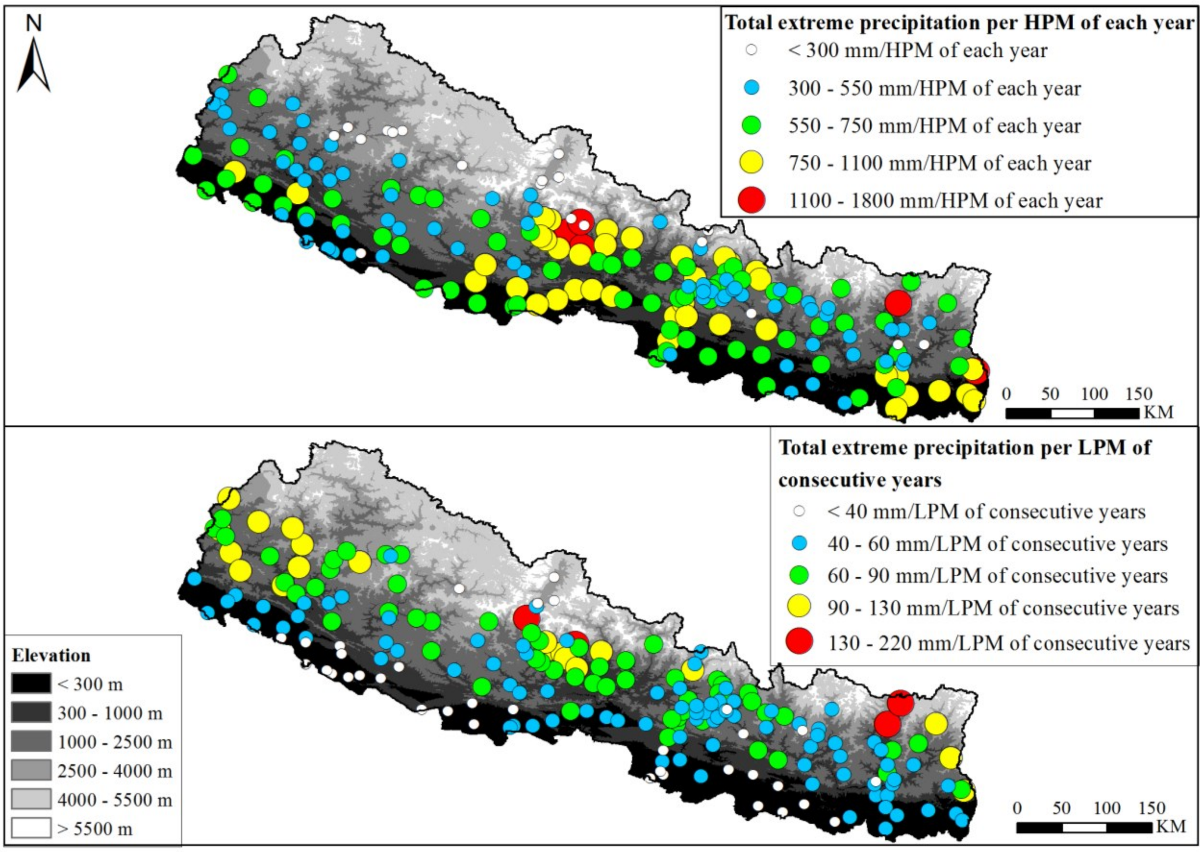

Figure 5.11. Total extreme precipitation amount (R90p) during high precipitation months (HPM) and low precipitation months (LPM) of each year in Nepal.

5.3 The Pattern of River Runoff Events

Except for the starting and ending years of the fourteen finalised river runoff stations as mentioned in chapter 5.1.2, there were multiple data gaps within these years which accounted for 6.35% of the total days of data. Such data gaps were recorded as blank while the years with more than 30 days of consecutive data gap were omitted from the calculation in order to remove any negative bias of that year in the per year calculation of the timeseries. Table 5.1 presents the list of finalised stations, including the station code, starting and ending year of the available data, total data available in the year before and after the filtration, name of the river, and its catchment area.

Table 5.2. Detail list of finalised river runoff stations from the Koshi River basin (DHM, 2016a).

Station Code	Year		Data Availability in Years		River	Catchment Area (km^2)
	Starting	Ending	Before Filtration	After Filtration		
6	1985	2008	24	23	Arun	26,750
7	1974	2008	35	33	Sabhaya	375
9	1976	2008	33	33	Arun	28,200
10	1986	2008	23	22	Arun	30,380
11	1974	2008	35	27	Bhote Koshi	2,410
12	1974	2006	33	32	Balephi	629
14	1974	2008	35	33	Sun Koshi	4,920
16	1974	2008	35	32	Tama Koshi	2,753
17	1974	2008	35	33	Khimti	313
18	1974	2008	35	27	Sun Koshi	10,000
19	1974	2008	35	23	Likhu	823
22	1974	2008	35	35	Dudh Koshi	4,100
26	1974	2008	35	34	Tamur	5,640
27	1977	2008	32	30	Saptakoshi	54,100

The river runoff data analysis follows a similar method used in the precipitation data analysis. Analysing the status of extreme river runoff is an essential part of this research because knowing the extreme runoff value will help understand the river's potential flood danger. Such information is still not available for most rivers of Nepal except some major rivers such as the Saptakoshi.

Moreover, those rivers with available information indicate generalisation of the data. For example, the International Centre for Integrated Mountain Development (ICIMOD), a regional intergovernmental knowledge sharing centre serving the eight Himalayan countries, states danger level of station 26 as 4,500 m^3/s, however, its 90^{th} percentile threshold from 1974-2008 is 835 m^3/s, and during this period there were only three days with more than 4,500 m^3/s of water runoff in station 26 (ICIMOD, 2019). For this analysis, four parameters were used, namely R90, R90d, R90p and Rx3days. These parameters were adopted from the precipitation data analysis, and its details are in Table 5.3 below.

Table 5.3. Parameters used in river water runoff analysis and its description adopted from the precipitation data analysis chapter 5.2.

Parameter	Description
R90	90^{th} percentile value (extreme water runoff threshold) of river runoff.
R90d	Days with higher water runoff than the R90 value.
R90p	Total extreme water runoff where runoff value is higher than the R90.
Rx3days	The number of events with three or more consecutive R90d.

The above-mentioned parameters were calculated for the entire timeseries and for representation, the R90d and R90p values were normalised by the number of years after filtration, while the R90 and Rx3days were represented as it was per timeseries. Since the objective of this research is to analyse the extreme river runoff situation, a similar data representation as done in the precipitation analysis part was done. This finding, when compared between rivers and its catchment area, will comprehend the level of threat from the extreme water runoff in the rivers of the Koshi River Basin (KRB). In line with the extreme precipitation chapter, the extreme river runoff events are also above the 90th percentile events. The detail findings of the four parameters, as described in Table 5.3 above, are elaborated below.

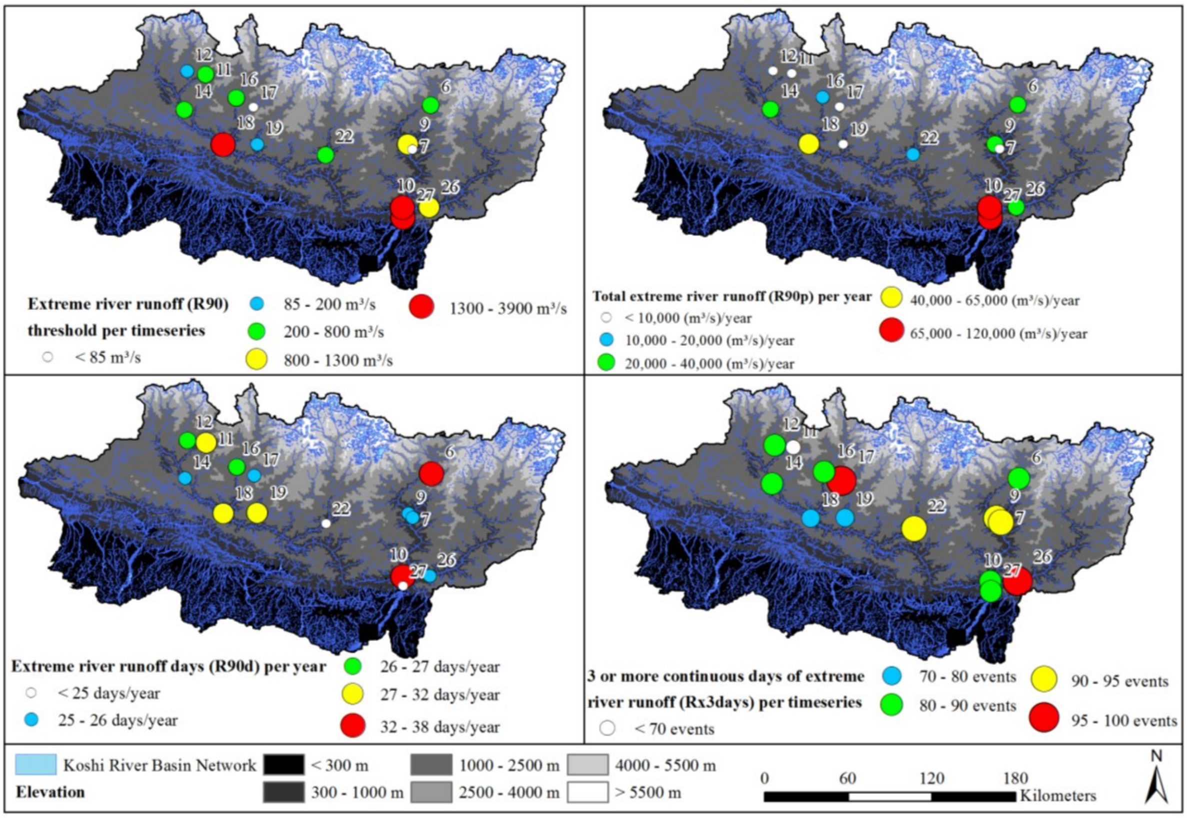

Figure 5.12. The spatial distribution of the values of extreme river runoff parameters in the selected Koshi River basin network of Nepal.

As seen in Figure 5.12, the 90th percentile value (R90) in the KRB ranges from 54.8 m^3/s to 3,900 m^3/s. Moreover, the R90 also shows a significant increasing relationship with the size of the catchment area of the river with a coefficient of correlation of 0.89 but none with the elevation. Furthermore, Sabhaya (7) and Khimti River (17) are tributaries of eight major rivers in the KRB and fall on the lowest R90 category. Likewise, the Saptakoshi (27), the merging point of all the KRB tributary rivers, has the largest R90 value of 3,900 m^3/s. While, Sun Koshi River (18) which is the merging point of all the western tributaries of the KRB, and the Arun (9 and 10) and Tamor River (26) which arrives from the eastern side of the Saptakoshi without major tributaries fall on the first and second-largest category. As a conclusion, the danger level or extreme river water flow is different in the hilly region or near to the origin compared to the plains, which is further related with the size of the river and shows a different level of rivers based on its location, catchment area and the point of origin.

Furthermore, as seen in Figure 5.12, the extreme river runoff days (R90d) does not show any significant relationship with the catchment area of the rivers. However, the interesting fact in R90d observation is the range of value between all the stations regardless of elevation, river size or origin, and the location is only 13 days per year. Such small range shows that the number of days or frequency of extreme events is similar throughout the KRB rivers.

Likewise, alike the R90 observation, which shows the intensity of the extreme conditions, the total extreme river runoff amount (R90p) also shows a significant increasing relationship with an increase of catchment area of the river with a coefficient of correlation of 0.9. Moreover, the range of R90d is comparatively small in all the KRB river tributaries, but the R90p varies greatly like the R90 values. These observations indicate similar flood frequency, even with different observed intensities. In general, the lower R90 or R90p intensity stations also possess a risk of similar flood days as of the higher intensity stations, as seen in Figure 5.13 below.

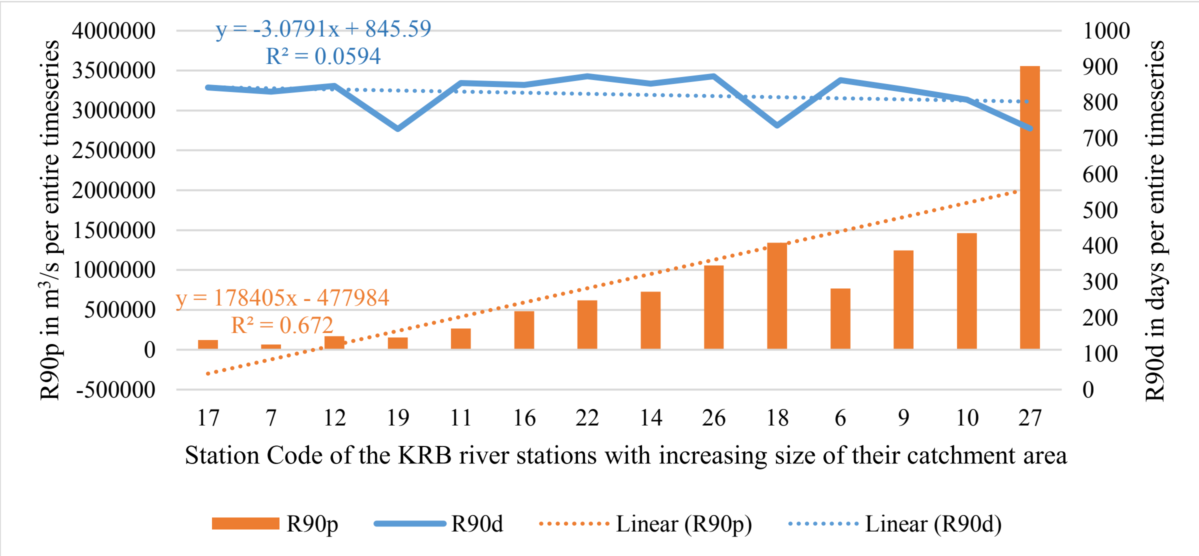

Figure 5.13. Lower to higher intensity stations showing almost similar R90d with increasing R90p.

Two parameters are measuring each intensity and frequency of the extreme river water runoff. Similar to the observations between R90 and R90p, which are the parameters of intensity, the R90d and the three or more consecutive days of extreme river runoff (Rx3days), parameters of frequency show much similarities. Alike the R90d, the Rx3days shows no observable relationship with a catchment area of the river or elevation while its occurrence has no significant pattern. For example, the river with the smallest catchment area (station 17) shares the highest Rx3days event with a mid-size river of station 26. Moreover, the intensity of station 17 is second from lowest, but, in contrast to high intensity, the stations 10 and 18 have low Rx3days, while stations 9 and 26 of almost similar intensity have high Rx3days.

5.4 The Trend of Extreme Precipitation and River Runoff Events

Analysing the trend of extreme events between related precipitation and river runoff stations will enhance knowledge on the state of extreme events in the Koshi River Basin (KRB) region. Thus, the scope of this analysis is to compare extreme precipitation and extreme river runoff trend between related precipitation and river runoff stations.

For this analysis, the precipitation stations which are related to the river runoff stations were identified based on its location and proximity and is identified in Figure 5.14. Out of the 17 precipitation stations, data of stations 4 and 10 starts from 1978 while the data from rest of the stations start from 1974. Likewise, the data from stations 3 and 15 ends at 2013 while the data from remaining stations end at 2014. However, there are years with missing data in these total years, which were left as blank during the calculation, as explained in the precipitation data analysis chapter.

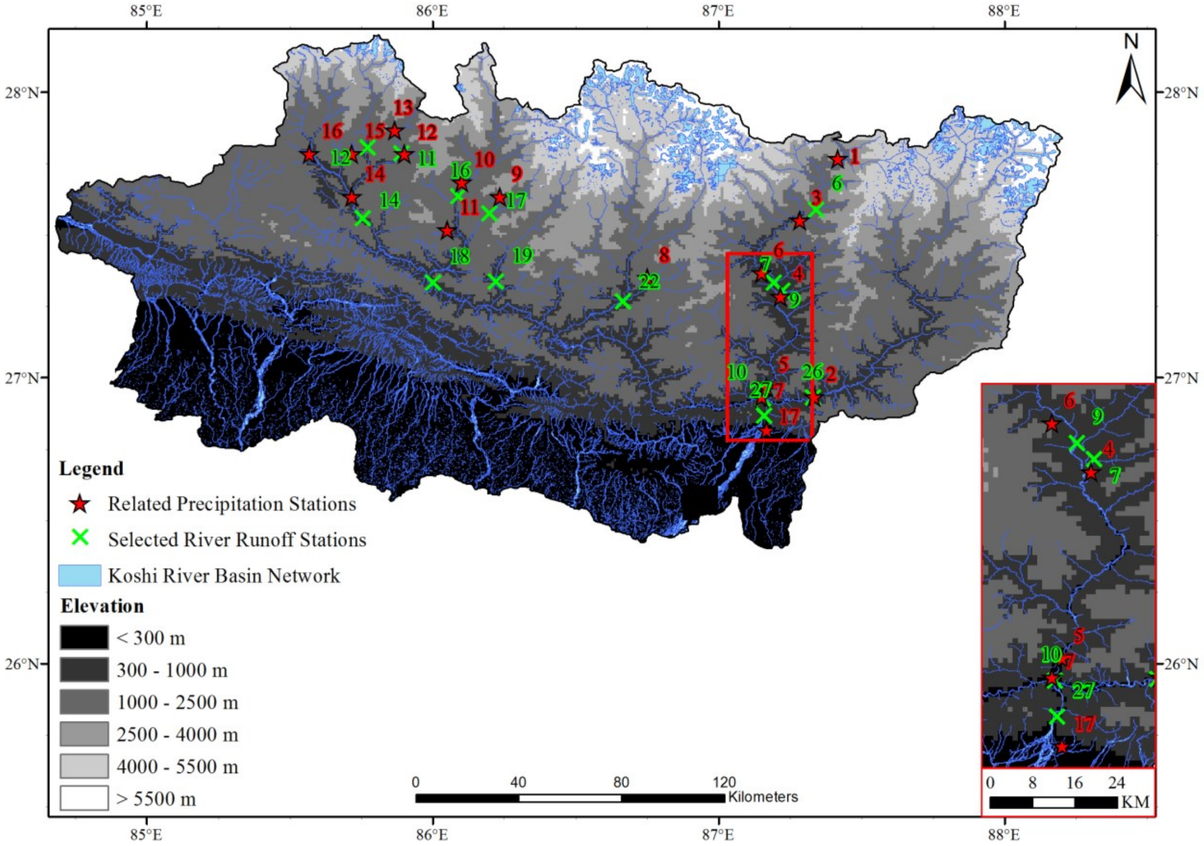

Figure 5.14. Related precipitation and river runoff stations in the Koshi River basin of Nepal.

The trend analysis was conducted using the Mann-Kendall trend test. The detailed methodology of this test is elaborated in chapter 3.4.1. The Mann-Kendall trend test was conducted on yearly extreme values of R90, R90d, R90p, and Rx3days of each station from both precipitation and river runoff stations. The details of the parameters are explained in chapter 5.2 and 5.3 for precipitation and river runoff stations, respectively.

Since the yearly data of each station did not exceed more than 41 years, and moreover, its sources were already quality controlled, any homogenisation test was not conducted. As seen in Figure 5.14 all river runoff stations are related with either one or more precipitation stations, while the river runoff station 19 is not related with any precipitation station, thus it was omitted from this analysis. Furthermore, to group the related precipitation and river runoff stations, they were compared based on their clusters as categorised in Table 5.4 below.

Table 5.4. A cluster of precipitation and river runoff stations based on their location and proximity. The first set of stations in the same cluster is between the furthest precipitation station compared to the river runoff station.

Station Code (Precipitation and River Runoff)	Cluster	Station Code (Precipitation and River Runoff)	Cluster
1 and 6	1	10 and 16	8
3 and 6	1	11 and 18	9
2 and 26	2	13 and 11	10
4 and 7	3	12 and 11	10
5 and 10	4	15 and 12	11
7 and 10	4	16 and 14	12
6 and 9	5	14 and 14	12
8 and 22	6	17 and 27	13
9 and 17	7		

The yearly extreme events of precipitation and river runoff are analysed over a period ranging from 37-41 years, and 22-35 years, respectively. Interestingly, there is more decreasing trend in extreme events compared to increasing trend. Table 5.5 presents the overall quantity of precipitation and river runoff stations with increasing or decreasing trend of extreme events.

Table 5.5. The trend of extreme events of precipitation and river runoff stations in different parameters.

Percentage of Stations with Extreme Precipitation Events Trend			Percentage of Stations with Extreme River Runoff Events Trend		
Parameter	**Increasing**	**Decreasing**	**Parameter**	**Increasing**	**Decreasing**
R90	5.88	17.65	R90	14.29	21.43
R90d	11.76	29.41	R90d	0.00	21.43
R90p	5.88	52.94	R90p	14.29	28.57
Rx3days	5.88	0.00	Rx3days	0.00	0.00

Except for Rx3days in precipitation stations, the other parameters experience more decrease of extreme event's trend. Likewise, no noticeable relationship of the trend between the related stations is observed, as seen in Figure 5.15. In R90 the stations of cluster 9 have a negative and positive trend in precipitation and river runoff stations, respectively. Similarly, in R90d, the first set of stations from cluster 10 has an increasing trend in precipitation station while decreasing in the river runoff station. In contrast, stations of both events in cluster 11 have a decreasing trend.

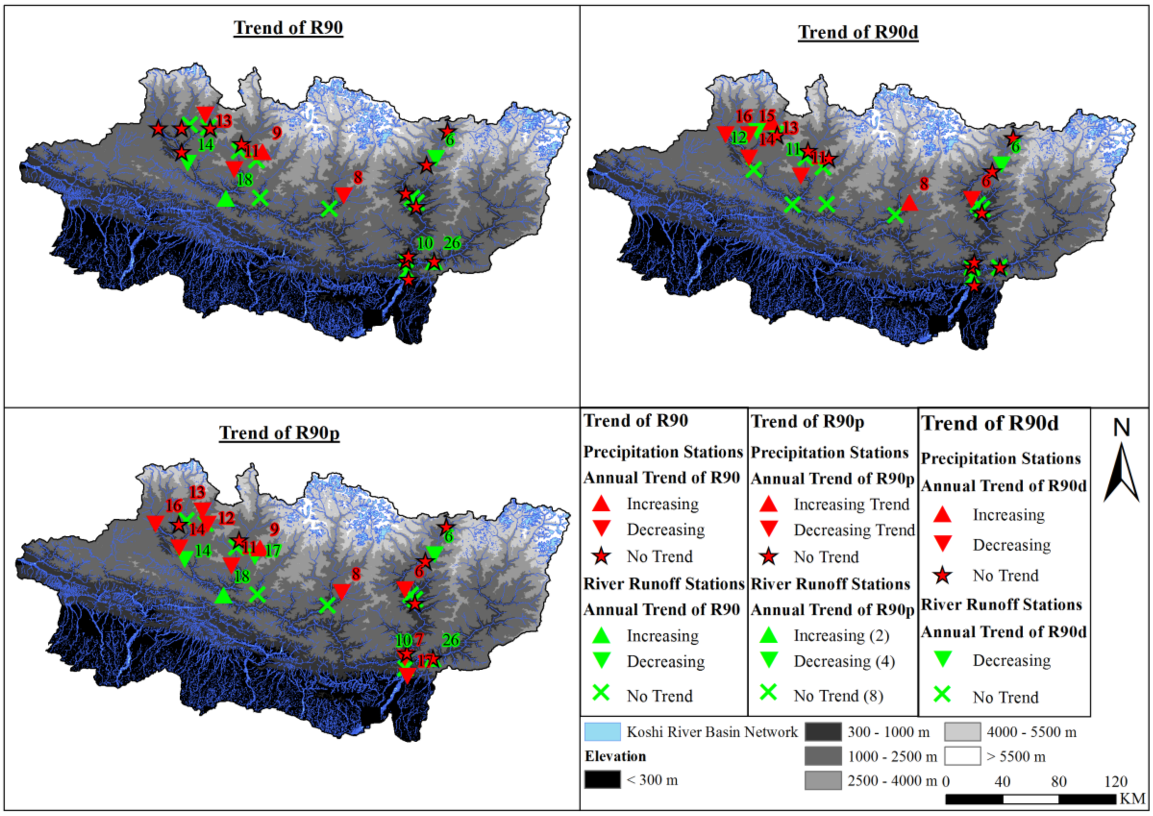

Figure 5.15. Trend analysis of precipitation and river runoff extreme events in the Koshi River basin of Nepal.

However, in R90p out of the total 17 clusters of stations, 5 clusters have some form of relationship. Cluster 7 has an increasing trend in precipitation station and a decreasing trend in river runoff station while this relationship is opposite in cluster 9. Furthermore, both sets of stations from cluster 12 have a decreasing trend of precipitation and river runoff, while the second set of stations from cluster 4 also has the same relationship.

Finally, there is only one increasing trend observed in the Rx3days between both parameters; thus, there is no relationship between its linked stations. The cluster 9 in R90 and R90p and precipitation stations of cluster 10 in R90d and Rx3days show a similar pattern. Likewise, in simultaneous order, for precipitation and river runoff stations, the extreme events have two situations with decreasing and increasing trend, two situations with increasing and decreasing trend and three situations with decreasing and decreasing trend, respectively. Thus, further elucidating the role of other factors than precipitation in determining the extreme events in the river runoff. Moreover, the location, frequency and intensity along with environmental conditions also impact the extreme event trend.

5.5 Relationship between Precipitation and River Runoff Events with the Southern Oscillation

Similar to the precipitation and river runoff data analysis, the Southern Oscillation (SO) data was also analysed based on the ETCCDMI parameters. The data analysis explores the relationship between the precipitation and river runoff parameters with the BEST index. The analysis is based on the methodology used by Krishnamurthy and Goswami (2000), and Shrestha (2000) who compared the ENSO events with the annual average Indian summer monsoon events and Nepal summer monsoon events, respectively. Likewise, the anomaly from the mean of the yearly data of each parameter above (below) positive Standard Deviation (SD or σ) (negative SD) represents the high (low) event of the given parameter (adopted from Krishnamurthy & Goswami, 2000). In addition to analysing the annual average values with the annual average BEST index, this analysis also explores average data of High Precipitation Months (HPM) and Low Precipitation Months (LPM) for the precipitation parameters.

The steps mentioned above analyse the data based on years and periods (HPM and LPM). Moreover, Krishnamurthy and Goswami (2000), and Shrestha (2000) used this method to compare El Niño Southern Oscillation (ENSO) events with total precipitation. However, this analysis explores not only the relationship of the ENSO events with total precipitation but also with the extreme precipitation and river runoff events. Thus, this analysis will highlight the importance and influence of the ENSO events in Nepal's extreme precipitation and river runoff events.

The total precipitation events, total precipitation amount (PRCPTOT) and total precipitation days (R0.1) show significant but the opposite relationship with the BEST index during the HPM and LPM as seen in Figure 5.16. However, both PRCPTOT and R0.1 do not show any relationship during all months or yearly events. These observations indicate that La Niña intensifies total precipitation events during the HPM while El Niño intensifies such events during the LPM.

Interestingly, 90^{th} percentile threshold of extreme precipitation (R90) has a significant relationship with the ENSO events only during the HPM and the yearly events. Likewise, the total extreme precipitation amount (R90p) shows a significant relationship with the ENSO events only during HPM. In contrast to these intensity-based parameters, the frequency-based parameters of extreme events, total days of extreme precipitation (R90d) and three or more consecutive days of extreme precipitation (Rx3days) do not show any significant relationship with the ENSO events in any time of a year. Furthermore, the extreme events show increasing relationship only towards the La Niña events, and more interestingly only the intensity of extreme events are influenced by La Niña but not the frequency of the extreme events, which can be seen in Figure 5.16.

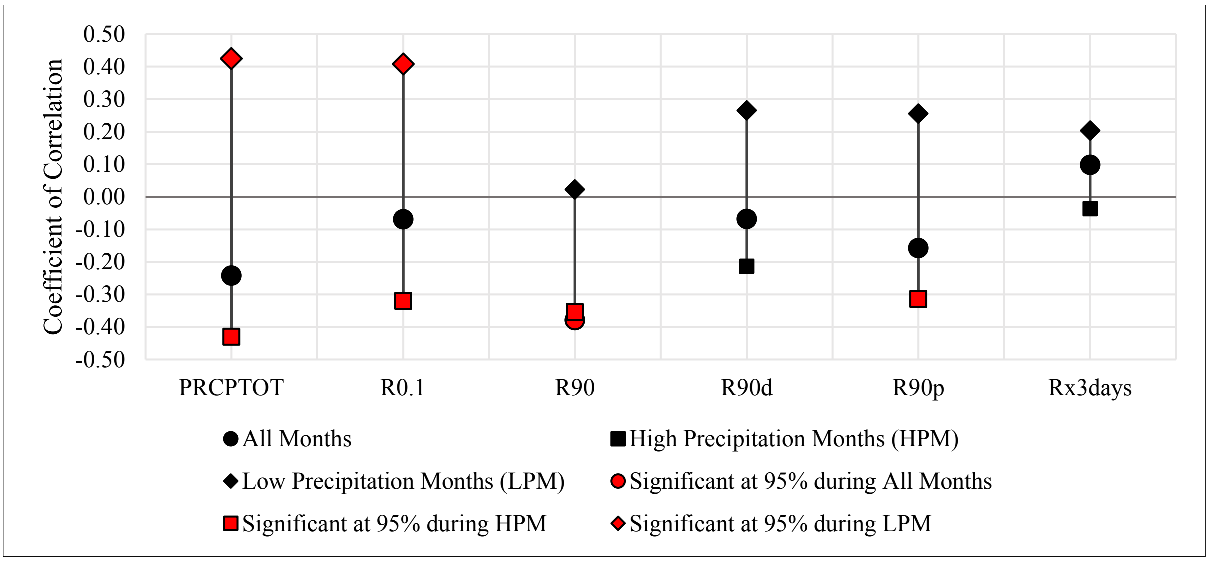

Figure 5.16. Coefficient of Correlation between the average values of parameters from the given duration period and the BEST index at a significant level of 95%.

Moreover, it is interesting to note that all the coefficients of correlation during all months and HPM are below 0, except Rx3days, while that of LPM are above 0. Although all these relationships are not significant, it shows the contrasting behaviour of ENSO events in Nepal during different weather periods. In general, the precipitation events during the wet months are triggered positively by La Niña, while the precipitation events during the dry months are triggered positively by El Niño.

As an example, the interannual relationship between a representative parameter, in this case, the extreme precipitation amount during HPM, and the BEST index is presented in Figure 5.17, which is the basis of data comparison and analysis in this chapter.

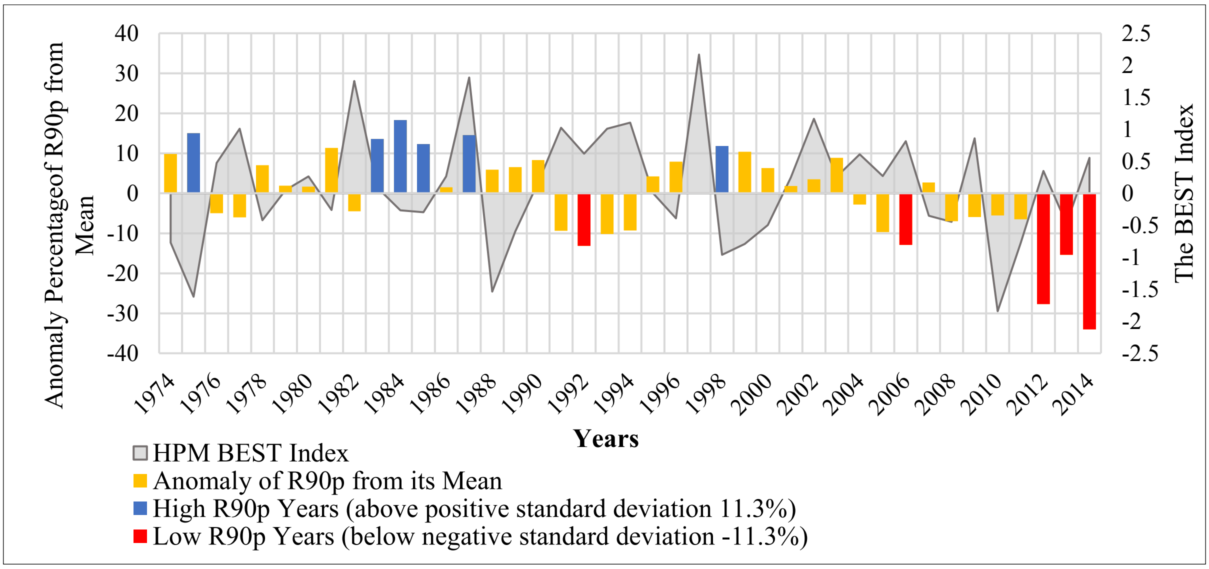

Figure 5.17. Interannual variation of R90p during the high precipitation months (HPM) period and its relationship with the BEST index.

The intensity of extreme precipitation amount (R90p) during the HPM shows a significant relationship with the decreasing BEST index (towards La Niña) but only one high R90p year (1975) coincides with a La Niña year as seen in Figure 5.17. However, out of the 41 years, 27 years have an in-phase relationship with the BEST index, i.e. anomaly percentage from the mean of R90p's timeseries below (above) 0 during positive (negative) BEST index years. Moreover, R90 has the highest in-phase relationship with the BEST index during the HPM with 31 years, while the significant relationship between total precipitation amount (PRCPTOT) and the BEST index is highest with a coefficient of correlation of -0.43 during the HPM period.

Interestingly, out of the four events of high and continuous years of R90p during the HPM period, two (1983-1985, and 1998) occur after an El Niño year, while one (1987) occurs during the El Niño year. Similarly, during ENSO years, and post-ENSO years the occurrence of high (above standard deviation of the timeseries) or low (below negative standard deviation of the timeseries) events are observed in other parameters too, but these observations do not signify any pattern as seen in Figure 5.18.

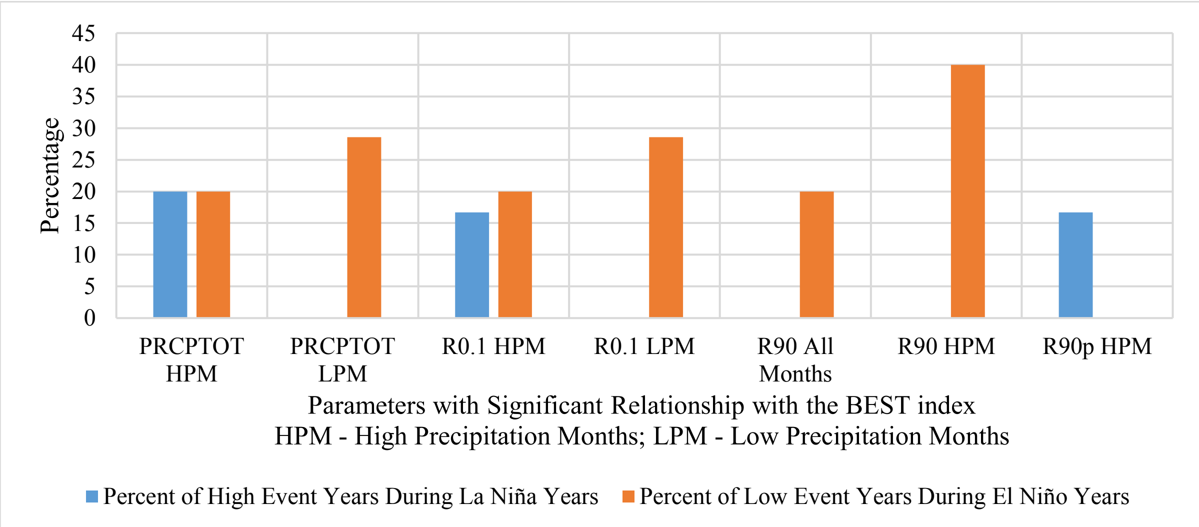

Figure 5.18. The occurrence of the parameters (having a significant relationship with the BEST index) during specified periods with high or low events during the ENSO years.

As seen in Figure 5.18, the occurrence of high or low events during the respective ENSO years is less than 40% in all significant parameters' duration. However, as observed in Figure 5.16 and 5.19, the negative correlation of all months and HPM duration events with the BEST index and the higher than 50% in-phase relationship of the same two duration events signify the impact of the BEST index during total as well as extreme precipitation events in Nepal. Specifically, the number of high and low events occurring during La Niña and El Niño years respectively is less, but the significant correlation values and the number of in-phase relationship years prove the impact of ENSO events in Nepal.

As a result, the total and extreme precipitation amount, total precipitation days, and extreme precipitation threshold shows increment (decrement) of events with a decrease (increase) of the BEST index during all months and HPM duration, i.e. towards La Niña (El Niño). Likewise, the total precipitation amount and days show increment (decrement) of events with an increase (decrease) of the BEST index during the LPM duration, i.e. towards El Niño (La Niña). In general, the difference of air pressure and sea surface temperature between the eastern and western tropical pacific region, also known as the southern oscillation, impacts the total precipitation intensity and frequency, but only the extreme precipitation intensity in Nepal during different periods of a year.

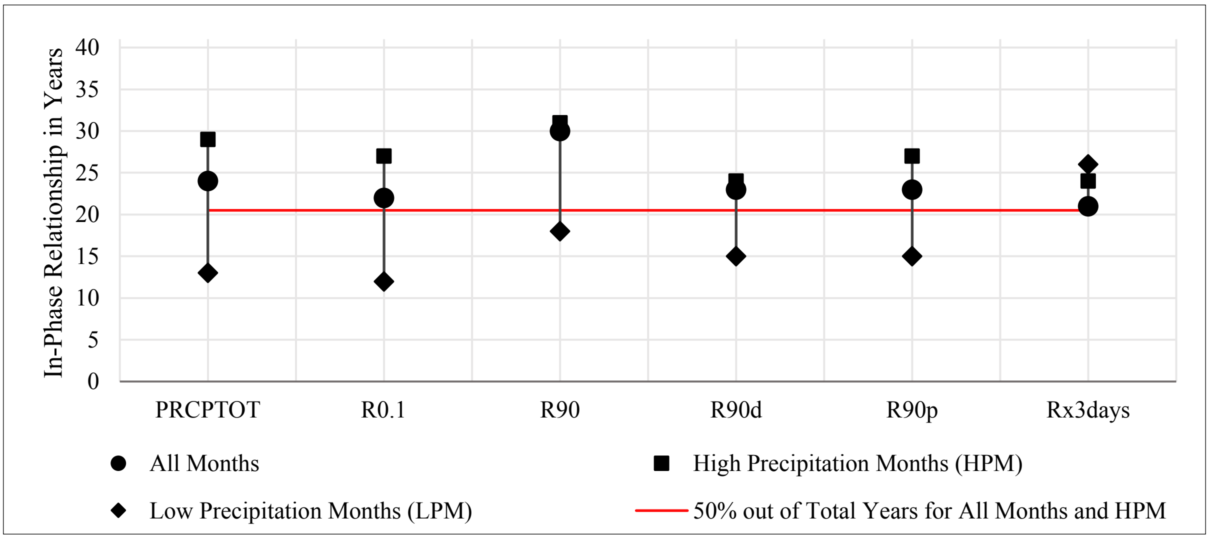

Figure 5.19. In-phase relationship of the parameters' events with the BEST index out of 40 years for LPM, and 41 years for the other two durations.

Furthermore, the average values of total and extreme precipitation events of stations under each 500m elevation range (e.g., 0-500m, 500m-1000m, and so on) do not show any significant relationship with the BEST index. This observation proves that there is no significant yet differing impact of ENSO events in different elevation levels of Nepal. Likewise, the extreme river runoff parameters also do not show any significant relationship with the BEST index, as seen in Table 5.6.

Table 5.6. Non-significant coefficient of correlation at 95% between extreme river runoff parameters and the BEST index.

Parameters	Correlation with the BEST index	p-value at 95%	In-Phase Relationship
R90	0.08	0.663	19
R90d	-0.04	0.828	19
R90p	0.10	0.579	20
Rx3days	-0.11	0.520	21

5.6 Key Findings

The significant findings from this chapter are listed below. The key findings include the total and extreme precipitation pattern in Nepal. Likewise, the key findings also include the pattern of extreme river runoff in the Koshi River basin of eastern Nepal and its trend compared with the extreme precipitation trend of the related stations. Finally, the relationship of total precipitation, extreme precipitation and river runoff events with the southern oscillation, are also listed out below. The key findings part is divided into four sections as precipitation, river runoff, the trend of related extreme precipitation and river runoff, and the relationship of extreme events with the southern oscillation sections.

5.6.1 The Pattern of Precipitation Events

The key findings of precipitation events are divided into total precipitation events and extreme precipitation events. However, all the parameters during all three periods, the entire year, High Precipitation Months (HPM), and Low Precipitation Months (LPM) have the highest concentration in the mid-central part of Nepal, near the city of Pokhara. Likewise, all the parameters during all three periods, except the threshold of extreme precipitation (R90), has specific high concentration in the northeast corner of Nepal too.

5.6.1.1 The Pattern of Total Precipitation Events

- Total precipitation amount (PRCPTOT) increases towards the east but not with elevation during an entire year and HPM period.
- PRCPTOT has a high concentration in the western part of high elevation (above 1000m) region during the LPM.
- Total precipitation days (R0.1) has a high concentration of events during an entire year and HPM period in the mid-central to the eastern part, with an increment of events with elevation and towards east.
- Events of R0.1 increases strongly with an increase of elevation with a major concentration in the western and mid-hills.

5.6.1.2 The Pattern of Extreme Precipitation Events

- The high concentration of extreme precipitation threshold (R90) is distributed evenly throughout the southern plains of Nepal with no relationship with direction during both entire year and HPM duration.
- During the LPM, the R90 has a high concentration in the plains, which increases towards western hills.

- The extreme precipitation days (R90d) shows exactly the same phenomenon as the R0.1 during all three duration periods.
- The total amount of extreme precipitation (R90p) has a high concentration in the central and eastern plains which gradually decreases from the plains with an increase of elevation and towards the west during both entire year and HPM period.
- The low R90d but high R90p in the plains signify intense extreme precipitation in less duration in the plains of Nepal during an entire year and HPM period.
- The R90p has a high concentration in the central and western hills, which gradually increases from the plains with an increase of elevation during the LPM period.
- The difference between R90d and R90p during LPM period signifies intense R90p per R90d until the mid-elevation range (<1500m) and increases towards the west.
- The three or more continuous days of extreme precipitation (Rx3days) increases with the increase of the elevation and towards the east during all months and HPM period, while high concentration stations occur in the north-eastern belt of the high Himalayan region.
- Most of the Rx3days stations do not have any occurrence of events during the LPM, but only a few stations have events in high elevation areas scattered randomly from west to east.

5.6.2 River Runoff Events

- The extreme river runoff threshold (R90) and the total amount of extreme river runoff (R90p), the two intensity-based parameters show an increment of concentration with an increasing catchment area of the river.
- The extreme river runoff days (R90d) and three or more continuous days of extreme river runoff (Rx3days), the two frequency-based parameters do not show any significant relationship with the catchment area or elevation of the river.
- The small range of R90d against a high range of R90p between all stations signifies a similar level of flood risk for all rivers disregard to river size or its extreme river runoff intensity level.

5.6.3 The Trend of Related Extreme Precipitation and River Runoff Stations

- There are more stations with decreasing extreme precipitation and river runoff trend than increasing in the Koshi River basin.
- There is no observable relationship between extreme event trend between precipitation and river runoff stations.

- In comparison, the trend of the total amount of extreme precipitation (R90p) and the total amount of extreme river runoff events are more related than other parameters.
- The decreasing trend of R90p events is highly related to the trend of the total amount of extreme river runoff events compared to the increasing trend of R90p events, but the trend of river runoff cannot be predicted based on the decreasing trend of R90p.

5.6.4 Relationship of Extreme Events with the Southern Oscillation

- Total precipitation amount and days during HPM intensify when the BEST index decreases, i.e. towards La Niña.
- Total precipitation amount and days during LPM intensify when the BEST index increases, i.e. towards El Niño.
- Extreme precipitation threshold during an entire year and HPM period intensify with decreasing BEST index.
- Total extreme precipitation amount increases with decreasing BEST index during the HPM period.
- Both the intensity and frequency of total precipitation events are impacted by decreasing BEST index in HPM and increasing BEST index in LPM.
- Only the intensity of extreme precipitation is impacted by decreasing BEST index during HPM.
- Frequency of extreme precipitation has no relationship with the BEST index.

6 Analysis of Environmental Education and Attitude

Various research emphasises the importance of education and attitude to influence the adaptive behaviour to the environmental crisis (e.g., Meinhold & Malkus, 2005; Clery & Rhead, 2013; Johnson & Činčera, 2015, Pyhälä et al., 2016). The previous chapter demonstrates capricious extreme precipitation events in Nepal, and inundates in the Koshi River basin of Eastern Nepal. Consequently, the risk of an extreme event in the future is vivid.

Thus, the environmental education and attitude of the children living near the Koshi River are essential to analyse. This analysis will identify the children's capacity to adapt to their vulnerable, river-dominated, surrounding. Therefore, this chapter presents the analytical findings of:

- The verified model of the 2-MEV tool, which analyses environmental values and attitudes of the children, to use in rural Nepal;
- The environmental attitude of the school going children of the research site (Chakraghatti); and
- The environmental education content followed by the schools of the research site.

6.1 Validation of the 2-MEV for Rural Nepal

The Two-Dimensional Model of Ecological Values (2-MEV) consists of a set of items/questionnaires. The validation process of the 2-MEV for rural Nepal includes three steps. First, the development of items for the 2-MEV tool as per the scenario of the rural Nepalese society. Second, the first survey using these items to select the items with the best loadings based on the component analysis and the understanding of the surveyed students. Finally, the second survey with an updated set of the items to finalise the items for the 2-MEV tool which fit into the Structural Equation Modelling (SEM) hence comprehending the construct of the attitude in rural Nepal. The developed items were translated into the Nepali language before using in the survey. The process of translation is elaborated in the methodology chapter 3.4.2.

6.1.1 Development of the Items

The main aim of the item development phase is to include and develop the items which represent the environmental and social scenario of the research site. The following two methods developed the items. First, importing the items from the previous 2-MEV research and modifying, if necessary, to fit into the local environmental, social and cultural context of the research site. Table 6.1 presents the details of the items used from previous 2-MEV research. Second, developing entirely new items based on the local context of the research site.

The process to develop new items consisted of observing the physical environment of Chakraghatti as well as the cultural beliefs and lifestyles. Usually, in previous 2-MEV research, the total number of items ranges from sixteen to twenty (Bogner & Wiseman, 1999; Johnson & Manoli, 2008; 2011). However, more than twenty items were developed and finalised for this research to have more options for the items to select from for the final 2-MEV model for rural Nepal. Finally, after following the item development process, twenty-seven items fit into this research as per the objectives.

Table 6.1. List of the items adopted/modified from the previous 2-MEV research.

Item	Original Form	Modified Form	Source
1	If someday I have free time, I would like to volunteer to help protect the environment.	*Same as Original.*	Schneller et al., 2013.
4	I would like to join and actively participate in an environmentalist group.	I would like to volunteer with an organisation that is working to protect the environment in my community.	Milfont & Duckitt, 2004; 2010.
5	I try to tell others that nature is important.	*Same as Original.*	Johnson & Manoli, 2008; 2011; Schneller et al, 2013.
9	There should be special nature reserves into which nobody be allowed to enter.	I support conservation of forest for wildlife protection.	Bogner & Wilhelm, 1996.
10	We must set aside areas to protect endangered species.	If necessary, land near my community should be separated to support endangered plants and animals.	Bogner & Wiseman, 2006.
12	I would like to sit by a pond and watch dragonflies.	I enjoy sitting under a tree to enjoy its shade.	Bogner & Wiseman, 1999; 2006; Milfont & Duckitt, 2004; Johnson & Manoli, 2008; 2011.
13	I enjoy trips to the countryside.	I prefer the environment of village compared to that of a city.	Bogner & Wiseman, 2006.
14	I like to go on trips to places like forests away from cities.	Walking through the forest and/or in the mountains brings me joy.	Bogner & Wiseman, 1999; Milfont & Duckitt, 2004; 2010; Johnson & Manoli, 2008; 2011; Schneller et al., 2013.
15	I like the quite of nature.	I enjoy sitting beside a river.	Bogner & Wiseman, 1999; Milfont &

			Duckitt, 2004; 2010; Johnson & Manoli, 2008; 2011.
16	I especially love the soft rustling of leaves when the wind blows through the treetops.	I enjoy hearing the soft rustling of leaves when the wind blows through the trees.	Bogner & Wiseman, 1999; Milfont & Duckitt, 2004.
18	People have the right to change the environment (nature).	People have the right to change the environment (nature). E.g., clearing forest, plotting land or draining stream	Bogner & Wiseman, 2006; Johnson & Manoli, 2008; 2011; Schneller et al., 2013.
19	Human beings were created or evolved to dominate the rest of nature. And, Humans have the right to change nature as they see fit.	People should be allowed to change the environment for their benefit without considering its effect on the environment.	Milfont & Duckitt, 2004; 2010; Bogner & Wiseman, 2006.
20	To feed people, nature must be cleared to grow food.	To feed people, forests must be cleared for agriculture to grow food.	Bogner & Wilhelm, 1996; Johnson & Manoli, 2008; 2011; Schneller et al., 2013.
21	I like a grass lawn more than a place where flowers grow on their own.	*Same as Original.*	Johnson & Manoli, 2008; 2011.
22	Building new roads is so important that trees should be cut down.	*Same as Original.*	Johnson & Manoli, 2008; 2011.
24	Since mosquitos live in wetlands, it would be better to drain these areas for farming.	*Same as Original.*	Johnson & Manoli, 2008; 2011.
25	Human beings should not tamper with nature even when nature is uncomfortable and inconvenient for us.	Instead of safeguarding the domesticated animals, it would be better to clear forests and displace wild animals that could attack the domesticated animals.	Milfont & Duckitt, 2004; 2010.
26	People are supposed to rule over nature.	*Same as Original.*	Schneller et al., 2013; Johnson & Manoli, 2008; 2011.
27	Human beings are more important than other creatures.	Since human beings are more intelligent, they have the greatest right to live.	Bogner & Wiseman, 2006.

The challenge to adapt 2-MEV items in this part of Nepal required modification of the items to reflect the local surrounding and lifestyle. In previous studies item such as *I try to save water by taking shorter showers or turning off the water when I brush my teeth* were used (Johnson & Manoli, 2008, 2011; Schneller et al., 2013). In the local context of the research site, this item makes less sense because there is no concept of the shower in Nepalese culture but only of bathing, and there is abundant water in the region. Out of the total twenty-seven items, nineteen items were adopted and used from the previous research. Out of these nineteen items, six items did not need any modification. Likewise, the remaining thirteen items were modified to suit the rural Nepalese context. Primary factors considered during the modification process of the items were the context of the item regarding the lifestyle of the community members and, communication with the local teachers. However, while modifying the items, it is essential to keep the same intent (B. Johnson, personal communication, December 3, 2015) and special attention was given in this process to maintain the intent of the item.

An example of the item modification due to its context is item 10. The original version of item 10 focuses on setting aside an area for the protection of endangered species. However, setting aside an area is a vague description for the children, as it does not define which area, thus leading to confusion. Hence, "setting aside an area" was modified to "a land near my community" to improve the item's connectedness with the children. Similarly, *I like to go on trips to places like forests away from cities* (item 14) was modified to *Walking through the forest or/and in the mountains, brings me joy*. Going on trips is not a common activity in rural Nepal. However, forests and mountains are part of rural Nepal and strolling in forests and mountains is an everyday activity for school children. Likewise, in item 20, the word "nature" is modified to "forest" to be more precise about the content of the item. The items were modified to make it simple, contextual and understandable for the children.

Furthermore, the imported items did not represent the rural Nepalese lifestyle and culture altogether. The previous 2-MEV and environmental attitude research were conducted mainly in developed countries but not in Nepal (e.g., Bogner & Wilhelm, 1996; Bogner & Wiseman, 1999; 2006; Milfont & Duckitt, 2004; 2010; Johnson & Manoli, 2008; 2011; Schneller et al., 2013). Therefore, these sets of available items did not represent the rural Nepalese context wholly. As a result, to fill this void, the remaining eight items were developed which tackled similar ideas of perception as used in the previous 2-MEV studies. These eight items were finalised by observing the physical environment and lifestyle of the research site as well as by consulting with the local teachers and the community members. Table 6.2 presents the list of newly developed items for this research. Moreover, while developing new items, special care was given to explore the intent of the children about their environment.

Table 6.2. List of newly developed items for this research.

Item	Newly Developed Items
2	I would like to participate in an afforestation campaign.
3	I would like to participate in a cleaning campaign.
6	After cutting one tree, I try to re-plant a new one.
7	I avoid dumping my waste into rivers.
8	I avoid burning my plastic waste.
11	To avoid water pollution, I do not use soap while bathing in the river.
17	I enjoy the natural sound of the flowing river.
23	To protect vulnerable riverside communities from flooding, rivers should be diverted.

Out of the newly developed eight items, six items are related either with river or with forest. Mostly, the livelihood in rural Nepal depends on the forest or the river (Heinen, 1993). Thus, the inclusion of these items is vital in the case of Nepal. For example, item 23 is essential to understand the children's intent towards their environment, which is highly prone to catastrophic floods. Similarly, the issues of cleanliness and waste management, which is one of the most significant sources of pollution in Nepal (Jha, 2007), were also included. Table 6.3 presents the complete list of adopted, modified and developed items while its original version, in the Nepali language, is presented in Annexe L.

Table 6.3. The complete set of the developed twenty-seven items for the 2-MEV tool with regards to the rural Nepalese society.

Number	Items
1	If someday I have free time, I would like to volunteer to help protect the environment.
2	I would like to participate in an afforestation campaign.
3	I would like to participate in a cleaning campaign.
4	I would like to volunteer with an organisation that is working to protect the environment in my community.
5	I try to tell others that nature is important.
6	After cutting one tree, I try to re-plant a new one.
7	I avoid dumping my waste into rivers.
8	I avoid burning my plastic waste.
9	I support conservation of forest for wildlife protection.
10	If necessary, land near my community should be separated to support endangered plants and animals.
11	To avoid water pollution, I do not use soap while bathing in the river.
12	I enjoy sitting under a tree to enjoy its shade.
13	I prefer the environment of village compared to that of a city.
14	Walking through the forest and/or in the mountains brings me joy.
15	I enjoy sitting beside a river.
16	I enjoy hearing the soft rustling of leaves when the wind blows through the trees.
17	I enjoy the natural sound of the flowing river.

18	People have the right to change the environment (nature). E.g., clearing forest, plotting land or draining stream.
19	People should be allowed to change the environment for their benefit without considering its effect on the environment.
20	To feed people, forests must be cleared for agriculture to grow food.
21	I like a well-cared for grass lawn more than a place where flowers grow on their own.
22	Building new roads is so important that trees should be cut down.
23	To protect vulnerable riverside communities from flooding, rivers should be diverted.
24	Since mosquitos live in wetlands, it would be better to drain these areas for farming.
25	Instead of safeguarding the domesticated animals, it would be better to clear forests and displace wild animals that could attack the domesticated animals.
26	People are supposed to rule over nature.
27	Since human beings are more intelligent, they have the greatest right to live.

6.1.2 First Survey and Component Analysis

The first survey aimed to analyse the efficiency of the developed items to explore the environmental attitude of the children and was conducted on 12.06.2016. The efficiency of the items was analysed by the capacity of the children to understand the item and the component loading of the items. The component loading of the items is the numerical representation of the pattern of relationships between the items (Gallagher & Brown, 2013). The capacity of the children to understand the item was analysed by adding "I did not understand the question" option in the survey as well as by asking them to underline the confusing word in the item. Likewise, the Principal Component Analysis (PCA) was used to obtain the component loading. The PCA was conducted to reduce a set of correlated items into a smaller set of independent composite variables, labelled as a component (Yong & Pearce, 2013).

Most of the 2-MEV research has used PCA to obtain the components (e.g., Bogner & Wiseman, 1997; 1999; 2002; Bogner, Brengelmann, & Wiseman, 2000; Manoli, Johnson, & Dunlap, 2007). Thus, this research also uses PCA. Moreover, the developed items are also related to each other. Each item shares some property with another item, and PCA method combines such items into a set of different components (Yong & Pearce, 2013). The PCA method analyses the pattern and correlation of each item against another based on the survey response (Russell, 2002). This survey was conducted using the worded Likert scale as proposed by Powell (2008), elaborated in the methodology chapter. Before conducting the survey, suggestions of the local teachers about the wording of the items and the items itself were also taken. This step yielded no change in the items.

Yong and Pearce (2013) suggest the rotation of the components for the better interpretation of the items. The main aim to iterate is to attempt to load an item on as few components as possible while maximising the number of high loadings in each variable (Rummel, 1970). There are two types of rotation method: orthogonal and oblique. The orthogonal rotation method is used for uncorrelated items while the oblique is for correlated items. Based on the features of the items used in this research, an oblique rotation method, namely Promax with Kappa 4, was used to interpret the component from the result of the first survey. The Promax method is known for its speed in the larger dataset and to obtain a simple structure by increasing the correlation between the items (Gorsuch & Hao, 1993).

Two hundred students of the research site participated in this survey, out of which 58.2% were female. The survey was conducted with the students from grade 8 to 10, with an average age of 14.76 (standard deviation: 1.36) and ranging from 12 to 19 years. All but one of the 200 students completed the survey. There is no clear rule of thumb whether how many respondents should participate in the survey for a PCA. However, suggestions are stating 3-20 respondents per item (Johnson & Manoli, 2008). Hence, with 199 respondents for 27 items, this survey had 7.37 respondents per item. During the analysis, the responses with the value “6” (I did not understand the question) were omitted and left blank to neglect its influence in the component loadings.

The suitability of the dataset to conduct PCA was verified by using the recommendations of Young and Pearce (2013). They recommend the determinant score of the items correlation matrix to be more than 0.00001 to ensure the absence of multicollinearity. In this survey, the determinant score was 0.001. Likewise, Bartlett’s Test of Sphericity had a significant level of 0.0 against the recommended value of less than 0.05. Similarly, Kaiser Meyer Olkin Measure (KMO) was 0.626 (recommended value is above 0.5). These observations determined that the survey result was adequate to conduct PCA with Promax rotation. Based on the obtained result, there are different ways to determine a suitable number of components.

However, the items which were adopted to use in this survey demonstrate two distinct components in their original 2-MEV research (e.g., Bogner & Wiseman, 1999; Milfont & Duckitt, 2004; 2010; Johnson & Manoli, 2008; 2011; Schneller et al., 2013). These two distinct components are Preservation and Utilisation. The items fall under either Preservation values or Utilisation values.

The items 1-17 and 18-27 used in this research represent Preservation and Utilisation values, respectively. Thus, a constrained two-component PCA was conducted from the result of this survey. The constrained PCA was done to see whether the items having the same traits as used in the previous research demonstrate a similar pattern or not. This PCA with two components explained 24.64% of the total variance. Table 6.4 presents the loading values of the two components. The PCA was conducted with a cut-off value of 0.32, meaning any item with loading below -/+0.32 was not displayed and disregarded for the second round of the survey. There is no rule to use a precise cut-off value, but most research use values between 0.3 and 0.4 (e.g., Johnson & Manoli, 2008; 2011).

Table 6.4. Two component's loading score of the first survey result.

Item Number	Component	
	Preservation	Utilisation
13	.664	
9	.650	
14	.633	
17	.595	
12	.550	
3	.530	
16	.517	
5	.515	
27	-.476	
1	.461	
2	.458	
15	.449	
22	-.430	
10	.427	
6	.378	
4	.323	
25		
21		
19		.668
11		-.621
20		.554
7		-.415
23		.397
8		-.378
24		-.346
18		
26		
Extraction Method: Principal Component Analysis. Rotation Method: Promax with Kaiser Normalisation.		

The PCA result demonstrated the pattern of two components identical to previous 2-MEV research, justifying the usage of the adopted and developed items. However, items 18, 21, 25 and 26 had loading value below the cut-off of 0.32 hence were disregarded from the set of items for the second survey. Two critical issues stood out from the PCA result. First, three items with preservative value (7, 8 and 11) load under Utilisation while two items with utilisation value (22 and 27) load under Preservation. Second, these items which load under opposite values had negative loadings. Thus, the second issue further justifies the usage of two components for the PCA. However, item 24, having a utilisation value had a negative loading under the Utilisation component. The negative loading demonstrates that it has exactly opposite characteristics compared to Utilisation, i.e. Preservation. Consequently, due to the context of item 24, it was against the social norm of the research site to protect mosquitoes as mosquito-related diseases are common threats in the area. Thus, instead of modifying item 24 to represent Preservative value, it was also disregarded from the set of items for the second survey.

Finally, based on the negative loading, five items were modified. Items 7, 8 and 11 were modified to represent utilisation value while items 22 and 27 were modified to represent preservative value for the second survey. For example, item 8, *I avoid burning my plastic waste* was modified to *Waste consisting of plastic materials should be burned*. The students responded with an average score of 2.24 (higher than 3 is preservative) resulting in a negative loading in the Utilisation component, thus suggesting modification of the item. Moreover, burning plastic and throwing waste into a river is also a common activity in rural Nepal as well as in the research site (Figure 6.1). Interestingly, farming by removing forest in item 20, being utilisation loaded under the utilisation component but item 22, need of road against the forest, loaded under preservation component. These facts indicate the agriculture-dominated society of rural Nepal.

Figure 6.1. Burning of plastic waste in the research site (Photo taken on 29.09.2016).

Furthermore, the feedback given by the students were also considered to modify the items. There were not many changes suggested by the students' other than a few words which were written in a different regional dialect. Likewise, items 19 and 24 had the highest "I did not understand the question" response rate of 23 each, while 17 students did not understand item 23. Similarly, 16 students did not understand item 10, 13 of them did not understand item 11 and, 12 and 11 of them did not understand item 16 and 4 respectively. For all the other remaining items "I did not understand the question" response was below 10.

The main difficulty for the students to understand were the complexity (items 4, 10 and 19) and unfamiliar terms/words (items 11, 16, 23 and 24) from the items. These issues were addressed by modifying the items 11 and 19. However, the modification in the items occurred due to the suggestions of the children can only be noticed in the Nepali version. While, items 4, 10, 16 and 23 were left as it was because of the lack of alternative words. Therefore, to remove any probable confusions, the intent of these items was thoroughly explained to the students before conducting the second round of the survey. Finally, a new set of items was obtained, as seen in Table 6.5. The modified version of the items in the Nepali language is listed in Annexe M.

Table 6.5. Final set of items for the second round of survey categorised according to two values, Preservation and Utilisation after two-component PCA and students' feedback.

	Preservation
Item	**Items**
1.	If someday I have free time, I would like to volunteer to help protect the environment.
2.	I would like to participate in an afforestation campaign.
3.	I would like to participate in a cleaning campaign.
4.	I would like to volunteer with an organisation that is working to protect the environment in my community.
5.	I try to tell others that nature is important.
6.	After cutting one tree, I try to re-plant a new one.
9.	I support conservation of forest for wildlife protection.
10.	If necessary, land near my community should be separated to support endangered plants and animals.
12.	I enjoy sitting under a tree to enjoy its shade.
13.	I prefer the environment of village compared to that of a city.
14.	Walking through the forest and/or in the mountains brings me joy.
15.	I enjoy sitting beside a river.
16.	I enjoy hearing the soft rustling of leaves when the wind blows through the trees.
17.	I enjoy the natural sound of the flowing river.
22.	Forests should not be cut down to build roads.
27.	Human beings should coexist with other creatures.
	Utilisation
Item	**Items**
7.	Waste should be thrown away in the river or streams.
8.	Waste consisting of plastic materials should be burned.
11.	Soap should be used while bathing in the river.
19.	People should be allowed to change the environment for their benefit without considering its effect on the environment.
20.	Forests must be cleared for agriculture.
23.	To protect vulnerable riverside communities from flooding, rivers should be diverted.

6.1.3 Second Survey and Confirmatory Factor Analysis

The participants of the second survey included partly the students from the first survey and partly the new students from different schools of the research site and was conducted on 15.11.2016. The 201 students from grade 8 to 10 took part in the second survey. The average age of the surveyed students was 15 (standard deviation: 1.4) and ranged from 12 to 20 years. All, 201 students completed the survey out of which 64% were female. The main aim of this second survey was to find a good-fitting model of the 2-MEV for rural Nepal. The second survey consisted of 22 modified items. Out of the total items, 6 represented the utilisation values while the remaining items represented preservative values.

The 2-MEV model is a bi-dimensional construct of attitude (Wiseman & Bogner, 2003). The PCA which confirmed two components as a higher-order structure, supported this fact. However, PCA does not provide the right fitting solutions. Thus, Confirmatory Factor Analysis (CFA) was used to investigate further the solution, which is based on the indices of goodness of fit (Milfont & Duckitt, 2004; Youg & Pearce, 2013). The CFA models the relationship between observed indicators and underlying latent variables (Gallagher & Brown, 2013). CFA evaluates how the set of items form a reliable model based on the observed data. However, CFA requires a theory or hypothesis which is tested by path coefficients between the factors (Hox & Bechger, 1998). Thus, every aspect of the models to be evaluated needs to be explicitly specified.

As elaborated in the previous chapters, the 2-MEV consists of five primary factors (attitudes), which are under the two higher order factors (values). The hypothetical items to be tested for two values was already obtained through PCA. Likewise, the items to be tested for primary factors was hypothesised based on the attitudinal characteristics of adopted items from their previous 2-MEV research and the context of the newly developed items. Based on this hypothetical stand, two sets of hypotheses to be tested were finalised and presented in Table 6.6 below.

Table 6.6. The developed hypothesis of the items to be tested using CFA under different attitudes and values.

Hypothesis 1	**Hypothesis 2**
Preservation	*Preservation*
• Attitude 1 Items to be tested: 1, 2, 3, 4 and 5.	• Attitude 1 Items to be tested: 1, 2, 3, 4 and 5.
• Attitude 2 Items to be tested: 6, 9, 10, 22 and 27.	• Attitude 2 Items to be tested: 6, 9, 10, 22 and 27.
• Attitude 3 Items to be tested: 12, 13, 14, 15, 16 and 17.	• Attitude 3 Items to be tested: 12, 13, 14, 15, 16 and 17.

Utilisation • Attitude 4 Items to be tested: 7, 8 and 11. • Attitude 5 Items to be tested: 19, 20 and 23.	*Utilisation* • Attitude 4 Items to be tested: 7, 8, 11 and 23. • Attitude 5 Items to be tested: 19 and 20.

The name of the values is already identified from the result of the first survey using PCA. However, the name of the attitudes is yet to be identified. Thus, in the hypothesis, the primary factors are named as attitude 1, 2, 3, 4 and 5. The attitudes will be named based on the theme of the items which fall under it. Hence, this can only be achieved after finding a good fit solution of the CFA.

The items 1, 2, 3, 4, and 5 were hypothesised to be under attitude 1 because the items 1, 4, and 5 were adopted from Schneller et al. (2013), Milfont and Duckitt (2004; 2010) and, Johnson and Manoli (2008; 2011) respectively where these items were placed under a common attitude namely: intent of support. Likewise, items 2 and 3, which were specifically developed for this research are also related to the intent to support the environment development activities.

Furthermore, items 6, 9, 10, 22, and 27 were hypothesised to be under attitude 2. These five items have a common theme related to the protection of nature. Moreover, the original version of item 9 adopted from Bogner and Wilhelm (1996) was placed under the attitude: consideration for conservation. Similarly, items 22 and 27, after modification, represent intent to protect nature while item 10 and the newly developed item 6 also share the same intent as other items hypothesised under attitude 2.

Lastly, the final attitude hypothesised to be under Preservation value is attitude 3 with items 12 to 17. Items 12 to 16 were adopted from previous 2-MEV research (see Table 6.1). In these research, these items were placed under a common attitude, namely enjoyment of nature. Likewise, item 17, which was developed for this research, also shares the common theme of enjoyment of nature. Thus, these items were placed under attitude 3.

Furthermore, in line with previous 2-MEV research, the six items under the utilisation value were hypothesised to distribute into two attitudes. In hypothesis scenario 1, attitude 4 was theorised to consist items 7, 8 and 11. These three items share a common intent of polluting the environment thus were placed under attitude 4. Similarly, items 19, 20 and 23 share a common intent of altering the nature thus were placed under attitude 5. Moreover, items 19 and 20 are placed under a common attitude: anti-anthropocentrism and altering nature, respectively, in previous 2-MEV research (Milfont & Duckitt, 2004; Johnson & Manoli, 2008; 2011). However, hypothesis scenario 2 theorises that items 7, 8, 11 and 23 were developed specifically for this research and needs to be placed under the same attitude, i.e. attitude 4. Thus, leaving only items 19 and 20 under attitude 5.

The CFA was carried out by using maximum likelihood estimation, which produced minimization history, standardized estimates, residual moments and modification indices with a threshold value of 4. During the analysis, the responses with the value “6” (I did not understand the question) were omitted and left blank to neglect its influence in the item’s correlation with its primary factor. The reliability of the CFA model 1 and 2 developed from hypothesis scenario 1 and 2, respectively were tested by using the goodness of fit indices as suggested by Johnson and Manoli (2011) and Kibbe et al. (2014). Table 6.7 presents the goodness of fit of model 1 and 2.

Table 6.7. Goodness of fit value of model 1 and 2 as compared with the recommended value.

The goodness of Fit Indices	**Recommended Value**	**Model 1**	**Model 2**
Chi-square(x^2)/df	< 2.0	2.36	1.697
GFI	> 0.90	0.845	0.876
AGFI	> 0.90	0.808	0.846
CFI	> 0.90	0.465	0.728
TLI	> 0.90	0.394	0.691
SRMR	< 0.08	0.144	0.0698
RMSEA	< 0.05	0.083	0.059

As observed in Table 6.7, both the hypothesised model failed to provide a fitting solution. Thus, to find a fitting model, various options of different groups of items were analysed in the next round, however, without shifting any item from its hypothesised attitude to another. As a result, two new models with fewer items were achieved. The two new models were named as model 3 and 4. Model 3 and 4 had item 2, 4, and 5 under attitude 1, item 10, 22 and 27 under attitude 2 and, item 13, 15 and 17 under attitude 3. Likewise, model 3 had item 7, 8 and 11 under attitude 4 and, item 19, 20 and 23 under attitude 5. However, model 4 had item 7, 8, 11 and 23 under attitude 4 and, item 19 and 20 under attitude 5. Table 6.8 presents the goodness of fit of model 3 and 4.

Table 6.8. Goodness of fit value of model 3 and 4 as compared with the recommended value.

The goodness of Fit Indices	**Recommended Value**	**Model 3**	**Model 4**
Chi-square(x^2)/df	< 2.0	1.14	1.12
GFI	> 0.90	0.942	0.943
AGFI	> 0.90	0.918	0.919
CFI	> 0.90	0.940	0.949
TLI	> 0.90	0.925	0.937
SRMR	< 0.08	0.053	0.052
RMSEA	< 0.05	0.027	0.025

As observed in Table 6.8, model 3 and 4 showed drastic improvement to provide a fitting solution compared to that of model 1 and 2. Comparatively, the difference between the goodness of fit values between model 3 and 4 was negligible. However, model 3 had three items per attitude, and each item under its attitude had a common theme, unlike the items under attitude 4 of model 4. Thus, model 3 was selected as the final model of 2-MEV for rural Nepal. Finally, based on the confirmed model, the attitudes were named according to the theme of the accepted items under them. Table 6.9 presents the list of accepted items along with their attitudes and values.

Table 6.9. The verified set of 2-MEV items for rural Nepal and their attitudes and values.

Preservation
Intent of Support
2. I would like to participate in an afforestation campaign.
4. I would like to volunteer with an organisation that is working to protect the environment in my community.
5. I try to tell others that nature is important.
Protection of Nature
10. If necessary, land near my community should be separated to support endangered plants and animals.
22. Forests should not be cut down to build roads.
27. Human beings should coexist with other creatures.
Enjoyment of Nature
13. I prefer the environment of village compared to that of a city.
15. I enjoy sitting beside a river.
17. I enjoy the natural sound of the flowing river.
Utilisation
Polluting Nature
7. Waste should be thrown away in the river or streams
8. Waste consisting of plastic materials should be burned.
11. Soap should be used while bathing in the river.
Altering Nature
19. People should be allowed to change the environment for their benefit without considering its effect on the environment.
20. Forests must be cleared for agriculture.
23. To protect vulnerable riverside communities from flooding, rivers should be diverted.

Items 4 and 5 were adopted from the attitude intent of support from previous 2-MEV research, while item 2 also represents intent to support environmental development activity. Thus, attitude 1 was named as the intent of support. Likewise, item 10 and 22 from attitude 2 demonstrate a willingness to protect nature, while item 27 represents human nature relationship for the protection of nature. Since all three items share a common theme of protection of nature, attitude 2 was named as protection of nature. Similarly, item 13 and 15 were adopted from the attitude enjoyment of nature from previous 2-MEV research, and item 17 also demonstrates enjoyment towards a natural setting. Thus, attitude 3 was named as the enjoyment of nature.

All three items under attitude 4, item 7, 8 and 11, were developed for this research. These three items share a common trait of polluting nature. Thus, attitude 4 was named as polluting nature.

Moreover, the intent of these items demonstrates polluting for the utilisation of natural resources, for example, bathing in the river with a soap. Similarly, items 19 and 20 were adopted from the attitude altering nature from previous 2-MEV research. Likewise, item 23 also focuses on altering the course of nature. Thus, attitude 5 was named as altering nature.

6.1.4 Construct of Environmental Attitude in Rural Nepal

Environmental attitude is established as a psychological index which is related to education and behaviour (Bogner & Wiseman, 1997; Kaiser et al., 1999; Johnson & Činčera, 2015). A bi-dimensional characteristic of environmental attitude was envisioned in the late 90s and early 2000s in a series of research with Western European children (11-16 years) population (e.g., Bogner & Wiseman, 1997; 1999; Wiseman & Bogner 2003). These research episodes led to the development of 2-MEV. The 2-MEV consists of two dimensions of environmental attitude and this structure have been verified in Western Europe, USA and New Zealand. However, the environmental attitude of Nepalese children has not received any attention yet. Thus, to address this gap, the 2-MEV was used in this research. Although a standard tool such as 2-MEV is desirable, modification to better reflect the local context is essential (Schneller et al., 2013). Therefore, a modified and verified 2-MEV tool for rural Nepal was developed in this research. In conclusion, the PCA and CFA validation process resulted in a two-dimensional model of 2-MEV for rural Nepal. The existence of both dimensions, Preservation and Utilisation in the 2-MEV is its most significant advantage. This allows a person to have both preservative and utilisation value at the same time (Wiseman & Bogner, 2003). Figure 6.2 presents this verified model of 2-MEV for rural Nepal.

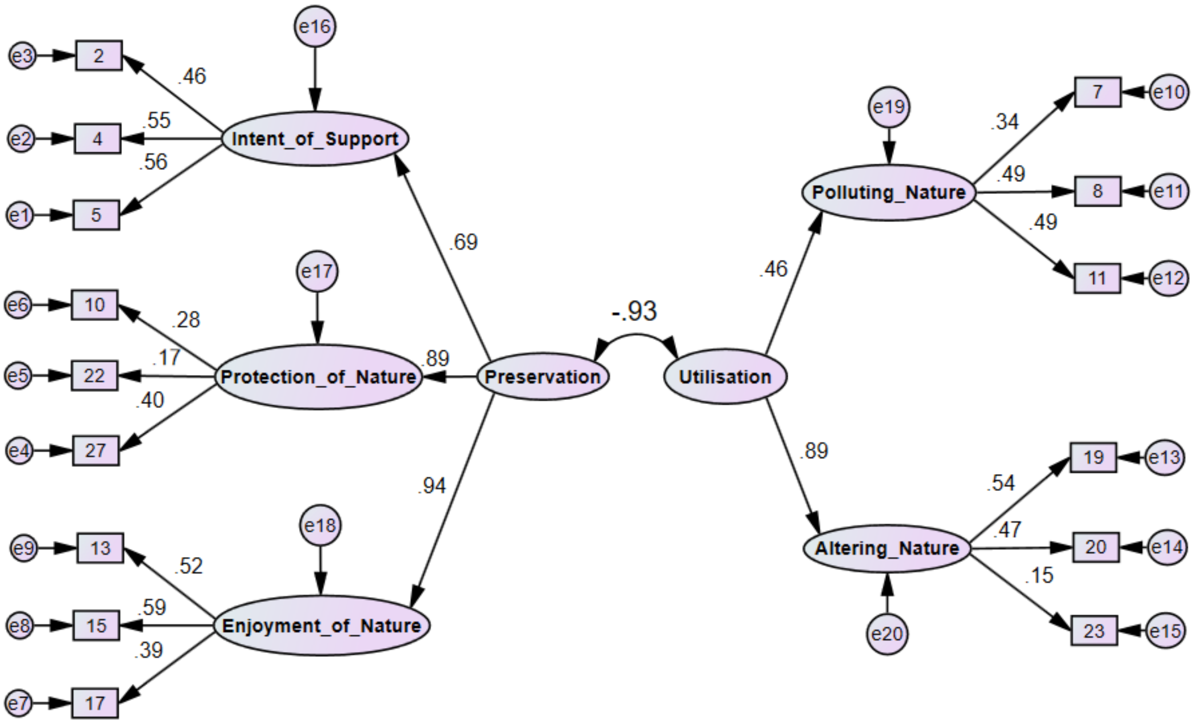

Figure 6.2. The verified model of 2-MEV, with two dimensions, for rural Nepal.

6.2 Environmental Value and Attitude of Rural Nepalese Children

The verification process of the 2-MEV tool resulted in five attitudes under two values. This result concludes the construct of the environmental attitude as two-dimensional in the case of rural Nepalese children, similar to that of the western European children (Bogner & Wiseman, 1999). The verified 2-MEV items were used to explore the environmental attitude of rural Nepalese children. A similar survey, like the surveys piloted during the verification process of the 2-MEV, was conducted in the research site. Fifteen items along with 5-scale worded Likert type responses were used in the survey. Moreover, the option of "I did not understand the question / Undecided" was also included to avoid creating any artificial intent of the students (Bogner & Wilhelm, 1996). Primarily, the 2-MEV is developed for children between 11-16 years old (Bogner & Wiseman, 1999). Since this research is based on a school environment, students from grade 8, 9, and 10 were considered for this survey.

There are five schools in the research site which conduct classes for grade 8, 9, and 10. In these five schools, there are 1,178 students in grade 8, 9, and 10 out of which 379 were surveyed for this research on 19-21.04.2017. According to the school structure of Nepal, students of grade 8, 9, and 10 are usually 12, 13, and 14 years old, respectively. However, the sample population had an average age of 14.37 (standard deviation: 1.32) and ranged from 12 to 18 years. Out of the five schools, students from four different schools were involved in the survey because during the survey period, students of one remaining school were on vacation thus were not included in the survey. Table 6.10 presents the detail of sample population from grade 8, 9, and 10 of the research site.

Table 6.10. A number of total and sample students from grade 8, 9, and 10 of the research site.

Grade	Total Population			Sample Population		
	Male	Female	Total	Male	Female	Total
8	154	176	330	56	65	121
9	189	247	436	58	65	123
10	184	228	412	50	85	135
Total	**527**	**651**	**1178**	**164**	**215**	**379**

Out of the total population of grade 8, 9, and 10, 55.2% are female students. Likewise, out of the sample population, 56.7% were female students. This signifies the representativeness of the surveyed sample population against the total student population. Moreover, following Arkin and Colton's (1963) sample size calculation the surveyed sample population represents 95% confidence level at the confidence interval of 4.15 against the total student population of grade 8, 9, and 10 of the research site. All 379 students completed the survey.

6.2.1 Analysis of the Environmental Values

The two-dimensions of environmental attitude is Preservative and Utilisation values. The 2-MEV, along with the attitude, also analyses the environmental values of the sample population, and Table 6.11 presents the descriptive statistics of two values. As per the Likert scale, mean above 3 in preservation means having preservative values. Similarly, the mean above 3 in utilisation means having utilisation values. It can be seen from Table 6.11 that the sample population holds preservative value with a mean above 3 in the preservation and mean below 3 in utilisation.

Table 6.11. Descriptive statistics of Preservation and Utilisation values.

Values	N Statistic	Minimum	Maximum	Mean		Standard Deviation
				Statistic	Std. Error	
Preservation	379	2.78	5.00	4.36	.02	.45
Utilisation	378	1.00	4.50	2.42	.04	.78

However, exploring individual student's mean statistics on preservative and utilisation values yielded a precise result. Out of the total 379 students, 298 are inclined towards preservative values, i.e., with mean above 3 in the preservation and mean below 3 in utilisation. Likewise, 1 is inclined towards utilisation value with higher mean in utilisation and lower (<3) in preservation. Similarly, 4 are neutral with the exact mean of 3 in both values. Lastly, 76 students are inclined towards both values with a statistical mean above 3 in both preservation and utilisation. However, out of these 76 students, 61 are further inclined towards preservation with mean value of preservation higher than that of utilisation. Likewise, 13 are inclined towards utilisation with higher mean value in utilisation compared to preservation. Lastly, 2 have an equal inclination towards preservation and utilisation, meaning exactly same mean value, above 3, in both preservation and utilisation. Table 6.12 presents the result of an individual's mean analysis in tabular form.

Table 6.12. Individual Preservation and Utilisation mean analysis of the sample students.

Environmental Values	Mean Values	Number of Students	Percentage of Students
Preservation	Above 3	298	78.63
Utilisation	Above 3	1	0.27
Preservation and Utilisation	Above 3	76	20.04
Neutral	Exactly 3	4	1.06
Total		**379**	**100**

Following Arkin and Colton's (1963) sample size calculation formula, this result proves with 95% confidence that 78.63% ± 4.15% of the total population have preservative values. Additionally, 78.63% of students have preservative values while 61 students (>80%) out of the

20.04% students who hold both the values are inclined towards preservation. The descriptive statistics of the two values reveal the positive environmental value of the sample population, which was also verified by the individual mean analysis of the sample population.

Furthermore, environmental values based on the grade and gender of the sample population is also explored. Bogner and Wilhelm (1996) found pupils of grade 5 and 6 more sensitives towards the environment compared to the pupils of grade 9. Likewise, more preservative value has been observed in girls compared to boys (Meinhold & Malkus, 2005; Johnson & Činčera, 2015). Table 6.13, 6.14, and 6.15 presents the descriptive statistics of the environmental values of the sample population based on their age, grade, and gender, respectively.

Table 6.13. The environmental values of the sample population based on their age.

Age	Preservation				Utilisation			
	N	Mean	Standard Error	Standard Deviation	N	Mean	Standard Error	Standard Deviation
12	34	4.30	0.08	0.48	34	2.62	0.11	0.68
13	57	4.39	0.06	0.45	56	2.39	0.1	0.78
14	112	4.31	0.04	0.48	112	2.52	0.07	0.78
15	113	4.43	0.04	0.44	112	2.33	0.07	0.78
16	39	4.38	0.07	0.43	39	2.27	0.12	0.78
17	17	4.20	0.1	0.43	17	2.5	0.18	0.76
18	6	4.30	0.19	0.47	6	2.36	0.27	0.66

From Table 6.13, it can be observed that there is no remarkable difference or tendency in the values based on the age of the children. However, as observed in Table 6.14, preservation value is higher, and the utilisation value is lower in grade 10, compared to 8.

Table 6.14. The environmental values of the sample population based on their grade.

Grade	Average Age	Preservation				Utilisation			
		N	Mean	Standard Error	Standard Deviation	N	Mean	Standard Error	Standard Deviation
8	13.5	121	4.19	0.04	0.49	121	2.76	0.07	0.76
9	14.3	123	4.45	0.04	0.41	123	2.35	0.07	0.74
10	15.2	135	4.44	0.04	0.42	134	2.20	0.06	0.71

Likewise, there is no significant difference in environmental values between genders. Nonetheless, when comparing each other's mean, female students have a slightly higher mean in the preservation and marginally lower mean in utilisation. Table 6.15 presents the environmental value mean calculation of the sample population based on their gender.

Table 6.15. The environmental values of the sample population based on their gender.

Gender	Average Age	Preservation				Utilisation			
		N	Mean	Standard Error	Standard Deviation	N	Mean	Standard Error	Standard Deviation
Male	14	164	4.36	0.04	0.46	164	2.59	0.06	0.8
Female	14	215	4.4	0.03	0.43	214	2.43	0.05	0.8

These findings show the increasing tendency of positive environmental values (increasing preservation and decreasing utilisation) with an increasing grade based on observation, however not by statistical calculation. Moreover, there is no observable tendency of increasing or decreasing mean value of environmental values in different age or gender. Although age is associated with grade, the standard deviation of age in grade 8, 9, and 10 is 1.22, 1.57, and 0.84, respectively, suggesting spread of different ages in each grade. Table 6.16 presents the spread of age in each grade of the sample population.

Table 6.16. Sample students' spread of age in each grade 8, 9, and 10.

Age / Grade	8	9	10	Total
12	30	3	1	34
13	32	24	1	57
14	37	50	25	112
15	17	32	65	114
16	2	10	27	39
17	2	3	12	17
18	1	1	4	6
Total	121	123	135	379

6.2.2 Analysis of the Environmental Attitudes

The analysis of environmental values of the rural Nepalese children yielded preservative trait. Values are considered as types of traits, while attitudes are considered as traits (Wiseman & Bogner, 2003). The verification of the 2-MEV for rural Nepal resulted in five attitudes with traits of the intent of support, protection of nature, enjoyment of nature, polluting nature, and altering nature.

The first three attitudes represent preservative value, while the last two represent utilisation value. This subchapter elaborates the analysis of the five environmental attitudes. The same survey response as elaborated in the previous subchapter is used in this analysis. Similarly, the mean above 3 in any attitude represent complying by the particular trait. Likewise, mean below 3 in any attitude signify contradicting the particular trait of the attitude. Table 6.17 presents descriptive statistics with a mean value of five attitudes.

Table 6.17. Descriptive statistics of five attitudes of the sample population.

Attitudes	N Statistic	Minimum	Maximum	Mean		Standard Deviation
				Statistic	Std. Error	
Intent of Support	379	2.33	5.00	4.74	0.02	0.45
Protection of	379	1.67	5.00	3.79	0.04	0.80
Enjoyment of	379	1.00	5.00	4.55	0.03	0.61
Polluting Nature	378	1.00	5.00	2.57	0.05	1.06
Altering Nature	378	1.00	5.00	2.29	0.05	0.9

The mean value of the first three attitudes: intent of support, protection of nature, and enjoyment of nature, are above 3. Likewise, the mean values of the last two attitudes, polluting nature and altering nature are below 3. In general, this represents that the students' have more intent to support, protect, and enjoy nature while less intent to pollute and alter nature. However, a higher standard deviation of polluting and altering the nature signifies non-uniformity of mean statistic on an individual scale. Table 6.18 outlines the state of the individual's response to the five different attitudes.

Table 6.18. Individual's mean statistics of each different attitude.

Attitude Number	Attitudes	Individual's Mean Statistic		
		Above 3	Below 3	Exactly 3
1	Intent of Support	374	2	3
2	Protection of Nature	300	45	34
3	Enjoyment of Nature	367	8	4
4	Polluting Nature	96	264	19
5	Altering Nature	92	252	35

As observed in Table 6.18, 96 and 92 students show inclination to pollute and alter nature, respectively, while only 2 and 8 students do not incline towards supporting and enjoying nature, respectively. Likewise, 45 students are not inclined to protect nature. This noticeable difference between attitude 2 against attitude 1 and 3 is due to the nature of commitment associated with questions under them, which are related to land use, forest, and community. In contrast, attitude 1 and 3 have questions related to customary actions and provides an option to be flexible while conducting the action.

Moreover, the questions from attitude 1 and 2 are specifically related to an individual and do not impact the livelihood directly. While questions under attitude 2 are related to necessary action, the community's belief and directly impacts the livelihood. The rural Nepalese community is directly associated with agriculture and forest for their livelihood (CBS, 2012). Likewise, the lack of proper waste management and need to utilise natural resources for the livelihood has led to a high number of students to favour polluting and altering nature. However, the higher number of students not supporting both polluting and altering nature represents the positive attitude of rural Nepalese students towards nature.

Out of the total 55 students whose mean score is below 3 in attitude 1, 2, and 3, none of them has mean below 3 in all three attitudes. Similarly, out of the 96 and 92 students who are inclined towards polluting and altering nature, respectively, only 35 of them have mean above 3 in both attitudes. However, out of these 35 students 21 have an average mean score above 3 on attitude 1, 2, and 3, and only 12 have an average mean score below 3 on attitude 1, 2, and 3, while 2 have precisely the same average mean score between attitude 1, 2, 3 and, 4 and 5. As a conclusion, students of rural Nepal have a positive attitude of supporting, protecting, enjoying, not polluting and not altering nature. Furthermore, attitude is also explored based on the age, grade, and gender of the sample students. Figure 6.3 presents the mean statistics of the students based on their age.

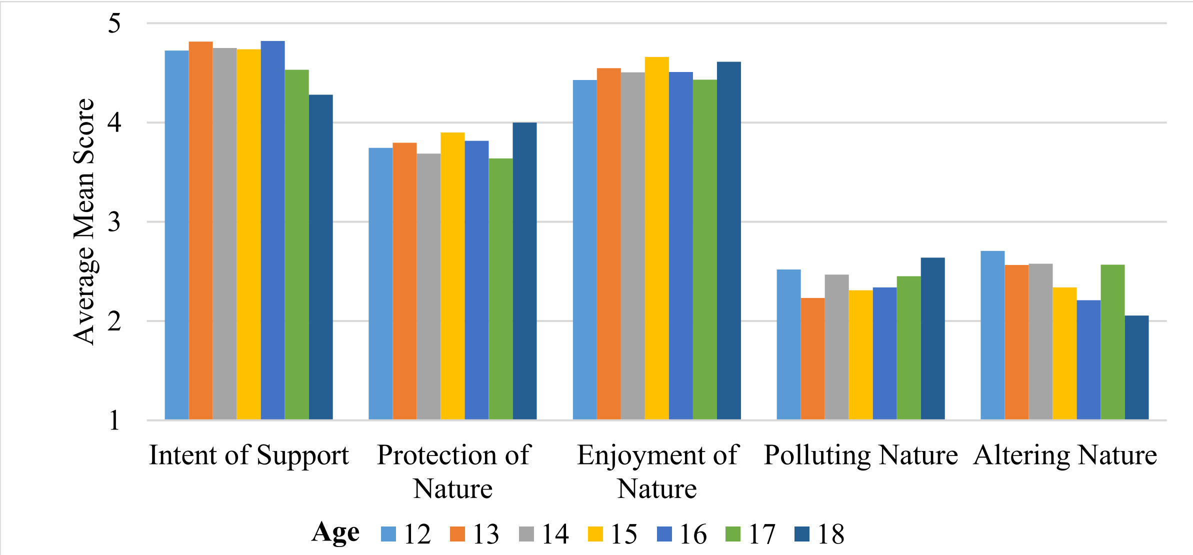

Figure 6.3. Mean statistics of five different attitude of the sample students based on their age.

From Figure 6.3, no significant difference or tendency between attitudes based on the age of the students was observed. Likewise, attitudinal preference based on gender is also slim, with a maximum difference of only less than 0.19 in mean statistic per attitude between female and male students. These findings are identical with the observation of environmental values based on the age and gender of the sample students. Table 6.19 presents the mean statistic of five different attitudes based on the gender of the sample students.

Table 6.19. Mean statistics of five different attitudes based on the gender of the sample students.

Attitude	Male			Female		
	N	Mean	Standard Deviation	N	Mean	Standard Deviation
Intent of Support	164	4.74	0.45	215	4.77	0.42
Protection of Nature	164	3.83	0.83	215	3.81	0.78

Enjoyment of Nature	164	4.50	0.63	215	4.60	0.55
Polluting Nature	164	2.47	0.88	214	2.33	0.84
Altering Nature	164	2.47	0.82	214	2.29	0.81

Likewise, Table 6.20 presents the mean statistic of five different attitudes based on the grade of the sample students. Similar to the findings in the previous subchapter, some noticeable tendency of mean statistic per attitude based on the grade of the students can be observed.

Table 6.20. Mean statistic of five different attitudes based on the grade of the sample students.

Attitude	**Grade 8**			**Grade 9**			**Grade 10**		
	N	**Mean**	**Std. Dev**	**N**	**Mean**	**Std. Dev**	**N**	**Mean**	**Std. Dev**
Intent of Support	121	4.65	0.51	123	4.84	0.33	135	4.74	0.47
Protection of Nature	121	3.50	0.79	123	3.88	0.82	135	3.95	0.72
Enjoyment of Nature	121	4.42	0.71	123	4.61	0.56	135	4.62	0.54
Polluting Nature	121	2.71	0.98	123	2.25	0.98	134	2.10	0.78
Altering Nature	121	2.81	0.96	123	2.44	0.87	134	2.06	0.69

The difference of the mean of the intent of support, protection of nature, and enjoyment of nature between grade 9 and 10 is not high, but it is increasing from grade 8 to 9. However, as the grade increases, the mean value of the protection of nature is also increasing. Similarly, with an increase in grade, the tendency to pollute and alter nature is decreasing. These differences of the attitudes' mean values between the grades indicate the efficiency of environmental education. The environmental education is a part of the course science and social studies at grade 8 and consists of more topics from grade 9 until 10 in the course health, population and environment (Central Department of Curriculum of Nepal, 2011). Therefore, to explore the content of environmental education in each grade from 8 until 10, the curriculum followed by the school going children of the research site is analysed. The contents followed by the students per grade could further elaborate on the change of values and attitudes with an increase of education achievement indicated via the grades.

6.3 Content of Environmental Education in Rural Nepal

The environmental education content followed in rural Nepal is analysed from the environment-related textbooks. These textbooks follow the curriculum set by the Curriculum Development Centre of Nepal (CDC) and are used in the schools of the research site. Since the students of grade 8, 9, and 10 have participated in this research, the environment related textbooks of these grades are analysed. For grades 8, 9, and 10, topics related to the environment are covered under *social studies* and *science* subjects while that for grade 9 and 10 are also covered under *Health, Population and Environment* (HPE) subject.

However, there is also an optional subject called environmental science, but this subject is not utilised in the research site due to lack of resources. For grade 8 textbook of my science and environment, and social studies and population education is analysed. Likewise, for grade 9 textbook of science and HPE are analysed. Finally, for grade 10 textbook of social studies is analysed. The analysis of the aforementioned textbooks was subject to availability during the data collection period hence leaving out science and HPE textbooks of grade 10. Late arrival and scarcity of textbooks in Nepal is a common problem faced every year, leading to conditional availability of school curriculum textbooks (Vaux, Smith, & Subba, 2006).

6.3.1 Analysis of Textbooks

A qualitative approach was used to analyse the contents of the textbooks. As a standard method, deductive content analysis method was used. In deductive, the predetermined or existing subjects are tested (Berg, 2001). This approach is suitable for this analysis because environment related sub-contents and contents in the textbooks are the already available codes and categories, respectively. Thus, the formulation of codes and categories, which are a vital part of the content analysis method, are adapted according to the source of data, as seen in table 6.21 (Erlingsson & Brysiewicz, 2017).

Table 6.21. Continuous steps of content analysis (Erlingsson & Brysiewicz, 2017) method and its adapted version used in this analysis.

S.N.	**Content Analysis Method**		**Adapted Content Analysis Method**	
	Analysis Step	**Method**	**Analysis Step**	**Method**
5	Theme	Based on categories.	Theme	Based on **S.N.** 1, 2 and 4.
4	Category	Derived from code.	Condensed Meaning	Condensed from the main statement.
3	Code	Derived from condensed meaning.	Main Statement	Text inside content or sub-content.
2	Condensed Meaning	Condensed from the main statement.	Code	Content or sub-content from the textbook.
1	Main Statement	Text data to analyse.	Category	Content from the textbook.

There are four significant steps in this analysis method, starting with condensation. In the condensation step, the available text is shortened while preserving its core meaning. Secondly, coding is done to describe the particular meaning of the condensed statement. Thirdly, the category is created by grouping related codes. Finally, the theme is structured based on two or more categories to express their underlying meaning. Themes are then used to interpret the data and are intended to communicate with the reader on both intellectual and emotional level (Erlingsson & Brysiewicz, 2017).

However, in the adapted version used in this analysis, the title of the content was used as a category. Likewise, sub-content was used as a code. In case, the sub-content was not available in the textbook; then the content was taken as a code and category were generated by following the original content analysis steps. Moreover, the condensed meaning was extracted from the main statement, which was under either content or sub-content in the textbook.

Main statements which are either one single statement from the text or are a mixture of many relevant statements which represent the content or sub-content were only considered in this process. Furthermore, based on the condensed meaning, the codes or categories were updated as per the necessity arising from the multiplicity of the statements, hinting usage of inductive content analysis method too. The inductive method tests the contents without any predetermined hypothesis, structure, or theory. Thus, this analysis process was not a continuum but a back-and-forth process to find the existing theme from the textbooks.

Moreover, textbooks *My Science and Environment* of grade 8 and *HPE* of grade 9 were available in English translated versions while the language of other textbooks was Nepali. Thus, the significant statements used from the Nepali medium textbooks were first translated to English without losing the essence and meaning from it. Finally, based on the condensed meaning, code, and category, the theme was interpreted, which was then compared with findings of different grades and subjects. Furthermore, the analysis of themes was based on their comparison but not on the quantification of words or contents. The category, code and condensed meaning are listed out in this analysis chapter while the main statements are presented in Annexe N.

6.3.1.1 My Science and Environment: Grade 8

This textbook is based on the basic education curriculum of grade 6 to 8 from the year 2012/13. This subject deals with physics, chemistry, biology, geology and environmental science. The topics from geology and environmental science are relevant to this research and are analysed here. Based on the adapted content analysis method, the analysed contents in the textbooks are categories. Thus, in this textbook, there are six categories under which the relevant sub-contents, which are the codes, are further explored to extract the condensed meaning and the themes.

Table 6.22. The condensed meaning, code, category and theme derived from my science and environment textbook of grade 8.

Condensed Meaning	Code	Category	Theme
• Soil is a mixture of different materials. • Organic substances in the soil are on the top layer. • Soil prepares plants and plants helps other living beings.	1. Soil and its Structure	1. Structure of the Earth	Structure of soil depends on the natural and human activities, while the
• Damage of soil due to river is soil erosion. • Damage soil in the river is deposited in another place. • High current of river and rain causes erosion.	2. Soil Erosion and Deposition		

• Deforestation is causing loss of soil in Nepal. • Reduced overgrazing and increased plantation protect the soil. • Constructions, which helps the protection of soil should be done.	3. Conservation of Soil		location of the Earth impacts the landscape, weather and climate.
• Moving away from equator increases coldness. • Temperature decreases with an increase in altitude. • Temperature is moderate near the sea.	4. Factors affecting Climate	2. Weather and Climate	
• A drastic change in altitude leads to different climates in Nepal. • Monsoon occurs in summer and leads to rainfall. • Heavy monsoon leads to flood and landslide.	5. Climate of Nepal		
• Earth has a suitable climate for living beings. • Earth is inclined at 66.5°. • Sunlight doesn't fall straight due to this inclination leading to different seasons.	6. Life on Earth	3. Earth and Space	
• Human survives from resources of nature. • Nature is conserved in Nepal. • Nepal has a different type of ecosystem and needs protection.	7. Environment and its Situation in Nepal	4. Environment and its Balance	Exploiting natural resources impacts human and environment, while sustainable development creates balance in the environment for its conservation from degradation.
• Excess smoke and dust pollute the air. • Polluted air harms health and heritage. • Wastewater and pesticides pollute water. • Polluted water harms health and nature. • Fertilisers and waste pollute the soil. • Polluted soil harms vegetation and underwater. • Uncontrolled sound cause noise pollution. • Noise pollution harms health.	8. Causes and effect of Pollution	5. Environmental Degradation and its Conservation	
• Trapping of sunlight in the atmosphere is the greenhouse effect and changes the climate. • Excess carbon and methane trap sunlight. • Climate change harms nature, agriculture and health.	9. Green House Effect and Acid Rain		
• Toxic gas reacts with water and air falls as acid rain. • Acid rain harms nature, agriculture and structures. • Reducing pollution reduces acid rain.	10. Acid Rain		
• Disasters are natural and human-made. • Flood, landslide, earthquake are common disasters in Nepal. • Overuse of resources and destroying nature causes disaster.	11. Disaster and its Causes		
• Stay in open space during an earthquake. • Stay away from a flooded river. • Protect area nearby river. • Keep a source of fire away from children. • Keep the environment clean. • Spread awareness and control pollution.	12. Disaster Management and Environmental Conservation		
• Living and non-living things interact with each other.	13. Biodiversity	6. Environment and	

• Species create species diversity; offspring create genetic diversity.		Sustainable Development	
• Develop while protecting nature. • Promotes the conservation and protection of humans. • Conserving natural, cultural, economic and social aspects.	14. Principles of Sustainable Development		
• Development should not harm the environment. • Appropriate use of resource and people's participation-based development.	15. Importance of Sustainable Development		

6.3.1.2 Social Studies and Population Education: Grade 8

This textbook is also based on the basic education curriculum of grade 6 to 8 from the year 2012/13. This subject mainly covers issues of society and population while one part is about the earth titled "Our Earth". This analysis focuses only on this part with its contents as codes. Since there are no sub-contents, the main sentences were presented under the code through which the category and themes were derived.

Table 6.23. The condensed meaning, code, category and theme derived from social studies and population education textbook of grade 8.

Condensed Meaning	Code	Category	Theme
• The inclination of the earth at 66.5° created seasons. • Temperature, air pressure and cloud determine the weather. • The annual average of weather is the climate.	1. Season Change and Weather	1. Weather Pattern	Weather, climate and disasters are mainly controlled by natural features of the earth while human actions also have an impact upon it.
• Distance from the equator. • The density of the air molecule. • Distance from the sea.	2. Factors affecting Temperature in Land		
• Burning fossil fuel increased the greenhouse effect. • Imbalance between living beings and the physical environment. • Decreases snow cover in the Himalayas.	3. Climate Change	2. Humanmade and Natural Disaster	
• Movement of underground rock plates causes an earthquake. • Travel of air from high to low-pressure area creates a storm. • Stay in a safe place during the earthquake and storm.	4. Earthquake and Storm		

6.3.1.3 Science: Grade 9

This textbook is based on the secondary education curriculum of grade 9 to 10 from the year 2014/15. This subject covers issues of physics, chemistry, biology and environment. However, the focus of this analysis is on the environment part. The contents from the environment part are considered as categories while the sub-contents as codes in this analysis.

Table 6.24. The condensed meaning, code, category and theme derived from the science textbook of grade 9.

Condensed Meaning	Code	Category	Theme
• The ecosystem is made from biotic and abiotic factors. • Abiotic factors are continuously available. • Producers produce food, consumers consume it and decomposers decompose all.	1. Factors influencing Plants and Animals	1. Nature and Environment	Nature maintains balance in the ecosystem as well as induces hazards.
• Plants and animals exist due to the terrestrial and aquatic ecosystem. • There are different kinds of producers and consumers. • Their interrelationship creates food chain and web.	2. The interrelationship between Plants and Animals		
• Products of the ecosystem, such as food. • Ecosystem regulates itself to provide service. • Balanced ecosystem promotes social and natural aspects.	3. Ecosystem Services		
• Natural accident and human-influenced accident create hazards. • Awareness helps to manage the natural hazard. • Maintenance helps to manage the humanmade hazard.	4. Natural and Humanmade Hazards	2. Hazards and its Management	
• Forecast and prepare for an emergency. • Use natural solutions and embankments. • Keep emergency service as a backup.	5. Preventive Measures to Manage Hazards		Knowledge, natural solution, and controlling pollution help to manage the environment and huhumanmade hazards.
• Melting of glacial and flooding in downstream is a glacial flood. • Storm in the sea due to differences in air pressure is a cyclone. • Global warming is increasing glacial flood and cyclone.	6. Glacial Flood and Cyclone		
• Carbon dioxide and methane trap sunlight in the atmosphere to create a greenhouse effect. • Simulating greenhouse in glass house helps food production. • Pollution creates a greenhouse and leads to climate change, damaging nature and society. • Awareness and conservation of natural resources manage climate change.	7. Green House Effect	3. Cause of Climate Change	

6.3.1.4 Health, Population and Environment Education: Grade 9

This textbook is based on the secondary level curriculum from the year 2014. This subject covers issues from three interrelated fields, health, population and environment. Some chapters cover these interrelated issues while some are related to the environment. This analysis covers the contents which are related to the environment either partially or entirely. However, the extracted main statements are related directly to the environment and its issues. Similar to previous textbooks, the contents are categories while the sub-contents are codes in this analysis.

Table 6.25. The condensed meaning, code, category and theme derived from health, population and environment education textbook of grade 9.

Condensed Meaning	Code	Category	Theme
• Things directly or indirectly connected to human is the environment. • Humans cause natural disasters, and environmental education helps to change human's behaviour. • It develops skills and attitude to protect the environment. • It develops knowledge and attitude to utilise resources. • It develops knowledge and skills to identify and solve environmental problems. • It ensures a healthy environment and population. • It is a multidimensional integrated subject.	1.Concept of Environment and its Education	1. Environment Education	Environment education helps to solve environmental problems by addressing knowledge, skills, attitude and behaviour while the balance of population, development and environment benefits both nature and human society.
• Human beings are part of the environment. • Human actions control population, development and conservation. • Balance of population, environment and development benefits to nature and society.	2.Interrelationship among population, environment and development	2. Population, Environment and Development	
• Utilise natural resources for economic development. • Everyone should have access to a clean environment and sanitation. • Human resources are needed to utilise, modernise and conserve natural resources.	3.Economic Improvement and Quality of Life		
• Urban area is increasing in Nepal. • It develops conscience and motivates people for conservation. • It creates pollution and imbalance between living and non-living things.	4.Effect of Urbanisation on Environment	3. Environment in Nepal	Increased urbanisation has challenged balanced utilisation and conservation of natural resources which can be achieved via legal, practical and people's participation method.
• Anything made without human contribution is natural resources. • Perpetual, renewable and non-renewable natural resources. • Natural resources are essential for human, nature and society.	5.Classification of Natural Resources and its Importance	4. Natural Resources and Biodiversity	
• Air is a composition of different gases. • 71% of the earth is water and more than 6000 rivers in Nepal. • Rocks, landscape and topography create different surface. • Nepal has snow, forest and 3 ecological regions. • Nepal has 4 different types of forest. • Nepal is a biodiverse country.	6.Types and Status of Natural Resource		

• Minerals and gas are found in Nepal.			
• Absolute conservation protects nature without change. • Relative conservation protects nature while utilising it. • Absolute conservation is theoretical but used in natural parks. • Relative conservation is practical and used in communities.	7.Conservation of Natural Resources		
• World conservation strategy explains legal aspects of conservation. • Any part of earth tampered affects all and is a common habitat. • Feature of earth covers all the natural means. • Knowledge and nature-friendly development lead to conservation. • Various legal instruments are also in use for conservation.	8.Earth and Caring for the Earth		
• Our existence depends on the status of the earth. • Utilisation shouldn't mean overexploitation. • Natural law should be taught to everyone. • Environmental education should be focused on. • The community should involve in environment protection.	9.Human Beings and the Earth		
• Quality in human health due to the quality of the environment. • Cleanliness of natural elements.	10. Concept of Environment Health	5. Environment Health	Pollution degrades the quality of the environment, which can be managed by controlling and reducing the source of pollution.
• The unhealthy environment is harmful and is known as pollution. • Pollution is caused by natural and humanmade reasons. • Cleanliness maintains environment health.	11. Environment Pollution and Management of Environment Health		
• Soil pollution impacts to soil, plant, animal and human health. • Water pollution impacts human and animal life. • Air pollution impacts health and, air and rain quality. • Sound pollution impact human health.	12. Environment Pollution and its Effect in Health		
• Greenery and waste management controls soil pollution. • Waste and wastewater management and afforestation controls water pollution. • Afforestation and filters in smoke exhaust control air pollution. • Awareness, afforestation, zoning and noise barrier controls sound pollution.	13. Controlling Measures of Environment Pollution		
• Degradable and non-degradable, and combustible and non-combustible waste. • Waste comes from houses, constructions and institutions.	14. Solid Waste and its Management		

• Burying, incinerating plastics and composting manages waste. • Reuse, recycle and reduce manages waste.			
• Drainage of wastewater is sewage. • Toilets should be built in houses. • Different types of toilet for different purposes.	15. Sewage and Toilet Management		

6.3.1.5 Social Studies: Grade 10

This textbook is based on the secondary education curriculum of grade 9 to 10 from the year 2014/15. This subject mainly covers issues of society and population while one part is about the earth titled "Our Earth". This analysis focuses only on this part with its contents as codes. Since there are no sub-contents, the main sentences are presented under the code through which the category and themes were derived.

Table 6.26. The condensed meaning, code, category and theme derived from social studies textbook of grade 10.

Condensed Meaning	Code	Category	Theme
• Distance from the equator. • Rise in elevation decreases temperature. • Nearby the sea is moderate weather. • Moisture level, wind current and soil colour determine weather.	1.Factors affecting Weather	1. Weather Pattern and Regions	Physical location and structure of the earth affect the weather, which leads to the development of different climatic regions, natural resources and cultures.
• 30° north and south latitude is tropical with 90% of the world's animal. • Warm climate with 200 cm of rainfall and consists of grasslands and deserts. • Optimal for agriculture and has largest rivers of the earth.	2.Tropical Region		
• 30° to 60° north and south latitude is temperate and is warm in summer and cold in winter. • Four different types of regions ranging from grassland to snowy and monsoon area. • Optimal weather for agriculture and factories and has the most human population.	3.Temperate Region		
• 60° to 90° north and south latitude is cold and is known as snow desert. • Siberian, tundra and Antarctica region are ranging from -2 to -45°C. • Few human settlements in the north with few farming and none in the south	4.Cold Region		
• Anything made without human contribution is natural resources. • Perpetual, renewable and non-renewable natural resources. • Natural resources are essential for human, nature and society.	5.Classification of Natural Resources and its Importance	2. Impact of Weather in Nature and Society	

• Evergreen forest found in tropical with big animals. • Deciduous forest with leaves shedding trees and medium-sized animals. • Coniferous forest with pointed leaves in cold region and thick fur animals.	6. Types of Vegetation and Animals in the World		
• People in the cold region rely on hunting and moving due to extreme weather. • The temperate region has optimal weather, and people are cultural and educated. • People in Amazon are still tribal due to the risk of survival. • Weather and earth's structure determine the lifestyle of people.	7. Role of Weather and Landscape in Lifestyle		
• Geological movement under the earth and sea surface lead to earthquake and tsunami. • It destroys the economy, heritage and spreads epidemic. • Precautionary measure and emergency materials prevent from earthquake and tsunami.	8. Earthquake and Tsunami	3. Natural Disaster	Natural disasters are ever occurring, and preventive measure help to tackle such disasters.

6.3.2 Comparing the Analysis of Textbooks

From the above analysis tables, it can be seen what the students are learning at school and their scope of environmental education. However, to understand the in-depth contents of their curriculum, this chapter elaborates the identified themes and in possible cases, compares it between grades. The first analysed textbook, *my science and environment* of grade 8, has two themes. Combining category 1, 2, and 3, the first theme from this textbook is "structure of soil depends on the natural and human activities, while the location of the Earth impacts the landscape, weather and climate." These three categories explain the types, formation and usage of soil, its erosion and deposition due to the river and how to conserve it in the context of Nepal. Likewise, the relation of latitude, altitude, atmospheric pressure, and distance from the sea on the weather is discussed with a focus on the Himalayas. Furthermore, the location of Nepal and factors such as altitude, monsoon wind, and floods and landslide during monsoon periods are discussed. Finally, the inclination of earth leading to seasons, weather and suitability of the earth for life is elaborated.

Furthermore, category 4, 5, and 6 led to the theme "exploiting natural resources impacts human and environment, while sustainable development creates balance in the environment for its conservation from degradation." Category 4 elaborates environment, ecology and conserved natural resources of Nepal. Likewise, category 5 discusses the causes and effect of environmental pollution in general, greenhouse effect and its impact in the Himalayas, extreme rainfall, crop production and biodiversity. Furthermore, it covers issues of disasters prone to

Nepal, its management and environmental conservation method for disaster management such as afforestation, alternative energy, etc. Finally, category 6 covers issues of types of ecosystem and interaction leading to biodiversity, sustainable development, its importance and principles for balanced development in the earth.

The third analysed textbook, *the science* of grade 9, also has two themes. Combing category 1 and parts of 2 the first theme of this textbook is “nature maintains balance in the ecosystem as well as induces hazards.” The first category elaborates on types of ecosystem, the interrelationship between actors and components of ecosystem and services provided from the ecosystem. Likewise, category 2 discusses issues of glacial lake outbursts and floods in the Himalayas and its downstream rivers, and other general natural disasters, its management and preventive measures such as raising awareness. Furthermore, remaining part of category 2 discusses general causes of humanmade disasters, its prevention and management while category 3 elaborates on causes, effect, prevention and management of greenhouse effect leading to the second theme “knowledge, natural solution and controlling pollution helps to manage the environment and humanmade hazards.”

As observed between the science textbooks of grade 8 and 9, grade 8 has covered more aspects compared to that of 9. Issues such as season, weather, the structure of the earth, ecosystem, sustainable development, pollution and disasters are covered in the science and my environment textbook of grade 8. In contrast, science textbook of grade 9 has only covered issues of ecosystem and, natural and humanmade disasters. However, issues of the ecosystem have more details in grade 9, while issues of disasters are also more focused and contains regional issues in grade 9. Furthermore, more issues related to environmental health and education are covered in *health, population and environment education* textbook of grade 9. This textbook has three themes combining category 1 and 2, 3 and 4, and 5.

The first theme is derived from category 1 and 2 as “environment education helps to solve environmental problems by addressing knowledge, skills, attitude and behaviour while the balance of population, development and environment benefits both nature and human society.” It covers issues of environmental education and how it develops skills, attitude, behaviour and knowledge to conserve and utilise natural resources, and to tackle environmental problems in order to solve it. Likewise, category 2 elaborates on the proper utilisation of natural resources for balanced development in the society and role of population in environment conservation while progressing with development. In general, it elaborates on the interrelationship between population, environment and development.

Likewise, category 3 elaborates about the positive and negative effect of urbanisation on the environment, such as the development of conscience or pollution. Furthermore, category 4 covers types and status of natural resources in general and in Nepal, its conservation using various philosophies, laws, public participation, education, and moral awareness. This led to the development of the second theme from this textbook as “increased urbanisation has challenged balanced utilisation and conservation of natural resources which can be achieved via legal, practical and people’s participation method.” Finally, the third theme “pollution degrades the quality of the environment, which can be managed by controlling and reducing the source of pollution” was derived from category 5. Category 5 elaborates in general what is environmental health and how to achieve it, pollution and its effect on health, and measures to control pollution such as incineration of plastic wastes, recycling etc. Due to the addition of HPE course in grade 9, there is a significant improvement in the environment related aspects covered by the curriculum.

The uncovered aspects in two textbooks of grade 9 compared to *my science and environment* of grade 8 such as season, weather and structure of the earth are believed to be covered in social studies course of grade 9, which is not analysed in this study, as seen from the contents of grade 8 and 10 which is elaborated below. Furthermore, the covered aspects in the above-analysed textbooks are directly or indirectly related to the local context; however, one point which stood out was the management of plastic solid waste using incineration method. There is an existing paradox in determining whether plastic is a degradable waste or not. In one statement from HPE textbook of grade 9 under degradable waste, it is mentioned that plastic should be incinerated while under nondegradable waste, it is mentioned that nondegradable wastes should be reduced, recycled and reused. This left it unclear whether plastic is considered as degradable or nondegradable waste. Interestingly, this question was on the surveyed 2-MEV tool, and 48.25% of the students from the total surveyed students answered this is the correct way to deal with the plastic waste.

Social studies and population education, from grade 8 was the second analysed textbook in this study and had one theme combining both categories 1 and 2. Category 1 discusses issues of inclination of the earth, temperature, air pressure, altitude, latitude, and distance from the sea as the factors affecting the season, weather and temperature. Likewise, category 2 elaborates on increased pollution from human activities leading to climate change, its impact in the Himalayas and natural disasters such as earthquake and storm, and how to stay safe during these disasters. These issues led to the theme “weather, climate and disasters are mainly controlled by natural features of the earth while human actions also have an impact upon it.”

Likewise, *social studies* of grade 10 have two themes. The first theme “physical location and structure of the earth affects the weather, which leads to the development of different climatic regions, natural resources and cultures” was derived from category 1 and 2. Category 1 discusses the impact of latitude, elevation, distance from the sea, moisture level, wind current, and colour of the soil to determine the weather of an area. Likewise, it also elaborates about the different weather conditions, land types, and livelihood of tropical, temperate, and cold region based on the latitude of the earth. Moreover, category 2 discusses the role of these different regions and landscape on the vegetation, wildlife, lifestyle, and culture of an area. Finally, category 3 covers issues of natural disasters namely, earthquake and tsunami, its causes and preventive measures which led to the final theme "natural disasters are ever occurring and preventive measure help to tackle such disasters."

In general, concepts of weather, environment and ecology, contemporary environmental problems such as floods, landslides, earthquake, tsunami, glacial lake outburst, storm, climate change, greenhouse effect, pollution, etc., its causes and effects, problems arising from it, its management and preventive measures, and role of environmental education to tackle these problems are covered in the environment related curriculum of grade 8, 9, and 10 in the schools of the research site. Likewise, issues related to Nepal and the Himalayas are also highlighted within these contents which are related to the environmental issues, problems and its solutions of the research site. Moreover, practical works, learning exercises, assignments, and messages to the teachers on how to address these environmental issues are also included in the textbook within the analysed contents. Whether these extra activities are conducted or not is a different question, but the curriculum's content is well linked to the research site, and enables the children to profit from that content to understand their local environmental circumstances.

6.4 Key Findings

The significant findings from this chapter are listed below. The key findings include the development and verification of the 2-MEV tool. Likewise, the survey result of the 2-MEV tool is also presented below. Finally, the content of environmental education, followed by the surveyed students, are also listed out below.

- The 2-MEV tool, when modified according to the economic, social and environmental situation of the society, can be used as a standard in a non-industrialised society too.
- The bi-dimensional construct of environmental attitude exists in rural Nepal too.
- The high negative correlation between two environmental values, utilisation and preservation, proves that a child has either utilisation value or a preservative value.
- More than 78% of students have preservative values while 61 students (>80%) out of the 20% students who hold both the values are inclined towards preservation.
- 0.26% of students have utilisation value, while 1.04% are neutral between utilisation and preservation.
- The preservative value increases from grade 8 to 9, while utilisation value decreases with the increase of the grade, but this tendency is not observed in age and gender.
- 98.7%, 79.7%, 96.8% of students have the intent of support, protection of nature and enjoyment of nature attitude respectively, which are under the preservation values.
- 69.7% and 66.7% of students are against polluting and altering nature, respectively, which are under the utilisation values.

- Out of the 25.3% and 24.3% students who agree to pollute and alter nature respectively, only 18.6% students agree on both attitudes while out of them 60% also agree towards the three attitudes under preservation value.
- The intent of support and enjoyment of nature increases from grade 8 to 9 but not from 9 to 10 however, the intend of protection of nature increases from grade 8 until 10, while the intend of polluting nature and altering nature decreases from grade 8 until 10.
- Similar to environmental values, no such tendency exists between environmental attitudes and, age or gender.
- In general, most students have more preservative values compared to utilisation. Likewise, more students have the intend of intent to support, protect nature and enjoy nature compared to pollute and alter nature.
- The environment-related textbooks cover concepts of weather, environment and ecology and, contemporary environmental problems, and offers children the learning opportunities about its causes and effects, problems arising from it, its management and preventive measures.
- The aspects related to environmental education, as mentioned in previous key finding, increase in detail and complexity with the grade, from 8 to 10.
- Environmental issues, including problems and solutions, related to Nepal and the Himalayas, e.g. floods, glacial lake outburst, landslide, and earthquake are also highlighted within these aspects which are related to the research site.
- The curriculum's content is well linked to the research site, and the children have the opportunity to profit from that content to understand their local environmental circumstances.
- The data of this research (grade 8-10) supports the hypothesis that the content of the textbooks enables a more detail structure of positive attitude towards the environment by having a slightly stronger – however not tested statistically – mean value in the answers to the 2-MEV questionnaire.

7 Discussion

The cloudiness in Asar (Nepalese month between mid-June and mid-July) and continuous rain shower in Shrawan (Nepalese month between mid-July and mid-August) is part of life in Nepal. The scientific community agrees by mentioning that Nepal can experience both stratiform and convective precipitation of varying sizes (Romatschke, Medina, & Houze Jr, 2010; Romatschke & Houze Jr, 2011). The rain showers soak and irrigate water sources in the hills. Likewise, good monsoon and good crop production are directly related issues in the Indian sub-continent (Webster et al., 1998). However, the events of extreme precipitation negatively impact the young hilly region and the socio-economic situation of the Nepal Himalayas. Likewise, locals from the research site still talk about how they used to renovate house/animal shed, store firewood, dig canals in the farmland, store food produce from the farm, and buy food products for storage to smoothly run the livelihood during the rainy season. However, these techniques are not enough to tackle extreme conditions; thus, education is considered as the tool to adapt to the environmental crisis in Nepal.

7.1 Status of Extreme Precipitation in Nepal

The precipitation, as well as extreme precipitation events, vary heterogeneously in Nepal. The findings of this research indicate different categories of total rainfall days and amount in Nepal based on their quantity. The southern belt, western part, and mid-north part of the country have lower precipitation days, while the mid-central to the mid-eastern and north-eastern part of the country has higher precipitation days during an entire year and High Precipitation Months (HPM).

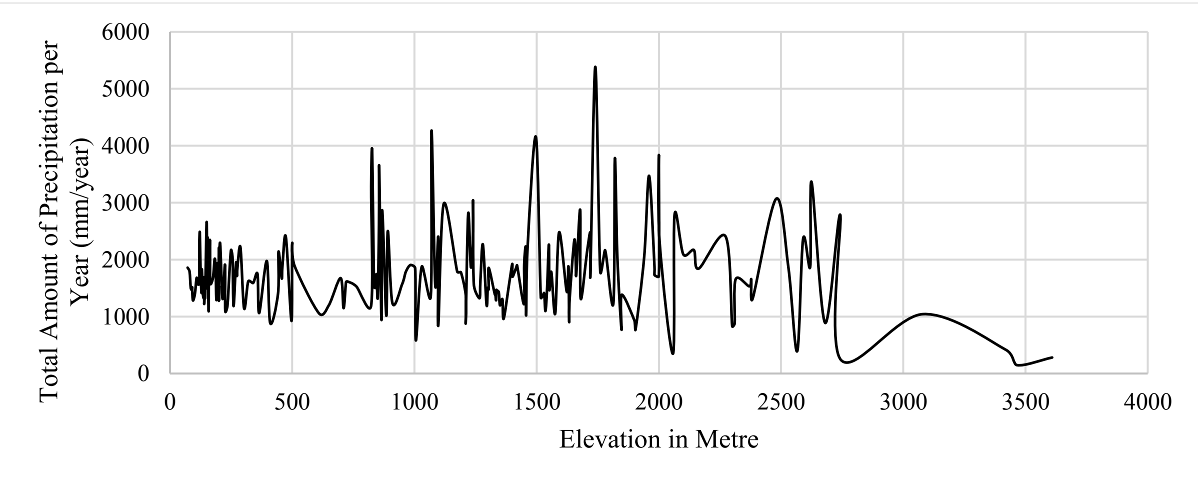

Figure 7.1. The total amount of precipitation per year and its comparison with the elevation.

Likewise, the total precipitation amount also has similar traits. The finding of total precipitation pattern supports the conclusion of Anders et al. (2006) who point out on the existence of a double band of high precipitation zones, one at the first rise of topography and second on the second rise. The total precipitation amount first increases around 1,000 m, and the second increment occurs around 1,500-1,800 m, predominantly in central to eastern Nepal, and can be seen in Figure 7.1 above in alignment with Figure 5.4 from chapter 5.2.1.

The Siwalik range escalates between 200-1,500 m while the Lesser Himalayas which is also known as the Mahabharat range protrudes between 500-3,000 m, suggesting two different rises near the two different intensifying point of precipitation. Likewise, Bookhagen (2010) mentions one peak of precipitation in the one-step rise of the topography, and two peaks of precipitation in two-step rise of the topography in the Himalayas. However, Nandargi and Dhar (2011) point out maximum rainfall occurs in the foothills of the Himalayas while the second maximum at near 2400m. In Nepal, these findings of Nandargi and Dhar are in contrast with the result of this research which points out that the first maximum precipitation occurs not in the foothills but at the high hills at the upper middle part of the country. This finding further emphasises the role of orography induced barrier and convection resulting in precipitation in the hills.

Furthermore, the nearby stations, which are less than 10 km apart, also show high variability in the amount of precipitation with changes of more than 1,000 mm. This finding proves the high spatiotemporal variation of precipitation in Nepal, which is also mentioned by Shrestha (2000), and Lang and Barros (2002). The spatiotemporal variation of precipitation is linked with the ubiquitous ridges of the Himalayan region, which is further supported by these findings. Likewise, the decrease of precipitation amount in the mid- and north-western part of Nepal during an entire year and HPM period is also in line with previous research (Barros, 2004). Moreover, an increase of precipitation and precipitation days observed in the central, western, and north-western part of the country during the Low Precipitation Months (LPM) period is also in-line with previous research (Wulf et al., 2010; Panthi et al., 2015). Furthermore, findings of this research reveal winter precipitation events occur mainly in the hills of western and central Nepal but not on the plains. The winter precipitation is known to bring rain and snow in the high Himalayas and their leeward side. This indicates arrival of the westerly wind from the western mid-northern to northern part of Nepal which is then blocked by the orography to travel southwards thus leaving the plains dry compared to the hills.

Moreover, Panthi et al. (2015)'s findings of high precipitation days in the plains and lesser Himalayas in central Nepal is not accurate in the case of entire Nepal. In Nepal, the precipitation days increase with the increase of elevation until ~2,700 m and are significantly low in the plains (<300m) with ~30 fewer precipitation days per year. However, the stations in plains of Nepal receive comparatively more precipitation than the precipitation days. Thus, there is a high risk of intense precipitation in the plains of Nepal. The monsoonal depression enters from the eastern plains of Nepal and moves to the hills which then extends till the southern slopes of the Himalayas. This arriving onset usually provides initial downpour in the plains in short period which again meets the plains when the monsoonal cloud is extended from the Himalayas to the plains.

The high precipitation amount and days during a year in the central and eastern hills (>300m) of Nepal show the relationship between summer precipitation and monsoonal onset from the Bay of Bengal. The term “hills” is explicitly used because the data used in this research represents fewer high mountains (>3,000m). Likewise, high precipitation amount and days during the winter period in central, western, and north-western part of Nepal show the influence of the Westerly wind arriving from the west of Nepal. However, the two-step rise observed in precipitation amount is not vivid in precipitation days suggesting the role of increasing elevation in increasing precipitation days and the role of topography in precipitation amount. Moreover, these high events of precipitation and precipitation days occurring mainly in the hills compared to the plains suggest an active and dominant role of the topography to shape the pattern of precipitation which has been mentioned in previous research too but not actively explored (Barros & Lang, 2003; Barros, 2004).

The pattern recognises identical or iterated characters based on the status while trend identifies the tendency of those characters over a period based on the last few statuses (Toronto District School Board, 2013). This research focuses on the identification of characters more than their tendencies. The pattern and trend are equally crucial in climate analysis; however, knowing the pattern then the trend helps to understand any region holistically. As an example, knowing that the extreme precipitation events are increasing in the western part of Nepal provides one information, while knowing that 27 mm is the threshold of extreme precipitation in western Nepal which is in an increasing trend since last few years provides holistic information. Furthermore, with holistic information, local stakeholders and policymakers can better prepare for any fore coming environmental crisis based on current information. Since, most of the extreme precipitation research in Nepal and the Himalayan region is focused on the trend (Chalise & Khanal, 2002; Baidya et al., 2008; Nandargi & Dhar, 2011; Shrestha et al., 2017; Karki et al., 2017; Bohlinger & Sorteberg, 2018), the majority of this research focuses on the status and pattern of extreme events in Nepal.

The status of extreme precipitation has received less attention. Nandarghi and Dhar (2011) state that most extreme rainfall occurs between the Siwalik (900-1,200 m) and the Great Himalayan range (5,000-8,848 m). Likewise, Bookhagen (2010) finds twofold extreme precipitation events in the high Himalayas than the plains and further reports more extreme events in the arid interiors of the Himalayas than the wet orogeny. The findings of this research show, although the days of extreme precipitation is higher in the hills (>300 m) of Nepal by about ~3 days per year compared to the plains, the threshold of extreme precipitation as well as extreme precipitation amount are higher in the plains than the hills by ~15 mm per timeseries and ~50 mm per year, respectively. However, the occurrence of high extreme precipitation frequency in the north-east belt and corner of Nepal partially supports Bookhagen's findings of extreme precipitation events in the high Himalayas.

In detail, the extreme precipitation amount in the central and eastern hills of Nepal are almost similar with a difference of -10 mm than the plains, while the extreme precipitation days in the hills are also ~3 days more than in the plains. Furthermore, the threshold value of extreme precipitation decreases with the increase of elevation. These findings imply that lower threshold of precipitation has a higher negative impact on the hills than the plains, but the central and eastern hills receive the almost same quantity of extreme precipitation in almost equal days as the plains. The hills are prone to landslide and flooding due to gradient and narrow rivers, respectively. Thus, the physical, as well as the socio-economic situation in the higher elevation areas of Nepal, stands delicately during extreme events.

The plains receive less extreme precipitation days but more extreme precipitation amount with a high threshold and ~88 mm of extreme precipitation amount per extreme precipitation days suggesting abrupt flooding in the region. Thus, the hills face more prolonged impact while the plains face the intense but shorter impact of extreme events. Both of these scenarios are responsible for disasters in Nepal. Table 7.1 below presents the change of precipitation events in different regions of Nepal. Moreover, the number of three or more continuous days of extreme events (Rx3days) in different regions of Nepal suggests the vulnerability of the hills. Likewise, the status of continuous extreme precipitation in the central and eastern hills of the country further elucidates vulnerability of the hills as continuous extreme precipitation also triggers floods and landslide in the hills as well as in the eastern plains of the country where the Koshi River basin is located. Furthermore, extreme precipitation days increases with elevation in Nepal, but total extreme precipitation amount concurs with a double band zoning of the precipitation pattern similar to the total precipitation amount. The high frequency of total and extreme precipitation days being higher in the hills further suggests the role of orography in the elevated regions with microclimatic features leading to occurrence of more, but short-lived, events than the plains.

Table 7.1. The average value of the stations based on the regions of Nepal per year.

Regions of Nepal	**PRCPTOT mm/year**	**R0.1 days/year**	**R90 mm/timeseries**	**R90d days/year**	**R90p mm/year**	**R90p per R90d**	**Rx3days events/time series**
Plains	1713	79	53	8	718	88	8
ME & NE	1877	118	38	12	708	58	12
Mid-West	1673	103	38	10	627	59	9
Hills	1777	111	38	11	668	58	11
The plains are below 300 m, while hills are above 300 m. Mid-East is above 300 m and above 84° longitude, while Mid-West is above 300 m and below 84° longitude. ME – Mid-eastern; NE – North-eastern.							

Bookhagen (2010) reports extreme precipitation days to be relatively constant (between 10 to 15 days) in the mountainous terrain of Nepal. This research finds that 62% and 65% of stations out of the total stations above 500 m and 1,000 m, respectively have extreme precipitation days between 10 and 15. However, in general, the plains receive more extreme precipitation than the hills of Nepal, which contrasts with the findings of Bookhagen (2010), and Nandargi and Dhar (2011). Although these scenarios highlight the status of extreme precipitation in Nepal, the pattern of the status of extreme precipitation days and extreme precipitation amount are similar to that of total precipitation days and total precipitation amount, respectively during a year and HPM duration. The total precipitation and extreme precipitation both show double band zone of peaks, while total precipitation days and extreme precipitation days increase with the elevation until ~2,700 m. The double band of total and extreme precipitation intensity with two-band rise of topography is also related with the orographic barrier creating convection along with storage of humid water vapour.

The pattern of extreme precipitation amount and days decrease towards the west during an entire year and HPM period. In contrast, the same events increase with elevation during the LPM, including the Rx3days but, excluding the concentration of extreme precipitation threshold, which is higher in the western plains. The extreme precipitation days during the LPM period ranges from less than 0 to ~5 days per LPM period of the consecutive years while that of extreme precipitation threshold is ~9 to ~38 mm, and that of extreme precipitation amount is ~15 to ~226 mm per LPM period of the consecutive years. Interestingly, the high extreme events during the LPM also occur in the mid-central part, north-east belt, and the north-eastern corner of the country. Specifically, the north-east belt and corner are in the high Himalayas, suggesting the high impact of extreme events in these parts, which make them vulnerable to erosion, not only during the monsoon dominated HPM but also during the LPM period. Except for these parts, most extreme events during the LPM are concentrated on the central and western hills of Nepal indicating dependency with the westerlies. Although in small number, the Rx3days during the LPM also show high events in the hills. These observations signify the high impact of westerly in the hills compared to the plains.

The status of extreme precipitation events is analysed based on the data of stations and elevation. The former provides information from each point while the latter highlights what or how much activity occurs in specific and different elevation levels. Thus, combining the findings of these two the empirical status of extreme precipitation in Nepal is obtained which is partly in line with previous research, partly in contrast, while new findings also elucidate the status and pattern of extreme precipitation events in Nepal. The findings of this research firmly accept the first research hypothesis that the status of rainfall intensity and duration depends upon the distance from the onset of monsoonal depression and the westerly depression. Regarding the relationship of intensity and duration with the orography, the frequency of both total and extreme precipitation events increases with the elevation. In contrast, the total and extreme precipitation's intensity show intensifying maximums with rising peaks of the orography. Thus, these findings point out how the intensity and duration are related to the orography and distance from the onset of depressions.

7.2 Extreme River Runoff and its Relationship with Extreme Precipitation Events

The research related to the status of extreme river runoff in Nepal has received less attention. Thus, this research, staying in-line with the environmental attitude research site, focuses on the status of extreme river runoff in rivers of the Koshi River Basin (KRB). As per the scope of the research, the need to compare the status of extreme river runoff with extreme precipitation status of the related stations, the parameters used are adapted from the extreme precipitation status analysis. The extreme precipitation threshold of the rivers in KRB range from ~55 to ~3,900 m^3/s. These threshold values increase with increasing river catchment area. Thus, the rivers in the hills (comparatively smaller rivers) of the KRB are prone to extreme events, even with a lower value of runoff. In general, the KRB rivers can be categorised according to the level of the threat posed by any river based on its threshold of extreme river flow.

In contrast, the difference between the range of days with extreme river flow in the rivers of the KRB is ~13 days/year. However, the extreme river runoff amount varies significantly in the KRB and increases with the increase of the catchment area. These findings are in line with the findings of Milliman (2001), and Gaume and Payrastre (2018) who indicate towards the dependent relationship between the catchment area of the river and the river water runoff. These observations prove that even with low extreme river runoff, the probable days of flooding are almost similar to that of high extreme river runoff. Although the intensity varies in the KRB rivers, a similar frequency shows almost similar danger level posed by the rivers' activity in the region. In general, the intensity of the extreme activity is dependent on the size of the river, while that of frequency is not dependent on the size but are almost similar throughout the KRB region. These findings can be attributed to the range of extreme precipitation days and amount in the KRB region, which is ~10 days/year and ~1,100 mm/year, respectively. The smaller range of extreme precipitation days could be one responsible factor for the small range of extreme river runoff days in the KRB region.

The findings of another frequency-based parameter, three or more continuous days of extreme river runoff, in the KRB rivers also indicate the same with no observable relationship with the size of the river. Thus, these findings partially agree with the second research hypothesis. The second research hypothesis states that the status of extreme river runoff intensity and duration in the KRB depends on the size of the catchment area. It can be argued that the larger the size of the catchment area, the larger the area to collect water for the river, thus, impacting the river runoff. However, the findings of this research show that the frequency of river runoff is not related to the size of the catchment area of the KRB rivers. Furthermore, this argument is not explored in this research; thus, it needs further analysis.

Chalise and Khanal (2002), and Baidya et al. (2008) report an increasing trend of extreme precipitation in Nepal. Similarly, Shrestha et al. (2017) report an increase of extreme precipitation over the KRB but without any significance. However, Karki et al. (2017) report increase of extreme precipitation in the southern plains, mid-western mountains, and high mountains of central Nepal, while dry days are increasing over the central and eastern middle mountains of Nepal. Likewise, Bohlinger and Sorteberg (2018) find increasing extreme precipitation events in western Nepal, but no trend in all-over Nepal. However, there are no studies reporting a trend of extreme river runoff in Nepal. In alignment with previous research out of the 17 precipitation stations less than two stations show an increment of extreme precipitation trends in all four extreme precipitation related parameters.

In contrast, the numbers of stations with a decreasing trend of extreme precipitation are comparatively higher. A similar pattern is observed in the extreme river runoff trend. The number of stations with decreasing extreme river runoff trend is higher than the increasing ones. Moreover, there is no observable relationship or pattern between increasing or decreasing trend of extreme precipitation and extreme river runoff in related stations. Thus, the third hypothesis of this research, which states that the trend of extreme river runoff in the Koshi River basin is related with the trend of extreme precipitation events of the related stations, cannot be agreed.

7.3 Extreme Events and its Relationship with Southern Oscillation

This analysis explores the relationship between the interannual variation of each parameter and the BEST index. The BEST index measures the intensity of El Niño Southern Oscillation (ENSO) events based on the difference of air pressure and sea surface temperature between the eastern and western regions of the tropical Pacific Ocean. In the BEST index events with intensity above +1 is El Niño, and below -1 is La Niña. Although the quantity of research regarding the relationship between ENSO and extreme precipitation in Nepal is limited, there are some existing notions. Shrestha (2000) reports below-average monsoon during El Niño years. However, Nandargi and Dhar (2011) report extreme precipitation events during El Niño years, even when the average monsoon was either above or below the average. Similarly, Bohlinger and Sorteberg (2018) mention no linear correlation between ENSO and the extreme events above the 99th percentile. Furthermore, they also state that seasonal rainfall correlates with ENSO while extreme daily precipitation does not.

This research shows a negative linear correlation between total precipitation (PRCPTOT) and extreme precipitation (R90p) amount with the BEST index, which is in-line with Shrestha's finding. However, this relationship is not significant during the entire year. Interestingly, a similar relationship exists between these two parameters, as well as the total precipitation days (R0.1), and the BEST index, however, only during the HPM months which is significant at 95%. Moreover, extreme precipitation threshold (R90) during an entire year and HPM period also show a significant negative relationship with the BEST index.

These observations can be categorised into two parts. Only the extreme precipitation intensity increases with the decreasing BEST index, i.e. towards La Niña. Moreover, this relationship exists during HPM period for both intensity-related parameters, but for extreme precipitation threshold, this relationship exists during an entire year period too. However, no frequency-based parameters are significantly impacted either negatively or positively by the BEST index.

Likewise, both total precipitation amount and days are impacted in an opposite way by the BEST index during the HPM and LPM periods. During the HPM periods, both total precipitation parameters intensify with decreasing BEST index, but during the LPM periods, both these parameters intensify with increasing BEST index. Thus, as per the finding of Bohlinger and Sorteberg (2018), the seasonal rainfall events correlate significantly with the ENSO events. However, in contrast to Bohlinger and Sorteberg's finding this research signifies the relationship between extreme events and ENSO events too. Interestingly, this relationship also exists during wet seasonal condition but not during the dry seasonal condition or throughout a year.

It is of utmost importance to note that the above-mentioned significant relationships do not prove the occurrence of extreme events during any of the ENSO events. However, the findings of this research imply, taking the findings of R90p as an example, that the decreasing BEST index during HPM has a significant probability of increasing R90p events. Moreover, all the parameters' duration with significant relationship during the HPM or an entire year period with the BEST index has higher than 65% of in-phase years relationship. The in-phase year's relationship means having high events (anomaly from mean higher than the positive standard deviation of the timeseries) during less than 0 BEST index, or vice-versa. Thus, the probability of occurrence of high events during decreasing BEST index is vivid in Nepal. In contrast, the occurrence of high events during an El Niño year, or the occurrence of low events during a La Niña year cannot be disregarded. These phenomenon are also observed in the findings of this research, which is in line with Nandargi and Dhar (2011)'s findings.

Furthermore, it is interesting to note that El Niño is known to trigger drought in South Asia, and this can be observed during the HPM period in Nepal. However, moving towards positive BEST index or El Niño increases the probability of total precipitation amount and days during LPM, which is a dry season, is a unique combination of relationship. A trigger of dryness, El Niño, increases wetness during a dry season is a unique finding of this research. However, this finding is only significant for total precipitation amount and days but not for any parameters of extreme events. Moreover, although not significant all the parameters during HPM and an entire year, except Rx3days, have negative coefficients of correlation with the BEST index, while during LPM all the parameters have positive coefficients of correlation with the BEST index. This relationship could be a result of time lag, as the ENSO events usually occur during the winter months thus needs further exploration.

The ENSO events show a relationship with seasonal total or extreme precipitation events. However, the ENSO events do not show any significant relationship with the total or extreme precipitation events based on elevation. Likewise, no significant relationship exists between ENSO events and extreme river runoff events. Furthermore, the findings of this research point out the possibility of intensifying intensity of extreme events with decreasing BEST index during HPM period, as well as the possibility of intensifying total precipitation events with decreasing or increasing BEST index during HPM and LPM, respectively. Based on the findings of this research, the fourth research hypothesis related to the relationship between total precipitation and extreme precipitation events with the ENSO can only be partially agreed. The fourth research hypothesis states that the southern oscillation causes a scant change in total rainfall amount but influences the storm intensity and storm duration significantly. In contrast, the findings of this research show that the ENSO impacts total rainfall amount as well as total rainfall days; however, during seasonal periods only. Likewise, the ENSO impacts extreme precipitation intensity but not the duration significantly. The significant association of these relationships adds a dimension in understanding the interannual variation of total and extreme precipitation in Nepal which is directly related with the socio-economic situation of the country, as elaborated in the literature review chapter.

7.4 Environmental Attitude and Environmental Education of the Children

There are two foundations for this research. First, the extreme environmental events are ubiquitous in Nepal, and second, the trend of these events are increasing. Thus, the vulnerable children's environmental attitude and education matters which promotes adaptive and pro-environmental behaviour. The research findings agree with the first foundation, as mentioned above, while the second foundation is found only to be partially true. In general, new research findings and findings of this research indicate that the trend of extreme precipitation events, as well as extreme river runoff events in the eastern part of Nepal, are not increasing significantly, but most stations demonstrate a decreasing trend. Moreover, there is no observable relationship between any trend of extreme precipitation events with the trend of extreme river runoff events. However, the events of extreme precipitation and extreme river runoff are occurring in the KRB region of Nepal. Furthermore, the vulnerability in the region is high, and examples of extreme precipitation induced hazards such as flooding are fresh.

This research uses a verified tool to explore the environmental attitude of the children. However, this tool described in chapter 1 and 2, the 2-MEV needed to be tested first in order to ensure its validity in the research site. The 2-MEV scale was developed based on a well-conceived theoretical argument (Bogner & Wilhelm, 1996; Wiseman & Bogner, 2003; Milfont & Duckitt, 2004; Johnson & Manoli, 2008). Previously, the 2-MEV scale was validated in different (western) regions around the world. These regions are different from Nepal in many aspects, such as geography, culture, lifestyle, education outreach and the ways of viewing environment. Thus, specific attention was given to the local culture and geography during this process.

The 2-MEV consists of sets of items. To address the local context of rural Nepal, previously used items from other research were modified along with the development of new items. For example, donating money for environmental cause was one of the most commonly used items in previous 2-MEV scales (e.g. Bogner & Wilhelm 1996, Johnson & Manoli 2008, 2011). However, Schneller et al. (2013) modified this item to volunteering instead of donating money because of the weak philanthropy culture in Mexico. The same is true in the case of Nepal. Thus, such changes were made in this research.

Furthermore, the lack of infrastructure development in rural Nepal has led to the utilisation of forest and river as people's primary sources of energy and livelihood. Likewise, rural Nepal is dependent on agriculture, and river water is the primary source of irrigation (Gautam & Andersen, 2016). Moreover, forest products are used for food for cattle, building materials, firewood, and construction. Thus, the modified and newly developed items are dominated by forest and river-related issues in this 2-MEV scale for rural Nepal.

Likewise, the items and model validation method using exploratory factor analysis and confirmatory factor analysis reveal alignment with the original findings of Bogner and Wiseman (1999). The two-dimensions of environmental attitude, Preservation (P) and Utilisation (U), prevails in Nepal too with five different attitudes under them. However, the nature of attitudes is not entirely same in this research compared to the ones used in previous 2-MEV research (Bogner & Wiseman, 1999; Johnson & Manoli, 2008; Schneller et al., 2013). The major reason for the modification of attitudes is the modification and new development of the items. In the case of three attitudes 1, 3, and 5, the verified items are dominated by the adopted/modified items from previous research, which were under the same attitudes. Thus, attitude 1, 3, and 5 have the same name as previous research. However, two items under attitude 2 were changed from utilisation to preservation value due to their factor loadings and score. Thus, it had no relationship with the original attitude from its source. This led to the development of a new attitude, while the same was true for attitude 4, which had all newly developed items leading to a new attitude. Finally, the verification of 2-MEV model with two values and five attitudes under them proved that the bi-dimensional nature of environmental attitude exists in a different region like rural Nepal too, compared to the western or developed regions of the world.

It is also useful to look at the mean value and attitude scores of the sample population in this research. As seen in Table 6.11 and 6.17, the children generally have positive environmental values and attitudes. Johnson & Manoli (2008) report a mean score of 3.62 and 2.52 of P & U, respectively in their pre-test sample. Similarly, Johnson & Manoli (2011) report a mean score of 3.52 and 2.59 of P & U, respectively, in their pre-test sample. Schneller et al. (2013) report a mean score of 4.22 for P and 2.45 for U, and 4.26 for P and 2.9 for U, respectively, for their two sample groups. The pattern of all these reported means is in line with the findings of this research. Furthermore, the items under attitude protection of nature, polluting nature, and altering nature have a relatively high standard deviation. Interestingly, the other two attitudes are related to personal concerns, while these three are related to communal concerns. Thus, the high standard deviation in these attitudes might be related to the dilemma of issues arising from the potential impact on the community or due to the pressure as well as wish to support the community. However, this phenomenon needs further exploration as previous research do not report such behaviour. Moreover, the attitudes in use in this research are relatively different from other 2-MEV research. Thus, such a comparison is not plausible.

Interestingly, the two attitudes with low standard deviation, the intent of support, and enjoyment of nature show an increasing tendency of positive attitude from grade 8 to 9, but not from 9 to 10. However, the other three attitudes which are related to communal issues, show a positive increasing tendency of attitudes from grade 8 until 10. Although these increments are interpreted based on observation but not on the statistical test, this tendency is clearly seen in Table 6.20. Thus, the items relationship with an individual or the community and its effect on the attitude needs further exploration. Moreover, the increasing tendency of positive attitude of all five attitudes from grade 8 to 9 could be related to the addition of a new environment-related subject in grade 9. The increase of details and complexity of environmental aspects in the curriculum with grade could be another factor too.

Furthermore, the preservation value also shows increasing tendency from grade 8 to 9, while utilisation value shows a decreasing tendency from grade 8 until 10. However, no observable tendency exists between values and attitudes with gender or age. Interestingly, Meinhold and Malkus (2005), and Johnson and Činčera (2015) report high preservative value in girls compared to boys, while Bogner and Wilhelm (1996) found children of grade 5 and 6 more sensitives towards environment compared to that of grade 9. Although there is a big difference between grade 5 or 6 with grade 9, this research reports the increasing tendency of positive environmental values and attitudes with an increase of grade from 8 to 9, and 9 to 10. Interestingly, Johnson and Manoli (2008, 2011), Schneller et al. (2013), and Bogner et al. (2015) also suggest increment of positive attitude, by using 2-MEV, with education but their research was based on environmental programmes with pre- and post-test but not on environmental education content followed at the children's school.

Likewise, the other significant difference between this research and other previously published results is in the relationship between preservation and utilisation. Typically, most 2-MEV research report low to a moderate negative correlation between preservation and utilisation. For example, Schneller et al. (2013) found a -.26 correlation, while Johnson and Manoli (2011) found -.45. Also, having a low to moderate negative correlation between preservation and utilisation indicates they are distinct yet related (Milfont & Duckitt, 2004). While this moderate negative relationship is more significant than Wiseman and Bogner (2003)'s claim (-0.174), they are much different from the strong relationship of -.93 in this research. However, Milfont and Duckitt (2004) also report a higher negative relationship of -.72 between preservation and utilisation. They point out this might be due to the controlled direction of wording in the items, i.e. including both pro- and anti-environmentally worded items under both values to eliminate the direction of wording effects. However, the items in this research were not considered for the wording direction. Moreover, this higher negative correlation might be due to the context of another region or country (Milfont & Duckitt, 2004).

As suggested by Bogner and Wilhelm (1996), and Kibbe et al. (2014), in the western culture the utilisation is a product of self-interest to use the components of nature either to harm them or to enjoy them. However, in this research, the verified items under the utilisation value suggest that the sample population utilised the components of nature to get rid of their problems but not for their self-interest. For example, a river is going to flood their community; thus, diversion of the river is necessary. Likewise, waste is not collected for its proper disposal, so the best way to get rid of the waste is either throw it away in a flowing river or burn it. Similarly, the growing population needs food, and there is no other source of income in the village; thus, the forest needs to be cleared for agriculture. Moreover, till today, not everyone has a bathroom in their home, thus the need to clean themselves in a river. As a conclusion, it is possible that this contrast between the west and the east about what utilisation of nature is done for has created this difference of correlation between preservation and utilisation. Furthermore, the different attitudes in this research compared to other 2-MEV research could also be another reason affecting the relationship between values. There is a need, however, to see if this relationship holds up in other studies in rural Nepal or similar places.

Corral-Verdugo and colleagues report no conflict in holding both pro- and anti-environmental belief in non-western and non-industrialised countries such as Mexico and Brazil (Bechtel, Corral-Verdugo & Pinheiro, 1999; Corral-Verdugo & Armendáriz, 2000). However, in rural Nepal, the case is observed to be different due to a high negative correlation. A high positive correlation suggests strong preservation associated with strong utilisation (Milfont & Duckitt, 2004), while a high negative correlation suggests strong preservation associated with weak utilisation, and vice-versa. The children who have strong positive preservation values also have strong negative utilisation values, and vice-versa. Since the finding of this research has a high negative correlation between preservation and utilisation, the relevance of dualism, as well as two dimensions in environmental attitude, strengthens. Along with the validation of bi-dimensionality of environmental attitude in Nepal, the majority in positive inclination towards environmental values and attitudes of the children living near the Koshi River, as found in this research, accepts the fifth research hypothesis and, the to test sixth research hypothesis. The fifth research hypothesis states the construct of environmental attitude (Preservation and Utilisation) in rural Nepal represents bi-dimensionality, while the sixth research hypothesis to be tested states that the children living nearby the Koshi River have a positive or negative environmental attitude. Moreover, the usage of 2-MEV, based on its development and verification while regarding the local context, to analyse the environmental attitude, is further validated.

The Government of Nepal (GoN) focuses on environmental education to identify and solve environmental problems along with the impact of human beings on such problems (Karki, 2000). Likewise, the indigenous traditional knowledge is not part of school education in Nepal (Sharma et al., 2009) and the anecdotes of the public from the research site indicate their inclination towards school education too (see chapter 4.3.2). The locals believe modern technology, which is a product of school education, has more to offer regarding the protection of their area from the vulnerability associated with the extreme environmental events than their indigenous traditional knowledge. School education is a comparatively new concept in Nepal, beginning only in 1892 (Wood, 1959). In the research site, the oldest school is only 51 years old. The International Labour Organisation (ILO) working in close coordination with the GoN set education as a prerequisite for rural transformation (ILO, 2012). GoN is focused on rural transformation, and the "National Literacy Campaign" was implemented by the GoN to achieve 75% adult (15-24 years as defined by GoN) literacy rate by 2015 in a process to eradicate illiteracy from Nepal (UNESCO, 2015). The adult literacy rate has increased from 57.4% in 2005 to 82.4% in 2011 (UNESCO, 2015). However, someone having traditional indigenous knowledge is not regarded as literate. Thus, parents and children are also concentrating on the modern school education system.

Furthermore, previous research indicate that environmental education affects environmental attitude, while environmental attitude influences adaptive and pro-environmental behaviour (see chapter 1 and 2.2.2). However, any research on children's environmental attitude is not available in Nepal. Furthermore, the only research related to the relationship between the centralised curriculum of Nepal and perception suggests no connection between the children's environment and the environmental problems stated by the children (Keinath, 2004). Moreover, Keinath (2004) states that the environment-related textbooks, from rural eastern Nepal, only highlight conventional environmental problems such as air pollution, but not their solutions. As the curriculum in Nepal is updated in every ten years, the findings of Keinath might not be relevant today. As a result, the findings of this research indicate the same. The curriculum followed by the children of the research site not only includes environmental problems, causes, and effect but also includes how to manage it, and its preventive measures.

Although localised contents are not precisely highlighted in the curriculum because of its centralised nature, the regional contents are included. Such contents include the issues related to Nepal and the Himalayas and highlights the associated major environmental problems such as floods and landslide, and their solutions and management including preventive measures, which are existent and relevant in the research site too. Thus, the curriculum is well linked to the research site, and the children have the opportunity to profit from that content to understand their local environmental circumstances. Likewise, the issues covered in the curriculum such as concepts of weather, environment and ecology, and environmental problems and solutions increase in detail and complexity with the increase of the grade. Furthermore, the addition of a new environment-related subject in grade 9, *Health, Population, and Environmental Education* which exists in grade 10 too, also adds to the increasing content of environmental education with the grade from 8 to 9. Table 7.2 presents the status of environmental education content followed by the school going children of the research site in relationship with the environmental education principles and goals recommended by the government of British Columbia from Canada and UNESCO-UNEP, respectively.

Table 7.2. The content of environmental education followed by the children in the research site in relationship with the environmental education principles and goals.

Grade	**Textbook**	**Theme Number**	**Environment Education Principles**	**Environment Education Goals**
8	Science	1	1 and 2	1 and 2
8	Science	2	1, 2, 3, and 4	1, 2, and 4
8	Social Studies	1	1 and 2	1 and 2
9	Science	1	1	1
9	Science	2	1, 2, 3, and 4	1, 2, 3, and 4
9	HPE	1	1, 3, and 4	1, 2, 3, and 4
9	HPE	2	1, 2, 3, and 4	1, 2, 3, and 4
9	HPE	3	1, 2, 3, and 4	1, 2, 3, and 4
10	Social Studies	1	1	1
10	Social Studies	2	1 and 3	1 and 3

As stated in chapter 2.2.1.3, the Kathmandu University School of Education, one of the few university faculties with a teacher training facility in Nepal, also recommends these environmental education principles and goals. The four environmental education principles are complexity (1), aesthetics (2), responsibility (3), and ethics (4) (British Columbia Ministry of Education, 2007). Likewise, the four environmental education goals are the ecological foundation (1), conceptual awareness (2), investigation and evaluation (3), and environmental action skill (4) (UNESCO-UNEP, 1994). As seen in table 7.2, the environmental education principles and goals are existing in the environmental education contents of the textbooks followed by the children. Moreover, the coverage of these principles and goals increase its frequency in grade 9 compared to 8.

However, due to the limitation of the availability of textbooks during the data collection period, the analysed textbook from grade 10 has less environmental education content compared to that of grade 8, and 9 thus represents few principles and goals. In general, the environmental education content followed in the research site meets the criteria set by the international and national organisations and institutes. In addition, the contents also include regional issues along with existing and relevant environmental issues, problems, and solutions to foster the environmental literacy of the children. Moreover, the contents include issues related to local conditions and needs based on usage and conservation of natural resources which is in regards to education for sustainable development.

As a result, the positive environmental values and attitudes show an observable increasing tendency with the increase of the grade but not with an increase of age or gender. Likewise, the practical and progressive curriculum, practical because it covers recommended contents and includes significant aspects of the environment from the research site, and progressive because of the changes observed between Keinath (2004)'s and this research's findings, covers more detail and complex aspects in higher grades compared to the lower ones. Moreover, the addition of a new environment-related subject at grade 9 further supports the broadening of the scope of environmental education, with an increase of the grade, including the details and complexity of the aspects. In addition, it is to be noted that the data collection for this research was done at the end of the academic year in Nepal thus students from each grade are most likely guided by the education they received in that particular year but the previous years. Thus, increasing environmental education aspects with grade supports the hypothesis, that the content of the textbooks enables a more detail structure of positive values and attitudes towards the environment. Therefore, the seventh research hypothesis that there is an observable relationship between the environmental education content followed by the school going children with their environmental attitude can be agreed.

8 Conclusion and Future Recommendations

This chapter summarises the research findings of each analysis part. Likewise, the future recommendation elaborates the questions arising from the new findings of this research and the need for further exploration.

8.1 Conclusion

This research combines the issues of the natural environment with the social environment. The extreme events impact the human social environment negatively, while education, as well as attitude, are keys to tackle such events. The Himalayan orography is responsible for the occurrence of the Indian Summer Monsoon (ISM). The ISM impacts the southern side of the Himalayas. Nepal is located in the central Himalayas and is part of the ISM region. The ISM majorly controls the water balance of Nepal. However, there has been an indication of the increase in extreme precipitation events. Although previous research and this research proves that the trend of extreme precipitation is not increasing in overall Nepal, the events of extreme precipitation have a strong history associated with havoc in the region. Thus, understanding the status of precipitation intensity and frequency in Nepal stands out as the first primary objective of this research. In general, all the parameters during all three periods, the entire year, High Precipitation Months (HPM), and Low Precipitation Months (LPM) have the highest concentration in the mid-central part of Nepal, near the city of Pokhara. Likewise, all the parameters during all three periods, except the threshold of extreme precipitation (R90), has specific high concentration in the northeast corner of Nepal too.

The findings of this research show that the total precipitation amount shows no noticeable relationship with the elevation during an entire year and HPM period but shows dependence with the rise of two-step topography in the two-peak form. However, the total precipitation amount during the LPM period shows a positive relationship with the elevation. The eastern and central parts of Nepal experience more precipitation amount during an entire year and HPM period, while the western hills (>300m) of Nepal experience more precipitation amount during the LPM period. Likewise, out of the total yearly precipitation ~91% precipitation falls during the HPM period. Interestingly, stations from the plains of Nepal has high intensity per frequency ratio than that of the hills.

The total precipitation days increase with the increase of the elevation during an entire year, HPM, and as well as during the LPM. Similarly, the total precipitation days are high in the eastern side of Nepal during an entire year and HPM. However, during the LPM, the total precipitation days are high on the western hills of Nepal. Furthermore, the LPM constitutes of only 16% of the total precipitation days.

The extreme precipitation threshold in Nepal is highest in the plains and decreases with increasing elevation during an entire year, HPM period, and as well as during the LPM period. Moreover, the same during the LPM increases significantly towards the west but not towards the east during a year or HPM period.

The extreme precipitation days are higher in the hills and increases with elevation and towards the east during an entire year and HPM period. Similarly, the extreme precipitation days during the LPM period also shows significant increment towards the north and noticeable concentration in the western, central, and as well as in the eastern hills. Similar to the total precipitation days, the extreme precipitation days also constitutes of only 16% of total extreme precipitation days per LPM.

The extreme precipitation amount is high in the plains, but the extreme precipitation days are low in the plains during an entire year and HPM period. Although the extreme precipitation significantly decreases with an increase of elevation, its amount is high in the plains and shows a relationship with the rise of two-step topography in a two-peak form. Likewise, the extreme precipitation amount during the LPM shows a significant positive relationship with the elevation, but it occurs mainly in the central and western hills of Nepal. Furthermore, out of the total extreme precipitation amount, 90% occur during the HPM period.

Finally, the three or more consecutive days of extreme precipitation occurs in the central and eastern part of Nepal throughout a year and HPM period and shows a significant relationship with the elevation. In contrast, the three or more consecutive days of extreme precipitation events are scattered in the hills of Nepal during the LPM period.

The precipitation intensity, except the threshold of extreme precipitation, increases with the rise of topography. Likewise, the precipitation intensity, except total precipitation amount, significantly decreases with the increase of the elevation, while precipitation frequency increases with the increase of the elevation. Moreover, the events are concentrated in the eastern side of Nepal during an entire year and HPM period, while the events are concentrated in the western side of Nepal during the LPM period.

After exploring the status of extreme precipitation events in Nepal, the research objective heads to the status of extreme river water runoff. The analysis then continues with observing a noticeable relationship between the trend of extreme precipitation and the trend of extreme river runoff. The trend of extreme precipitation has been the objective of a few research, but its relationship with the trend of river runoff as well as the status of river runoff in Nepal has not received any attention. Since the river runoff and livelihood are interlinked, and the research site of environmental education and attitude part is in the Koshi River Basin (KRB) region of Nepal, this analysis focuses on the river discharge and precipitation stations of the KRB region.

This research finds a relationship between the threshold value of extreme river runoff with the size of the river. The increasing threshold value is related to the increasing size (catchment area) of the river.

The difference between the days with extreme river runoff in the rivers of the KRB is only 13 days/year, and it is not related to the size of the river. However, the extreme river runoff increases with the increase in the size of the river. Likewise, the three or more consecutive days of extreme river water runoff has a similar pattern to that of the days with extreme river water runoff.

Furthermore, there are more stations with a decreasing trend of extreme precipitation and extreme river runoff in the KRB than the increasing trend. Moreover, there is no observable relationship between the increasing or decreasing trend of extreme precipitation with that of extreme river runoff.

The impact of southern oscillation in the precipitation and river runoff regime of Nepal is another focal point of this research. The southern oscillation and its relationship with the precipitation events in Nepal have received some, but very less, attention. However, its relationship with the extreme precipitation and river runoff events in Nepal was yet to explore. Thus, this research questions the impact of southern oscillation on extreme precipitation events over the Nepal Himalayas.

The total precipitation amount and days have significant, but the opposite relationship with the BEST index during the HPM and LPM period. During the HPM the events of the parameters intensify towards decreasing BEST index, i.e. La Niña, but during LPM the events of the parameters intensify towards the increasing BEST index, i.e. El Niño.

The threshold of extreme precipitation has a significant relationship with the BEST index during both HPM and entire year period. During both these periods, the threshold of extreme precipitation intensifies with the decreasing BEST index.

The total amount of extreme precipitation has a significant relationship with the BEST index only during the HPM period, where the total amount of extreme precipitation intensifies with decreasing BEST index.

There is no significant relationship between the extreme precipitation frequency and the BEST index, as well as between the total and extreme precipitation events in different elevation, and the extreme events of river runoff with the BEST index.

Finally, the pattern of extreme precipitation and river runoff is known. The decreasing BEST index increases extreme precipitation amount in Nepal during HPM is also known. More stations show a decreasing trend of extreme precipitation and extreme river runoff in the KRB region of Nepal is also known along with their non-observable relationship in any scenario.

However, the extreme events persist in Nepal and in the KRB too, and the Koshi River is the largest river of Nepal, which is always associated with natural hazards in the region. Thus, the final three objectives of this research, questions the construct and state of environmental attitude and the state of environmental education in the KRB region by conducting multiple surveys with the children and analysis of their school textbooks.

The construct of environmental attitude is bi-dimensional in Nepal. Thus, the debated bi-dimensional construct of environmental attitude is further strengthened. Moreover, when considering the local context by regarding social, cultural, economic, and environmental aspects, the 2-MEV can be used as a standard tool to analyse environmental attitude globally.

The relationship between preservation and utilisation, the environmental values, is strong but negative in rural Nepal, suggesting a person holds either a preservative value or a utilisation value. In the research site, which is in rural Nepal, more than 78% children (n=379) are inclined towards preservative value while more than 80% children out of the 20% children who are inclined towards both values are further inclined towards preservation. Furthermore, the mean score of preservation value increases with the grade from 8 to 9 but not from 9 to 10, while that of utilisation value decreases with the grade. However, this tendency is not observed with age or gender.

Majority of the children are inclined towards the attitude of the intent of support, protection of nature, and enjoyment of nature, while most of the children are not inclined towards the attitude to pollute and alter nature. Out of the total number of the children who are inclined towards the attitude to pollute and alter the nature, only 18.6% of children incline on both attitudes, while 60% out of the 18.6% are also inclined towards the first three attitudes.

The mean score of attitudes of the intent of support and enjoyment of nature increases from grade 8 to 9 but not from 9 to 10. However, the mean score of the attitude protection of nature increases from grade 8 until 10, while that of attitude to pollute and alter the nature decreases from grade 8 until 10. Similar to the environmental values, any tendency between positive attitudes and age or gender is not observable.

The environment-related textbooks or curriculum covers all the important concepts of environment, nature and universe. Furthermore, the curriculum also covers contemporary and regional environmental problems, such as floods and landslides, as well as the ways to manage them, solve them, and their preventive measures. Moreover, the regional environmental problems include issues of Nepal and the Himalayas which are related to the research site.

Furthermore, the covered aspects regarding environmental knowledge and regional environmental knowledge increase in detail and complexity in the curriculum with the increase of the grade. Thus, supporting the hypothesis that the contents of increasing grade enables a more detail structure of positive attitude with increasing grade towards the environment by having a slightly stronger – however not tested statistically – mean value in the answers to the 2-MEV questionnaire.

Finally, the research findings conclude with these specific points, as mentioned below:

1) The total and extreme precipitation intensity decreases with increasing elevation but increases with the rise of the topography while the total and extreme precipitation frequency increase with the elevation; however, both these aspects of total and extreme precipitation are high in the eastern part of Nepal during an entire year and HPM period, while they are high in the western part during the LPM period.
2) The total and extreme precipitation threshold are high in the plains than in the hills.
3) The total and extreme precipitation intensity and frequency, except its 90^{th} percentile threshold, is higher in the hills compared to the plains during the LPM period.
4) The increasing intensity of the BEST index towards the negative scale (La Niña) increases total precipitation intensity and frequency, and extreme precipitation intensity during the HPM period but not the extreme precipitation frequency.
5) The increasing intensity of the BEST index towards the positive scale (El Niño) increases total precipitation intensity and frequency during the LPM period.
6) The extreme river runoff intensity depends on the size of the river, but the frequency is almost uniform and independent from the size of the river in the Koshi River basin.
7) There are more stations in the Koshi River basin with a decreasing trend of extreme precipitation and extreme river runoff events than the increasing, and there is no relationship between them.
8) The bi-dimensional construct of environmental attitude prevails in rural Nepal with a strong negative correlation of -0.93.
9) The state of environmental attitude, as well as the environmental values of the children living near the Koshi River, is in general positive.
10) The status of environmental education is well linked to the research site, and the children have the opportunity to profit from that content to understand their local environmental circumstances.
11) The findings of this research support the hypothesis that the content of the textbooks enables a more detail structure of positive attitude towards the environment by having a slightly stronger – however not tested statistically – mean value in the answers to the 2-MEV questionnaire.

Finally, based on the above-mentioned findings, this research can be concluded by completely accepting the research hypotheses 1, 5, 6, and 7, while 2 and 4 are partially accepted, but 3 is rejected.

8.2 Future Recommendations

The scope of the research and limitations arising with or without the scope limits the findings. Based on the limitations, this sub-chapter presents the recommendations for future research works.

- The ubiquitous complex terrain of Nepal or the Himalayas limits the concentration of ground stations. Inclusion of high-quality data sets will further improve the result of related research. However, the challenge is to identify the source of high-quality data which could most probably be satellite data, while extrapolation methodologies might not be beneficial due to the high variability of topographic gradient and elevation in short distance in the Himalayas. Moreover, the usage of satellite data is also debatable because of the high error associated with it. Thus, a high-quality dataset derived from the combination of a dense network of ground stations, from the similar region as the Himalayas, and its relationship with satellite data such as remote sensing could be a direction in improving the findings in this field.
- A broadened research site with the scope to analyse the pattern of extreme precipitation events and the pattern of extreme river runoff events will be crucial for the Himalayan region. The Himalayan region is home to some of the largest river systems of the world and the least understood weather pattern: monsoon. Thus, conducting similar research in other parts of the Himalayas will help to comprehend what is the threshold of danger in a particular region of the Himalayas and this information will be very crucial for the locals of these regions to identify and prepare for the environmental crisis in advance.
- The data related to snowfall in the Himalayas is minimal, but so is its research. The Himalayas has the largest ice mass outside the poles of the earth. These ice masses are dependent on the amount of snowfall, and the rivers of the region are dependent on the ice mass. Furthermore, more than a billion people depend on these rivers for freshwater in the Himalayan belt. Thus, exploring the status of snowfall, its pattern, and the trend will be an essential finding.
- The environmental attitude has shown a bi-dimensional construct in rural Nepal, which is in-line with the previous findings of 2-MEV research. However, the strong negative relationship between the two dimensions of environmental attitude in rural Nepal has added interesting questions. Does this relationship prevail in other parts of Nepal or south Asia or similar community too? Is there any underlying reason for this relationship, or is it entirely dependent on the sample population? Moreover, does the bi-dimensional construct of environmental attitude prevail in an urban society of an unindustrialised country?
- The findings of this research indicate a difference in attitude variability based on the difference of items under those attitudes. The attitudes with items related to community show comparatively high increasing tendency of positive attitude with an increase of grade while, attitudes with items related to an individual show less variability with low standard deviation. Thus, exploring the impact of items relationship with an individual or

community to affect the attitude will be an interesting research to elaborate on the construct of environmental attitude further.

- Various research indicates that positive environmental attitude increases with environmental education. However, due to the limitation of the research, this research could not explore the relationship between environmental education content and attitude deeply by taking in regards to the source of environmental knowledge. Thus, analysing the environmental knowledge based on environmental education content and other sources to impact the attitude of the children will further strengthen the discussion of environmental education to impact the environmental attitude of the children.
- Milfont and Duckitt (2004) explored the bi-dimensional construct of environmental attitude because of the single-dimension environmental attitude's low to moderate strength to predict environmental behaviour. Milfont and Duckitt verified the bi-dimensional construct of environmental attitude using the 2-MEV tool but the fact whether 2-MEV (a bi-dimensional construct of environmental attitude) better predicts the environmental behaviour is still a question to explore. Thus, relating the finding of 2-MEV with environmental behaviour will further explore the strength as well as reliability of the bi-dimensional construct of environmental attitude.

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Annexe

A - List of Finalised Precipitation Stations with Calculated Values of All Analysed Parameters for 12 Months Period

Annexe 1. All the units are per timeseries (years of data).

Station_ID	Latitude	Longitude	Elevation (m)	PRCPTOT (mm)	R0.1 (days)	PRCPTOT/R0.1 (mm/day)	R90 (mm)	R90d (days)	R90p (mm)	R90p/R90d (mm/day)	Rx3days (events)	Years with Data
101	29.65	80.50	842	61666.2	4337	14.22	36.54	434	24014.90	55.33	3	41
102	29.55	80.42	1635	53622.1	3626	14.79	34.70	363	19020.80	52.40	9	41
103	29.47	80.53	1266	54146.6	4126	13.12	32.00	419	21026.40	50.18	10	41
104	29.30	80.58	1848	56696	4768	11.89	31.00	483	24662.60	51.06	14	41
105	29.03	80.22	176	63962.9	2699	23.70	61.20	272	25916.20	95.28	12	38
106	28.68	80.35	159	67591.1	2826	23.92	55.65	283	27364.50	96.69	8	41
107	29.85	80.57	1097	98545.7	5281	18.66	42.40	539	33976.50	63.04	17	41
108	29.53	80.47	2370	58174.5	4059	14.33	38.10	410	22634.50	55.21	13	38
201	29.62	80.87	1456	90122.6	5847	15.41	40.10	589	35201.90	59.77	15	41
202	29.55	81.22	1304	59083.3	4550	12.99	32.02	455	22009.20	48.37	7	40
203	29.27	80.98	1360	53463.5	3502	15.27	35.20	357	19377.70	54.28	7	41
204	29.38	81.32	1400	73004.3	4022	18.15	41.50	405	24668.40	60.91	5	38
205	29.00	81.13	1388	60545.7	3292	18.39	43.00	335	24024.20	71.71	12	38
206	28.95	81.45	650	49199.3	3584	13.73	34.57	359	19477.70	54.26	1	41
207	28.53	81.12	140	64269.6	3143	20.45	52.56	315	28058.10	89.07	5	38
208	28.75	80.92	195	79536.3	3129	25.42	65.20	314	32437.30	103.30	6	41
209	28.80	80.55	187	72732.6	3535	20.57	55.60	356	33007.10	92.72	7	41
210	28.97	81.12	340	60401.9	3078	19.62	48.93	308	23853.30	77.45	12	38
212	28.57	80.82	152	58284.4	2499	23.32	56.42	250	24121.20	96.48	3	39
214	29.12	80.68	1304	72360.5	4388	16.49	40.43	439	30121.60	68.61	9	39

215	28.87	80.63	288	86580.6	3217	26.91	68.28	322	34179.80	106.15	8	39
217	29.15	81.28	1345	54238.2	3507	15.47	38.44	351	20834.60	59.36	4	38
302	29.32	81.77	1006	23768.1	2728	8.71	20.00	290	9184.80	31.67	1	41
303	29.28	82.17	2300	33221.3	4804	6.92	16.70	485	13036.00	26.88	13	40
304	29.28	82.32	3080	39612.6	4601	8.61	19.70	462	13375.20	28.95	21	38
305	29.13	81.60	1210	53647.5	3933	13.64	34.00	400	21483.00	53.71	9	39
308	29.20	81.90	1905	31965.6	3985	8.02	18.20	401	11670.50	29.10	4	41
309	29.23	81.63	1814	43276.6	2932	14.76	32.00	298	12646.40	42.44	11	36
310	29.27	82.22	2310	34185.9	3820	8.95	19.00	384	11002.10	28.65	15	39
312	28.93	82.92	2058	14296	2665	5.36	11.60	268	5593.10	20.87	12	41
401	28.88	81.25	950	64472.2	3611	17.85	44.40	362	24854.30	68.66	3	41
402	28.85	81.72	1402	69737.4	4220	16.53	38.50	423	23309.30	55.10	12	41
403	28.78	81.33	260	46145.1	3052	15.12	40.60	308	17406.30	56.51	14	39
404	28.70	82.20	1231	74651	3531	21.14	47.50	355	25502.80	71.84	6	40
405	28.65	81.27	225	74569.5	3431	21.73	54.63	434	38009.90	87.58	4	39
406	28.60	81.62	720	65729.4	4566	14.40	37.35	457	27354.00	59.86	6	41
407	28.02	82.12	235	46301.3	2259	20.50	45.04	226	18320.10	81.06	8	39
408	28.17	81.35	215	52475.5	2446	21.45	52.00	248	22327.70	90.03	4	40
409	28.10	81.57	190	51540.6	2634	19.57	47.94	264	22535.40	85.36	6	40
410	28.78	81.58	610	42187.9	2821	14.95	36.50	285	16814.70	59.00	2	40
411	28.43	81.10	129	53660.9	2041	26.29	59.20	206	20595.30	99.98	0	38
412	28.27	81.72	135	56497.8	2642	21.38	49.75	265	22811.50	86.08	11	41
413	28.35	81.70	510	73547	2895	25.40	60.40	292	27706.90	94.89	4	39
414	28.05	81.90	226	43715	1833	23.85	41.22	184	12673.20	68.88	4	40
415	28.43	81.35	200	61340.2	3314	18.51	45.77	332	25546.40	76.95	4	40
416	28.07	81.62	144	55041	2601	21.16	51.00	266	23701.40	89.10	7	41
417	28.38	81.35	200	45920.2	2102	21.85	49.13	211	17941.40	85.03	1	36
418	28.98	82.28	2000	66709.2	4121	16.19	38.40	419	20965.80	50.04	19	39
419	28.03	81.78	195	53429.1	2454	21.77	50.00	247	20768.70	84.08	7	36

501	28.60	82.63	1560	60580.1	4097	14.79	36.54	410	21582.20	52.64	9	36
504	28.30	82.63	1270	67041.3	3743	17.91	42.20	381	23563.30	61.85	3	41
505	28.10	82.87	823	48940.3	3665	13.35	33.80	368	20403.50	55.44	4	41
507	28.22	82.12	698	68687.1	3491	19.68	45.30	351	26967.10	76.83	2	41
508	28.13	82.30	725	66307.8	3623	18.30	43.30	364	25388.30	69.75	9	41
510	27.70	82.53	320	66297.2	2375	27.91	71.38	238	25103.00	105.47	7	41
511	28.38	82.17	1457	41765.6	3429	12.18	28.84	343	16937.30	49.38	1	41
512	28.30	82.28	885	41632.1	3211	12.97	32.50	322	17375.10	53.96	5	41
513	28.63	82.20	910	46960.8	3675	12.78	34.00	371	18306.40	49.34	4	38
514	28.63	82.48	2100	85787.9	4839	17.73	41.00	492	29377.70	59.71	7	41
601	28.78	83.72	2744	9941.4	1937	5.13	11.40	210	4392.80	20.92	4	41
604	28.75	83.70	2566	15650	3582	4.37	10.39	359	6889.10	19.19	8	40
605	28.27	83.60	984	74352.3	4105	18.11	44.00	412	26474.80	64.26	8	39
606	28.48	83.65	1243	64218.7	5807	11.06	26.24	581	22771.90	39.19	9	41
607	28.63	83.60	2384	54120.1	5998	9.02	20.50	602	19905.30	33.07	6	41
608	28.82	83.88	3609	11231.5	2207	5.09	10.44	221	3705.70	16.77	8	40
609	28.35	83.57	835	62174.3	4621	13.45	33.20	463	22523.20	48.65	7	41
610	29.05	83.88	3465	5429.2	793	6.85	15.00	83	2127.30	25.63	1	37
613	28.18	83.75	1720	91527.6	4645	19.70	47.06	465	33243.30	71.49	6	37
614	28.22	83.70	891	102561.3	5120	20.03	49.00	517	36388.20	70.38	10	41
615	28.40	83.10	2273	89056.9	4166	21.38	47.75	417	27612.70	66.22	14	37
616	28.60	83.22	2530	66847.9	4478	14.93	35.13	448	21823.00	48.71	13	36
619	28.40	83.73	2742	108690.2	6191	17.56	40.30	620	37425.40	60.36	28	39
701	27.95	83.43	442	57579.5	3156	18.24	45.55	316	23465.90	74.26	3	41
702	27.87	83.53	1067	53215.1	2956	18.00	45.45	296	22440.00	75.81	6	39
703	27.70	83.47	205	93896.3	3538	26.54	63.86	354	36717.20	103.72	4	41
704	27.68	84.05	150	109139.3	4099	26.63	68.44	410	46416.80	113.21	5	41
705	27.52	83.43	109	68850.1	3664	18.79	50.00	368	33190.20	90.19	13	41
706	27.68	84.22	154	96445.4	3988	24.18	59.00	400	39137.00	97.84	4	41

707	27.53	83.47	120	64416.3	3007	21.42	52.20	335	31364.50	93.63	10	41
708	27.53	83.67	125	70688.1	3513	20.12	53.02	352	32848.30	93.32	5	39
710	27.58	83.87	164	88711.2	3077	28.83	70.18	308	36765.30	119.37	9	40
715	27.93	83.15	1760	73727.6	4643	15.88	41.00	470	35465.20	75.46	14	41
716	27.55	83.07	94	52566.2	2296	22.89	57.00	268	24814.90	92.59	8	41
721	27.77	83.05	200	90472.3	3400	26.61	66.20	341	34995.90	102.63	2	41
722	28.17	83.27	1280	92907.1	3846	24.16	50.20	386	30528.60	79.09	8	41
723	27.68	82.80	80	71599.6	2663	26.89	63.00	273	29310.80	107.37	2	40
801	28.37	84.90	1334	52666.8	3938	13.37	30.90	395	17288.10	43.77	3	41
802	28.28	84.37	823	134893.1	6308	21.38	50.50	635	48571.90	76.49	10	41
804	28.22	84.00	827	160294.2	6765	23.69	62.00	678	68002.20	100.30	16	41
805	28.10	83.88	868	117615.5	5183	22.69	56.48	519	46643.50	89.87	11	41
807	28.13	84.35	855	107507.7	4256	25.26	59.45	426	37890.70	88.95	5	41
808	27.93	84.42	965	73320.1	3821	19.19	43.30	383	26523.60	69.25	15	41
809	28.00	84.62	1097	70467.2	4584	15.37	38.60	463	26781.00	57.84	12	41
810	27.88	83.82	460	77419.8	3641	21.26	53.00	365	31566.60	86.48	4	41
811	28.12	84.12	856	148007.8	6242	23.71	59.60	626	60249.90	96.25	16	41
814	28.30	83.80	1740	220837.5	7645	28.89	77.12	765	86610.50	113.22	23	41
815	28.03	84.10	500	90320.3	4642	19.46	50.98	465	36517.40	78.53	6	40
816	28.55	84.23	2680	34698.1	4488	7.73	16.00	467	11451.80	24.52	17	39
817	27.97	84.28	358	71641.9	4026	17.79	43.50	404	28742.30	71.14	6	41
818	28.27	83.97	1070	174987.6	6134	28.53	78.51	614	66445.40	108.22	16	41
820	28.67	84.02	3420	16171.8	3218	5.03	12.00	330	6658.60	20.18	8	39
821	28.38	83.80	1960	128455.7	6128	20.96	50.20	617	44525.70	72.16	33	37
823	28.20	84.62	1120	107364.9	4813	22.31	51.40	483	36949.20	76.50	8	36
824	28.37	84.10	1820	139650.6	7050	19.81	48.20	706	53101.80	75.22	20	37
902	27.62	84.42	256	82978.9	5063	16.39	42.80	508	37173.20	73.18	10	41
903	27.58	84.53	270	79575.1	4126	19.29	43.80	413	30399.60	73.61	14	41
904	27.55	85.13	1706	87391.2	5272	16.58	40.00	532	37966.40	71.37	16	41

905	27.60	85.08	2314	62837.7	4421	14.21	34.00	446	26766.60	60.01	25	38
906	27.42	85.05	474	98293.4	5432	18.10	44.20	545	44684.40	81.99	25	41
907	27.28	85.00	396	81027.8	2975	27.24	65.52	298	32086.40	107.67	7	41
909	27.17	84.98	130	75122.2	3768	19.94	55.76	377	35940.20	95.33	7	41
910	27.18	85.17	244	75782.6	3745	20.24	49.84	375	33052.20	88.14	16	41
911	27.07	84.97	115	64055.8	3037	21.09	55.72	304	27614.90	90.84	7	41
912	27.02	85.38	152	66335.8	2903	22.85	55.88	291	28046.00	96.38	10	41
915	27.62	85.15	1530	58023.2	4615	12.57	31.12	462	25962.50	56.20	14	41
918	27.00	84.87	91	59086	3033	19.48	49.88	304	26301.80	86.52	8	39
919	27.42	85.17	1030	75095.7	3991	18.82	41.40	472	34055.70	72.15	16	40
920	27.55	84.82	274	68476.1	3903	17.54	40.00	482	32568.30	67.57	17	40
921	27.03	85.00	140	46372.6	1950	23.78	58.12	237	21433.70	90.44	4	38
1001	28.28	85.38	1900	38135.7	3825	9.97	20.50	393	11991.90	30.51	6	41
1004	27.92	85.17	1003	73857.5	3994	18.49	41.27	400	24476.50	61.19	12	40
1005	27.87	84.93	1420	77837.6	4033	19.30	44.00	423	26873.90	63.53	11	41
1006	27.87	85.87	2000	157336.9	6124	25.69	48.28	613	40924.00	66.76	30	41
1007	27.80	85.25	2064	113945.3	5873	19.40	46.20	595	40433.50	67.96	11	41
1008	27.80	85.62	1592	101699.8	5461	18.62	46.50	548	37418.50	68.28	10	41
1009	27.78	85.72	1660	77965.4	4972	15.68	40.00	520	28417.10	54.65	8	40
1015	27.68	85.20	1630	76915.4	4908	15.67	37.30	494	28350.70	57.39	21	41
1016	27.95	85.60	2625	124275.9	5208	23.86	56.00	524	40965.50	78.18	28	37
1017	27.87	85.57	1550	92853	5425	17.12	43.20	547	33963.10	62.09	11	41
1018	27.78	85.57	845	71541.6	4180	17.12	40.70	420	24376.00	58.04	1	41
1020	27.70	85.65	1365	36543.2	3266	11.19	26.10	328	13753.40	41.93	5	38
1022	27.58	85.40	1400	72476.9	5188	13.97	35.20	520	28779.80	55.35	13	41
1023	27.63	85.72	710	45915.4	4273	10.75	27.76	428	18147.60	42.40	3	40
1024	27.62	85.55	1552	54379.3	3908	13.91	34.00	401	20495.00	51.11	4	37
1025	27.92	85.63	1240	91568.4	4178	21.92	48.40	421	28916.80	68.69	20	38
1027	27.78	85.90	1220	115212.1	5872	19.62	43.19	588	38181.50	64.93	17	41

1029	27.67	85.33	1350	49092.3	4853	10.12	25.00	493	19762.20	40.09	13	41
1030	27.70	85.37	1337	59933.3	5380	11.14	29.60	539	25024.30	46.43	11	41
1035	27.75	85.48	1449	78647.7	4867	16.16	40.00	533	28146.80	52.81	10	41
1036	27.68	85.63	865	37781.4	3037	12.44	30.70	367	16499.60	44.96	4	40
1038	27.72	85.18	1085	64064.3	4372	14.65	35.20	440	24038.20	54.63	10	41
1039	27.73	85.33	1335	57298.8	4332	13.23	32.30	437	20810.40	47.62	7	39
1043	27.70	85.52	2163	75551.7	5221	14.47	37.00	524	28385.20	54.17	6	41
1049	27.58	85.52	1517	54687.6	5181	10.56	27.30	520	23522.30	45.24	9	41
1052	27.67	85.42	1330	59261.8	5163	11.48	30.10	520	23758.00	45.69	6	41
1054	28.17	85.32	1847	31953.3	5482	5.83	15.00	585	13879.50	23.73	26	41
1055	28.10	85.30	1982	73403.3	4797	15.30	39.60	484	22782.70	47.07	6	39
1057	28.02	85.12	1240	124067.8	5040	24.62	51.00	509	37091.90	72.87	15	41
1058	28.00	85.55	2480	125827.6	6295	19.99	50.00	642	46258.80	72.05	31	41
1059	27.70	85.42	1543	60895.4	4494	13.55	32.98	536	25857.30	48.24	10	40
1060	27.60	85.33	1448	47458	4054	11.71	27.90	488	22853.10	46.83	15	39
1101	27.68	86.10	850	49420.6	3762	13.14	30.50	378	17723.50	46.89	16	37
1102	27.67	86.05	1940	84082.8	6007	14.00	35.00	603	30851.00	51.16	15	41
1103	27.63	86.23	2003	94886.4	6563	14.46	36.60	660	34731.30	52.62	28	41
1104	27.52	86.05	1536	43871	4143	10.59	25.70	420	16543.80	39.39	7	40
1107	27.28	85.97	1463	84432.3	3821	22.10	49.00	458	39281.60	85.77	17	38
1108	27.18	86.17	1417	76582.9	4857	15.77	38.00	505	31195.90	61.77	14	41
1109	27.08	85.67	275	74440.6	3332	22.34	50.86	334	29644.10	88.75	6	41
1110	27.03	85.92	457	68511.3	2974	23.04	54.17	298	25422.10	85.31	7	41
1111	26.72	85.97	90	59918.9	2905	20.63	50.00	297	26484.50	89.17	10	41
1112	26.92	86.17	165	64892.3	2325	27.91	58.32	233	20093.10	86.24	12	41
1115	27.45	85.82	1098	35539.1	2148	16.55	40.00	216	13190.80	61.07	4	41
1117	27.33	85.50	250	78155.6	3090	25.29	51.91	369	34786.70	94.27	11	36
1202	27.70	86.72	2619	76732.8	5299	14.48	32.48	617	28285.70	45.84	26	41
1203	27.43	86.57	1982	70875.4	4853	14.60	36.40	487	25104.50	51.55	9	41

1204	27.35	86.75	2143	88948.1	4809	18.50	41.20	483	30797.60	63.76	12	41
1206	27.32	86.50	1720	71992	5714	12.60	34.30	574	31169.30	54.30	11	41
1207	27.48	86.42	1576	43160	3280	13.16	31.61	328	16345.30	49.83	4	41
1210	27.13	86.43	497	37833.7	3321	11.39	28.20	333	17687.40	53.12	10	41
1211	27.03	86.83	1295	49576.5	3427	14.47	36.00	355	21452.10	60.43	8	41
1213	26.93	86.52	1175	69802	3892	17.93	40.30	392	23911.00	61.00	15	39
1215	26.73	86.43	138	50383.4	2375	21.21	46.00	241	18626.20	77.29	4	38
1216	26.65	86.22	102	57419.5	2720	21.11	53.20	273	23352.00	85.54	5	41
1219	27.50	86.58	2378	67813.6	5758	11.78	27.86	576	22565.30	39.18	21	41
1222	27.22	86.80	1623	59030.6	4365	13.52	32.00	443	22006.00	49.67	9	41
1223	26.55	86.75	91	59837.3	3120	19.18	44.40	313	22736.10	72.64	13	41
1224	27.55	86.38	1662	71214.5	5042	14.12	31.30	506	22677.50	44.82	20	41
1226	26.60	86.90	85	58505.9	2636	22.19	52.00	307	26173.00	85.25	7	39
1301	27.55	87.28	1497	162028.7	6787	23.87	53.50	681	59357.10	87.16	14	39
1303	27.28	87.33	1329	55526.8	5083	10.92	27.30	511	21671.20	42.41	3	40
1304	27.05	87.28	1680	51436.2	4235	12.15	31.10	509	25114.40	49.34	10	39
1305	27.13	87.28	410	35364.1	3269	10.82	27.20	330	13953.10	42.28	2	40
1307	26.98	87.35	1210	37790.1	4333	8.72	22.78	434	18252.20	42.06	12	40
1308	26.93	87.33	365	42508.7	3636	11.69	29.35	364	19397.50	53.29	8	40
1309	26.93	87.15	143	62960	4293	14.67	40.00	434	28287.80	65.18	4	40
1311	26.82	87.28	444	85635.8	4795	17.86	45.50	483	37177.20	76.97	12	40
1312	26.62	87.38	152	82837.9	3806	21.77	56.40	384	34212.70	89.10	14	40
1314	27.13	87.55	1633	35708.5	3147	11.35	26.88	315	12753.70	40.49	3	39
1316	26.82	87.17	183	80617.7	4073	19.79	50.76	408	33960.10	83.24	6	40
1317	27.77	87.42	2590	94466.4	7511	12.58	28.50	758	30127.30	39.75	17	40
1319	26.48	87.27	72	76226.4	4353	17.51	47.00	438	34870.10	79.61	11	41
1320	26.70	87.27	200	69707.3	4115	16.94	45.00	413	31083.50	75.26	11	39
1321	27.28	87.22	303	42417.9	2761	15.36	37.10	342	17042.20	49.83	2	37
1322	26.97	87.17	158	44347.3	3232	13.72	31.40	326	18158.20	55.70	3	40

1325	27.37	87.15	1190	71146.8	4365	16.30	40.30	439	26917.90	61.32	8	40
1403	27.55	87.78	1780	86600.1	7353	11.78	29.10	737	29340.20	39.81	27	40
1406	27.20	87.93	1830	80490.2	7075	11.38	28.46	708	32036.10	45.25	27	39
1407	26.92	87.90	1300	60237.7	3934	15.31	39.47	394	24665.10	62.60	12	40
1408	26.67	87.70	163	95750.1	3944	24.28	60.10	396	38028.50	96.03	10	41
1409	26.63	87.98	122	101631.9	4058	25.04	62.83	406	40336.20	99.35	13	41
1410	26.88	88.03	1654	95903.7	5223	18.36	44.00	524	38940.00	74.31	15	41
1412	26.57	88.05	120	92878.6	3453	26.90	60.38	346	34119.30	98.61	15	41
1416	26.87	88.07	1678	117924.1	5527	21.34	54.34	553	51300.10	92.77	15	41
1420	27.35	87.60	763	58024.8	4142	14.01	31.50	421	18116.80	43.03	6	38

B - Calculated Values of All Analysed Parameters for High Precipitation Months Period (May-October)

Annexe 2. All the units are per timeseries (years of data).

Station_ID	Latitude	Longitude	Elevation (m)	PRCPTOT (mm)	R0.1 (days)	PRCPTOT/R0.1 (mm/day)	R90 (mm)	R90d (days)	R90p (mm)	R90p/R90d (mm/day)	Rx3days (events)	Years with Data
101	29.65	80.50	842	54065.7	3489	15.50	41	350	20585.6	58.82	1	41
102	29.55	80.42	1635	43958.9	2805	15.67	35.86	281	15281.2	54.38	9	41
103	29.47	80.53	1266	45674	3230	14.14	33.8	324	17281.1	53.34	8	41
104	29.30	80.58	1848	46674.6	3721	12.54	32.5	375	20304.6	54.15	14	41
105	29.03	80.22	176	59648.8	2301	25.92	66.5	232	23293	100.40	9	38
106	28.68	80.35	159	63274.2	2379	26.60	60.42	238	24672.9	103.67	8	41
107	29.85	80.57	1097	87841.7	4244	20.70	46	426	28760.8	67.51	10	41
108	29.53	80.47	2370	48784.2	3150	15.49	40.2	316	18494.5	58.53	10	38
201	29.62	80.87	1456	79898.2	4581	17.44	43	463	29596	63.92	12	41
202	29.55	81.22	1304	48930.7	3559	13.75	34	359	17915.5	49.90	5	40
203	29.27	80.98	1360	44268	2727	16.23	36.5	276	15885.8	57.56	5	41
204	29.38	81.32	1400	61545.9	3180	19.35	42.5	320	20411	63.78	5	38
205	29.00	81.13	1388	52766.8	2729	19.34	45	280	20937.1	74.78	10	38
206	28.95	81.45	650	41430	2840	14.59	36.1	286	16192.8	56.62	0	41
207	28.53	81.12	140	59620.2	2669	22.34	58.04	267	25191.9	94.35	5	38
208	28.75	80.92	195	74854.3	2690	27.83	70.2	271	29416.4	108.55	5	41
209	28.80	80.55	187	68336.3	2984	22.90	62.28	299	29547.2	98.82	6	41
210	28.97	81.12	340	52243.7	2451	21.32	52.4	250	20190.8	80.76	10	38
212	28.57	80.82	152	54177	2125	25.50	61	214	21949.2	102.57	2	39
214	29.12	80.68	1304	63193.2	3553	17.79	41.6	357	26115	73.15	8	39
215	28.87	80.63	288	81561	2806	29.07	73	282	31238.1	110.77	5	39
217	29.15	81.28	1345	43642.8	2745	15.90	39.06	275	16619.8	60.44	5	38

302	29.32	81.77	1006	16396.5	2031	8.07	18	217	6349.8	29.26	2	41
303	29.28	82.17	2300	25443.6	3700	6.88	16.5	371	9714.9	26.19	13	40
304	29.28	82.32	3080	33324.7	3625	9.19	20.2	370	10996	29.72	16	38
305	29.13	81.60	1210	45518	3163	14.39	35	327	18246.2	55.80	5	39
308	29.20	81.90	1905	22093.8	2965	7.45	16.8	299	7805.1	26.10	4	41
309	29.23	81.63	1814	33970.2	2176	15.61	32.7	218	9659.6	44.31	7	36
310	29.27	82.22	2310	27417.2	2999	9.14	20	302	8727.4	28.90	10	39
312	28.93	82.92	2058	11249.3	2175	5.17	10.72	218	4263.3	19.56	14	41
401	28.88	81.25	950	57378.7	3024	18.97	46.27	303	21777.2	71.87	3	41
402	28.85	81.72	1402	63236.3	3507	18.03	40.4	354	20510.7	57.94	9	41
403	28.78	81.33	260	40861.8	2472	16.53	42.6	250	14846.1	59.38	10	39
404	28.70	82.20	1231	67703.5	3025	22.38	50.1	307	22756.3	74.12	5	40
405	28.65	81.27	225	81355.4	3493	23.29	59.96	350	33418.6	95.48	3	39
406	28.60	81.62	720	59401.8	3880	15.31	39.6	391	24420.7	62.46	6	41
407	28.02	82.12	235	43021	1947	22.10	48.28	195	16754.8	85.92	6	39
408	28.17	81.35	215	48988.5	2104	23.28	56	215	20516	95.42	4	40
409	28.10	81.57	190	48183.5	2246	21.45	52.55	225	20543.1	91.30	4	40
410	28.78	81.58	610	36941.5	2365	15.62	38	242	14881.4	61.49	3	40
411	28.43	81.10	129	49769.9	1760	28.28	63.64	176	18620	105.80	0	38
412	28.27	81.72	135	53188.1	2307	23.06	55.2	232	21083.8	90.88	9	41
413	28.35	81.70	510	69370.1	2593	26.75	62.28	260	25623.8	98.55	3	39
414	28.05	81.90	226	39076.1	1526	25.61	48.05	153	11268.1	73.65	3	40
415	28.43	81.35	200	57222.7	2835	20.18	48.5	285	23214.5	81.45	3	40
416	28.07	81.62	144	51359.9	2244	22.89	54.42	225	21485.7	95.49	6	41
417	28.38	81.35	200	42957.6	1807	23.77	52	187	16705	89.33	1	36
418	28.98	82.28	2000	58715.8	3427	17.13	40.4	352	18037.1	51.24	14	39
419	28.03	81.78	195	50287.4	2199	22.87	52.6	222	19406.4	87.42	6	36
501	28.60	82.63	1560	53737.6	3377	15.91	40	347	18951	54.61	7	36
504	28.30	82.63	1270	59401.5	3135	18.95	42.5	324	20552.9	63.43	1	41

505	28.10	82.87	823	43621.7	3039	14.35	35.4	306	17996.4	58.81	2	41
507	28.22	82.12	698	63737	3049	20.90	48.4	306	24653.1	80.57	2	41
508	28.13	82.30	725	62273.3	3192	19.51	46.29	320	23296.7	72.80	7	41
510	27.70	82.53	320	62368.1	2080	29.98	76.76	208	22786.3	109.55	6	41
511	28.38	82.17	1457	35658.7	2848	12.52	29.73	285	14543	51.03	3	41
512	28.30	82.28	885	35625.1	2638	13.50	33.63	264	14952.8	56.64	4	41
513	28.63	82.20	910	41713.8	2970	14.05	37	304	15812.2	52.01	3	38
514	28.63	82.48	2100	78851.4	4121	19.13	42.5	414	25919.2	62.61	4	41
601	28.78	83.72	2744	7544.3	1502	5.02	10.5	152	3116.4	20.50	1	41
604	28.75	83.70	2566	11645.1	2735	4.26	10	287	5394.4	18.80	7	40
605	28.27	83.60	984	68306.8	3463	19.72	46.5	348	23425.9	67.32	5	39
606	28.48	83.65	1243	56365.2	4734	11.91	28.3	475	19395	40.83	8	41
607	28.63	83.60	2384	40510.9	4520	8.96	20	469	14749.1	31.45	10	41
608	28.82	83.88	3609	8951.7	1701	5.26	10.5	178	3075.5	17.28	7	40
609	28.35	83.57	835	56384	3891	14.49	35.5	392	19802.1	50.52	7	41
610	29.05	83.88	3465	3974	572	6.95	14.09	58	1554.8	26.81	2	37
613	28.18	83.75	1720	84102.5	3872	21.72	50.5	394	29678.5	75.33	5	37
614	28.22	83.70	891	95084.5	4340	21.91	52.11	434	32116.9	74.00	8	41
615	28.40	83.10	2273	83113.5	3627	22.92	50.2	365	24933	68.31	12	37
616	28.60	83.22	2530	60985	3788	16.10	36.5	381	19147	50.25	11	36
619	28.40	83.73	2742	99369.8	5026	19.77	43.5	506	32606.9	64.44	19	39
701	27.95	83.43	442	52325.8	2710	19.31	49	272	21147.7	77.75	3	41
702	27.87	83.53	1067	48834.2	2534	19.27	48.67	254	20343.1	80.09	6	39
703	27.70	83.47	205	89568.7	3188	28.10	66.72	319	34381.7	107.78	4	41
704	27.68	84.05	150	103227.9	3593	28.73	75.28	360	42684.2	118.57	5	41
705	27.52	83.43	109	65085.3	3159	20.60	56	318	30467.8	95.81	9	41
706	27.68	84.22	154	90715.3	3539	25.63	61.64	354	36253.6	102.41	3	41
707	27.53	83.47	120	67997.3	2892	23.51	61.56	290	30327.4	104.58	6	41
708	27.53	83.67	125	66460.6	3073	21.63	57.2	309	30394.2	98.36	4	39

710	27.58	83.87	164	84212.2	2739	30.75	75.6	274	34171.3	124.71	5	40
715	27.93	83.15	1760	67072.1	3903	17.18	43.38	391	31636.4	80.91	11	41
716	27.55	83.07	94	57301.7	2344	24.45	62.47	235	23203.1	98.74	7	41
721	27.77	83.05	200	86517.5	3028	28.57	72	304	32425.1	106.66	1	41
722	28.17	83.27	1280	85622.7	3383	25.31	52	343	28095.7	81.91	6	41
723	27.68	82.80	80	67508.9	2300	29.35	68	234	26706	114.13	1	40
801	28.37	84.90	1334	43283.8	3193	13.56	30.5	326	13930.7	42.73	6	41
802	28.28	84.37	823	123035.8	5128	23.99	55	515	41837.7	81.24	7	41
804	28.22	84.00	827	148822.1	5425	27.43	70	551	59626.5	108.22	8	41
805	28.10	83.88	868	108760.9	4294	25.33	62.4	431	41397	96.05	7	41
807	28.13	84.35	855	97512.1	3510	27.78	64.54	351	32951.9	93.88	3	41
808	27.93	84.42	965	65274.5	3168	20.60	47.86	317	23154	73.04	9	41
809	28.00	84.62	1097	63081.7	3811	16.55	40.4	383	23359.6	60.99	8	41
810	27.88	83.82	460	70766.3	3068	23.07	57.5	309	28356.8	91.77	3	41
811	28.12	84.12	856	137754.8	5075	27.14	67.1	509	52822.2	103.78	8	41
814	28.30	83.80	1740	208704.8	6040	34.55	85.52	604	73424.5	121.56	12	41
815	28.03	84.10	500	81728.7	3788	21.58	55.2	382	31864.7	83.42	4	40
816	28.55	84.23	2680	26616.4	3360	7.92	16	353	8667.9	24.55	15	39
817	27.97	84.28	358	63677.7	3334	19.10	46	336	25064.1	74.60	6	41
818	28.27	83.97	1070	163831.7	4999	32.77	84	506	57726.7	114.08	12	41
820	28.67	84.02	3420	11633.9	2266	5.13	11.95	227	4753.9	20.94	10	39
821	28.38	83.80	1960	117224.5	4727	24.80	55.3	475	37021.1	77.94	20	37
823	28.20	84.62	1120	99627.9	4034	24.70	56	406	32810.7	80.81	5	36
824	28.37	84.10	1820	120135.9	5210	23.06	54.2	523	42788.3	81.81	14	37
902	27.62	84.42	256	77666.4	4416	17.59	46.65	442	34127.3	77.21	6	41
903	27.58	84.53	270	73855.5	3641	20.28	45.6	365	28051.5	76.85	11	41
904	27.55	85.13	1706	79890.2	4438	18.00	42	453	34307.2	75.73	15	41
905	27.60	85.08	2314	56588.1	3824	14.80	35	392	24499.9	62.50	24	38
906	27.42	85.05	474	92269.1	4709	19.59	47.24	471	41207	87.49	16	41

907	27.28	85.00	396	76746.7	2635	29.13	70	269	30073.8	111.80	7	41
909	27.17	84.98	130	70855.6	3250	21.80	61.8	326	32890.8	100.89	7	41
910	27.18	85.17	244	71311.2	3236	22.04	55.5	325	30276.7	93.16	13	41
911	27.07	84.97	115	60448.5	2623	23.05	59.18	263	25255.9	96.03	4	41
912	27.02	85.38	152	62151.6	2502	24.84	60.4	257	25985.5	101.11	10	41
915	27.62	85.15	1530	50959.4	3879	13.14	33.32	388	22892.4	59.00	14	41
918	27.00	84.87	91	55782.8	2627	21.23	55.08	263	24108.4	91.67	5	39
919	27.42	85.17	1030	82382.3	4131	19.94	42.4	414	31477.7	76.03	14	40
920	27.55	84.82	274	73315.6	4067	18.03	40.4	414	29733.7	71.82	17	40
921	27.03	85.00	140	49702.3	2005	24.79	60.42	201	19162.4	95.34	3	38
1001	28.28	85.38	1900	32606.2	3208	10.16	21	323	9757.1	30.21	6	41
1004	27.92	85.17	1003	68488.3	3418	20.04	44.5	343	22025.3	64.21	6	40
1005	27.87	84.93	1420	70839.9	3453	20.52	45	379	24764.1	65.34	7	41
1006	27.87	85.87	2000	145064.4	5269	27.53	50.2	535	36836.3	68.85	19	41
1007	27.80	85.25	2064	106780.2	5014	21.30	49.2	506	36121.3	71.39	7	41
1008	27.80	85.62	1592	95387.6	4629	20.61	50.64	463	33261.2	71.84	6	41
1009	27.78	85.72	1660	72398.9	4244	17.06	40.47	425	24407.2	57.43	6	40
1015	27.68	85.20	1630	69497.7	4268	16.28	39.53	427	25437.7	59.57	18	41
1016	27.95	85.60	2625	117541	4411	26.65	60	450	36634.6	81.41	20	37
1017	27.87	85.57	1550	86053.4	4564	18.85	46.4	460	29943.1	65.09	7	41
1018	27.78	85.57	845	66024.4	3534	18.68	42.5	356	21628.7	60.75	0	41
1020	27.70	85.65	1365	33463.8	2811	11.90	29.8	283	12282.5	43.40	5	38
1022	27.58	85.40	1400	66402.7	4411	15.05	37.5	443	25643.2	57.89	13	41
1023	27.63	85.72	710	41082.4	3563	11.53	29.8	358	15901	44.42	2	40
1024	27.62	85.55	1552	49215.1	3286	14.98	36.05	329	17846.4	54.24	2	37
1025	27.92	85.63	1240	86435.2	3628	23.82	50.2	364	26038	71.53	17	38
1027	27.78	85.90	1220	107016.6	4894	21.87	47.85	490	33575	68.52	12	41
1029	27.67	85.33	1350	43689.3	4076	10.72	26.3	408	17193.2	42.14	7	41
1030	27.70	85.37	1337	54094.6	4499	12.02	32.2	452	22122.2	48.94	5	41

1035	27.75	85.48	1449	73122.9	4272	17.12	40.4	432	24030.8	55.63	8	41
1036	27.68	85.63	865	38969.6	3013	12.93	32.5	304	14233.5	46.82	3	40
1038	27.72	85.18	1085	58673.8	3744	15.67	38	378	21642.9	57.26	7	41
1039	27.73	85.33	1335	52352.8	3795	13.80	33.8	381	18702.5	49.09	5	39
1043	27.70	85.52	2163	69706.5	4442	15.69	39.18	445	25192.4	56.61	4	41
1049	27.58	85.52	1517	49071.4	4381	11.20	28.6	440	20743.1	47.14	7	41
1052	27.67	85.42	1330	53763.5	4398	12.22	32	445	21211.2	47.67	5	41
1054	28.17	85.32	1847	27556.8	4303	6.40	17	436	11162	25.60	16	41
1055	28.10	85.30	1982	62276.3	3686	16.90	40.4	371	18086.5	48.75	5	39
1057	28.02	85.12	1240	116114.3	4388	26.46	54	447	33776.8	75.56	12	41
1058	28.00	85.55	2480	117470.3	5216	22.52	55	525	40111	76.40	21	41
1059	27.70	85.42	1543	61800.7	4457	13.87	34.58	446	22379.2	50.18	6	40
1060	27.60	85.33	1448	48564.4	4088	11.88	29.4	411	20285.5	49.36	13	39
1101	27.68	86.10	850	44710.3	3233	13.83	32.18	324	15753.4	48.62	13	37
1102	27.67	86.05	1940	77126	5010	15.39	37.51	501	27010.9	53.91	9	41
1103	27.63	86.23	2003	87074.4	5401	16.12	40	543	30192.6	55.60	20	41
1104	27.52	86.05	1536	39449	3544	11.13	27.64	355	14612.9	41.16	7	40
1107	27.28	85.97	1463	92892.6	3952	23.51	51.09	396	35730.9	90.23	17	38
1108	27.18	86.17	1417	69262.2	4138	16.74	40	441	28283.6	64.14	12	41
1109	27.08	85.67	275	70150.8	2922	24.01	55.94	293	27341.5	93.32	5	41
1110	27.03	85.92	457	64483.2	2628	24.54	56.2	265	23538.2	88.82	7	41
1111	26.72	85.97	90	56260.1	2502	22.49	53.19	251	24063	95.87	8	41
1112	26.92	86.17	165	61521.5	2079	29.59	60.32	208	18573.1	89.29	11	41
1115	27.45	85.82	1098	31434	1811	17.36	40.4	183	11721.5	64.05	4	41
1117	27.33	85.50	250	82448.3	3156	26.12	56	317	31664.6	99.89	7	36
1202	27.70	86.72	2619	79686.1	5107	15.60	35.5	519	24924.4	48.02	18	41
1203	27.43	86.57	1982	66139.8	4164	15.88	40	418	22264.7	53.26	5	41
1204	27.35	86.75	2143	82421.1	4188	19.68	44.13	419	27844.3	66.45	9	41
1206	27.32	86.50	1720	66634.4	4787	13.92	38	480	27689.7	57.69	7	41

1207	27.48	86.42	1576	39098.6	2792	14.00	34	281	14686.4	52.26	4	41
1210	27.13	86.43	497	33528.1	2777	12.07	30.34	278	15660.4	56.33	8	41
1211	27.03	86.83	1295	44607.3	2909	15.33	38.12	291	18834.3	64.72	8	41
1213	26.93	86.52	1175	64905	3466	18.73	40.8	349	21892.1	62.73	12	39
1215	26.73	86.43	138	46863.5	2071	22.63	50	211	17171.2	81.38	3	38
1216	26.65	86.22	102	53868.8	2336	23.06	56.6	235	21273.3	90.52	4	41
1219	27.50	86.58	2378	62841.6	4901	12.82	29.2	493	20007.7	40.58	17	41
1222	27.22	86.80	1623	53641.9	3803	14.11	34.18	381	19683.1	51.66	9	41
1223	26.55	86.75	91	56132.3	2758	20.35	46.03	276	21037.2	76.22	12	41
1224	27.55	86.38	1662	65384.3	4263	15.34	33.88	427	20045.4	46.94	12	41
1226	26.60	86.90	85	60953	2614	23.32	58.7	262	23624.4	90.17	6	39
1301	27.55	87.28	1497	142400.6	5333	26.70	57	535	49749.6	92.99	8	39
1303	27.28	87.33	1329	48498.4	4203	11.54	28.5	429	18891.3	44.04	1	40
1304	27.05	87.28	1680	52649.1	4214	12.49	33.2	424	21848.3	51.53	9	39
1305	27.13	87.28	410	30284.7	2715	11.15	28	278	11853.7	42.64	2	40
1307	26.98	87.35	1210	33186.2	3629	9.14	24.32	363	16156.4	44.51	9	40
1308	26.93	87.33	365	37775	3091	12.22	32	311	17284.3	55.58	7	40
1309	26.93	87.15	143	58224.1	3747	15.54	41.64	375	25680.1	68.48	3	40
1311	26.82	87.28	444	79901.2	4226	18.91	48	428	34449.7	80.49	11	40
1312	26.62	87.38	152	77417.9	3380	22.90	59.71	338	31508.7	93.22	12	40
1314	27.13	87.55	1633	30309.9	2595	11.68	27.4	261	10732.9	41.12	3	39
1316	26.82	87.17	183	75017.6	3514	21.35	53.57	352	30864.5	87.68	6	40
1317	27.77	87.42	2590	76833	5623	13.66	30.4	564	23152.3	41.05	13	40
1319	26.48	87.27	72	72000	3809	18.90	51.02	381	32035.3	84.08	6	41
1320	26.70	87.27	200	64807.5	3567	18.17	49.34	357	28319.3	79.33	8	39
1321	27.28	87.22	303	42106.4	2787	15.11	39.34	279	14351.4	51.44	2	37
1322	26.97	87.17	158	40546	2796	14.50	35	282	16461.3	58.37	2	40
1325	27.37	87.15	1190	64740.4	3651	17.73	42.5	366	23830.9	65.11	5	40
1403	27.55	87.78	1780	77064.4	5864	13.14	31.4	590	24578.6	41.66	14	40

1406	27.20	87.93	1830	70458.7	5571	12.65	32	568	27307.8	48.08	19	39
1407	26.92	87.90	1300	55465.4	3411	16.26	41	348	22624.4	65.01	11	40
1408	26.67	87.70	163	90125.6	3428	26.29	63.5	344	34784.4	101.12	9	41
1409	26.63	87.98	122	96337.3	3608	26.70	67.06	361	37374.6	103.53	10	41
1410	26.88	88.03	1654	88831.6	4506	19.71	47.5	455	35508	78.04	12	41
1412	26.57	88.05	120	88103.1	3058	28.81	66	307	31631	103.03	13	41
1416	26.87	88.07	1678	109780.7	4597	23.88	60	461	45580	98.87	10	41
1420	27.35	87.60	763	49255.7	3333	14.78	32.78	334	14991.3	44.88	4	38

C - Calculated Values of All Analysed Parameters for Low Precipitation Months Period (November-April)

Annexe 3. All the units are per timeseries (years of data).

Station _ID	Latitude	Longitude	Elevation (m)	PRCPTOT (mm)	R0.1 (days)	PRCPTOT/R0.1 (mm/day)	R90 (mm)	R90d (days)	R90p (mm)	R90p/R90d (mm/day)	Rx3days (events)	Years with Data
101	29.65	80.50	842	7600.5	848	8.96	21.5	87	2845.7	32.71	0	40
102	29.55	80.42	1635	9663.2	821	11.77	26.9	83	3616.8	43.58	0	40
103	29.47	80.53	1266	8472.6	896	9.46	23.1	90	3375.3	37.50	0	40
104	29.30	80.58	1848	10021.4	1047	9.57	25.28	105	4092.5	38.98	2	40
105	29.03	80.22	176	4314.1	398	10.84	26	41	1675.9	40.88	0	37
106	28.68	80.35	159	4316.9	447	9.66	25.38	45	1716.6	38.15	0	40
107	29.85	80.57	1097	10704	1037	10.32	24.6	106	4043.3	38.14	1	40
108	29.53	80.47	2370	9390.3	909	10.33	25.06	91	3583.4	39.38	1	37
201	29.62	80.87	1456	10224.4	1266	8.08	21.45	127	4440.9	34.97	0	40
202	29.55	81.22	1304	10152.6	991	10.24	26	100	4033.8	40.34	1	39
203	29.27	80.98	1360	9195.5	775	11.87	28.3	79	3258.6	41.25	0	40
204	29.38	81.32	1400	10687.8	807	13.24	32.62	81	3872.1	47.80	0	37
205	29.00	81.13	1388	7778.9	563	13.82	37.82	57	3091.5	54.24	0	37
206	28.95	81.45	650	7769.3	744	10.44	26.17	75	3173.4	42.31	0	40
207	28.53	81.12	140	4649.4	474	9.81	23.17	48	2013.3	41.94	0	37
208	28.75	80.92	195	4682	439	10.67	26	45	1921.5	42.70	0	40
209	28.80	80.55	187	4396.3	551	7.98	20.4	56	2053.3	36.67	0	40
210	28.97	81.12	340	8158.2	627	13.01	31.14	63	3537.7	56.15	0	37
212	28.57	80.82	152	4107.4	374	10.98	25.7	38	1704.7	44.86	0	38
214	29.12	80.68	1304	9167.3	835	10.98	31.16	84	3860.5	45.96	0	38
215	28.87	80.63	288	5019.6	411	12.21	29	43	2043.3	47.52	0	38
217	29.15	81.28	1345	9524.3	698	13.65	35.49	70	3698.9	52.84	0	37
302	29.32	81.77	1006	7371.6	697	10.58	26	71	2643.4	37.23	0	40

303	29.28	82.17	2300	7777.7	1104	7.05	17.5	113	3300.6	29.21	2	39
304	29.28	82.32	3080	6287.9	976	6.44	15.25	98	2380.3	24.29	0	37
305	29.13	81.60	1210	8129.5	770	10.56	27.9	78	3317.6	42.53	0	38
308	29.20	81.90	1905	9871.8	1020	9.68	24	105	3767.1	35.88	1	40
309	29.23	81.63	1814	9306.4	756	12.31	26.95	76	2783	36.62	2	35
310	29.27	82.22	2310	6768.7	821	8.24	17.1	83	2272.9	27.38	0	38
312	28.93	82.92	2058	3046.7	490	6.22	13.46	49	1288.6	26.30	1	40
401	28.88	81.25	950	7093.5	587	12.08	28.78	59	2785.9	47.22	0	40
402	28.85	81.72	1402	6501.1	713	9.12	22	74	2324.7	31.41	0	40
403	28.78	81.33	260	5283.3	580	9.11	23.22	58	2127.2	36.68	2	38
404	28.70	82.20	1231	6947.5	506	13.73	32	51	2532.2	49.65	0	39
405	28.65	81.27	225	5068.8	518	9.79	23.59	52	2254.3	43.35	1	38
406	28.60	81.62	720	6327.6	686	9.22	26.05	69	2718.9	39.40	0	40
407	28.02	82.12	235	3280.3	312	10.51	27.89	32	1325.6	41.43	0	38
408	28.17	81.35	215	3487	342	10.20	22.93	35	1223.8	34.97	0	39
409	28.10	81.57	190	3357.1	388	8.65	21.49	39	1262.9	32.38	0	39
410	28.78	81.58	610	5246.4	456	11.51	28	48	1987.4	41.40	0	39
411	28.43	81.10	129	3891	281	13.85	31	29	1435.8	49.51	0	37
412	28.27	81.72	135	3309.7	335	9.88	23.2	34	1190.1	35.00	0	40
413	28.35	81.70	510	4176.9	302	13.83	31.18	31	1529.8	49.35	0	38
414	28.05	81.90	226	4638.9	307	15.11	24.5	37	1186.1	32.06	0	39
415	28.43	81.35	200	4117.5	479	8.60	21.54	48	1685.7	35.12	0	39
416	28.07	81.62	144	3681.1	357	10.31	24.7	36	1340.4	37.23	0	40
417	28.38	81.35	200	2962.6	295	10.04	24	32	1146.1	35.82	0	35
418	28.98	82.28	2000	7993.4	694	11.52	24.74	70	2684.2	38.35	1	38
419	28.03	81.78	195	3141.7	255	12.32	31.12	26	1077.5	41.44	0	35
501	28.60	82.63	1560	6842.5	720	9.50	24.42	72	2565.1	35.63	0	35
504	28.30	82.63	1270	7639.8	608	12.57	28.03	61	2827.9	46.36	0	40
505	28.10	82.87	823	5318.6	626	8.50	21.6	63	2126.4	33.75	0	40

507	28.22	82.12	698	4950.1	442	11.20	29.07	45	1957.9	43.51	0	40
508	28.13	82.30	725	4034.5	431	9.36	21.6	44	1524.7	34.65	0	40
510	27.70	82.53	320	3929.1	295	13.32	31.86	30	1429.7	47.66	0	40
511	28.38	82.17	1457	6106.9	581	10.51	26.7	59	2401	40.69	0	40
512	28.30	82.28	885	6007	573	10.48	27.94	58	2374.5	40.94	0	40
513	28.63	82.20	910	4905.1	674	7.28	20.38	68	2058.6	30.27	0	37
514	28.63	82.48	2100	6936.5	718	9.66	23.5	73	2585.7	35.42	0	40
601	28.78	83.72	2744	3117.6	610	5.11	12	65	1278.2	19.66	0	40
604	28.75	83.70	2566	4004.9	847	4.73	11.5	87	1635.5	18.80	0	39
605	28.27	83.60	984	6045.5	642	9.42	22	67	2260.3	33.74	0	38
606	28.48	83.65	1243	7853.5	1073	7.32	17.5	111	3080.3	27.75	0	40
607	28.63	83.60	2384	13609.2	1478	9.21	22.65	148	5418.6	36.61	0	40
608	28.82	83.88	3609	2279.8	506	4.51	9.5	54	737.3	13.65	0	39
609	28.35	83.57	835	5790.3	730	7.93	18.4	74	2213.5	29.91	0	40
610	29.05	83.88	3465	1455.2	221	6.58	15.3	23	540.6	23.50	0	36
613	28.18	83.75	1720	7425.1	773	9.61	21.9	78	2647.9	33.95	0	36
614	28.22	83.70	891	7476.8	780	9.59	23	82	2792.3	34.05	0	40
615	28.40	83.10	2273	5943.4	539	11.03	24.22	54	1944.5	36.01	0	36
616	28.60	83.22	2530	5862.9	690	8.50	20	76	2360.3	31.06	0	35
619	28.40	83.73	2742	9320.4	1165	8.00	19.42	117	3137.2	26.81	0	38
701	27.95	83.43	442	5253.7	446	11.78	25.5	45	2026.9	45.04	0	40
702	27.87	83.53	1067	4380.9	422	10.38	25.1	44	1698.1	38.59	0	38
703	27.70	83.47	205	4327.6	350	12.36	30	36	1619.4	44.98	0	40
704	27.68	84.05	150	5911.4	506	11.68	31.75	51	2483.2	48.69	0	40
705	27.52	83.43	109	3764.8	505	7.46	21	52	1687.3	32.45	0	40
706	27.68	84.22	154	5730.1	449	12.76	29.6	45	2125.6	47.24	1	40
707	27.53	83.47	120	3928.3	572	6.87	18.6	60	1854.8	30.91	0	40
708	27.53	83.67	125	4227.5	440	9.61	24.22	44	1595.7	36.27	0	38
710	27.58	83.87	164	4499	338	13.31	31.6	34	1807.8	53.17	0	39

715	27.93	83.15	1760	6655.5	740	8.99	24.03	74	3007.6	40.64	0	40
716	27.55	83.07	94	3329.3	352	9.46	22.95	36	1254.4	34.84	0	40
721	27.77	83.05	200	3954.8	372	10.63	22.93	38	1342.8	35.34	0	40
722	28.17	83.27	1280	7284.4	463	15.73	35.16	47	2322.5	49.41	0	40
723	27.68	82.80	80	4090.7	363	11.27	25	42	1566.4	37.30	0	39
801	28.37	84.90	1334	9383	745	12.59	31.8	75	3538	47.17	0	40
802	28.28	84.37	823	11857.3	1180	10.05	24.6	119	4904.8	41.22	0	40
804	28.22	84.00	827	11472.1	1340	8.56	22.91	134	4834.4	36.08	0	40
805	28.10	83.88	868	8854.6	889	9.96	25.32	89	3169	35.61	1	40
807	28.13	84.35	855	9995.6	746	13.40	33.3	75	3664.9	48.87	0	40
808	27.93	84.42	965	8045.6	653	12.32	28.94	66	2834.9	42.95	0	40
809	28.00	84.62	1097	7385.5	773	9.55	22.58	78	2774	35.56	1	40
810	27.88	83.82	460	6653.5	573	11.61	27	59	2394.4	40.58	0	40
811	28.12	84.12	856	10253	1167	8.79	22.88	117	4045.8	34.58	2	40
814	28.30	83.80	1740	12132.7	1605	7.56	20	166	5286	31.84	1	40
815	28.03	84.10	500	8591.6	854	10.06	25	87	3409.2	39.19	0	39
816	28.55	84.23	2680	8081.7	1128	7.16	16	114	2783.9	24.42	1	38
817	27.97	84.28	358	7964.2	692	11.51	28.19	70	3349.1	47.84	0	40
818	28.27	83.97	1070	11155.9	1135	9.83	25.22	114	4844.7	42.50	1	40
820	28.67	84.02	3420	4537.9	952	4.77	12.3	99	1856.2	18.75	1	38
821	28.38	83.80	1960	11231.2	1401	8.02	18.2	148	3991	26.97	1	36
823	28.20	84.62	1120	7737	779	9.93	26.02	78	2968.2	38.05	0	35
824	28.37	84.10	1820	19514.7	1840	10.61	25.41	184	8138.1	44.23	1	36
902	27.62	84.42	256	5312.5	647	8.21	22.94	65	2282.8	35.12	0	40
903	27.58	84.53	270	5719.6	485	11.79	27.6	49	2019.6	41.22	0	40
904	27.55	85.13	1706	7501	834	8.99	24	85	3312.3	38.97	0	40
905	27.60	85.08	2314	6249.6	597	10.47	24.62	60	2324	38.73	0	37
906	27.42	85.05	474	6024.3	723	8.33	21.98	73	2500.2	34.25	0	40
907	27.28	85.00	396	4281.1	340	12.59	30.82	34	1494.1	43.94	0	40

909	27.17	84.98	130	4266.6	518	8.24	21.48	52	1860.6	35.78	0	40
910	27.18	85.17	244	4471.4	509	8.78	21.36	51	1801.6	35.33	0	40
911	27.07	84.97	115	3607.3	414	8.71	20.5	43	1283.3	29.84	0	40
912	27.02	85.38	152	4184.2	401	10.43	22.5	43	1705.4	39.66	0	40
915	27.62	85.15	1530	7063.8	736	9.60	25	75	2964.1	39.52	0	40
918	27.00	84.87	91	3303.2	406	8.14	20.2	41	1303.6	31.80	0	38
919	27.42	85.17	1030	5385.5	546	9.86	21.85	55	1982	36.04	0	39
920	27.55	84.82	274	4727.9	499	9.47	24	51	1753.1	34.37	0	39
921	27.03	85.00	140	3553.8	304	11.69	28.82	31	1324.9	42.74	0	37
1001	28.28	85.38	1900	5529.5	617	8.96	17.48	62	2045.4	32.99	1	40
1004	27.92	85.17	1003	5369.2	576	9.32	20.45	58	1663.8	28.69	0	39
1005	27.87	84.93	1420	6997.7	580	12.07	28	60	2374.6	39.58	0	40
1006	27.87	85.87	2000	12272.5	855	14.35	27.3	86	3589	41.73	2	40
1007	27.80	85.25	2064	7165.1	859	8.34	20.2	87	2705.3	31.10	0	40
1008	27.80	85.62	1592	6312.2	832	7.59	20.36	84	2550.9	30.37	0	40
1009	27.78	85.72	1660	5566.5	728	7.65	19.72	73	2277.8	31.20	1	39
1015	27.68	85.20	1630	7417.7	640	11.59	28.05	64	2619.5	40.93	0	40
1016	27.95	85.60	2625	6734.9	797	8.45	20	83	2671.8	32.19	0	36
1017	27.87	85.57	1550	6799.6	861	7.90	19.4	87	2718.4	31.25	0	40
1018	27.78	85.57	845	5517.2	646	8.54	20.4	67	2001.6	29.87	0	40
1020	27.70	85.65	1365	3079.4	455	6.77	15.4	48	1245.6	25.95	0	37
1022	27.58	85.40	1400	6074.2	777	7.82	19.14	78	2573.4	32.99	0	40
1023	27.63	85.72	710	4833	710	6.81	17.03	71	1906	26.85	0	39
1024	27.62	85.55	1552	5164.2	622	8.30	19	64	1845.4	28.83	0	36
1025	27.92	85.63	1240	5133.2	550	9.33	24	56	1974.6	35.26	0	37
1027	27.78	85.90	1220	8195.5	978	8.38	21.03	98	3330.7	33.99	3	40
1029	27.67	85.33	1350	5403	777	6.95	17	80	2202.3	27.53	0	40
1030	27.70	85.37	1337	5838.7	881	6.63	16.8	89	2366.9	26.59	0	40
1035	27.75	85.48	1449	5524.8	595	9.29	22.5	64	1972.4	30.82	0	40

1036	27.68	85.63	865	4103.7	580	7.08	16.3	60	1661.6	27.69	0	39
1038	27.72	85.18	1085	5390.5	628	8.58	20.56	63	1965.3	31.20	0	40
1039	27.73	85.33	1335	4946	537	9.21	21.24	54	1806.5	33.45	0	38
1043	27.70	85.52	2163	5845.2	779	7.50	18	79	2241.6	28.37	0	40
1049	27.58	85.52	1517	5616.2	800	7.02	16	81	2458.1	30.35	0	40
1052	27.67	85.42	1330	5498.3	765	7.19	18	78	2206	28.28	0	40
1054	28.17	85.32	1847	4396.5	1179	3.73	9	122	1943.6	15.93	2	40
1055	28.10	85.30	1982	11127	1111	10.02	26	113	4177.2	36.97	0	38
1057	28.02	85.12	1240	7953.5	652	12.20	28.36	66	2756.9	41.77	0	40
1058	28.00	85.55	2480	8357.3	1079	7.75	19.02	108	3347.1	30.99	0	40
1059	27.70	85.42	1543	5768.8	815	7.08	17.52	82	2275.6	27.75	0	39
1060	27.60	85.33	1448	5217.8	707	7.38	19.14	71	2157.8	30.39	0	38
1101	27.68	86.10	850	4710.3	529	8.90	19.76	53	1720.4	32.46	0	36
1102	27.67	86.05	1940	6956.8	997	6.98	16	107	2699.2	25.23	0	40
1103	27.63	86.23	2003	7812	1162	6.72	17	119	3047.5	25.61	1	40
1104	27.52	86.05	1536	4422	599	7.38	17.42	60	1608.9	26.82	0	39
1107	27.28	85.97	1463	7149.7	561	12.74	30	60	2804	46.73	0	37
1108	27.18	86.17	1417	7320.7	719	10.18	25	73	2954.7	40.48	1	40
1109	27.08	85.67	275	4289.8	410	10.46	23.55	41	1495.9	36.49	0	40
1110	27.03	85.92	457	4028.1	346	11.64	25.05	35	1390.9	39.74	0	40
1111	26.72	85.97	90	3658.8	403	9.08	22.28	41	1391.6	33.94	0	40
1112	26.92	86.17	165	3370.8	246	13.70	28.75	25	1020.3	40.81	0	40
1115	27.45	85.82	1098	4105.1	337	12.18	26.58	34	1330.6	39.14	0	40
1117	27.33	85.50	250	4572.5	424	10.78	27.21	43	1559.3	36.26	0	35
1202	27.70	86.72	2619	6237.8	1041	5.99	14	109	2433.1	22.32	1	40
1203	27.43	86.57	1982	4735.6	689	6.87	15.84	69	1915.1	27.76	0	40
1204	27.35	86.75	2143	6527	621	10.51	22.9	63	2232.3	35.43	0	40
1206	27.32	86.50	1720	5357.6	927	5.78	14.6	94	2317	24.65	0	40
1207	27.48	86.42	1576	4061.4	488	8.32	19.79	49	1445.9	29.51	0	40

1210	27.13	86.43	497	4305.6	544	7.91	18.47	55	1859.8	33.81	0	40
1211	27.03	86.83	1295	4969.2	518	9.59	24.32	52	1953.9	37.58	0	40
1213	26.93	86.52	1175	4897	426	11.50	27.15	43	1832.3	42.61	0	38
1215	26.73	86.43	138	3519.9	304	11.58	25	37	1209.8	32.70	0	37
1216	26.65	86.22	102	3550.7	384	9.25	21.3	40	1265.2	31.63	0	40
1219	27.50	86.58	2378	4972	857	5.80	13.5	87	1928.9	22.17	0	40
1222	27.22	86.80	1623	5388.7	562	9.59	20.5	58	1914	33.00	0	40
1223	26.55	86.75	91	3705	362	10.23	25.58	37	1300.1	35.14	0	40
1224	27.55	86.38	1662	5830.2	779	7.48	15.62	78	1810.5	23.21	0	40
1226	26.60	86.90	85	4346.7	395	11.00	28	43	1720	40.00	0	38
1301	27.55	87.28	1497	19628.1	1454	13.50	32	149	8256.4	55.41	3	38
1303	27.28	87.33	1329	7028.4	880	7.99	19.82	88	2731.8	31.04	0	39
1304	27.05	87.28	1680	5406.1	731	7.40	18.2	74	2389.9	32.30	0	38
1305	27.13	87.28	410	5079.4	554	9.17	24	58	2235.7	38.55	0	39
1307	26.98	87.35	1210	4603.9	704	6.54	16.27	71	1956.7	27.56	0	39
1308	26.93	87.33	365	4733.7	545	8.69	20.56	55	2001.2	36.39	0	39
1309	26.93	87.15	143	4735.9	546	8.67	21.5	56	1973.3	35.24	0	39
1311	26.82	87.28	444	5734.6	569	10.08	26.6	57	2340.4	41.06	0	39
1312	26.62	87.38	152	5420	426	12.72	30.45	43	1881.3	43.75	0	39
1314	27.13	87.55	1633	5398.6	552	9.78	22.76	56	2043.2	36.49	0	38
1316	26.82	87.17	183	5600.1	559	10.02	24.34	56	2381	42.52	0	39
1317	27.77	87.42	2590	17633.4	1888	9.34	21	190	6416.4	33.77	0	39
1319	26.48	87.27	72	4226.4	544	7.77	21.44	55	1705.8	31.01	0	40
1320	26.70	87.27	200	4899.8	548	8.94	23.54	55	2061.2	37.48	0	38
1321	27.28	87.22	303	5419.7	469	11.56	29	48	1883.5	39.24	0	36
1322	26.97	87.17	158	3801.3	436	8.72	22.05	44	1463.2	33.25	0	39
1325	27.37	87.15	1190	6406.4	714	8.97	20.21	72	2166.7	30.09	0	39
1403	27.55	87.78	1780	9535.7	1489	6.40	15.52	149	3626.4	24.34	0	39
1406	27.20	87.93	1830	10031.5	1504	6.67	15.74	151	4171.9	27.63	1	38

1407	26.92	87.90	1300	4772.3	523	9.12	23	55	1868.3	33.97	0	39
1408	26.67	87.70	163	5624.5	516	10.90	27.4	52	2200.6	42.32	0	40
1409	26.63	87.98	122	5294.6	450	11.77	28.11	45	1795.4	39.90	0	40
1410	26.88	88.03	1654	7072.1	717	9.86	24	73	2900.8	39.74	0	40
1412	26.57	88.05	120	4775.5	395	12.09	32	41	1662	40.54	0	40
1416	26.87	88.07	1678	8143.4	930	8.76	22	95	3893.4	40.98	0	40
1420	27.35	87.60	763	8769.1	809	10.84	24.4	82	2787.6	34.00	0	37

D - Relationship of Precipitation Events with Increasing Elevation and Direction

Annexe 4. The values in bold are significant at 95%.

Events of an Entire Year								
Coefficient of Correlation	*PRCPTOT*	*R0.1*	*PRCPTOT/R0.1*	*R90*	*R90d*	*R90p*	*R90p/R90d*	*Rx3days*
Increasing Elevation	-0.04	**0.44**	**-0.58**	**-0.61**	**0.44**	**-0.17**	**-0.69**	**0.41**
Longitude towards East	**0.15**	**0.31**	-0.10	-0.10	**0.33**	**0.15**	-0.11	**0.25**
Events of High Precipitation Months								
Coefficient of Correlation	*PRCPTOT*	*R0.1*	*PRCPTOT/R0.1*	*R90*	*R90d*	*R90p*	*R90p/R90d*	*Rx3days*
Increasing Elevation	-0.08	**0.37**	**-0.56**	**-0.62**	**0.38**	**-0.22**	**-0.69**	**0.42**
Longitude towards East	**0.17**	**0.38**	-0.10	-0.10	**0.38**	**0.16**	-0.11	**0.24**
Events of Low Precipitation Months								
Coefficient of Correlation	*PRCPTOT*	*R0.1*	*PRCPTOT/R0.1*	*R90*	*R90d*	*R90p*	*R90p/R90d*	*Rx3days*
Increasing Elevation	**0.37**	**0.57**	**-0.42**	**-0.47**	**0.58**	**0.34**	**-0.46**	**0.23**
Longitude towards East	-0.05	0.08	**-0.24**	**-0.27**	0.09	-0.05	**-0.29**	-0.06

E - List of Finalised River Runoff Stations from the Koshi River Basin with Calculated Values of All Analysed Parameters

Annexe 5. All the units are per timeseries (years of data after filtration).

Year with Data	River	Latitude	Longitude	Station _ID	Station Code	Elevation (m)	Catchment Area (km^2)	R90 (m^3/s)	R90d (days)	R90p (m^3/s)	R90p/R90d ((m^3/s)/day)	Rx3days (events)
33	Khimti	27.58	86.20	650	17	1520	313	84.7	842	123359.0	146.51	99
33	Sabhaya	27.31	87.22	602	7	305	375	54.8	830	65337.1	78.72	91
32	Balephi	27.81	85.77	620	12	793	629	143.0	846	170718.0	201.79	86
23	Likhu	27.34	86.22	660	19	543	823	147.0	726	152627.0	210.23	77
27	Bhote Koshi	27.79	85.89	610	11	840	2410	203.0	854	265161.0	310.49	62
32	Tama Koshi	27.63	86.09	647	16	849	2753	432.0	849	483182.0	569.12	87
35	Dudh Koshi	27.27	86.66	670	22	460	4100	543.0	873	620924.0	711.25	94
33	Sun Koshi	27.56	85.75	630	14	589	4920	640.0	852	729157.0	855.82	84
34	Tamur	26.93	87.33	690	26	276	5640	835.0	873	1057241.0	1211.04	99
27	Sun Koshi	27.33	86.00	652	18	455	10000	1320.0	736	1342240.0	1823.70	71
23	Arun	27.59	87.34	600.1	6	1294	26750	676.0	862	767345.0	890.19	90
33	Arun	27.33	87.19	604.5	9	414	28200	1120.0	836	1247030.0	1491.66	94
22	Arun	26.93	87.15	606	10	152	30380	1320.0	808	1461380.0	1808.64	83
30	Saptakoshi	26.87	87.16	695	27	140	54100	3900.0	728	3555070.0	4883.34	81

F - List of Precipitation Stations Related with the River Runoff Stations from the Koshi River Basin

Station_ID	Station Code	Latitude	Longitude	Start Year	End Year	Years with Data
1317	1	27.77	87.42	1974	2014	40
1308	2	26.93	87.33	1974	2014	40
1301	3	27.55	87.28	1974	2013	39
1321	4	27.28	87.22	1978	2014	37
1322	5	26.97	87.17	1974	2014	40
1325	6	27.37	88.50	1974	2014	40
1309	7	26.93	88.50	1974	2014	40
1204	8	27.35	86.75	1974	2014	41
1103	9	27.63	86.23	1974	2014	41
1101	10	27.68	87.00	1978	2014	37
1104	11	27.52	86.50	1974	2014	40
1027	12	27.78	85.90	1974	2014	41
1006	13	27.87	85.87	1974	2014	41
1023	14	27.63	85.72	1974	2014	40
1009	15	27.78	85.72	1974	2013	40
1018	16	27.78	85.57	1974	2014	41
1316	17	26.82	87.17	1974	2014	40

G - Relationship of River Runoff Events with Increasing Elevation and Size of the Catchment Area

Annexe 6. The values in bold are significant at 95%.

Coefficient of Correlation	*R90*	*R90d*	*R90p*	*Rx3days*
Increasing Elevation	-0.50	0.37	-0.52	0.13
Increasing size of Catchment Area	**0.89**	-0.38	**0.90**	-0.03

H - Mann-Kendall Trend Test Table of Related Precipitation and River Runoff Stations (R90 and R90d)

Annexe 7. The values in bold are significant at 95%.

R90					R90d				
Station Code (Precipitation and River Runoff Stations)	Kendall's tau		p-value		Station Code (Precipitation and River Runoff Stations)	Kendall's tau		p-value	
1 and 6	-0.2	-0.47	0.071	**0.002**	1 and 6	-0.113	-0.367	0.331	**0.041**
3 and 6	-0.091	-0.47	0.425	**0.002**	3 and 6	-0.005	-0.367	0.973	**0.041**
2 and 26	0.056	0.385	0.616	**0.001**	2 and 26	-0.222	-0.008	0.059	0.969
4 and 7	0.033	0.182	0.784	0.141	4 and 7	-0.217	-0.11	0.079	0.44
17 and 27	-0.095	0.032	0.395	0.817	17 and 27	-0.224	-0.048	0.06	0.77
5 and 10	-0.175	-0.443	0.116	**0.004**	5 and 10	-0.1	0.216	0.391	0.242
7 and 10	0.008	-0.443	0.954	**0.004**	7 and 10	-0.196	0.216	0.098	0.242
6 and 9	0.053	0.235	0.641	0.057	6 and 9	-0.327	-0.081	**0.004**	0.577
8 and 22	-0.359	0.029	**0.001**	0.82	8 and 22	0.422	-0.176	**0**	0.212
9 and 17	0.218	-0.21	**0.046**	0.088	9 and 17	0.192	-0.225	0.097	0.112
10 and 16	-0.027	-0.004	0.824	0.987	10 and 16	-0.208	-0.228	0.089	0.124
11 and 18	-0.543	0.396	**< 0.0001**	**0.004**	11 and 18	-0.304	0.127	**0.008**	0.42
13 and 11	-0.438	-0.126	**< 0.0001**	0.37	13 and 11	0.353	-0.337	**0.002**	**0.032**
12 and 11	-0.148	-0.126	0.178	0.37	12 and 11	-0.041	-0.337	0.725	**0.032**
15 and 12	0.217	0.036	0.05	0.783	15 and 12	-0.461	-0.284	**< 0.0001**	**0.05**
16 and 14	0.151	-0.549	0.167	**< 0.0001**	16 and 14	-0.316	-0.091	**0.007**	0.545
14 and 14	0.085	-0.549	0.449	**< 0.0001**	14 and 14	-0.466	-0.091	**< 0.0001**	0.545

I - Mann-Kendall Trend Test Table of Related Precipitation and River Runoff Stations (R90p and Rx3days)

Annexe 8. The values in bold are significant at 95%.

R90p					Rx3days				
Station Code (Precipitation and River Runoff Stations)	Kendall's tau		p-value		Station Code (Precipitation and River Runoff Stations)	Kendall's tau		p-value	
1 and 6	-0.166	-0.391	0.129	**0.01**	1 and 6	-0.054	0.056	0.689	0.757
3 and 6	-0.189	-0.391	0.084	**0.01**	3 and 6	-0.182	0.056	0.165	0.757
2 and 26	-0.054	0.376	0.629	**0.002**	2 and 26	0.013	-0.142	0.933	0.287
4 and 7	-0.075	0.095	0.522	0.448	4 and 7	-0.028	-0.258	0.867	0.054
17 and 27	-0.254	-0.069	**0.02**	0.605	17 and 27	0.236	-0.146	0.078	0.298
5 and 10	-0.176	-0.411	0.108	**0.008**	5 and 10	-0.126	-0.193	0.352	0.248
7 and 10	-0.229	-0.411	**0.036**	**0.008**	7 and 10	0.012	-0.193	0.946	0.248
6 and 9	-0.259	0.197	**0.018**	0.111	6 and 9	-0.249	-0.118	0.06	0.388
8 and 22	-0.266	0.064	**0.015**	0.599	8 and 22	0.174	0.057	0.183	0.662
9 and 17	0.444	-0.318	**< 0.0001**	**0.01**	9 and 17	0.026	-0.13	0.843	0.33
10 and 16	-0.132	0.052	0.255	0.685	10 and 16	0.187	-0.048	0.17	0.735
11 and 18	-0.566	0.402	**< 0.0001**	**0.004**	11 and 18	-0.002	-0.158	1	0.291
13 and 11	-0.29	-0.14	**0.008**	0.317	13 and 11	0.284	-0.23	**0.022**	0.125
12 and 11	-0.288	-0.14	**0.008**	0.317	12 and 11	-0.058	-0.23	0.659	0.125
15 and 12	-0.095	0.02	0.387	0.884	15 and 12	-0.241	0.009	0.068	0.96
16 and 14	-0.244	-0.485	**0.025**	**< 0.0001**	16 and 14	-0.099	0.149	0.473	0.272
14 and 14	-0.261	-0.485	**0.017**	**< 0.0001**	14 and 14	-0.16	0.149	0.238	0.272

J - Relationship Between Precipitation Parameters and the BEST Index

Annexe 9. The values in bold are significant at 95%, where HPM is high precipitation months, and LPM is low precipitation months.

Parameters	Period	Coefficient of Correlation	p-value at 95%	In-Phase Relationship
PRCPTOT	All Months	-0.24	0.128	24
	HPM	**-0.43**	**0.005**	**29**
	LPM	**0.42**	**0.006**	**13**
R0.1	All Months	-0.07	0.669	22
	HPM	**-0.32**	**0.041**	**27**
	LPM	**0.41**	**0.009**	**12**
R90	All Months	**-0.38**	**0.015**	**30**
	HPM	**-0.35**	**0.023**	**31**
	LPM	0.02	0.888	18
R90d	All Months	-0.07	0.675	23
	HPM	-0.21	0.181	24
	LPM	0.27	0.097	15
R90p	All Months	-0.16	0.325	23
	HPM	**-0.31**	**0.046**	**27**
	LPM	0.26	0.112	15
Rx3days	All Months	0.10	0.540	21
	HPM	-0.04	0.822	24
	LPM	0.20	0.207	26

K - Relationship Between River Runoff Parameters and the BEST Index

Annexe 10. The values in bold are significant at 95%.

Parameters	Coefficient of Correlation	p-value at 95%	In-Phase Relationship
R90	0.08	0.663	19
R90d	-0.04	0.828	19
R90p	0.10	0.579	20
Rx3days	-0.11	0.520	21

L - Set of Modified and Developed 27 Items of 2-MEV for the First Survey in Nepali Language (Devanagari Script)

१) यदि कुनै दिन म संग खाली समय भए, म आफ्नो खुसिले वातावरण संरक्षणको लागि श्रमदान गर्न __________ ।

☐ कहिल्यै चाहन्न ☐ खासै चाहन्न ☐ चाहनपनि सक्छु नचाहनपनि सक्छु ☐ कहिले काहीं चाहन्छु ☐ सँधै चाहन्छु ☐ प्रश्न बुझिन / थाहा छैन

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२) म वृक्षरोपण कार्यक्रममा सहभागी हुन __________ ।

☐ कहिल्यै चाहन्न ☐ खासै चाहन्न ☐ चाहनपनि सक्छु नचाहनपनि सक्छु ☐ कहिले काहीं चाहन्छु ☐ सँधै चाहन्छु ☐ प्रश्न बुझिन / थाहा छैन

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३) म वातावरण सरसफाई कार्यक्रममा सहभागी हुन __________ ।

☐ कहिल्यै चाहन्न ☐ खासै चाहन्न ☐ चाहनपनि सक्छु नचाहनपनि सक्छु ☐ कहिले काहीं चाहन्छु ☐ सँधै चाहन्छु ☐ प्रश्न बुझिन / थाहा छैन

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४) म, मेरो समुदायमा वातावरण संरक्षण सम्बन्धि काम गर्न कोशिश गर्ने संस्थासंग संरक्षणको काम गर्न __________ ।

☐ कहिल्यै रुचाउदिन ☐ खासै रुचाउदिन ☐ रुचाउनपनि सक्छु नरुचाउनपनि सक्छु ☐ कहिले काहीं रुचाउँछु ☐ सँधै रुचाउँछु ☐ प्रश्न बुझिन / थाहा छैन

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५) म अरुलाई प्रकृति महत्वपुर्ण छ भनेर __________ ।

☐ कहिल्यै भन्दिन ☐ खासै भन्दिन ☐ भन्नपनि सक्छु नभन्न पनि सक्छु ☐ कहिले काहीं भन्छु ☐ सँधै भन्छु ☐ प्रश्न बुझिन / थाहा छैन

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६) एउटा रुख काटेपछि, त्यसको सट्टा म अर्को रुख रोप्ने प्रयास __________ ।

☐ कहिल्यै गर्दिन ☐ खासै गर्दिन ☐ गर्नपनि सक्छु नगर्न पनि सक्छु ☐ कहिले काहीं गर्छु ☐ सँधै गर्छु ☐ प्रश्न बुझिन / थाहा छैन

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७) म सँग भएको फोहोर म खोला-नालामा __________ ।

☐ कहिल्यै फाल्दिन ☐ खासै फाल्दिन ☐ फाल्नपनि सक्छु नफाल्नपनि सक्छु ☐ कहिले काहीं फाल्छु ☐ सँधै फाल्छु ☐ प्रश्न बुझिन / थाहा छैन

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८) म प्लास्टिकको फोहोर __________ ।

☐ कहिल्यै जलाउँदिन ☐ खासै जलाउँदिन ☐ जलाउनपनि सक्छु नजलाउनपनि सक्छु ☐ कहिले काहीं जलाउँछु ☐ सँधै जलाउँछु ☐ प्रश्न बुझिन / थाहा छैन

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९) म जंगली जनावरको बचाऊको लागि जंगलको संरक्षण गर्न __________ ।

☐ कहिल्यै रुचाउँदिन ☐ खासै रुचाउँदिन ☐ रुचाउँनपनि सक्छु नरुचाउँनपनि सक्छु ☐ कहिले काहीं रुचाउँछु ☐ सँधै रुचाउँछु ☐ प्रश्न बुझिन / थाहा छैन

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१०) रुख बिरुवा र जनावरको संरक्षणको लागि चाहिने जति जमिन __________ ।

☐ अलिकतिपनी छुट्याउनु हुँदैन | ☐ खासै छुट्याउनु हुँदैन | ☐ छुट्याएपनि हुन्छ नछुट्याएपनि हुन्छ | ☐ आवश्यकता अनुसार छुट्याउनुपर्छ | ☐ सँधै छुट्याउनैपर्छ

☐ प्रश्न बुझिन / थाहा छैन

११) जल प्रदूषण हुन नदीन, म खोलामा नुहाउँदा साबुन प्रयोग ______________ ।

☐ कहिल्यै गर्दिन ☐ खासै गर्दिन ☐ गर्नपनि सक्छु नगर्न पनि सक्छु ☐ कहिले काहीं गर्छु ☐ सँधै गर्छु ☐ प्रश्न बुझिन / थाहा छैन

१२) मलाई रुख (खर, पीपल) को छहारीमा बस्दा ________________ ।

☐ कहिल्यै आनन्द लाग्दैन ☐ खासै आनन्द लाग्दैन ☐ कहिलेकाहीं आनन्द लाग्छ कहिलेकाहीं लाग्दैन ☐ ठिकै आनन्द लाग्छ ☐ सँधै आनन्द लाग्छ ☐ प्रश्न बुझिन / थाहा छैन

१३) मलाई शहर भन्दा गाउँको वातावरण _______________ ।

☐ अलिकतिपनि मनपर्दैन ☐ खासै मनपर्दैन ☐ कहिलेकाहीं मनपर्छ कहिलेकाहीं मनपर्दैन ☐ ठिकै मनपर्छ ☐ एकदमै मनपर्छ ☐ प्रश्न बुझिन / थाहा छैन

१४) मलाई वन-जंगल अथवा डाँडा-काँडामा हिँड्दा ________________ ।

☐ अलिकतिपनि रमाइलो लाग्दैन ☐ खासै रमाइलो लाग्दैन ☐ कहिलेकाहीं रमाइलो लाग्छ कहिलेकाहीं लाग्दैन ☐ ठिकै रमाइलो लाग्छ ☐ एकदमै रमाइलो लाग्छ ☐ प्रश्न बुझिन/थाहा छैन

१५) मलाई खोलाको किनारमा बस्दा _______________ ।

☐ अलिकतिपनि आनन्द आउँदैन ☐ खासै आनन्द आउँदैन ☐ कहिलेकाहीं आनन्द आउँदैन कहिलेकाहीं आउँछ ☐ ठिकै आनन्द आउँछ ☐ एकदमै आनन्द आउँछ ☐ प्रश्न बुझिन/थाहा छैन

१६) मलाई रुखहरु सुसाएको सुन्दा _______________ ।

☐ अलिकतिपनि आनन्द आउँदैन ☐ खासै आनन्द आउँदैन ☐ कहिलेकाहीं आनन्द आउँदैन कहिलेकाहीं आउँछ ☐ ठिकै आनन्द आउँछ ☐ एकदमै आनन्द आउँछ ☐ प्रश्न बुझिन/थाहा छैन

१७) मलाई बगिरहेको खोलाको आवाज सुन्दा _______________ ।

☐ अलिकतिपनि रमाइलो लाग्दैन ☐ खासै रमाइलो लाग्दैन ☐ कहिलेकाहीं रमाइलो लाग्छ कहिलेकाहीं लाग्दैन ☐ ठिकै रमाइलो लाग्छ ☐ एकदमै रमाइलो लाग्छ ☐ प्रश्न बुझिन/थाहा छैन

१८) मानिसले आफ्नो चाहना अनुसार प्राकृतिक स्रोतको प्रयोग गर्न ______________ ।

☐ कुनैपनि हालतमा पाउनु हुँदैन ☐ चाहिएपनि पाउनु हुँदैन ☐ पाएपनि हुन्छ नपाएपनि हुन्छ ☐ अलि-अलि पाउनु पर्छ ☐ पुरै पाउनु पर्छ ☐ प्रश्न बुझिन/थाहा छैन

१९) मानिसले आफ्नो सुविधाको लागि प्रकृतिमा फेर बदल गर्न ________________ ।

☐ कुनैपनि हालतमा पाउनु हुँदैन ☐ चाहिएपनि पाउनु हुँदैन ☐ पाएपनि हुन्छ नपाएपनि हुन्छ ☐ अलि-अलि पाउनु पर्छ ☐ पुरै पाउनु पर्छ ☐ प्रश्न बुझिन/थाहा छैन

२०) **खेती गर्न वन फँडानी ________________ ।**

गर्नु एकदमै गलत हो | गर्नु हुँदैन | गरेपनि हुन्छ नगरेपनि हुन्छ | अलि-अलि गर्नुपर्छ | गर्नु एकदमै ठिक हो | प्रश्न बुझिन/थाहा छैन

२१) **मलाई बगैंचामा फुलेको भन्दा जंगलमा फुलेको फुल हेर्न ________________ ।**

अलिकतिपनि मनपर्दैन | खासै मनपर्दैन | कहिलेकाहीं मनपर्छ कहिलेकाहीं मनपर्दैन | ठीकठीकै मनपर्छ | एकदमै मनपर्छ | प्रश्न बुझिन /थाहा छैन

२२) **बाटो बनाउन वन-जंगल फँडानी गर्दा ________________ ।**

केहीपनि फरक पर्दैन | खासै फरक पर्दैन | फरक पर्न पनि सक्छ नपर्न पनि सक्छ | अलिक फरक पर्छ | एकदमै फरक पर्छ | प्रश्न बुझिन/थाहा छैन

२३) **कुनै बस्तीमा खोलाबाट असर पर्दा, खोला घुमाउनु ठिक कि मान्छेको बस्ति सारेको ठिक ?**

खोला घुमाउनु एकदम ठीक | बस्तीमा असर नपर्ने गरि खोला मिलाउनु ठीक | खोला र बस्ती दुइटै मिलाएको ठीक

खोलामा असर नपर्ने गरि बस्ति मिलाउनु ठीक | मान्छेको बस्ति सार्नु एकदम ठीक | प्रश्न बुझिन/थाहा छैन

२४) **लाम्खुट्टे दलदल, सिमसार, पानी जम्ने पोखरीमा बस्छ, त्यस्तो पोखरी सुकाएर खेती ________________ ।**

मजाले गरे हुन्छ | अलि-अलि गरे हुन्छ | गरे पनि हुन्छ नगरे पनि हुन्छ | नगरेकै राम्रो | गर्नै हुँदैन | प्रश्न बुझिन/थाहा छैन

२५) **घर पालुवा जनावर बचाउन जंगल फँडानी गरेर जंगली जनावरलाई धपाउनु ठीक हो ?**

जंगलमा असर परे पनि जंगली जनावरलाई धपाउनु एकदम ठीक हो | जंगलमा असर नपर्ने गरि जंगली जनावरलाई धपाउनु ठीक हो

जंगली जनावरलाई धपाए पनि ठीक नधपाए पनि ठीक हो | घर पालुवा जनावरलाई असर नपर्ने गरि जंगली जनावरलाई जंगलमा नै राखेको ठीक हो

जंगली जनवारलाई नाधपाएको नै एकदम ठिक हो | प्रश्न बुझिन/थाहा छैन

२६) **मानिस र प्रकृतिमा को ठुलो ?**

मानिस ठूलो | मानिस प्रकृति भन्दा अलिक ठूलो | मानिस र प्रकृति बराबर हुन् | प्रकृति मानिस भन्दा अलिक ठूलो | प्रकृति ठूलो | प्रश्न बुझिन/थाहा छैन

२७) **संसारको सबैभन्दा बुद्धिमानी प्राणी मान्छे भएकोले गर्दा, यो संसारमा मान्छेले मात्रै बाँच्न पाउनु पर्छ ?**

हो, मान्छेले मात्रै बाँच्न पाउनु पर्छ | मान्छेले अरु जीवलाई बाँच्न दिएपनि हुन्छ | मान्छे मात्रै बाँचे पनि ठीक, मान्छे अरु जीवसँग मिलेर बाँचे पनि ठीक

मान्छेले अरु जीवलाई दबाउन खोज्नु हुन्न | होइन, सबै जीवले मान्छे सरह बाँच्न पाउनु पर्छ | प्रश्न बुझिन/थाहा छैन

M - Set of Modified and Finalised 22 Items of 2-MEV for the Second Survey in Nepali Language (Devanagari Script)

1_ **यदि कुनै दिन म संग खाली समय भए, म आफ्नो खुसिले वातावरण संरक्षणको लागि श्रमदान गर्न** _______________.

कहिल्यै चाहन्न	खासै चाहन्न	चाहनपनि सक्छु नचाहनपनि सक्छु	कहिले काहीं चाहन्छु	सँधै चाहन्छु	प्रश्न बुझिन / थाहा छैन

2_ **म वृक्षरोपण कार्यक्रममा सहभागी हुन** _______________.

कहिल्यै चाहन्न	खासै चाहन्न	चाहनपनि सक्छु नचाहनपनि सक्छु	कहिले काहीं चाहन्छु	सँधै चाहन्छु	प्रश्न बुझिन / थाहा छैन

3_ **म वातावरण सरसफाई कार्यक्रममा सहभागी हुन** _______________.

कहिल्यै चाहन्न	खासै चाहन्न	चाहनपनि सक्छु नचाहनपनि सक्छु	कहिले काहीं चाहन्छु	सँधै चाहन्छु	प्रश्न बुझिन / थाहा छैन

4_ **म, मेरो समुदायमा वातावरण संरक्षण सम्बन्धि काम गर्न कोशिश गर्ने संस्थासंग संरक्षणको काम गर्न** _______________.

कहिल्यै रुचाउदिन	खासै रुचाउदिन	रुचाउनपनि सक्छु नरुचाउनपनि सक्छु	कहिले काहीं रुचाउँछु	सँधै रुचाउँछु	प्रश्न बुझिन / थाहा छैन

5_ **म अरुलाई प्रकृति महत्वपुर्ण छ भनेर** _______________.

कहिल्यै भन्दिन	खासै भन्दिन	भन्नपनि सक्छु नभन्न पनि सक्छु	कहिले काहीं भन्छु	सँधै भन्छु	प्रश्न बुझिन / थाहा छैन

6_ **एउटा रुख काटेपछि, त्यसको सट्टा म अर्को रुख रोप्ने प्रयास** _______________.

कहिल्यै गर्दिन	खासै गर्दिन	गर्नपनि सक्छु नगर्न पनि सक्छु	कहिले काहीं गर्छु	सँधै गर्छु	प्रश्न बुझिन / थाहा छैन

7_ **फोहोरहरू खोला-नालामा** _______________.

फाल्नु पर्छ	फाले हुन्छ	फालेपनी ठिक नाफालेपनी ठिक	नफालेको ठिक	फाल्नै हुँदैन	प्रश्न बुझिन / थाहा छैन

8_ **प्लास्टिकको फोहोर** _______________.

जलाउँनु पर्छ	जलाको ठिक	जलाएपनि ठिक नजलाएपनि ठिक	नजलाएको ठिक	जलाउँनु हुँदैन	प्रश्न बुझिन / थाहा छैन

9_ **म जंगली जनावरको बचाउको लागि जंगलको संरक्षण गर्न** _______________.

कहिल्यै रुचाउँदिन	खासै रुचाउँदिन	रुचाउँनपनि सक्छु नरुचाउँनपनि सक्छु	कहिले काहीं रुचाउँछु	सँधै रुचाउँछु	प्रश्न बुझिन / थाहा छैन

10_ **रुख बिरुवा र जनावरको संरक्षणको लागि चाहिने जति जमिन _______________ .**

☐ अलिकतिपनी छुट्याउनु हुँदैन | ☐ खासै छुट्याउनु हुँदैन | ☐ छुट्याएपनि हुन्छ नछुट्याएपनि हुन्छ | ☐ आवश्यकता अनुसार छुट्याउनुपर्छ | ☐ सँधै छुट्याउनैपर्छ

☐ प्रश्न बुझिन / थाहा छैन

11_ **खोलामा नुहाउँदा साबुन प्रयोग _____________________ .**

☐ गर्नु पर्छ ☐ गरे हुन्छ ☐ गरे पनि हुन्छ नगरे पनि हुन्छ ☐ नगरेको ठिक ☐ गर्नै हुदैन ☐ प्रश्न बुझिन / थाहा छैन

12_ **मलाई रुख (खर, पीपल) को छहारीमा बस्दा _______________ .**

☐ कहिल्यै आनन्द लाग्दैन ☐ खासै आनन्द लाग्दैन ☐ कहिलेकाहीँ आनन्द लाग्छ कहिलेकाहीँ लाग्दैन ☐ ठिकै आनन्द लाग्छ ☐ सँधै आनन्द लाग्छ

☐ प्रश्न बुझिन / थाहा छैन

13_ **मलाई शहर भन्दा गाउँको वातावरण _______________ .**

☐ अलिकतिपनि मनपर्दैन ☐ खासै मनपर्दैन ☐ कहिलेकाहीँ मनपर्छ कहिलेकाहीँ मनपर्दैन ☐ ठिकै मनपर्छ ☐ एकदमै मनपर्छ ☐ प्रश्न बुझिन / थाहा छैन

14_ **मलाई वन-जंगल अथवा डाँडा-काँडामा हिँड्दा _______________ .**

☐ अलिकतिपनि रमाइलो लाग्दैन ☐ खासै रमाइलो लाग्दैन ☐ कहिलेकाहीँ रमाइलो लाग्छ कहिलेकाहीँ लाग्दैन ☐ ठिकै रमाइलो लाग्छ ☐ एकदमै रमाइलो लाग्छ

☐ प्रश्न बुझिन/थाहा छैन

15_ **मलाई खोलाको किनारमा बस्दा _______________ .**

☐ अलिकतिपनि आनन्द आउँदैन ☐ खासै आनन्द आउँदैन ☐ कहिलेकाहीँ आनन्द आउँदैन कहिलेकाहीँ आउँछ ☐ ठिकै आनन्द आउँछ ☐ एकदमै आनन्द आउँछ

☐ प्रश्न बुझिन/थाहा छैन

16_ **मलाई रुखहरू सुसाएको सुन्दा _______________ .**

☐ अलिकतिपनि आनन्द आउँदैन ☐ खासै आनन्द आउँदैन ☐ कहिलेकाहीँ आनन्द आउँदैन कहिलेकाहीँ आउँछ ☐ ठिकै आनन्द आउँछ ☐ एकदमै आनन्द आउँछ

☐ प्रश्न बुझिन/थाहा छैन

17_ **मलाई बगिरहेको खोलाको आवाज सुन्दा _______________ .**

☐ अलिकतिपनि रमाइलो लाग्दैन ☐ खासै रमाइलो लाग्दैन ☐ कहिलेकाहीँ रमाइलो लाग्छ कहिलेकाहीँ लाग्दैन ☐ ठिकै रमाइलो लाग्छ ☐ एकदमै रमाइलो लाग्छ

☐ प्रश्न बुझिन/थाहा छैन

19) **वातावरणमा जस्तो सुकै असर परे पनि मानिसले आफ्नो चाहना अनुसार वातावरण परिवर्तन गर्न** ______________ ।
जस्तैः वन फँडानी। .

☐ पाउनु हुँदैन ☐ नपाए ठीक ☐ पाए पनि ठीक नपाए पनि ठीक ☐ पाएको ठीक ☐ पाउनु पर्छ ☐ प्रश्न बुझिन/थाहा छैन

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20) **खेती गर्न वन फँडानी** ________________ .

☐ गर्नु एकदमै गलत हो ☐ गर्नु हुदैन ☐ गरेपनि हुन्छ नगरेपनि हुन्छ ☐ अलि-अलि गर्नुपर्छ ☐ गर्नु एकदमै ठिक हो ☐ प्रश्न बुझिन/थाहा छैन

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22) **म बाटो बनाउन वन-जंगल फँडानी गर्ने कार्यको** ________________ .

☐ विरोध गर्दिन ☐ खासै विरोध गर्दिन ☐ विरोध गर्न पनि सक्छु नगर्न पनि सक्छु ☐ अलि-अलि विरोध गर्छु ☐ विरोध गर्छु ☐ प्रश्न बुझिन/थाहा छैन

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23) **कुनै बस्तीमा खोलाबाट असर पर्दा, खोला घुमाउनु ठीक कि मान्छेको बस्ती सारेको ठीक ?**

☐ खोला घुमाउनु एकदम ठीक ☐ बस्तीमा असर नपर्ने गरि खोला मिलाउनु ठीक ☐ खोला र बस्ती दुइटै मिलाएको ठीक

☐ खोलामा असर नपर्ने गरि बस्ति मिलाउनु ठीक ☐ मान्छेको बस्ति सार्नु एकदम ठीक ☐ प्रश्न बुझिन/थाहा छैन

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27) **मानिसले सबै जनावर र प्राणी सँग मिलेर** ______________________________ ?

☐ बस्नुपर्छ ☐ बसेको ठिक ☐ बसे पनि ठिक नबसे पनि ठिक ☐ नबसे पनि हुन्छ ☐ बस्नै हुदैन ☐ प्रश्न बुझिन/थाहा छैन

N – Data of First Survey for Validation of the 2-MEV Model

Annexe 11. S.N. represents number of children while in gender 1 is male and 2 is female.

S.N.	Gender	Age	Grade	Questions																										
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	1	13	8	3	4	5	5	5	5	5	5	5	5	4	4	4	3	4	2	5	5	5	4	4	2	3	2	1	3	2
2	1	13	8	5	5	5	5	5	4	5	1	5	4	5	3	4	2	5	6	2	5	4	1	4	5	4	2	4	1	3
3	1	13	8	5	5	3	5	5	3	5	1	3	4	5	5	5	4	1	4	1	3	5	4	4	2	2	2	2	2	1
4	1	13	8	3	4	5	4	4	5	2	4	4	6	5	4	5	5	4	2	2	1	1	4	5	1	2	5	2	3	1
5	1	13	8	5	5	5	4	4	4	5	2	6	4	2	4	5	5	5	5	3	4	4	2	5	2	1	4	4	4	3
6	1	13	9	4	5	5	5	4	5	4	1	5	4	4	5	4	5	4	5	5	4	4	4	1	2	5	1	3	1	1
7	1	13	9	4	5	5	4	4	5	4	5	5	4	4	5	5	5	5	5	5	5	5	2	1	1	5	1	3	1	1
8	1	14	8	5	5	5	5	5	5	5	1	5	4	5	5	4	4	4	5	4	5	5	1	5	1	1	1	4	1	1
10	1	14	8	4	4	5	5	5	5	5	2	5	1	5	5	5	4	3	2	5	2	4	1	1	2	5	1	2	5	4
11	1	14	8	5	4	5	5	5	5	5	5	5	4	5	4	5	2	4	2	5	4	4	2	2	1	2	5	2	3	1
12	1	14	8	4	5	5	3	4	5	5	2	4	4	5	5	5	5	3	3	5	4	1	1	4	1	1	5	2	3	1
13	1	14	8	4	5	4	3	5	4	4	5	3	4	5	5	5	5	3	3	5	4	1	1	4	1	1	5	2	3	1
14	1	14	8	4	4	5	2	4	5	5	4	5	4	5	4	5	4	5	5	5	4	2	1	2	2	3	2	2	3	1
15	1	14	8	4	5	5	6	5	5	5	1	5	4	5	5	5	5	2	6	5	5	5	2	2	3	3	1	2	3	1
16	1	14	8	4	5	5	6	5	5	5	1	5	4	5	5	5	5	2	6	5	5	5	2	1	3	3	1	2	3	1
17	1	14	8	5	4	3	6	5	5	5	3	5	4	5	3	5	5	4	4	4	4	4	1	1	1	5	1	2	1	1
18	1	14	8	3	5	2	5	5	5	3	6	5	4	2	5	5	5	4	5	5	3	5	1	2	4	3	2	4	3	1
19	1	14	9	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	1	5	5	1	1	1	1	1	1	2	5	1
20	1	14	9	6	5	5	5	5	5	5	1	5	4	6	5	5	5	5	5	5	5	5	5	1	1	1	1	2	1	1
21	1	14	9	4	4	4	4	5	5	1	1	4	4	2	4	5	5	5	4	5	5	5	4	1	2	3	1	2	2	1
22	1	14	9	5	5	5	5	4	5	5	1	5	5	5	5	5	4	2	2	4	5	5	2	5	1	4	2	3	1	1
23	1	14	9	4	5	5	5	5	5	5	3	5	4	4	4	5	4	5	5	4	4	1	1	2	2	4	5	2	3	1

24	1	15	8	4	4	5	5	4	5	5	4	5	4	2	4	5	4	4	5	5	5	2	1	1	1	3	2	2	3	1
25	1	15	8	5	5	5	5	5	5	1	1	4	4	2	2	3	3	4	3	4	3	3	5	1	1	3	1	4	1	3
26	1	15	8	5	5	5	5	6	5	1	1	5	4	1	4	2	3	1	3	5	5	4	4	4	2	6	4	6	3	3
27	1	15	8	5	5	5	4	4	4	3	3	4	4	3	5	4	3	2	5	3	2	2	2	4	2	4	4	4	3	4
28	1	15	8	5	5	5	5	5	5	5	5	5	4	5	4	5	4	3	5	5	5	1	1	1	1	6	6	1	3	1
29	1	15	8	5	5	5	5	5	5	5	5	5	4	5	5	5	4	3	5	5	5	1	1	2	1	2	6	1	3	1
30	1	15	8	5	5	5	1	5	5	1	1	1	6	1	1	3	5	5	5	5	5	5	2	4	2	4	5	3	5	1
31	1	15	9	5	4	5	4	5	5	4	4	5	5	4	5	4	2	2	4	2	4	5	5	1	2	4	5	2	1	1
32	1	15	9	5	5	5	5	5	5	1	1	2	5	1	4	5	5	5	3	4	4	5	5	1	2	4	5	2	5	1
33	1	15	9	5	5	5	5	5	5	5	1	5	4	1	5	5	5	5	5	5	5	4	2	1	5	2	5	2	3	1
34	1	15	9	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	6	5	4	2	2	1	3	4	1	1	1	1
35	1	15	9	5	5	5	5	5	5	5	5	5	5	1	4	5	5	5	3	4	4	4	1	2	2	4	5	2	5	1
36	1	15	9	5	5	5	5	5	5	5	5	5	5	3	5	5	5	4	5	2	5	4	1	2	3	3	5	2	5	1
37	1	15	9	4	5	5	5	5	5	5	1	5	4	5	5	5	5	5	6	5	5	5	1	3	3	4	5	2	4	1
38	1	15	9	5	5	5	5	4	5	5	1	5	5	5	5	5	5	5	5	5	5	5	2	1	1	1	2	3	1	1
39	1	15	9	5	5	5	5	5	5	5	1	5	5	5	5	5	5	5	5	5	4	1	2	1	1	1	1	1	1	1
40	1	15	9	4	5	5	5	5	5	5	1	5	4	5	4	5	5	2	5	5	4	4	2	1	1	4	1	1	3	3
41	1	16	8	3	3	4	1	4	5	1	1	5	4	1	5	4	5	5	6	4	6	4	6	2	4	4	3	4	4	6
42	1	16	8	4	4	4	5	5	1	5	1	4	4	2	5	5	4	5	5	3	5	4	1	2	3	3	2	2	3	1
43	1	16	8	3	5	4	5	5	5	5	3	5	4	4	5	4	5	3	4	5	5	3	2	1	3	3	1	2	1	4
44	1	16	9	5	5	5	5	5	5	5	1	5	4	5	5	4	5	4	5	4	5	5	1	2	3	4	1	2	3	1
45	1	16	9	4	5	5	5	5	5	5	1	5	4	1	4	5	5	2	5	5	5	5	2	1	1	4	1	1	1	1
46	1	16	9	4	5	5	5	5	5	1	3	5	6	4	2	5	3	4	4	2	5	5	1	2	2	4	5	2	3	3
47	1	16	9	4	5	5	5	2	5	4	1	5	5	2	4	5	5	4	4	5	5	4	2	6	2	1	1	2	2	1
48	1	16	9	4	5	5	5	5	4	5	3	5	4	4	4	5	4	4	5	4	4	1	1	2	2	4	5	2	3	4
49	1	17	9	3	3	4	4	6	3	2	1	2	6	5	5	4	5	4	4	4	2	5	5	2	5	4	1	3	3	1
50	1	18	9	5	3	5	5	4	5	1	1	3	4	3	5	4	4	4	4	5	5	5	2	5	5	4	1	5	2	4
51	2	12	8	6	5	5	5	5	5	5	1	5	4	2	5	4	5	4	5	5	5	6	2	2	2	3	5	2	3	1

52	2	12	8	5	5	5	5	4	3	5	3	3	4	4	4	4	4	3	3	5	4	4	1	2	1	6	2	2	3	1
53	2	12	8	5	5	5	5	5	5	5	1	5	4	4	4	5	5	4	4	2	5	5	1	2	1	6	2	1	3	1
54	2	12	8	5	5	5	5	5	4	5	2	5	6	5	5	5	5	4	4	5	4	5	1	2	2	1	5	2	3	1
55	2	12	8	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	5	5	2	1	1	4	1	2	1	1
56	2	12	8	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	4	5	1	1	1	4	1	2	3	1
57	2	12	8	5	4	5	4	3	5	1	1	5	4	1	4	5	5	5	4	5	5	5	2	2	3	6	6	2	3	1
58	2	13	8	6	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	5	5	1	2	1	3	6	4	3	1
59	2	13	8	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	5	5	2	4	1	3	6	4	3	1
60	2	13	8	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	4	5	1	1	3	2	1	2	3	1
61	2	13	8	5	4	5	5	5	5	5	5	5	2	1	5	5	4	2	4	4	4	5	1	1	2	4	2	2	3	1
62	2	13	8	6	5	5	5	4	3	5	2	5	4	5	5	5	5	5	5	5	4	6	2	2	1	3	1	2	3	1
63	2	13	8	5	5	5	5	1	5	5	1	1	1	5	4	5	4	5	5	5	5	5	2	1	2	5	1	2	3	3
64	2	13	8	5	5	5	5	4	4	5	4	4	6	5	5	5	4	4	5	5	5	5	2	4	2	6	6	2	1	1
65	2	13	8	5	4	5	5	5	1	5	1	5	4	2	5	5	5	5	5	4	5	5	2	2	1	4	5	2	5	3
66	2	13	8	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	5	5	2	1	1	4	1	2	3	3
67	2	13	8	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	5	5	2	1	1	4	1	2	3	1
68	2	13	8	5	5	5	5	5	5	5	1	5	4	5	4	5	4	3	5	5	5	5	2	1	1	4	5	2	3	1
69	2	13	8	5	5	5	5	5	5	1	1	5	4	5	4	5	5	5	5	5	4	5	1	1	1	4	1	2	3	1
70	2	13	8	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	4	5	1	1	1	4	1	2	3	1
71	2	13	9	3	5	4	2	2	3	5	2	1	6	4	4	5	4	4	4	3	6	6	5	2	5	3	6	6	2	1
72	2	13	9	5	4	5	4	4	5	2	1	4	4	4	5	5	5	5	5	5	4	4	2	1	2	3	2	2	3	1
73	2	13	9	5	4	5	5	5	4	5	5	5	4	5	5	5	5	5	5	5	4	1	1	1	1	3	5	2	1	1
74	2	14	8	5	5	5	6	4	5	5	6	6	4	5	4	4	4	1	6	1	5	6	2	6	6	6	6	2	3	3
75	2	14	8	5	5	5	5	1	6	1	1	5	4	5	5	5	5	5	5	5	5	5	2	2	1	4	2	2	3	1
76	2	14	8	5	5	5	5	5	5	2	2	5	1	2	5	5	5	5	5	5	3	5	2	2	1	4	1	1	3	1
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78	2	14	8	4	4	5	5	5	5	5	5	5	4	5	5	5	5	5	5	4	5	3	4	5	3	4	2	5	1	3
79	2	14	8	5	5	5	4	3	4	1	1	5	5	1	4	4	4	3	2	4	5	5	3	1	3	6	2	4	2	4

80	2	14	8	5	5	5	5	5	5	5	1	5	4	1	5	5	4	1	4	5	5	5	1	4	2	3	1	4	3	1
81	2	14	8	4	5	5	5	5	3	5	4	3	4	1	5	5	4	4	4	5	5	4	4	2	3	4	2	2	1	1
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92	2	14	9	5	5	5	5	5	5	5	1	5	6	5	5	5	5	5	5	5	5	6	1	4	3	4	2	1	1	1
93	2	14	9	5	5	5	5	4	5	5	1	5	5	5	5	5	5	4	5	5	5	1	1	2	1	1	5	1	1	1
94	2	15	8	5	5	5	5	5	5	5	5	6	5	5	4	5	5	4	5	5	5	6	2	1	1	2	1	4	3	3
95	2	15	8	5	5	5	5	4	5	5	6	5	4	5	1	4	3	3	3	5	5	5	2	1	6	6	6	2	3	3
96	2	15	8	5	5	5	5	4	5	1	5	6	4	5	4	4	6	1	3	1	5	6	2	6	6	6	5	2	5	3
97	2	15	8	4	4	4	5	5	1	5	1	5	4	1	5	5	4	4	4	4	5	5	1	2	1	2	2	2	3	1
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99	2	15	8	5	4	5	6	5	3	5	1	5	1	4	4	4	2	3	5	3	4	5	1	2	3	4	2	5	5	3
100	2	15	8	5	5	5	5	5	5	5	1	5	4	5	5	5	5	6	5	5	5	5	2	4	2	1	6	2	1	1
101	2	15	8	5	3	5	4	3	5	1	1	5	4	1	4	5	5	5	6	5	5	5	2	2	3	6	6	2	4	3
102	2	15	9	4	3	4	4	4	4	5	2	4	4	2	4	4	4	5	3	5	5	5	2	2	2	1	3	2	3	4
103	2	15	9	5	5	5	5	4	4	5	2	5	1	4	4	4	2	4	4	5	3	4	2	4	3	3	1	1	3	1
104	2	15	9	5	5	5	5	5	5	1	1	5	5	6	4	5	5	5	5	5	5	5	2	4	1	1	6	3	5	6
105	2	15	9	5	5	6	5	5	5	1	1	5	5	6	4	5	4	5	5	5	5	5	3	1	1	1	6	4	5	6
106	2	15	9	5	5	5	5	4	5	5	1	5	4	5	5	5	5	5	4	5	5	6	1	1	1	3	2	4	5	1
107	2	15	9	5	5	4	6	5	5	5	5	5	4	3	3	5	5	5	5	6	5	2	2	4	1	4	1	2	2	1

108	2	15	9	5	5	5	5	5	5	1	1	3	4	1	5	3	2	4	2	4	5	5	3	1	1	6	1	5	1	1
109	2	15	9	5	5	4	5	5	4	5	4	4	5	1	5	5	4	5	5	5	5	5	2	1	4	1	6	1	1	1
110	2	15	9	5	5	5	5	4	5	5	1	5	4	5	5	5	5	5	4	5	5	6	2	2	4	4	2	4	1	1
111	2	15	9	5	4	5	4	4	5	2	1	4	4	1	5	5	5	5	5	5	5	4	2	4	1	4	2	4	2	2
112	2	16	8	5	4	5	3	4	1	5	4	3	2	5	5	3	5	3	4	2	3	3	2	4	4	5	4	2	6	3
113	2	16	8	4	5	5	3	2	5	1	5	3	4	5	3	5	1	5	2	1	5	6	2	4	2	4	1	3	1	4
114	2	16	8	5	5	4	5	4	5	5	1	2	4	1	5	5	5	2	5	5	6	5	1	2	5	6	5	2	3	1
115	2	16	9	5	5	5	5	5	1	1	1	5	4	5	5	5	5	5	5	5	1	1	1	1	1	1	1	5	1	1
116	2	16	9	5	5	5	5	5	5	5	1	5	4	2	5	5	5	5	1	4	5	5	2	2	2	3	2	1	2	1
117	2	16	9	5	5	5	4	5	5	1	1	5	4	1	5	5	4	5	4	5	5	5	3	1	1	6	1	1	3	1
118	2	17	8	4	5	5	6	6	5	1	1	5	5	1	5	5	4	4	5	4	4	5	5	1	1	3	1	6	1	6
119	1	13	9	5	5	5	5	5	5	5	1	5	4	5	4	5	5	5	5	5	4	2	4	2	2	3	3	4	3	1
120	1	14	9	5	3	5	5	5	5	5	1	5	4	1	4	5	4	5	5	4	4	5	4	4	1	3	3	5	3	3
121	1	14	9	6	3	3	6	6	4	6	6	4	4	2	6	3	3	2	6	6	4	6	6	2	3	4	1	6	4	6
122	1	14	9	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	2	2	1	4	1	6	5	2	1	1
123	1	15	9	5	5	5	4	5	5	1	1	5	3	4	5	5	5	5	5	4	5	5	2	4	1	1	1	2	3	1
124	1	15	9	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	2	2	1	4	1	1	5	2	1	1
125	1	15	9	5	5	5	5	4	5	5	5	5	4	5	5	4	5	4	5	5	5	1	1	4	1	4	1	4	3	3
126	1	15	10	5	5	5	5	5	5	5	1	5	4	5	5	5	5	2	5	5	5	6	1	1	1	5	1	4	1	3
127	1	15	10	5	5	5	5	4	5	1	1	5	4	1	2	5	3	4	2	2	5	1	2	4	1	1	5	4	1	1
128	1	16	9	3	3	4	3	3	4	5	3	4	4	2	4	4	3	3	4	3	4	6	1	2	2	1	2	1	6	6
129	1	16	9	5	5	5	5	5	5	5	1	5	4	5	4	4	4	4	4	4	4	4	3	3	2	4	3	2	3	1
130	1	16	9	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	5	2	2	2	2	3	4	4	3	1
131	1	16	9	5	4	5	2	5	5	1	2	3	2	2	5	4	4	4	3	4	5	4	1	3	1	2	5	1	3	1
132	1	16	9	5	5	5	5	5	5	5	5	5	4	5	4	5	5	4	5	5	5	5	1	4	1	4	5	4	1	1
133	1	16	9	5	3	5	2	5	5	1	5	5	2	5	4	5	5	2	1	5	4	6	1	5	1	5	6	4	2	3
134	1	16	9	5	5	5	5	5	5	5	5	5	4	1	5	5	5	5	5	5	5	2	2	1	1	2	1	2	3	1
135	1	16	10	5	5	5	5	4	5	4	2	4	4	2	4	5	4	3	4	4	4	4	4	2	1	4	3	2	1	1

136	1	16	10	5	5	4	5	5	5	5	4	5	4	5	5	5	3	5	3	4	1	1	1	2	2	4	3	1	2	1
137	1	16	10	4	5	4	2	4	3	5	4	4	4	2	5	5	4	2	5	4	5	5	2	1	4	1	4	2	3	1
138	1	16	10	4	5	5	5	5	5	1	5	5	4	6	2	5	4	2	2	5	1	1	2	1	1	4	5	2	1	1
139	1	16	10	4	5	5	5	5	5	5	5	5	4	6	4	5	4	5	5	5	5	1	1	1	1	1	5	2	2	3
140	1	17	9	4	4	4	5	3	3	2	2	3	3	3	4	4	4	3	4	4	4	4	1	2	2	1	3	2	4	1
141	1	17	9	2	5	5	5	4	3	2	1	5	4	1	4	5	1	2	1	3	5	4	5	1	2	4	4	2	2	3
142	1	17	9	5	2	5	4	5	2	5	1	5	5	5	5	5	4	4	5	5	5	2	2	1	1	4	1	2	3	1
143	1	17	10	4	4	5	5	4	4	5	5	5	4	5	5	5	4	5	5	4	5	6	2	2	4	1	5	2	3	1
144	1	17	10	5	5	5	3	4	5	5	2	5	4	6	2	5	1	3	1	5	6	5	4	2	1	4	5	4	3	1
145	1	17	10	5	4	4	5	5	5	5	5	5	4	4	5	5	5	1	5	5	4	4	4	1	1	3	6	2	5	1
146	1	17	10	5	5	4	5	5	5	5	2	5	4	5	5	5	5	4	5	3	4	1	1	1	2	4	3	1	2	1
147	1	17	10	5	5	4	5	4	5	2	1	4	4	5	5	5	5	4	4	4	4	4	1	2	1	1	5	2	1	1
148	1	17	10	5	5	5	5	4	4	5	3	5	4	2	5	3	3	3	5	4	4	4	4	3	2	3	3	2	3	1
149	1	18	10	5	4	5	3	5	4	5	4	5	4	5	5	5	4	5	5	5	4	4	2	2	1	2	4	2	2	1
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151	1	18	10	5	5	4	5	5	5	2	2	5	4	5	5	5	4	5	5	5	4	5	2	1	1	3	5	2	1	1
152	1	19	10	4	5	5	5	5	5	1	1	5	4	5	5	5	1	5	5	5	1	1	1	1	2	1	5	1	5	1
153	2	13	9	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	4	1	2	1	1	1	1	1	1	1
154	2	13	9	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	4	1	2	6	1	1	1	1	1	1
155	2	13	10	5	5	4	5	5	5	5	1	5	4	4	5	5	4	4	5	2	4	4	1	1	2	4	5	2	3	1
156	2	13	10	4	5	5	5	5	5	5	4	5	4	5	5	5	5	5	5	5	4	4	2	1	1	4	5	2	3	1
157	2	14	9	5	5	5	5	5	5	1	5	5	5	5	5	5	4	2	5	5	5	5	4	1	1	3	6	6	5	6
158	2	14	9	5	4	5	4	5	5	5	1	5	4	2	5	5	5	5	5	5	5	1	4	1	3	3	5	2	1	1
159	2	14	9	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	6	1	2	1	4	1	2	3	3
160	2	14	9	5	5	5	5	5	5	5	5	5	5	5	5	5	4	2	5	5	5	6	2	1	1	3	5	1	2	1
161	2	14	9	5	4	5	2	5	5	5	1	5	1	1	5	5	4	4	2	1	5	5	1	5	1	1	5	5	2	5
162	2	14	9	3	3	5	5	5	5	5	1	5	6	5	5	5	5	5	5	5	5	6	2	2	1	2	1	5	3	1
163	2	14	9	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	4	1	1	3	1	1	1	2	3	1

164	2	14	9	5	5	3	6	4	5	5	1	5	3	5	5	5	5	5	3	3	5	3	5	4	1	3	1	4	1	1
165	2	14	10	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	1	2	2	1	2	5	1	3	1
166	2	14	10	3	3	3	4	2	3	5	5	1	1	5	1	1	2	3	1	1	3	1	1	1	3	4	4	5	3	4
167	2	14	10	5	4	5	4	5	4	1	1	2	6	5	2	5	3	4	4	2	5	2	2	5	3	6	2	2	3	1
168	2	14	10	5	5	5	5	5	5	5	6	5	4	6	5	5	5	5	5	5	5	1	2	2	1	2	5	1	3	1
169	2	14	10	5	5	5	5	5	5	5	1	5	4	6	5	5	5	5	5	5	5	5	2	1	1	4	5	2	3	1
170	2	14	10	3	5	5	5	5	5	5	5	5	4	5	5	5	5	5	1	5	5	4	2	2	1	5	5	2	1	1
171	2	15	9	5	5	5	5	5	5	1	5	5	5	5	5	5	4	2	5	5	5	5	4	1	1	3	6	2	3	1
172	2	15	9	5	5	5	5	5	5	5	1	5	6	5	4	5	4	4	4	4	2	2	1	1	4	5	1	5	3	1
173	2	15	9	3	3	4	4	4	5	5	1	5	6	5	5	5	5	5	5	5	5	4	2	2	1	2	1	5	3	1
174	2	15	9	5	5	5	5	5	5	1	1	5	5	1	5	5	5	5	5	5	5	5	1	1	1	3	1	2	1	4
175	2	15	9	5	5	5	5	5	6	1	1	5	5	1	5	5	5	5	5	5	5	5	5	1	1	3	1	2	1	4
176	2	15	9	5	5	5	4	5	5	5	1	5	5	4	5	5	5	5	5	5	6	4	1	1	1	5	5	2	1	1
177	2	15	9	5	5	5	5	4	5	5	5	5	4	5	5	5	5	5	5	5	5	1	1	2	1	4	1	2	1	1
178	2	15	10	5	5	5	5	5	5	5	5	5	4	4	5	5	3	5	1	5	4	4	2	1	1	4	2	2	3	1
179	2	15	10	5	5	4	5	4	3	1	1	4	1	2	4	5	5	5	5	5	4	5	4	1	2	5	4	2	3	3
180	2	15	10	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	5	1	2	1	1	4	5	1	3	1
181	2	15	10	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	5	1	1	1	1	2	5	1	3	1
182	2	15	10	6	4	5	6	4	4	5	5	5	6	6	5	5	5	4	6	4	6	6	1	1	6	6	6	6	3	1
183	2	15	10	5	5	5	5	5	5	4	1	5	5	5	5	5	5	5	5	5	5	1	2	2	1	2	5	1	3	1
184	2	15	10	5	5	5	5	2	5	5	1	5	5	6	5	6	5	4	4	4	4	4	1	4	1	4	4	2	2	1
185	2	15	10	5	5	5	5	5	5	5	1	5	4	6	5	5	5	5	5	5	5	5	2	1	1	4	2	5	3	1
186	2	15	10	4	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	4	4	4	1	1	2	4	5	2	3	1
187	2	16	9	5	5	5	5	5	5	5	1	5	6	5	4	5	2	4	5	5	2	2	1	1	4	5	1	5	3	1
188	2	16	9	4	3	4	2	4	4	6	2	4	4	5	4	5	4	4	4	4	4	5	2	1	1	1	1	3	5	1
189	2	16	9	5	4	5	4	1	5	1	1	4	5	2	5	5	4	5	3	4	4	2	4	1	4	5	4	2	1	1
190	2	16	9	5	5	5	5	5	5	1	1	5	4	1	4	5	5	4	4	5	5	3	1	1	1	3	1	1	1	1
191	2	16	10	5	5	5	5	5	5	5	1	5	4	5	5	5	5	5	5	5	5	1	2	2	1	2	5	1	3	1

192	2	16	10	5	5	4	5	5	5	5	5	5	4	6	4	5	4	3	5	4	5	5	1	1	3	1	5	2	3	1
193	2	16	10	1	4	5	5	4	4	1	5	3	4	5	4	5	5	4	4	4	5	4	2	4	4	4	2	6	3	1
194	2	16	10	1	5	5	5	5	4	1	2	4	4	0	0	0	0	0	0	0	0	0	5	2	4	5	2	3	3	1
195	2	16	10	5	5	5	5	6	5	6	1	6	6	1	5	5	4	6	5	5	5	6	6	6	6	4	6	6	6	6
196	2	17	9	5	5	5	6	6	4	1	5	5	5	1	5	4	4	4	4	4	4	5	2	1	2	4	1	6	2	6
197	2	17	10	5	5	5	5	5	5	5	1	5	5	5	5	5	5	5	5	5	5	1	1	2	1	1	3	1	5	3
198	2	17	10	5	5	5	4	5	5	1	1	5	4	2	4	5	5	5	5	5	5	5	4	1	1	1	5	2	3	1
199	2	17	10	5	5	4	4	4	3	1	1	4	4	1	5	5	2	5	4	3	2	2	1	3	3	3	6	4	1	1
200	2	17	10	6	3	5	5	5	5	1	1	4	4	6	5	5	5	5	5	5	6	6	1	1	3	4	5	2	1	3

O – Data of Second Survey for Validation of the 2-MEV Model

Annexe 12. S.N. represents number of children while in gender 1 is male and 2 is female.

S.N.	Gender	Age	Grade	Questions																					
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	22	23	27
1	1	14	8	3	3	5	5	5	5	3	5	5	4	3	3	5	5	5	4	5	5	2	5	4	4
2	1	14	8	4	5	4	4	4	5	1	1	4	4	2	2	5	5	5	4	4	1	1	5	2	1
3	1	13	8	5	5	5	5	5	5	1	1	5	4	2	4	5	4	5	5	5	1	2	5	2	5
4	1	14	8	5	5	5	5	5	5	1	5	5	5	1	5	5	5	5	5	5	1	4	5	3	5
5	1	14	8	5	5	5	5	5	5	1	5	5	5	1	5	5	5	5	5	5	1	4	5	3	5
6	1	13	8	4	5	3	3	5	5	2	2	4	4	4	5	5	4	2	4	2	1	1	2	3	4
7	2	17	8	2	4	5	3	1	3	2	5	5	4	3	5	4	4	5	1	5	1	4	5	5	5
8	1	14	8	3	5	3	2	5	5	1	3	5	4	2	5	5	5	1	5	5	3	4	2	3	2
9	1	14	8	5	4	5	5	4	5	1	4	5	4	3	4	5	5	5	2	5	2	2	5	1	4
10	2	14	8	5	5	5	5	5	5	1	5	5	4	1	5	5	5	5	5	5	1	1	5	4	5
11	2	13	8	5	5	5	5	5	5	1	5	5	4	1	5	5	5	5	5	5	1	1	5	4	5
12	2	13	8	4	4	5	4	5	5	1	4	4	1	5	4	5	4	4	5	5	1	1	5	4	5
13	2	13	8	5	5	5	5	5	5	1	4	5	4	5	4	5	4	4	4	4	5	1	5	4	5
14	2	14	8	4	4	5	5	5	5	1	1	5	4	1	5	5	5	5	5	5	1	1	1	3	5
15	2	14	8	5	4	5	5	5	5	1	5	5	4	1	5	5	5	5	3	5	1	1	1	3	5
16	1	14	8	5	4	5	4	4	5	1	5	5	1	5	5	4	3	4	5	5	5	1	5	5	5
17	2	12	8	4	4	3	4	5	5	2	4	5	4	2	4	5	4	4	2	2	5	2	5	3	5
18	2	15	8	4	5	5	4	5	3	1	1	5	4	1	5	5	4	5	3	4	5	1	5	3	4
19	2	12	8	5	5	5	5	5	5	2	5	5	4	3	5	5	5	5	5	4	1	2	5	5	4
20	1	15	8	5	5	5	5	4	5	1	1	4	4	3	5	5	5	4	5	5	5	4	4	4	5
21	2	12	8	5	5	5	5	5	5	1	5	5	4	1	5	5	5	4	5	5	1	2	5	2	5
22	2	15	8	3	5	5	5	5	5	1	5	5	4	1	5	5	4	4	4	5	1	1	5	1	3

23	1	14	8	5	5	5	4	5	5	2	4	4	4	5	5	5	1	5	5	5	5	2	5	1	1
24	2	14	8	3	5	5	5	5	5	1	1	5	4	5	4	5	3	4	5	5	1	1	1	3	3
25	2	14	8	4	4	4	3	4	5	2	1	4	4	1	4	5	4	4	5	4	1	2	5	3	4
26	2	14	8	4	5	5	5	5	5	2	5	5	4	3	5	5	5	5	5	5	1	1	5	5	4
27	2	12	8	5	5	5	4	5	5	1	5	5	4	5	5	5	5	5	2	5	1	2	1	1	5
28	2	15	8	5	5	5	4	5	5	1	5	5	4	5	5	5	5	5	2	5	2	2	1	1	5
29	1	15	8	5	5	5	4	4	5	1	1	5	4	5	5	5	5	5	5	4	5	1	4	4	5
30	1	15	8	5	5	5	5	5	5	1	2	5	4	1	4	5	5	5	4	4	1	2	2	3	5
31	1	15	8	4	4	4	4	4	3	6	2	4	4	2	3	3	4	3	4	2	5	4	3	6	2
32	1	13	8	4	5	4	2	4	4	1	5	6	6	6	5	5	5	2	5	5	5	1	6	3	3
33	1	14	8	5	5	5	5	5	5	1	5	5	4	1	4	5	5	5	4	4	1	2	2	3	5
34	1	16	8	5	5	5	5	5	5	1	5	5	4	2	4	3	3	4	4	5	1	2	5	5	4
35	2	15	8	5	5	5	5	5	5	1	1	5	4	5	5	5	5	5	5	5	5	1	5	4	5
36	2	13	8	5	5	5	5	5	5	1	5	5	4	5	5	5	5	5	5	5	5	1	5	4	5
37	1	16	8	5	5	5	5	4	5	1	4	5	4	2	3	5	3	3	4	5	2	2	1	5	5
38	2	15	8	5	4	5	5	5	5	1	4	5	4	5	5	5	5	4	2	2	1	1	2	2	5
39	2	14	8	5	5	5	5	4	4	1	1	4	4	1	5	5	4	5	5	4	1	1	5	5	5
40	2	16	8	5	4	5	5	5	3	1	5	4	6	5	5	6	5	4	4	5	1	1	2	2	5
41	2	14	8	5	5	5	5	5	5	1	1	5	4	1	5	5	5	5	5	5	1	1	5	1	3
42	1	14	8	4	5	4	5	5	5	1	3	5	4	2	4	5	3	4	1	4	4	1	1	5	5
43	2	13	8	5	5	5	5	5	5	1	5	5	4	1	5	5	4	5	5	5	1	2	5	3	5
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198	2	15	10	5	5	5	5	5	5	2	4	5	4	5	5	5	5	2	4	5	2	2	5	5	3
199	2	16	10	5	4	5	3	5	5	2	5	5	4	2	5	4	4	5	5	4	2	1	2	2	5
200	1	15	10	5	4	5	5	5	4	1	5	4	5	5	5	5	5	4	4	4	1	1	5	3	3
201	1	15	10	5	4	5	5	4	5	1	1	5	4	5	5	5	3	5	5	5	1	3	5	3	4

P – Data of Final Survey of the 2-MEV Model

Annexe 13. S.N. represents number of children while in gender 1 is male and 2 is female.

S.N.	Gender	Age	Grade	Questions														
				2	4	5	10	22	27	13	15	17	8	19	20	7	11	23
1	1	14	8	5	4	4	4	5	4	5	2	2	4	6	2	2	3	4
2	1	13	8	5	5	5	3	1	5	5	4	5	5	5	1	1	1	2
3	1	13	8	5	5	5	4	1	4	4	4	4	1	5	2	1	1	1
4	1	13	8	5	5	5	1	1	5	1	6	1	1	5	5	5	5	3
5	1	15	8	5	5	4	5	1	3	5	5	5	2	5	5	2	3	6
6	1	16	8	5	4	2	4	1	3	5	1	4	5	6	2	1	5	4
7	1	15	8	5	5	4	4	1	6	4	5	5	1	5	5	1	1	5
8	1	13	8	5	5	3	4	4	3	2	1	5	5	4	1	2	5	4
9	2	12	8	5	3	4	4	3	3	3	2	3	1	3	2	2	5	5
10	2	12	8	5	3	4	4	3	3	3	2	3	1	3	2	2	5	5
11	2	13	8	5	5	4	4	3	3	3	5	3	1	3	2	2	5	5
12	2	15	8	5	3	4	5	3	5	3	4	3	5	3	2	1	5	5
13	2	13	8	5	5	4	4	1	5	5	5	5	5	5	5	1	5	5
14	1	13	8	5	5	4	4	1	5	5	5	5	5	5	5	1	5	5
15	2	14	8	4	4	5	4	5	5	5	5	5	1	1	2	1	5	5
16	2	15	8	4	4	5	4	5	5	5	5	5	1	1	2	1	5	3
17	1	14	8	4	5	5	4	1	1	5	4	4	1	5	5	1	1	3
18	2	12	8	5	5	5	4	5	5	5	5	5	1	1	2	1	5	1
19	1	14	8	5	5	5	4	4	5	5	5	5	1	1	1	1	1	3
20	1	15	8	6	5	5	4	4	2	5	5	5	2	3	4	4	3	3
21	2	15	8	5	5	5	4	1	5	5	5	5	1	5	2	1	5	1
22	2	14	8	5	5	5	5	1	5	5	5	5	1	5	2	1	5	1
23	2	12	8	5	5	5	5	5	5	5	5	5	5	1	2	1	1	1
24	2	14	8	4	5	5	4	5	5	5	5	5	1	4	2	4	5	1
25	1	14	8	5	5	5	4	5	1	5	5	5	1	1	1	1	1	4
26	1	17	8	5	5	6	4	3	3	3	2	3	3	4	5	3	4	6
27	2	12	8	5	5	5	4	1	5	5	5	5	1	5	2	1	5	4
28	2	14	8	5	5	5	5	5	5	5	5	5	1	1	1	1	1	1
29	1	14	8	5	4	5	4	5	5	5	2	4	2	4	1	1	1	3
30	1	12	8	5	5	5	4	4	5	4	5	5	2	4	2	2	3	4
31	2	12	8	5	5	5	4	1	5	4	4	5	1	5	2	1	3	4
32	2	12	8	5	5	5	4	4	5	5	5	5	1	5	2	1	3	4
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35	2	15	10	5	5	5	5	5	5	5	5	5	1	1	1	1	1	1
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37	2	14	10	5	5	4	4	2	5	5	5	5	5	5	4	1	3	3
38	1	15	10	5	5	4	4	2	5	4	5	5	5	5	4	1	3	3

39	2	16	10	5	5	5	4	2	5	5	5	5	5	5	2	2	3	3
40	1	16	10	5	5	5	4	2	5	5	5	5	1	1	1	1	2	4
41	1	17	10	4	5	5	4	1	2	4	2	4	1	1	1	4	4	5
42	2	16	10	5	5	5	4	5	5	5	5	5	1	1	1	1	1	5
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44	2	15	10	4	5	5	4	5	5	5	4	5	1	1	1	1	2	4
45	1	15	10	4	5	5	4	5	4	5	5	5	1	1	1	1	1	4
46	1	15	10	5	5	5	4	2	5	5	5	5	1	6	1	1	2	1
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48	1	16	10	5	4	4	4	5	5	4	5	5	5	1	1	2	1	1
49	1	17	10	5	3	4	4	3	4	4	5	5	2	2	2	2	4	1
50	1	15	10	5	5	5	4	5	5	5	5	5	1	1	2	1	1	1
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53	1	16	10	4	3	5	4	3	6	5	4	5	1	1	2	5	1	6
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64	1	15	9	5	5	5	5	5	5	5	4	5	2	1	1	1	1	1
65	1	17	9	4	4	5	4	6	1	5	4	5	5	1	2	1	1	6
66	1	14	9	5	5	5	4	6	4	4	4	5	6	1	2	1	1	6
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125	2	12	8	5	5	5	4	5	5	5	5	5	5	5	1	1	1	1
126	2	15	8	5	5	5	4	1	5	5	4	5	5	5	2	1	1	4
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147	1	12	8	5	5	5	4	5	5	5	5	5	1	1	1	1	1	1
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188	1	12	10	5	3	5	4	2	3	3	5	3	2	2	2	1	5	4
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192	1	13	9	5	5	5	4	5	5	5	5	5	1	1	2	1	5	3
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196	1	16	10	5	5	5	4	1	5	5	5	5	2	1	1	1	1	1
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Q - Analysed Main Statements of Environmental Education Textbooks

Class 8: My Science and Environment

Structure of the Earth

Soil and its Structure

- Soil is a mixture of small rocks, sand, minerals, living organism and its fossil.
- Different types of soil have different composition but organic substances are found on the top layer.
- Plants get required minerals from soil to prepare food and provides appropriate environment for living beings in the Earth.

Soil Erosion and Deposition

- Sliding of land, cracking and damaging of soil due to river water are example of soil erosion.
- This eroded soil mixes into flowing river water which delivers it to another place, mainly plains, and deposits there.
- Erosion is caused by high speed of rain, air, river water and water wave in ocean.

Conservation of Soil

- With sloppy land in the mountains and deforestations is causing the loss of thousands of tons of soil by the action of water in Nepal.
- Deforestation and overgrazing should be controlled and afforestation and terrace farming should be done.
- Blasting in mountains for construction works should be banned and retaining walls should be constructed along the river banks.

Weather and Climate

Factors affecting Climate

- The earth is spherical and sunlight falls straight to the equator throughout the year and as we move north or south from equator the coldness increases.
- As the altitude of land increases, the temperature decreases due to atmospheric pressure and greenhouse effect, thus the Himalayas are cold.
- Temperature of water and land are different during day and night thus distance from the sea influences temperature and rain as the air from sea to land is moist.

Climate of Nepal

- Even though Nepal lies in tropical zone the climate in Nepal varies from tropical to tundra due to altitude ranging from 60 m to more than 5000 m.
- Monsoon is a periodic wind which flows from sea (Bay of Bengal) to land (Nepal) in summer with moist air which causes rainfall in Nepal.

- The problems like flood, landslide, soil erosion etc. are caused by heavy monsoon rainfall.

Earth and Space

Life on Earth

- Living being has been evolved in the earth because there is air, water and suitable temperature for survival.
- Due to the inclination of the earth at 66.5°, the length of day and night is not equal at all the time and places except at equator.
- Due to this inclination the sunlight does not fall straight all the time at a place, thus this change of earth and sun's position creates different climate.

Environment and its Balance

Environment and its Situation in Nepal

- Human beings depend upon natural resource for air, water, habitat and food.
- For conservation of natural environment there are 10 national parks, 3 wildlife reserves, one hunting reserve and 6 conservation areas in Nepal.
- Different types of trees can be found in different parts of Nepal, plains, hills and mountains and along with vegetation, wildlife is also in danger due to loss of their habitat.

Environmental Degradation and its Conservation

Causes and effect of Pollution

- Production of smoke from vehicles, industries, fire wood, wheat stalk, mining, road construction and smell of garbage creates air pollution.
- Air pollution causes respiratory and eye diseases, destroys plant and cultural heritage, increases temperature and causes acid rain.
- Close proximity of sewer and water pipeline, washing clothes, mixing household and industrial waste products in water bodies and use of pesticides in farmlands causes water pollution.
- Water pollution causes diseases like cholera, typhoid etc., it harms aquatic plants and animals, affects photosynthesis of plants and spreads bad smell.
- Usage of chemical fertiliser and insecticides in farm, and throwing waste in soil and indecomposable material causes land pollution.
- Land pollution causes death of earthworms which help to improve soil quality, reduces fertility of soil, decreases production of crops and pollutes water under land.
- Noise in markets, announcements through mics, traffic, construction, factories and uncontrolled sound of electronic items cause noise pollution.
- Noise pollution causes high blood pressure, ruptures eardrum, causes insomnia, disrupts digestive orders and reduces concentration power.

Green House Effect and Acid Rain

- The increase in temperature of earth due to the trapping of sunlight and heat by different gases in the atmosphere is called greenhouse effect which leads to climate change.
- Forest fire, gases coming out from industries, vehicle emission etc. release carbon into the atmosphere and methane production from waste or landfill cause greenhouse effect.
- Climate change leads to melting of snow in the Himalayas, sea level rise, unseasonal and extreme rainfall and drought, decrease in crop production, epidemic and reduction in biodiversity.

Acid Rain

- Industries produces different toxic gases as well as carbon dioxide and reacts with water and air in the atmosphere which pours down as acid rain.
- Acid rain causes health problems to living beings, depletes rocks, houses, acidifies soil and reduces growth of plants.
- Acid rain can be controlled by decreasing source of pollution, using alternative energy and pollution filters.

Disaster and its Causes

- Natural disasters are earthquake, flood, landslides, storm, hailstorm, hurricane, etc while manmade disasters are desertification, chemical accident, road accident etc.
- Flood, landslide, storm, hailstorm, thunder, avalanche, explosion of glacial lake, epidemic, earthquake are common disasters in Nepal.
- Unscientific mining, building water canals, construction of road and factories, improper urbanisation, lack of waste management, deforestation, weak and steep geographical structure cause disasters.

Disaster Management and Environmental Conservation

- Safe place inside and outside of the house should be identified and remain in this place during earthquake.
- Stay away from flooded river and inform if landslide blocks river.
- To prevent from flood or landslide embankment should be constructed and human settlement should be removed from the side of river, houses should not be constructed in steep place and loose soil, afforestation and terrace farming should be done with proper water outlet from houses.
- Source of fire must be stored safely and away from children, establish pond near the village and adopt measures to avoid the spread of fire.
- Keeping environment clean and conducting awareness programmes will help to manage and deal the risk of epidemic.
- Environment can be conserved with people awareness, plantation, land conservation, conservation of water resources, pollution control, conservation of cultural heritage and environmental cleanliness.

Environment and Sustainable Development

Biodiversity

- Terrestrial and aquatic ecosystem is a type of ecosystem diversity where living beings, non-living beings and physical environment interact to balance their livelihood.
- Different species create species diversity while transmission of parental features to offspring creates genetical diversity in living beings.

Principles of Sustainable Development

- Development activities carried out while protecting the natural environment is sustainable development.
- Sustainable development promotes the conservation and protection of human beings and the earth.
- Conservation of ecosystem, cultural heritage and biodiversity, improving health, education, employment, security etc., population control, development of human resources, people participation and conducting development activities considering available resources of earth are the principles of sustainable development.

Importance of Sustainable Development

- The development works should not harm the environment.
- Appropriate use of resources, sense of responsibility, development of basic aspect, people's participation-based development, determination of the limit of development and long-term vision are the importance of sustainable development.

Class 8: Social Studies and Population Education

Season Change and Weather

- The earth is aligned at an angle of 66.5°, thus the sun rays fall in different parts of the earth in different time of a year creating different seasons.
- An area with hot temperature heats up the air decreasing the air pressure, this leads to arrival of air from low pressure area leading to storm or rain, thus the situation of temperature, air pressure, cloud and rain defines the weather.
- Annual average of the weather is known as the climate of a place.

Factors affecting Temperature in Land

- Increase in latitude decreases temperature due to the alignment of the earth.
- The density of air molecule is high in lower altitude thus it captures the heat from the sun and increases air temperature in low altitude compared to high altitude.
- Water warms up slowly and cools down slowly while it's exactly opposite in the land, this phenomenon leads to constant temperature near the coastal area.

Climate Change

- With the start of industrial revolution, the burning of fossil fuel has increased leading to greenhouse effect.
- Living beings and physical environment operate in accordance to climate but when there is imbalance in their operation then this could be due to climate change, however, weather change is not climate change.
- Major source of climate change is excess production of carbon dioxide and this leads to increase in temperature which will excessively decrease snow cover of our Himalayas.

Earthquake and Storm

- The land of the earth sits on massive rock plates which are not a single body and keep on moving leading to its collision which in result produces earthquake.
- Storm arises due to travel of air from high pressure area to low pressure area mainly from sea to land or mountain to valley.
- During earthquake take cover under desk or tables with duck cover hold position and get out of the building towards a safe place while during storm stay away from electric poles or trees and always keep the windows closed.

Class 9: Science

Nature and Environment

Factors influencing Plants and Animals

- Ecosystem is part of environment which is made up of abiotic factors such as: air, water, soil, sun, energy etc. and biotic factors such as: producers, consumers and decomposers.
- Abiotic factors help to maintain ecosystem by continuously being available.
- Green plants are producers, living beings who consume producers are consumers and organisms which decay and decompose dead living beings are decomposers which is reused by producers.

Interrelationship between Plants and Animals

- There are two types of ecosystem, terrestrial which includes jungle, plain and desert ecosystem, and aquatic which includes sea and lake ecosystem.
- Autotrophic such as green plants produce their own food, heterotrophic rely on other organisms for food which are parasite (completely reliable on others), saprophyte (relies on other dead organisms) and holozoic (consumes any type of organism for nutrition).
- The process between organisms for the exchange of food creates food chain and food web.

Ecosystem Services

- Products obtained from the ecosystem is provisioning services such as: food and fibre, fuel and ornamental resource, etc.
- Services obtained from balanced operation of ecosystem is regulating services such as: climate regulation, water purification, pollination, etc.
- Natural beauty and cultural resources also develop from the balanced ecosystem while services such as nutrient recycling, soil formation, etc. are also part of ecosystem services.

Natural Hazard

Natural and Manmade Hazards

- Hazards which are out of human control such as floods and landslides are natural hazards while accident, desertification, chemical accident, etc. are manmade hazards.
- Natural hazards can be managed by increasing public awareness, rescue, physical and financial help.
- Manmade hazards can be managed by maintaining rules and regulations, decreasing usage of nuclear power plants, environment cleanliness, maintaining forests, maintaining soil quality, urban planning, etc.

Preventive Measures to Manage Hazards

- Analyse and forecast hazard, prepare an emergency plan and store rescue and emergency materials safely.
- Use organic or natural techniques to tackle hazards, construct embankments in rivers to protect human settlement against floods or landslides.
- Keep first aid service, emergency food service, emergency clothing and temporary shelter service as backup.

Glacial Flood and Cyclone

- Melting of glacier in the Himalayas due to global warming leads to formation of glacial lake which is upheld by ice and snow structures, in the case of melting of these structure the glacial lake outbursts and creates flooding in the downstream river.
- In a sea when the high-pressure air arrives from all direction towards a point with low air pressure (high temperature) then this leads to the formation of cyclone which leads to destructive storms and storm surge.
- Both glacial lake formation, its outburst and cyclone are increasing due to the events of global warming.

Green House Effect

- Trapping of sunlight from exiting the earth's atmosphere due to increase of gases such as carbon dioxide, methane, etc. leads to greenhouse effect.
- Trapping the sunlight artificially in a glass house helps to create environment for production of food.

- Greenhouse effect due to industrialisation and pollution leads to climate change which increases temperature and impacts the natural ecosystem, human settlement, energy balance and food production.
- Public awareness programmes, afforestation, usage of renewable and alternative energy, waste management and conservation of natural environment helps to manage climate change.

Class 9: Health, Population and Environment Education

Environment Education

Concept of Environment and its Education

- The things which are directly or indirectly connected with human beings is combinedly known as environment such as physical environment, artificial environment, biological environment and social/cultural environment.
- Natural disasters are results of human activities and environment education provides us answers to such questions and helps to change the human behaviour.
- Environment education provides information and knowledge about environment and helps to develop skills and attitude about the need and importance of dimensions of environment to protect and conserve them.
- Environment education helps to develop knowledge, attitude and skills for the proper utilisation of means and resources along with its protection and preservation.
- Environment education develops knowledge and skills for identification and solution of general as well as complicated environmental problems and accelerates consciousness for national use of environmental factors.
- Health and population are related with environment thus environment education which helps to ensure healthy environment also has a positive impact on health and population of the society.
- Environment education is a multidimensional integrated subject which covers biological, physical, social and cultural aspects.

Population, Environment and Development

Interrelationship among population, environment and development

- Human beings are part of the environment and if they think rationally to conduct the development activities it will contribute to population control, conservation of environment and development.
- Population and development are related to agriculture, industry, health, security, habitat, communication, education, technology, culture and human resource, and human beings should be responsible to conserve the environment while developing these sectors.
- It is a must to maintain balance among population, environment and development to use natural resources, conduct development activities and economic development, and to conduct socio-cultural activities.

Economic Improvement and Quality of Life

- Natural resources are unevenly distributed and it calls for maximum utilisation of natural resources with the help of human resource for economic development.
- Each individual in the society should get orientation to sanitation, public places, sources of drinking water and natural environment.
- Proper planning and training will develop skilled human resources which can work towards mobilisation and utilisation of natural resources, modernisation of agriculture, development of infrastructure and conservation of environment.

Demographic Status and Environment in Nepal

Effect of Urbanisation on Environment

- Urban area is increasing in Nepal and it creates both positive and negative effect on the environment.
- It motivates people for conservation of environment and develops conscience related to environment.
- It creates pollution, deforestation, degradation of natural resources and, imbalance between living and non-living creatures.

Natural Resources and Biodiversity

Classification of Natural Resources and its Importance

- Any living or non-living things made up without human contribution are natural resources and can be classified into three as: perpetual, renewable and non-renewable.
- Perpetual are everlasting resources such as: sea tides, wind energy, water etc., renewable is those which renew overtime such as: fresh air, fertile soil, plants and animals, etc. and non-renewable are limited resources such as: fossil fuel, minerals, metals, etc.
- Natural resources are important because they provide fresh air and water, habitat and shelter, source of food, natural beauty, tourism, economic development, etc.

Types and Status of Natural Resource

- Air is a mixture of gases and forms atmosphere and consists of 78.09% of nitrogen, 20.95% of oxygen, 0.03% of carbon dioxide, 0.93% of argon, and 0.004% of other gases.
- About 71% part of the earth surface is covered by water and there are more than 6000 rivers and rivulets in Nepal which depends on rain water, while water lying under the earth are known as underground water.
- The surface structure of the earth is lithosphere with geological structure differing due to different nature, structure and quality of rocks, land structure and topography of place.
- 15% of Nepal's land is covered by snow mountains, 38% by forest and shrubs and the land is divided ecologically into mountain, hilly and terai region.

- 29% of Nepal's land is covered by forest while 11.8% by grassland and tropical (up to 1000m), sub-tropical (1200-2000 m), temperate (1700-3100 m) and alpine (3000-4200 m) forests are found in Nepal.
- According to biodiversity project report of 1995 there are 5160 species of angiosperm (flower plants), 181 species of mammals, 844 species of birds, 6356 species of butterflies, 5000 species of insects, 185 species of fish, 3 species of reptiles, python, other carious species of snakes and many other aquatic species are found in Nepal.
- Likewise, iron, copper, lead, limestone, talc stone, slate, coal, nickel, gold, petroleum and gas are found in Nepal.

Conservation of Natural Resources

- Absolute concept of conservation means conserving nature by maintaining the quality and quantity of natural resource without any destruction to their original status.
- Relative concept of conservation means conserving natural resource with the integration of conservation and utilisation of natural resources.
- Absolute conservation prevents consumption of natural resources, it is useful for creatures which are going to be naturally extinct and can be used in natural parks or reserves but is a theoretical conservation.
- Relative conservation is practical and is used by community to consume as well as to conserve such as community forest, bee keeping, etc.

Earth and Caring for the Earth

- A world conservation strategy which explained legal aspects related to the conservation of natural resources and sustainable development was started on 1980 AD from the joint efforts of IUCN, UN and WWF.
- Earth's location in the solar system created favourable condition on the earth for living beings and if one part is tampered it affects the other parts too and is a common habitat of all living beings.
- Structure of land, air, season change, water, heat and light, food and recycling by natural means are the feature of the earth.
- Conservation of natural resources and living beings can be done by gaining knowledge of the structure of the earth, respecting the nature, nature friendly development, proper use of natural resources, and involvement in conservation programmes.
- Worldwide conservation policy, national conservation policy, environmental planning, formulation of policies and their implementation, institutional reform, and awareness raising are legal instruments used in the conservation of the earth.

Human Beings and the Earth

- One should be aware that our existence is possible only if the earth is conserved and rational use of natural resources must be done while reducing greenhouse gas emission.
- We shouldn't overexploit the resources in the name of utilising them.
- We should teach the art of living to agree with natural law and should consider the carrying capacity of the earth.
- Forestry and agriculture education should be focused.

- Community should be involved in environment protection by planting on barren lands, reducing usage of fertilisers and pesticides, controlling population, preserving cultural places, managing waste, reusing water, formulating policies, etc.

Environment Health

Concept of Environment Health

- Bringing qualitative change in human health through the qualitative improvement in all the environmental elements is known as environment health.
- Cleanliness and purity of the elements like water, air, soil and sound is environment health.

Environment Pollution and Management of Environment Health

- Unhealthy environment adversely affects all the other things like air, water, soil, living beings, trees, river, monuments, hills, etc. and such contaminations in the environment is known as pollution.
- Changes in temperature in the earth, volcano, earthquake, flood, ozone layer depletion, deforestation, excavation, construction, industrialisation and wars cause pollution.
- Maintaining cleanliness around home and school, proper waste management, plantation, gardening, controlled construction and industrialisation helps to maintain environmental health.

Environment Pollution and its Effect in Health

- Soil pollution reduces cultivation, weakens health of animals living under soil, pollutes underwater and impacts health of human beings and other animals.
- Water pollution increases harmful microorganisms and chemicals in sources of water leading to various diseases in human beings and animal life.
- Air pollution increases harmful gases in the air and leads to respiratory problems, destroys ozone layer and creates acid rainfall.
- Sound pollution generates compression in the body to stimulate high blood pressure and impacts human body organs.

Controlling Measures of Environment Pollution

- To control soil pollution, develop greenery, treat wastewater from industries, manage hostile materials such as mercury and glasses, minimise pesticides, and stop open defecation.
- To control water pollution, stop direct drainage to rivers, afforestation in mountains, no dumping of garbage into the river and focus on waste to energy, wastewater treatment, banning washing, bathing, animal grazing and defecation around water resources, and neutralise radioactive substances.
- To control air pollution, do afforestation around industries, use chimneys and filters in factories, locate factories far from human settlement, stop forest fire, and ban old vehicles.
- To control sound pollution, generate awareness among people, locate airport and factories far from human settlement, ban loud sound machine from schools, hospitals

and factories, do plantation around factories, schools, roads and hospitals, and use ear mask while working in high sound area.

Solid Waste and its Management

- Degradable, non-degradable, combustible and non-combustible solid materials generated from human activities and thrown away are called solid waste.
- Solid waste generates from homes, industries, hotels, packing stations, vegetable stalls, schools, construction works, hospitals and roads.
- Degradable solid waste can be managed by accumulation however, this method is banned these days, burying, incineration of plastics, composting and making a manure pit.
- Non-degradable solid waste can be managed by less production, reusing, recycling and reducing packaging.

Sewage and Toilet Management

- Set out of drainage to let out faeces, liquid wastage of factories, hospitals and roads is known as sewage.
- To stop open defecation, people should be encouraged to build toilets in their houses.
- There are different types of toilets used for different purposes such as: trench, bore hole, ditch hole or simple pit, and improved pit toilet.

Class 10: Social Studies

Factors affecting Weather

- The more you go away from the equator (latitude) the sunlight falls in an inclined angle thus the temperature decreases with distance from the equator.
- As the elevation increases the air pressure decreases thus temperature also decreases while hills facing windward side experience more rain compared to the opposite side, e.g. Himalayas.
- During the day the land warms up faster near the sea while water warms up slower but during the night the land cools faster and water cools slower thus the area near the sea always has a moderate temperature.
- Moisture level in the air and forest area attracts more rainfall in a region while wind current arising from sea also plays major role in the local weather, and colour of soil such as black soil area has warm weather while white colour of soil has cool weather.

Tropical Region

- 5° north and south of equator is the equatorial region while that from equator to 30° is known as the tropical region with 90% of animal habitat of the world.
- The climate is mostly warm in this region with 50 to 200 cm of rainfall per year and the grasslands of savanna, and deserts of Asia and Africa fall in this region.
- This region is optimal for agriculture while region north and south from 20° is optimal for human settlement too and has the biggest rivers of the earth.

Temperate Region

- 30° to 60° in the northern and southern hemisphere is the temperate region which is warm during the summer and cold during the winter.
- There are four types of regions in this part, equatorial sea area (with 2 seasons and rainfall during winter), temperate grassland (less rainfall and snowfall during winter), temperate sea area (not warm or cold but rainy throughout the year), and temperate monsoon area (warm summer with rainfall and cold winter).
- This is the most human populous area in the world with optimal weather and climate for survival, agriculture, raising animals and operating factories and businesses.

Cold Region

- 60° to 90° latitude in both hemispheres are known as cold region which also known as the snow desert and may contain up to 4km deep ice layers.
- 60° to 70° latitude area is known as the Siberian weather area where summer is only for 4 months while 70° to 90° area is known as tundra weather area where summer ranges from -2 to -5°C while winter ranges from -35 to -45°C, and 66° to 90° is also known as the Antarctica weather area where there are no human settlements and average climate is always below -45°C.
- In the northern hemisphere of cold region there are few human settlements who reply on hunting and farming of pulp while in the southern hemisphere there is no human settlement except for research bases.

Types of Vegetation and Animals in the World

- Evergreen forests are on the tropical region and experience more than 200 cm of rainfall per year with strong wood and less branches e.g., rubber tree, here big animals such as elephants and crocodiles are found.
- Region with deciduous forest with trees such as oak, maple, etc. are warm during summer and cold during winter with 100 cm average rainfall per year and sheds leaves during winter and grows back during summer, here medium sized animals such as monkeys and birds are found.
- Coniferous forest is evergreen and have pointed leaves such as pine etc. and are found in the cold region with average rainfall of 50 cm per year, and are habitat to snow leopards, mountain bear etc.

Role of Weather and Landscape in Lifestyle

- In the cold region the local inhabitants are vulnerable due to weather and thus rely on hunting and moving for food and survival.
- Places which fall on the temperate region have moderate weather and landscape for agriculture thus the people living here are progressive, cultural and educated.
- People living in the amazon area still live in pre-industrialisation settings due to the roughness and risk related to survival in the region.
- People living in cold and hilly region are more active compared to those living in warm area, while lifestyle such as Islam way of life is also derived from the desert and

hotness of the land where Islam was founded, e.g. using sand in construction, covering face to protect from sun, praying the moon because moon provides coolness.

Earthquake and Tsunami

- Any geological movement occurring under the earth leads to earthquake while occurrence of earthquake in the base of sea leads to sea wave known as tsunami.
- Both these disasters lead to economic and cultural heritage damage and spreads epidemic.
- To prevent from earthquake and tsunami preventive measures should be taken such as earthquake resistance buildings and arrangement of emergency materials.

R - Curriculum Vitae

First Name: **Shakil**
Last Name: **Regmi**

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Education

06/2017 – 07/2020

PhD: Geography Didactics (Dr. paed.)
Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany.

- Study emphasis: Geography, environmental science, environmental education and psychology.
- Dissertation topic: "Analysing the Extreme Environmental Events in the Nepal Himalayas and Environmental Attitude of the Downstream Children." – Supervisor: Professor Dr Martin Lindner, Professor Dr Bodo Bookhagen and Associate Professor Dr Bed Mani Dahal.
- Final grade: Magna cum Laude.

08/2013 – 11/2016

Master of Education in Environmental Education and Sustainable Development
Kathmandu University, School of Education, Hattiban, Nepal.

- Study emphasis: Climate Change and Sustainable Development, Statistical Technique for Survey and Research, Study Skills and Academic Writing, Global Change, Research Methods.
- Master's thesis: "Exploring the Targets of Sustainable Development for Nepal based on Rio +20." – Supervisor: Mr. Indra Mani Yamphu Rai.
- Final Grade: 3.51 out of 4. (0 – Failed … 4 – Excellent).
- Thesis Grade: Satisfactory (S). (U - Not Satisfactory, S -, H - Honours)

08/2011 – 05/2013

Bachelor of Engineering in Environmental Engineering
Mikkeli University of Applied Sciences, Mikkeli, Finland.

- Study emphasis: Environmental Protection, Environmental Management, Environmental Technology, Mathematical Simulation and Analysis, Computational and Statistical Methods, Waste Management, Measurement of Water Treatment Processes, Environmental Monitoring.
- Bachelor's thesis: "Wastewater Treatment in Kathmandu: Management, Treatment and Alternative." – Supervisor: PhLic. Maritta Jokela.
- Final Grade: 4 out of 5. (1 – Satisfactory … 5 – Excellent).
- Thesis Grade: 5 out of 5. (1 – Satisfactory … 5 – Excellent).
- Remarks: Completed 4 years course (243 ECTS out of obligatory 240 ECTS) in 21 months.

Training Courses

10/2014 – 03/2015 **Climate Change and Ecosystem Services**
Hochschule Weihenstephan-Triesdorf, Freising, Germany.

- Climate change observation, impacts on ecosystem, and future policy.
- Training and seminar on IPCC assessment and working process.

10/2014 – 03/2015 **Economics of Renewable Resources**
Hochschule Weihenstephan-Triesdorf, Freising, Germany.

- Introduction to economics of renewable resources and research-based development of renewable energy project.

10/2014 – 03/2015 **Intercultural Communication**
Hochschule Weihenstephan-Triesdorf, Freising, Germany.

- Importance of intercultural communication in work space and social space.
- Ethics and methods of intercultural communication.
- Unique importance of different cultures.

10/2014 – 03/2015 **Sustainable Rural Development in Developing and Industrialised Countries**
Hochschule Weihenstephan-Triesdorf, Freising, Germany.

- Challenges of sustainable development in rural areas of developing and industrialised countries.
- History, concept and importance of sustainable development in agriculture, development and project management.

Publications

Regmi, Shakil. (2013). Flow rate should be checked to preserve Bagmati River. *Face to Face*, Sept-Nov, 8-9.

Regmi, S., Johnson, B. & Dahal, B.M. (2020). Analysing the Environmental Values and Attitudes of Rural Nepalese Children by Validating the 2-MEV Model. *Sustainability*, 12(1), 164.

Regmi, S., Bookhagen, B. (2020). The spatiotemporal pattern of extreme precipitation from 40 years of gauge data in the Central Himalaya. *Weather and Climate Extremes* (under review).

Conference Invitations and Thesis Supervisions

29/10/2014 **“Wastewater Treatment in Kathmandu: Management, Treatment and Alternative”**, International Water Association (IWA) Specialist Conference – Global Challenges: Sustainable Wastewater Treatment and Resource Recovery, Kathmandu, Nepal.

03/04/2019	**"Validating a Modified Model of Ecological Values (2-MEV) in Rural Nepal: A Unique Cultural Perspective"**, NARST Annual Conference 2019, Baltimore, USA
29/08/2019	**"Observing Extreme Environmental Events in the Himalayas and Status of Environmental Education and Attitude of the Downstream Community"**, European Science Education Research Association (ESERA) Conference 2019, Bologna, Italy
24/10/2016	**Bachelor Thesis Supervision: Green Infrastructure in Kathmandu Present state, possibilities for implementation and expected results**, Mikkeli University of Applied Sciences, Mikkeli, Finland.

Related Conference Participations

07/10/2015 – 09/10/2015	Science Camps: Impact on Student's Attitude towards Career in Science. Berlin, Germany.
29/10/2015 – 30/10/2015	Project based Education in Science Education XIII. Prague, Czech Republic.

Awards and Scholarships

06/2017 – 05/2020	Full scholarship for PhD according to the Graduate Promotion Act of the State of Saxony-Anhalt, Germany.
04/2020 – 08/2020	Forschung von Wissenschaftler*innen in der Qualifikationsphase (research by scientists in qualification phase) from Faculty of Philosophy III, Martin-Luther-University Halle-Wittenberg for research and project initiative.

Work Experience

05/2012 – 08/2012

Research Intern
Environment, Culture, Agriculture, Research and Development Society (ECARDS) – Nepal. (ecardsnepal.org.np/)
Kathmandu, Nepal.

- Theme of work: Environmental assessment of leasehold forest in central lesser-Himalayan region of Nepal;
- Conducted activity: Field observation, focal group discussion, sample collection, statistical analysis of data and lab analysis of water and soil samples; and
- Final work: Report preparation, submission and presentation to Department of Forests under Ministry of Forests and Soil Conservation of Nepal.

05/2013 – 01/2015

Environmental Engineer
Nepal Environmental and Scientific Services (NESS) Private Limited. Kathmandu, Nepal. (nesspltd.com/company/)

- Quantitative and Qualitative Data Analytics for Environmental Impact Assessment (EIA) of private and public projects, e.g., private and public hospitals, hydropower projects, dam development and construction, water supply and water quality projects etc. in Nepal;
- Sampling, analysis and study of drinking water status and sanitation from 26 districts of Nepal for Rural Water Supply and Sanitation Fund Development Board (RWSS) and preparation of report with direct coordination with related governmental authority, local non-governmental organisations and community president of the project district; and
- Conduct quality control of data analysis and its interpretation for report preparation, advice and produce training materials related to research and development in the field of environmental science for staff members.

10/08/2016 – 19/08/2016
18/09/2017 – 29/09/2017

Visiting Lecturer
Mikkeli University of Applied Sciences. (xamk.fi/en/frontpage/)
Mikkeli, Finland.

- Creating intense course contents for building technology and community planning and conducting intense course for the students of bachelors of environmental engineering; and
- Conducting final examination and supervising bachelor thesis.

05/2017 – 09/2017

Research Assistant
University of Potsdam, Institute of Geosciences.
Potsdam, Germany. (uni-potsdam.de/en/geo/)

- Collecting, managing, and analysing meteorological and hydrological data of Nepal to study extreme events.

Ongoing Postdoc/Research Projects

09/2015 – Present

Research Associate
Martin-Luther-University Halle-Wittenberg.
Halle (Saale), Germany. (didaktik.geographie.uni-halle.de/)

- Study and analysis of extreme climate events, remote sensing for earth study, statistical analysis of environmental data, environmental psychometrics, and environmental education with a focus on sustainable development goals in the Himalayan region.
- Leading and conducting a project “Global South Sustainability Project” in cooperation with universities of three different countries from South America, South Africa and, South Asia to develop programmes and solutions in regards to SDGs 2, 3, 4, 7, and 13.

03/2019 – 03/2020 04/2020 – Present	**Data Analyst; and** **Chief Information Officer** RootsGoods Private Limited. (rootsgoods.com) Bangalore, India.

- Virtually collecting, managing, and analysing social, meteorological, hydrological and land use data of the state of Karnataka, India using remote sensing and self-collection techniques such as drone mapping, sensor instalments and interviews/surveys; and
- Analysing the spatial data using GIS applications to ensure the effectiveness of farm management and prediction of the price of agricultural produce using available data.

04/2020 – Present	**Environmental Analyst** Vriksha Foundation. Lalitpur, Nepal. (vrikshafoundation.org)

- Data collection, analysis and planning of environmental and sustainable aspects such as waste/waste-water management, urban bio-diversity regeneration, and eco-friendly solutions in major urban/open space regeneration projects in Kathmandu, Nepal.
- Studying and defining urban environmental psychology in old-settlement of Kathmandu Valley with focus on public and religious open spaces.

Languages

- Nepali (native language)
- English (C3)
- German (A1)

CEFR scale: A – basic user, B – independent user, C – proficient user.

Reference Person

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Confirmation of Validity

I, hereby, state that all the information provided above is correct.

S - Certification of Validation

Erklärung zum Wahrheitsgehalt der Angaben / Declaration concerning the truth of information given

Ich erkläre, die Angaben wahrheitsgemäß gemacht und wissenschaftliche Arbeit an keiner anderen wissenschaftlichen Einrichtung zur Erlangung eines akademischen Grades eingereicht zu haben. / I declare that all information given is accurate and complete. The thesis has not been used previously at this or any other university in order to achieve an academic degree.

Halle (Saale), 30.07.2019
Ort/Place, Datum/Date

Unterschrift / Signature

Eidesstattliche Erklärung / Declaration under oath

Ich erkläre an Eides statt, dass ich die Arbeit selbstständig und ohne fremde Hilfe verfasst, keine anderen als die von mir angegebenen Quellen und Hilfsmittel benutzt und die den benutzten Werken wörtlich oder inhaltlich entnommenen Stellen als solche kenntlich gemacht habe. / I declare under penalty of perjury that this thesis is my own work entirely and has been written without any help from other people. I used only the sources mentioned and included all the citations correctly both in word or content.

Halle (Saale), 30.07.2019
Ort/Place, Datum/Date

Unterschrift / Signature

Vorstrafen, Ermittlungsverfahren / Preliminary investigations

Hiermit erkläre ich, dass ich weder vorbestraft bin noch dass gegen mich Ermittlungsverfahren anhängig sind. / I hereby declare that I have no criminal record and that no preliminary investigations are pending against me.

Halle (Saale), 30.07.2019
Ort/Place, Datum/Date

Unterschrift / Signature