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Climate Adaptation and Job Creation:
Addressing the Climate and Livelihoods Crises in India

Anjana Thampi

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Anjana Thampi[2]

Abstract

India was seventh in a list of the ten most affected countries due to extreme weather events in 2019. A sharp increase in the frequency and intensity of such events in the country by the end of the twenty-first century is projected. At the same time, relatively high economic growth rates have not resulted in secure and sustainable employment opportunities in the Indian economy. The loss of millions of jobs due to climate hazards in the country is also projected. In this context, I raise two key questions. First, are livelihoods in certain regions within India more vulnerable to climatic changes? The priority regions for adaptation planning and intervention are identified by constructing a livelihoods vulnerability index. Second, can institutional climate adaptation activities simultaneously address the climate and livelihoods crises in the country? The job creation estimates through five representative adaptation activities support the need for increased spending in a climate adaptation programme. Spending 1.5 percent of the GDP on a climate adaptation programme could create jobs to the extent of 1.3 percent of the labour force as of 2017-18. Investing 3 percent of the GDP on a combined climate adaptation and mitigation programme over the same amount spent instead on a fossil fuel-based programme would lead to net employment gains of around 2 percent of the labour force. This paper argues that investing in climate adaptation activities can secure livelihoods while improving mechanisms to build resilience to climate hazards. Such activities, if planned and implemented in accordance with the geographies, vulnerabilities, and socio-economic patterns of each region, could be transformational.

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[2] Fulbright-Kalam postdoctoral fellow, Political Economy Research Institute, University of Massachusetts Amherst, and assistant professor, O. P. Jindal Global University, India

1 Introduction

The existential threat of climate change interacts deeply with the vulnerabilities associated with insecure livelihoods. Climatic changes and variability are estimated to lead to the loss of millions of jobs over the next few decades (ILO 2019). Conventional approaches to address either the ecological problem alone or the employment problem alone may not succeed and could even exacerbate the other problem (Forstater 2004). This paper assesses the potential of climate adaptation activities to simultaneously address the climate and livelihoods crises in India.

Across the world, climate change is being experienced through extreme weather events, rising sea levels, variability in monsoon rainfall, droughts, and their impacts on food and water security, health and nutrition, lives and livelihoods. Globally, a disaster related to a weather, climate, or water hazard occurred every day on average between 1970 and 2019 and caused damages worth USD 3.64 trillion (WMO 2021). Some parts of the world will experience greater warming than others (Krishnan, et al. 2021), and the worst affected by the effects of global warming are poor countries and poor people across countries (Boyce 2019, Chancel, Bothe and Voituriez 2023). For instance, 91 percent of the deaths due to weather, climate, and water hazards occurred in developing economies (WMO 2021).

Although low-income countries tend to be most vulnerable, government-led adaptation interventions are predominantly in wealthy countries (Araos, et al. 2016). The world is at danger of descending into ‘adaptation apartheid’, where well-off residents of rich countries are temporarily protected from the effects of climate change while the poorest and most vulnerable are left to fend for themselves (Tutu 2007). Tutu (2007) powerfully argued in favour of bringing climate change adaptation to the heart of the international poverty agenda. In the same spirit, this paper links climate adaptation to supporting job creation and livelihoods in India.

India was seventh in a list of the ten most affected countries due to extreme weather events in 2019 (Eckstein, Künzel and Schäfer 2021). Between 1970 and 2021, there were 434 recorded disasters in India that affected 2.3 billion people and caused damages of around USD 140 billion (ESCAP 2023). By the end of the 21st century, a sharp increase in the frequency and duration of heat waves and in the variability of monsoon rainfall are projected under a trajectory of intermediate carbon emissions

(Krishnan, et al. 2021). The total average annual loss (AAL)[i] from cascading climate risks for India is estimated at 4.8 percent of GDP under the moderate climate change scenario (Representative Concentration Pathway or RCP 4.5) and 8.1 percent of GDP under the worst-case climate change scenario (RCP8.5) (ESCAP 2022). The adverse effects of climate-induced natural disasters on productive assets tend to persist for long, particularly among households with low wealth (Dercon 2004, Carter, et al. 2007).

At the same time, despite relatively high rates of economic growth, a livelihoods crisis has been building in the Indian economy for several years and compounded during the Covid-19 pandemic (Anand and Thampi 2021). Cultivators and workers have had to contend with low rates of growth of agricultural output and inadequate generation of employment opportunities (Binswanger-Mkhize 2013, Rao and Vakulabharanam 2019). Around 80 to 90 percent of the workforce is informally employed with insecure employment, low wages, and poor working conditions.

Multiple climate change hazards may overlap or follow in close succession, and each of them compound the impact on lives and livelihoods. Erratic rainfall in regions that earlier had steady rainfall patterns has resulted in severe losses for cultivators in different parts of India (Hardikar 2019, Sainath 2019). The loss of income from the reduction in working hours due to extreme heat in India in 2021 was estimated at 5.4 percent of the GDP (Climate Transparency 2022). Such effects are expected to compound in the future. For instance, the equivalent of 34 million full-time jobs could be lost in India by 2030 due to the increase in the frequency and intensity of heat stress (ILO 2019).

I raise two key questions in this paper. First, are livelihoods in certain regions within India more vulnerable to changes in climate? Within countries, climate change impacts vary across space and time (Dasgupta, et al. 2021). The spatial variability in the vulnerability of livelihoods to climatic changes is assessed through a constructed index. Second, can institutional climate adaptation activities simultaneously address the climate and livelihoods crises in the country? The jobs generated through five representative adaptation activities addressing different climate hazards are estimated. Forecasted climatic changes are linked with potential adaptation activities and associated employment generation.

Through this paper, I contribute to the literature on climate adaptation and livelihoods as follows. First, the most vulnerable regions in the country in terms of livelihoods and climatic changes are identified for adaptation planning and intervention. Second, potential adaptation activities are listed and mapped to various climate hazards and associated risks. Third, job creation through representative adaptation activities is estimated, and the estimates support the hypothesis that increased spending in climate adaptation activities can contribute towards addressing the climate and livelihoods crises in India.

Section 2 of the paper covers a brief overview of forecasted climate changes in India and the relevant literature on climate adaptation and job creation. The data and methodology used are described in Section 3. In Section 4, a livelihoods vulnerability index is constructed to identify the most vulnerable regions in the country. Section 5 lists adaptation activities mapped to different climate hazards or risks and estimates job creation through investments in representative adaptation activities. Section 6 discusses the findings of the paper, and Section 7 concludes.

2 Background

2.1 Forecasted climatic changes over India

A review of forecasted climatic changes would be useful to identify key climate hazards for India, and to list and map potential adaptation activities to each hazard. Under the intermediate carbon emissions trajectory of RCP4.5, climate models predict an average rise in temperature of 2.3°C for the Indian region by the middle of the century (2040–2069) over the pre-industrial period (Dhara and Koll 2021). More frequent heat waves of longer duration, higher intensity, and greater spatial coverage are also predicted (Im, Pal and Eltahir 2017, Sanjay, et al. 2020). Higher warming is projected in the north and northwestern parts of the country (Sanjay, et al. 2020).

Changes in rainfall patterns are a key area of concern in India, with livelihoods predominantly dependent on the agricultural sector. Climate models largely predict a rise in the variability in the quantum of monsoon rainfall and in extreme rainfall events between longer dry periods (Dhara and Koll 2021). The sea level along the Indian coast is projected to rise by 20–30 cm by the end of the twenty-first century under RCP4.5 (Swapna, et al. 2020). Tropical cyclones pose a constant threat to states on the eastern coast such as Odisha, Andhra Pradesh, and Tamil Nadu (Vellore, et al. 2020).

Droughts and floods have increased in frequency since the middle of the twentieth century and are projected to increase further (Mujumdar, et al. 2020). In particular, the frequency of droughts is projected to increase in the central and northern parts of India, and the frequency of floods is projected to increase in southern peninsular India, and the Ganges and Brahmaputra basins (Mujumdar, et al. 2020).

Based on such forecasts and past climate-related hazards, a list of climate hazards and associated risks was compiled. The list includes the following broad heads: storms and flooding; extreme wind; heatwave; drought; soil erosion; coastal protection; land degradation; water degradation; groundwater depletion; shortage of essentials; livestock damage; financial loss or loss of property; biodiversity loss; and loss of livelihoods. Potential adaptation activities for each hazard or risk were then identified.

2.2 Climate adaptation and job creation

Current responses to climatic risks do not necessarily build adaptive capacity for the future and could even be maladaptive (Singh, et al. 2018). The most common type of adaptation responses are behavioural or cultural in nature, and institutional responses are a minority (Berrang-Ford, et al. 2021, Simpson, et al. 2023). In India, institutional responses include heat action plans at sub-national levels. Of 37 heat action plans, only two conducted vulnerability assessments and the plans do not always consider vulnerable groups (Pillai and Dalal 2023). Other institutional responses in India include the National Action Plan on Climate Change (NAPCC) 2008 and the National Adaptation Fund for Climate Change.

The NAPCC has been described as “simultaneously significant and hollow”, as it linked development and climate but without a long-term vision (Pillai and Dubash 2021, S99). With respect to mitigation, the targets for emissions reduction cannot be achieved if economies such as India continue on growth trajectories that are powered by fossil fuels consumption (Pollin and Chakraborty 2015). At the same time, rich countries have greater responsibilities to reduce emissions and higher capabilities to finance mitigation investments (Chomsky and Pollin 2020, Pachauri, et al. 2022, Semieniuk, Ghosh and Folbre 2023). Countries across different levels of development would experience significant net gains in job creation with a transition from fossil fuel to clean energy investments (Pollin, Garrett-Peltier, et al. 2015). Such a transition in India is estimated to result in net gains in the range of 4.8 million–6.3 million jobs or 1–1.3 percent of the labour force in 2015 (Pollin and Chakraborty 2015, Azad and Chakraborty 2018). This paper assesses whether climate adaptation activities could also result in job creation in India.

The NAPCC emphasised a ‘development first’ approach with a focus on the climate co-benefits of developmental policies (Government of India 2008). Instead, a preferable strategy would be one that simultaneously achieves multiple objectives. This paper puts forward a strategy to simultaneously address the climate and livelihoods crises in India through a combined climate adaptation and mitigation programme.

3 Data and methodology

The spatial variability in vulnerability was identified by constructing a livelihoods vulnerability index (LVI) for regions in India. The calculation of the index used the Periodic Labour Force Survey (PLFS) 2021-22, All India Debt and Investment Survey (AIDIS) 2019, and Situation Assessment Survey and Land and Livestock Holdings (SAS–LHS) of Agricultural Households 2019. As the PLFS is representative only at the NSS region level (and not at the district level), the indicators were estimated at the region level. Maps were plotted by assigning the LVI of a region to all the districts in the region.

The index combines the following indicators: informal non-agricultural employment; absence of owned land; sectors that are heavily reliant on natural resources; population share of historically marginalised communities; gendered labour relations; irrigated agricultural land; reliance on groundwater for irrigation; and loss of crop due to climate hazards. The last three indicators are only included in the rural index. The rural LVI includes eight indicators and the urban LVI includes five. The selection of indicators and associated variables are discussed in section 4.

All indicators, except one, are assessed to be positively related to vulnerability of livelihoods, that is, vulnerability increases with a rise in the value of each indicator. As such, the value of each indicator was normalised by subtracting the minimum value[ii] from it and dividing by the range:

$$NI_{ir} = \frac{I_{ir} - Min_r\{I_{ir}\}}{Max_r\{I_{ir}\} - Min_r\{I_{ir}\}}$$

Here, NI_{ir} is the normalised value of indicator i in NSS region r,

I_{ir} is the actual value of indicator i in region r,

$Min_r\{I_{ir}\}$ is the minimum value of indicator i across all regions,

and $Max_r\{I_{ir}\}$ is the maximum value of indicator i across all regions.

As the indicator on irrigated agricultural land is inversely related to livelihoods vulnerability, it was normalised as follows:

$$NI_{ir} = \frac{Max_r\{I_{ir}\} - I_{ir}}{Max_r\{I_{ir}\} - Min_r\{I_{ir}\}}$$

The indicator values were normalised separately for rural and urban areas. The rural/ urban LVI of a region was calculated by averaging the normalised values of all indicators. That is,

$$LVI_r = \frac{\sum_{i=1}^{n} NI_{ir}}{n}$$

LVI_r is the livelihoods vulnerability index of NSS region r,

and n is the number of indicators.

Following the regional vulnerability assessment, potential adaptation activities to address these vulnerabilities were listed and mapped to climate hazards and associated risks. Adaptation responses were identified using various sources – in particular, Ministry of Rural Development (2005); National Disaster Management Authority (NDMA), Government of India (2018); Pillai and Dalal (2023); Patra (2016); National Bank for Agriculture and Rural Development (NABARD), Government of India (2015); Scottish Natural Heritage (2000); Linham and Nicholls (2010); and Department of City Planning, City of New York (2013).

Five adaptation activities were selected from the list, each addressing different climate hazards. The selected activities are safe houses (disasters); cooling centres or winter shelters[iii] (heatwaves/ extreme cold); seawalls (coastal protection); water storage reservoirs (droughts); and constructed or restored wetlands and mangroves (flooding). For estimating the job creation through these adaptation activities, the 2018 input–output table (IOT) for India from the OECD database (2021 edition) was used along with the PLFS 2017-18. The PLFS is a nationally representative employment survey, conducted by the Ministry of Labour and Employment, that collects information on usual activity status, industry, and occupation of each member of the sampled household.

A brief description of the methodology to estimate job creation through the input-output framework follows. The overview is based on Miller and Blair (2022) and earlier studies of climate mitigation activities. Input-output tables show the flows of products between industries during a given time period, where each industry is listed as both a seller and a buyer. Input-output coefficients a_{ij} represent the value of the inputs from industry i per unit value of output of industry j:

$$a_{ij} = \frac{z_{ij}}{x_j}$$

where x_j denotes the total output of industry j, and z_{ij} denotes the monetary values of inter-industry sales by industry i to all industries j, including itself. For the time period under consideration, the input-output coefficients are fixed – that is, the input-output framework assumes constant returns to scale.

$(\mathrm{I} - \mathrm{A})^{-1}$ is the Leontief inverse matrix, where A is the matrix of input-output coefficients. Multiplying the employment-output coefficients of industries (workers per unit of output in each industry) with the Leontief inverse matrix gives the simple employment multipliers. The direct jobs generated through stimulating economic activity in the same industry and the indirect jobs generated through stimulating demand in other industries supplying intermediate inputs can then be estimated.

To operationalise this methodology, the work participation rates, disaggregated by sector and sex and estimated using PLFS data, were multiplied with the population projections of the Technical Group on Population Projections (2020). The population was estimated for the mid-point of the reference period. That is, for the survey year 2017-18, the reference period for the usual status of employment was 1 July 2016 to 1 June 2018, and the population was estimated for June 2017. The PLFS data was also used to identify the distribution of the workforce across different industries. The shares of the workforce were multiplied by the projected population to reach the number of workers across industries. The employment-output ratios were then calculated using the estimated number of workers and the output of each industry in the IOT. The sectors in the IOT were matched to the industries in the PLFS survey as in Appendix Table A3.

After estimating the direct and indirect jobs corresponding to each industry, weights were assigned to industries supplying inputs according to their relative importance in costs for each activity. For climate mitigation activities, the weights were assigned to industries as in Azad and Chakraborty (2023). For climate adaptation activities, the weights used are listed in Appendix Table A4 and were based on the following sources: FEMA (2008); NABARD (2015); Hudson, Keating and Pettit (2015); Multi-Hazard Mitigation Council (2019); and the costing spreadsheet tool of the Environment Agency, UK Government. The number of jobs created is estimated under the assumption that the total amount invested is equally divided between the five selected adaptation activities.

4 Regional vulnerability assessment

The first question raised in this paper is on spatial variability in the vulnerability of livelihoods to climatic changes. Vulnerabilities interact, intersect, and compound, spatially and temporally. Effectively addressing the climate and livelihoods crises calls for an assessment of regional and socio-economic variations in vulnerability to identify priority regions for adaptation action.

A climate vulnerability assessment was conducted by state governments with the objective of informing adaptation interventions (Dasgupta, et al. 2021). The vulnerability index in the report included indicators relating to reliance on the agricultural sector and natural resources, employment, infrastructure, and health care (Dasgupta, et al. 2021). By this assessment, the states most vulnerable to climatic changes tend to lie in the eastern regions of the country, and several districts in Assam, Bihar, and Jharkhand are highly vulnerable (Dasgupta, et al. 2021).

Vulnerability can also be defined in terms of five interlinked components that capture exposure to risk from natural hazards: strength and resilience of livelihoods; well-being; self-protection; and social protection and governance; of which the first is considered a key component of vulnerability (Cannon 2008). This could be why adaptation responses to extreme heat are focussed on agriculture and livelihoods in developing economies (Turek-Hankins, et al. 2021). Insecurity and precarity of livelihoods influence and are in turn influenced by the extent to which human societies are exposed to and affected by extreme events and climate variability. I construct a regional livelihoods vulnerability index (LVI) using a set of socio-economic indicators that capture the intersections between livelihoods, climatic changes, and socio-economic characteristics. This index represents the extent to which livelihoods are likely to be affected by climate hazards.

4.1 Livelihoods vulnerability index

Vulnerability of livelihoods is represented through indicators of sensitivity or susceptibility to harm and capacity to adapt, in accordance with the IPCC (2022) definition of vulnerability. A contextual vulnerability approach is used, in that vulnerability to climate change is considered to be influenced not only by biophysical changes, but also by dynamic social, economic, political, institutional, and technological processes and structures (O'Brien, et al. 2007, Bassett and Fogelman 2013).

The ability to adapt is shaped by social divisions such as gender, caste, class, race, age, or disability (Vincent, et al. 2014, Pearse 2017, Rao, Lawson, et al. 2019). Social and spatial characteristics are relevant for addressing livelihoods vulnerability, for instance, of communities residing in the Eastern Himalayan region and in the Gangetic plains in India (Singh, et al. 2017, Das, et al. 2020). Adaptation can be transformative, and not merely technical, by changing underlying inequalities in socio-political relations that reproduce vulnerabilities (Pelling, O'Brien and Matyas 2015, Eriksen, et al. 2021). Putting marginalised groups at the centre of adaptation planning is therefore crucial (Eriksen, et al. 2021). Without explicitly accounting for socio-economic inequalities, adaptation measures could be ineffective or even maladaptive (Schipper, et al. 2020).

As such, the indicators of the LVI are motivated by the sustainable livelihoods framework, as reformulated by Natarajan, et al. (2022). The revised framework includes considerations of politics, relations, climatic and environmental changes, and global finance (Natarajan, et al. 2022). The components of the LVI have been selected to represent certain dimensions of the framework using indicator variables captured in household sample surveys. The indicators are listed below with the corresponding dimension of the framework in square brackets:

1. Informal non-agricultural employment [as an indicator of livelihood characteristics, vulnerability, and opportunity]: the proportion of workers that are informally employed in the non-agricultural sector. Here, informally employed workers include all self-employed and casual workers, as well as regular workers without a written job contract or social security benefits.
2. Absence of owned land [physical assets]: the proportion of households that do not own land. This indicates the capacity to adapt of households through fall-back earning opportunities and livelihoods diversification.
3. Sectors that are heavily reliant on natural resources [climate and environmental context and relations]: the proportion of workers employed in agriculture, forestry, fishing, mining, or quarrying. This indicator represents susceptibility to harm in terms of exposure to outdoor conditions as well as the possible severity of damages to livelihoods due to extreme events.
4. Marginalised communities in the population [relational power (human, social, political)]: population share of the Scheduled Castes (SC) and Scheduled Tribes (ST) in the region. These communities tend to be more vulnerable to climate variability due to their relative poverty and reliance on natural resources for subsistence and livelihoods (Sharma, Reddy and Sahu 2014, Jha, et al. 2017).
5. Gendered relations in labour [relational power (human, social, political)]: the proportion of women that are primarily engaged in unpaid domestic work. Women are disproportionately affected by climatic changes, and the social organisation of reproductive and productive labour of women shapes their disproportionate vulnerability to climate risks (Pearse 2017). Environmental degradation and hazards could decrease access to resources such as water and increase the burden of unpaid household labour on women, particularly in households that rely on farming or agricultural labour (Venkatasubramanian and Ramnarain 2018, Rao, Prakash, et al. 2021). Increased burden of domestic labour could also constrain women's participation in paid work and reduce further their capacity to adapt to climatic changes.[iv]
6. Irrigated agricultural land [livelihood characteristics, vulnerability, and opportunity]: the proportion of plots of agricultural land that are irrigated. Only this indicator among the selected ones is inversely related to livelihoods vulnerability. Cultivators of rainfed agricultural land are likely to be more

vulnerable to climatic changes, with the forecasted rise in the variability of rainfall patterns. This indicator is relevant for rural agricultural households and is only included in the rural index.

7. Reliance on groundwater for irrigation [livelihood characteristics, vulnerability, and opportunity]: the proportion of irrigated agricultural land for which groundwater is a primary source of irrigation. Cultivators reliant on groundwater for irrigation face the difficulties associated with the depletion of the groundwater table. This indicator is only included in the rural index.
8. Loss of crop due to climate-related hazards [climate and environmental context and relations]: the proportion of crop loss (without receipt of insurance claim)[v] due to drought, flood, or natural disasters in the region. Non-receipt of insurance claim is included to indicate differential experiences of crop loss. As with indicators 6 and 7, this indicator is also only included in the rural index.

These indicators are computed and normalised for all regions (as per the National Sample Survey classification), separately for rural and urban regions.

The ranking by the vulnerability index identifies the priority regions for policy action (Figure 1 and Table A1). As the data is available at the level of NSS regions, maps are plotted by assigning the LVI of a region to all districts in the region. The range of the rural LVI is 0.21–0.68 and the range of the urban LVI is 0.24–0.54. The index is a relative measure, and it cannot be inferred that regions with low indices have low vulnerability in absolute terms.

By the LVI, the rural regions that face the highest vulnerability of livelihoods with climatic changes include the following:

i. Western and southern Rajasthan (western dry region/ central plateau and hills)
ii. Inland northern Maharashtra (western plateau and hills)
iii. Northern Chhattisgarh (eastern plateau and hills)
iv. Kachchh region, Gujarat (Gujarat plains and hills)
v. Ranchi plateau, Jharkhand (eastern plateau and hills)

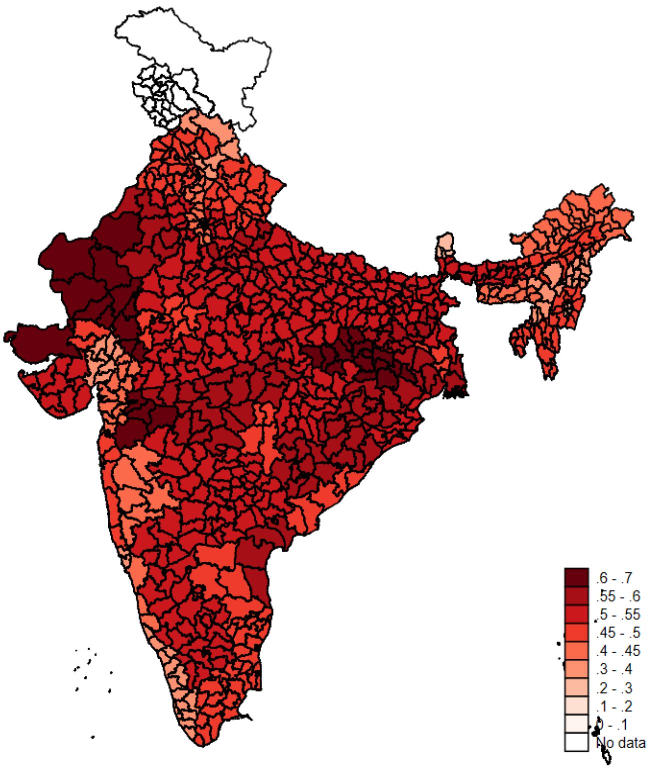
The agro-climatic zone of each region is included in brackets. The zone reflects the biophysical environment, and the regions in an agro-climatic zone have relatively homogeneous agro-climatic conditions.

The most vulnerable urban regions (Figure 2 and Table A1) include:

i. Northern Chhattisgarh (eastern plateau and hills)
ii. Northern Odisha (eastern plateau and hills)
iii. Southern upper Ganga plains, Uttar Pradesh (upper Gangetic plains)
iv. Inland northeastern Telangana (southern plateau and hills)
v. Northern Rajasthan (Trans-Gangetic plains/ western dry region)

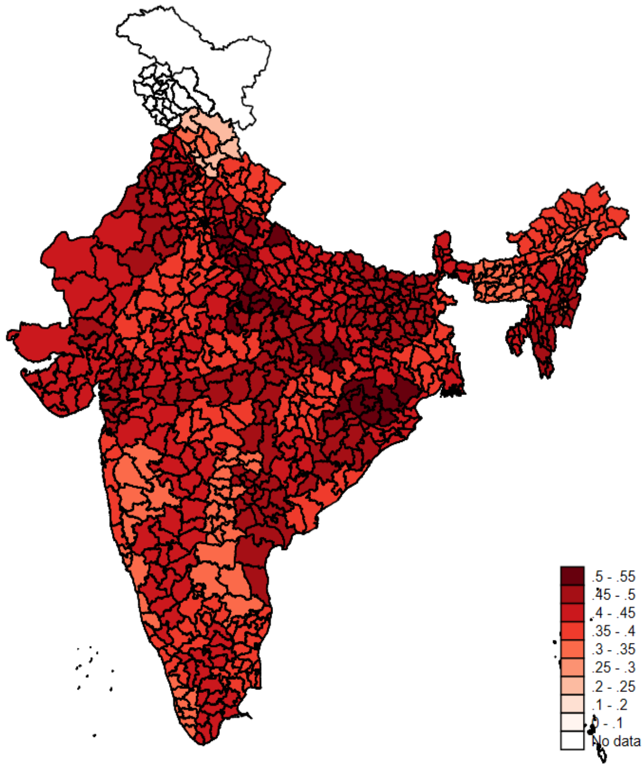
Thus, regions across different states and parts of the country and varying agro-climatic characteristics (plains/ plateau/ hills, Gangetic plains/ dry regions) are highly vulnerable to the climate and livelihoods crises.

Figure 1: Rural livelihoods vulnerability index



Source: Computed using PLFS 2021-22, AIDIS 2019, and SAS-LHS 2019
Union territories (except Delhi) have not been included in the calculation of the index.

Figure 2: Urban livelihoods vulnerability index



Source: Computed using PLFS 2021-22, AIDIS 2019, and SAS-LHS 2019
Union territories (except Delhi) have not been included in the calculation of the index.

5 Climate adaptation

With vulnerable livelihoods across biophysical environments and geographical regions, the second question raised in the paper addresses whether institutional climate adaptation activities can contribute towards addressing these vulnerabilities. Various adaptation interventions were listed and mapped to climate hazards. Five representative activities that address different climate hazards were then selected and the number of jobs created through investing in these activities was estimated.

5.1 Listing and mapping adaptation activities

Climate hazards and associated risks were listed on the basis of the forecasted climatic changes over India (reviewed in section 2.1). The list includes storms and flooding, extreme wind, heat wave, drought, soil erosion, coastal protection, land or water degradation, groundwater depletion, shortage of essentials, damages to livestock, financial loss or loss of property, harm to biodiversity, and loss of livelihoods. Appendix Table A2 lists the possible adaptation activities that can be used to address each climate hazard or risk. Just as climate change hazards overlap or follow each other and compound impacts, climate change solutions can also address multiple climate risks (Dhara and Koll 2021). The list in Appendix Table A2 reinforces this point – several activities are mapped to multiple hazards or risks. For instance, restoring wetlands can address storms and flooding, sea level rise, water degradation, groundwater depletion, and loss of biodiversity. Certain activities, such as sustainable agroforestry, can also perform the functions of both climate adaptation and mitigation.

5.2 Job creation through adaptation activities

To estimate the jobs generated through climate adaptation, five activities were selected from the list compiled in section 5.1. These activities are responses to different climate hazards and include safe houses for disasters, cooling centres or winter shelters for extreme heat or cold, seawalls for coastal protection, water storage reservoirs for droughts, and constructed or restored wetlands and mangroves for flooding. The selected activities also broadly align with the five priority adaptation measures highlighted by the Global Commission on Adaptation (The Global Commission on Adaptation 2019). For India, the order of priority based on estimated average annual losses is strengthening early warning systems, building new resilient infrastructure (score of 5 each), resilient water resources management, improving dryland agriculture crop production (score of 4 each), and protecting mangroves or nature-based solutions (score of 1) (ESCAP 2023).

The jobs created through the five representative adaptation activities were estimated using input-output analysis. For instance, take the case of safe houses that can be used for disaster management. The Multi-Hazard Mitigation Council estimated the job creation in different sectors through increase in demand for structural materials needed to exceed the design requirements for earthquake shelters in the United

States (Multi-Hazard Mitigation Council 2019). In the absence of similar data for India, the proportions estimated for different sectors were used as weights to estimate job creation through investments in safe houses. The industries identified were mining and quarrying, wood and wood products, metal products, construction, and repair and installation of machinery and equipment, and the respective weights assigned to these industries are listed in Appendix Table A4. Using these weights, the increase in output, and therefore employment, in different industries by building more safe houses was estimated. Investing USD 1 million in safe houses creates around 177 jobs, that is, 96 direct jobs and 81 indirect jobs (Table 1).

The exercise was similar for cooling centres or winter shelters, sea walls, water storage reservoirs, and constructed wetlands. Adaptation responses to the projected increase in the frequency and intensity of heat waves could include constructing cooling centres, structures for water storage, and retrofitting buildings (Table A2). Spending USD 1 million on cooling centres is estimated to create around 157 jobs, of which 100 are direct and 57 are indirect jobs (Table 1). In response to the projected rise in sea level along the Indian coast, using the same amount to construct sea walls could generate 136 jobs. Restoring wetlands or mangroves for floods and constructing water storage reservoirs for droughts and other extreme weather events, with investments of USD 1 million each, are estimated to generate around 83 jobs and 99 jobs, respectively. Investing USD 1 million, equally divided between these five representative climate adaptation activities, is estimated to generate around 130 jobs, of which 70 are direct and 60 are indirect jobs.

Table 1: Job creation with investments of USD 1 million in climate adaptation

	Direct	**Indirect**	**Total**
A. Safe houses	96.3	80.5	176.9
B. Cooling centres/ winter shelters	100.4	56.6	157.0
C. Seawalls	73.0	62.8	135.8
D. Water storage reservoirs	43.2	55.6	98.7
E. Constructed/ restored wetlands or mangroves	36.3	46.9	83.2
Climate adaptation [0.20*(A+B+C+D+E)]	**69.8**	**60.5**	**130.3**

Note: The estimated jobs represent jobs per USD 1 million invested in climate adaptation activities.

Source: Calculated using 2018 OECD input-output table (2021 ed.), PLFS 2017-18, and Technical Group on Population Projections (2020)

5.3 Investing in climate adaptation

Under the worst-case climate change scenario (RCP8.5), the annual adaptation costs for South and South-West Asia have been estimated at USD 61.5 billion, of which around 93 percent is for climate-related hazards and the rest for biological hazards (ESCAP 2022). Of the countries considered, India has the highest total adaptation costs at USD 45.3 billion (ESCAP 2022). The methodology followed by ESCAP (2019) to calculate adaptation costs is as follows. Spatial datasets are used to estimate the population and infrastructure exposed to hazards in hotspots. The AAL is estimated using the extensive risks, indirect losses, and population exposure of each hazard. The economic impact of hazards is the estimated AAL for the current scenario, RCP4.5, or RCP8.5. The adaptation costs for climate-related hazards are the composite of the adaptation costs for droughts, floods, and tropical cyclones (ESCAP 2019, 2021):

$$\begin{aligned}&Climate\ related\ hazards\ AAL\ under\ RCP8.5\ (flood, tropical\ cyclone, drought)\\&= (Extensive\ risk\\&- multihazard\ AAL\ including\ indirect\ losses\ from\ tropical\ cyclone\ and\ floods\\&+ drought\ AAL\ \ under\ RCP8.5)\end{aligned}$$

By this measure, the annual adaptation costs for climate-related hazards amounts to around 1.5 percent of the GDP for India (ESCAP 2022). Assessing that at least this amount would need to be spent in adapting to climate change, I estimate the job creation effects of investing 1.5 percent of the GDP on adaptation activities. From section 5.2, investing USD 1 million, equally divided between the five representative climate adaptation activities, is estimated to generate around 130 jobs. Scaling up the amount to 1.5 percent of the GDP (approximately USD 50 billion)[vi], around 6.5 million jobs could be created through investment in climate adaptation activities. This accounts for around 1.3 percent of the labour force as of 2017-18.

5.4 A combined climate adaptation-mitigation programme

Along with adaptation, mitigation activities are needed to slow the frequency and intensity of extreme weather events. Transitioning to clean renewable energy sources and increasing energy efficiency have been identified as feasible routes for economies to reduce carbon emissions while raising or maintaining their per capita energy consumption (Pollin and Chakraborty 2015). Investing in a green energy programme over a fossil fuel programme has been estimated to increase net employment apart from its environmental benefits (Pollin and Chakraborty 2015, Azad and Chakraborty 2018, 2023). The methodology was replicated, and the estimates were updated with recent data to determine the job creation estimates of a combined investment programme in climate mitigation and adaptation.

Investing USD 1 million in climate mitigation activities (renewable energy and energy efficiency) would generate around 158 jobs, of which 94 are direct jobs and 64 are indirect jobs (Table 2). Two-thirds of the investment in the climate mitigation programme is on expanding the use of renewable energy sources and one-third is on increasing energy efficiency. If USD 1 million had instead been invested in a fossil fuel-based programme (coal, oil, and gas), only 47 jobs would have been generated (Table 3).

Table 2: Job creation with investments of USD 1 million in climate mitigation

	Direct	**Indirect**	**Total**
A. Renewable energy [0.20*(i+ii+iii+iv+v)]	97.6	60.8	158.5
i. Bioenergy	196.9	44.1	241.0
ii. Wind energy	68.9	72.3	141.2
iii. Solar energy	50.2	66.9	117.1
iv. Geothermal	96.0	61.0	157.0
v. Small hydro	76.2	59.7	135.9
B. Energy efficiency [0.25*(i+ii+iii+iv)]	87.0	69.3	156.3
i. Retrofitting buildings	109.5	71.6	181.1
ii. Industrial efficiency	104.1	69.0	173.1
iii. Improved smart grids	67.0	76.1	143.1
iv. Public transport	67.5	60.4	127.9
Climate mitigation [(0.67*A) + (0.33*B)]	**94.1**	**63.6**	**157.7**

Note: The estimated jobs represent jobs per USD 1 million invested in climate mitigation activities.

Source: Calculated using 2018 OECD input-output table (2021 ed.), PLFS 2017-18, and Technical Group on Population Projections (2020)

Table 3: Job creation with investments of USD 1 million in climate adaptation/ climate mitigation/ fossil fuel programme

	Direct	Indirect	Total
Climate adaptation	69.8	60.5	130.3
Climate mitigation	94.1	63.6	157.7
Fossil fuel programme	5.4	41.7	47.1

Note: The estimated jobs represent jobs per USD 1 million invested in each of the three activity types.

Source: Calculated using 2018 OECD input-output table (2021 ed.), PLFS 2017-18, and Technical Group on Population Projections (2020)

From section 5.3, 1.5 percent of the GDP invested in a climate adaptation programme could generate around 6.5 million jobs. This accounts for around 1.3 percent of the labour force in 2017-18. An additional 1.5 percent of the GDP spent on climate mitigation activities would create around 7.9 million jobs (1.6 percent of the labour force in 2017-18). The net gains in employment from investing 3 percent of the GDP in a combined programme of climate mitigation and adaptation activities over the same amount spent instead on a fossil fuel-based programme would be 9.7 million jobs (around 2 percent of the labour force as of 2017-18). Thus, the job creation estimates of investing in a combined programme of climate adaptation and mitigation activities suggest its potential to simultaneously address the climate and livelihoods crises in India.

6 Discussion

For the Indian region, climate models project serious implications of continued anthropogenic global warming, such as changes in the mean, variability, and extremes of parameters (Krishnan, et al. 2021). Past climate hazards have had immense economic costs, with a cyclone in 2020 causing over USD 13 billion of damages (Picciariello, et al. 2021) and a flood in 2014 causing USD 16.9 billion of losses (WMO 2021). Developing countries, such as India, have lower capacities to adapt, and the livelihoods of people in these countries tend to be more dependent on natural resources. In the Indian economy, climate hazards affect livelihoods in a context where relatively high rates of economic growth have not generated sustainable or secure jobs.

In this context, I raise and respond to two key questions. First, are livelihoods in certain regions within India more vulnerable to changes in climate? An index capturing vulnerability in livelihoods and to climatic changes was constructed to identify priority regions for adaptation planning and intervention. The most vulnerable regions identified by the index are located in different states and parts of the country and differ widely in agro-climatic characteristics. In the context of poverty alleviation, policies implemented within or across states may be more relevant than state-level policies as initial conditions and agro-climatic zones do not overlap with state boundaries (Mishra and Harriss-White 2015, Palmer-Jones and Sen 2015). Likewise, regions sharing common agro-climatic characteristics across different states may face similar climate hazards, risks, and vulnerabilities. Policymaking on adapting to climate hazards could benefit from combined adaptation planning and interventions that encompass regions facing similar climate risks across states and administrative boundaries. Just as extreme weather events could be compounding, adaptation measures could address multiple climate risks (Dhara and Koll 2021). With loss of livelihoods among the climate risks, this paper assesses whether this risk could be addressed alongside biophysical risks through institutional responses and climate adaptation investments.

Second, can climate adaptation activities simultaneously address the climate and livelihoods crises in the country? Forecasted climatic changes were used to identify key climate hazards and associated risks for India, and potential adaptation activities were listed. Five representative adaptation activities addressing different climate hazards were selected, and the number of direct and indirect jobs generated through an expansion in these activities was estimated. The job creation estimates support the hypothesis and validate the need for expanded investment in climate adaptation activities. The annual adaptation costs for climate-related hazards have been estimated at around 1.5 percent of the GDP of India. Investing this amount on adaptation activities would generate around 6.5 million jobs, and this accounts for around 1.3 percent of the labour force in 2017-18.[vii] The exercises in this paper do not include estimates of the induced jobs generated through the multiplier effects of the programme. The job creation estimates are therefore likely to underestimate the effects of a climate adaptation programme.

Climate mitigation activities are also needed to slow the pace and intensity of climatic changes. The estimates in the paper suggest that the net gains in employment from investing 3 percent of the GDP in a combined climate adaptation and mitigation programme over a fossil fuel-based programme could generate around 9.7 million jobs, accounting for around 2 percent of the labour force as of 2017-18. The job creation estimates of investments in climate adaptation and mitigation activities suggest the strong potential for such a programme to simultaneously address the climate and livelihoods crises in India.

Concerns relating to livelihoods have been raised about the clean energy transition in India. The targeted addition to solar capacity with the clean energy transition in India is estimated to generate jobs primarily in the western and southern parts of the country while job losses would be concentrated in the coal-rich eastern states (Sharma and Banerjee 2021), and climate mitigation policies could exacerbate regional inequalities (Mitra and Chandra 2023). On the other hand, the vulnerability assessment reveals that livelihoods in regions across different parts of the country are highly vulnerable to climatic hazards and risks, although the nature of the risk could differ. Adaptation activities are therefore needed across regions and could correct inequalities and any imbalances in job creation.

The vision for the combined adaptation-mitigation programme is that the new jobs directly created through the programme would be formal jobs with sustainable and secure earnings and working conditions. In a country where 80 to 90 percent of the workforce is informally employed, such a programme could transform their lives and livelihoods.

7 Conclusion

Adaptation actions that account for socio-economic vulnerabilities are urgently needed to avoid descending into 'adaptation apartheid' (Tutu 2007). In this paper, I propose expanded investments in institutional climate adaptation activities to simultaneously address the climate and livelihoods crises in the Indian economy and estimate the job creation through such activities. Investing in climate adaptation can secure livelihoods along with improving mechanisms to cope with climate hazards. Such activities, if planned and implemented carefully in accordance with the geographies, vulnerabilities, and socio-economic patterns of each region, could be transformational.

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Appendix

Table A1: Rural and Urban Livelihoods Vulnerability Index (LVI)

Region	Rural LVI	Region	Urban LVI
Western Rajasthan	0.680	Northern Chhattisgarh	0.537
Inland northern Maharashtra	0.620	Northern Odisha	0.520
Northern Chhattisgarh	0.620	Southern upper Ganga plains, UP	0.509
Southern Rajasthan	0.617	Inland northeastern Telangana	0.499
Kachchh, Gujarat	0.617	Northern Rajasthan	0.476
Ranchi plateau, Jharkhand	0.607	Northern upper Ganga plains, UP	0.471
Southern Odisha	0.598	Southern Punjab	0.470
Northern Odisha	0.592	Mizoram	0.470
South Madhya Pradesh	0.570	Hills, Manipur	0.470
Inland eastern Maharashtra	0.567	Northern Bihar	0.466
Southern Chhattisgarh	0.565	Vindhya, Madhya Pradesh	0.466
Hazaribagh plateau, Jharkhand	0.560	South Madhya Pradesh	0.463
Southwestern Madhya Pradesh	0.558	Southwestern Madhya Pradesh	0.462
Southern Uttar Pradesh	0.558	Southern Odisha	0.462
Western plains, West Bengal	0.557	Southeastern Gujarat	0.461
Northern Rajasthan	0.554	Central Bihar	0.460
Southern plains, West Bengal	0.554	Dry areas, Gujarat	0.460
Coastal southern Andhra Pradesh	0.552	Eastern Maharashtra	0.456
Central Bihar	0.548	Hazaribagh plateau, Jharkhand	0.451
Northeastern Rajasthan	0.548	Coastal southern Andhra Pradesh	0.451
Vindhya region, Madhya Pradesh	0.542	Inland central Maharashtra	0.449
Central Madhya Pradesh	0.541	Northern Madhya Pradesh	0.448
Inland northern Karnataka	0.538	Inland northern Karnataka	0.446
Northern Madhya Pradesh	0.537	Central Uttar Pradesh	0.445
Inland Tamil Nadu	0.536	Saurashtra region, Gujarat	0.444
Plains, western Assam	0.536	Inland eastern Karnataka	0.437
Himalayan region, West Bengal	0.534	Eastern Uttar Pradesh	0.433
Inland central Maharashtra	0.532	Inland northern Maharashtra	0.432
Saurashtra region, Gujarat	0.524	Plains, northern Gujarat	0.432
Inland southern Karnataka	0.522	Himalayan region, West Bengal	0.431
Northern Bihar	0.520	Cachar plains, Assam	0.429
Eastern Uttar Pradesh	0.519	Southern Tamil Nadu	0.428
Malwa, Madhya Pradesh	0.519	Southern plains, West Bengal	0.426
Coastal Odisha	0.515	Sikkim	0.425
Southern upper Ganga plains, UP	0.510	Coastal Odisha	0.424

Inland northwestern Telangana	0.510	Southern Chhattisgarh	0.421
Western Haryana	0.509	Southern Uttar Pradesh	0.418
Inland eastern Karnataka	0.507	Northern Punjab	0.416
Inland northeastern Telangana	0.507	Inland Tamil Nadu	0.415
Mahanadi basin, Chhattisgarh	0.506	Kachchh, Gujarat	0.415
Eastern plains, West Bengal	0.502	Nagaland	0.413
Central Uttar Pradesh	0.501	Western Haryana	0.413
Coastal northern Andhra Pradesh	0.499	Western Rajasthan	0.406
Northern upper Ganga plains, UP	0.496	Tripura	0.406
Central Brahmaputra plains, Assam	0.496	Ranchi plateau, Jharkhand	0.405
Central plains, West Bengal	0.495	Malwa, Madhya Pradesh	0.403
Dry areas, Gujarat	0.494	Delhi	0.401
Inland southern Andhra Pradesh	0.489	Uttarakhand	0.397
Coastal Maharashtra	0.488	Southeastern Rajasthan	0.390
Uttarakhand	0.485	Central plains, West Bengal	0.387
Tripura	0.482	Inland eastern Maharashtra	0.386
Northern Punjab	0.478	Mahanadi basin, Chhattisgarh	0.384
Coastal northern Tamil Nadu	0.478	Coastal northern Andhra Pradesh	0.384
Central Himachal Pradesh	0.473	Northeastern Rajasthan	0.380
Southern Punjab	0.470	Arunachal Pradesh	0.378
Plains, eastern Assam	0.466	Coastal northern Tamil Nadu	0.376
Southern Tamil Nadu	0.462	Coastal Maharashtra	0.371
Southeastern Rajasthan	0.461	Eastern Haryana	0.366
Hills, Manipur	0.458	Coastal Tamil Nadu	0.365
Mizoram	0.455	Central Madhya Pradesh	0.363
Coastal Tamil Nadu	0.454	Northern Kerala	0.363
Eastern Maharashtra	0.451	Central Brahmaputra plains, Assam	0.363
Inland western Maharashtra	0.439	Western plains, West Bengal	0.362
Southeastern Gujarat	0.437	Eastern plains, West Bengal	0.358
Coastal and Ghats, Karnataka	0.434	Inland southern Karnataka	0.356
Meghalaya	0.431	Southern Rajasthan	0.355
Arunachal Pradesh	0.413	Plains, eastern Assam	0.349
Eastern Haryana	0.405	Plains, western Assam	0.345
Cachar plains, Assam	0.400	Inland northwestern Telangana	0.340
Northern Kerala	0.396	Southern Kerala	0.333
Delhi	0.395	Inland western Maharashtra	0.329
Plains, northern Gujarat	0.393	Inland southern Andhra Pradesh	0.323
Southern Kerala	0.387	Meghalaya	0.319
Trans-Himalayan and southern HP	0.377	Plains, Manipur	0.317
Nagaland	0.364	Goa	0.308
Goa	0.341	Central Himachal Pradesh	0.308
Plains, Manipur	0.272	Coastal and Ghats, Karnataka	0.304
Sikkim	0.209	Trans-Himalayan and southern HP	0.239

Note: i. UP: Uttar Pradesh; HP: Himachal Pradesh
ii. Union territories, apart from Delhi, have been excluded from the calculations.
Source: Computed using PLFS 2021-22, AIDIS 2019, and SAS–LHS 2019

Table A2: List of adaptation activities by climate hazard or associated risk

Sr. no.	Activity/ structure	Climate hazards/ associated risks
1	Stormwater drains	
2	Block/ belt plantations/ vegetation	
3	Drainage channels	
4	Staggered trench	
5	Flood control/ diversion channels	
6	Embankment	
7	Silvopasture	
8	Permeable pavements	
9	New buildings with higher foundations/ on stilts	
10	Storm surge barriers	
11	Wetlands restoration	
12	Constructed treatment wetlands	
13	Floating agricultural systems	
14	Flood walls	
15	Raising and relocating buildings and other facilities	
16	Restoration of salt marshes	
17	Bunds	
18	Cyclone shelters	
19	Check dams	
20	Mangroves restoration	
21	Watersheds	
22	Dune management (vegetation transplanting, thatching, and fencing)	
23	Cooling centres	
24	Retrofitting buildings (installing green roofs; shutters for windows; reinforcing foundations)	
25	Reservoirs and storage for water supply	
26	Recharge pits	
27	Irrigation systems, level bench terraces	
28	Rainwater harvesting infrastructures	
29	Water efficiency retrofitting	
30	Construction of new wells/ Well deepening	
31	Spurs (riverbanks)	
32	Sea walls, levees, and impermeable revetments	
33	Breakwaters	
34	Groynes	
35	Beach nourishment	
36	Permeable revetments	
37	Beach recycling	
38	Sandbag structures	
39	Beach drainage	
40	Gabion structures	
41	Artificial dunes, dune rehabilitation, manmade reefs	

42	Restoration of waste/ fallow land							Land degradation							
43	Community farming, kitchen gardens, cooperative edible wild plant nurseries							Land degradation	Water degradation		Shortage of essentials				Loss of livelihoods
44	Restoration of water bodies								Water degradation						
45	Wastewater treatment systems				Drought				Water degradation						
46	Drinking water utilities				Drought				Water degradation		Shortage of essentials				
47	Underground dykes									Groundwater depletion					
48	Storage structures for foodgrains, seeds				Drought						Shortage of essentials				
49	Livestock shelters	Storms and flooding	Extreme wind	Heat wave								Livestock damage			
50	Agroforestry										Shortage of essentials	Livestock damage		Biodiversity loss	
51	Green belts with drought-resilient and soil-stabilising species				Drought	Soil erosion					Shortage of essentials			Biodiversity loss	Loss of livelihoods
52	Financial insurance										Shortage of essentials		Financial loss, loss of property		Loss of livelihoods
53	Artificial islands, nesting grounds													Biodiversity loss	
54	Restoration of seagrass beds						Coastal protection							Biodiversity loss	
55	Job guarantee														Loss of livelihoods

Legend:

- Storms and flooding
- Extreme wind
- Heat wave
- Drought
- Soil erosion
- Coastal protection
- Land degradation
- Water degradation
- Groundwater depletion
- Shortage of essentials
- Livestock damage
- Financial loss, loss of property
- Biodiversity loss
- Loss of livelihoods

Table A3: Matching industries in the input-output table and employment survey

IOT Code and Industry	NIC 2008 Section	NIC 2008 Division
D01T02: Agriculture, hunting, forestry	A	1 + 2
D03: Fishing and aquaculture	A	3
D05T06: Mining and quarrying, energy-producing products	B	5 + 6
D07T08: Mining and quarrying, non-energy-producing products	B	7 + 8
D09: Mining support service activities	B	9
D10T12: Food products, beverages, and tobacco	C	10 + 11 + 12
D13T15: Textiles, textile products, leather and footwear	C	13 + 14 + 15
D16: Wood and products of wood and cork	C	16
D17T18: Paper products and printing	C	17 + 18

D19: Coke and refined petroleum products	C	19
D20: Chemical and chemical products	C	20
D21: Pharmaceuticals, medicinal chemical and botanical products	C	21
D22: Rubber and plastics products	C	22
D23: Other non-metallic mineral products	C	23
D24: Basic metals	C	24
D25: Fabricated metal products	C	25
D26: Computer, electronic and optical equipment	C	26
D27: Electrical equipment	C	27
D28: Machinery and equipment, nec	C	28
D29: Motor vehicles, trailers and semi-trailers	C	29
D30: Other transport equipment	C	30
D31T33: Manufacturing nec; repair and installation of machinery and equipment	C	31 + 32 + 33
D35: Electricity, gas, steam and air conditioning supply	D	35
D36T39: Water supply; sewerage, waste management and remediation activities	E	36 to 39
D41T43: Construction	F	41 + 42 + 43
D45T47: Wholesale and retail trade; repair of motor vehicles	G	45 + 46 + 47
D49: Land transport and transport via pipelines	H	49
D50: Water transport	H	50
D51: Air transport	H	51
D52: Warehousing and support activities for transportation	H	52
D53: Postal and courier activities	H	53
D55T56: Accommodation and food service activities	I	55 + 56
D58T60: Publishing, audio-visual and broadcasting activities	J	58 + 59 + 60
D61: Telecommunications	J	61
D62T63: IT and other information services	J	62 + 63
D64T66: Financial and insurance activities	K	64 + 65 + 66
D68: Real estate activities	L	68
D69T75: Professional, scientific and technical activities	M	69 to 75
D77T82: Administrative and support services	N	77 to 82
D84: Public administration and defence; compulsory social security	O	84
D85: Education	P	85
D86T88: Human health and social work activities	Q	86 + 87 +88
D90T93: Arts, entertainment and recreation	R	90 to 93
D94T96: Other service activities	S	94 to 99

Table A4: Weights assigned to climate adaptation activities

Industry	Cooling centres	Sea walls	Safe houses	Constructed wetlands	Water storage reservoirs
D03: Fishing and aquaculture				0.3	
D05T06: Mining and quarrying, energy producing products	0.03696				

D07T08: Mining and quarrying, non-energy producing products	0.001505	0.2	0.027		
D16: Wood and products of wood and cork	0.052962		0.2339		
D17T18: Paper products and printing	0.005684				
D20: Chemical and chemical products	0.01631				
D22: Rubber and plastics products	0.027489				
D23: Other non-metallic mineral products	0.099379				
D24: Basic metals	0.032137	0.2	0.1392		
D25: Fabricated metal products	0.032137	0.2	0.3158		
D28: Machinery and equipment, nec	0.025277			0.1	0.2
D31T33: Manufacturing nec; repair and installation of machinery and equipment	0.0168		0.0907		
D35: Electricity, gas, steam and air conditioning supply					0.1
D36T39: Water supply; sewerage, waste management and remediation activities				0.3	0.2
D41T43: Construction	0.3	0.3	0.1934		0.2
D45T47: Wholesale and retail trade; repair of motor vehicles	0.244041				
D49: Land transport and transport via pipelines	0.028112				
D52: Warehousing and support activities for transportation				0.1	0.2
D64T66: Financial and insurance activities	0.018102				
D68: Real estate activities	0.005306				
D69T75: Professional, scientific and technical activities	0.057799	0.1			
D84: Public administration and defence; compulsory social security				0.2	0.1

Source: Weights assigned based on FEMA (2008); NABARD (2015); Hudson, Keating and Pettit (2015); Multi-Hazard Mitigation Council (2019); and the costing spreadsheet tool of the Environment Agency, UK Government.

Notes:

[i] Average annual loss (AAL) refers to the expected value of loss every year during a long time period (ESCAP 2022). The calculation assumes that the occurrence of hazards is stationary and that the costs would be covered through annual payments of the amount (ESCAP 2022).

[ii] The maximum and minimum values were taken after excluding the union territories.

[iii] The government of Delhi operates 'rain basera' or night shelters during winters.

[iv] Additionally, women in the workforce often face the double burden of paid work and unpaid household labour, and the intensification of unpaid labour after climate hazards could increase this burden.

[v] This only includes non-receipt of insurance claim for reasons other than non-coverage or loss of documents.

[vi] The GDP of India in 2022 was around USD 3.2 trillion. 1.5 percent of the GDP is around USD 48 billion. USD 50 billion is used as the amount invested in the exercises in sections 5.3 and 5.4.

[vii] The number and nature of the jobs generated could vary over time. Part of these activities, such as those in construction, may be one-time activities but could generate jobs for the maintenance of adaptation structures over time.