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Food security and climate change vulnerability: A multidimensional approach

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Abstract

Food security in South Asia remains highly vulnerable due to persistent socioeconomic constraints and increasing climate variability. Although global food production is sufficient, food insecurity continues to be determined mainly by limited access, particularly in developing regions where agriculture is highly climate dependent. This study examines food security vulnerability in South Asian countries using a multidimensional Hunger and Climate Vulnerability Index (HCVI), which combines climatic, environmental, agricultural, infrastructural, and socioeconomic indicators. Secondary data were collected from the World Bank, CMIP6 climate datasets, and other international sources for the period 1976-2023. Principal Component Analysis (PCA) was used to derive weights for indicators related to exposure, sensitivity, and adaptive capacity. The indicators were normalized, and a composite vulnerability index was constructed using an additive approach. The results show substantial differences in vulnerability across countries. Afghanistan and Pakistan exhibit high vulnerability due to greater exposure and weak adaptive capacity, whereas Bhutan and Maldives show low vulnerability, supported by better environmental conditions and stronger adaptive capacity. The findings highlight the importance of strengthening adaptive capacity through improvements in human capital, infrastructure, and inclusive economic growth to enhance food security resilience. The study offers policy-relevant evidence for climate-resilient agricultural planning and regional food security strategies in South Asia.

Keywords: Food security, vulnerability, adaptive capacity, south-Asia

Introduction

Food Security

Food security is defined as a situation in which all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996). Global food security depends not only on adequate food production but also on effective access to food. Although sufficient food is produced worldwide, more than 10 per cent of the global population remains undernourished, indicating that limited access rather than production is the primary constraint to food security.

Food security is commonly understood through four interrelated dimensions. Food availability refers to the supply of food determined by domestic production, stock levels, and trade. Food access involves the ability of individuals and households to obtain food, influenced by income, prices, markets, and purchasing power. Food utilization relates to how food is consumed and absorbed by the body, shaped by diet quality, food preparation, health, and intra-household distribution. Stability depicts the consistency of these three dimensions over time, as food insecurity may arise from seasonal shortages, climate shocks, economic instability, or political disturbances. Food insecurity remains a major development challenge,

with over 800 million people undernourished globally (FAO/IFAD/WFP, 2012). Climate change is expected to further increase the population at risk of hunger by 10-20 per cent. In South Asia, food insecurity is intensified by rapid population growth, dependence on climate-sensitive agriculture, declining arable land, and limited adaptive capacity. Addressing these challenges requires sustainable agricultural practices, climate-resilient technologies, improved infrastructure, and investments in human capital and livelihoods to enhance long-term food security.

Climate Change and Hunger

Climate change poses serious threats to food systems by increasing production costs, unsettling supply chains, and reducing agricultural productivity. Extreme weather events such as droughts, floods, and storms damage crops and infrastructure, leading to lower yields and higher food prices. These impacts disproportionately affect vulnerable populations, deepening food insecurity and poverty.

South Asia is particularly vulnerable to climate change due to its exposure to natural disasters and heavy reliance on monsoon-dependent agriculture. Rising temperatures are expected to alter monsoon patterns, potentially increasing rainfall in parts of Bangladesh and Myanmar while reducing precipitation in India, Pakistan, and Nepal. Additionally, the

melting of Himalayan glaciers threatens water availability and increases the risk of flooding, undermining agricultural and water security.

Climate projections indicate that yields of major staple crops such as rice and wheat could decline by up to 30 per cent by the mid-21st century. According to the Human Development Report (2006), nearly 2.5 billion people in South Asia may face water stress by 2050, further aggravating food and livelihood insecurity. Climate change is projected to increase hunger risk by 10-20 per cent (FAO/WFP, 2010), making it clear that achieving Zero Hunger is not possible without urgent climate action. Promoting climate-smart agriculture, sustainable water management, and regional cooperation is essential to build resilience and ensure food security in South Asia.

Agriculture in South Asia

Agriculture is the main support of South Asian economies. A large share of the population lives in rural areas and depends on farming for income and employment. The sector plays an important role in economic growth, contributing about 29 per cent to GDP and providing jobs to nearly 65 per cent of the labour force (World Bank, 2008). Many industries and services linked to agriculture also add significantly to the regional economy.

Agricultural growth is closely linked with poverty reduction in South Asia. It increases farmers' incomes and helps reduce poverty in rural areas. Higher agricultural production also helps keep food prices affordable, which is especially important for poor households that spend a large part of their income on food. Despite its importance, South Asia continues to face serious problems of food insecurity and malnutrition. Hunger and under nutrition remain widespread, particularly among children and low-income groups. Strengthening agriculture is therefore essential for improving food availability and access in the region. Past investments in irrigation, research, improved seeds, and market access have helped increase productivity and food supply.

Most farming in South Asia depends on rainfall, making agriculture highly vulnerable to climate change. Changes in rainfall, rising temperatures, and reduced soil moisture affect crop yields and water availability (Wani *et al.*, 2009)^[22]. These changes increase the risk faced by food-insecure households. Climate-resilient farming practices are necessary to protect livelihoods and ensure long-term food security in South Asia.

Research Gap

In addressing the challenges of assessing vulnerability, the report introduces an experimental Hunger and Climate Vulnerability Index. This index aggregates readily available global datasets covering various socioeconomic and environmental indicators. It aims to contribute to the discussion on identifying those most vulnerable to climate change and to pinpoint the South Asian countries most susceptible to climate impacts in relation to food security.

By systematically quantifying vulnerabilities, the index enables a more comprehensive analysis of the specific factors that make a country vulnerable to the adverse effects of climate change. The Hunger and Climate Vulnerability Index offers a country-level evaluation of food security and climate risk, aiding in strategic planning especially in South-Asia. This methodology can be adapted for South-Asian nations assessments to identify and evaluate risks specific to different contexts.

Analytical frame work

Vulnerability comes from the complex mix of social, economic, institutional, and environmental factors, which makes it hard to measure. Even so, trying to measure vulnerability is important for prioritizing and planning actions, especially for adapting to climate change.

Vulnerability broadly refers to climatic conditions like rainfall variations, temperature changes, and extreme weather events that intensify the food security risks for households or communities during a shock. It is determined by how households, communities, countries, or regions are affected by and cope with the adverse consequences (such as injury, damage, or loss) resulting from these shocks.

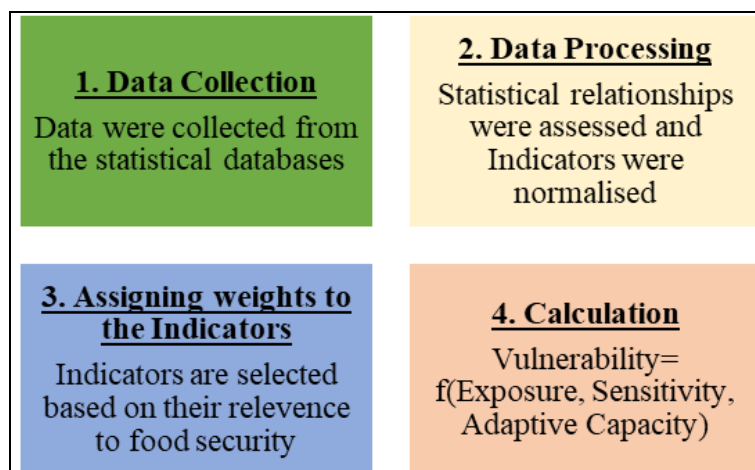
The Intergovernmental Panel on Climate Change (IPCC WGII, 2007) further defines vulnerability to climate change as the interaction between three components:

- **Exposure:** The magnitude and duration of climate-related exposure;
- **Sensitivity:** The sensitivity of a target system (in this case, food security) to climate risk;
- **Adaptive Capacity:** The ability of a system to withstand or recover from the exposure (adaptive capacity).

Climate change can increase the vulnerability of food-insecure households. In many of the most food-insecure countries, agriculture relies heavily on rain-fed systems (Wani *et al.*, 2009)^[22]. As climate change alters weather patterns, it can affect the suitability of regions for crop production, leading to changes in crop yields. Water availability is also impacted, as shifts in rainfall patterns can affect water supply, deteriorating agricultural vulnerabilities. Additionally, temperature and soil moisture, both crucial for agriculture, will change due to climate change, potentially increasing the vulnerability of food-insecure households. Changes in temperature can affect water and soil moisture needs, further influencing agricultural sensitivity.

Ultimately, the impact of climate variability, extremes, and change on food security depends on the ability of at-risk communities and countries to respond to these challenges. The strategies employed to manage and adapt to climate risks are highly specific to each context (IPCC WGII, 2007).

Method: The method used for this report consisted of a four-step process in order to develop the Hunger and Climate Vulnerability Index



(Source: Krishnamurthy *et al.*, 2022)

Fig 1: Methodological Process.

The Figure.01 represents the steps of vulnerability index. First step is to collect the data from the various statistical sources like world bank, ILO. Second step is to assign the

statistical relationships and normalisation of the data followed by assigning weights to the indicators (PCA) and calculation of vulnerability index (CVI)

Table 1: Summary of the Components and indicators used for the vulnerability index

Component	Input				
	Profile	Indicator	Functional Relationship	Data	Year
	Climate	Minimum Temperature	+	cmip6 Climate data, World Bank	1976-2022
		Mean Temperature	+	cmip6 Climate data, World Bank	1976-2022
		Maximum Temperature	+	cmip6 Climate data, World Bank	1976-2022
		Precipitation	+	cmip6 Climate data, World Bank	1976-2022
	Environment and Agriculture	Forest area (% of land area)	-	WDI, World Development Indicators, World Bank	1976-2022
		Arable land (% of land area)	+	WDI, World Development Indicators, World Bank	1976-2023
		Food production index (2014-2016 = 100)	+	WDI, World Development Indicators, World Bank	1976-2024
		Consumer price index	-	WDI, World Development Indicators, World Bank	1976-2025
		Arable land (hectares per person)	+	WDI, World Development Indicators, World Bank	1976-2026
	Infrastructure	Rural population (% of total population)	-	WDI, World Development Indicators, World Bank	1976-2027
	Socioeconomic structure	GDP per capita (constant 2015 US\$)	+	WDI, World Development Indicators, World Bank	2022
		Road density (Km/Km2)	+		2022
		Unemployment, total (% of total labour force) (national estimate)	-	WDI, World Development Indicators, World Bank	2022
		Poverty headcount ratio at national poverty lines (% of population)	-	WDI, World Development Indicators, World Bank	2022
		Life expectancy at birth, total (years)	+	WDI, World Development Indicators, World Bank	2022
		Literacy rate, adult total (% of people ages 15 and above)	+	WDI, World Development Indicators, World Bank	2022

Table 1 indicates the profile, indicators and data source from which the indicators have been selected. To calculate the exposure the data on climate has been taken like mean temperature, Minimum temperature, Maximum temperature and precipitation from the cmip6, Climate data, World Bank from the year 1976-2022. For Exposure Calculation the

indicators were forest area, arable lands, food price index and consumer price index followed by Adaptive capacity indicators like GDP per capita, paved roads, Literacy rate and life expectancy has been taken.

Vulnerability: There are various approaches to studying the

vulnerability generally measuring exposure (risk of exposure to a disturbance), sensitivity (sensitivity of the system to that disturbance) and adaptive capacity (capacity of the system to adapt to the disturbance) (IPCC, 2022b). These approaches tried in several countries have attempted to quantify the impact of climate change through the development of indices (Adger & Agnew, 2004; Ahsan & Warner, 2014; Brooks *et al.*, 2005; Cardona, 2005; Lummen & Yamada) [1, 2, 4, 5].

Exposure

Exposure is the nature and degree to which a system is exposed to significant climate variation. Agricultural production could be adversely affected by exposure to short-term and long-term abnormal climatic events. This effect can be captured by selective indicators based on the combination of inputs from literature review and experts' opinions. In the present study, minimum temperature, maximum temperature, rainfall have been used to find the extent of agricultural production exposure to climate change. Short-term variations in annual precipitation, annual minimum temperature, and annual maximum temperature for the triennium ending (TE) 2020 were considered based on Monterroso *et al.* (2014) [11] and Sendhil *et al.* (2018) [14]. The coefficient of variation was initially used to capture long-term trends in the time series data. However, it tends to overestimate the level of variation (Kumar *et al.*, 2012) [8]. Therefore, a group of experts, including 14 researchers, 6 policymakers, and 10 academicians, recommended using the Mann-Kendall test to determine the long-term trend coefficient, represented by the z statistic, and to measure the trend's magnitude using Sen's slope (Jain & Kumar, 2012; Radhakrishnan *et al.*, 2017) [8, 13].

Sensitivity

Sensitivity is actually how agriculture production and food security is responding to climate change. The sensitivity indicators like forest area (% of land area), arable land (% of land area), arable land (hectares per person), Food production index (2014-16), and consumer price index from years 1976 to 2022. Forest land is actually taken as negative sign followed by arable land which is suitable for growing crops taken as positive sign, the more the arable land the greater will be the production. Arable land (Hectares per person) was taken as a positive sign. Food production index is taken as negative followed by Consumer price Index as positive.

Adaptive Capacity

For the Adaptive Capacity the variables like GDP per capita which is taken as a positive indicator followed by Road length which is taken as a positive means better the road, better will be the transportation. Other indicators like rural population, unemployment, poverty head count ratio, literacy rate followed by literacy rate particularly adult literacy were taken.

Normalisation of data

Data on variables used to estimate the vulnerability index were normalized to make them unit and scale-free for comparison. When the variables have positive relationship in relation to indicators, normalization was done using the

formula given below

$$\text{Normalization} = \frac{\text{Actual value} - \text{Minimum value}}{\text{Maximum value} - \text{Minimum value}}$$

When the variables have negative relationship in relation to indicators, normalization was done as given below.

$$\text{Normalization} = \frac{\text{Maximum value} - \text{Actual value}}{\text{Maximum value} - \text{Minimum value}}$$

To compute the composite index, weights have been assigned to the normalized values (0 to 1) of the respective variables

Assigning weights to variables

In general, to assign weights for the variables, expert opinion (Brooks *et al.*, 2005) [4], equal weightage (Lucas & Hilderink, 2005; O'Brien *et al.*, 2004) [10, 12] and statistical methods such as principal component analysis (PCA) or factor analysis (Cutter *et al.*, 2003; Thornton *et al.*, 2006) [6, 15] are used. The expert opinion is usually considered to be subjective and limited to availability of experts, number of variables and research time to get the response; Equal weights may weaken or overestimate some variable that stimulate the index disproportionately; advantage of PCA over other two methods is the technique used to extract the linear combination that best captures the information from large group of variables

In the present study, PCA is applied due to the use of multidimensional data to calculate the weight of each variable. Some of the studies used only the first component of factor loading to assign the weight (Kumar *et al.*, 2012; Monterroso *et al.*, 2014) [8, 11], but a majority selected the components with eigen value more than one which account for maximum variation in the data (Kaiser, 1960; Kale *et al.*, Sendhil *et al.*, 2018) [9, 14]. Therefore, to show maximum data variation, the following framework with the component. (Eigen value more than one was taken in the present study)

$$X_t = \Lambda_t F_t + e_t$$

where, X_t is the N-dimensional vector of variables influencing vulnerability, Λ_t is the $r \times 1$ common factor, F_t is the factor loading, and e_t is the associated idiosyncratic error-term of order $N \times 1$

Weight was calculated as mentioned in the below-given formula

$$W_i = \sum |L_{ij}| E_j$$

Here, W_i is the weight of i^{th} variable, E_j is the eigen value of j^{th} factor and L_{ij} is the loading value of i^{th} variable on j^{th} factor.

Expressing the above-calculated weights for each variable for all the shrimp-producing states in the following formula will provide a composite index value for each state

$$\text{Index} = \frac{\sum_{i=1}^n X_i W_i}{\sum_{i=1}^j W_i}$$

Here, X_i is the normalized value of i th variable, and W_i is the weight of i th variable.

Composite vulnerability index and its classification

Two additive and multiplicative can be used to establish the composite vulnerability index (Allison *et al.*, 2009) [3]. Exposure and sensitivity are weighed one quarter each, and adaptive capacity is weighed one half of the vulnerability score in multiplicative method. Comparing to the multiplicative approach, the final vulnerability value arrived through additive approach relies equally on all the three exposure, sensitivity and adaptive capacity (Hajkowicz, 2006) [7]. Avoid the curbing nature of multiplicative method in robust weighing, we applied the following formula of additive method in the present study to arrive the composite vulnerability index.

$$\text{Vulnerability} = [(\text{Exposure} + \text{Sensitivity}) - \text{Adaptive capacity}]$$

The composite vulnerability of South Asian Countries were classified into three categories namely low, moderate and high that relies on the distribution of composite index value.

$$\text{Low} = \text{Index} < (\bar{X} - 0.5 \sigma)$$

$$\text{Moderate} = (\bar{X} - 0.5 \sigma) \leq \text{Index} \leq (\bar{X} + 0.5 \sigma)$$

$$\text{High} = \text{Index} > (\bar{X} + 0.5 \sigma)$$

Results

Table 2: Components and weights for the variable under sensitivity dimension

Variables	Component		Weight
	1	2	
Mean temp	-0.98	0.06	5.80
Mini temp	-0.96	-0.06	5.71
Maxi temp	-0.95	0.22	5.95
Precipitation	0.12	-0.97	2.56
cv of Mean temp	0.96	0.20	5.93
cv of Mini temp	0.97	0.18	5.95
cv of Maxi temp	0.94	0.26	5.95
cv of Precipitation	0.27	0.92	3.37
Variance %	72.0	24.06	
Cumulative %	72.0	96.1	
Eigen Values	5.76	1.92	

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

The Table.2: shows that Rotated Component Matrix from the Principal Component Analysis (PCA) reveals critical insights into how the variables group into two principal

components. Component one is strongly associated with temperature measures mean, minimum, and maximum temperatures and their respective coefficients of variation. The high loadings (ranging from -0.986 to 0.971) indicate that Component one captures the general "temperature and its variability" factor. Conversely, Component two is predominantly defined by precipitation and its coefficient of variation, as indicated by the strong loadings of -0.971 for precipitation and 0.926 for its coefficient of variation, suggesting a "precipitation variability" factor.

These two components together explain (96.10%) of the total variance in the data, with Component one accounting for (72.03%) and Component 2 explaining (24.06%). This high cumulative variance suggests that the PCA effectively reduces the dimensionality of the data while retaining most of the information. The eigenvalues of 5.76 for Component one and 1.925 for Component two further confirm the significant variance captured by these components.

The PCA indicates a clear differentiation between temperature-related variables and precipitation-related variables, simplifying the complex dataset into two distinct, interpretable factors. Component 1 highlights the importance of temperature measures and their fluctuations, while Component 2 highlights the variability in precipitation. This dimensionality reduction facilitates more manageable and insightful analysis, aiding in understanding the underlying patterns and relationships within the dataset.

Table. 3: Component matrix and weights for the variables under sensitivity dimension

Variables	Component			Weight
	1	2	3	
Forest area (% of land area)	-0.81	0.37	0.03	1.93
Arable land (% of land area)	0.75	0.39	-0.24	2.06
Arable land (hectares per person)	-0.03	-0.07	0.94	1.11
Food production index (2014-2016 = 100)	0.69	0.19	0.43	1.91
Consumer price index	0.04	0.94	-0.03	1.28
% Variance	35.14	25.14	20.77	
Cumulative %	35.14	60.28	81.05	
Eigenvalues	1.76	1.26	1.04	

The Rotated Component Matrix from this Principal Component Analysis (PCA) provides a comprehensive understanding of how different variables are grouped into three principal components. Component 1 is primarily related to land use and agricultural productivity. This component has strong negative loading on the percentage of forest area (-0.81), indicating that as the percentage of forest area decreases, the importance of this component increases. It also has strong positive loadings on the percentage of arable land (0.75) and the food production index (0.69). This suggests that areas with more arable land tend to have higher food production but lower forest coverage. This component explains the largest portion of the variance, accounting for (35.14%), highlighting the significant role of land use in this dataset.

Component 2, which explains (25.14%) of the variance, is primarily defined by economic measures, specifically the consumer price index (0.94). This strong positive loading indicates that this component is closely associated with inflationary trends in consumer prices. Additionally, it has

moderate positive loadings on the percentage of forest area (0.37) and arable land (0.39), though these associations are secondary. This suggests that while economic conditions are the main focus of this component, there is some relationship with land use metrics as well.

Component 3 captures (20.77%) of the variance and is

mainly characterized by arable land per person (0.94), with a strong positive loading indicating a focus on agricultural land availability relative to population size. This component also has a moderate positive loading on the food production index (0.43), suggesting that individual access to arable land can influence overall food production.

Table 4: Component matrix and weights for variables under adaptive capacity dimension

Variables	Component			Weight
	1	2	3	
GDP per capita (constant 2015 US\$)	0.79	-0.40	-0.33	3.86
Road density (Km/Km2)	0.15	-0.06	0.98	1.77
Rural population (% of total population)	-0.15	0.83	0.15	1.82
Unemployment, total (% of total labour force) (national estimate)	-0.13	0.86	-0.26	1.93
Poverty headcount ratio at national poverty lines (% of population)	-0.90	0.17	-0.11	3.72
Life expectancy at birth, total (years)	0.96	-0.14	0.12	3.94
Literacy rate, adult total (% of people ages 15 and above)	0.97	-0.01	0.25	3.92
% of Variance	53.57	18.98	16.48	
Cumulative %	53.57	72.54	89.03	
Eigenvalues	3.75	1.33	1.15	

The Rotated Component Matrix from this Principal Component Analysis (PCA) reveals insightful groupings of variables into three principal components, each representing distinct primary dimensions within the dataset. Component 1, which explains (53.57%) of the total variance, is predominantly characterized by socio-economic and health indicators. High positive loadings on life expectancy at birth (0.96), literacy rate (0.97), and GDP per capita (0.79) indicate that this component represents a wealth and human development dimension. Additionally, there is a strong negative loading on the poverty headcount ratio (-0.90), suggesting that higher economic prosperity and better health outcomes are associated with lower poverty levels.

Component 2, explaining (18.98%) of the variance, is mainly defined by demographic and employment factors. This component shows strong positive loadings on rural population percentage (0.83) and unemployment rate (0.86), indicating that areas with higher rural population proportions tend to have higher unemployment rates. These associations highlight the demographic and labour market conditions prevalent in rural regions, where employment opportunities may be scarcer compared to urban areas.

Component 3, accounting for (16.48%) of the variance, focuses on infrastructure, specifically road density. The strong positive loading on road density (0.98) signifies that

this component is primarily concerned with the availability and distribution of transportation infrastructure, which is crucial for connectivity and economic development. This component also has moderate negative and positive loadings on GDP per capita (-0.33) and rural population (0.15), respectively, but these relationships are secondary to the primary focus on road density.

Together, these three components cumulatively explain (89.03%) of the total variance, significantly reducing the complexity of the dataset while preserving most of its informational content. Component 1 highlights the importance of economic development and human capital, with higher GDP, literacy, and life expectancy being indicative of lower poverty. Component 2 highlights the demographic challenges, particularly in rural areas with higher unemployment rates. Component 3 emphasizes the critical role of infrastructure, specifically road density, in economic and social development.

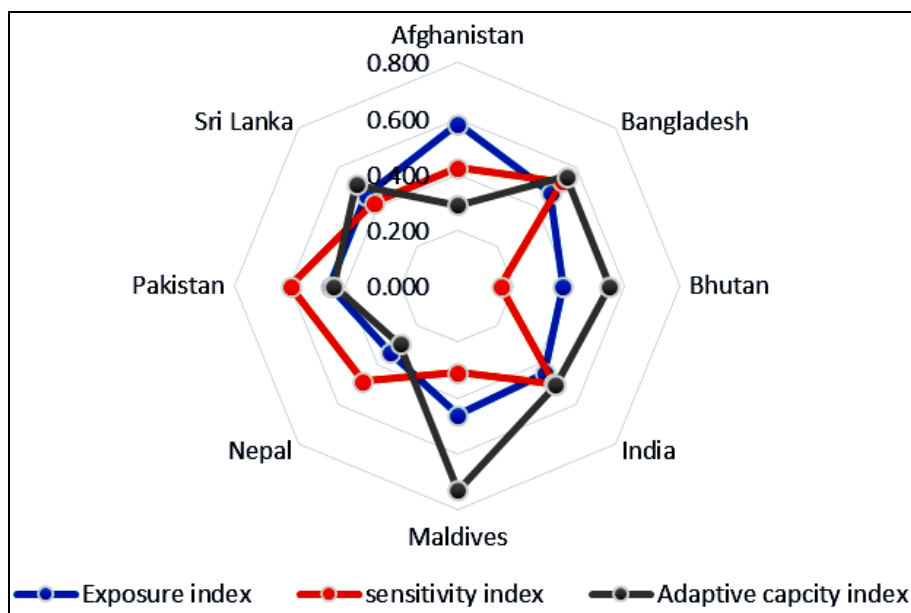
This dimensionality reduction simplifies the data into three interpretable factors, providing a clearer understanding of the relationships between socio-economic development, demographic characteristics, and infrastructure.

Vulnerability Index

Table 5: Exposure, Sensitivity and Adaptive capacity of South Asian Countries with respect to food security

Country	Exposure index		Sensitivity index		Adaptive capacity index		Composite Vulnerability Index	
Afghanistan	0.580	Moderate	0.42	Moderate	0.290	Low	0.7119	High
Bangladesh	0.472	Moderate	0.53	Moderate	0.554	Moderate	0.4486	Moderate
Bhutan	0.378	Low	0.16	Very low	0.545	Moderate	-0.0103	Very low
India	0.441	Moderate	0.49	Moderate	0.499	Moderate	0.4336	Moderate
Maldives	0.460	Moderate	0.31	Low	0.730	High	0.0387	Very low
Nepal	0.338	Low	0.48	Moderate	0.292	low	0.5266	Moderate
Pakistan	0.456	Moderate	0.60	Moderate	0.445	Moderate	0.6098	High
Sri Lanka	0.460	Moderate	0.42	Moderate	0.513	Moderate	0.3691	Low

(Based on Authors calculations)



Source: Authors own Calculation

Fig 6: Radar chart of exposure, Sensitivity and adaptive capacity indices in South-Asian Countries

The Composite Vulnerability Index table as well figure evaluates the vulnerability of eight countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka) to climate change, with a specific focus on food security. This analysis considers three main indices: Exposure, Sensitivity, and Adaptive Capacity, each representing different aspects of vulnerability. The Exposure Index measures the extent to which countries are exposed to climate change impacts, using minimum temperature, maximum temperature, and mean temperature as indicators. Countries with higher exposure are more likely to experience extreme weather events, which can adversely affect agricultural productivity and food security. Afghanistan, with an Exposure Index of (0.5796), and Bangladesh (0.4722) show Moderate exposure, indicating significant susceptibility to temperature fluctuations. Nepal (0.3383) and Bhutan (0.3785), with Low exposure, are relatively less vulnerable to temperature extremes, which may provide a safeguard against climate-induced agricultural disruptions. The Sensitivity Index assesses the degree to which a country's food security is affected by climate change, considering factors such as forest area, arable land, food production index, and consumer price index. Countries with high sensitivity are more prone to adverse effects on food production and market stability. Pakistan (0.599) and Bangladesh (0.530) show Moderate sensitivity, reflecting their significant dependence on agriculture and potential vulnerability to food production disruptions. Bhutan (0.156) demonstrates Very Low sensitivity due to its substantial forest cover and lower dependency on arable land, providing resilience against climate impacts on food security. The Adaptive Capacity Index indicates how well countries can adapt to climate change impacts, considering infrastructure (road length), demographic factors (rural population), and socio-economic conditions (poverty rates, unemployment, GDP per capita, life expectancy, literacy rates). Maldives (0.7298) shows High adaptive capacity, suggesting robust infrastructure and socio-economic conditions that enhance resilience.

Afghanistan (0.2904) and Nepal (0.2921), with **Low** adaptive capacity, are less equipped to manage climate impacts, potentially exacerbating food security challenges

Policies in Agriculture Sectors and Food security in South Asia

Food availability is the most important component to assess a nation's food security situation, but food availability does not ensure the overall food security. Accessibility, stability and utilization of food to the population are equally important. Most of the South Asian countries are net importers of food and have suffered severe terms of trade shocks and accelerated food price situation due to recent food crisis. Therefore it is necessary to reinforce a sustainable system for achieving food security, coupled with sound economic management for sustaining growth and poverty reduction in the region. Governments of South Asian countries are making some major steps which are directly or indirectly linked to achieve the goal of food security.

In Afghanistan, food security is more vulnerable than any other South Asian country due to its highly complicated political and economic context. The agricultural sector is under extreme pressure and faces a great challenge to supply food for all. There is little scope for farmers to receive guidance and technical support for the development of farming activities. Moreover, employment opportunities are not increasing compared to the population growth rate (annual population growth rate is 2.62 per cent). Therefore, they could not provide a secure livelihood to a large segment of population. Different policies have been taken through Ministry of Rural Rehabilitation and Development in various years but they are yet to make sustained impacts due to conflicts. The National Risk and Vulnerability Assessment (NRVA, 2005) suggests that approximately 61 per cent of the Afghan population experience low dietary diversity and very poor food consumption. One of the major sources of income for Afghans is to export fresh and dry fruits. Various International development agencies are

helping them to secure food by increasing their income through the development of this sector. This includes a substantial amount of food aid. World Food Programme (WFP) is the largest food aid programme in Afghanistan. WFP targets chronically poor and food-insecure families, school children, teachers, illiterate people, tuberculosis patients and their families, internally displaced persons and ex-combatants with particular emphasis on the vulnerable group of women and girls. WFP also gives them training and educational facilities collaborating with Afghan Government, non-government partners and communities. European Commission Humanitarian Aid Office and US Department of Agriculture (USDA) have also arranged various food aid programmes.

Over the last three and a half decades, Bangladesh Government has introduced reform measures and policies for agricultural development in its quest for ensuring food security for all. In early 1980, Bangladesh has pursued a policy of agricultural modernisation by supplying modern agricultural inputs such as seed, fertiliser and irrigation and modern agriculture technologies. The government also liberalised the seed market and developed the seed policy act of 1992 and 1998, for encouraging the involvement of the private sectors and NGOs in the seed delivery system. More recently, the newly elected government has decided to extend fertiliser subsidy to promote balanced fertiliser use. During this period, the Bangladesh government also took a series of measures to expand its irrigation network. To promote the use of irrigation facilities, electricity and diesel for irrigation purposes are subsidised. In recent time these subsidies are allocated through the card system, so that the farmers can avail the facilities directly.

Domestic procurement of both rice and wheat is made by the government with a view to provide support to farmers and to procure quantity of food grains required to support the public food grain distribution system. The government distributes rice and wheat under the Public Food grain Distribution System (PFDS) both through monetised channels like Essential Priority (EP), Other Priority (OP), Large Employee Industries (LEI), Flour Mill (FM), Open Market Sales (OMS), and Fair Price Card (FPC) and non-monetised (targeted) channels like Food for Work (FFW), Test Relief (TR), Gratuitous Relief (GR), Vulnerable Group Development (VGD), Vulnerable Group Feeding (VGF), Food for Education (FFE) and other relief channels. To ease the deficit in food availability from domestic production, import of agricultural commodities was liberalised and import duties and para-tariffs on various food items were substantially reduced by successive governments. In FY 2007 and FY 2008, government allocated special funds for agricultural research and currently a big project titled National Agricultural Technology Project (NATP) is being implemented. In 2009, four types of programmes are being implemented- cash transfer programmes, food security programmes, micro-credit programmes and, special funds and development sector programmes.

Bhutan has initiated several agricultural, food and trade policies to increase food production and ensure food security since 1961. But the limited resources and technology knowledge, makes it difficult for the multilateral and bilateral agencies to support them to achieve food self-sufficiency. In 1983, the International Development

Research Centre (IDRC) and IRRI supported "Rice Farming Systems Research" to build Bhutan's rice research capabilities and this led to a remarkable process in rice production. Now Bhutan Government is giving the training facilities of govt. officials and farmers to improve food production. Moreover, Bhutan has also set up the Food Corporation of Bhutan (FCB) to import food to meet domestic demand. Under the FAO and the Netherlands Partnership Programme (FNNP), the government chose rice, maize, citrus fruits and potatoes for pro-poor commodity chain analysis to both improve food security and increase rural incomes. Now Bhutan is intensifying and diversifying production to adopt an integrated approach to nutrient and pest management and to achieve at least 70 per cent self-sufficiency in food grains.

Agricultural policy in Nepal has been shaped by the Agricultural Perspective Plan (APP), which covers the period 1995-2010. The main objectives of the APP are to achieve economic growth and poverty reduction through accelerated growth of agriculture. In 2004, the National Agricultural Policy (NAP) added new food access provisions for vulnerable groups which are more radical than those of the APP. The interim constitution of Nepal 2006-07 recognised food sovereignty as a fundamental human right. The Food and Nutrition Security Plan (FNSP) that was subsequently introduced (NPC, 2007) places emphasis on self-reliance, food safety, adequacy of nutrition and improved food access. Nepal government also subsidised the transport sector for distributing food to the deficit hill and mountain areas. World Food Programme (WFP) collaborating with the Nepal government provided rural employment opportunities to the poor people. A food for education programme in Nepal is directed at improving the nutritional status and school enrolment and attendance by children, a mother and child health initiative aimed at improving the health and nutritional status of pregnant women. These programmes are implemented by the Nepal government for a long-term basis for its vulnerable people to ensure food security in the future.

Pakistan does not have any national food policy except for a few food security policies at the regional level. Food production in Pakistan increased but it is not sufficient to meet the country's consumption needs. Procurement, handling, marketing, storage and supplies are handled by the four provincial food departments and the national agency, the Pakistan Agricultural Services and Supplies Corporation (PASSCO). The main role of the corporation is to provide support to the farmers, ensuring adequate supplies in deficit provinces, intervening in the open market to stabilise prices of agricultural commodities and above all maintaining strategic reserves to meet any emergent situation. In 2007-08, government revisited the food production and food security issues due to significant food crisis in that fiscal year. The Planning Commission of Pakistan formulated a task force to provide policy recommendation to ensure food security in 2008. Two major initiatives taken by the Pakistan government to improve food access are the Benazir Income Support Programme (BISP) and the Food Support Programme (FSP). The main aim of BISP is to cover almost 15 per cent of the entire population, which constitutes 40 per cent of the population below the poverty line and support them to increase their monthly income. Food Support

Programme (FSP) was launched in 2002-03, targeting the poor to improve their living standard by providing them with financial support.

There are three main food security-related programmes in Sri Lanka targeted at special groups and the poor. These are Samurdhi programme, Thriposha Programme and the Mid-day meal programme in schools. The main objective of those programmes is to ensure food security. The Samurdhi programme is the largest welfare programme with the twin objectives of ensuring food security and reducing poverty which was launched in 1995. Intended to cover a target of 20 per cent of the population which is 17 below the poverty line, the programme actually covers half the total number of households in the country. The Thriposha Programme focuses on the specific group of mothers in low income groups with children below the age of one year and distribute supplement food cereals, pulses and micro-nutrient among the target group. The school mid-day meal programme targets children with the objective of improving school attendance and children's nutrition which have at least 30 per cent malnourished children.

Fisheries sectors are the main source of food security in Maldives and the Ministry of Fisheries, Agriculture and Marine Resources (MOFAMR) is responsible for the sustainable management and development of fisheries, agricultural and marine resource of the nation. Hydroponics Agriculture Pilot Project is one of the most important initiatives for achieving food security in Maldives taken up by the MOFAMR in 2006. The project aims to promote the development of hydroponics production system both by household and on a commercial scale to achieve food security, to provide additional avenue of employment and income generation, to increase availability of high quality horticultural products and to improve nutritional status in the nation. Besides, various food safety monitoring guidelines were developed for food processing units, resorts, hotels and guesthouse and port health authorities by Ministry of Health. These guidelines were basically developed on the lines of "Good Manufacturing Practices" (GMP) and "Good Hygiene Practices" (GHP). The government is considering the establishment of a National Food Safety Committee (NFSC) to provide a strong coordinating mechanism for uniform enforcement of food safety norms.

Market intervention aimed at both income and price stabilization, and increase in agricultural production are the main strategies for the Indian government to ensure food security for its citizen. To protect the poor from the vagaries of the market and to control production, supply and distribution of essential commodities, the Indian government introduced the Essential Commodities Act (ECA) in 1955. The main aim of the act was to ensure equitable distribution of food grains at the fair price. In the mid 1960 "green revolution" was initiated in India by encouraging the farmers to use high yielding varieties of seed, chemical fertiliser, and to expand the irrigation network. Most of the agricultural subsidies in these sectors help access agricultural inputs and improve farm productivity in the 1960's. One of the oldest initiatives taken by the Indian government was the establishment of a Public Distribution System (PDS) with the objective of making basic food grains available to all at a reasonable

price.

The PDS is seen by the government as the most effective programme to ensure food security both at national and households levels. It was implemented by the cards system. The cards entitle the household to monthly food stamps from prescribed distribution centres which could be encashed in food from any food store at a subsidised rate. In 1975, Indian government launched the Integrated Child Development Scheme (ICDs) to provide nutrition and health care services to children and women. The Antyodaya Anna Yojana (AAY) seeks to provide affordable food to below poverty level (BPL) households. The objective of the scheme is to make the PDS more focused and targeted an identified 10 million of the poorest of poor in the different states in India. Mid-day meal scheme programme was launched in 1995 for the benefit of student by supplying free food grain. In 2005, the government passed the National Rural Employment Guarantee Act to improve the livelihood security of rural households by providing them with guaranteed wage employment for a minimum number of days in a year. Semi-skilled and unskilled workers living below the poverty line in rural areas have been specifically targeted under the programme. The National Rural Employment Guarantee Scheme was preceded by the National Food for Work Programme (NFFWP) which was implemented in 2004 in 150 of the most backward districts of the country. The objectives of the programme are to provide additional resources apart from the resources available under the Sampoorna Grameen Rozgar Yojana (SGRY) to generate supplementary wage employment and to provide food security. In 2007, the Indian government approved two initiatives, the National Policy for Farmers and the Rastriya Krishi Vikas Yojana. The main objective is to secure food by supplying 25 kg food grains which are below poverty line (BPL families).

Conclusion

Food security in South Asia continues to be a serious concern due to economic constraints, reliance on food imports, climate variability, and structural weaknesses in agricultural systems. Ensuring food security requires more than sufficient production; access, stability, and proper utilization of food remain equally important. Government policies and programmes have improved food security in several countries through agricultural development, food distribution systems, income support, and nutrition schemes, though progress remains uneven across the region. Countries facing political instability and weak institutions continue to experience high levels of food insecurity, while others have benefited from sustained investments and effective policy implementation. Climate change further increases vulnerability, particularly in rain-fed agricultural systems. Achieving long-term food security in South Asia requires an integrated approach that strengthens agriculture, improves access and distribution, supports vulnerable populations, and enhances resilience to climate change.

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