

Original Research

Assessing the Effect of Climatic Factors and Adaptation on Migration Intention of the Residents in Gandaki Province, Nepal: Using Structural Equation Modeling

Madhab Prasad Baral^{1*}, Vikash Kumar K.C.²

¹Central Department of Statistics, Tribhuvan University, Kathmandu, Nepal

²Prithvi Narayan Multiple Campus, Tribhuvan University, Nepal

Received: 12 April 2025

Accepted: 08 November 2025

Abstract

Climatic variability and its impacts, such as extreme weather events and resource scarcity, are key drivers of migration, especially in ecologically vulnerable areas like Nepal's hilly and mountain regions. This study explores how climatic variability, severity, perceived impacts, and adaptation strategies affect migration intentions in Gandaki Province, Nepal, based on the Theory of Planned Behaviour (TPB) and Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze survey responses from 493 residents across four districts (Baglung, Myagdi, Mustang, and Lamjung). The results show that climate change impacts and adaptation efforts positively influence migration intentions and are significant. Climatic variability and severity have a negative but statistically insignificant relationship with migration intentions. Additionally, adaptation is a key mediator between the impacts of climate change and migration intentions, strengthening this link, while its mediating role between variability/severity and migration remains negative and insignificant. These findings highlight the need for targeted adaptation policies to address climate-induced migration pressures. Policymakers and institutions should prioritize resilience-building measures to reduce displacement risks while supporting vulnerable communities. The purpose of this study is to provide critical insights for evidence-based decision-making, aiding governments and stakeholders in managing the complex relationship between climate change and human mobility in vulnerable regions.

Keywords: climate change, Gandaki Province, migration intention, structural equation modeling, Theory of Planned Behavior

Introduction

Climate change, driven by industrialization and urbanization, affects all aspects of life and poses a significant challenge to sustainable development [1-3]. Its effects are regionally variable and worsening, as evidenced by historical changes in temperature and rainfall [4], causing irreversible damage as systems exceed their adaptive limits [5, 6]. Developing countries face severe impacts due to limited adaptation resources [7]. Understanding local perceptions is crucial for effective policy [8-10], as social, economic, and environmental factors, including climate threats to livelihoods, shape migration intentions [11-14].

Climate change influences migration intentions, yet older household heads and those with strong community ties show lower intent to migrate [15, 16]. While unemployment strongly predicts migration, gradual climatic changes are more likely to trigger movement than sudden shocks, with effects mediated by capability and vulnerability [17]. Existing research lacks a thorough examination of climate-driven migration intentions. This study addresses that gap by analyzing perceptions of climatic variability, severity, impacts, and adaptation. Using structural equation modeling (SEM), it finds that climatic factors increase migration intentions, affirming migration as a critical response despite available coping strategies [18].

While existing research on migration intention focuses on economic, social, demographic, and environmental factors, this study addresses a gap by specifically examining how climate change, through its variability, severity, and impact, influences migration intention through adaptation strategies. The objectives are:

- To assess the effect of climatic factors (variability, severity, and impact) on adaptation and migration intention,
- To examine how adaptation strategies affect migration intention,
- To measure the mediating role of adaptation between climate factors and migration intention.

Theoretical Concept and Model Development

Climatic Variability and Adaptation

Human-induced climate change is amplifying global weather extremes [6]. Climatic variability, through shifts in temperature and precipitation, shapes adaptive responses such as migration or local infrastructure upgrades [19]. While all regions are affected, the presence of local strategies shows migration is not always the primary response [20]. Despite increased damage from frequent extremes, development efforts have helped reduce vulnerability [21]. Based on this, the following hypothesis is proposed:

H₁: Climate variability directly and positively influences adaptation practices.

Climatic Variability and Migration Intention

Climate variability drives human migration in fundamentally context-dependent ways [22]. Research indicates that temperature anomalies have a greater impact on internal migration than on international movement, while the effects of precipitation changes are more varied and less consistent [20]. Although extreme weather events can trap populations in agricultural-based economies, rising temperatures have been shown to increase migration, particularly among vulnerable communities [23]. The relationship is complex, as precipitation deficits (especially in Asia) can suppress migration [24, 25], whereas higher temperatures generally increase migration intentions, most notably for less-educated rural inhabitants [26]. The vast majority of climate-related displacement is internal rather than cross-border [27], with weather-related extremes forcing over 20 million people from their homes each year since 2008 [28]. Therefore, the second hypothesis is formulated as:

H₂: Climate variability positively influences migration intention.

Climatic Severity and Adaptation

Climatic severity, meaning severe increases or decreases in temperature and precipitation, threatens agricultural resilience and food security [29]. It raises the incidence of climate-related disasters [28]. While migration can be an adaptation, it may exacerbate vulnerabilities [30, 31]. Effective adaptation strategies, like agricultural intercropping, are vital to minimize shocks and reduce economic losses [32], proving more profitable than traditional farming in regions like Nepal [33, 34]. Thus, we propose our third hypothesis.

H₃: The severity of climate change has a direct and positive influence on adaptation.

Climatic Severity and Migration Intention

The link between severe climate conditions like extreme temperatures, droughts, and floods [28] and migration intentions is increasingly recognized [35]. Such severity drives migration as an adaptive strategy but also heightens migrant risks and does not always improve outcomes [36]. The influence varies by demographics and region [37], exacerbating health vulnerabilities [38]. Understanding this complex relationship is crucial for developing effective policies to address climate-induced migration [26]. We therefore hypothesize that:

H₄: The severity of climate change directly influences migration intention.

Climate Change Impact and Adaptation

Climate change severely impacts agriculture, coastal areas, and infrastructure, driving migration

and threatening food security, especially in developing nations [22, 39, 40]. Effective adaptation is essential, employing climate-resilient agricultural strategies, technological innovation, and collaborative governance [40, 41]. Such proactive measures not only mitigate immediate impacts but also foster sustainable development and reduce vulnerability, thereby strengthening societal resilience against climate-induced disruptions [42, 43]. Based on these facts, the following hypothesis is proposed.

H₅: The impact of climate change influences adaptation.

Climate Change Impact and Migration Intention

Climate change impacts interact with economic, social, and political factors to influence migration [28]. Such impacts (e.g., floods, droughts, wildfires) displaced over 32 million people in 2022 [44], particularly threatening climate-vulnerable agricultural livelihoods [45]. These disasters shift migration from opportunity-driven to threat-response behavior [35, 46]. We therefore test the hypothesis that:

H₆: The impact of climate change positively influences migration intention.

Adaptation to Climate Change and Migration Intention

Climate and civil threats are increasing migration intention as an adaptive survival strategy, potentially escalating irregular cross-border movement [47]. Adaptation and migration are strategic responses to climate-induced livelihood disruption [28]. Local adaptation is a cognitive process, driven by risk perception and self-efficacy [48]. In contrast, migration is not an immediate or inevitable outcome [49] but is often emotionally triggered by direct experiences with climatic threats [48]. Based on this fact, the following hypothesis is made.

H₇: Adaptation to climate change influences migration intention.

Role of Adaptation between Climatic Factors (Variability, Severity, and Impact) and Migration Intention

Climate change severity, variability, and impact shape migration intentions [20]. Adaptation strategies are crucial to reduce these negative effects and manage climate-induced migration [28, 50]. Temporary migration is an observed adaptive response to climate stress [51], while extreme events exacerbate food and water insecurity [52]. Diverse adaptation strategies enhance resilience and reduce adverse migration outcomes [53]. We propose three hypotheses to examine whether adaptation mediates between climatic factors and migration intentions.

H₈: Adaptation plays the mediating role between the climate change impact and migration intention.

H₉: Adaptation plays the mediating role between the climatic severity and migration intention.

H₁₀: Adaptation plays the mediating role between climatic variability and migration intention.

Theoretical Framework

This study primarily focuses on measuring the migration intention caused by various climatic factors by applying the theory of planned behavior (TPB), developed by Ajzen (1991), [54, 55] which is shown in Fig. 1.

The application of the Theory of Planned Behaviour (TPB), developed by Ajzen [54], to migration studies in the early 2000s offered a robust psychological framework for understanding migration intentions. This theory is currently used to explain various conscious behaviors and has applications across many fields [56]. TPB has recently been employed by different researchers in migration studies and is considered

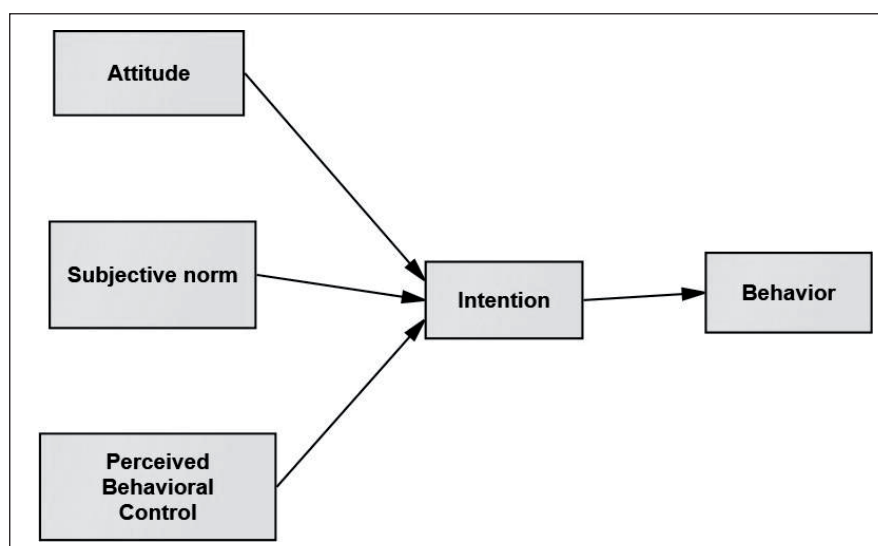


Fig. 1. Theory of Planned Behavior (TPB) model adopted from Ajzen (1991).

an effective tool for measuring migration (moving) intention [57-59]. The study's theoretical framework, which models migration intention as influenced by climatic factors (variability, severity, impact, and adaptation), is presented in Fig. 2.

Structural Equation Modeling

Structural equation modeling (SEM) is a class of multivariate techniques that combines factor analysis and regression to examine and evaluate complex relationships between multiple variables simultaneously [60]. This methodology is particularly powerful for its ability to model latent variables and its flexibility in specifying relationships. Specifically, SEM can identify which independent variables affect dependent variables and allows dependent variables to be independent variables in other relationships [35].

Structural Equation Modeling (SEM) encompasses two primary methodologies: Covariance-Based SEM (CB-SEM) and variance-based Partial Least Squares SEM (PLS-SEM), each tailored to different research objectives and data characteristics [61]. PLS-SEM does not impose specific assumptions regarding the data distribution [62]. It is helpful for structural equation modeling in applied research projects, especially in scenarios with limited sample size and skewed data distribution, as it demonstrates robustness against non-normality, heteroscedasticity, and autocorrelation in error terms. The prediction tool maximizes the explained variance in the dependent variable(s) and calculates composites for the latent variables [63].

Materials and Methods

Study Area

Four districts were selected as study areas: Baglung, Myagdi, Mustang, and Lamjung in Gandaki Province, based on the overall vulnerability index, the glacier lake outburst flood (GLOF) index, and the combined exposure index. Among these, Myagdi and Baglung are classified as very high (0.778-1.0), while Mustang and Lamjung fall into the high category (0.623-0.777) in the overall vulnerability index. In the glacier lake outburst flood (GLOF) index, Mustang is rated very high (0.911-1.0), Lamjung is rated high (0.767-0.910), and both Baglung and Myagdi are listed as low (0.001-0.597). Regarding the combined exposure index (or multiple risks), Lamjung is very vulnerable, Baglung and Myagdi are highly vulnerable, and Mustang is moderately vulnerable [64]. The map of the study area is presented in Fig. 3.

Population and Sample

The total population of these four districts is 526,548, with a positive growth rate in Mustang and a decline in Baglung, Myagdi, and Lamjung districts [65]. The study area covers 9,346 km², ranging from upper tropical to alpine climates and featuring diverse topography [66]. Most residents belong to indigenous communities, and migration is common among them. Four hundred ninety-three respondents (households) were chosen from three urban and seven rural municipalities using the Kish [67] sample size estimation formula shown in Table 1. Mostly, the head of the HHs was interviewed. If they were unavailable, another adult member present was interviewed. Therefore, the number of households equals the number of respondents.

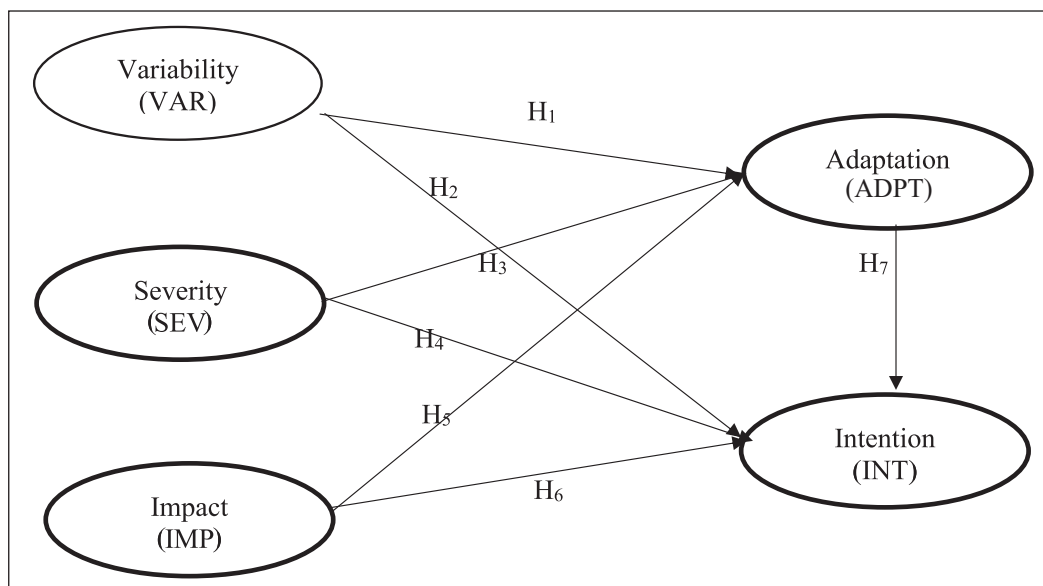


Fig. 2. Proposed conceptual framework of migration intention with hypotheses.

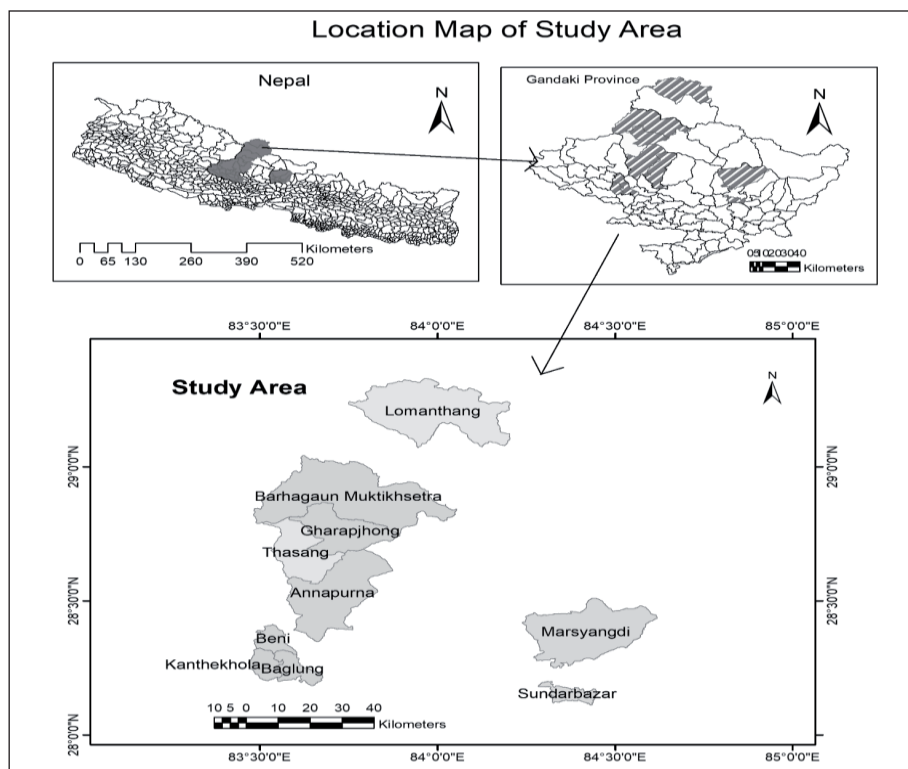


Fig. 3. Map of the study area.

Sampling Design

Four districts (Baglung, Myagdi, Mustang, and Lamjung) were chosen purposively. Two districts (Baglung, Myagdi) from the very high category and the other two districts (Mustang and Lamjung) from the high category were selected using the vulnerability index [68]. One rural municipality and one municipality were randomly chosen from each district of Baglung, Myagdi, and Lamjung, and four rural municipalities from the Mustang district.

Research Instrument

A structured questionnaire assessed people's perceptions, knowledge of climatic factors, and migration intentions. Each indicator within the constructs was measured on a five-point Likert scale, from 1 ("strongly disagree") to 5 ("strongly agree"). The first part of the questionnaire covers demographic and socio-economic variables. The other sections address the constructs "Variability" (B01.1 to B01.6), "Severity" (B02.1 to B02.7), "Impact" (C05.1 to C05.7), "Adaptation"

Table 1. The number of respondents selected in the study area.

Name of Municipality	District	Number of Respondents	Percent
Baglung municipality	Baglung	113	22.9
Kathekhola rural municipality	Baglung	51	10.3
Beni municipality	Myagdi	58	11.8
Annapurna Rural municipality	Myagdi	67	13.6
Lomanthang rural municipality	Mustang	24	4.9
Baragung Muktichhetra rural municipality	Mustang	15	3.0
Gharapjhong rural municipality	Mustang	3	0.6
Thasang rural municipality	Mustang	12	2.4
Sundar bazar municipality	Lamjung	87	17.6
Marsyangdi rural municipality	Lamjung	63	12.8
Total		493	100

(D01.1 to D01.8), and “Migration Intention” (G02.1 to G02.19) under study.

Results and Discussion

Selected Background Characteristics of Respondents

Four hundred ninety-three sample respondents were randomly selected from the four districts of Gandaki Province. Table 2 shows that about three-fifths (60.9%) of respondents are male. The age range of respondents is from 24 to 91 years, with a mean age of 46.5 years. More than 93% of respondents are married, and over 84% follow the Hindu religion. More than four-fifths of the residents (85.8%) own their own house. The infrastructure of over three-fourths of households (76.1%) is permanent. The main occupation for about one-third of respondents is agriculture, followed by government jobs (29.2%), business (23.3%), and private jobs (12.6%).

Measurement Model Assessment

The measurement model was evaluated following the guidelines of [59] to assess the reliability and

validity of the latent constructs. Indicators with a loading value of below the suggested thresholds of 0.7 were removed, resulting in only 20 of the 47 indicators across five constructs remaining judged as acceptable. Table 3 shows the list of constructs and corresponding indicators.

The mean, standard deviation, and factor loadings of selected indicators of the considered constructs, along with Cronbach's alpha, Rho_A, Composite Reliability (CR), and Average Variance Extracted (AVE) values, are presented in Table 4.

Table 4 shows that the loading value for each indicator of the constructs exceeds the recommended value of 0.7. Each construct's Cronbach's alpha and rho values are above 0.6 [35]. The composite reliability (CR) and average variance extracted (AVE) for all constructs are higher than the suggested thresholds of 0.7 and 0.5, respectively, confirming the data's internal consistency or reliability and convergent validity. The values of CR and AVE for five constructs are presented in Fig. 4.

To test discriminant validity (DV), the methods used include the criterion of Fornell and Larcker, the concept of Cross-Loadings, and the Heterotrait-Monotrait (HTMT) ratio. The DV values from the Fornell-Larcker criterion and HTMT are shown in Table 5. The HTMT ratio value of the constructs is also presented in Fig. 5.

Table 2. Socio-demographic Status of Respondents.

Characteristics	Number	Percent	Characteristics	Number	Percent
Age (Years)			Ownership of House		
<= 35	145	29.4	Owned	425	86.2
36-45	101	20.5	Rented	50	10.1
46-55	123	24.9	Institutional shelter	18	3.7
55+	124	25.2			
Sex of Respondent			Marital Status		
Male	300	60.9	Unmarried	34	6.9
Female	193	39.1	Married	459	93.1
Educational Level			Type of Infrastructure		
Informal	76	15.4	Permanent	375	76.1
Primary	92	18.7	Semi-permanent	76	15.4
Secondary	143	29.0	Kachchi	42	8.5
Bachelor's and above	182	36.9			
Religion			Occupation		
Hindu	416	84.4	Agriculture	163	33.1
Buddhism	63	12.8	Government Job	144	29.2
Islam	6	1.2	Business	115	23.3
Christian	6	1.2	Private Job	62	12.6
Others	2	0.4	Others	9	1.8

Table 3. Indicators for constructs.

Construct	Symbol	Indicator	References
CC-Variability (VAR)	B01.1	Perceived that the summer/winter temperature has changed.	[69]
	B01.2	The timing of rainfall has changed.	[70]
	B01.3	The timing of the snowstorm has changed.	[69]
	B01.4	The amount of intensity of rainfall has changed.	[70]
	B01.5	The timing of cloudy/foggy days has changed.	[69]
	B01.6	The timing of the hailstorm has changed.	[69]
CC-Severity (SEV)	B02.1	Increase in summer temperature	[69]
	B02.2	Increase in winter temperature	[69]
	B02.4	Increase in the amount of rainfall	[69]
	B02.6	Increase in the intensity of rainfall	[71]
	B02.7	Increase in the number of cloudy/foggy days	[70]
CC-Impact (IMP)	C05.5	Depletion of the natural water resources	[72]
	C05.6	Increase in the frequency of drought due to climate change.	[70]
	C05.7	Increase in climate change-induced Migration	[70]
Adaptation (ADPT)	D01.6	Increase in the production of livestock by improving their breed	[72]
	D01.7	Changes in cropping patterns (crop rotation, intercropping)	[69]
	D01.8	Optimum utilization of the climatic adaptation program of the government	[69]
Migration Intention (INT)	G02.14	Lack of social security for severe climatic disasters like landslides, soil erosion	[73]
	G02.15	Lack of a scientific weather forecast system	[72]
	G02.17	Lack of programs from the government for controlling natural resources	[73]
	G02.18	Lack of a policy of reward/punishment for conserving/misusing the natural resources	[74]

Table 5 shows that the square root of the AVE for each construct exceeds the inter-construct correlation, and all HTMT values are below 0.90 [75], confirming discriminant validity (DV). The overall results from Tables 4 and 5 satisfy the reliability and validity criteria of the measurement model and are therefore suitable for the structural model. According to Hair et al. [63], if the measurement models meet all required criteria, it is only necessary to assess the structural model.

Structural Model Assessment

After assessing the measurement model, the structural model is conducted in the next step. For the structural model, hypotheses are tested through a series of steps using the Bootstrap resampling method, which involves 5000 resamples [76]. The regression coefficient, standard error, t-statistic, and p-value for each hypothesis of the structural direct relationships are presented in Table 6.

Table 6 indicates that climate change impact has a significant positive effect on adaptation. Therefore, H_5 is supported. This aligns with the substantial impacts of climate change that heavily influence human migration,

especially in coastal areas [22]. It also negatively affects crop productivity and food security, especially in developing nations [40]. Responses to climate change have the potential to reduce poverty and inequality, while promoting a shift toward resilient livelihoods and sustainable development [42]. Similarly, there is a significant positive and direct effect of climate change impact on migration intention and adaptation on migration intention, supporting hypotheses H_6 and H_7 . This aligns with the negative impacts of climate change on farming productivity ultimately influence migration intentions [46] and the conceptualization of migration as an adaptation strategy to minimize exposure to risks and prevent the loss of human lives and properties [53]. Adaptation practices significantly influence migration intentions by helping people handle local challenges or increasing their likelihood of migrating. Measures such as diversifying crops, adopting water management techniques, and strengthening social networks can boost community resilience and decrease migration pressures. However, when adaptive resources are lacking, the need to migrate grows, and migration can become a strategy for adapting, allowing individuals to find alternative livelihood opportunities. This aligns with findings that

Table 4. Loading values, reliability, and validity.

Constructs	Indicator	Mean	SD	Loading value	Cronbach Alpha	Rho_A	CR	AVE
CC_Variability (VAR)	B01.1	3.627	1.091	0.774	0.887	1.041	0.909	0.625
	B01.2	3.586	1.063	0.741				
	B01.3	3.661	1.237	0.819				
	B01.4	3.469	0.953	0.706				
	B01.5	3.773	1.046	0.798				
	B01.6	4.209	1.120	0.893				
CC_Severity (SEV)	B02.1	3.824	1.010	0.854	0.920	0.998	0.933	0.736
	B02.2	4.116	1.071	0.933				
	B02.4	3.789	0.954	0.838				
	B02.6	4.197	1.112	0.911				
	B02.7	3.779	0.925	0.741				
CC_Impact (IMP)	C05.5	4.067	0.947	0.792	0.729	0.772	0.841	0.638
	C05.6	3.909	0.861	0.770				
	C05.7	3.611	0.927	0.832				
CC_Adaptation (ADPT)	D01.6	4.010	0.664	0.838	0.687	0.711	0.825	0.612
	D01.7	4.189	0.630	0.768				
	D01.8	4.249	0.693	0.737				
Mig_Intention (INT)	G02.14	4.049	0.655	0.742	0.802	0.817	0.870	0.626
	G02.15	3.878	0.787	0.807				
	G02.17	4.069	0.662	0.845				
	G02.18	4.095	0.693	0.767				

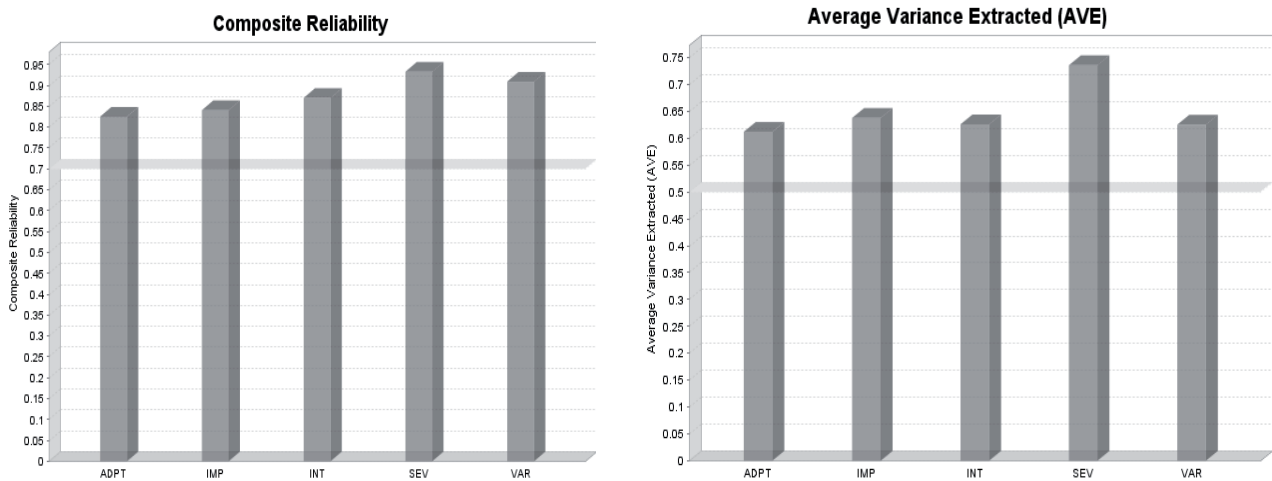


Fig. 4. Smart-PLS charts to show the CR and AVE values of the constructs.

populations with limited access to adaptive resources experience higher migration rates as people relocate to avoid the chronic stress of climate impacts [52].

There is a negative impact of variability and severity on adaptation and migration intention, but insignificant,

which aligns with the fact that the impact of climate variability on migration intention is insignificant in Nepal, Nigeria, and Senegal, but contradicts findings that migration in Uganda tends to rise with temperature anomalies, while migration in Kenya and Burkina Faso

Table 5. Discriminant validity (Fornell, Larcker, and HTMT) of the constructs.

Constructs	VAR	SEV	IMP	ADPT	INT
VAR	<i>0.791</i>	0.608	0.179	0.094	0.150
SEV	0.592	<i>0.858</i>	0.145	0.123	0.148
IMP	-0.093	-0.137	<i>0.799</i>	0.377	0.442
ADPT	-0.059	-0.09	0.285	<i>0.782</i>	0.329
INT	-0.149	-0.163	0.362	0.249	<i>0.791</i>

Note: The data on the diagonal (highlighted in bold and italics) represents the square root of the AVE of the constructs. The values above the diagonal correspond to HTMT ratios, while those below the diagonal indicate correlations with other constructs.

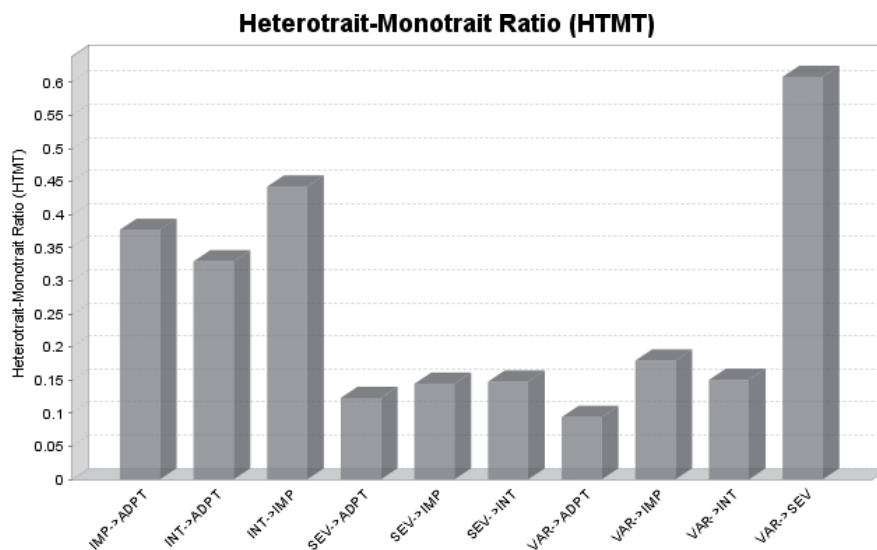


Fig. 5. Smart PLS charts to show the HTMT ratio values of the constructs.

Table 6. Results of the structural model path coefficient (direct relationships).

Hypothesis	Relationship	β	SE	T-value	P-Value	Decision
H ₁	VAR-->ADPT	-0.003	0.065	0.054	0.957	Not supported
H ₂	VAR-->INT	-0.075	0.055	1.261	0.207	Not supported
H ₃	SEV-->ADPT	-0.05	0.058	0.867	0.386	Not supported
H ₄	SEV-->INT	-0.071	0.068	1.014	0.353	Not supported
H ₅	IMP-->ADPT	0.278	0.052	5.382	0.000	Supported
H ₆	IMP-->INT	0.346	0.043	8.472	0.000	Supported
H ₇	ADPT-->INT	0.152	0.045	3.329	0.001	Supported

declines [20]. These results contradict that adverse weather events, such as extreme temperatures and droughts, significantly influence people’s migration plans, with variations across different demographic groups and regions [36].

Fig. 6 shows the overall structural model with its loading values, p-values, path coefficients, coefficient of determination, and the proposed hypotheses of the constructs and indicators.

Mediation Analysis

Finally, H₈ assesses whether adaptation acts as a bridge linking the impact of climate change and migration intention. The results show a significant effect of adaptation on mediating impact and migration intention ($\beta = 0.042$, $t = 2.687$, $p = 0.007$). H₉ tests whether adaptation mediates the relationship between severity and migration intention. The results indicate

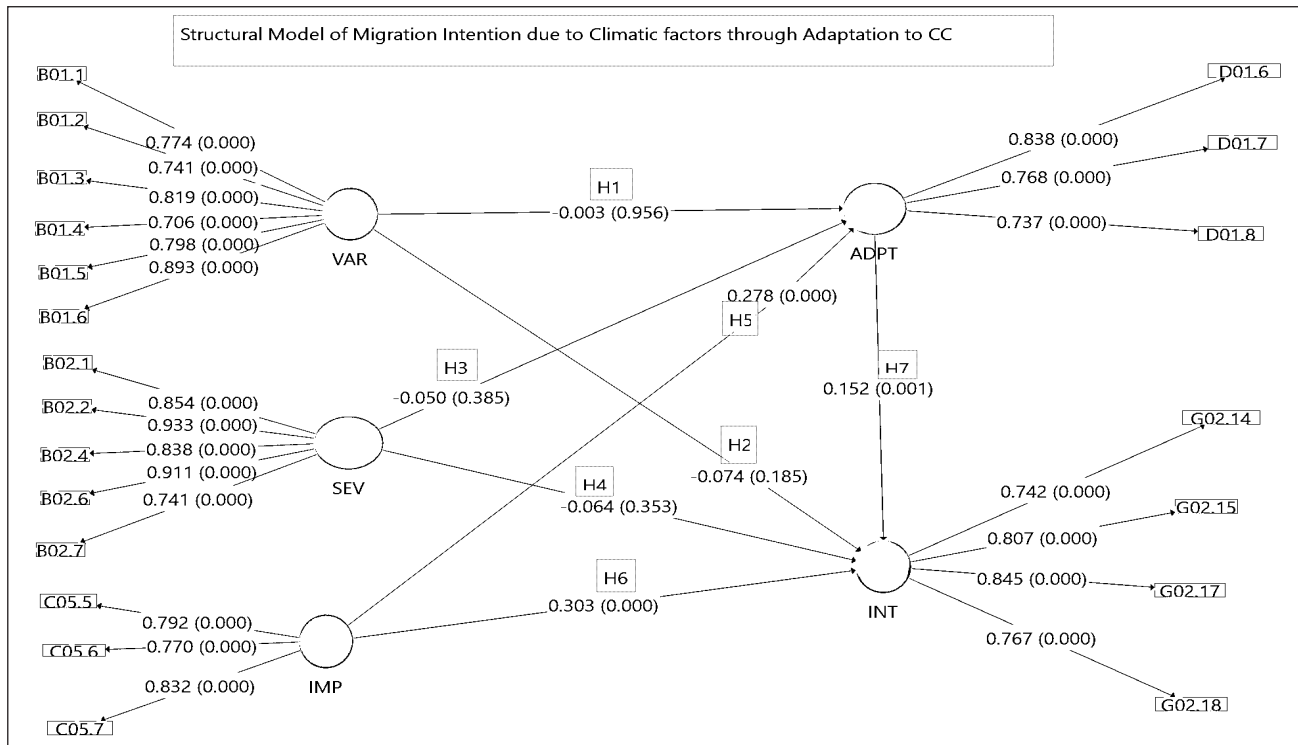


Fig. 6. Structural model for climatic factors' impact on migration intention through adaptation.

an insignificant effect of adaptation on mediating severity and migration intention ($\beta = -0.008$, $t = 0.803$, $p = 0.422$). H_{10} examines whether adaptation mediates the relationship between climate change variability and migration intention. The results reveal an insignificant effect of adaptation on mediating variability and migration intention ($\beta = -0.001$, $t = 0.053$, $p = 0.958$). The findings from the mediation analysis are summarized in Table 7.

Table 7 shows that the indirect effect of climate change impacts on migration intention (through adaptation to climate change) is significant. However, the indirect impact of climatic variability and severity on migration intention through adaptation is not significant. Therefore, this research indicates that only adaptation to climate change significantly influences people's migration intentions affected by climate change.

This study examined how people's perceptions of climate variability, severity, and impact affect their intention to migrate, with adaptation to climate change serving as a mediating factor. The findings showed that the impact of climate change positively influences migration intention through adaptation. However,

the variability and severity of climate change do not significantly influence migration intentions among residents of Gandaki Province, Nepal. Additionally, the direct effects indicate that climate change impact has a positive and significant effect on both adaptation and migration intent. In contrast, other factors have an insignificant impact on migration intention.

Numerous studies highlight how increasingly unpredictable weather patterns, extreme weather events, and gradual environmental degradation due to climate change alter livelihoods, especially in rural, climate-dependent regions. Erratic rainfall and rising temperatures often affect agricultural yields, resulting in food insecurity and economic instability, which aligns with findings that populations reliant on agriculture or natural resources may consider relocation an adaptive response, with the limited infrastructure or institutional support for alternative livelihoods [72]. The variability in temperature does not influence the migration intention in Gandaki Province, which contradicts findings that temperature variability influences the migration decisions of climate refugees in Bangladesh [22].

Table 7. Summary of Mediation Analysis results.

Hypothesis	Path	Indirect		Mediation effect		T Value	P value	Decision
		β	Path	β	SD			
H_8	IMP->ADPT	0.278	ADPT->INT	0.152	0.042	2.687	0.007	Supported
H_9	SEV->ADPT	-0.05	ADPT->INT	0.152	-0.008	0.803	0.422	Not supported
H_{10}	VAR->ADPT	-0.003	ADPT->INT	0.152	-0.001	0.053	0.958	Not supported

In South Asia, variations in annual and seasonal rainfall patterns greatly affect agricultural productivity. Growing climate variability indicates that the region will encounter a wider range of yearly weather conditions, resulting in a rainy season that is less predictable and more inconsistent [73].

The impact of climate change increased the migration intention, which aligns with Massey's explanation of local migration driven by perceived declines in productivity, declining land cover, and a longer time required to gather firewood [77].

Severe climate events like floods, landslides, and long-lasting droughts cause immediate and often severe disruptions, which can lead to temporary or permanent migration. This "distress migration" process is common in areas prone to repeated extreme weather, as people are forced to move to places with better resilience or support systems. Research also indicates that the strength of climate impacts affects migration choices; people from regions experiencing high-impact climate events are more likely to migrate than those facing less intense issues [78].

Conclusions

This study aimed to understand the influence of constructs like climatic variability, severity, and the impact of climate change on the adaptation practices and migration intentions of residents in the Gandaki Province, Nepal, using Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings show that among the examined factors, the impact of climate change is the only significant determinant affecting both adaptation practices and migration intentions, highlighting the crucial role of perceived and experienced impacts of climate change in shaping people's responses to environmental challenges.

Contrary to expectations, climatic variability and severity are found to have an insignificant influence and may suggest that individuals prioritize sensible and long-term impacts of climate change, such as livelihood disruption and resource scarcity, over short-term or less perceptible climatic fluctuations when making decisions about adaptation or migration. When calculating the indirect effect, it is shown that migration intentions are significantly influenced by climate change's impact, with adaptation playing a mediating role.

These findings emphasize the need to address both the direct and indirect effects of climate change through policy actions and support systems that boost community resilience and adaptive capacity. Additionally, migration as a response to climate change should be viewed as a necessary strategy rather than a voluntary choice, highlighting the importance of targeted policies to effectively manage and support climate-induced migration.

Future research should investigate the underlying mechanisms by which climate change influences

adaptation and migration decisions, and evaluate the role of social, economic, and institutional factors in shaping these responses.

Acknowledgments

The authors acknowledge with gratitude the financial support for this research, which was conducted as part of a Ph.D. program provided by the University Grant Commission (UGC) Nepal (Award Number Ph.D.-76/77-S & T-14). We also wish to sincerely thank all the respondents for their valuable participation.

Conflict of Interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

- SOHAIL D. A PLS-SEM approach to determine farmers awareness about climate change mitigation and adaptation strategies: Pathway toward sustainable environment and agricultural productivity. *Environmental Science and Pollution Research*. **30**, 18191, **2022**.
- LIU J.C.E. Public opinion on climate change in China: Evidence from two national surveys. *Public Library of Science (PLOS) Climate*. **2** (2), 65, **2023**.
- SHAFIQ M.U., RAMZAN S., AHMED P., MAHMOOD R., DIMRI A.P. Assessment of present and future climate change over Kashmir Himalayas, India. *Theoretical and Applied Climatology*. **137** (3-4), 3183, **2019**.
- THAKUR' A., MISHRA P.K., NEMA A.K., SAHOO S.P. Spatio-temporal trends and shift analysis of temperature for Wainganga sub-basin, India. *International Journal of Environmental Studies*. **77** (3), 464, **2020**.
- KHADAM M.M. Stakeholders' perspective on climate change vulnerability and adaptation strategies in mountainous areas of the Punjab and Khyber Pakhtunkhwa, Pakistan (Ph D Dissertation no: 390597847), University of Agriculture, Faisalabad, Pakistan, **2023**.
- IPCC. Summary for policymakers. In: *Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, **2021**.
- AJUANG C.O., ABUOM P.O., BOSIRE E.K., DIDA G.O., ANYONA D.N. Determinants of climate change awareness level in upper Nyakach Division, Kisumu County, Kenya. *Springerplus*. **5** (1), 2699, **2016**.
- CHITSA M., SIVAPALAN S., MAHINDER SINGH B.S., LEE, K.E. Citizen participation and climate change within an urban community context: Insights for policy development for bottom-up climate action engagement. *Sustainability*. **14** (6), 3701, **2022**.
- LI F., ZHANG G., LI H., LU W. Land use change impacts hydrology in the Nenjiang River Basin, Northeast China. *Forests*. **10** (6), 1, **2019**.
- GILMORE E.A., WRATHALL D., ADAMS H., BUHAUG H., CASTELLANOS E., HILMI N., MCLEMAN R.,

- SINGH C., ADELEKAN I. Defining severe risks related to mobility from climate change. *Climate Risk Management*. **44**, 100601, **2024**.
11. BARIŠIĆ A., GHODSI M., SABOUNIHA A., STEHRER R. The factors driving migration intentions and destination preferences in Central, East, and Southeast European Countries. *The Vienna Institute for International Economic Studies*. 247, **2024**.
 12. ZABELINA E., NIKOLAEVA E., IVANOVA A., VALKO D. Socioeconomic predictors of migration intentions: Systematic analysis. *Bull Chelyabinsk State University*. **482** (12), 152, **2024**.
 13. SHERCHAN P. Understanding the nexus of climate change and migration: A case of Dhye peoples from upper Mustang, Nepal. *Grassroots Journal of Natural Resources*. **2** (1-2), 1, **2019**.
 14. KAUFFMAN N., HILL K. Climate change, adaptation planning, and institutional integration: A literature review and framework. *Sustainability*. **13** (19), 10708, **2021**.
 15. DAO T.H., DOCQUIER F., PARSONS C., PER G. Migration and development: Dissecting the anatomy of the mobility transition. *The institute for the study of labor (IZA)*, 10272, **2016**.
 16. SU T.Y.M. Internal migration of foreign-born in the US: Impacts of population concentration and risk aversion. <https://scholarship.richmond.edu/honors-theses/1511>. Honor Theses, **2020**.
 17. KACZAN D.J., ORGILL-MEYER J. The impact of climate change on migration: A synthesis of recent empirical insights. In *Climate Change* Springer. **158** (3-4), 281, **2020**.
 18. CARETTA M.A., MARTINA A., FANGHELLA V., RITTELMAYER P., SRINIVASAN J., PANDAY P.K., PARAJULI J., PRIYA R., REDDY E.B., UDAY B., SEIGERMAN C.K., MUKHERJI A. Migration as adaptation to freshwater and inland hydroclimatic changes? A meta-review of existing evidence. *Springer Science and Business Media*. **176** (100), 1, **2023**.
 19. DUIJNDAM S., BOTZEN W., ENDENDIJK T., DE MOEL H., SLAGER K., AERTS J. A look into our future under climate change? Adaptation and migration intentions following extreme flooding in the Netherlands. *International Journal of Disaster Risk Reduction*. **95**, 103840, **2023**.
 20. GRAY C., WISE E. Country-specific effects of climate variability on human migration. *Climatic Change*. **135** (3-4), 555, **2016**.
 21. BOLAN S., PADHYE L.P., JASEMIZAD T., GOVARTHANAN M., KARMEGAM N., WIJESEKARA H., AMARASIRI D., HOU D., ZHOU P., BISWAL B.K., BALASUBRAMANIAN R., WANG H., SIDDIQUE K.H.M., RINKLEBE J., KIRKHAM M.B., BOLAN N. Impacts of climate change on the fate of contaminants through extreme weather events. *Science of the Total Environment*. **909**, 168388, **2024**.
 22. ABIR T.M., XU X. Assessing the factors influencing migration decision of climate refugees in coastal areas of Bangladesh. *American Journal of Climate Change*. **8** (2), 190, **2019**.
 23. REYES C.B., THIEDE B.C. Climatic variability and cause-specific migration in rural and urban India. *OSF*. **2022**.
 24. THIEDE C.B., ABBIE R., CLARK G. Climatic variability and mnternal migration in Asia: Evidence from big microdata. *Population and Development Review*. **50** (2), 513, **2024**.
 25. THIEDE C.B., ROBINSON A., GRAY C. Climatic variability and internal migration in Asia: Evidence from Integrated Census and Survey Microdata. *OSF*. **2022**.
 26. YUE S., WANG C., LIU H., HAO Z. How does climate change affect migration intention? Evidence from China. *Applied Economics Letters*. **32** (3), 398, **2023**.
 27. SILCHENKO D., MURRAY U. Migration and climate change: The role of social protection. *Climate Risk Management*. **39**, 100472, **2023**.
 28. SHUKLA P.R., SKEA J., SLADE R., VAN DIEMEN R., HAUGHEY E., MALLEY J., PATHAK M., PORTUGAL PEREIRA J. Technical Summary. In: *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*. IPCC. **2019**.
 29. TOMY V., MISHRA S.N., DASH A. Adaptation strategies against climate-induced changes by farming communities: The case of Chilika lake wetland ecosystem of Odisha. *International Journal of Plant and Soil Science*. **34** (24), 700, **2022**.
 30. MCAULIFFE M., TRIANDAFYLLIDOU A. World migration report 2022. Geneva: International Organization for Migration (IOM). **2022**.
 31. TRAVIS W.R. Weather and climate extremes: Pacemakers of adaptation? *Weather and Climate Extremes*. **5-6**, 29, **2014**.
 32. REGAN P.M., KIM H., MAIDEN E. Climate change, adaptation, and agricultural output. *Regional Environmental Change*. **19** (1), 113, **2019**.
 33. FAO. A framework for land evaluation. *Food and Agriculture Organizations of United Nations*. **9** (3), **1976**.
 34. MANANDHAR S., PANDEY V.P., KAZAMA F. Climate change and adaptation: An integrated framework linking social and physical aspects in poorly-gauged regions. *Climatic Change*. **120** (4), 727, **2013**.
 35. BLACK R., ADGER W.N., ARNELL N., DERCON W.S., GEDDES A., THOMAS D.S.G. The effect of environmental change on human migration. *Global Environmental Change*. **21** (1), S3, **2011**.
 36. TAN Y. Resettlement and climate impact: Addressing the migration intentions of resettled people in west China. *Australian Geographer*. **48** (1), 97, **2017**.
 37. CHEN Y., CHEN X., AI H., TAN X. Temperature and migration intention: Evidence from the unified national graduate entrance examination in China. *International Journal of Environmental Research, Public Health*. **19** (16), 10244, **2022**.
 38. NASTRIN N., HAIDER M.Z., ABSAN M.N. Trend in climate change-induced migration: A bibliometric analysis. *Khulna University Studies. Special issue (ICES)*. 119, **2023**.
 39. ABBASS K., QASIM M.Z., SONG H., MURSHED M., MAHMOOD H., YOUNIS I. A review of the global climate change impacts, adaptation, and sustainable mitigation measures. *Environmental Science and Pollution Research*. **29** (28), 42539, **2022**.
 40. KUMAR M., BORUAH A., SONIA H., PADHA K. Building agricultural resilience: Strategies for climate change adaptation. *International Journal of Environmental Climate Change*. **14** (11), 561, **2024**.
 41. WILLIAMS D.S., CELLIERS L., UNVERZAGT K., VIDEIRA N., MAÑEZ COSTA M., GIORDANO R. A method for enhancing the capacity of local governance for climate change adaptation. *Earth's Future*. **8** (7), 1, **2020**.

42. IPCC, Climate Change 2022: Impacts, adaptation and vulnerability Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University. **2022**.
43. BORDERON M., SAKDAPOLRAK P., MUTTARAK R., KEBEDE E., PAGOGNA R., SPORER E. Migration influenced by environmental change in Africa: A systematic review of empirical evidence. *Demographic Research*. **41**, 491, **2019**.
44. LIAO C. Beyond linear pathways: An interconnected framework for understanding the climate-migration nexus. *International Migration*. **62**, 284, **2024**.
45. FAO. The state of food security and nutrition in the world 2021: Transforming food systems for food security, improved nutrition and affordable healthy diets for all. **2021**.
46. LACZKO F. Migration, risk management, and climate change: Evidence and policy responses. Switzerland: International Organization for Migration (IOM), **6**, **2016**.
47. DONATO K.M., MASSEY D.S. Twenty-first-century globalization and illegal migration. *The Annals of the American Academy of Political and Social Science*. **666** (1), 7, **2016**.
48. WONG-PARODI, G., FEYGINA, I. Hurricane adaptation behaviors in Texas and Florida: exploring the roles of negative personal experience and subjective attribution to climate change. *Environmental Research Letters* **17** (3), 03433, **2022**.
49. ENTWISLE B., WILLIAMS N., VERDERY A. Climate change and migration: New insights from a dynamic model of out-migration and return migration. *American Journal of Sociology*. **125** (6), 1469, **2020**.
50. NABONG E., OPDYKE A. Promoting migration as an adaptation to climate change: Addressing mobility barriers. *Development in Practice*. **33** (1), 128, **2023**.
51. SARKAR B. An Assessment of the Impact of Temporary Migration on Household Adaptive Capacity to Climate Variability (e.g., Drought) in Rural India, Rural and Regional Development. **3** (3), 10010, **2025**.
52. IPCC. Climate change 2023: Synthesis report. contribution of working groups I, II, and III to the sixth assessment report of the Intergovernmental Panel on Climate Change. Core Writing Team, LEE H., ROMERO J. (eds.). IPCC. **2023**.
53. ALMULHIM A.I., ALVERIO, SHARIFI G.N., SHAW A., HUQ R., MAHMUD S., AHMAD M.J., ABUBAKAR S., ISMAILA RIMI A.I. Climate-induced migration in the global south: An in-depth analysis. *Nature Partner Journal Climate Action*. **3** (1), **2024**.
54. AJZEN I. The theory of planned behavior. *Organizational Behavior and Human Decision Processes*. **50** (2), 179, **1991**.
55. AJZEN I., FISHBEIN M. The influence of attitudes on behavior. In: ALBARRACÍN D., JOHNSON B.T., ZANNA M.P. (eds.), *The handbook of attitudes*. Lawrence Erlbaum Associates Publishers, **2005**.
56. WANNER P. Can migrants' emigration intentions predict their actual behaviors? Evidence from a Swiss Survey. *Journal of International Migration and Integration*. **22** (3), 1151, **2021**.
57. MASNÁ E., STOKER A., HASMAN J., NOVOTNÝ J. Understanding migration aspirations using the extended theory of planned behavior: A case study from Western Province of Zambia. *Journal of Rural Studies*. **114**, 103501, **2025**.
58. GÖDRI I., FELEKY G.A. Selection of migrants and realization of migration intentions – lessons from a panel study. (Working papers on population, family and welfare) Hungarian Demographic Research Institute. **29**, **2017**.
59. KLEY S. Facilitators and constraints at each stage of the migration decision process. *Population Studies*. **71** (1), 35, **2017**.
60. HAIR J.F., HULT G.T.M., RINGLE C.M., SARSTEDT M., DANKS N.P., RAY S. Partial least squares structural equation modeling (PLS-SEM) using R. Springer, **2021**.
61. KLINE R.B. Principles and practice of structural equation modeling, (5th edition), Guilford Press. **11** (1), **2023**.
62. VINZI V.E., TRINCHERA L., AMATO S. PLS path modeling: From foundations to recent developments and open issues for model assessment and improvement. In *handbook of partial least squares.*, V. Esposito Vinzi, W. Chin, J. Henseler, and H. Wang, Eds., Berlin, Heidelberg: Springer, pp. 47-82, **2009**.
63. HAIR J.F., BABIN B.J., KREY N. Covariance-based structural equation modeling: Review and recommendations. *Journal of Advertising*. **46** (1), 163, **2017**.
64. MoFE. Vulnerability and risk assessment and identifying adaptation options: Summary for policymakers. Ministry of Forest and Environment, Government of Nepal. Kathmandu, Nepal, 1, **2021**.
65. NSO. National Population and Housing Census 2021. National report. Kathmandu: NSO, **1**, **2021**.
66. NSO. Provincial report of Gandaki Province in National Population and Housing Census 2021. **1**, **2023**.
67. KISH L. Survey sampling. John Wiley & Sons Inc. New York, **1965**.
68. MoFE. Vulnerability and risk assessment and identifying adaptation options. Kathmandu, **2021**.
69. CBS. National Climate Change Impact Survey 2016. Central Bureau of Statistics Kathmandu Nepal, **2017**.
70. KARKI R., UL HASSON S., SCHICKHOFF U., SCHOLTEN T., BÖHNER J. Rising precipitation extremes across Nepal. *Climate*. **5** (1), 1, **2017**.
71. MoFE. In climate change scenarios for Nepal: National adaptation plan (Issue February). Ministry of Forest and Environment Kathmandu Nepal, **2019**.
72. MCLEMAN R., HERMANS K. Climate change, drought, land degradation, and migration: Exploring the linkages. Elsevier, **2021**.
73. RAHAMAN A., HARUN M., FERDOUS J. Factors of climate-induced migration in south Asia: A security question In: Ullah, A.A.(eds) *Handbook of migration, international relations and security in Asia*. Springer Nature, Singapore, pp. 1-17, **2024**.
74. SWALLOW B.M., KALLESOE M.F., LFTIKHAR U.A., VAN NOORDWIJK M., BRACER C., SCHERR S.J., RAJU K.V., POATS S.V., DURAJAPPAH A.K., OCHIENG B.O., MALLEE H., RUMLEY R. Compensation and rewards for environmental services in the developing world: Framing pan-tropical analysis and comparison. *Ecology and Society*, **14** (2), 26, **2009**.
75. HENSELER J., RINGLE C.M., SARSTEDT M. A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*. **43** (1), 115, **2015**.
76. HAIR J.F.JR., HULT G.T.M., RINGLE C.M., SARSTEEDT M. A primer on partial least squares structural equation modeling (PLS-SEM). SAGE publications, **2013**.

77. MASSEY D.S. Towards an integrated model of international migration. *Eastern Journal of European Studies*. **3** (2), 9, **2012**.
78. SZABOOVA L.A., SAFRA DE CAMPOS W., MAHARJAN R., SAKDAPOLRAK A., STERLY P.,

CONWAY H., CODJOE D., ABU S.N.A., MUMUNIL. Evaluating migration as successful adaptation to climate change: Trade-offs in well-being, equity, and sustainability. *In One Earth*. **6** (6), 620, **2023**.