

ARTIFICIAL INTELLIGENCE AND BORDER SECURITY IN NEPAL



A Thesis

**Submitted to APF Command & Staff College,
Faculty of Humanities and Social Sciences
Tribhuvan University
In Partial Fulfillment of the Requirements
For Master's Degree in
Security, Development and Peace Studies**

Submitted by

SHIVA PRASAD GAIHRE

Seventh Batch (2078-2080)

Roll No: 28 MSDPS 40008

TU Registration No.: 12272-95

**APF Command and Staff College
Sanogaucharan, Kathmandu, Nepal**

July, 2023

**ARTIFICIAL INTELLIGENCE AND BORDER SECURITY IN
NEPAL**

A Thesis

**Submitted to APF Command & Staff College,
Faculty of Humanities and Social Sciences
Tribhuvan University
In Partial Fulfillment of the Requirements
For Master's Degree in
Security, Development and Peace Studies**

Submitted by

SHIVA PRASAD GAIHRE

Seventh Batch (2078-2080)

Roll No: 28 MSDPS 40008

TU Registration No.: 12272-95

**APF Command and Staff College
Sanogaucharan, Kathmandu, Nepal**

July 2023

DECLARATION

I hereby declare that the thesis entitled **ARTIFICIAL INTELLIGENCE AND BORDER SECURITY IN NEPAL** submitted to **APF Command and Staff College**, entirely my original work prepared under guidance of my supervisor.

I have made due acknowledgement to all ideas and information borrowed from different sources in course of preparing this thesis. The result of this thesis has not been presented or submitted anywhere else for the award of any degree or for any other purposes. I assure that no part of the content of this thesis has published in any form before. I shall be solely responsible if any evidences found against my research paper.

This thesis is being submitted to APF Command and Staff College, Faculty of Humanities and Social Sciences, Tribhuvan University in Partial Fulfillment of Master Degree in Security, Development and Peace Studies.

.....

Shiva Prasad Gaihre

TU Reg. No: 12272-95

(July, 2023)

LETTER OF RECOMMENDATION

This thesis entitled **ARTIFICIAL INTELLIGENCE AND BORDER SECURITY IN NEPAL** was prepared by **Mr. Shiva Prasad Gaihre** under my supervision. The researcher has fulfilled the criteria prescribed by Faculty of Humanities and Social Sciences, Tribhuvan University. I hereby forward this for final evaluation and approval.

.....

Dr. Naresh Rimal

Thesis Supervisor

Date.....



**Government of Nepal
Ministry of Home Affairs
APF Command and Staff College**

Ph. No. :- 01-4513159/9851072030
Email :- paacademic2015@gmail.com
Website:- <https://csc.apf.gov.np>

**Academic Section
Sanogaucharan,
Kathmandu**

Ref. No.: - (080/081)/

Date: - 2080/04/

LETTER OF APPROVAL

This Thesis entitle **ARTIFICIAL INTELLIGENCE AND BORDER SECURITY IN NEPAL** submitted by **SHIVA PRASAD GAIHRE** to APF Command and Staff College, Faculty of Humanities and Social Sciences, Tribhuvan University in partial fulfillment of Master's Degree in Security, Development and Peace Studies has been approved by the undersigned members of the Evaluation Committee.

Evaluation Committee:

.....
Dr. Naresh Rimal
Thesis Supervisor

.....
Prof. Dr. Tara Prasad Bhusal
External Examiner

.....
DSP Santosh Rayamajhi
Thesis Co-Supervisor

.....
Prof. Dr. Sohan Kumar Karna
External Examiner

.....
SP Netra Bahadur Karki
Internal Examiner

.....
SP Suresh Sapkota
Internal Examiner

... July 2023

ACKNOWLEDGEMENTS

I would like to express my cordial thanks and sincere gratitude to my supervisor, Dr. Naresh Rimal, for his guidance, practical advice, and unwavering inspiration that have been instrumental in the successful completion of this study. I am also extremely grateful to Dr. Ramesh Raj Kunwar for his valuable suggestions and profound insights that have enriched the research work. Furthermore, I acknowledge Associate Professor Ananta Risal, Ethics in Artificial Intelligence, Kathmandu University, whose valuable contribution and insights enhanced the value of this research.

I am grateful to the Acting Commandant, Academic Coordinator and Directing Staffs of APF Command and Staff College for their continued support for the study and research work. I am indebted to co-supervisor DSP Santosh Rayamajhi and all faculty members, senior and junior officers, other ranks, library management and administration team of APF Command and Staff College for their assistance and providing a conducive environment for the study. Similarly, I am also grateful to all respected lecturers and staffs of the department for helping me in different ways.

I am thankful to the Chief District Officer of Parsha Hiralal Regmi and Superintendent of Armed Police Force Suman Thapaliya for providing valuable time and active participation during the data collection for the study. I am also thankful to Anil Agrawal, president of FNCCI, Birjung, Parsa for their remarkable cooperation and participation during the field visit of Parsa district. Last but not the least, I wish to acknowledge Deputy Superintendent of Armed Police Force Ramjung Pandey, Deputy Superintendent of Armed Police Force Santos Basnet and Assistant Sub-Inspector Madhab Adhikari for their cooperation, hospitality and necessary arrangements for data collection.

ABSTRACT

Integrating AI-powered technologies possesses immense potential to fortify and reinforce Nepal's border security apparatus, elevating it to new heights. This study meticulously explores the boundless possibilities of harnessing AI to bolster Nepal's border security while diligently examining both its advantages and disadvantages. Moreover, it goes beyond mere exploration, presenting ingenious and effective strategies to mitigate risks and ensure the responsible and ethical implementation of AI technologies in Nepal's border security operations.

The research employed thematic and SWOT analyses to evaluate the potential and challenges of AI in Nepal's border security. Thematic analysis was utilized to analyze primary data, and a SWOT analysis precisely appraises the implementation of AI in Nepal's border security. Through interviews, self-observations, and meticulous data analysis, this study offers a profound assessment of the current state of border security in Nepal, unlocking the immense potential of AI to augment its effectiveness.

The study shows that the implementation of AI-powered surveillance technology emerges as an exceptionally promising solution, equipping Nepal with intelligent surveillance, predictive analytics, automated border control, risk assessment, and cutting-edge drone surveillance capabilities. By leveraging AI's capabilities, Nepal can reinforce its ability to identify potential threats swiftly, make informed decisions, and staunchly safeguard the safety and security of its borders. By harnessing these remarkable AI capabilities, the APF can elevate its mandate of border security to unprecedented levels, effectively countering border crimes and mitigating associated risks. The findings underscore the need for comprehensive awareness campaigns, formulating standardized policies, robust cybersecurity measures, capacity building in the APF, Nepal, and substantial investments in digital infrastructure. These essential measures will lay the foundation for the seamless integration of AI-powered technologies into Nepal's border security.

Keywords: artificial intelligence, border security, privacy, drone surveillance, intelligent surveillance

TABLE OF CONTENTS

TITLE PAGE	i
DECLARATION	ii
LETTER OF RECOMMENDATION	iii
LETTER OF APPROVAL	iv
ACKNOWLEDGEMENT	v
ABSTRACT	vi
TABLE OF CONTENTS	vii
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF ABBREVIATIONS AND ACRONYMS	xi
CHAPTER I INTRODUCTION	1-7
1.1 Background	1
1.2 Statement of the Problem	5
1.3 Objectives of the Study	6
1.4 Rationale of the Study	6
1.5 Limitations of the Study	7
CHAPTER II LITERATURE REVIEW	8- 27
2.1 Defining the AI	8
2.2 AI as Writing Tools	11
2.3 Use of AI in Urban Transportation	13
2.4 Use of AI in Agricultural Sector	14
2.5 Use of AI in Industrial Sector	15
2.6 Use of AI in Medical Sector	17
2.7 Use of AI in International Border	19
2.8 Legal Provisions	23
2.9 Critics and Proponents in the Use of AI	25

CHAPTER III RESEARCH METHODOLOGY	28-31
3.1 Research Design	28
3.2 Sources of Data	28
3.3 Data Collection	29
3.4 SWOT Analysis	29
3.5 Study Area	30
3.6 Ethical Consideration	31
CHAPTER IV FINDINGS AND DISCUSSION	32-62
4.1 Enhancing Border Security of Nepal	32
4.1.1 Intelligent Surveillance	32
4.1.2 Predictive Analytics	35
4.1.3 Automated Border Control	36
4.1.4 Risk Assessment	38
4.1.5 Drone Surveillance	39
4.1.6 Robotics	40
4.1.7 Summary	41
4.2 SWOT Analysis	42
4.2.1 Strengths	43
4.2.2 Weakness	48
4.2.3 Opportunities	52
4.2.4 Threats	57
4.2.5 Summary	61
CHAPTER V SUMMARY AND CONCLUSION	63-66
5.1 Summary	63
5.2 Conclusion	64
APPENDICES	67-72
REFERENCES	73-89

LIST OF TABLES

Table 3.1	SWOT Analysis of Use of AI in Nepal Border	30
Table 4.1	Cost of Recruitment of APF Constable in one Time	44

LIST OF FIGURES

Figure 1.1	Sectors of AI	3
Figure 3.1	Map of observation area at Birjung, Parsa	31
Figure 4.1	Illegal Border Crossing in EU Border From 2009 to 2022	33
Figure 4.2	Human Trafficking Victims in Nepal	35
Figure 4.3	ACB Process Steps	37
Figure 4.4	Respondents of General Interview	59

LIST OF ABBREVIATIONS AND ACRONYMS

ABC	Automated Border Control
AI	Artificial Intelligence
AI HLEG	High-Level Expert Group on Artificial Intelligence
ALPR	Automated License Plate Recognition
APA	American Psychological Association
APF	Armed Police Force
BFI	Banking and Financial Institution
BOP	Border Out Post
CAIR	Centre for Artificial Intelligence and Robotics
CBP	Customs and Border Protection
CCTV	Closed-circuit Television
CIDSS	Command Information and Decision Support System
CNN	Convolutional Neural Networks
COVID-19	Coronavirus Disease 2019
DL	Deep Learning
DRDO	Defense Research and Development Organization
DSRPA	Dartmouth Summer Research Project on Artificial Intelligence
EU	European Union
FGD	Focus Group Discussion
FST	Foreign Study Tour
IBM	International Business Machines
ICP	Integrated Check Post
Iot	Internet of Things
IP	Information and Technologies
ISR	Intelligence Surveillance and Reconnaissance

KII	Key Informant Interview
Km	Kilometer
LIDAR	Light detection and ranging
ML	Machine Learning
NIST	National Institute of Standards and Technology
NLP	Natural Language Processing
OECD	Organization for Economic Co-operation and Development
RNN	Recurrent Neural Networks
SMS	Short Message Service
SSB	Seema Surakshya Bal
SWOT	Strength, weakness, opportunities and threats
UASR	Unmanned Aircraft System Requirements
UNDOC	United Nations Office on Drugs and Crime
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
ZTE	Zhongxing New Telecommunications Equipment

CHAPTER I

INTRODUCTION

1.1 Background

Artificial Intelligence (AI) is the creation of computer systems that can carry out operations that ordinarily require intellect akin to that of a human, such as speech recognition, decision-making, and problem-solving (Tucci, 2021). John McCarthy, a mathematician, first used the term AI to describe machine learning (ML), the idea that computer systems can automatically learn from and adapt to new data without human assistance (Frankenfield, 2022). The history of AI can be traced back to ancient times, when philosophers and inventors first began to consider the possibility of creating intelligent machines. However, the field of AI did not start to take shape as a scientific discipline until the middle of the 20th century, although it was first recognized as a separate field in the 1950s (Rockwell, 2017).

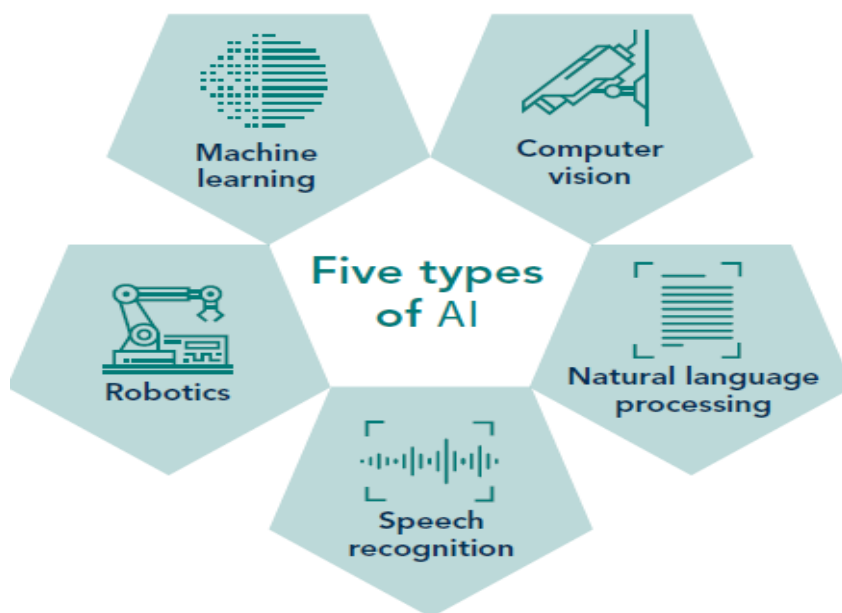
The Dartmouth Summer Research Project on Artificial Intelligence (DSRPAI), which is largely regarded as the origin of AI as a modern academic topic, hosted the inaugural AI program in 1956, which constituted a turning point in the development of AI (Rockwell, 2017). Before 1949, computers lacked a crucial component of intelligence as they could not store commands; they could only execute them (Oppy & Dowe, 2021). A group of researchers met at this conference to discuss the viability of creating machines that could think and reason like humans (Oppy & Dowe, 2021). The DSRPAI, regarded as one of the first AI research programs, was established as a result of this conference (Veisdal, 2023).

The advancement of AI research took place in fits and starts throughout the ensuing decades, with periods of tremendous optimism being followed by depressing periods and reduced funding in the 1970s and 1980s, a period called the "AI winter" (Schuchmann, 2020). Despite these setbacks, significant progress was made in the areas of Natural Language Processing (NLP), computer vision, and expert systems that incorporate medical knowledge to support doctors' decision-making (Sheikh et al., 2023). Due in part to the computer industry's explosive expansion and the growing availability of powerful and reasonably priced computer hardware in the late 1980s and early 1990s, interest in and investment in AI increased (Jones, 2015). A total of \$400 million was invested in the sector between 1982 and 1990 with the intention of

revolutionizing computer processing, introduce logic programming, and enhance AI; however, this goal was not accomplished but inspired the young generation (Rockwell, 2017). The implementation of speech recognition software, the creation of Kismet (a robot that could recognize and display emotions), and other landmark achievements in AI during the 1990s and 2000s were made despite the lack of government funding and public hype (Fieux-Castagnet & Santucci, 2019). For example, International Business Machines (IBM) Deep Blue, a chess-playing computer program, defeated Gary Kasparov in the game.

To improve the precision and speed of screening and monitoring procedures, AI is being used more frequently in border security (Tyler, 2022). AI-enabled systems can analyze a vast amount of data, including passport data, travel habits, and biometric data, to identify potential threats and suspicious behavior (Dumbrava, 2021), which enables border control agents to quickly flag high-risk people for further investigation and prevent unauthorized entry. Facial recognition technology, which uses AI algorithms, a step by step process to achieve outcome (Malhotra, 2021), to compare people's faces to a database of suspects and known offenders, is one of the most widely used applications of AI in border security (Gentzel, 2021). In order to spot questionable behavior or activities, AI can also be used to examine video footage from border crossings and surveillance cameras (Milivojevic, 2022). AI algorithms, for instance, can identify irregularities in the flow of cars or individuals and alert border control personnel to conduct an additional investigation. In addition, AI-driven solutions can assist in automating repetitive operations like document verification and luggage screening, freeing up border control employees to concentrate on higher-level security duties (Khan & Efthymiou, 2021).

The present approach to AI distinguishes itself by utilizing Deep Learning (DL) and ML algorithms that learn from data rather than relying on rigid rules or logic (Haenlein & Kaplan, 2019). The key components as illustrated in Figure 1.1, encompass various technologies and techniques such as Big Data, ML, DL, NLP, Computer Vision, Reinforcement Learning, and Transfer Learning (Janiesch et al., 2021). These components aim to develop intelligent systems that adapt and learn from data in new situations, rather than being strictly programmed. Big data refers to substantial databases requiring specialized tools for processing and analysis (Taylor, 2023). ML, leading the innovation of DL (Sheikh et al., 2023), enables computers to learn from experience (Awad & Khanna, 2015). The availability of vast data and advancements in computer power and cloud computing are significant factors in the current "golden age" of AI, enabling complex algorithms and efficient data processing (Collins et al., 2021).

Figure 1.1*Sectors of AI**Source:* Sheikh et al., (2023)

The growing trend of integrating AI technologies into border security operations in recent years has been supported by both governments and tech proponents. These technologies, which may distinguish between people and wildlife in far-off border regions, include facial recognition, biometric analysis, and scanner software (Feldstein, 2019). Further AI poses questions about privacy and expanding government surveillance while also promising to expedite processes and make better forecasts (Zuiderwijk et al., 2021). AI systems are frequently used as supplements for border officials, allowing fewer people to monitor more territory and scan more migrants and other travelers in less time than would otherwise be possible (Tyler, 2022). Critics have warned about the possibility of technology creep, where systems developed for border zones slowly make their way into mainstream society (Dumbrava, 2021).

Nepal shares its borders with China and India, which are among the most populous nations globally. The border with India spans approximately 1880 Kilometer (Km) and consists of a flat landmass on the southern side, while the Hindu Kush Himalayan arc stretches for about 800 to 850 Km from east to west along the border between Nepal and China (Bhandary et al., 2013). Rasuwagadhi and Tatopani have altitudes of 1,983 m and 2,300 m, respectively, enabling their usability in winter while the remaining crossings are located at elevations

exceeding 3,000 m in the six border crossings (Rana, 2020). Approximately 22,000 Armed Police Force (APF), Nepal personnel, and Border Out Posts (BOP) are positioned at intervals of 15 Km along the border, while India has deployed 45,000 Seema Surakshya Bal (SSB) and established BOPs at intervals of 3 Km (Upreti, 2021). In the northern region, Nepal has set up 8 BOPs from the APF, Nepal. At the same time China has deployed approximately 728 personnel in 18 units of the People Armed Police Force at a distance of roughly 79 Km (Upreti, 2022). More than 12 ministries at the federal level and more than 670 agencies at the borderline of Nepal coordinate with each other for desired output (Upreti, 2022); the number itself demands the technologies for cooperation. Nepal has been unable to implement such technologies, which can somewhat lessen the security risks it has been dealing (Pulami, 2023).

Nepal implemented three different border systems to regulate its border (Rimal, 2021). It faces numerous challenges in ensuring border security due to its extensive and porous borders with India, as well as the rugged terrain along its border with China (Upreti, 2021). Nepal's effective border security enables the cultivation of positive relationships with neighboring countries, facilitating legal trade, tourism, and cultural exchanges. This also promotes improved coordination and collaboration on shared concerns such as disaster management, border disputes, and counterterrorism efforts (MoFA, 2020). The significance of border security cannot be understated, as it serves as a cornerstone for upholding regional stability and advancing diplomatic ties. Ensuring orderly security is of paramount importance to Nepal, as it guarantees the preservation of territorial integrity, safeguards national security, and bolsters regional stability. By prioritizing robust border security measures, Nepal can protect its sovereignty, combat illicit activities, nurture favorable relations with neighbors, and actively contribute to the overall goals of peace, development, and prosperity (Upreti, 2019).

Nepal has initiated policy through the implementation of the "Digital Nepal Framework, 2019" to explore the potential of AI (Jha & Yadav, 2022). One specific area where AI is being employed in Nepal is in the use of biometric identification systems, which can verify the identities of individuals and detect those using fake documents or aliases (Suman, 2022). In addition, the banking and financial institutions (BFIs) in Nepal have embraced AI-based technology in various areas such as financial technology, SMS banking, internet banking, mobile banking, e-wallets, and payment gateways (Niroula, 2021). Furthermore, Closed-circuit Television (CCTV) cameras are employed to monitor key checkpoints along the Nepal-India border (Tripathi, 2018). These initiatives highlight the potential of AI in enhancing border

security in Nepal by improving the efficiency and accuracy of security screening processes, enhancing public safety, and safeguarding the nation's borders from potential security threats.

The benefits of AI for Nepal's border security are numerous. Firstly, with the data collected from sensors, surveillance cameras, and other sources, AI can detect suspicious patterns and actions, aiding in identifying potential security threats (Beduschi, 2021). Moreover, AI has the potential to significantly enhance the efficiency of border security. Through automation, AI can handle routine tasks like monitoring and detecting illegal border crossings, thereby freeing up valuable resources for more critical operations (Kumar, 2021). Secondly, AI enables real-time decision-making, leading to faster response times and improved effectiveness in managing border security (Tyler, 2022). A third advantage of AI lies in its ability to enhance border security intelligence. By analyzing open-source data such as social media and news feeds, AI can identify potential threats and provide early warning signals by tracking the movements of individuals or groups of interest, thereby delivering valuable intelligence to border security agencies (Timsina, 2019). The integration of AI into Nepal's border security measures can offer benefits such as efficient data analysis, enhanced operational effectiveness, and improved intelligence gathering, contributing to bolstering border security and safeguarding the nation.

Regardless of the potential benefits of AI in border security management, many challenges must be addressed before widespread adoption. The first challenge is the technical issues, such as inadequate infrastructure, limited resources and connectivity. These challenges need to be addressed to ensure the continuous integration of AI into the border security system (Khan & Efthymiou, 2021). The second challenge is data privacy concerns because AI relies on massive amounts of data, including personal information, to examine and make decisions. This raises privacy concerns that need to be addressed through appropriate policies and regulations (Kerry, 2020). The third challenge is the need for skilled personnel. AI requires trained personnel to develop and maintain the system. Nepal needs to invest in developing the necessary skills and expertise to effectively manage the AI-based border security system (Suman, 2022).

1.2 Statement of the Problem

The application of AI in border security has gained traction recently, offering solutions to various challenges and enhancing the efficiency and accuracy of border security operations. However, there are several hurdles associated with utilizing AI in this context, including

privacy concerns, technical limitations, and legal and ethical considerations. Nonetheless, the adoption of AI in border security is expected to continue growing as governments and border security agencies strive to improve their operations' effectiveness and efficiency.

In Nepal, border security faces numerous challenges, such as illegal immigration, smuggling of goods and weapons, terrorism, and human trafficking. These challenges necessitate effective and efficient border security measures, which can be augmented through the implementation of AI technologies. However, the use of AI in border security management in Nepal also presents significant issues and challenges, including privacy concerns, technical limitations, and legal and ethical considerations. Thus, it is important to investigate the possible risks and benefits of using AI in border security in Nepal and to identify strategies for mitigating these risks and ensuring that AI is used responsibly and ethically. Despite multiple efforts to manage the borders in Nepal, there has been a persistent increase in border crimes and other illicit activities. So, this study aims to pave some of the needy ways of incorporating AI in Nepal's border security management and poses the following research questions:

- a. How AI be utilized to enhance border security in Nepal?
- b. What are the potential strengths, weaknesses, opportunities, and threats associated with the use of AI in Nepal's border security?

1.3 Objectives of the Study

The broad objective of the study is to investigate AI and border security in Nepal and the specific objectives are:

- a. To explore the potential of AI in enhancing border security in Nepal.
- b. To identify and analyze the potential strengths, weaknesses, opportunities, and threats associated with the use of AI for border security in Nepal.

1.4 Rationale of the Study

Border security holds immense importance for any nation as it serves as a crucial barrier against illegal activities like human trafficking, drug smuggling, arms trade, and terrorism. In the case of Nepal, the country faces unique challenges due to its porous border with India and its rugged

geography shared with China, underscoring the need to explore the potential of AI in strengthening border security. Despite the promising potential of AI for bolstering border security, there is a dearth of research on its specific applications in Nepal. This study aims to bridge that gap by analyzing the potential use cases of AI in enhancing border security within the country. Additionally, the study seeks to identify the associated risks and challenges that arise from employing AI for border security in Nepal. Such insights will be instrumental in formulating strategies and policies to address these challenges and enhance overall border security nationwide. Ultimately, the study aims to contribute valuable findings to relevant agencies, academia, and policymakers, focusing on the utilization of AI for enhancing border security, identifying current challenges, and improving border security in Nepal.

1.5 Limitations of the Study

This study does not cover all the major borders of Nepal due to time limitations. The field study area is confined to the border areas of Birjung, Parsa, as it is one of the major customs points for trade and transit between Nepal and India. Additionally, this study focuses on the current status of border security in Nepal and does not delve into historical or political factors that may have contributed to the current situation.

CHAPTER II

LITERATURE REVIEW

Previous studies on AI, Border Security, and AI technologies in border security were reviewed to provide theoretical knowledge on AI and its potential in border security that could enhance the efficiency and accuracy of screening processes, improve threat detection capabilities, and increase overall security. With the growing number of people and commodities crossing borders increasing every year, AI might be a key factor in ensuring that only authorized individuals and things are admitted, as well as preventing the entry of harmful contraband and unauthorized people.

According to an assessment by the United Nations Office of Drugs and Crime (UNDOC), Nepal's borders are susceptible to illegal operations like human trafficking, smuggling, and drug trafficking (UNDOC, 2020). The necessity for better border security measures, including the application of advanced technology like AI, is also highlighted in the report. The potential of AI in border security has been examined in a number of studies. For instance, Kaur (2021) proposed a system for identifying and categorizing suspicious activity at border checkpoints using AI-based algorithms, which was successful in identifying suspicious behavior and had the potential to enhance border security. Tyler (2022) asserted a similar claim that an AI-based system for spotting suspicious people at border checkpoints was proven to have high accuracy and may help to improve border security. Another study by Fontes et al. (2022) looked at the application of AI to border monitoring to spot and stop unlawful activity. According to the study, AI-based technologies could help to increase border security and improve the precision and effectiveness of border surveillance. However, there are also concerns about the potential risks and challenges associated with the use of AI in border security (Dumbrava, 2021).

2.1 Defining the AI

The term 'Artificial Intelligence' coined by John McCarthy in 1955 and defined AI as "the science and engineering of making intelligent machines where intelligence is the computational part of the ability to achieve goals in the world" (Ribeiro, 2023). AI pioneer Marvin Minsky in 1968 defined AI as "the science of making machines do things that would require intelligence

if done by men” (Fjelland, 2020). Marsden (2017) defined “Artificial Intelligence as a technology that behaves intelligently using skills associated with human intelligence, including the ability to perceive, learn, reason and act autonomously. The High-Level Expert Group on Artificial Intelligence (AI HLEG) of the European Union (EU), described AI as “Systems that display intelligent behavior by analyzing their environment and taking actions with some degree of autonomy to achieve specific goals” (AI HLEG, 2018).

Awad and Khanna (2015) described that artificial neural networks are used in the field of DL which is a branch of ML and AI. With numerous layers of interconnected nodes that can process and interpret massive quantities of data, these neural networks are built to mimic the human brain. In addition, DL can examine huge, complex datasets and find hidden links and patterns that would be challenging or impossible for a human to find. The most significant advancements in DL are the development of Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs). RNNs are employed for NLP and speech recognition, while CNNs are made to analyze images and video. These advanced neural networks have led to significant strides in computer vision, speech recognition, and language translation.

Janiesch et al. (2021) defined that ML is a subgroup of AI, the development of algorithms and statistical models that allow computers to learn from data, recognize patterns, and make decisions with little human involvement. Additionally, the fundamental idea behind ML is to give computer systems the capacity to automatically pick up new skills and refine existing ones based on experience rather than solely on pre-programmed rules. This enables more effective and precise decision-making in a variety of fields, including image recognition, speech recognition, NLP, and predictive analytics. supervised learning, unsupervised learning, and reinforcement learning are the three basic categories under which ML algorithms are commonly categorized.

Fran (2021) defined robotics as the combination of sensors, actuators, and control systems that enables robots to perform a variation of tasks, from simple repetitive tasks to more multifaceted activities that require decision-making and problem-solving skills. Further, it is playing an important role in renovating industries and creating new opportunities for innovation and development in the field of military, manufacturing, healthcare, agriculture, transportation, and logistics.

Khurana et al. (2022) defined NLP as a subfield of AI that enables computers to comprehend, interpret, and produce human language, NLP poses the key elements of daily living. NLP analyzes and processes written or spoken natural language using a variety of methods and models. Some of the techniques used in NLP include tokenization, Parts-of-Speech tagging, sentiment analysis, machine translation, and text. It integrates various applications, such as speech recognition, chatbots, sentiment analysis, machine translation, and virtual assistants.

Hossein (2022) claimed that computer vision is more accurate and can perform complex visual tasks with increasing efficiency that focused on enabling machines to analyze, interpret, and understand images and videos. This involves using mathematical and statistical techniques to extract information from visual data, including object recognition, scene reconstruction, and image segmentation. Additionally, there are numerous uses for computer vision, including those in self-driving cars, facial recognition software, medical imaging, and industrial automation.

Surianarayanan et al. (2023) defined the neural networks (simulated neural networks or artificial neural networks) as a subsection of ML that serves as the foundation for DL algorithms. They are stimulated by the structure and functioning of the human brain, featuring layers of nodes, including input, hidden, and output layers. Connections between nodes are assigned weights and thresholds, and activated nodes transmit data to the next layer based on the specified threshold, while inactive nodes do not. With the aid of training data, neural networks enhance their accuracy over time, making them effective tools in supercomputers and AI. They excel in tasks such as speech recognition and image identification, significantly reducing the time needed in comparison to human manual identification.

Sheikh et al. (2023) argued on the absence of a generally agreed-upon universally accepted definition of AI. The broad definition of AI as an algorithm is not helpful because it includes numerous unrelated tasks like how a pocket calculator works or how to follow recipe directions. On the other hand, the precise definition of AI as machines replicating human intelligence is not realistic as many contemporary applications are still quite rudimentary, which would be erroneous to say that AI does not exist at the moment. Understanding AI's implications and potential requires settling on a realistic definition. The difficulty of describing AI reflects the diversity and underlying complexity of the phenomenon, which requires a nuanced approach to avoid confusion and misunderstanding.

AI, is the science of creating intelligent machines that can achieve goals in the world. It was coined by John McCarthy in 1955. By the above definition, it can be concluded that the definition of the AI has changed over time and that focuses on creating machines that can perform tasks. These tasks can range from simple ones, such as recognizing images, to complex ones, such as playing games or driving cars. It involves ML, NLP, computer vision, and robotics, which have made significant advancements in recent years.

2.2 AI as Writing Tools

Gruetzemacher (2022) highlighted the significant advancements in AI writing tools, particularly in the field NLP. Among these tools, GPT-3 from OpenAI stands out as a leading language model. Its ability to predict subsequent words based on context has revolutionized text analytics tasks. With a size ten times larger than previous models, GPT-3 excels in advanced applications such as programming and high school-level math problem solving. The latest version, InstructGPT, showcases improved alignment with human values and user intentions. Businesses have experienced promising outcomes in writing, coding, and discipline-specific reasoning with GPT-3. Codex, a GPT-3-based model, assists programmers in creating code from natural language, redefining the nature of programming work. GPT-3 and similar foundation models extend their capabilities to other data forms like images and videos, presenting new research and innovation opportunities.

Widyassari et al. (2022) provided an overview of the significant advancements in the NLP regarding automatic text summarization using AI. The researchers categorized these techniques into extractive and abstractive methods, highlighting the unique strengths and limitations of each approach. To evaluate the quality of automated summaries, various evaluation metrics have been developed, taking into account factors such as coherence, relevance, and informativeness. In addition, AI-based tools have been created to assist writers in enhancing their written compositions by addressing grammar and style issues. These tools employ sophisticated algorithms to detect and rectify grammatical errors, leading to improved clarity and coherence in the text. Moreover, the exploration of style transfer models has shown promise in refining writing styles to better align with the intended audience or purpose. By harnessing the capabilities of AI technologies, these advancements offer the potential for more efficient and effective writing processes in various domains.

Ramesh and Sanampudi (2022) emphasized the growing interest in using AI systems to automate the grading and scoring of essays. Various techniques have been developed, including the use of NLP and ML algorithms, to evaluate essays based on predetermined criteria such as content, organization, and language proficiency. However, there are still challenges and limitations in automating essay scoring, such as accurately capturing the intricacies of human writing and identifying subtle errors. Additionally, concerns have been raised about the fairness and potential biases in the evaluation process.

Khurana et al. (2022) extensively investigated the application areas of NLP. They examined the utilization of NLP techniques in Machine Translation, Text Categorization, Spam Filtering, and Information Extraction. The review delved into the challenges faced in each domain and discussed the notable advancements made in NLP for addressing these challenges. Moreover, the authors elucidated the specific methods and algorithms employed in NLP to facilitate tasks such as bridging the language barrier, categorizing vast amounts of text data, combating email spam, and extracting pertinent information. The review emphasized the crucial role of NLP in enhancing accessibility to multilingual data and enhancing the efficiency of text analysis tasks.

Singh (2023) conducted an analysis of the impact of recent advancements in AI writing tools on the field of humanities. These tools have demonstrated significant influence for several reasons, including enhanced productivity and efficiency. However, their emergence also raises concerns regarding the authenticity and originality of human expression, as well as potential repercussions such as job displacement and diminished human expertise. As AI writing tools have evolved over time, their effects on the humanities have been both positive and negative. While they have simplified the writing process and elevated the quality of authors' work, it is crucial to ensure their responsible and ethical utilization. Achieving a harmonious balance between technological development and human involvement in the creative process becomes imperative. Vigilance in monitoring the impact of AI on the humanities and implementing policies that align with ethical and social norms is of utmost importance.

Ali et al. (2023) asserted that user perception and acceptance of AI writing tools are pivotal in determining their widespread adoption. They emphasize that factors like transparency in AI algorithms and the ability to customize outputs can significantly impact user trust. In terms of design considerations for user-friendly AI interfaces, authors highlighted the importance of prioritizing simplicity, intuitiveness, and clear instructions to ensure a seamless user

experience. Furthermore, the authors underscore the collaborative potential between humans and AI in the writing process. They note that AI tools can provide suggestions, generate content, and automate repetitive tasks, while humans contribute critical thinking, context, and emotional intelligence. Striking the right balance between human input and AI assistance is deemed essential for optimizing the writing process and achieving high-quality outcomes.

Researchers have investigated the utilization of AI writing tools in the field of NLP, examining their impact and benefits. They have also explored various application areas of NLP techniques, such as machine translation and information extraction. Furthermore, studies have been conducted to understand the effects of AI writing tools on the humanities, including concerns about authenticity and job displacement. Advancements have been made in automatic text summarization and the development of AI-based tools to enhance writing quality. The use of AI in automated essay scoring has also been examined, considering both challenges and potential advantages. Additionally, researchers have emphasized the importance of user perception and acceptance of AI writing tools, as well as the collaborative potential between humans and AI in the writing process.

2.3 Use of AI in Urban Transportation

Biswas and Wang (2023) emphasized the pivotal role of AI in the development of autonomous vehicles. The authors highlighted that AI technologies enable vehicles to effectively perceive their surroundings, make real-time decisions, and navigate through intricate traffic scenarios. This transformative capacity of AI has the potential to revolutionize urban transportation by significantly improving road safety, reducing traffic congestion, and enhancing transportation accessibility for individuals who are unable to drive. Autonomous vehicles can utilize AI algorithms to analyze sensor data, such as cameras and radar, to identify obstacles, interpret traffic patterns, and make informed decisions accordingly. By eliminating human error and leveraging AI's ability to process vast amounts of data, autonomous vehicles offer the promise of safer and more efficient transportation systems.

Wang et al. (2023) shed light on the transformative role of AI in traffic management. The authors emphasized that AI algorithms have emerged as powerful tools for analyzing real-time traffic data from diverse sources, including sensors, cameras, and GPS devices. Through this analysis, AI algorithms can accurately identify congestion hotspots, predict traffic patterns, and

optimize signal timings accordingly. The dynamic adjustment of traffic signal timings based on the current traffic conditions leads to a substantial reduction in congestion, minimizing travel times, and improving the overall flow of vehicles. Thus, the integration of AI in traffic management offers great promise in alleviating the challenges posed by urban congestion, enhancing transportation efficiency, and improving the overall quality of urban mobility.

Bharadiya (2023) emphasized that AI algorithms can analyze historical data, passenger demand, and traffic patterns to optimize routes, schedules, and fleet management. This optimization process enables public transportation operators to offer more efficient and reliable services, leading to an increase in ridership and a reduction in congestion on roads. By harnessing the capabilities of AI, public transportation systems can effectively meet the changing needs of commuters, providing them with seamless and convenient travel experiences.

AI plays a pivotal role in the development of autonomous vehicles, enabling real-time decision-making and navigation through complex traffic scenarios, leading to safer and more efficient transportation systems. In traffic management, AI algorithms analyze real-time data to identify congestion hotspots, predict traffic patterns, and optimize signal timings, resulting in reduced congestion and improved traffic flow. Additionally, AI optimization of routes, schedules, and fleet management in public transportation enhances efficiency, reliability, and rider experience. AI-powered ride-sharing and on-demand transportation platforms further contribute to efficient transportation systems and sustainable urban environments by optimizing routes and resource allocation. These advancements in AI are revolutionizing urban transportation, offering improved safety, reduced congestion, and enhanced convenience for commuters.

2.4 Use of AI in Agricultural Sector

Akhter and Sofi (2022) described how the application of ML using Internet of Things (IoT), data analytics in the agricultural sector offered new opportunities to meet the growing demand for food production. These advancements had the potential to revolutionize traditional agricultural approaches, despite some limitations. The authors emphasized the power and capabilities of computing techniques, such as the IoT, ML, wireless sensor networks, and data analytics, in the agricultural context. AI facilitated precision agriculture by analyzing data from various sources, including sensors, drones, satellites, and weather stations. It enabled farmers

to make data-driven decisions regarding crop planting, irrigation, fertilizer application, and pest control.

Taneja et al. (2023) conducted a comprehensive study to explore the transformative effects of recent developments in AI technology on the agri-food sector. The authors shed light on the significant improvements in efficiency, waste reduction, and food safety and quality resulting from the integration of AI in agricultural practices. By analyzing historical data, soil conditions, weather patterns, and other relevant factors, AI algorithms can accurately predict crop yields, providing farmers with valuable insights for decision-making. These insights enable farmers to make informed choices regarding planting strategies, storage capacity, and market planning, leading to optimized agricultural practices and enhanced outcomes in the agri-food industry.

Chithambarathanu and Jeyakumar (2023) highlighted the need to improve disease prediction in various plants using DL algorithms. They proposed a hybrid DL-based strategy to enhance plant disease identification. The integration of Internet facilities, such as agricultural IoT and mobile terminal processors, is emphasized for real-time monitoring and pest identification in grain storage warehouses, promoting agricultural modernization. AI-powered systems utilizing image recognition algorithms and machine learning enable accurate and efficient detection of pests, diseases, and weeds, reducing pesticide use and environmental impact.

The application of ML and IoT data analytics in agriculture is a topic of great significance. By harnessing the power of ML algorithms and leveraging IoT data, farmers can make informed decisions to optimize various aspects of agricultural practices, such as planting, irrigation, and pest control. This integration of AI-powered technologies enables precision agriculture, improving efficiency, reducing waste, and enhancing food safety. Furthermore, the development of DL algorithms in disease prediction for plants holds countless potential for improving crop health and yield. With the adoption of these advancements, traditional farming methods can be revolutionized, leading to sustainable and efficient agricultural practices that meet the demands of a growing population.

2.5 Use of AI in Industrial Sector

Regona et al. (2022) underscored the significant momentum gained by the use of AI in the industrial sector. They emphasized that AI technologies offer a multitude of benefits, including

operational optimization, productivity improvement, and innovation advancement across diverse industries. The authors particularly highlighted predictive maintenance as a prominent application of AI in the industrial sector. By harnessing machine learning algorithms, AI systems can analyze extensive data collected from sensors and machinery to predict equipment failures and proactively schedule maintenance. This approach not only reduces downtime and maintenance costs but also enhances overall operational efficiency. The study also revealed the potential of AI in the construction industry, specifically in accurate event, risk, and cost forecasting during the planning stage. Furthermore, the authors identified the opportunity to streamline work processes and reduce time spent on repetitive tasks through the adoption of big data analytics. However, the fragmented nature of the construction industry poses challenges in data acquisition and retention for successful integration of AI on construction sites.

Baduge et al. (2022) highlighted the impact of AI in quality control and inspection processes has become increasingly significant. They emphasized that AI-powered vision systems have the ability to analyze real-time images and video streams, facilitating the detection of defects or anomalies in products and manufacturing processes. This automation of quality control tasks significantly improves accuracy, expedites the inspection process, and enables early identification of potential issues. Consequently, the integration of AI in quality control leads to enhanced product quality and reduced waste.

Smith (2023) revealed the transformative potential of AI in supply chain management. The author highlighted how AI is increasingly harnessed to optimize critical aspects such as inventory management, demand forecasting, and logistics. Through the analysis of historical data, market trends, and external factors, AI algorithms possess the remarkable ability to generate highly accurate demand forecasts. Consequently, organizations can strategically optimize their inventory levels, thus achieving streamlined supply chain operations and reaping significant cost reductions. Moreover, AI's prowess extends to the optimization of transportation routing and scheduling, leading to enhanced delivery efficiency and further cost savings.

Keshvarparast et al. (2023) made a compelling assertion regarding the profound impact of AI-powered robotics and automation on manufacturing processes. The authors highlighted the emergence of collaborative robots, colloquially known as Cobots, that integrate advanced AI

capabilities to revolutionize the manufacturing landscape. By working alongside human workers, these intelligent machines effectively automate repetitive or hazardous tasks, resulting in remarkable gains in both productivity and worker safety. Furthermore, the application of AI algorithms enables real-time optimization of production processes, dynamically adjusting parameters to maximize operational efficiency while minimizing waste. This groundbreaking approach not only signifies a paradigm shift in traditional manufacturing practices but also propels industries towards unprecedented levels of productivity, safety, and operational excellence. The findings of this study provide unequivocal evidence of the immense potential that AI-driven robotics and automation hold in transforming manufacturing processes.

The use of AI in the industrial sector has gained significant momentum, offering numerous benefits and opportunities for optimizing operations and driving innovation. Predictive maintenance, a prominent application of AI, enables proactive scheduling of maintenance by analyzing sensor and machinery data, reducing downtime and enhancing operational efficiency. AI-powered vision systems revolutionize quality control processes by detecting defects and anomalies, improving product quality and reducing waste. In supply chain management, AI optimizes inventory management, demand forecasting, and logistics, leading to streamlined operations and cost reductions. AI-powered robotics and automation enhance productivity and worker safety by automating tasks and optimizing production processes.

2.6 Use of AI in Medical Sector

Hariton et al. (2023) underscored the remarkable progress and transformative potential of AI in the medical field. They highlighted the diverse range of applications where AI is being utilized, including diagnosis, treatment planning, drug discovery, and patient monitoring. Notably, the authors emphasized the significant impact of AI in medical imaging. By employing advanced algorithms, AI systems can effectively analyze various medical images such as X-rays, CT scans, and MRIs. This enables the detection of abnormalities and provides valuable support to radiologists in making precise and accurate diagnoses. Consequently, this integration of AI improves diagnostic accuracy, expedites the interpretation process, and aids in prioritizing critical cases.

Singh et al. (2023) highlighted the critical role of AI in advancing personalized medicine. The authors emphasized that through the analysis of extensive datasets, AI algorithms have the

capacity to identify intricate patterns and correlations. This capability proves invaluable in tailoring treatment plans and accurately predicting patient outcomes. By leveraging AI, healthcare professionals are empowered to deliver individualized care that takes into account a patient's unique characteristics and medical history. The integration of AI in personalized medicine represents a substantial leap forward in healthcare, enabling more precise and targeted approaches that enhance patient outcomes and overall quality of care.

Blanco-González et al. (2023) shed light on the groundbreaking role of AI in the field of drug discovery. The authors emphasized that AI algorithms possess the capability to process extensive datasets, enabling them to identify potential drug candidates, predict their efficacy, and optimize drug formulation. This transformative capacity of AI significantly accelerates the drug development process, ultimately leading to the creation of more efficient and targeted treatments for a wide range of diseases. By leveraging AI in drug discovery, researchers and pharmaceutical companies can streamline their efforts, bringing novel therapies to patients in a more expeditious manner. The findings of this study highlight the immense potential of AI in revolutionizing drug discovery, thereby transforming the landscape of healthcare and providing new hope for patients in need of innovative treatments.

Shaik et al. (2023) underscored the significant role of AI in remote patient monitoring and telemedicine. The authors highlighted that through the utilization of wearable devices and sensors, AI algorithms have the capacity to continuously collect and analyze patient data. This real-time monitoring enables the detection of trends and abnormalities, empowering healthcare providers to intervene early and provide personalized care management. Moreover, the integration of AI in remote patient monitoring extends healthcare beyond traditional settings, allowing for remote and virtual consultations. This has the potential to enhance accessibility to care, particularly for patients in remote areas or those with limited mobility.

AI has shown remarkable progress and transformative potential in the medical field, with applications ranging from medical imaging to personalized medicine. In medical imaging, AI algorithms can analyze images to detect abnormalities and aid in accurate diagnoses, improving diagnostic accuracy and prioritizing critical cases. In personalized medicine, AI can analyze extensive datasets to identify patterns and correlations, enabling tailored treatment plans and accurate predictions of patient outcomes. AI also plays a crucial role in drug discovery by processing large datasets to identify potential drug candidates and optimize formulations,

accelerating the development of targeted treatments. Additionally, AI is utilized in remote patient monitoring, continuously analyzing data from wearable devices to detect trends and abnormalities, allowing for early intervention and personalized care management, even outside traditional healthcare settings. These studies highlight the significant impact of AI in advancing healthcare and improving patient outcomes.

2.7 Use of AI in International Border

Feldstein (2019) stated that the usage of AI surveillance technology has extended to at least 75 nations globally, with China serving as a primary driver of this trend. Feldstein also identified the countries and businesses participating in this proliferation that Sixty-three countries now have access to AI surveillance technology from Chinese firms like Huawei, Hikvision, Dahua, and Zhongxing New Telecommunications Equipment (ZTE). Huawei alone has offered this technology to fifty countries. However, US businesses like IBM, Palantir, and Cisco are also active in this field, and US companies have AI surveillance technology deployed in 32 nations. The author also points out that while liberal democracies make heavy use of AI surveillance technology, the most crucial factor in deciding whether governments will utilize it for oppressive reasons is the quality of governance. Finally, the author highlights the strong relationship between a country's military expenditures and its use of AI surveillance systems.

Roy (2020) explained the use of autonomy and machine learning in Intelligence Surveillance and Reconnaissance (ISR) capabilities, which is essential for situational awareness. India's armed forces have already started using unmanned aerial vehicles (UAVs) for surveillance and reconnaissance operations. The Defense Research and Development Organization (DRDO) of India has developed several versatile UAVs, including Nishant, Lakshya, and Rustom, and with Idea Forge, they have created Netra, a mini-UAV quadcopter with autonomous navigation and guidance systems. The Command Information and Decision Support System (CIDSS), developed by the Centre for Artificial Intelligence and Robotics (CAIR) of India, facilitates the storage, retrieval, processing, and visualization of tactical data, providing decision support to commanders in real-time. The integration of autonomy and machine learning into ISR capabilities would allow for the simultaneous collection and processing of data from various sources, leading to more in-depth analysis and better decision-making.

Akhmetova and Harris (2021) argued that the deployment of AI algorithms in the US and Canada for migration governance and border control, and the risks associated with automating these processes that the use of AI technologies. The role of tech corporations in working with military, security, and intelligence institutions to mine the data of migrants from a counter-terrorism and security perspective. The authors suggest that the use of AI technologies is motivated by a combination of factors, including the desire to create "smart borders", the interests of private technology and security companies, and the desire to refuse entry to "undesirable" migrants.

Dombrova (2021) stated the overview of EU initiatives to enhance border security and control using AI technologies. It discusses the evolution of identifying technology historically, EU policies on smart borders, and significant EU initiatives on AI for borders. Four categories of AI applications are discussed; biometric identification, emotion detection, algorithmic risk assessment, and AI tools for migration monitoring, analysis, and forecasting. The author also covered issues with reliability and fundamental rights that were brought up by the creation and use of such AI applications. The author concluded with reflections on a broader understanding of technologies and attention to the pitfalls of technological determinism and the idea that technological neutrality.

Milivojevic (2022) explored the growth and potential effects of AI systems and devices placed along physical borders on the movement of undocumented immigrants and border security in the Global North. In order to examine the function of AI systems in thwarting illegalized mobility and reorganizing border control, the author utilized the single-case study of the Silicon Valley-based AI startup Anduril and focused on the US-Mexico border. The author made the case that, given technology's potentially negative effects on controlling illegal immigration, border studies must turn their attention to AI advancements. In addition, the author criticized tech-solutionism in mobility management in the US and other countries as it develops. In his conclusion, the author highlights the opaque and anti-humanitarian aspect of creating virtual borders utilizing AI systems and argues for important ethical questions to be asked regarding AI experiments in border control.

Khan and Efthymiou (2021) provided an overview that how AI can enhance biometric identity systems through face detection, decision-making, and security issues. To enroll in a biometric system, an individual's external documents containing biographical details, such as a passport,

must be presented. The individual's biometric identifier, such as a fingerprint or eye scan, is recorded and linked to the presented external document. Subsequent encounters with the biometric system involve the comparison of the individual's biometric data to the template created during the enrollment phase.

Tyler (2022) explained that the US Customs and Border Protection (CBP) have installed a system of 200 or so autonomous surveillance towers that are outfitted with cameras, radar, and algorithms by the end of 2022. These 33-foot-tall solar-powered towers can easily be moved to new sites as needed and are designed to scan isolated border areas and detect the cause of movement. They can also communicate with one another to follow items that passage out of range. A system called Lattice receives information from these towers as well as other sources like cameras, drones, LIDAR laser systems, and infrared sensors and instantly interprets it. The AI system is qualified to evaluate an object's movement to distinguish between a person, an automobile, and a tumbleweed and avoid animals and other false positives. When the system spots movement by people or vehicles, it will alert the border patrol.

Tyler (2022) further argued that the growing use of AI in border security, which promises to improve operations efficiency, speed, and safety, highlights various AI technologies like emotional expression evaluation algorithms, biometric analysis, and scanner software that have been integrated into border operations. AI also promises to enhance surveillance capabilities, which raises questions about privacy and governmental surveillance. Globally, facial recognition technology has been implemented, especially in airports, although critics have expressed concern about the potential for technology creep and broader societal surveillance which was reinforced by COVID-19 cases.

Nor et al. (2022) underscored the imperative for Malaysia to bolster its border control measures and security due to the ease of smugglers crossing its borders. They proposed that AI technology can effectively supplement limited manpower and enhance existing border security measures, drawing insights from other countries. AI technology can contribute to various facets of border control, including data collection, continuous monitoring, prompt response, decision-making, and performance improvement with minimal human intervention. Embracing AI technology at the Malaysia-Thailand border can enable enforcement agencies to work more efficiently, address external security threats, and combat activities like migrant smuggling.

Channaiah (2023) explored the challenges faced by the Indian defense forces in securing the country's borders and highlights the potential of video analytics in addressing these challenges. The article emphasizes the benefits of video analytics, such as intrusion detection, facial recognition, object recognition, motion detection, and predictive analytics. It also discusses the impact of Deep sight AI Labs in providing video analytics solutions for defense, including detecting sudden crowds, perimeter intrusion detection, threat detection, facial recognition, vehicle tracking, crowd management, perimeter protection, and post-incident analysis.

Gaire (2023) examined how several powers in the "geopolitical chessboard" have already begun to exploit AI for military applications, including intelligence analysis, surveillance, autonomous weaponry, reconnaissance, and logistics. He further predicts the future of military applications, their constraints, and challenges, and also recommends the steps to be pursued by technologically fragile countries like Nepal to acclimatize with these AI-induced transformations. The increasing impact of AI on the military domain and its implications for national security, with a focus on the future of military applications and highlights the remarkable advancements in the entire ecosystem of AI-associated technologies and their innovative usage in pioneering military technologies and strategies.

Upreti (2021) stated that the challenges faced by security forces in Nepal's border regions because of cross-border crimes, smuggling, and illegal trade, which endanger both internal and foreign security. Due to its open border, the Nepal-India border in particular presents difficulties for security forces on a daily basis. These difficulties include geographical landscape, socioeconomic parallels, operational issues, border regulations, morals, and ethics.

Shor (2023) highlighted the revolutionary impact of AI technology on border security, emphasizing its role in enhancing surveillance, improving efficiency, and streamlining operations. Real-time scanning of large populations and vehicles facilitated the detection of suspicious activities and the prevention of security breaches. Autonomous surveillance towers, AI-based software, drones, and robots were deployed to patrol borders, reducing the need for human intervention. Noteworthy projects such as ROBORDER in the European Union and the development of AGNI-D software in India exemplified the integration of AI in border surveillance and security systems. The increasing global adoption of AI in border protection signified its potential to enhance security and operational effectiveness in this domain.

The widespread utilization of AI surveillance technology on a global scale, with China playing a prominent role and companies like Huawei leading the way. Concurrently, American companies are actively involved in this field. The effective and ethical implementation of AI surveillance hinges upon the quality of governance. Furthermore, the integration of autonomy and machine learning significantly enhances intelligence surveillance capabilities. The European Union has initiated various AI applications for border security, although issues surrounding reliability and fundamental rights emerge. AI systems deployed on physical borders impact undocumented immigration and give rise to ethical inquiries. Additionally, AI demonstrates its value in enhancing biometric identity systems. The deployment of autonomous surveillance towers yields improved border security outcomes. However, the expanding use of AI in border security raises valid apprehensions pertaining to privacy and governmental surveillance. The military sector has also leveraged AI for diverse applications, while Nepal faces distinct security challenges in its border regions, necessitating comprehensive efforts to address cross-border crimes and security concerns.

2.8 Legal Provisions

The Organization for Economic Co-operation and Development (OECD), presented the first intergovernmental guidelines (Sheikh et al., 2023), stating that AI has the potential to bring significant benefits to society. However, it also carries significant risks, including threats to privacy and security, potential biases, and lack of accountability and transparency. The OECD guidelines stress the importance of international cooperation to address the global challenges posed by AI and emphasize the importance of human-centric design, robustness and safety, privacy and security, and accountability and explainability. They recognize the prerequisite for a multidisciplinary approach involving stakeholders from government, industry, civil society, and academia.

The AI HLEG (2019) provided guidelines focus on four key areas: human-centric AI, robust and secure AI, transparent and explainable AI, and socially and environmentally responsible AI. These guidelines emphasize the importance of ensuring that AI is developed and deployed in a way that is transparent, accountable, and respects fundamental rights and values and provides a comprehensive framework for the responsible development and deployment of AI systems in the EU. They offer valuable guidance for policymakers, industry leaders, and other

stakeholders who are working to ensure that AI is used to its full potential while minimizing its risks to society.

Lai (2022) stated that the US government has established various initiatives and guidelines related to the development and use of AI technology, including the National AI Initiative Act, 2020, and the Principles for AI Governance developed by the National Institute of Standards and Technology (NIST). These policies and laws protected the fields like Intellectual Property, Data Privacy, Liability, Employment Law, and Product Liability.

Digital Nepal Framework (2019) outlined a comprehensive set of guidelines to guide the development and implementation of digital initiatives across Nepal for digital transformation. The framework outlines a range of key priorities, including the development of infrastructure, the promotion of digital literacy, and the creation of an enabling policy environment, and emphasized the importance of leveraging emerging technologies such as cloud computing, data analytics, and AI to drive innovation and enable the development of new digital services.

NSTIP (2019) promulgated National Science, Technology Policy 2019 by the Ministry of Education, Science, and Technology of Nepal, has incorporated emerging and novel technologies like AI, biological information, and robotics shall be utilized at the optimal levels and thus assist in the rapid development of industries, commerce, and other sectors.

The Unmanned Aircraft System Requirements (UASR) (2021), regulation of Nepal outlined the requirements for obtaining a license to operate drones, including the type of drones allowed, qualifications and training for operators, and regulations for flying drones in different areas such as near airports, over congested areas, and at night for various commercial and non-commercial purposes such as aerial surveying, photography, and videography to ensure safety and security.

UNESCO (n.d.) stated the policy areas that are not found in Nepal are algorithmic transparency and accountability, intellectual property of AI, ethical guidelines for AI design, technical infrastructure related to AI, open AI research, import and export policy for data and models.

Fors and Meissner (2022) examined the utilization of biometrics-based AI systems in border control and raised concerns about their reliability from a human rights standpoint. They contended that existing regulations and ethical guidelines tend to prioritize the protection of AI

systems rather than the well-being of migrants. The authors proposed the development of responsible bordering technologies that steer clear of discriminatory practices based on biometric identification and recognize migration as a broader social concern.

The global legal provisions and guidelines for the use of AI technology continue to develop and become more prevalent, it is likely that legal provisions related to its use will continue to evolve, with an emphasis on transparency, accountability, and respect for fundamental rights. As digital transformation takes center stage, countries like Nepal are developing frameworks, such as the Digital Nepal Framework, to harness the potential of emerging technologies, including AI, for innovation and the creation of new digital services. Additionally, Nepal has implemented regulations, like the UASR, to ensure the safe and responsible operation of drones. However, there is a need for further focus on areas such as algorithmic transparency, intellectual property rights, ethical guidelines, technical infrastructure, open AI research, and data and model import or export policies.

2.9 Critics and Proponents of the Use of AI

Horowitz et al. (2018) explained how the explosion of data from various sources, including smart devices, the Internet, and human internet activity, can be analyzed using AI tools to reveal insights and patterns that would be impossible for humans to manually process and understand. AI can help identify suspicious activity, spot trends, fuse disparate elements of data, map networks, and predict future behavior, making the clandestine activity more challenging. Additionally, it also explores the value of AI in intelligence analysis, including the ability to track and analyze large amounts of data, process audio, video, and text-based foreign language information, and generate automated reports.

Beduschi (2021) stated that the application of AI algorithms can improve data-driven and evidence-based policymaking, but it also requires more data to be collected and examined. He further discussed the possible impact of AI technology on international migration management and policymaking and that the use of AI has the potential to change how nations and international organizations handle global migration. It is capable of carrying out duties including data analysis connected to visa and asylum seekers, identification checks, border control, and security. Some nations, including Canada and Germany, have already incorporated AI technologies into their procedures for determining immigration and asylum.

Rodrigues (2020) emphasized the significance of acknowledging the ethical considerations surrounding the use of AI in migration processes. While AI has the potential to bring benefits, it is crucial to address issues related to fairness, bias, and privacy rights. The implementation of AI systems in the context of migration should be approached with caution due to the profound impact these technologies can have, especially on vulnerable individuals and groups. Respecting human rights becomes paramount in ensuring that the adoption of AI in migration is done in a responsible and ethical manner. By carefully considering these concerns, policymakers and stakeholders can strive to leverage the potential of AI while safeguarding the well-being and rights of migrants.

Vavoula (2021) argued that the use of AI systems in the framework of migration and border control, poses serious risks and potential adverse effects on fundamental rights that the AI-based technologies for surveillance, detection, and recognition of human beings, which could lead to illegal interdiction, exacerbate violence at border crossings and racial profiling, and other forms of discrimination. These systems could also increase the risk of harm for people on the move, forcing them to use unsafe routes and increasing their reliance on smugglers. The use of AI-based surveillance systems raises concerns about mass surveillance, and all AI systems used for border control should be subject to the obligations under the AI to ensure accountability and transparency of their use and their impact on fundamental rights. The author highlights the need for greater regulation and oversight of the use of AI systems in the context of migration and border control to protect fundamental rights and prevent structural injustices.

Zhao and Gómez Fariñas (2023) emphasized the necessity of establishing a regulatory framework that ensures technological neutrality and proportionality to effectively manage the risks associated with AI. They argue that unregulated AI poses a threat due to its lack of sustainability and monitoring mechanisms, hindering the assessment of its impact on the economy, society, and environment. A well-designed regulatory framework not only fosters consensus on risk prevention but also enforces ethical and trustworthy use of AI in boardrooms. This transformation would enable AI to become a common good, playing a vital role in human development. It is crucial to address the concerns raised by critics while leveraging the potential benefits highlighted by proponents, striking a balance for responsible and ethical implementation of AI.

AI tools can analyze vast amounts of data to uncover patterns and insights that are beyond human capabilities, aiding in identifying suspicious activity, predicting behavior, and improving intelligence analysis. AI algorithms can enhance policymaking through data-driven approaches, particularly in international migration management. However, AI in migration and border control poses risks to fundamental rights, including illegal interdiction, violence, racial profiling, and increased harm to migrants. Adequate regulation and oversight are necessary to ensure accountability, transparency, and protection of rights when deploying AI systems.

AI, a subset of computer science, focuses on creating machines that can perform various tasks. Recent advancements in AI have been made in areas such as ML, NLP, computer vision, and robotics. Researchers have explored the impact and benefits of AI writing tools in NLP, including machine translation and information extraction. They have also examined the effects of AI on the humanities and automated essay scoring. In the industrial sector, AI is utilized for predictive maintenance, quality control, and supply chain management, optimizing operations and driving innovation. In healthcare, AI applications range from medical imaging and personalized medicine to drug discovery and remote patient monitoring, significantly improving patient outcomes. AI also plays a crucial role in autonomous vehicles and urban transportation, enabling safer and more efficient systems through real-time decision-making and traffic optimization.

2.10 Research Gap

There has been an increasing trend in the study and research on AI discipline in the world but in the context of Nepal, there is very limited research regarding the use of AI in border security. The studies highlight the potential effectiveness of AI in detecting and preventing illegal activities at border checkpoints, there may be practical challenges associated with implementing such systems in Nepal's border security infrastructure. Moreover, there may be challenges associated with training personnel on how to use and interpret the data generated by AI-based systems, as well as concerns about the potential impact of such systems on the roles and responsibilities of border security personnel. Further, this research could explore these practical challenges and identify potential solutions for implementing AI-based systems in a real-world border security context in Nepal to better understand the potential benefits and limitations of AI in border security, as well as engage with stakeholders to identify their needs and priorities.

CHAPTER III

RESEARCH METHODOLOGY

This research paper aims to systematically analyze AI and its use in the border security in Nepal. This study is based on a review and examination of information gathered from various sources, including published literature, books, reports from related organizations and government agencies, several websites, and fieldwork data. The primary and secondary data sources are used for the justification of the study. For the qualitative data interpretation, thematic analysis and Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis are used as technique to collect data through interviews.

3.1 Research Design

This study utilizes a qualitative research approach to examine the implementation of AI in border security in Nepal. The research methodology involves general interviews, Focus Group Discussions (FGD), and Key Informant Interviews (KII) alongside questions and observations to address the study's question. A qualitative checklist with carefully selected semi-structured questions are used for data collection, and the findings are strengthened through cross-referencing the content of responses from different sources. This approach allows for a comprehensive and nuanced analysis of the topic, providing valuable insights into the use of AI in Nepal's border security.

3.2 Sources of Data

The research is based on primary and secondary data and information. Information and data were collected from field visit, interviews, observations as well as various published books, literatures, journals, articles, research papers, reports from related organizations and government agencies, and concerned authorities.

3.2.1 Primary Data

The primary data for the study based on the interview questions for the people crossing the through Birjung border of Parsa District, KII, FGD and self-observation. The primary data was

collected by face-to-face interview using questions by the researcher. The researcher designed the questions well to understand easily by the respondents and asked questions effectively and clearly. The researcher briefed about the purpose of the study to the respondents.

Collected data was checked and verified at the end of work. Any inaccuracy and inconsistency were corrected accordingly. To control the data quality, researcher regularly verified the data during the data collection time.

3.2.2 Secondary Data

The secondary data was taken from journal articles, books, government and intergovernmental organization's reports, research papers. Likewise, the laws and regulations promulgated by the governments on the use of AI and advance technologies and regulation of Nepal about the use of digital technologies 2019 and regulation to operate drones also was the sources of secondary data.

3.3 Data Collection

Snowball Sampling method was adapted to select the 25 participants of general interview questions were modeled to residents nearby the border and travelers who were crossing borders to learn their opinions on the use of AI at borders (Appendix C). FGD were conducted with representatives from the APF, Nepal HQ, Information and Technologies Section (Computer Sub-section), and the Federation of Nepalese Chambers of Commerce and Industry, Birjung, to learn more about the situation and to find ways to boost AI's effectiveness and efficiency in border protection (Appendix B). Similarly, KII was conducted with 9 respondents (Appendix A). Self-observation of about 12km (Figure 3.1) was carried out to understand the deployment of security agencies and the number of entry points through the border in the observation area.

3.4 SWOT Analysis

The procedure in SWOT is to segregate the available information about the case into four groups. “**S**” stands for strengths: everything that is the advantages, and positive characteristics of the analyzed object. “**W**” stands for weaknesses: everything that is characterized by fragility, obstacles, and defects of the analyzed object; “**O**” stands for opportunities: everything that

creates the chance for useful changes of the analyzed object; “**T**” stands for threats: everything that creates the danger of changes in regard to the analyzed object (Bratko et al., 2021).

Review of secondary data and literature to understand the present issues, challenges, rules, and policies surrounding AI use for border security in Nepal. Thematic analysis is used to assess data gathered from the primary source. Further, to learn more about the potential and possibility of using AI for border security in Nepal, a SWOT analysis was conducted.

Table 3.1

SWOT Analysis of the Use of AI on Nepal’s Border

<p>Strengths</p> <ul style="list-style-type: none"> Increased Efficiency Cost Effective Enhance Accuracy Improved Decision Making 	<p>Weakness</p> <ul style="list-style-type: none"> Dependence on Technology Bias Lack of Data Security Risk
<p>AI in Nepal’s Border Security</p>	
<p>Opportunities</p> <ul style="list-style-type: none"> Collaboration Enhance Surveillance Improved Resource Allocation Advancement in Technology 	<p>Threats</p> <ul style="list-style-type: none"> Privacy Concern Lack of Transparency Employment Loss

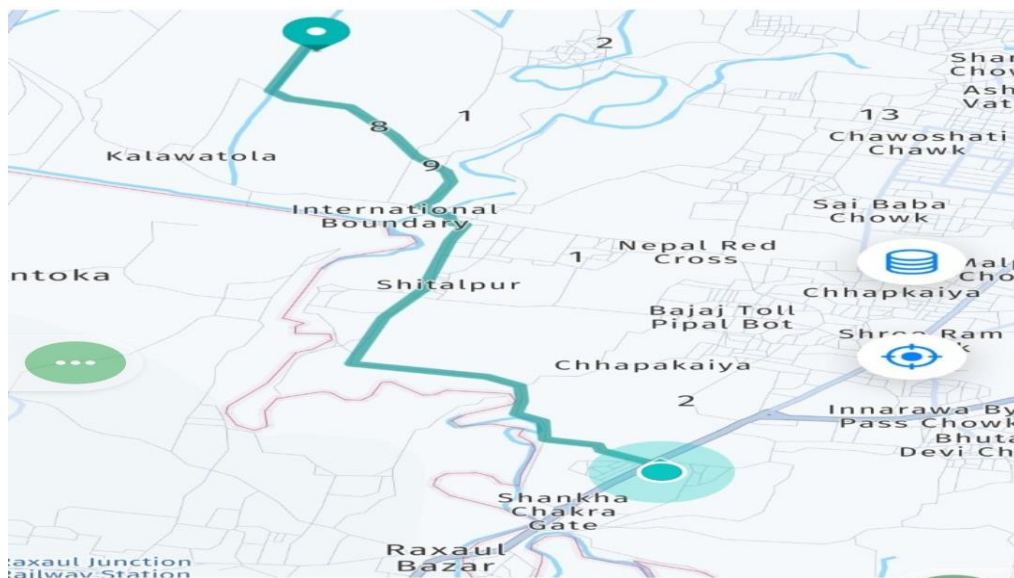
Source: The author own work, 2023

3.5 Study Area

Birgunj Customs, located in the Parsa District of Nepal, is recognized as one of the country's major customs points. Equipped with a Dry Port and an Integrated Check Post, it serves as a crucial gateway for the import and export of various commodities. Given its prominence as a highest import point, Birgunj Customs and the border areas of Birgunj in the Parsa District offer an excellent study area for a thesis focusing on the use of AI for border security. The region's shared characteristics and strategic location along the Nepal-India border, particularly in the plane areas, make it an ideal setting to delve into the dynamics of utilizing AI technologies to enhance border security.

Figure 3.1

Map of observation area at Birjung, Parsa



Note: The map covers the physical observation area about 12 Km of the study.

Source: Field Study, 2023

3.6 Ethical Consideration

Ethical consideration in research refers to the norms and standards for conduct. Norms and values, ethics and discipline, honesty and integrity, carefulness and confidentiality, respect for international property rights, openness and honor, legality and value to respondents are considered as ethical considerations. During this research, the code of ethics of the American Psychological Association (APA), 7th edition is followed strictly.

The research is purely academic and there is no sponsorship for the research purpose. Acknowledgment and intellectual property rights are reserved as per the law of the research during the entire process. This study promised to protect the confidentiality of individuals and organizations respectively. There is no dishonest practice in the entire research. The sources and data are kept confidential as per the fundamental ethic of research. Therefore, this research is conducted by adopting the general principles of ethics as responsibility, justice, respect for intellectual property rights, the consciousness of multiple roles, rule of consent, confidentiality, and privacy.

CHAPTER IV

FINDINGS AND DISCUSSION

Nepal's border with China and India presents challenges in maintaining effective border security due to various illicit activities taking place across the border (Upreti, 2021). However, the implementation of AI technology can help to address concerns related to intelligent surveillance, predictive analytics, automated border control, risk assessment, and drone surveillance (Tyler, 2022). By utilizing AI, the nation can enhance its border security measures and mitigate the aforementioned issues.

4.1 Enhancing Border Security of Nepal

Nepal's border with China and India presents demanding situations in keeping powerful border security because of numerous illicit activities taking place throughout the border (Upreti, 2021). But, the implementation of AI technology can assist to cope with issues related to sensible surveillance, predictive analytics, automated border management, threat evaluation, and drone surveillance (Tyler, 2022). The effectiveness of border control measures is hampered by challenges in tracking remote border areas, and the insufficient availability of resources and trained personnel (McLinden et al., 2011). However, the utilization of AI technology for intelligent monitoring and predictive analytics has the potential to address these concerns and significantly enhance border security (Fontes et al., 2022). By harnessing the AI-power, Nepal can improve its ability to identify potential security threats and make informed decisions, thereby bolstering the safety and security of the country's borders.

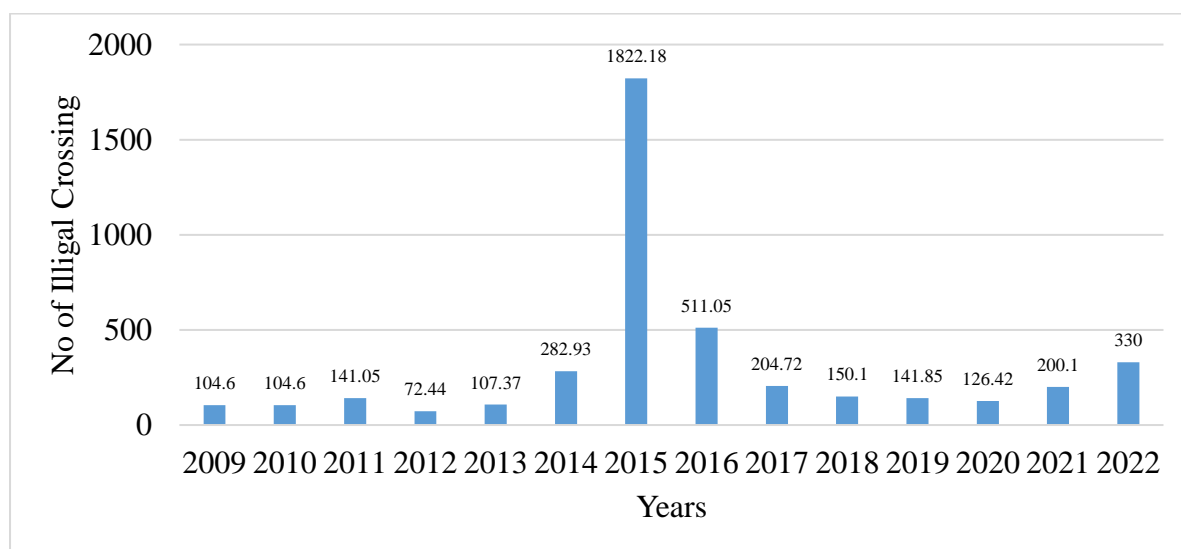
4.1.1 Intelligent Surveillance

AI-powered surveillance systems can be utilized to enhance surveillance by using sophisticated video analytics, facial recognition software, and object identification algorithms to monitor suspicious activities, monitor border crossings, and spot potential security issues (Dumbrava, 2021). The US government has been employing sophisticated surveillance technology tower outfitted with cameras, radar, and algorithms that detect unwanted movement and alert the border control agencies on the border with Mexico enabling the detection and tracking of

people attempting illegal border crossings by the use of cameras, sensors, and drones in combination has reduced the number of unauthorized border crossings and aided identify criminal activity (Rockwell, 2020). The CBP of US plan to install about 723 towers to construct a virtual border between the southern and northern border which can detect a person from 7.5 miles away (Ryan-Mosley, 2023).

Figure 4.1

Illegal Border Crossing in EU Border From 2009 to 2022



Source: Ryan-Mosley (2023)

The EU has been utilizing advanced surveillance technologies to keep a watch on its air, sea, and land borders. Following the 2015 refugee crisis, law enforcement personnel have also been allowed for finger print searches in the EU decreased in illegal border crossing (Figure 4.1), due to better surveillance and consequently better visibility of migrant vessels (Dumbrava, 2021). This system uses a combination of cameras, sensors, and drones to identify and track potentially dangerous behavior which has been effective in boosting border security and thwarting illicit activities like smuggling and human trafficking (Garijo, 2020).

India has been using intelligent surveillance technology to monitor the India-Pakistan border (Katara & Pokhriyal, 2017). Cameras and sensors are used in the technology to track and identify suspicious activity and potential security risks has enhanced border security and stopped unlawful acts like terrorism (Suman, 2022).

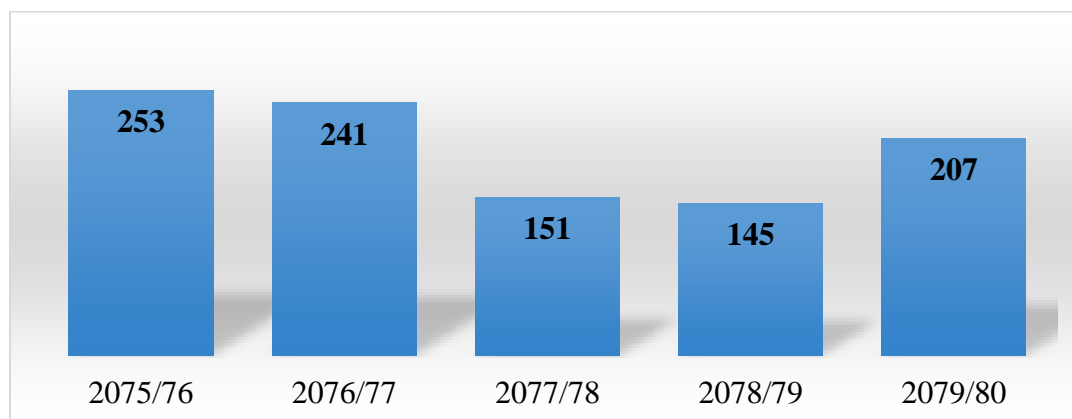
The security forces face a range of operational difficulties in the border areas of Nepal, particularly along the border with India. Nepal has been identified as a major hub for the illicit trade of drugs (Hannan, 2018), as highlighted by the arrest of seven South African women in Kathmandu on June 17, 2022, with the seizure of 51 kilograms of heroin, with an estimated value exceeding Rs 1 billion (Republica, 2022). Regrettably, the effectiveness of the security forces is hindered by a lack of active cooperation, coordination, and support from local authorities, exacerbating the challenges they face in carrying out their operations (Upreti, 2021). Implementing effective strategies for managing the border between Nepal and India can involve several practical solutions. These solutions may encompass the establishment of checkpoints, the adoption of advanced surveillance technology, and the enhancement of the capabilities of border security forces (Aryal & Jung, 2023).

During the KII, one of the key informants mentioned during the field visit that:

Border crimes, such as smuggling and human trafficking, pose persistent challenges, and the implementation of AI-based border security systems can greatly enhance efforts to combat these crimes. In the Parsa district alone, 114 border pillars have been lost. By utilizing AI-powered capabilities in surveillance and intelligence analysis, Nepal can strengthen continuous border surveillance and bolster its border security measures. This proactive approach will help mitigate the risks associated with border crimes by enabling the timely alerting of the APF in Nepal to address these challenges.

During the FGD, it was disclosed that employing AI-based surveillance in scenarios involving open borders like Nepal-India would be beneficial in promptly identifying criminal activities through real-time data. One of the participant groups expressed their views on the utilization of AI technology for enhancing border security in Nepal that:

The employment of AI-enabled CCTV cameras at all border crossings between Nepal and India provides real-time data for surveillance which ultimately lead to a reduction in border crimes such as smuggling of illegal goods and cattle, counterfeiting, and money laundering. This proactive measure would benefit both countries by enhancing security and facilitating more efficient border management by sharing the records of criminals and smugglers in the respective security organizations.

Figure 4.2*Human Trafficking Victims in Nepal*

Source: Retrieved from <https://www.nepalpolice.gov.np/news/83/>

Border crimes persist in Nepal by due to the number of border crossings between Nepal and India border illustrated by Figure 4.2 shows human trafficking over the four fiscal years and the illicit transportation of synthetic drugs from India using domestic channels (Rimal, 2021), necessitating the application of AI-powered surveillance technology for enhanced border monitoring, real-time data generation, and improved capabilities of the APF, Nepal. Given the presence of open borders and a culturally homogeneous society (Pyakural, 2015; in Rimal, 2021), the complexity of the situation is heightened, particularly with reports of 81 border pillars being shifted in the Bara district (Paudyal, 2014). This development exacerbates border problems, emphasizing the need for effective monitoring and surveillance. Implementing AI technology with 24/7 surveillance for border pillars and border areas creates virtual or digital wall which would enable APF, Nepal to bolster its monitoring of remote border areas, enhance situational awareness, and respond promptly to potential security threats, ultimately curbing illegal activities such as smuggling and human trafficking.

4.1.2 Predictive Analytics

AI algorithms can be used to analyze historical data and identify patterns and trends that may indicate potential security risks which help border security agencies to be more proactive in their approach and prevent security breaches before they occur (Sheikh et al., 2023). Predictive analytics is a type of AI technology that can be used to enhance border security in Nepal which involves analyzing historical data to identify patterns and trends that may indicate potential

security risks (Gaire, 2023). By using predictive analytics, border security agencies can be more proactive in their approach and prevent security breaches before they occur.

For many years, the US government has been using predictive analytics to keep an eye on the 2,000 miles long US-Mexico border (Romero Meza, 2019). According to data compiled by the Texas Center for Border Economic and Enterprise Development there are 167 land ports of entry, through which over 130 million people, 62 million cars, 12.5 million commercial trucks, and 3.5 million railroad cars are processed annually on US's borders with Canada and Mexico (Covarrubias & Cedillo, 2023). The analysis of this data can subsequently be used to improve border crossing efficiency, quantity, and quality.

More than 90 percent of unauthorized immigrants who entered the EU by the use of smugglers for part or all of their journeys (Frontex, 2022). Predictive analytics has been used by the EU to keep an eye on its air, sea, and land borders which have been successful in enhancing border security and stopping criminal operations including smuggling and human trafficking (Tyler, 2022). Israel has been monitoring the Israel-Palestine border using predictive analytics (Weitzberg, 2021).

The Nepal-India border has altogether 929 recognized border entry (Rimal, 2021), vulnerable to criminal activities, with offenders hiding on both sides (Pulami, 2023). During the Study, researchers discussed the potential of sharing criminal data for future predictive analytics. Acknowledging the significance of data in bolstering security measures, encouraging responses were received, particularly considering India's ongoing efforts to establish a robust data infrastructure. By harnessing predictive analytics and data sharing, APF, Nepal can monitor the border more effectively, analyzing crime trends, and historical data, and identifying potential security threats.

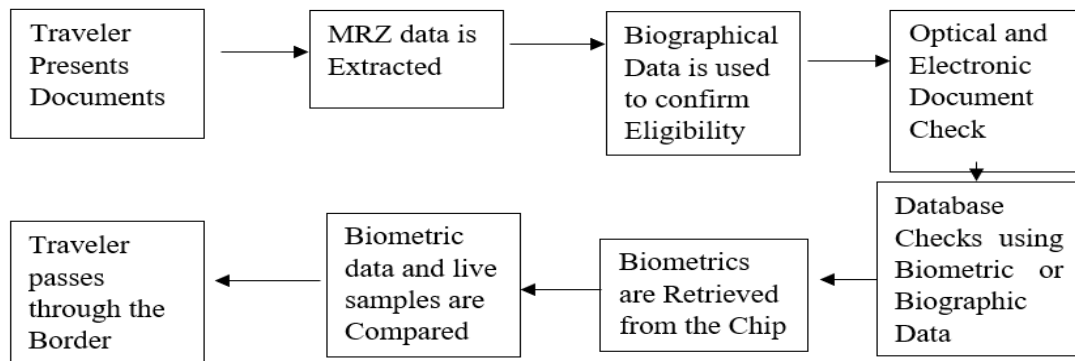
4.1.3 Automated Border Control

In order to efficiently and accurately process travelers at a number of border crossings, the US and Canadian governments have started using Automated Border Control (ABC) technology which has successfully reduced wait times and improved border security (Sanchez Del Rio et al., 2016). The EU has successfully reduced wait times and improved border security at a number of land, sea, and air borders by processing travelers using automated border control

systems (Garijo, 2020). Similarly, Singapore and Malaysia have begun processing visitors at a number of border crossings utilizing ABC technologies, which has successfully reduced wait times and improved border security (Nor et al., 2022).

Figure 4.3

ACB Process Steps



Source: Labati et al., (2016)

ABC involves the designated steps (Figure 4.3) and utilizing advanced biometric and identification technologies to expedite the processing of travelers, resulting in time and cost savings (Labati et al., 2016). The ABC system operates with remarkable speed, enabling passengers to pass through in just 15 to 20 seconds (Oostveen et al., 2020). With the aid of AI-powered technologies, the border check procedure can be automated, increasing efficiency and reducing the need for human involvement.

One of the Key informants stated about the implementation of ABC that:

There are several busy border crossing points in Nepal with India, including Kakarbhitta, Biratnagar, Birgunj, Bhairahawa, Nepalgunj, and Mahendranagar, which often experience heavy flow of border crossings. The implementation of AI technology at these locations would alleviate the need for physical inspections, ensuring a smoother flow of travel without disruptions. Nepal can adopt ABC systems that use facial recognition technology and biometric data to identify travelers which helps in reducing the time consumed and ensure better security by avoiding human errors.

During the field visit, the researcher noted a significant volume of traffic and a high influx of people at the Birjung border crossing, where 9 border crossing points span a mere 12 Km. This situation calls for the implementation of an ABC system to streamline the process and reduce wait times for passengers and vehicles. By leveraging ABC technology, APF, Nepal can enhance its ability to screen individuals entering the borders, improving effectiveness and accuracy in identifying potential security concerns and preventing illicit activities. A data-driven approach through ABC systems can contribute to more efficient border operations and heightened security measures at the Birjung border crossing.

4.1.4 Risk Assessment

The risk posed by people or cargo crossing the border can be evaluated using AI algorithms based on information like their travel history, criminal background, and other pertinent data (Tyler, 2022). This can help border security agencies to make more informed decisions about who to allow into the country and can more precisely detect potential security threats and manage their resources by employing risk assessment. The US administration has been observing the US-Mexico border by utilizing risk assessment equipment which enhanced border security and stopped criminal activity like drug trafficking and terrorism (Milivojevic, 2022). The technology has been successful in enhancing border security and stopping criminal acts including smuggling and human trafficking on the EU border (Dumbrava, 2021). The use of technology has enhanced border security and stopped unlawful acts like terrorism on the Israel-Palestine border (Weitzberg, 2021).

During the expert interview, one of the experts reckoned that:

Nepal can utilize risk assessment technology to effectively oversee its border areas, empowering border security agencies to enhance their capabilities in accurately detecting potential security threats and optimizing resource allocation. By leveraging the potential of risk assessment technology, APF, Nepal can bolster its effectiveness in monitoring remote border regions and effectively combat illicit activities like smuggling and terrorism.

The Nepal-India border encompasses fifteen transit and twenty-two trading points, along with an open border management system that allows unrestricted movement of individuals including

criminals (Das, 2013, K.C., 2019) and six in northern side. However, this lack of a dedicated screening mechanism poses a significant threat to national security for both countries. The absence of stringent checks and controls at these transit and trading points creates opportunities for criminals and terrorists to exploit the open border, compromising the safety and well-being. To mitigate these risks, it is crucial to establish effective screening protocols and advanced AI-based technologies that can identify individuals with criminal backgrounds or suspicious activities even read facial expression. Strengthening coordination and information-sharing between border security agencies is also essential to enhance border security, minimize criminal infiltration, and safeguard the national interests of Nepal and India.

4.1.5 Drone Surveillance

Drones with AI capabilities can be utilized to patrol and watch over the border, providing ongoing monitoring and enabling border security organizations to act swiftly in the event of any security risks. Border security organizations may more effectively monitor bigger areas and spot potential security risks from a safe distance by deploying drone surveillance (Tyler, 2022). Despite the MQ-1C Gray Eagle drone, operated by the Department of Defense, remaining on call throughout 2018, the US government has been utilizing drones to monitor the US-Mexico border since 2005 (Koslowski & Schulzke, 2018). Since 2010, Israel has been using drones to keep an eye on the Israel-Palestine border (Goodfriend, 2023). Drones have been used by India to monitor the border with Bangladesh since March 2019 which enabled border security services to monitor remote locations and spot potential security risks, this has boosted border security and eliminated criminal operations like smuggling and human trafficking (Bajwa, 2022).

During the key informant interview, one of the informants specified that:

Drones provide a valuable tool for real-time monitoring, rapid response, and data collection, enabling proactive measures to ensure border security which can strengthen border control capabilities. The utilization of drone surveillance in Nepal's border security allows for efficient coverage of expansive areas and identification of potential security risks from a safe distance enabling APF, Nepal in their effectiveness in monitoring remote border regions and addressing illegal activities.

There are only eight BOPs established along the 1,414 Km-long Nepal-China border (Upreti, 2022). During the field visit, one of my colleagues visited Korala in Mustang, which is situated on the northern border of Nepal with China. In his description, he characterized the border as:

The BOP of the APF, Nepal is strategically positioned at Nechung Village which is 14 Km away from the northern border line of Mustang. In contrast to the neighboring Chinese border, Nepal's BOP lacks essential infrastructure nearby. To address this disparity, the integration of cutting-edge drone technologies empowered with AI could revolutionize border security. By employing AI-enabled drones for surveillance, the BOP would gain a significant advantage in monitoring the expansive border area, allowing for efficient and effective security measures.

The Home Ministry of Nepal has announced its intent to utilize drones for monitoring the open border with India, showcasing a proactive approach to border security (Shrestha, 2018). In 2021, the Civil Aviation Authority of Nepal issued regulations permitting the use of Unmanned Aerial Vehicle in the country (CAAN, 2021). Despite these developments, the actual implementation of drones for border patrolling is yet to materialize. However, if drones are deployed for border surveillance, they have the potential to provide real-time data and enable efficient monitoring of vast border areas, including challenging terrains. This could empower APF, Nepal personnel to swiftly respond to security threats. Nevertheless, the adoption of drone technology for border surveillance necessitates addressing challenges such as skill development, establishing robust communication infrastructure in remote areas, and navigating regulatory frameworks. Successful integration of drones into border security operations requires meticulous planning, training, interagency collaboration, and the establishment of clear protocols for data management and privacy safeguards. By overcoming these challenges, Nepal can effectively harness the advantages offered by drone technology, bolstering its border surveillance capabilities and enhancing security along its border.

4.1.6 Robotics

Robots with cameras and sensors can be used to monitor the border continuously, alerting border control personnel in real-time to any suspicious activity such as unauthorized crossings (Kaur, 2021). Autonomous robots, such as the TALON SWORDS robot developed by the US military, are being tested for use in border patrol which are equipped with cameras, sensors,

and weapons and can patrol the border autonomously (Cooney et al., 2023). Land-based robots, such as the Roborder project developed by the EU, are used to detect and track human activity at the border with installed cameras, sensors, and ML algorithms to identify suspicious behavior and alert border control agents (Tyler, 2022).

During the expert interview, it was revealed that the employment of robotics will be effective for monitoring the northern border of Nepal that have only high altitude passes through and cliff mountain geography. The experts advocate that:

Robotic technology has the potential to enhance security measures at border checkpoints by identifying illicit and hazardous materials like explosives and narcotics. Autonomous robots can play a crucial role in border patrolling, particularly in Nepal's challenging northern region characterized by complex geography and adverse weather conditions. These robots can adeptly navigate through rugged terrains, including hills and mountains, covering extensive distances. Equipped with sensors and cameras, they can promptly detect any illegal activities and promptly alert border control agency like APF, Nepal in real-time.

The geographical and climatic conditions of Nepal's northern border present formidable challenges having high altitude passes through (Rana, 2020), characterized by rugged landscapes and high-altitude mountain ranges (Wang et al., 2019). These demanding terrains create logistical obstacles that hinder effective monitoring and navigation. However, the integration of robotics offers a promising solution to overcome these challenges. By deploying robotics equipped with advanced sensors and cameras, APF, Nepal can improve surveillance capabilities in remote and inaccessible areas. Robotics can enhance border monitoring efficiency, minimize risks faced by human personnel, and enable timely response to potential security threats. To fully harness the potential of robotics, investments in research, training programs, and dedicated robotics units are crucial, fostering collaboration and ensuring the effective utilization of technologies for border security along Nepal's northern frontier.

4.1.7 Summary

The utilization of AI-based technology holds significant potential for bolstering border security in Nepal. Researchers have highlighted several key areas where AI can enhance border surveillance and protection. These include the implementation of intelligent surveillance

systems that can identify potential security threats, track suspicious behavior, and prevent illegal activities such as smuggling and human trafficking. The introduction of predictive analytics can enable the analysis of crime trends and historical data, aiding in the identification of potential security threats and informing proactive measures. The establishment of ABC systems can streamline the process at border crossings, reducing wait times for passengers and vehicles while improving the accuracy of security screenings. Additionally, the deployment of drone surveillance and robotics can overcome the challenges posed by difficult terrains, enabling APF, Nepal for efficient monitoring of remote and inaccessible areas.

During the field visit at Birjung, Parsa, a notable observation was the absence of AI implementation for border security measures. In the case of Nepal, the utilization of AI-powered technologies in border security seems distant due to the lack of existing AI infrastructure and the policies of using AI in border security. However, it is imperative to initiate the construction of the necessary infrastructure for AI and expedite the formulation of policies.

Nepal's distinct challenges of an open border with India, coupled with its challenging border terrain with China, emphasizes the pressing need to secure its borders, which can be achieved through investments in AI infrastructure and policy development, enabling APF, Nepal to effectively address border security concerns and establish a resilient and efficient system for border protection. This would contribute to safeguarding national security, preventing illegal activities, and ensuring the safety and well-being of its citizens.

4.2 SWOT Analysis

AI has the potential to greatly enhance border security in Nepal by improving the efficiency and accuracy of threat detection and response. The use of AI-powered surveillance systems can help identify and track potential security threats in real-time, enabling security personnel to respond quickly and effectively. Additionally, AI can aid in the analysis of vast amounts of data, including surveillance footage, to identify patterns and trends that may indicate security risks. However, the adaptation of AI in border security also presents some weaknesses and challenges (Suman, 2022). For example, AI systems can be prone to errors and biases, particularly if they are not properly calibrated or trained. Furthermore, it raises concerns about

secrecy and civil liberties, particularly if the technology is used for surveillance and monitoring of citizens.

4.2.1 Strengths

The use of AI in border security in Nepal can provide significant strengths, including enhanced surveillance capabilities and improved accuracy in threat detection. AI algorithms can process large amounts of data in real-time and identify potential threats more accurately than traditional surveillance methods, enabling security personnel to respond quickly and effectively to security breaches. Moreover, AI systems offer the advantage of continuous operation, devoid of fatigue or distraction, which makes them ideal for monitoring the border of Nepal. With AI-powered surveillance systems, potential threats, unauthorized border crossings, or suspicious activities can be consistently and reliably detected. This uninterrupted monitoring capability enhances border security and allows for prompt responses to any identified risks or breaches.

4.2.1.1 Increased Efficiency

Nepal's border security currently faces a discrepancy in deployment, with approximately 2,200 APF personnel and BOPs established in about every 15 km, while the counterpart Seema Surakshya Bal (SSB) has deployed 45,000 personnel and established 511 BOPs in about every 3 Km (Upreti, 2021). The stark contrast between the deployment of APF personnel and SSB personnel, as well as the disparity in BOP distances, clearly indicates a shortage of human resources in Nepal's border security. AI-powered surveillance and monitoring technologies can bridge this gap by providing real-time detection of suspicious activities, analyzing large data sets for security risks, and automating routine tasks.

During the interview with the border crossing individuals, one respondent stated the view of border security that:

By employing Automated License Plate Recognition (ALPR) systems driven by AI algorithms, APF, Nepal can automatically read and recognize license plates at border checkpoints. This technology aids in the identification of stolen or suspicious vehicles, while also providing valuable data for security analysis. Implementing ALPR systems can greatly enhance the efficiency and effectiveness of APF, Nepal border operations, streamlining border control processes and contributing to overall security measures.

AI technology in Nepal's border security can enhance efficiency in several ways. Firstly, surveillance cameras and sensors powered by AI can detect and monitor suspicious activities along the border in real-time, enabling them to respond rapidly to possible threats. Secondly, AI algorithms can analyze extensive data from diverse sources, such as satellite imagery and social media, to identify patterns and trends that may direct security hazards. This aids APF, Nepal in devising targeted and effective strategies for border protection. Thirdly, AI-powered biometric systems, like facial recognition, can accurately and rapidly identify individuals crossing the border, minimizing the chance of human error and expediting border crossings. Therefore, AI has the potential to automate numerous routine tasks, such as processing travel documents, allowing APF, Nepal personnel to dedicate their efforts to more intricate security matters.

4.2.1.2 Cost Effective

AI has the potential to significantly reduce the expenses associated with inspections at entry ports that handling costs can be minimized, and processing times can be reduced by as much as 90 percent (Covarrubias, 2023). Recruitment carries a high price tag, the US Army spending an average of \$15,000 per soldier enlisted (Buddin, 2005).

Table 4.1

Cost of Recruitment of APF Constable in one Time without Training Cost

Particulars	Amount (in NRS)
Meeting Allowance and Advertisement Cost	545000
Preliminary Physical Test	95750
Physical Endurance Test	95750
Medical Test	30000
Written Test	14000
Interview	88000
Approval	22000
Total	8,90,500

Source: APF, Nepal Headquarters, (2023)

The field visit revealed significant findings regarding the entry and exit points in the study area, with a total of 9 (including authorized) points within a mere 12 Km distance. This observation highlights the presence of numerous access points along the Nepal-India border. Furthermore, it was evident that the deployment of APF, Nepal personnel, and Nepal Police personnel was extensive, with personnel stationed at all 9 entry and exit points, indicating a substantial manpower allocation throughout the entire border region. The total cost of recruitment at one time for the constable of APF (Table 4.1), depends on the number of personnel recruited at a time. During the FGD, it came to light that APF, Nepal intends to initiate a pilot project for the installation of surveillance towers. These towers would possess a range capacity of 5 Km (2.5Km both side) and are estimated to cost approximately 50-60 Lakhs per tower, depending on their distance from the control room. If this pilot project is implemented, the study area could be effectively monitored using only 3 towers, significantly reducing the need for over 60 personnel to be deployed around the clock.

Traditional border security methods heavily rely on manual patrols and inspections, which necessitate a considerable number of security personnel. In contrast, AI-based solutions offer an analytical approach that automates many of these tasks, thereby reducing the dependence on a large workforce. This reduction in human resource requirements directly translates into cost savings encompassing salaries, training, and operational expenses. The cost-effectiveness of AI-based border security solutions in Nepal lies in the reduced reliance on human resources and the enhanced efficiency of threat detection. By automating repetitive tasks and optimizing the allocation of resources, the APF, Nepal can achieve substantial cost savings in the long term. Although there may be an initial investment involved in setting up AI infrastructure and providing training, these expenses can be offset by the long-term benefits of reduced operational costs and improved security outcomes. The systematic approach offered by AI solutions enables more efficient deployment of resources, minimizing wastage and maximizing the effectiveness of border security measures.

4.2.1.3 Enhanced Accuracy

Extensive research studies have consistently shown that fingerprint identification technologies exhibit an exceptional level of accuracy, with an impressively low error rate of approximately 0.1 percent (Dumbrava, 2021). On the other hand, the performance of face recognition algorithms is highly reliant on the quality of the captured image, resulting in a relatively higher

error rate of around 1 percent (Dumbrava, 2021). Considering the significant volume of individuals crossing the border between Nepal and India, the integration of AI-powered technologies becomes even more crucial as it can significantly enhance the accuracy of decision-making processes. By adapting these advanced technologies, APF, Nepal can improve identification and authentication procedures, thereby contributing to enhanced border security and smoother cross-border operations.

During the interview with the key informants, one of the key informants described the use of AI in border increase the accuracy rates that:

Utilizing AI in Nepal's border security enhances accuracy and reduces security breaches. AI-powered surveillance systems analyze data from various sources, providing a comprehensive view of the border area for effective threat detection. Biometric systems employing AI, such as facial recognition, improve the accuracy of border security checks. AI algorithms adapt to new behavior patterns, enhancing accuracy and reducing false alarms. Automation of routine tasks, like document verification, minimizes errors caused by human fatigue or distraction.

The integration of AI technology within Nepal's border security framework has the potential to significantly enhance efficiency and effectiveness in multiple ways. By adopting AI-powered surveillance cameras and sensors, the detection and monitoring of suspicious activities along the border can occur in real-time. This capability enables rapid responses to possible threats, minimizing the time lapse between detection and action. Moreover, AI algorithms can analyze vast amounts of data from diverse sources, including satellite imagery and social media platforms. Through this analysis, patterns and trends that may indicate potential security hazards can be identified. This information empowers the APF, Nepal to develop targeted and effective strategies for border protection, focusing resources where they are most needed and reducing response times. AI-driven biometric systems, such as facial recognition technology, play a vital role in accurately and swiftly identifying individuals crossing the border. By minimizing the chance of human error, these systems enhance security measures and expedite border crossings. As a result, routine tasks like processing travel documents can be automated, freeing up APF personnel to dedicate their efforts to more intricate security matters. The automation of these routine tasks through AI technology not only improves operational efficiency but also reduces the burden on human resources. Furthermore, AI's automation of

routine tasks, including document verification, serves to decrease the potential for errors arising from human fatigue or distraction. Consequently, the adoption of AI in Nepal's border security represents a transformative step towards bolstering accuracy, fortifying security measures, and minimizing the likelihood of security breaches.

4.2.1.4 Improve Decision-making

AI systems can assist decision-makers in identifying and analyzing data to make informed decisions that could improve border security measures. AI-powered surveillance systems can generate real-time alerts based on anomalies or suspicious behavior, allowing security personnel to respond quickly and make informed decisions based on accurate data (Bozic, 2023). AI-powered risk assessment systems can evaluate the potential threat posed by individuals or vehicles crossing the border, enabling security personnel to make informed decisions based on the level of risk involved (Nalbandian, 2022).

During the interview with the key informants, one of the key informants stated that:

Implementing AI in Nepal's border security can revolutionize decision-making through real-time data analysis, pattern recognition, accurate identification, and risk assessment. By harnessing AI capabilities, APF, Nepal can enhance situational awareness, optimize resource allocation, and mitigate potential risks more effectively. AI technologies enable rapid and accurate processing of vast amounts of data, enabling timely and informed decisions. This empowers APF, Nepal to make better-informed choices, enhance operational efficiency, and ensure the safety and security of the country.

The use of AI in Nepalese border security can improve decision making in several ways that Nepalese border security can lead to more efficient and effective decision making, improving the safety and security of the borders. The integration of AI-powered applications in border security has the potential to revolutionize decision-making processes and enhance security measures. By leveraging AI's capabilities in surveillance, logistics, cognitive insight, and situational awareness, APF, Nepal can effectively address evolving threats and streamline operations. However, overcoming challenges related to data capture, infrastructure, processing power, and skill development is crucial for successful implementation. With the right strategies

and investments, Nepal can harness the power of AI to secure its borders and protect national security.

4.2.2 Weaknesses

In the context of Nepal's border security, there are several shortcomings associated with the incorporation of AI that require attention. A key concern is the susceptibility of AI algorithms to errors or biases. Such algorithms have the potential to generate false alarms or overlook legitimate threats, thereby compromising security measures or impeding operational effectiveness. Furthermore, depending heavily on AI may result in decreased human supervision and decision-making, consequently elevating the likelihood of errors or biases within the system.

4.2.2.1 Dependence on Technology

The use of AI in Nepalese border security could lead to an increase in technology dependency. AI systems require significant amounts of data to function effectively, and if these systems fail, border security could be compromised (Tyler, 2022). Additionally, if the AI systems are not maintained and updated regularly, they could become outdated and ineffective, leading to a false sense of security (Hunter & Sheppard, 2018). This could lead to over-reliance on technology, which could have negative consequences if the technology fails or is hacked. Moreover, the use of AI in border security could also lead to ethical concerns, such as privacy violations and discrimination, which could further increase dependency on technology. For instance, the use of facial recognition technology in border security could lead to privacy violations if the data is used for other purposes without consent (Fontes et al., 2022).

During the FGD, the issue of technological dependency sparked a heated discussion. One of the participants expressed their concern by stating that:

Relying heavily on AI in Nepal's border security poses the risks of errors and inadequate human supervision. The use of AI-powered surveillance systems results in the generation of a significant amount of data, which necessitates the proper infrastructure and skilled technical personnel. The adoption of AI-based biometrics reduces the need for manual checks, thereby increasing reliance on technology for

verification purposes. Additionally, AI algorithms decrease human involvement, potentially leading to excessive reliance on technology.

An analysis of AI systems reveals potential drawbacks associated with over-reliance. These drawbacks include a lack of human oversight and susceptibility to technical glitches, resulting in decision-making errors. Firstly, the utilization of AI-powered surveillance systems and sensors generates an enormous volume of data that necessitates substantial processing power and infrastructure for efficient management. Consequently, this engenders a heightened demand for specialized technical personnel, which requires a large investment in the capacity development of APF, Nepal personnel and fosters a dependence on technology for data handling and analysis. Secondly, AI-powered biometric systems diminish the necessity for manual identity checks, thereby amplifying reliance on technology for identity verification. Thirdly, AI algorithms employed in data analysis and security risk detection diminish the requirement for human intervention, potentially augmenting reliance on technology for decision-making processes. Therefore, the development and implementation of AI systems entail significant investments in terms of technology and personnel, cultivating a reliance on technology and its associated infrastructure. Hence, it becomes crucial to ensure a balanced integration of AI within Nepalese border security. This balanced integration requires not only the deployment of AI-based technology but also the inclusion of adequate human oversight and the ethical and responsible utilization of AI to prevent unwarranted over-dependency on AI systems and mitigate the risks associated with a lack of human supervision and susceptibility to technical glitches, thereby enhancing the overall effectiveness in border security of Nepal.

4.2.2.2 Bias

During the interview with the key informants, one of the key informants stated that:

AI systems may exhibit bias when trained on biased data, leading to incorrect threat detection outcomes. Biased or incomplete data can perpetuate discrimination, affecting accuracy. AI systems can exacerbate existing biases and discrimination during decision-making. Privacy concerns emerge in border security's AI usage, especially with biometric data and facial recognition. This can disproportionately impact marginalized groups, further entrenching bias and discrimination. So, it is vital to address this issue by

developing a legal mechanism to prevent the amplification of discrimination in Nepal's border security.

AI systems can be biased if the data used to train them is biased, leading to false positives or negatives in detecting threats. AI systems are only as effective as the data they are trained on, which means that biased or incomplete data can lead to inaccurate or unfair outcomes. For example, if the data used to train facial recognition algorithms is biased towards certain ethnic or racial groups, it can lead to misidentification or false positives, potentially resulting in discrimination. Another concern is the replication and amplification of existing biases and discrimination within AI systems. For example, if an AI system is trained on data that reflects biased decision-making, it may replicate this bias and lead to further discrimination. Further, the use of AI in border security can raise privacy concerns, particularly when it comes to the use of biometric data and facial recognition technology. This can disproportionately affect certain groups, such as refugees or minority communities, leading to further bias and discrimination. Therefore, in the absence of standard policies, the use of AI on Nepal's border has the potential to be biased, and it is essential to address these issues for the use of AI in border security of Nepal.

4.2.2.3 Lack of Data

Without sufficient data, AI systems may not be able to accurately identify potential threats which could lead to false positives or false negatives (Tyler, 2022). Additionally, the lack of data could also lead to biases in the AI algorithms, which could result in discriminatory practices and false accusations (Stinson, 2022). Moreover, Nepal's lack of digital infrastructure and limited access to technology could also contribute to the lack of data available for AI systems (Marasini, n.d.). This could further limit the effectiveness of AI in border security. Therefore, it is important to ensure that the AI systems used in Nepalese border security have access to sufficient and diverse data to ensure their accuracy and effectiveness.

During the FGD, one member of the group put forth the view that:

Insufficient data impairs pattern identification and prediction of security threats. Border security data scarcity, including crossings and smuggling activities, compounds the challenge and fosters biased algorithms. This leads to inaccurate predictions, false

alarms, and missed threat detection opportunities. Collecting and analyzing high-quality border security data in Nepal is crucial due to the lack of AI infrastructure. Thus, the lack of data weakens the use of AI in Nepal's border security, as AI systems require substantial data for optimal functionality.

Insufficient data poses a significant challenge for AI systems in the context of Nepal's border security, introducing vulnerabilities into the system. Effective operation and accurate predictions of AI systems rely heavily on extensive and high-quality data. However, the limited and incomplete availability of data pertaining to border crossings, smuggling activities, and security risks present notable difficulties. This deficiency can result in compromised threat detection, leading to inaccurate predictions, false alarms, and missed opportunities to identify security threats. If the training data used is restricted or incomplete, the resulting algorithms may fail to accurately represent the true nature of security risks at the border. Mitigating this weakness necessitates the collection and thorough analysis of high-quality border security data specific to Nepal. Additionally, it is crucial to develop AI algorithms that can effectively operate and yield reliable predictions even in the face of limited data availability. The lack of data in Nepal's border security poses a notable vulnerability in the utilization of AI systems, given their substantial data requirements for optimal functionality.

4.2.2.4 Security Risks

During the interview with the key informants, one of the key informants stated that:

In the context of Nepal border security, the use of AI technology is susceptible to cyber-attacks, which can compromise the entire system. The vast amount of data generated by AI-powered sensors creates an opportunity for cyberattacks. The AI algorithms used to detect security risks can produce false positives or negatives, resulting in incorrect identification. The use of AI-powered biometric systems can also pose security threats if not secured, leading to the compromise of sensitive data. Furthermore, the use of AI in border security can raise privacy concerns, leading to legal challenges and erosion of public trust.

The use of AI in Nepal's border security could increase security risks in several ways. Firstly, the AI systems used in border security could be vulnerable to hacking and cyber-attacks, which

could compromise the security of the border (Mazhar et al., 2023). Hackers could potentially gain access to sensitive data and use it to plan attacks or intrusions. Secondly, the use of AI systems in border security could lead to false positives or false negatives, which could result in security breaches or missed opportunities to prevent threats (Tyler, 2022). Thirdly, the lack of transparency in AI algorithms could lead to biases and discrimination, which could result in false accusations and violations of human rights (Stinson, 2022). Moreover, Nepal's lack of digital infrastructure and limited access to technology could also contribute to security risks in the use of AI in border security (Marasini, n.d.). The lack of digital infrastructure in Nepal could make AI systems more vulnerable to attacks, and limited access to technology could limit the effectiveness of AI in border security. Therefore, the limited access to technology may hinder the effectiveness of AI in enhancing border security measures. To address these concerns, it is crucial to prioritize security measures, ensuring robust safeguards and protection against potential threats and minimize biases that could impact the fairness and effectiveness of AI systems in Nepalese border security.

4.2.3 Opportunities

The use of AI in border security in Nepal also presents several opportunities, including improved resource allocation and advancements in technology. AI-powered surveillance systems and sensors can help to identify areas of the border that are most vulnerable to security threats, enabling security personnel to target their resources more effectively. Additionally, the use of AI algorithms to analyze data can enable the development of more sophisticated and accurate threat detection systems. This can help to improve the accuracy and reliability of security operations and reduce the potential for false alarms or missed security threats.

4.2.3.1 Improved Resource Allocation

The use of AI in Nepal's border security can improve resource allocation by enabling more efficient deployment of personnel and equipment. AI-powered systems can help analyze data from various sources, such as surveillance cameras and sensors, to identify patterns and trends in border crossings and other security threats (Tyler, 2022). This can help border security personnel to allocate resources more effectively and efficiently, based on the areas and times of highest risk. Moreover, AI can also help optimize the allocation of resources by predicting

potential security threats and identifying vulnerabilities in the border security system (Gyawali, 2019). This can help border security agencies proactively address security risks and prevent security breaches. Furthermore, AI can also help improve resource allocation by automating routine tasks, such as customs and border clearance procedures, which can free up personnel to focus on higher-level security tasks (Chen, 2022). This can help improve the overall efficiency of border security operations and enable more effective resource allocation.

During the interview with key informants, a prominent voice emphatically stated that the use of AI in resource allocation can revolutionize border security in Nepal that:

AI systems analyze extensive data from various sources to identify potential vulnerabilities, enabling more effective allocation of resources by APF, Nepal. Real-time information on security threats and incidents provided by AI systems optimizes the deployment of personnel and equipment, facilitating swift and efficient responses to security challenges. As a result, AI in border security improves resource allocation and enhances the operational effectiveness of APF, Nepal in safeguarding Nepal's borders.

The use of AI in border security in Nepal can improve resource allocation by providing data-driven insights on security risks and threats. AI-powered systems can analyze huge amounts of data generated by sensors, cameras, and other devices to identify potential security threats and vulnerabilities. This can help APF, Nepal to prioritize its resources and allocate them more effectively to areas that require more attention. Additionally, the utilization of AI-based systems enables the optimization of deployment personnel and equipment by providing real-time information on security threats and incidents. This can enable APF, Nepal to respond more quickly and effectively to security challenges, enhancing the overall security of Nepal's borders. Therefore, the implementation of AI in border security can help to improve resource allocation and enhance the effectiveness of APF, Nepal's operations.

4.2.3.2 Collaboration

During the FGD, a group member passionately advocated for a collaborative approach to the use of AI in border security, highlighting the potential field for AI to enhance security that:

AI-based border security systems in Nepal foster cooperation and collaboration among government agencies and stakeholders. These systems generate extensive data and insights

that can be shared and analyzed to enhance coordination. Collaboration among border control, law enforcement, and intelligence agencies benefits from the shared data and insights to identify security threats and coordinate responses. Additionally, AI facilitates international cooperation by providing a platform for data and insight sharing across countries.

During the study, the fruitful discussions held that:

It was recognized that collaboration and data sharing with counterparts would serve as a significant milestone in effectively controlling criminal activities along the Nepal-India border. The implementation of AI technology, informed by the shared data, holds the potential to greatly enhance the capabilities of the APF, Nepal in tracking criminals and identifying illicit activities. By leveraging the power of AI can bolster border security and foster a safer environment for both nations, ensuring the well-being and prosperity of our communities.

The use of AI in the Nepalese border can provide opportunities for collaboration in various areas, including cross-border security and surveillance, trade and commerce, and disaster response and management. One way is by improving cross-border security and surveillance through the use of AI-powered technologies such as drones and facial recognition systems (Kerry et al., 2021). These technologies can help monitor and detect potential security threats, such as illegal border crossings or smuggling activities, and provide real-time alerts to border security personnel for timely action. Another way AI can facilitate collaboration is by improving trade and commerce across borders. AI-powered systems can help automate and streamline customs and border clearance procedures, reducing processing times and costs for businesses (WCO, 2022). This can lead to increased trade and investment opportunities between Nepal and its neighboring countries by reducing the wait time, which can ultimately contribute to the economic growth and development of the region. Furthermore, AI can also be used to improve disaster response and management along the Nepalese border (Bhandari, 2022) as it is prone to floods and inundation. For instance, AI-powered systems can help predict and monitor natural disasters, such as floods and landslides, and provide early warnings to communities at risk. This can help improve disaster preparedness and response, and facilitate cross-border collaboration in disaster management efforts.

4.2.3.3 Enhanced Surveillance

The use of AI-powered drones that can help monitor and detect potential security threats along the border (Tyler, 2022). These drones can be equipped with advanced sensors and cameras that can capture high-resolution images and videos, and transmit the data to a central control room in real-time. This can help border security personnel to quickly identify and respond to potential threats. Another way AI can enhance surveillance is through the use of facial recognition systems that can help identify and track individuals who may pose a security threat (Kerry et al., 2021). These systems can be integrated with existing surveillance cameras and databases to identify individuals who are on watchlists or have a history of criminal activity. Moreover, AI can also be used to analyze large amounts of data from various sources, such as social media and satellite imagery, to identify potential security threats (Timsina, 2019). This can help border security personnel to proactively monitor and prevent security breaches. So, the use of AI in Nepal's border security can enhance surveillance through the use of drones, facial recognition systems, and data analysis.

During the interview with key informant, one of the informants stated that:

AI systems have the ability to completely transform Nepal's border security by improving surveillance capabilities in difficult or dangerous locations. These systems are capable of real-time analysis of massive volumes of data, including sensor and video data. This makes it possible for APF, Nepal professionals to recognize and respond to potential threats quickly. AI algorithms equip security personnel with the tools they need to respond quickly to security breaches by spotting suspicious activity and tracking the movement of people and vehicles.

The integration of AI systems in Nepal's border security presents a transformative opportunity to bolster surveillance capabilities in challenging and inaccessible regions. By harnessing the power of AI algorithms, border monitoring can be elevated to new levels of efficiency and effectiveness. Real-time analysis of vast amounts of data, such as video footage, sensor readings, and relevant information, equips APF, Nepal personnel with the means to swiftly discern potential threats and take appropriate action. Through the utilization of AI, patterns of movement and behavior can be scrutinized, enabling the detection of suspicious activity and identification of individuals engaged in unauthorized border crossings. Furthermore, AI

algorithms facilitate the continuous tracking and monitoring of people and vehicles, empowering APF, Nepal to promptly counter any breaches in security. Embracing AI in Nepal's border security promises substantial enhancements to surveillance capabilities, empowering APF, Nepal personnel with real-time detection and response capabilities to effectively address evolving security challenges.

4.2.3.4 Advancements in Technology

The use of AI in Nepal can provide opportunities for advancements in technology, foster collaboration and knowledge-sharing (Jha & Yadav, 2022), and ultimately contribute to the safety and security of the country.

During the FGD, one of the groups stated the use of AI in border security in Nepal can provide opportunities for advancements in technology that:

The adoption of AI in APF, Nepal presents opportunities for technological advancements within Nepal. As AI technologies continue to progress, APF, Nepal can harness these advancements to create more advanced and efficient security systems. This can lead to the emergence of novel technologies and innovations that can be applied across various domains, including disaster response, public safety, and national security. Moreover, integrating AI into border security offers prospects for collaboration and knowledge exchange among diverse stakeholders, fostering a culture of innovation and creativity.

The adoption of AI in APF, Nepal represents a significant opportunity for technological advancements and a paradigm shift in border security practices. By embracing AI-powered systems, such as facial recognition and biometric analysis, APF, Nepal can significantly enhance its surveillance capabilities and optimize resource allocation. This integration of AI not only strengthens border security but also has the potential to revolutionize various critical domains, including disaster response, public health and safety, education, financial sector, and national security. Striking a balance between technological advancement and safeguarding individual rights is crucial for ensuring responsible and lawful implementation of AI technologies. As technology continues to evolve, the future of AI in Nepal's border security holds tremendous promise, contributing to a safer and more secure nation.

4.2.4 Threats

The use of AI in border security in Nepal also poses several threats that need to be addressed, including potential security breaches and cyber-attacks, privacy concerns, and unintended consequences. AI systems can generate vast amounts of sensitive data, and if this data is not properly secured, it can be vulnerable to theft or misuse by malicious actors. Additionally, the use of AI can also raise privacy concerns, particularly if the technology is used to monitor and track individuals or groups. Finally, the use of AI in border security can also have unintended consequences, such as the displacement of jobs or the impact on local communities.

4.2.4.1 Privacy Concerns

The use of AI in border security in Nepal poses threats to privacy concerns. Civil liberties and privacy groups have raised concerns that the use of AI technologies in border zones, such as facial recognition systems and drones (Tyler, 2022), could infringe on the human rights of foreign and Nepali nationals (Gentzel, 2021). The use of facial recognition systems, for example, can lead to the collection and storage of biometric data, which can be vulnerable to misuse or abuse. Moreover, the use of AI technologies can also lead to the creation of large databases of personal information, which can be vulnerable to cyber-attacks or unauthorized access (Husztik-Orban & Aolain, 2020). Furthermore, the lack of transparency and explainability of AI algorithms can also pose privacy concerns. AI systems can make decisions based on complex algorithms that are difficult to understand or interpret. This can make it challenging for individuals to know how their personal information is being used, and to challenge decisions made by AI systems (Sarker, 2022).

During the FGD, one of the groups stated the use of AI on the border poses serious threats that:

The absence of specific AI policies in countries like Nepal raises concerns about the protection of private data. AI-powered surveillance systems have the potential to collect vast amounts of sensitive information, including biometrics and travel history, posing privacy risks. Inadequate security measures can expose the data to cyber-attacks and misuse, compromising individual privacy. Furthermore, the lack of transparency in cutting-edge AI implementation in border security hinders individuals' understanding of data usage and the level of privacy protection afforded to them.

The use of AI in border security of Nepal without the specific Act and policies can raise the issue regarding privacy. One of the primary concerns is the collection and storage of biometric data, like facial recognition and fingerprint analysis. There is a risk that this data could be misused or accessed by unauthorized individuals, potentially leading to identity theft and other malicious activities. Additionally, AI systems are vulnerable to cyber-attacks, which could compromise border security and put individuals' privacy at risk. Another issue is the lack of transparency and explainability of AI algorithms, which can make it difficult to understand how decisions are being made and who is responsible for them. This lack of specific policies and transparency can lead to concerns about bias and discrimination, as well as the potential for errors or mistakes. Therefore, it is crucial to address these privacy concerns to ensure that the use of AI technologies in border security in Nepal to make it responsible and lawful.

4.2.4.2 Lack of Transparency

The lack of algorithmic transparency is a major problem (Rodrigues, 2020). According to (Desai & Kroll, 2017), people who were denied jobs, refused loans, were put on no-fly lists or denied benefits without knowing “why that happened other than the decision was processed through some software”. This lack of transparency in AI decision-making is a major concern in border security, where decisions can have serious consequences (Tyler, 2022).

During the interview with key informants, one of the key informants alerts the transparency issue for the use of AI in border security in Nepal that:

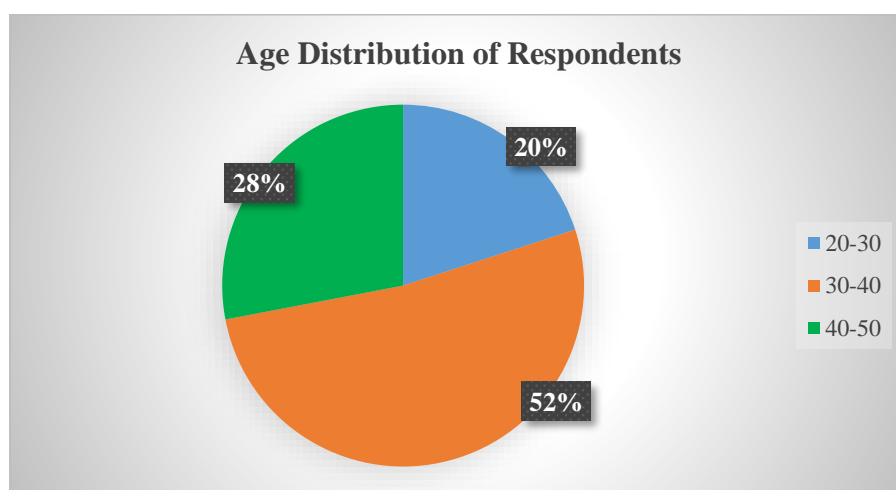
The Lack of specific policies in Nepal and transparency in AI border security systems undermines trust. Opacity in algorithms and decision-making makes it hard to understand how decisions are made, leading to mistrust in accuracy and fairness. Without understanding data collection, people hesitate to share information, reducing system effectiveness. Lack of transparency also limits recourse for unfair targeting. To ensure trust and efficacy, Nepal's AI-based border security must prioritize transparency by offering accessible information on system functioning, data collection, and usage.

During a general interview conducted with 25 participants (Figure 4.4) crossing the border in the study area, including farmers, businessmen, students, drivers, self-employed individuals, government servants, and computer operators, it was observed that only 10 respondents had a

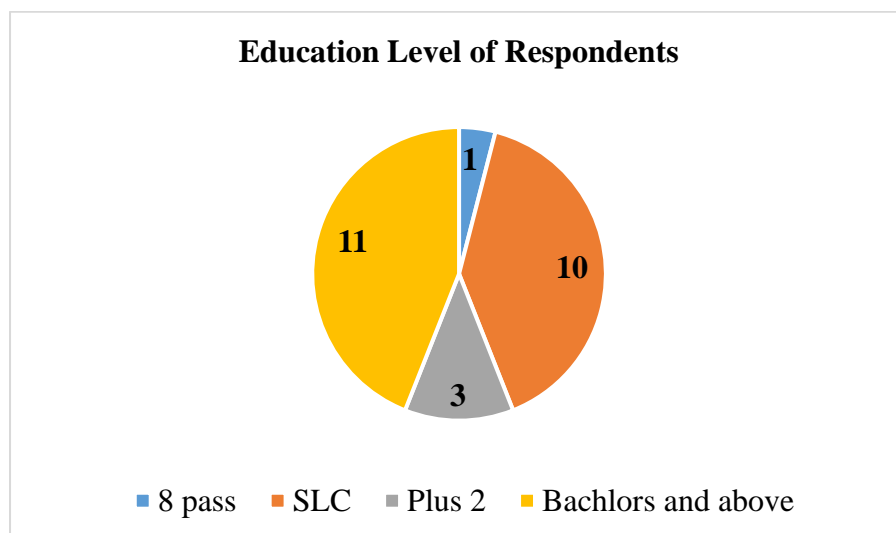
basic understanding of AI. Most of them mistakenly identified CCTV cameras as AI technology. This highlights the lack of widespread knowledge about AI among the general population crossing Nepal's borders. Given this situation, the implementation of AI in border security needs to address the challenge of transparency in order to overcome potential denial and mistrust.

Figure 4.4

Respondents of General Interview (Age and Education)



Note: Field Survey, 2023



Note: Field Survey, 2023

To ensure transparency in the implementation of AI, it is highly recommended to raise awareness about AI among the general public through various media forums and social media

platforms. This awareness campaign should focus on educating people about the positive impacts of AI in border security. By disseminating accurate information, the misconceptions surrounding AI, such as confusing it with CCTV cameras, can be addressed. Through these awareness efforts, individuals will be able to make informed judgments about the use of AI in border security, fostering a sense of transparency and trust. By proactively educating the public about AI and its benefits, potential skepticism and resistance can be minimized. This will create an environment conducive to the successful implementation of AI in border security in Nepal. Awareness campaigns should emphasize the improved efficiency, accuracy, and enhanced decision-making capabilities that AI can offer in identifying and addressing potential security threats. Open dialogue, information sharing, and engaging the public in discussions about AI can help build trust and acceptance of AI systems.

A Lack of transparency in AI systems can undermine trust in the border security system. If the algorithms and decision-making processes used in AI systems are not transparent, it can be difficult for individuals to understand how and why decisions are being made. This lack of transparency can lead to mistrust and skepticism about the accuracy and fairness of the system. Additionally, if individuals are not able to understand how their data is being collected and used, they may be hesitant to share information with the system, further undermining its effectiveness. Furthermore, a lack of transparency can make it difficult for individuals to seek redress if they believe they have been unfairly targeted by the system. Thus, it is crucial to ensure that AI systems used in border security in Nepal are transparent and that individuals are provided with clear and accessible information about how the system works, what data is being collected, and how it is being used. In order to establish effective AI systems in Nepal's border security, it is imperative to prioritize transparency and provide individuals with clear and accessible information regarding system functioning, data collection, and data utilization which fostered trust between the system and the public.

4.2.4.3 Employment Loss

It is important to acknowledge that integrating AI into border security has the potential to automate specific tasks and decrease the requirement for human labor in those particular areas. This may potentially result in job displacement within those areas. However, it is equally important to recognize that the utilization of AI can generate new employment prospects in fields like data analysis and system maintenance (Dumbrava, 2021).

While conducting interviews with key informants, a participant expressed concerns about the potential negative impact of employing AI-based border security in APF, Nepal, stating that:

AI-based border surveillance decreases the need for human patrols and security personnel, leading to job losses in APF, Nepal. Implementation of AI systems may require significant investment in technology and infrastructure, which may not be feasible for some organizations or governments, resulting in budget cuts and job losses. However, AI implementation can also generate new jobs and opportunities in areas like data analysis, system design, and maintenance. Policymakers and organizations must consider the employment implications and implement strategies to mitigate negative effects.

The implementation of AI-based border security systems in Nepal could potentially lead to job losses, particularly in APF, Nepal and other border agencies. AI systems can automate many of the tasks that were earlier performed by human operators, such as surveillance, monitoring, and analysis. As a result, some jobs may become redundant or may require different skill sets. For example, the practice of AI systems for border surveillance may reduce the need for human patrols and security personnel, leading to job losses in those areas. Additionally, the implementation of AI systems may require significant investment in new technology and infrastructure, which may not be feasible, leading to budget cuts and job losses. However, it is also worth noting that the AI systems could create new jobs and opportunities in areas such as data analysis, system design, and maintenance. It is important for policymakers and organizations to carefully consider the potential impact of AI-based border security systems on employment in APF, Nepal, and to implement strategies to mitigate any negative effects.

4.2.5 Summary

It should be noted that the SWOT analysis mentioned above are not exhaustive and may vary depending on the specific context and implementation of AI-based border security systems in Nepal. The integration of AI technology in Nepal's border security presents a significant opportunity to enhance operational efficiency, accuracy, and decision-making processes. By employing AI-powered surveillance systems, a vast amount of real-time data can be processed, enabling more precise identification and tracking of potential threats compared to traditional methods. This empowers personnel from APF, Nepal to respond promptly and effectively to security breaches. Moreover, AI algorithms have the capability to analyze diverse data sources,

allowing the identification of patterns and trends that signify security risks, thereby enabling targeted strategies for border protection.

The implementation of AI-based border security solutions in Nepal offers cost-saving opportunities by reducing the dependence on a large workforce. By automating repetitive tasks and optimizing resource allocation, significant savings can be achieved in terms of salaries, training, and operational expenses. Furthermore, AI systems enhance resource allocation by providing data-driven insights on security risks and threats, allowing APF, Nepal to allocate resources more effectively and respond to security challenges more efficiently.

While the adoption of AI-based border security systems may lead to job losses in certain border agencies particularly in APF, Nepal. It can also create new job opportunities in data analysis, system design, and maintenance. Policymakers and organizations need to carefully consider the potential impact on employment and implement strategies to mitigate any negative effects.

To ensure the transparent implementation of AI in border security, it is imperative to undertake a comprehensive awareness campaign targeting the general public through various media platforms and social media channels. This campaign should primarily focus on educating individuals about the positive impacts of AI in border security, dispelling misconceptions. By providing accurate information, the public can make well-informed assessments, fostering transparency and trust in AI systems. Proactive education efforts can also help minimize skepticism and resistance, creating an environment conducive to successful AI implementation.

Additionally, addressing weaknesses requires human oversight, responsible technology utilization, standardized policies, and the capacity building of the APF, Nepal with AI-trained personnel in border security. Insufficient data and limited digital infrastructure in Nepal pose challenges in achieving optimal functionality and accuracy in AI systems. To mitigate data scarcity challenges, comprehensive data collection and analysis specific to Nepal's border security are crucial. Robust cybersecurity measures must be in place to safeguard AI systems from cyber threats and protect sensitive border security data. Transparency in AI algorithms is essential to prevent biases and discrimination. Furthermore, investing in digital infrastructure and technology access can enhance the effectiveness and security of AI implementations.

CHAPTER V

SUMMARY AND CONCLUSION

The overall goal of this study is to contribute for the development of strategies and policies that take into account Nepal's unique challenges and context, aiming to improve overall border security nationwide. The integration of AI technologies holds immense potential for enhancing border security in Nepal. This thesis analyzes the potential use of AI in strengthening border security in Nepal. It investigates the risks and benefits associated with AI implementation and presents strategies to mitigate these risks and ensure responsible and ethical utilization of AI technologies. The study emphasizes the importance of addressing challenges such as privacy concerns, technical limitations, and legal and ethical considerations in deploying AI for border security.

5.1 Summary

Nepal's geographical location, sharing borders with densely populated countries such as China and India, presents significant challenges to effective border security. Illegal immigration, smuggling, terrorism, and human trafficking are among the major concerns that demand attention. Despite numerous efforts, border crimes and illicit activities have continued to escalate, necessitating more effective security measures. Nepal's porous border with India and the rugged geography shared with China present unique challenges for border security. The potential of AI in addressing these challenges has gained global recognition. AI technologies offer promising solutions by providing intelligent surveillance, predictive analytics, risk assessment, and drone-surveillance capabilities. The integration of AI-powered surveillance technology can significantly enhance border security in Nepal. It can assist in identifying potential threats, tracking suspicious behavior, and preventing illegal activities, such as smuggling and human trafficking.

However, the adoption of AI in Nepal encounters obstacles, such as privacy issues, technical limitations, and legal and ethical considerations. The implementation of AI in border security raises concerns regarding privacy, algorithm biases, and overreliance on technology. To ensure the success of AI systems, proper calibration and training are crucial for avoiding errors and

biases that may compromise security measures. Ethical issues surrounding the surveillance and monitoring of citizens must be addressed, along with concerns about the impact of AI on human decision making and the potential for discrimination.

The collaboration among government agencies and stakeholders presents a favorable prospect for maximizing the capabilities of AI in border security. Through fostering cooperation, sharing information, and engaging in joint efforts, Nepal can address obstacles, effectively harness the power of AI-based technology, and establish a robust and streamlined system for safeguarding its borders. Comprehensive awareness campaigns are necessary to educate the public on the positive impacts of AI and dispel misconceptions. Human oversight, responsible technology utilization, standardized policies, and capacity building are essential for mitigating risks. Global legal provisions and guidelines for AI technology are evolving with an emphasis on transparency and accountability. Nepal's Digital Nepal Framework aims to leverage emerging technologies such as AI for innovation, whereas regulations such as the UASR govern the safe use of drones. However, there is a need for additional attention to algorithmic transparency, intellectual property, ethical guidelines, technical infrastructure, open AI research, and data policy. Data collection, analysis, and robust cybersecurity measures are crucial for overcoming data-scarcity challenges and protecting sensitive information. Transparency in AI algorithms and investments in digital infrastructure and technology access are also necessary to optimize AI implementation.

Implementing AI in Nepal's border security requires several challenges to be addressed. Proper calibration and training, along with human oversight, are crucial for avoiding errors and biases. Standardized policies, capacity building, and comprehensive awareness campaigns are necessary to mitigate risks and educate the public. Additionally, data collection, analysis, and robust cybersecurity measures are crucial for overcoming data-scarcity challenges and protecting sensitive information. The adoption of AI may result in job losses in certain border agencies particularly APF, Nepal but can also create new employment prospects in areas such as system design, data analysis, and maintenance.

5.2 Conclusion

AI has evolved as a field in computer science that emphasizes on creating machines capable of performing various tasks. The definition of AI has undergone changes and debates ranging

from a broad understanding of algorithms to the precise replication of human intelligence. The complexity of AI requires a nuanced approach to avoid confusion and misunderstandings. Despite the challenges in defining AI, its potential benefits in border control have garnered significant attention. As AI technology advances, it is crucial for policymakers and stakeholders to consider its potential risks and benefits to ensure that its deployment adheres to the principles of transparency, accountability, and respect for human rights. AI tools can analyze huge amounts of data, uncover patterns, and provide insights that surpass human capabilities. In the context of border security, AI algorithms can aid in identifying suspicious activities, predicting behavior, and improving intelligence analysis. However, Nepal's limited research on AI implementation and practical challenges in border security infrastructure require personnel training and addressing infrastructure limitations for optimal utilization.

The analysis of Nepal's border security challenges and the potential role of AI technology revealed that Nepal's border with China and India faces persistent issues related to illicit activities, such as smuggling, human trafficking, and the infiltration of criminals and terrorists. These challenges necessitate the adoption of advanced measures to improve border security. The implementation of AI-powered technology offers a promising solution by providing intelligent surveillance, predictive analytics, automated border control, risk assessment, and drone surveillance capabilities. By harnessing these AI capabilities, APF, Nepal can significantly strengthen its mandate of border security and mitigate risks associated with border crimes.

AI-powered intelligent surveillance enables real-time monitoring and prompt identification of criminal activities, enhancing border management and reducing crimes like smuggling. Predictive analytics and data sharing aid in identifying potential security threats, while automated border control systems streamline processes and improve accuracy. Drone surveillance provides a powerful tool for monitoring vast border areas. AI-powered systems provide valuable data-driven insights on security risks and threats, enabling the effective allocation of resources and efficient responses to security challenges. The automation of repetitive tasks and the optimization of resource allocation led to cost savings by reducing the reliance on a large workforce in long-term. AI technology also offers the potential for improved accuracy in threat detection, adapting to new behavioral patterns, and minimizing errors caused by human fatigue or distraction.

APPENDICES

Appendix A: For KII

Namaste!!

My Name is Shiva Prasad Gaihre, a MSDPS Student at Armed Police Force, Nepal Command and Staff Collage, Sanogaucharan, Kathmandu. I am doing research for my MA thesis work on the topic AI and border security in Nepal. In this regard, I would like ask some questions and hope that you will answer it accurately. You may stop me during interview or skip the questions if you don't like to response them. However, I expect that you will answer my questions as this will help to identify challenges and issues regarding use of AI in border security, with your consent, I would like to record the interview hope that you will be fine with this.

Address:

Name/Name list:

1. How do you perceive the current state of border security in Nepal?

.....

2. In your opinion, what are some of the most pressing challenges faced by border security agencies in Nepal?

.....

3. Are there any specific AI-based border security systems that you think would be particularly effective in Nepal, and why?

.....

4. Can you explain the potential benefits of using AI in border security in Nepal, and how do you think they compare to traditional border security measures?

.....

.....

5. Can you explain how AI can be used to improve the accuracy and efficiency of border security checks in Nepal?

.....

6. How can AI technologies be integrated with existing border security systems and processes in Nepal, and what kind of infrastructure would be required?

.....

7. What are the potential cyber threats that could compromise the AI-based border security systems in Nepal, and how can these threats be mitigated to ensure the safety and security of the country's borders?

.....

8. Who are the key stakeholders involved in the development and implementation of AI-based border security systems in Nepal, and how can they be effectively engaged?

.....

9. What kind of training and education do you think is necessary for border security personnel to effectively operate and maintain AI-based systems?

.....

10. What are some of the challenges associated with implementing AI-based border security systems in Nepal, and how can they be addressed?

.....

11. How can private sector companies be incentivized to invest in the development and implementation of AI-based border security systems in Nepal?

.....

12. What are some potential risks associated with the use of AI in border security, and how can they be mitigated through appropriate safeguards?

.....

13. How can the benefits of AI-based border security systems be effectively communicated to the public and other stakeholders in Nepal, and what role can the media play in this process?

.....

Thank you very much for your participation.

Appendix B: For FGD

Namaste!!

My Name is Shiva Prasad Gaihre, a MSDPS Student at Armed Police Force, Nepal Command and Staff Collage, Sanogaucharan, Kathmandu. I am doing research for my MA thesis work on the topic AI and border security in Nepal. In this regard, I would like ask some questions and hope that you will answer it accurately. You may stop me during interview or skip the questions if you don't like to response them. However, I expect that you will answer my questions as this will help to identify challenges and issues regarding use of AI in border security, with your consent, I would like to record the interview hope that you will be fine with this.

Meeting Participants:

S. No	Name	Address	Organization	Signature

1. How do you perceive the current state of border security in Nepal?

.....

2. In your opinion, what are some of the most pressing challenges faced by border security agencies in Nepal?

.....

3. Are there any specific AI-based border security systems that you think would be particularly effective in Nepal, and why?

.....

4. Can you explain the potential benefits of using AI in border security in Nepal, and how do you think they compare to traditional border security measures?

.....

5. Can you explain how AI can be used to improve the accuracy and efficiency of border security checks in Nepal?

.....

6. How can AI technologies be integrated with existing border security systems and processes in Nepal, and what kind of infrastructure would be required?

.....

7. What are the potential cyber threats that could compromise the AI-based border security systems in Nepal, and how can these threats be mitigated to ensure the safety and security of the country's borders?

.....

8. Who are the key stakeholders involved in the development and implementation of AI-based border security systems in Nepal, and how can they be effectively engaged?

.....

9. What kind of training and education do you think is necessary for border security personnel to effectively operate and maintain AI-based systems?

.....

10. What are some of the challenges associated with implementing AI-based border security systems in Nepal, and how can they be addressed?

.....

11. How can private sector companies be incentivized to invest in the development and implementation of AI-based border security systems in Nepal?

.....

12. What are some potential risks associated with the use of AI in border security, and how can they be mitigated through appropriate safeguards?

.....

13. How can the benefits of AI-based border security systems be effectively communicated to the public and other stakeholders in Nepal, and what role can the media play in this process?

.....

Thank you very much

Appendix C: General Interview Questions

Namaste!!

My Name is Shiva Prasad Gaihre, a MSDPS Student at Armed Police Force, Nepal Command and Staff Collage, Sanogaucharan, Kathmandu. I am doing research for my MA thesis work on the topic AI and border security in Nepal. In this regard, I would like ask some questions and hope that you will answer it accurately. You may stop me during interview or skip the questions if you don't like to response them. However, I expect that you will answer my questions as this will help to identify challenges and issues regarding use of AI in border security, with your consent, I would like to record the interview hope that you will be fine with this.

Shall we proceed for interview? Yes [Proceed for interview]

Name:

Education:

Age:

Gender: a) Male

b) Female

Occupation:

Designation:

Address:

Contact Number:

Email:

Date of Survey:

Q.N.1 Do you know about Artificial Intelligence (AI):

a) Yes

b) No

If yes, what are the potential applications of AI in border security in Nepal?

.....

Q.N.2 How you feel about the use of AI-based technologies in border security checks?

a) Excellent

b) Good

c) Neutral

d) Bad

e) Very Bad

Q.N.3 What are your perceptions of the current state of border security in Nepal?

.....

Q.N.4 Have you experienced any issues or delays at the border checkpoint?

- a) Yes b) No

If yes, do you think AI-based technologies could help to address these issues?

- a) Yes b) No

If yes, how AI-based could help to address the issues?

.....

Q.N.6 Do you see about potential ethical or privacy concerns related to the use of AI in border security?

- a) Yes b) No

If yes, how do you think that the ethical and privacy concerns can be address?

.....

Q.N.7 Do you believe that AI-based technologies could improve the accuracy and efficiency of border security checks in Nepal?

- a) Yes b) No

Q.N.8 Do you see any challenges associated with implementing AI-based border security in Nepal?

- a) yes b) No

If yes, what are they?

.....

Thank you very much

REFERENCES

- AI HLEG. (2018). *A definition of AI: Main capabilities and scientific disciplines*. Brussels: European Union. https://ec.europa.eu/futurium/en/system/files/ged/ai_HLEG_definition_of_ai_18_December_1.pdf
- AI HLEG. (2019). *Ethics guidelines for trustworthy AI*. Brussels: European Union. <https://www.aepd.es/sites/default/files/2019-12/ai-ethics-guidelines.pdf>
- Akhmetova, R., & Harris, E. (2021). Politics of technology: The use of artificial intelligence by US and Canadian immigration agencies and their impacts on human rights. In E. E. Korkmaz (Ed.). *Digital Identity, Virtual Borders and Social Media* (pp. 52–68). Edward Elgar Publishing. <https://doi.org/10.4337/9781789909159>
- Akhter, R., & Sofi, S. A. (2022). Precision agriculture using IoT data analytics and machine learning. *Journal of King Saud University - Computer and Information Sciences*, 34(8, Part B), 5602–5618. <https://doi.org/10.1016/j.jksuci.2021.05.013>
- Ali, S., Abuhmed, T., El-Sappagh, S., Muhammad, K., Alonso-Moral, J. M., Confalonieri, R., Guidotti, R., Del Ser, J., Díaz-Rodríguez, N., & Herrera, F. (2023). Explainable Artificial Intelligence (XAI): What we know and what is left to attain Trustworthy Artificial Intelligence. *Information Fusion*, 101805. <https://doi.org/10.1016/j.inffus.2023.101805>
- Armed Police Force. (2023). APF, Nepal Headquarters, recruitment and selection section.
- Aryal, S., & Jung, M. (2023). Finding an end to border disputes: The India-Nepal imperative. *Observer Research Foundation*, 633, 20.

- Awad, M., & Khanna, R. (2015). Machine learning. In M. Awad & R. Khanna (Eds.), *Efficient learning machines: Theories, concepts, and applications for engineers and system designers* (pp. 1–18). Apress. https://doi.org/10.1007/978-1-4302-5990-9_1
- Baduge, S. K., Thilakarathna, S., Perera, J. S., Arashpour, M., Sharafi, P., Teodosio, B., Shringi, A., & Mendis, P. (2022). Artificial intelligence and smart vision for building and construction 4.0: Machine and deep learning methods and applications. *Automation in Construction*, *141*, 104440. <https://doi.org/10.1016/j.autcon.2022.104440>
- Bajwa, C. gurpreet S. (2022). *Border management: Lessons from India-Bangladesh border* (Issue Brief No. 326; p. 18). Centre for Land Warfare Studies. [https://www.claws.in/static/IB-326_Modernising border management lessons from India-Bangladesh border.pdf](https://www.claws.in/static/IB-326_Modernising%20border%20management%20lessons%20from%20India-Bangladesh%20border.pdf)
- Beduschi, A. (2021). International migration management in the age of artificial intelligence. *Migration Studies*, *9*(3), 576–596. <https://doi.org/10.1093/migration/mnaa003>
- Bhandari, V. (2022). Use of technology in disaster management. *Unity Journal*, *3*(01), 292–304. <https://doi.org/10.3126/unityj.v3i01.43333>
- Bhandary, N. P., Yatabe, R., Dahal, R. K., Hasegawa, S., & Inagaki, H. (2013). Areal distribution of large-scale landslides along highway corridors in central Nepal. *Georisk: Assessment and management of risk for engineered systems and geohazards*, *7*(1), 1–20. <https://doi.org/10.1080/17499518.2012.743377>
- Bharadiya, J. (2023). Artificial intelligence in transportation systems: A critical review. *American Journal of Computing and Engineering*, *6*, 34–45. <https://doi.org/10.47672/ajce.1487>

- Biswas, A., & Wang, H.-C. (2023). Autonomous vehicles enabled by the integration of IoT, Edge Intelligence, 5G, and Blockchain. *Sensors*, 23(4), Article 4.
<https://doi.org/10.3390/s23041963>
- Blanco-González, A., Cabezón, A., Seco-González, A., Conde-Torres, D., Antelo-Riveiro, P., Piñeiro, Á., & Garcia-Fandino, R. (2023). The role of AI in drug discovery: Challenges, opportunities, and strategies. *Pharmaceuticals*, 16(6), Article 6.
<https://doi.org/10.3390/ph16060891>
- Bozic, V. (2023). Role of AI in securing real-time systems in healthcare. *Research Gate*.
<https://doi.org/10.13140/RG.2.2.17353.01123>
- Bratko, A., Oleshko, D., Datskov, A., Vychavka, V., Olytskyi, O., & Balytskyi, I. (2021). Use of the SWOT analysis in the field of national security planning. *Emerging Science Journal*, 5(3), 330–337. <https://doi.org/10.28991/esj-2021-01280>
- Buddin, R. J. (2005). *Success of first-term soldiers: The effects of recruiting practices and recruit characteristics*. Rand. ISBN 978-0-8330-3732-9.
- CAAN, (2021). Testimony of CAAN.
<https://caanepal.gov.np/storage/app/media/drone/UAS%20Requirement%20final.pdf>
- Channaiah, R. (2023, March 11). *Defending India's borders: How video analytics is revolutionizing army security*. LinkedIn. <https://www.linkedin.com/pulse/defending-indias-borders-how-video-analytics-army-security-rakesh/>
- Chen, Z. (2022). The AI revolution is underway, and this is good news for customs. *WCO News*. <https://mag.wcoomd.org/magazine/wco-news-99-issue-3-2022/ai-revolution-is-underway/>

- Chithambarathanu, M., & Jeyakumar, M. K. (2023). Survey on crop pest detection using deep learning and machine learning approaches. *Multimedia Tools and Applications*.
<https://doi.org/10.1007/s11042-023-15221-3>
- Collins, C., Dennehy, D., Conboy, K., & Mikalef, P. (2021). Artificial intelligence in information systems research: A systematic literature review and research agenda. *International Journal of Information Management*, 60, 102383.
<https://doi.org/10.1016/j.ijinfomgt.2021.102383>
- Cooney, M., Shiomi, M., Duarte, E. K., & Vinel, A. (2023). A broad view on robot self-defense: Rapid scoping review and cultural comparison. *Robotics*, 12(2), Article 2.
<https://doi.org/10.3390/robotics12020043>
- Covarrubias, D. (2023). Smart borders: The key to more resilient international trade and cross-border transportation. *Texas A&M International University*, 10.
- Covarrubias, D., & Cedillo, G. (2023). A living lab at the southern border. *The Wilson Quarterly*. <https://www.wilsonquarterly.com/quarterly/strategic-competition/a-living-lab-at-the-southern-border>
- Das, P. (2013, September 19). *Need to effectively manage the India-Nepal border*. Manohar Parrikar Institute for Defence Studies and Analyses.
https://www.idsa.in/idsacomments/ManagetheIndiaNepalBorder_pdas_190913
- Desai, D. R., & Kroll, J. A. (2017). *Trust but verify: A guide to algorithms and the law* (SSRN Scholarly Paper No. 2959472). <https://papers.ssrn.com/abstract=2959472>

Digital Nepal framework, 359 (2019).

https://nepalindata.com/media/resources/items/15/bEN_Digital_Nepal_Framework_V7.2March2019.pdf

Dobrava, C. (2021). *Artificial intelligence at EU borders: Overview of applications and key issues*. Publications Office. <https://data.europa.eu/doi/10.2861/91831>

Feldstein, S. (2019, September 17). *The global expansion of AI surveillance*. Carnegie Endowment for International Peace. <https://carnegieendowment.org/2019/09/17/global-expansion-of-ai-surveillance-pub-79847>

Fieux-Castagnet, G., & Santucci, G. (2019). Artificial intelligence: A civilizational challenge, a generational duty. <https://promethosia.com/2020/12/24/artificial-intelligence-a-civilizational-challenge-a-generational-duty/>

Fjelland, R. (2020). Why general artificial intelligence will not be realized. *Humanities and Social Sciences Communications*, 7(1), Article 1. <https://doi.org/10.1057/s41599-020-0494-4>

Fontes, C., Hohma, E., Corrigan, C. C., & Lütge, C. (2022). AI-powered public surveillance systems: Why we (might) need them and how we want them. *Technology in Society*, 71, 102137. <https://doi.org/10.1016/j.techsoc.2022.102137>

Fors, K. L., & Meissner, F. (2022). Contesting border artificial intelligence: Applying the guidance-ethics approach as a responsible design lens. *Cambridge University Press*, 4, 36. <https://doi.org/10.1017/dap.2022.28>

Fran. (2021, November 5). The future of robotics: How will robots change the world? *Future Learn*. <https://www.futurelearn.com/info/blog/general/introduction-robotics-future-robots>

Frankenfield, J. (2022, July 6). *Artificial Intelligence: What it is and how it is used.*

Investopedia. <https://www.investopedia.com/terms/a/artificial-intelligence-ai.asp>

Frontex. (2022). *Strategic risk analysis 2022* (p. 44). Risk Analysis Unit, Frontex.

[https://frontex.europa.eu/assets/Publications/Risk Analysis/strategic risk analysis 2022.pdf](https://frontex.europa.eu/assets/Publications/Risk%20Analysis/strategic%20risk%20analysis%202022.pdf)

Gaire, U. S. (2023). Application of artificial intelligence in the military: An overview. *Unity Journal*, 4(01), 161–174. <https://doi.org/10.3126/unityj.v4i01.52237>

Garijo, F. V. (2020). Drones, border surveillance and the protection of human rights in the European Union. *Public Security and Public Order*, 15. <https://doi.org/10.13165/PSPO-20-25-09>

Gentzel, M. (2021). Biased face recognition technology used by government: A problem for liberal democracy. *Philosophy & Technology*, 34(4), 1639–1663. <https://doi.org/10.1007/s13347-021-00478-z>

Goodfriend, S. (2023, January 20). What the rise of drone warfare means for Palestinians. *Foreign Policy*. <https://foreignpolicy.com/2023/01/20/israel-palestine-west-bank-attack-surveillance-drones-far-right-settlers/>

Gruetzemacher, R. (2022, April 19). The Power of Natural Language Processing. *Harvard Business Review*. <https://hbr.org/2022/04/the-power-of-natural-language-processing>

Gyawali, M. (2019, August 31). Data and development: Harnessing AI in Nepal. *The Diplomat*. <https://thediplomat.com/2019/08/data-and-development-harnessing-ai-in-nepal/>

- Haenlein, M., & Kaplan, A. (2019). A brief history of artificial intelligence: On the past, present, and future of artificial intelligence. *California Management Review*, 61(4), 5–14. <https://doi.org/10.1177/0008125619864925>
- Hannan, A. (2018). Geography of informal trade, commodity flows and livelihoods in Indo-Nepal border. *I(2)* 24. <https://www.osderpublications.com/uploads/1568726955.pdf>
- Hariton, E., Pavlovic, Z., Fanton, M., & Jiang, V. S. (2023). Applications of artificial intelligence in ovarian stimulation: A tool for improving efficiency and outcomes. *Fertility and Sterility*, 120(1), 8–16. <https://doi.org/10.1016/j.fertnstert.2023.05.148>
- Horowitz, M. C., Allen, G. C., Saravalle, E., Cho, A., Frederick, K., & Scharre, P. (2018). *Artificial intelligence and international security*. ETH Zurich. https://css.ethz.ch/content/dam/ethz/special-interest/gess/cis/center-for-securities-studies/resources/docs/CNAS_AI%20and%20International%20Security.pdf
- Hossein, A. (2022, May 13). What is computer vision: Meaning, examples, and applications in 2022. *Spiceworks*. <https://www.spiceworks.com/tech/artificial-intelligence/articles/what-is-computer-vision/>
- Hunter, A. P., & Sheppard, L. R. (2018). The importance of the AI ecosystem. *Center for Strategic & International Studies*, 78.
- Hushti-Orban, DR. K., & Aolain, Prof. F. N. (2020). *Use of biometric data to identify terrorists: Best practice or risky business?* (p. 45). Office of the United Nations High Commissioner for Human Rights. <https://www.ohchr.org/sites/files/Documents/Issues/Terrorism/biometricsreport.pdf>

Janiesch, C., Zschech, P., & Heinrich, K. (2021). Machine learning and deep learning.

Electronic Markets, 31(3), 685–695. <https://doi.org/10.1007/s12525-021-00475-2>

Jha, J., & Yadav, D. A. K. (2022, February 10). How is artificial intelligence changing the

world? What Nepal should do to tap it? *Nepal Live Today*.

<https://www.nepallivetoday.com/2022/02/10/how-is-artificial-intelligence-changing-the-world-what-nepal-should-do-to-tap-it/>

Jones, S. (2015, October 25). Nepal earthquakes leave bitter legacy as children become quarry for

traffickers. *The Guardian*. [https://www.theguardian.com/global-](https://www.theguardian.com/global-development/2015/oct/25/nepal-earthquake-six-month-anniversary-children-orphans-people-traffickers)

[development/2015/oct/25/nepal-earthquake-six-month-anniversary-children-orphans-people-traffickers](https://www.theguardian.com/global-development/2015/oct/25/nepal-earthquake-six-month-anniversary-children-orphans-people-traffickers)

Katara, S., & Pokhriyal, A. (2017). *Strengthening Indian border security through integrated*

ICT based framework (p. 44). <https://doi.org/10.1145/3055219.3055225>

Kaur, H. (2021). Machine learning and border security. *PalArch's Journal of Archaeology of*

Egypt/Egyptology, 18(1), 3467-3475.

K.C., D. (2019). Cross-border crime and its security concerns in Nepal. *Journal of APF*

Command and Staff College, 2, 21–31. <https://doi.org/10.3126/japfsc.v2i1.26729>

Kerry, C. F. (2020, February 10). Protecting privacy in an AI-driven world. *Brookings*.

<https://www.brookings.edu/research/protecting-privacy-in-an-ai-driven-world/>

Kerry, C. F., Meltzer, J. P., Renda, A., Engler, A. C., & Fanni, R. (2021). Strengthening

international cooperation on AI. *Brookings*, 123.

- Keshvarparast, A., Battini, D., Battaia, O., & Pirayesh, A. (2023). Collaborative robots in manufacturing and assembly systems: Literature review and future research agenda. *Journal of Intelligent Manufacturing*. <https://doi.org/10.1007/s10845-023-02137-w>
- Khan, N., & Efthymiou, M. (2021). The use of biometric technology at airports: The case of customs and border protection (CBP). *International Journal of Information Management Data Insights*, 1(2), 100049. <https://doi.org/10.1016/j.ijime.2021.100049>
- Khurana, D., Koli, A., Khatter, K., & Singh, S. (2022). Natural language processing: State of the art, current trends and challenges. *Multimedia Tools and Applications*, 82. <https://doi.org/10.1007/s11042-022-13428-4>
- Koslowski, R., & Schulzke, M. (2018). Drones along borders: Border security UAVs in the United States and the European Union. *International Studies Perspectives*, 19(4), 305–324. <https://doi.org/10.1093/isp/eky002>
- Kumar, S. (2021, August 16). Artificial intelligence capability in securing the LAC. *Center For Land Warfare Studies (CLAWS)*. <https://www.claws.in/artificial-intelligence-capability-in-securing-the-lac/>
- Labati, R., Genovese, A., Muñoz, E., Piuri, V., Scotti, F., & Sforza, G. (2016). Biometric recognition in automated border control: A survey. *ACM Computing Surveys*, 49, 1-39. <https://doi.org/10.1145/2933241>
- Lai, N. T. L. and S. (2022, May 17). The U.S. can improve its AI governance strategy by addressing online biases. *Brookings*. <https://www.brookings.edu/blog/techtank/2022/05/17/the-u-s-can-improve-its-ai-governance-strategy-by-addressing-online-biases/>

- Malhotra, R. (2021). *Artificial Intelligence and the Future of Power: 5 Battlegrounds*. Rupa Publications India Pvt Ltd.
- Marasini, M. K. (n.d.). *Digital development: Opportunities & challenges perspectives from Nepal*. https://unctad.org/system/files/non-official-document/tdb66_2c_pres_MMa
- Marsden, D. P. (2017, September 4). Artificial Intelligence Defined: Useful list of popular definitions from business and science. *Digitalwellbeing.Org*.
<https://digitalwellbeing.org/artificial-intelligence-defined-useful-list-of-popular-definitions-from-business-and-science/>
- Mazhar, T., Irfan, H. M., Khan, S., Haq, I., Ullah, I., Iqbal, M., & Hamam, H. (2023). Analysis of cyber security attacks and its solutions for the smart grid using machine learning and blockchain methods. *Future Internet*, 15(2), 83. <https://doi.org/10.3390/fi15020083>
- McLinden, G., Fanta, E., Widdowson, D., & Doyle, T. (Eds.). (2011). *Border management modernization*. The World Bank. <https://doi.org/10.1596/978-0-8213-8596-8>
- Milivojevic, S. (2022). Artificial intelligence, illegalized mobility and lucrative alchemy of border utopia. *Criminology & Criminal Justice*, 174889582211238. <https://doi.org/10.1177/17488958221123855>
- MoFA. (2020). *Report on Nepal's foreign affairs (2019-2020)* (p. 166). MoFA. <https://www.mofa.gov.np>.
- Naik, B., Mehta, A., Yagnik, H., & Shah, M. (2022). The impacts of artificial intelligence techniques in augmentation of cybersecurity: A comprehensive review. *Complex & Intelligent Systems*, 8(2), 1763–1780. <https://doi.org/10.1007/s40747-021-00494-8>

- Nalbandian, L. (2022). An eye for an 'I:' a critical assessment of artificial intelligence tools in migration and asylum management. *Comparative Migration Studies*, 10(1), 32.
<https://doi.org/10.1186/s40878-022-00305-0>
- Nepal, P. (2022, December 28). Crime data. <https://www.nepalpolice.gov.np/news/83/>
- Niroula, A. (2021, February 19). Banking in Nepal: Greater use of AI. *The Himalayan Times*.
<https://thehimalayantimes.com/opinion/banking-in-nepal-greater-use-of-ai>
- Nor, N., Majid, D. M. A., & Wahab, D. A. AB. (2022). Potential application of artificial intelligence in safeguarding Malaysia-Thailand border from migrant smuggling activities: A preliminary assessment. *Social Science Journal*, 12(2), 14.
- National Science Technology and innovation policy 2019, (2019) (testimony of NSTIP).
https://moe.gov.np/assets/uploads/files/STI_Policy.pdf
- Oostveen, A.-M., Kaufmann, M., Krempel, E., & Grasmann, G. (2020). Automated border control: A comparative usability study at two European airports. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.2432461>
- Oppy, G., & Dowe, D. (2021). The turning test in E. N. Zalta (Ed.). *The Stanford Encyclopedia of Philosophy* (2021st ed.). Metaphysics Research Lab, Stanford University.
<https://plato.stanford.edu/archives/win2021/entries/uring-test/>
- Paudyal, G. (2014). Border dispute between Nepal and India. *A Research Journal of Culture and Society*, 1(2), 35–48. <https://doi.org/10.3126/researcher.v1i2.9884>
- Pulami, M. J. (2023). Introducing the idea of border governance for Nepal-India open border. *Journal of Political Science*, 23, 77–97. <https://doi.org/10.3126/jps.v23i1.52285>

- Ramesh, D., & Sanampudi, S. K. (2022). An automated essay scoring system: A systematic literature review. *Artificial Intelligence Review*, 55(3), 2495–2527.
<https://doi.org/10.1007/s10462-021-10068-2>
- Rana, S. S. (2020, November 3). *Considering the Nepal-China border*.
<https://www.recordnepal.com/considering-the-nepal-china-border>
- Regona, M., Yigitcanlar, T., Xia, B., & Li, R. Y. M. (2022). Opportunities and adoption challenges of ai in the construction industry: A PRISMA Review. *Journal of Open Innovation: Technology, Market, and Complexity*, 8(1), 45.
<https://doi.org/10.3390/joitmc8010045>
- Republica. (2022, June 17). Seven south African women held with 51 kgs of narcotics worth over Rs 1 billion. *My Republica*. <http://myrepublica.nagariknetwork.com/news/127952/>
- Ribeiro, J. (2023, March 12). These are the best definitions of artificial intelligence you can read today. *The Startup*. <https://medium.com/swlh/these-are-the-best-definitions-of-artificial-intelligence-you-can-read-today-7c53c0e38584>
- Rimal, N. (2021). *COVID-19 led migrant returnees to understand its relationship with border security and Nepal's foreign affairs*. Institute of Foreign Affairs, Kathmandu, Nepal. ISBN: 978-9937-9274-9-9.
- Rockwell, A. (2017, August 28). The history of artificial intelligence. *Science in the News*.
<https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/>
- Rockwell, M. (2020, July 6). CBP expands border surveillance tower network. *GCN*.
<https://gcn.com/emerging-tech/2020/07/cbp-expands-border-surveillance-tower-network/315062/>

- Rodrigues, R. (2020). Legal and human rights issues of AI: Gaps, challenges and vulnerabilities. *Journal of Responsible Technology*, 4, 100005.
<https://doi.org/10.1016/j.jrt.2020.100005>
- Romero Meza, M. S. (2019). The power struggle along the US-Mexico border: A space of dehumanization and of assertion of justice. *Geopolítica(s), Revista de Estudios Sobre Espacio y Poder*, 10(2), 185–206. <https://doi.org/10.5209/geop.66403>
- Roy, K. (2020). Rationales for introducing artificial intelligence into India's military modernization programme. In P. Topychakanov (Ed.), *The Impact of Artificial Intelligence on Strategic stability and Nuclear Risk: Vol. III* (pp. 17–24). Stockholm International Peace Research Institute. [https://www.sipri.org/sites/default/files/2020-04/impact of ai on strategic stability and nuclear risk vol iii topychkanov 1.pdf](https://www.sipri.org/sites/default/files/2020-04/impact%20of%20ai%20on%20strategic%20stability%20and%20nuclear%20risk%20vol%20iii%20topychkanov%201.pdf)
- Ryan-Mosley, T. (2023, April 17). EU illegal border crossings 2021. *MIT Technology Review*.
<https://www.statista.com/statistics/454775/number-of-illegal-entries-between-bcps-eu/>
- Sanchez Del Rio, J., Moctezuma, D., Conde, C., Martin De Diego, I., & Cabello, E. (2016). Automated border control e-gates and facial recognition systems. *Computers & Security*, 62, 49–72. <https://doi.org/10.1016/j.cose.2016.07.001>
- Sarker, I. H. (2022). AI-based modeling: Techniques, applications and research issues towards automation, intelligent and smart systems. *SN Computer Science*, 3(2), 158.
<https://doi.org/10.1007/s42979-022-01043-x>
- Schuchmann, S. (2020, May 16). History of the first AI winter. *Medium*.
<https://towardsdatascience.com/history-of-the-first-ai-winter-6f8c2186f80b>

- Shaik, T., Tao, X., Higgins, N., Li, L., Gururajan, R., Zhou, X., & Acharya, U. R. (2023). Remote patient monitoring using artificial intelligence: Current state, applications, and challenges. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, 13. <https://doi.org/10.1002/widm.1485>
- Sheikh, H., Prins, C., & Schrijvers, E. (2023). *Mission AI: The new system technology* (C. Prins & F. Brom, Eds.). Springer International Publishing. <https://doi.org/10.1007/978-3-031-21448-6>
- Shor, N. (2023, March 15). *How AI is changing border protection*. TAR Ideal. <https://www.tarideal.com/how-ai-is-changing-border-protection/>
- Shrestha, A. (2018, April 4). Home Ministry plans to use drones for surveillance along border. *TechLekh*. <https://www.techlekh.com/nepal-use-drones-surveillance-border/>
- Singh, A. V., Chandrasekar, V., Paudel, N., Laux, P., Luch, A., Gemmati, D., Tisato, V., Prabhu, K. S., Uddin, S., & Dakua, S. P. (2023). Integrative toxicogenomics: Advancing precision medicine and toxicology through artificial intelligence and OMICs technology. *Biomedicine & Pharmacotherapy*, 163, 114784. <https://doi.org/10.1016/j.biopha.2023.114784>
- Singh, R. A. (2023). AI-Powered writing tools and their impact on the Humanities. *The ArmChair Journal*, 6. <https://doi.org/10.5281/ZENODO.7880155>
- Smith, O. (2023, June 20). AI in Supply Chain Management: Revolutionizing the Future of Logistics. *Global Trade Magazine*. <https://www.globaltrademag.com/ai-in-supply-chain-management-revolutionizing-the-future-of-logistics/>
- Stinson, C. (2022). Algorithms are not neutral. *AI and Ethics*, 2(4), 763–770. <https://doi.org/10.1007/s43681-022-00136-w>

- Suman, S. (2022). Augmented intelligence for national security and development. *Unity Journal*, 3(01), 245–252. <https://doi.org/10.3126/unityj.v3i01.43329>
- Surianarayanan, C., Lawrence, J. J., Chelliah, P. R., Prakash, E., & Hewage, C. (2023). Convergence of artificial intelligence and neuroscience towards the diagnosis of neurological disorders: A scoping review. *Sensors (Basel, Switzerland)*, 23(6), 3062. <https://doi.org/10.3390/s23063062>
- Taneja, A., Nair, G., Joshi, M., Sharma, S., Sharma, S., Jambrak, A. R., Roselló-Soto, E., Barba, F. J., Castagnini, J. M., Leksawasdi, N., & Phimolsiripol, Y. (2023). Artificial Intelligence: Implications for the Agri-Food Sector. *Agronomy*, 13(5), Article 5. <https://doi.org/10.3390/agronomy13051397>
- Taylor, D. (2023, January 6). What is big data? Introduction, types, characteristics, examples. *GURU99*. <https://www.guru99.com/what-is-big-data.html>
- Timsina, A. (2019, January 15). Artificial intelligence (AI) and it's impact in Nepal. *NepaliTelecom*. <https://www.nepalitelecom.com/2019/01/ai-nepal.html>
- Tripathi, R. (2018, November 17). Birgunj to install 6 CCTV cameras on border. *My Republica*. <http://myrepublica.nagariknetwork.com/news/53547/>
- Tucci, L. (2021, July 9). A guide to artificial intelligence in the enterprise. *Enterprise AI*. <https://www.techtarget.com/searchenterpriseai/Ultimate-guide-to-artificial-intelligence-in-the-enterprise>
- Tyler, H. (2022, February 1). *The increasing use of artificial intelligence in border zones: Prompts privacy questions*. (Washington, DC: Migration Policy Institute, 2016). <https://www.migrationpolicy.org/article/artificial-intelligence-border-zones-privacy>

- UNDOC. (2020, June 25). *UNODC World Drug Report 2020*. World Relief Web.
<https://reliefweb.int/report/world/unodc-world-drug-report-2020>
- UNESCO. (n.d.). *AI policy and ethics guideline in Nepal*. [https://www.naamii.org.np/wp-content/uploads/2021/11/Infographic AI policy Nepal.pdf](https://www.naamii.org.np/wp-content/uploads/2021/11/Infographic_AI_policy_Nepal.pdf)
- Unmanned Aircraft System Requirements 2021, 01 01 23 (2021).
<https://caanepal.gov.np/storage/app/media/drone/sep%2024%202022/UAS%20Requirement%20final.pdf>
- Upreti, B. R. (2019). Security for enhancing peace and stability in changing context of Nepal. *Journal of APF Command and Staff College*, 2(1), 1–13.
<https://doi.org/10.3126/japfcsc.v2i1.26727>
- Upreti, Y. (2021). Issues in border security of Nepal. *Journal of APF Command and Staff College*, 4(1), 152–160. <https://doi.org/10.3126/japfcsc.v4i1.34145>
- Upreti, Y. (2022). A study of inter-agencies cooperation in border governance of Nepal. *Journal of APF Command and Staff College*, 5(1), 109–130.
<https://doi.org/10.3126/japfcsc.v5i1.49351>
- Vavoula, N. (2021). Artificial intelligence (AI) at Schengen borders: Automated processing, algorithmic profiling and facial recognition in the era of techno-solutionism. *European Journal of Migration and Law*, 23(4), 457–484. <https://doi.org/10.1163/15718166-12340114>
- Weisdal, J. (2023, February 19). The birthplace of AI. *Medium*.
<https://www.cantorsparadise.com/the-birthplace-of-ai-9ab7d4e5fb00>

- Wang, C., Atkison, T., & Park, H. (2023). Dynamic adaptive vehicle re-routing strategy for traffic congestion mitigation of grid network. *International Journal of Transportation Science and Technology*. <https://doi.org/10.1016/j.ijtst.2023.04.003>
- Wang, Y., Wu, N., Kunze, C., Long, R., & Perlik, M. (2019). Drivers of change to mountain sustainability in the Hindu Kush Himalaya. In P. Wester, A. Mishra, A. Mukherji, & A. B. Shrestha (Eds.), *The Hindu Kush Himalaya assessment: Mountains, climate change, sustainability and people* (pp. 17–56). Springer International Publishing. https://doi.org/10.1007/978-3-319-92288-1_2
- WCO. (2022). *The role of advanced technologies in cross-border trade: A customs perspective*. WCO and WTO. https://www.wto.org/english/res_e/publications_e/wcotech22_e.htm
- Weitzberg, K. (2021). Biometrics and counter-terrorism: Case study of Israel/Palestine (p. 25). *Privacy International*.
- Zhao, J., & Gómez Fariñas, B. (2023). Artificial Intelligence and Sustainable Decisions. *European Business Organization Law Review*, 24(1), 1–39. <https://doi.org/10.1007/s40804-022-00262-2>
- Zuiderwijk, A., Chen, Y.-C., & Salem, F. (2021). Implications of the use of artificial intelligence in public governance: A systematic literature review and a research agenda. *Government Information Quarterly*, 38(3), 101577. <https://doi.org/10.1016/j.giq.2021.101577>

However, the implementation of AI in Nepal's border security requires addressing several challenges. Transparency in AI algorithms, responsible technology utilization, standardized policies, and capacity building are crucial for mitigating risks and ensuring the effective and ethical use of AI systems. Data availability, analysis, and robust cybersecurity measures are necessary to overcome challenges related to data scarcity and protect sensitive information. Additionally, the potential impact on employment must be carefully considered, with strategies in place to mitigate any negative effects and facilitate the transition to new roles.

Collaboration between government agencies, stakeholders, and international partners is vital to harnessing the full potential of AI in border security. Strengthened coordination and information sharing between border security agencies are essential for minimizing criminal infiltration and safeguarding national interests. By fostering cooperation, information sharing, and joint efforts, Nepal can overcome challenges, effectively leverage AI technology, and establish a resilient and efficient system for border protection.

AI-powered systems can bridge the gap in human resources, automate routine tasks, and enhance resource allocation. The employment of AI-powered technology has immense potential for Nepal to enhance its border security measures and address the challenges posed by illicit activities across its borders. APF, Nepal can strengthen its ability to identify potential threats, make informed decisions, and safeguard the safety and security of borders by leveraging intelligent surveillance, predictive analytics, automated border control, risk assessment, and drone surveillance capabilities. However, capacity building in APF, Nepal, and careful consideration must be given to addressing the weaknesses and risks associated with AI implementation to ensure responsible and effective use of this AI-powered technology for border protection.