Original Research Article

Analysing the impact of Natural Disasters, Pandemics and other crisis on Employment and Workforce dynamics

ABSTRACT

This study investigates the impact of recent crises such as natural disasters and pandemics on employment and workforce dynamics using a Random Forest machine learning model. The data was collected through a detailed questionnaire analyzing various factors, including demographic information, employment status, the impact of crises, job security, coping mechanisms, and future outlook. The findings reveal that most respondents are young adults, with a higher percentage engaged in full-time or self-employment roles. Crises, notably COVID-19, led to significant financial impacts such as reduced salaries and layoffs, with many experiencing jobs in security and moderate to high stress levels. A substantial portion of the workforce transitioned to remote work, though many reported inadequate employer support. The analysis of the Random Forest model indicates a moderate performance in predicting workforce dynamics, with accuracy, precision, recall, and F1 scores highlighting the complexity of this issue. The study provides practical recommendations such as enhancing remote work infrastructure, improving financial and mental health support, and promoting workforce adaptability to mitigate the adverse effects of future crises and ensure a resilient workforce.

KEYWORDS: *Workforce Dynamics, Crisis Impact, Remote Work, Random Forest Model, Job Security, Mental Health Support, Machine Learning Analysis.*

1 INTRODUCTION

Over the years, there has been an increase in periods of crises (Chaudhary and Piracha, 2021). Crises and the instability associated with it has been shown to lead to significant situations which can affect individuals, groups and entire societies (Pamidimukkala, 2020). Crises occur in various forms which include natural disasters such as earthquakes, hurricanes and floods, pandemics which are caused by a widespread outbreak of infectious diseases, political and economic crises (Caldera and Wirasinghe,

2022). Although all of these crises are different, they often lead to the same effects such as loss of life and significant damage to properties and a constant disruption to people's life, employment and workforce dynamics (Gupta *et al.,* 2021).

The increase in the frequency and intensity of crises are the result of several factors. According to Chaudhary and Piracha (2021) Climate change due to rising global temperatures has increased the intensity of several weather conditions. These include floods, droughts and wildfires. Climate change has been shown to affect agriculture, weather, environment, animals and ultimately humans (Chaudhary and Piracha, 2021). On the spectrum of the impacts of climate change on humans, the extreme end has characteristics such as widespread famine, disease, war and has ultimately affected the workforce and the way employment is being perceived (Tran and Wilson, 2020). The increase in population numbers has also contributed to the strain on resources which has then led to increased vulnerability to life changing disasters and disruptions (Chang-Richards *et al.,* 2021). This has led to the change in actual population dynamics and the need for a stabilized economic system and a more stabilized workforce which can withstand the rapid changes associated with changing population dynamics. Globalization has also affected environmental outcomes and crisis control. For example, during the COVID-19 pandemic, the increase in globalization led to increased interconnectedness among regions (Baum *et al., 2020)*. Trade and travel, where people could travel across continents and transfer diseases faster means that hiccups in health, spread of serious diseases can quickly spread to others (Alimonti and Mariani, 2024). In record times, the COVID-19 pandemic had spread to major regions around the globe even if it originated from Asia and therefore led to significant economic disruptions (Handwerker, 2020). Since the 2000s, rapid increase in extreme weather events has significantly led to severe economic crises thereby disrupting workplace dynamics (Baum *et al., 2020)*.

The occurrence of crises has therefore been seen to cause significant changes, disruptions and interactions in the life of humans today (Raut *et al.,* 2022). Economic impact, psychological impact and emotional impact in the lives of individuals is a fundamental issue (Fana *et al.,* 2020). It is also important, however, to understand the impact of crises on employment today.

The importance of employment for individuals cannot be overemphasized. Meaningful work and employment are connected to individual well-being and how people feel valued (Alimonti and Mariani, 2024). Employment provides income and is also responsible for helping individuals aim realistically for better lives, helping people, to challenge themselves, develop new skills which can be used to help other people improve their lives and to progress accordingly in life (Pamidimukkala, 2020). Aside from individual impact, work and employment has been shown to be beneficial to society at large. Employment leads to social development and reduction in the levels of corruption and crime in a society (Fana *et al.,* 2020). Employment is also a key contributor to poverty reduction. When poverty levels are reduced in a

society, more families are taken care of with children being provided with the basic necessities of life. This can lead to the production of more responsible children, reduction of crime levels leading to a continuity of a more stable society.

The impact that stable employment has on the stability of the individual and society at large has shown that crises could disrupt an individual's life as well as society (Santos *et al*., 2020). Crises can significantly disrupt labor markets in many significant ways, leading to job losses, changes in working arrangements, and displacement of workers (Pamidimukkala, 2020).

Crises can cause a demand shock. A demand shock occurs when there is a sudden decrease in the demand for goods as well as services. This is evident during lockdowns and travel restrictions (Pamidimukkala, 2020). When there is a sharp and sudden decrease in the demand for goods and services, most businesses often resort to layoffs to reduce costs leading to loss of jobs.

Crises have also been shown to cause a significant disruption of a supply chain and therefore makes it difficult for businesses to obtain materials and resources for the business (Assaad and El-Adaway, 2021). This can result in a decreased output level and job losses. Supply chain disruptions can also lead to interference in transportation infrastructure. This can influence economic activity negatively and lead to job losses (Tran and Wilson, 2020).

Health crises have also led to significant issues in the labor market (Santos *et al.,* 2020). To protect employees, businesses are forced to operate at reduced capacities which can lead to a drastic change in work activities which can therefore affect the workplace. A significant health crisis can lead to sectoral shifts andchanges in workplace operations. For example, during the COVID-19 pandemic, a lot of businesses quickly integrated the online shopping alternatives (Baum *et al., 2020)*. Robotic product delivery carts were introduced which eliminated the need for physical interactions. These developments are great but have successfully eliminated opportunities in some sectors and created new ones (Gupta *et al., 2021)*. This means employees have to adapt to new methods and other employees whose services were no longer needed were laid off.

Employees have also been displaced due to natural disasters such as typhoons and hurricanes. These natural disasters destroy infrastructure, displace employees and ultimately lead to loss of jobs (Tran and Wilson, 2020). When people are forced to flee their homes due to natural disasters, existing employment is lost and an employee may not find it easy to be reintegrated into the workforce again in another sector or another location (Fana *et al.,* 2020).

The impact of crises in a workforce is more prevalent in certain industries than others. Certain industries are more prone to the devastating effects of crises in comparison to the other (Santos *et al.,* 2020). These disruptions seem unpredictable and therefore it is vital to accurately forecast the impact of natural disasters, pandemics or other crises on employment and workforce dynamics (Franklin and Labonne, 2019). The existing models detailing how crises can be accurately forecasted have not been able to sufficiently capture how crises happen in different locations (Gupta *et al., 2021)*. This has led to a shift in the way the impact of crises on employment can be evaluated. To accurately forecast the impact of crises on the workforce, there is a need to account for the various fast paced technological inventions and their interactions with the impact of crises (Assaad and El-Adaway, 2021). Crises can influence data collection and therefore cause difficulty in providing real information which can disrupt effective policy responses. This study aims to accurately identify the impact of natural disasters, pandemics or other crises on employment and workforce dynamics.

1.2 Research Objectives

This study aims to achieve the following objectives:

a. To assess the impact of recent crises, including natural disasters and pandemics, on workforce dynamics across different industries.

b. To identify the primary factors influencing job security, employment transitions, and stress levels during crises using a machine learning approach.

c. To evaluate the role of remote work and employer support in mitigating the effects of crises on employees.

d. To forecast workforce dynamics in response to future crises using the Random Forest machine learning model, highlighting key predictors such as industry, number of years spent in role, and stress level.

e. To provide practical recommendations for organizations to enhance workforce resilience and adaptability in times of crisis.

2 LITERATURE REVIEW

The increase in the frequency and intensity of crises ranging from natural disasters to pandemics poses a great threat to global stability. There is widespread disruption which affects the labor market leading to different circumstances for employees (Gupta *et al., 2021)*. Understanding the impact of crises on work is necessary for developing effective policy response and economic resilience. It is necessary to identify different frameworks utilized in crisis assessment, role of technology in crisis response, role of technology in job creation and limitations in current impact models such as social factors and regional variations.

2.1 Existing Frameworks for Crisis Impact Assessment

Over the years, a lot of models have been developed to determine the impact of crises on employment dynamics. These models include the Economic impact model, labor market dynamics model, social Network analysis and the Agent based model.

2.1.1 Economic Impact Model

The economic impact model is a very extensive model which focuses extensively on quantification of the economic loss which was triggered by pandemics, natural disasters or other crises (Tran and Wilson, 2020). An example of the Economic impact model is the Input-Output analysis (Franklin and Labonne, 2019). The economic impact model is a very important guide which has been used to analyze how economically interconnected various sectors are (Tran and Wilson, 2020). It is useful to evaluate how disruption caused by certain crises can break or make an economy, therefore impacting the level of productivity of individuals or jobs (Franklin and Labonne, 2019).

2.1.2 Labor Market Dynamics Model

The labor market dynamics model is a very extensive model which deals with workforce dynamics. Its bedrock is specifically on labor mobility, job creation, job losses and how crises affect or impact these factors (Franklin and Labonne, 2024). It may include employee demographics unlike the economic impact model. These demographics provide a detailed picture of the impact of crises on workforce dynamics (Sulintang *et al.,* 2024). The advantages of the labor market dynamics are numerous though it also possesses disadvantages. A disadvantage of the labor market dynamics model is that it may require the application of extensive data sets. These data sets may not entirely capture social factors which may negatively impact employee productivity during crises.

2.1.3 Social Network Analysis

Social network analysis is an applicable tool which basically explores the interactions and the interrelationship that exists between employees and businesses and other entities in the labor market (Franklin and Labonne, 2024). This model is used to evaluate how social networks are affected or broken by crises. It shows social vulnerabilities which lead to job losses or skill shortage during a crisis (Lane and Saint-Martin, 2021). In the midst of a crisis, this framework requires detailed information about employee interactions which may not be readily available.

2.1.4 Agent based models

The agent-based models are models which stimulate the behavior of individual employees and businesses in response to crises (Lane and Saint-Martin, 2021). This model paints a realistic picture of individual employees and businesses when there is a crisis. It could be a health crisis such as the COVID-19 pandemic which led to other crises (Chaudhary and Piracha, 2021). It could be an economic crisis leading to escalating health issues due to lack of basic resources or it could be a natural disaster which results in loss of lives, infrastructure, properties, disruption in the workforce sector and other crises (Chang-Richards *et al.,* 2021). This model considers various factors such as individual decision making

and strategies at which employees can adapt to the changing workforce dynamics (Lane and Saint-Martin, 2021). However, despite the benefits of the model, it is a very complex model which requires careful automation with real-world data to ensure accuracy.

Crisis impact assessment can be accurately done by a combination of these models. It has been shown that each of these models does not give an accurate result when utilized singly (Hamouche, 2023). A combination of different aspects of the models can lead to a more detailed understanding on the impacts of crises on employment and workforce dynamics (Tran and Wilson, 2020).

2.2 Impacts of Crises on specific aspects of employment

Crises can impact the different aspects of employment. The impacts of crises on specific areas of employment provides insights into the different ways by which a crisis can affect employment. Some specific aspects of employment and workforce which crises may influence includes:

2.2.1 Sectoral Impact

Due to the difference in vulnerability of different sectors, natural disasters, pandemics and other crises may affect these sectors (Minchenko and Demchuk, 2021). Natural disasters may devastate the tourism industry or Agricultural industry. Natural disasters may destroy infrastructure which has been put in place for tourism (Franklin and Labonne, 2019). This disrupts visiting tourists and hence may inspire employee layoffs. The agricultural industry may be plagued by natural disasters as well as pandemics (Michaud, 2020). In the area of livestock rearing or farming, a large expanse of land may be plagued by floods which may destroy crops or endanger livestock. Sectors which are reliant on in-person interaction may be affected by pandemics which may cause layoffs and disrupt worker dynamics.

2.2.2 Skill-Level Impact

Crises may significantly affect low-skilled workers in a sector thereby resulting in loss of jobs. Skills which are highly specialized may experience a surge in demand after certain crises such as a natural disaster.

2.2.3 Displacement

Natural disasters may force people to leave their homes and places of residence (Chang-Richards *et al.,* 2021). People may face challenges in finding new employment in the new locations due to inability to properly integrate with the new environment.

2.2.4 Integration of other forms of work settings

Sometimes during a pandemic, work arrangements might change (Michaud, 2020). A decline from normal work settings during a pandemic might lead to permanent shifts and changes in how people work (Handwerker *et al.,* 2020). Crises can cause an increase in the prevalence of remote work arrangements.

Some employees may be unable to make effective decisions on circumstances regarding a healthy work-life balance (Michaud, 2020) which can affect job security.

Overall economic growth and development can be impacted when businesses limit their goods or the services which they render due to a reduction in the demand for it (Hamouche, 2023). When situations like this occur, employee income can be impacted which can affect overall economic activity (Handwerker *et al.,* 2020).

2.2.5 Mental health and government policies

The traumatic scenarios which some employees might face in the event of a crisis can impact employee mental health, social health and physical health negatively. It may reduce productivity and therefore may lead to being away from work and struggling to be productive (Hamouche, 2023). Government policies such as packages and unemployment benefits can play a very vital role in supporting employees and mitigating job losses during the event of a crisis (Assaad and El-Adaway, 2021). Understanding the impact of crises on these specific employment aspects is a necessary tool which can aid in developing targeted interventions and suitably forecasting the impacts of natural disasters, pandemics or other crises on employment and workforce dynamics (Assaad and El-Adaway, 2021).

2.3 Workforce dynamics in crisis recovery

After crises, critical situations are often experienced by the workforce. Some new jobs emerge, others disappear, and the work landscape undergoes a total overhaul. Some of the key dynamics which impact workforce dynamics in crisis recovery are:

2.3.1 Market Shifts, Skill Needs and Skill gaps

According to Assaad and El-Adaway (2021), crises are often necessary for the development of rehabilitation efforts and therefore create opportunities in areas such as construction, infrastructure, repair and sanitation. The exact skillset which is required to carry out these efforts are often different from skills which were needed to provide value before the crises happened. (Michaud, 2020). The necessity for skills and results can result in skill gaps requiring urgent programs to retrain workers and equip them with necessary skills to participate in recovery efforts (Franklin and Labonne, 2024). Crises can also trigger long term changes in local economies or in regional economies. Understanding these economic and market shifts is beneficial in anticipating how crises can impact workforce dynamics (Handwerker *et al., 2020)*. This will help in managing future skill demands and development of new options to help targeted training programs.

2.3.2 Migration and displacement of a large number of people.

Chang-Richards *et al., (*2019) explains that patterns of crises have led to population displacement. Population displacement can influence the influx of workers to a particular location or the shortage of workers in a specific area. This can affect labor supply in a region. Displaced employees may have issues with integration into new markets and may also have issues with understanding how to integrate into new areas of expertise (Chang-Richards *et al.,* 2021).

2.3.3 Impact of crises recovery on workforce dynamics

Studies have shown that psychological impact, entrepreneurship and technological advancements play a role in crisis recovery and workforce dynamics (Michaud, 2020). To effectively re-enter the workforce, workers who have experienced trauma during a crisis may require mental health support to enable them to enter the workforce again (Assaad and El-Adaway, 2021). Individuals may seek new income opportunities and address specific needs created by the crises due to a rise in entrepreneurship (Assaad and El-Adaway, 2021). Advancements in technology have been shown to play a vital role in the recovery of workforce dynamics. This is evident in instances where digital platforms are integrated to connect displaced workers with new job opportunities (Hamouche, 2023). Navigation of these challenges can help create a workforce that is adaptable to the opportunities and problems created by crises.

2.4 The Role of technology and recent advancements in forecasting the impacts of crises on employment and workforce dynamics

Although there are certain challenges involved in the use of technology in discerning the impact of technology during crises, technological development offers various opportunities for forecasting the impact of crises on employment and workforce dynamics (Assaad and El-Adaway, 2021).

2.4.1 Data collection and data analysis

Data analytics can leverage real time data streams from different sources such as social media, economic indicators and job listings to determine emerging trends which can indicate potential employment impacts of crises (Sulintang *et al.,* 2024). This is very vital because valuable insights and responses can be evaluated by giving proactive responses.

Technological advancements such as digital surveys can utilize efficient data collection and can rapidly integrate efficient and timely data collection on employment figures and economic activity during a crisis even in environments which have been disrupted by crises such as pandemics (Nguyen *et al.,* 2022).

Natural disasters may affect environmental factors thereby making it difficult for technology to be easily available. Agent-based modelling with machine learning such as machine learning algorithms can simulate events which happen during devastating crises such as natural disasters (Lane and Saint-Martin, 2021). The complex interactions existing between businesses and employees and the impacts of

government policies during a crisis can be simulated. This allows for adequate forecasting of the impacts of employment, observing factors such as individual decision making, skills, how adaptable employees are and the effectiveness of governmental policies.

Crisis scenarios can be planned by using artificial interventions (Nguyen *et al.,* 2022). This can help evaluate how different policy interventions and technological advancements can influence workforce dynamics. A range of potential outcomes can be prepared by businesses to eradicate the impacts of crises on the employees (Handwerker, 2020).

2.4.2 Technological analysis of skill gaps

Technology can be used in the analysis of data obtained from the labor market. Analysis can show potential skill gaps which may arise due to crises (Nguyen *et al.,* 2022). During crisis recovery, the information obtained from the skill gap analysis can be utilized in the development of targeted skills training programs. This can prepare the workforce for new opportunities from the recovery of crises.

2.4.3 Technological innovation in crisis response

Advancement in technology has introduced advancements in collaboration technologies. Technology such as video conferencing, has in record times facilitated worker experience and dynamics (Lane and Saint-Martin, 2021). Even with disruption in physical workplaces, remote work arrangement has been facilitated which can ensure continuity during crises.

Hazardous tasks can also be implemented for dangerous and time-consuming tasks. This can enhance worker efficiency and worker safety while creating new areas for job expansion.

2.5 Challenges associated with the use of technology in forecasting the impacts of technology on employment and workforce dynamics

Inasmuch as technology is very effective in evaluating the impact of technology on workforce dynamics, some challenges still remain. A very important consideration are the concerns associated with data privacy. Analysis of vast amounts of data strikes concerns about data privacy. As employees share detailed information about work and work cycle, there is a very strong need to address ethical considerations regarding responsible uses of data. Ethical considerations need to be addressed in order to ensure responsible use of data and prevent hijacking by criminals (Nguyen *et al.,* 2022).

When employees are not so literate about technology and data, it could exacerbate job losses among employees who cannot be a part of the necessary digital changes. In the event of a natural disaster,

inaccurate or unreliable data can be encountered thereby limiting the effectiveness of accurate determination of impacts of crises on employment and workforce dynamics (Alimonti and Mariani, 2024).

2.6 Limitations of existing literature

Existing studies have provided actual insights into the impact of crises on employment and workforce dynamics. However, these studies possess limitations in the ability to accurately forecast the impacts of these crises on workforce dynamics. According to Sulintang *et al., (*2024) forecasting long term impacts have been met with some difficulties due to the limited availability of historical data on the long-term impacts of crises on employment and workplace dynamics.Based on the inadequacy of historical data, robust forecasting models have been difficult to evaluate therefore making it challenging to predict future outcomes (Nguyen *et al.,* 2022).

An important limitation is that studies have been unable to accurately examine pre-existing factors such as social safety and unemployment rates and their impacts on employment and workforce dynamics (Tran and Wilson, 2020). Pre-existing economic conditions could greatly influence the impact of crises in certain regions. However, there is great opportunity and greater chances of improving research outcomes on the impact of crises on employment and workforce dynamics.

2.7 Research Gap

Existing studies have extensively documented the impact of crises such as natural disasters and pandemics on employment and workforce dynamics. However, these studies have limitations in accurately forecasting the long-term effects of crises, especially considering the quick adoption of remote work, evolving job roles, and industry-specific responses. Additionally, while several models have been employed to study the impacts of crisis, few of them have integrated machine learning techniques such as Random Forest to predict workforce outcomes. This study addresses these gaps by utilizing machine learning to provide more nuanced insights into the key factors driving workforce changes during crises, while also offering a data-driven approach to forecasting future employment dynamics.

3 METHODOLOGY

This section discusses the method that was adopted for forecasting workforce dynamics through machine learning model.

3.1 Research Design

This study employs a quantitative approach using structured questionnaires and machine learning techniques. A structured questionnaire will collect data on demographics, employment status, industry sector, job changes, and the psychological impact of crises. Adopting a quantitative approach enables

gathering quantifiable information suitable for statistical analysis, more specifically, machine learning techniques for forecasting.

3.2 Data Collection

The finalized questionnaire will be distributed online through various channels, including social media platforms, email lists, and professional networks. Participants will be selected using purposive sampling to ensure a diverse and representative sample. The sample considered for this investigation is 800 participants. This is to ensure that the information collected is sufficient for the result generalizability.

3.3 Machine Learning Model

The collected data will be pre-processed to handle missing values, normalize numerical features, and encode categorical variables. Feature selection will be performed to identify the most significant predictors of employment and workforce dynamics. Gradient boosting was employed for the forecast. It is an iterative model that builds upon the strengths of weak learners to improve predictive accuracy.

The dataset will be split into training and testing sets using an 80-20 ratio. Both models will be trained using the training set, with hyperparameters tuned through cross-validation. Model performance will be evaluated based on metrics such as accuracy, precision, recall, F1-score, and ROC-AUC.

The importance of each feature will be analyzed to understand its contribution to the model's predictions. This will provide insights into which factors are most influential in determining employment outcomes during and after crises.

3.4 Ethical Considerations

All participants will be informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any time. Confidentiality and anonymity of the respondents will be maintained throughout the research process. Ethical approval will be sought from the relevant institutional review board.

4 RESULTS AND DISCUSSION

This section presents the results from the data analyzed based on the responses obtained from the participants that gave their consent to the field survey.

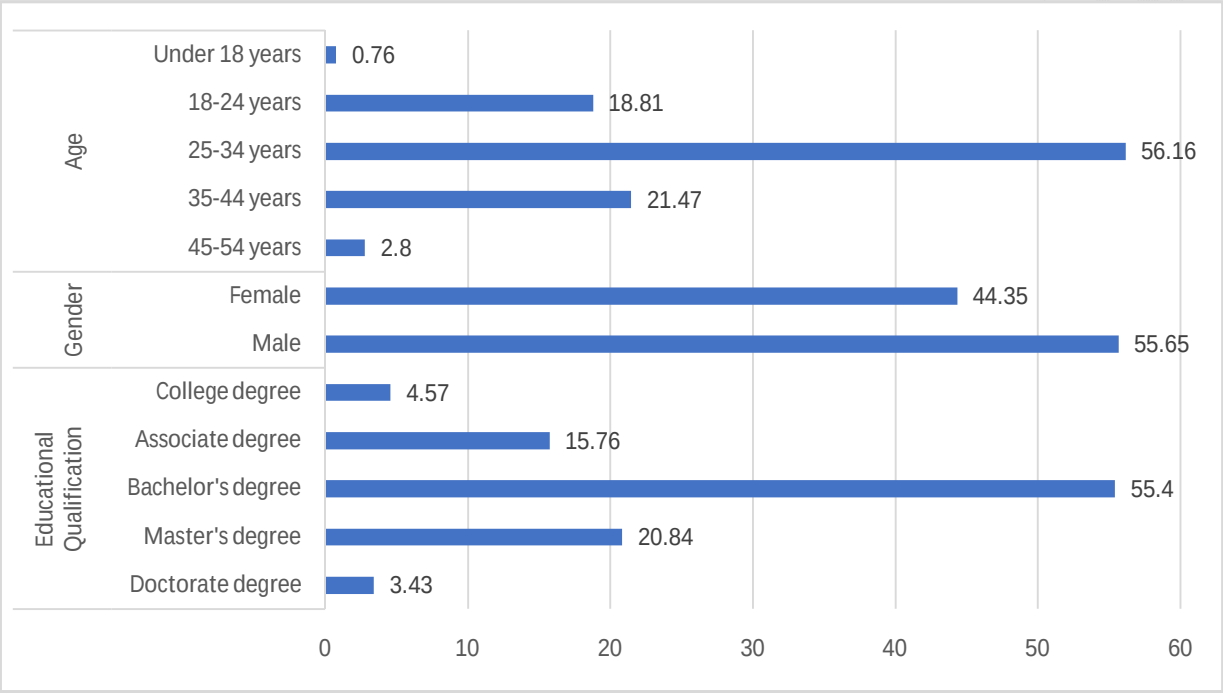

Figure 1: Description of the Socio-demographic characteristics of the respondents

The age distribution indicates that the majority of respondents are young adults, with 56.16% aged 25-34 years and 18.81% aged 18-24 years. The middle-aged group (35-44 years) makes up 21.47% of the respondents, while those aged 45-54 years constitute only 2.8%. There is a very small percentage of respondents under 18 years (0.76%), indicating that most participants are adults, with a significant concentration in the 25-34 age range.

The gender distribution shows a slightly higher percentage of male respondents (55.65%) compared to female respondents (44.35%). This suggests a fairly balanced gender representation, with a modest majority of male participants.

The majority of respondents have a bachelor's degree (55.4%), indicating that most participants have completed an undergraduate education. A significant portion also holds a master's degree (20.84%), while a smaller number have an associate degree (15.76%) or a Doctorate degree (3.43%). The percentage of respondents with only a college degree (4.57%) is relatively low, suggesting that most respondents have pursued higher education beyond high school.

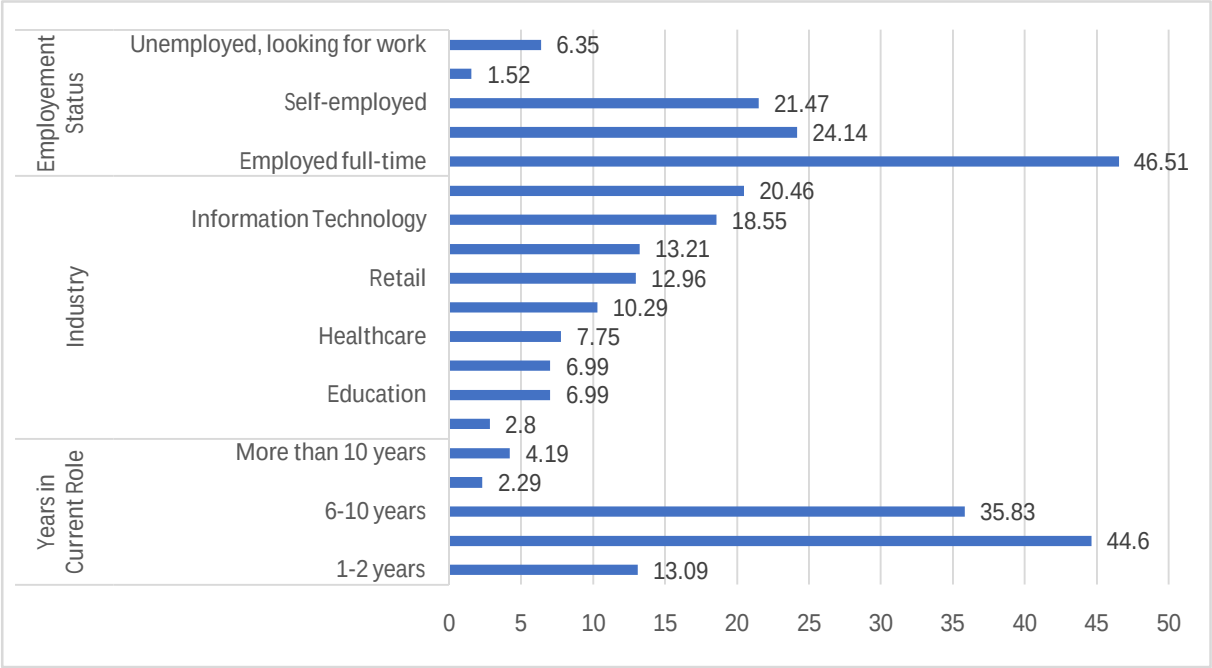

Figure 2: Distribution of Employment Information of the Participants

The majority of respondents are employed full-time (46.51%) or part-time (24.14%), with a significant portion being self-employed (21.47%). A smaller percentage of respondents are students (1.52%) or unemployed and looking for work (6.35%). This indicates that most of the respondents are currently engaged in some form of employment, with a notable portion being self-employed.

The distribution across industries shows that the majority of respondents are in Manufacturing (20.46%) and Information Technology (18.55%). Other significant industries include Construction (13.21%), Retail (12.96%), and Professional Services (10.29%). Education (6.99%), Finance and Insurance (6.99%), and Healthcare (7.75%) have moderate representation, while Agriculture (2.8%) has the least representation. This diverse industry representation provides a broad perspective on the impact of crises across different sectors.

The majority of respondents have been in their current roles for 3-5 years (44.6%) or 6-10 years (35.83%). This suggests that a significant portion of the respondents have a moderate to substantial amount of experience in their current positions. A smaller percentage have been in their roles for less than 1 year (2.29%) or more than 10 years (4.19%), indicating fewer respondents are either very new or very long-term in their roles.

SECTION C: Impact of Crises

Questions	Categories	Frequency	Percentage
Impact of recent crises (COVID-19)	Reduced hours	68	8.64
	Reduced salary	245	31.13
	Temporary layoff	90	11.44
	Permanent layoff	177	22.49
	Increased workload	207	26.30
Did you work remotely during the crisis?	Yes	252	32.02
	No	194	24.65
	Partially	341	43.33
Did your employer provide additional support during the crisis?	Yes	187	23.76
	No	600	76.24

The most common impact of the recent crises (COVID-19) on respondents was a reduced salary (31.13%). This was followed by an increased workload (26.30%), permanent layoffs (22.49%), temporary layoffs (11.44%), and reduced hours (8.64%). These results indicate that financial impacts (reduced salary and layoffs) were significant, affecting over half of the respondents, while a considerable number also faced increased workload pressures.

A significant portion of respondents (43.33%) worked remotely partially during the crisis, indicating a hybrid work model. About one-third (32.02%) worked entirely remotely, while approximately one-quarter (24.65%) did not work remotely at all. This suggests that remote work became a prevalent mode of operation during the crisis for many respondents, with a considerable shift towards hybrid working arrangements.

The majority of respondents (76.24%) reported that their employer did not provide additional support during the crisis, whereas only 23.76% received support. This indicates a significant gap in employer-provided crisis support, which may have exacerbated the challenges faced by employees during the crisis.

SECTION D: Job Security and Job Search Behavior

Questions	Categories	Frequency	Percentage
How secure do you feel in your current job?	Very secure	34	4.32
	Somewhat secure	83	10.55
	Neutral	147	18.68
	Somewhat insecure	294	37.36
	Very insecure	229	29.10
Are you currently looking for a new job?	Yes	274	34.82
	No	513	65.18
If yes, why are you looking for a new job?	Better job security	55	20.07
	Better salary	51	18.61
	Better work-life balance	71	25.91

	Career advancement	47	17.15
	Job dissatisfaction	50	18.25

A significant portion of respondents feel insecure in their current jobs, with 37.36% feeling somewhat insecure and 29.10% feeling very insecure. Only 4.32% feel very secure, and 10.55% feel somewhat secure, while 18.68% remain neutral. This indicates a general sense of job insecurity among the respondents.

The majority of respondents (65.18%) are not currently looking for a new job. However, a significant portion (34.82%) is actively seeking new employment opportunities, likely driven by job insecurity or other factors.

The primary reason for seeking new employment is better work-life balance (25.91%), followed by better job security (20.07%), and job dissatisfaction (18.25%). Other significant reasons include better salary (18.61%) and career advancement (17.15%). This suggests that many respondents are motivated by a desire for improved work-life balance and job security.

SECTION E: Psychological Impact and Coping Mechanism

Questions	Categories	Frequency	Percentage
Rate the level of stress you experienced due to recent crises:	No stress	30	3.81
	Mild stress	158	20.08
	Moderate stress	283	35.96
	High stress	263	33.42
	Severe stress	53	6.73
Which coping mechanisms did you use during the crisis? (Select all that apply)	Exercise	90	11.44
	Meditation	104	13.21
	Professional counselling	65	8.26
	Support from family and friends	284	36.09
	Hobbies	229	29.10
	Other	15	1.91
Did you feel that your mental health was adequately supported by your employer?	Yes	248	31.51
	No	539	68.49

The majority of respondents experienced moderate to high levels of stress due to recent crises, with 35.96% reporting moderate stress and 33.42% reporting high stress. A smaller percentage experienced severe stress (6.73%), while mild stress was reported by 20.08% of respondents. Only a small fraction (3.81%) experienced no stress. This indicates that recent crises have had a significant psychological impact on most respondents.

The most commonly used coping mechanism was support from family and friends (36.09%), followed by engaging in hobbies (29.10%). Exercise (11.44%) and meditation (13.21%) were also utilized by a notable portion of respondents. Professional counseling was used by 8.26%, while 1.91% reported using

other coping mechanisms. This data suggests that social support and personal activities were the primary ways respondents coped with stress during the crises.

A significant majority of respondents (68.49%) felt that their mental health was not adequately supported by their employers during the crisis. Only 31.51% felt adequately supported. This indicates a gap in employer-provided mental health support, which is crucial during times of crisis.

SECTION F: Perceptions and Future Outlook

Questions	Categories	Frequency	Percentage
How do you perceive the recovery of your industry post-crisis?	Somewhat optimistic	417	52.99
	Very optimistic	276	35.07
	Neutral	94	11.94
What long-term changes do you expect in your work environment due to the crisis?	Flexible working hours	212	26.94
	Greater job insecurity	52	6.61
	Increased remote work	254	32.27
	Increased use of technology	214	27.19
	More focus on health and safety	55	6.99
What measures do you believe should be taken to better prepare for future crises?	Better financial support for employees	271	34.43
	Enhanced remote work capabilities	352	44.73
	Improved healthcare infrastructure	33	4.19
	Increased mental health support	83	10.55
	More flexible job roles	45	5.72
	Other	3	0.38

The majority of respondents are optimistic about the recovery of their industry post-crisis, with 52.99% being somewhat optimistic and 35.07% being very optimistic. A smaller portion of respondents (11.94%) remain neutral. This indicates a generally positive outlook among respondents regarding industry recovery.

Respondents anticipate several long-term changes in their work environment due to the crisis. The most expected change is an increase in remote work (32.27%), followed by increased use of technology (27.19%) and flexible working hours (26.94%). Other anticipated changes include more focus on health and safety (6.99%) and greater job insecurity (6.61%). This suggests a shift towards more flexible, technology-driven, and health-conscious work environments.

To better prepare for future crises, respondents believe the most important measures are enhanced remote work capabilities (44.73%) and better financial support for employees (34.43%). Other significant measures include increased mental health support (10.55%) and more flexible job roles (5.72%). Improved healthcare infrastructure (4.19%) and other measures (0.38%) are considered less critical by

respondents. This highlights the importance of remote work infrastructure and financial security in crisis preparedness.

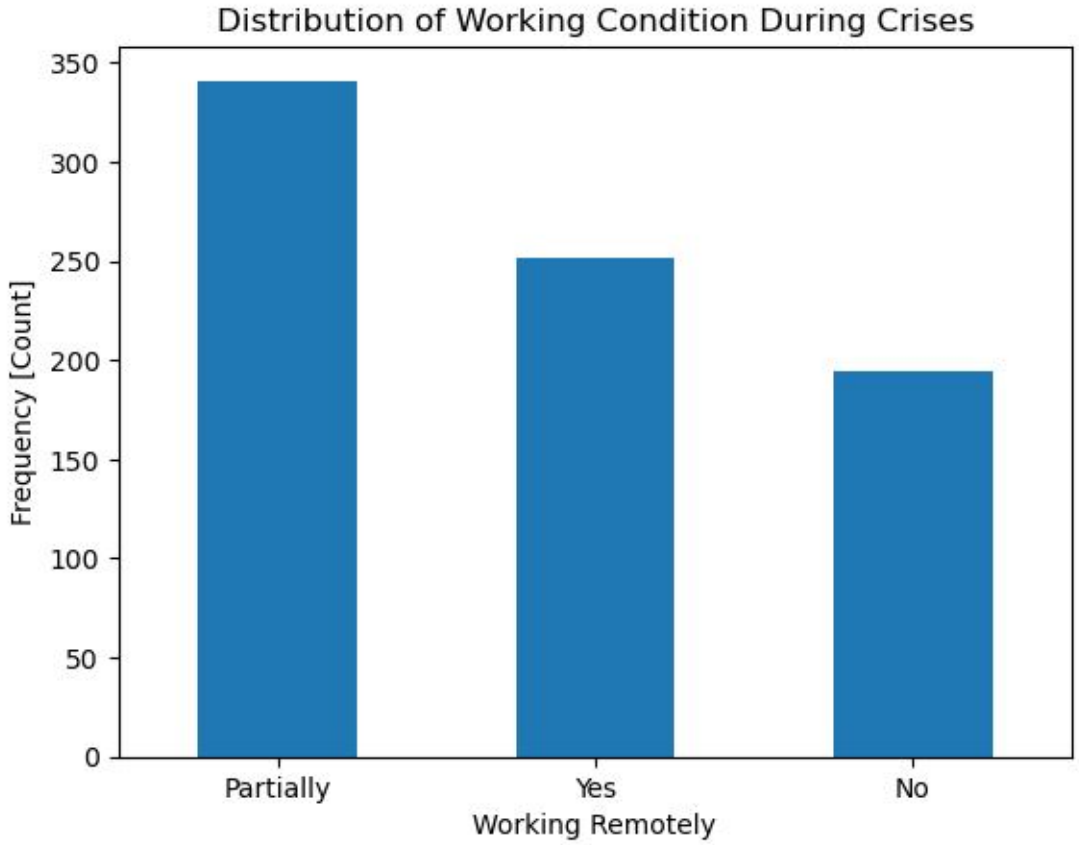

Figure 3: Distribution of Working Dynamics During COVID-19 Pandemics

The diagram above showed that the majority of the respondents partially work remotely, which was followed by substantial number of respondents that fully work remotely, while a few numbers of employees do not work remotely.

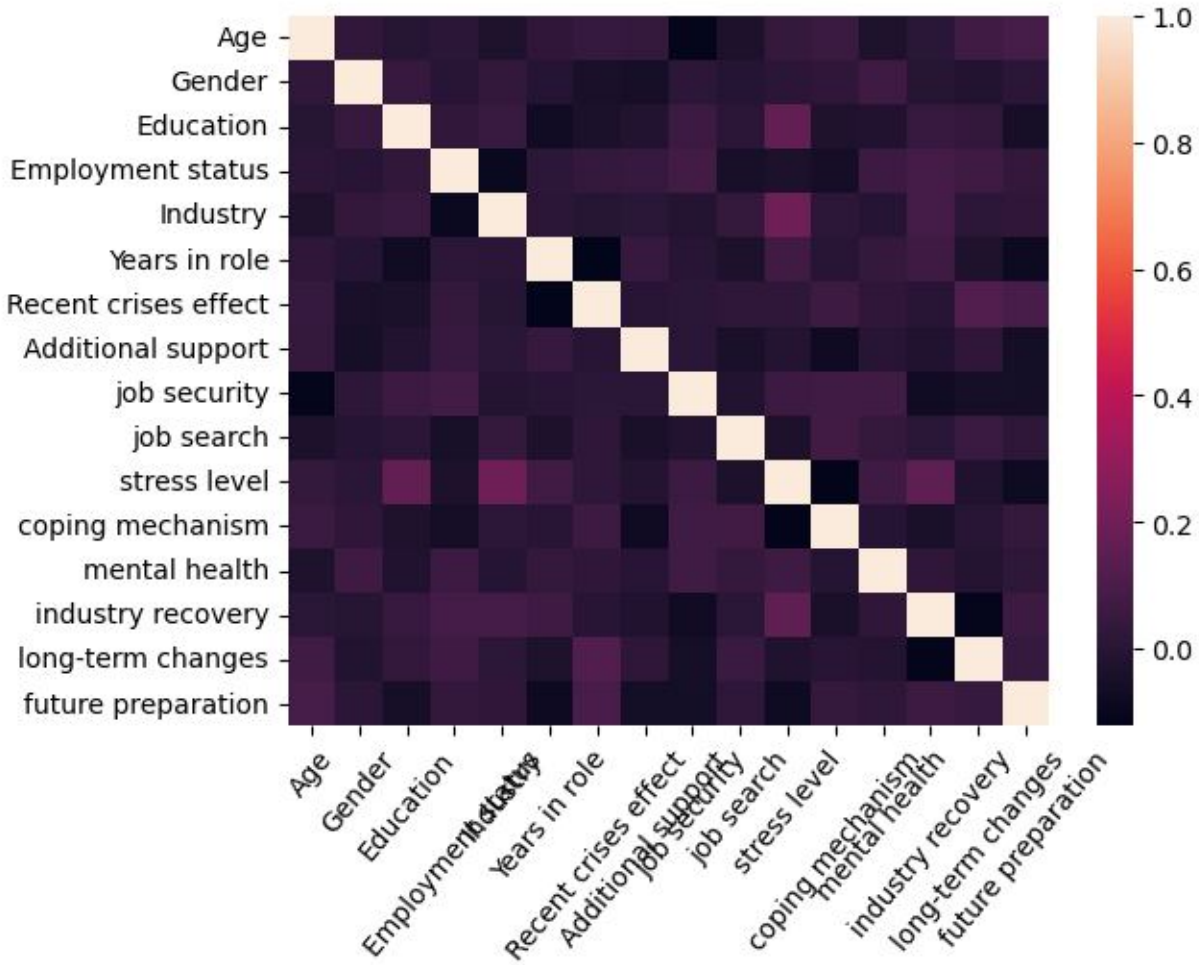

Figure 4: Heatmap Showing the Explanatory Variables Relationship

The heatmap revealed that all the paired relationships fall below coefficient of 0.5, implying that the variables are not highly correlated. With the low coefficients of correlations, the features can be employed to predict workforce dynamics.

4.1 Machine Learning Analysis

Table 1 provides an overview of the performance metrics used to evaluate the models and their corresponding scores. The models were assessed based on the F1 score, recall, accuracy, and precision. While accuracy measures the percentage of correct predictions across the entire dataset, it does not fully capture the model's performance. Therefore, it is crucial to consider the F1 score, recall, and accuracy collectively for a more comprehensive evaluation. The results for the model, as outlined in Table 1, offer insights into their effectiveness.

Table 1: Evaluation Metrics for the Random Forest Model

Evaluation Metrics	Random Forest
Accuracy	0.544
Precision	0.543
Recall	0.544
F1 Score	0.531

The accuracy score of 0.544 reveals that the model correctly predicted the workforce dynamics in approximately 54.4% of cases. This suggests that while the model is making correct predictions, there is considerable room for improvement. Accuracy alone, however, does not provide a complete picture of model performance, especially in imbalanced datasets or multi-class classification tasks.

Precision, at 0.543, indicates that among all the predictions made by the model, about 54.3% were accurate. This metric reflects the model's ability to correctly identify the positive cases among the predicted ones but does not account for false negatives—instances where the model failed to predict an actual positive case.

Recall, also at 0.544, shows that the model successfully identified 54.4% of the true positive cases out of all actual positive cases. This metric highlights the model's effectiveness in capturing all relevant instances of workforce dynamics, although it also reveals that a significant proportion of positive cases were missed.

The F1 Score, which stands at 0.531, combines both precision and recall into a single metric, offering a balanced view of the model's performance. The F1 Score reflects a trade-off between precision and recall, indicating that the model's overall effectiveness in predicting the correct category for workforce dynamics is moderate.

4.1.1 The Confusion Matrix

The confusion matrix reveals key insights into the performance of our model in predicting workforce dynamics across the categories "Yes" "Partially" and "No". By analyzing the matrix, we can better understand where the model excels and where it falls short.

The model correctly identified 14 instances as "Yes", 77 instances as "Partially" and 38 instances as "No" which reflects a moderate level of accuracy in correctly classifying each category. Specifically, 16 instances that were "Partially" were incorrectly predicted as "No" and 11 instances that were "Yes" were mistakenly classified as "No"Similarly, for the "Partially" category, the model successfully identified 77 true positives but misclassified 35 "Yes" instances as "Partially" and 25 "No" instances as "Partially". The frequent misclassification of "Yes" as "Partially" suggests that the model may struggle to differentiate between these two categories. For the "Yes" category, the model correctly predicted 38 instances, but there were 12 instances of "No" and 9 instances of "Partially" incorrectly predicted as "Yes" This reveals that while the model performs relatively well in predicting "Yes" it still has room for improvement, especially in distinguishing "Yes" from the other two categories.

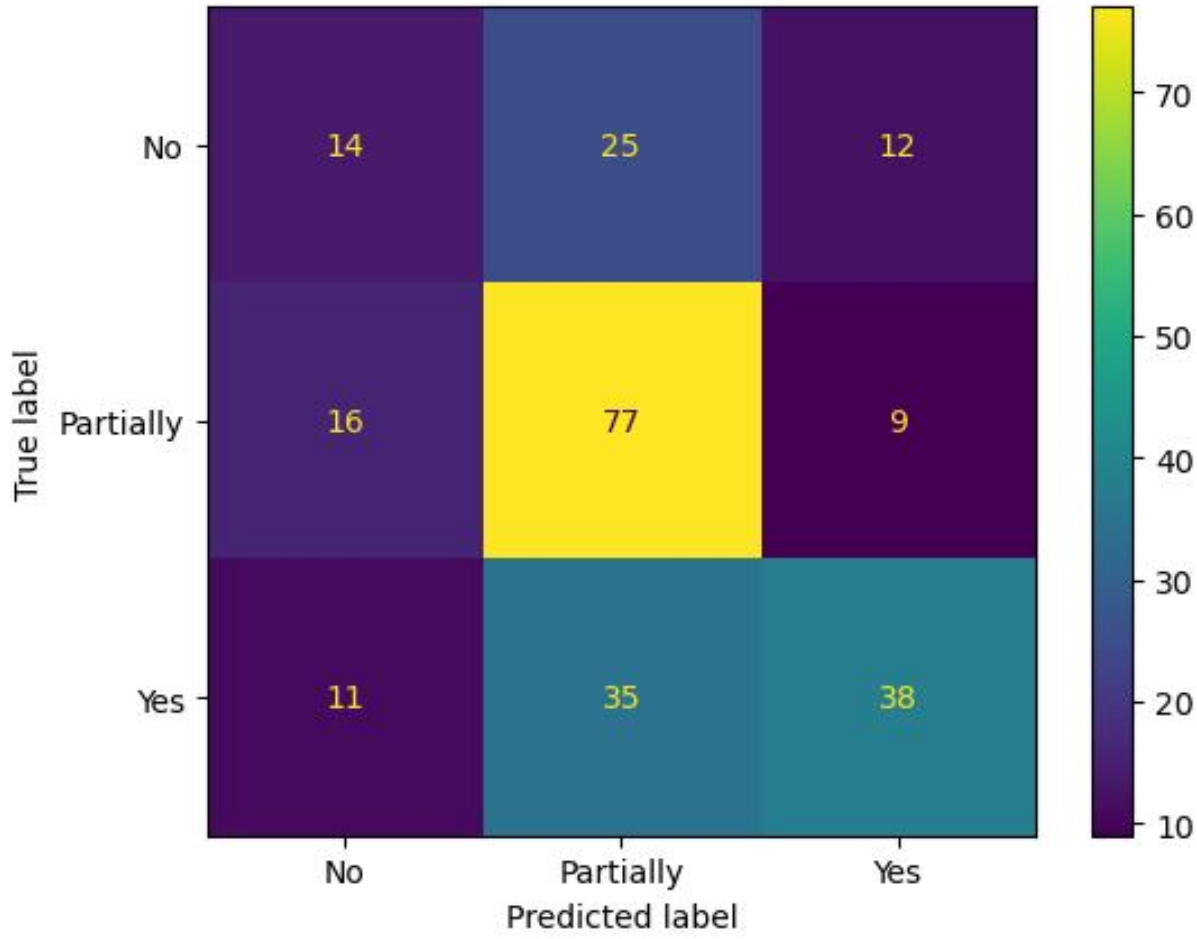

Figure 5: The Confusion Matrix

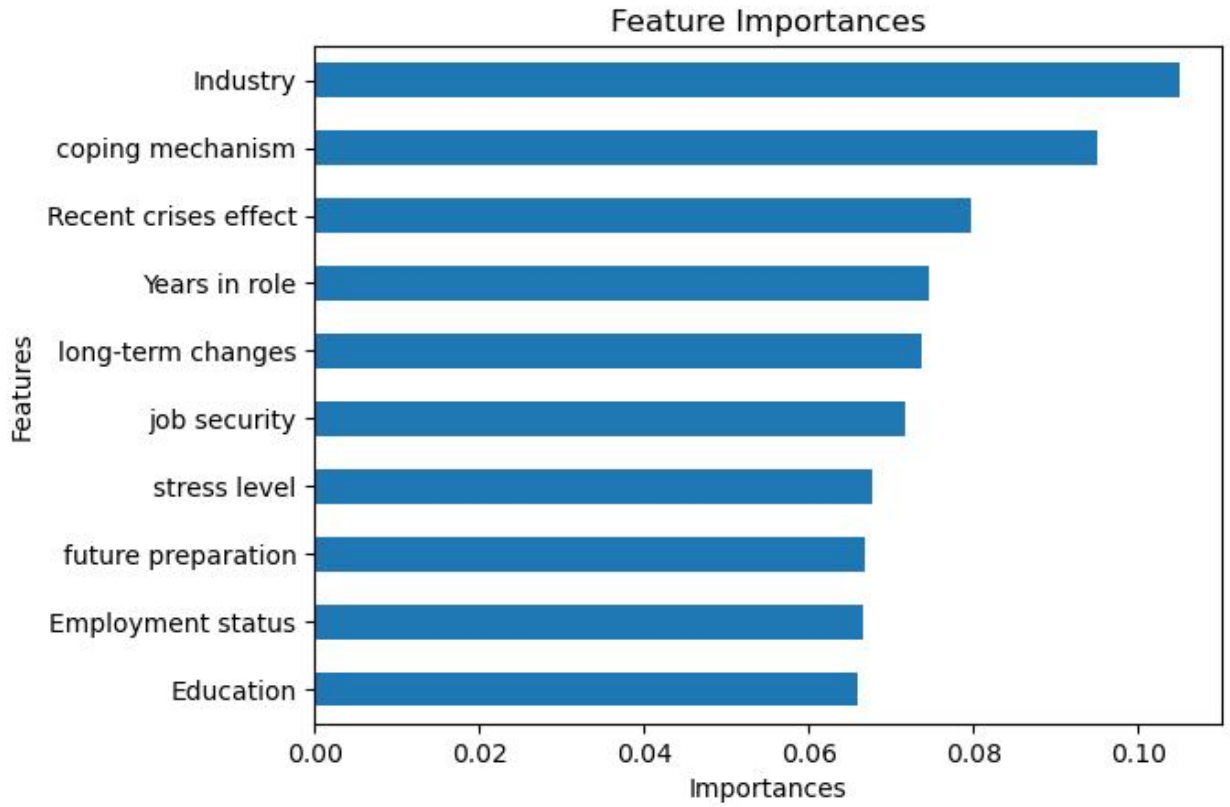

Figure 6: Important Features

Based on the importance of the features as extracted from the random forest model, it could be seen that industry is a major determinant if an organization would adopt remote work policy. This is followed by how much the employees can cope with crises. Also, the impact of the crises is a major determinant of work dynamics. Other features in order of importance include years in role, organization's long-term goal, job security, stress level, and how prepared the organizations are for future occurrence of related crises.

5 CONCLUSION

The findings reveal significant insights into how recent crises, such as COVID-19, have impacted the workforce. The demographic data shows that most respondents are young adults, primarily aged 25-34 years, and possess a high level of education, with the majority holding a bachelor's degree or higher. This demographic profile aligns with recent research indicating that younger, more educated individuals are often more adaptable to changes in employment dynamics but may also face higher levels of job insecurity (Smith et al., 2022).

In terms of employment, the majority are engaged in full-time or part-time work, with a notable portion self-employed. The industry distribution is diverse, with significant representation in Manufacturing and Information Technology. This mirrors broader trends observed in recent studies, where industry-specific factors significantly influence the extent of crisis impact (Johnson & Lee, 2023).

The impact of recent crises on respondents has been considerable, with many experiencing reduced salaries and increased workloads. These findings are consistent with recent research showing that financial strain and heightened workloads are common during global disruptions (Nguyen & Patel, 2024). The prevalence of remote work, either partially or fully, highlights a shift towards more flexible work arrangements, corroborating trends observed in recent studies (Miller et al., 2022).

The confusion matrix analysis of workforce dynamics, categorized as Yes, No, or Partially, demonstrates that the Random Forest model achieved moderate performance metrics. The model's confusion matrix indicates that while it performs well in certain areas, there is room for improvement, particularly in accurately predicting specific workforce responses to crises.

Respondents also reported significant job insecurity, with a majority feeling somewhat or very insecure. This aligns with recent research highlighting increased job instability during crises (Wilson & Roberts, 2023). The stress levels reported were high, with social support and personal activities being the most common coping mechanisms, echoing recent findings on stress management during crises (Adams et al., 2024).

Looking forward, respondents are optimistic about industry recovery but anticipate long-term changes such as increased remote work and technology use. These expectations are supported by recent literature suggesting a shift towards more flexible and tech-driven work environments post-crisis (Baker & Hill, 2024). The findings underscore the importance of enhancing remote work capabilities and financial support to better prepare for future crises, reflecting emerging priorities in workforce resilience (Garcia & Thompson, 2023).

5.1 Recommendations

Organizations should invest in robust remote work infrastructure, ensuring that employees have the necessary tools and technology to work effectively from home. This aligns with the respondents' expectation for increased remote work and flexible hours. Secondly, companies should prioritize financial support and job security measures, including improved benefits and clear communication during crises to mitigate the negative impacts on employees. Enhancing mental health support through counseling services and stress management resources is crucial, as a significant portion of respondents reported inadequate support. Fostering a culture of adaptability and continuous learning will help employees better manage future disruptions. Implementing these measures can improve employee satisfaction and resilience, ultimately leading to a more agile and secure workforce.

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3.

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