School Of Humanities, Social Sciences and Management

National Institute of Technology, Karnataka

SUBJECT: Economics

PROJECT REPORT ON

Expanding the Multidimensional poverty by adding environmental dimension

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Expanding the Multidimensional poverty by adding environmental dimension

Abstract-

When evaluating multifaceted poverty and human development, environmental indicators are crucial. They record deprivations brought on by the effects of extreme weather events or by a lack of access to essential environmental resources like clean air, water, and food. Accurate poverty measurement depends on these environmental deprivations since they are linked to other aspects of poverty, such as income, health, education, and living standards. It is becoming more widely acknowledged that incorporating environmental factors into poverty indices, like the Multidimensional Poverty Index (MPI), is essential to comprehending the entire extent of deprivation. In order to achieve the Sustainable Development Goals (SDGs), this project highlights the significance of integrating environmental indicators into the measurement of poverty. They document the hardships brought on by a lack of access to essential environmental resources like clean air, water, It looks at how multidimensional poverty indices currently fall short, especially when it comes to incorporating external environmental deprivations, and suggests ways to improve poverty measurement by taking environmental sustainability into consideration. This approach provides a thorough framework for policymakers to address the interconnected problems of poverty and environmental degradation by bridging the gap between environmental sustainability and poverty measurement.

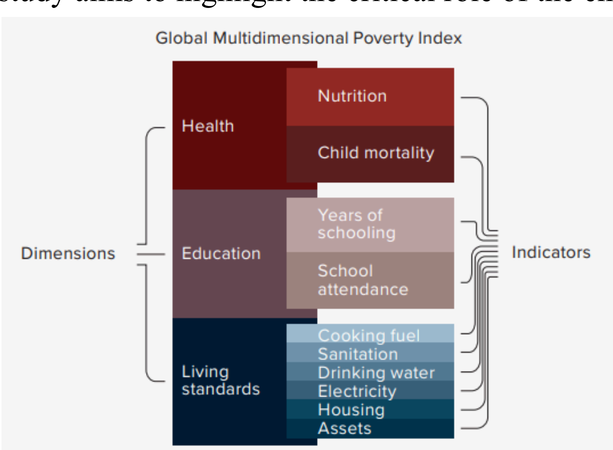
Introduction-

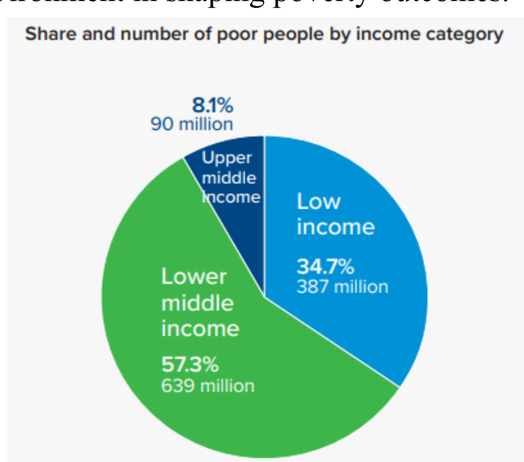
In the conversation about global development, the relationship between poverty and environmental sustainability has gained attention. Environmental indicators are now essential components of a holistic understanding of poverty, not just a supplement to measures of human development. Human deprivation is largely caused by exposure to air pollution, inadequate cooking fuels, the aftermath of natural disasters, and a lack of access to clean drinking water. The economic, social, and health aspects of poverty are closely related to these environmental deprivations, which do not exist in a vacuum. These environmental factors are crucial to the study of multidimensional poverty because, for example, the effects of climate change on agriculture or the poor air quality in urban areas frequently worsen income inequality and health vulnerabilities.

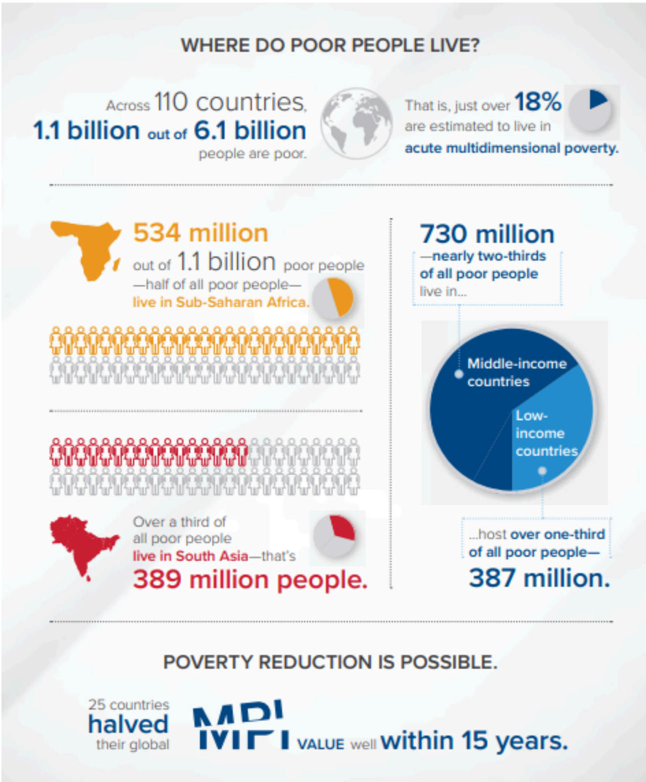
A healthy environment and human well-being are inextricably linked, as acknowledged by the Sustainable Development Goals (SDGs), especially those pertaining to poverty, health, and environmental sustainability. Tracking progress toward 13 of the 17 SDGs requires consideration of environmental factors, highlighting the necessity of integrated solutions that concurrently address social, economic, and environmental deprivations. There is still a big gap in addressing external environmental factors like climate change, natural disasters, and the depletion of natural resources, which disproportionately affect the poorest communities, even though environmental deprivations are frequently included in poverty measurement through household indicators (like access to clean water or energy). This project aims to explore the role of environmental indicators in multidimensional poverty measurement, examining how these factors can be systematically integrated into existing poverty indices to provide a more accurate picture of human deprivation. By doing so, we aim to support more informed policymaking that aligns poverty alleviation efforts with environmental sustainability goals.

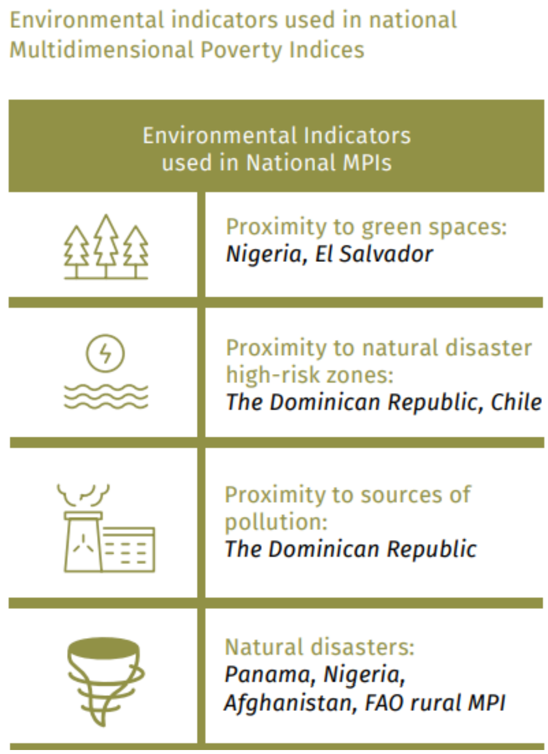
Objective-

The primary objective of this project is to integrate environmental indicators into multidimensional poverty measurement to provide a more comprehensive assessment of human development. By examining environmental deprivations—both within households (e.g., access to clean water and cooking fuel) and external factors (e.g., air pollution, natural disasters)—the study aims to highlight the critical role of the environment in shaping poverty outcomes.









Analysis-

the present level of understanding regarding climate change, its effects, hazards, and possible adaptation and mitigation measures. Surface temperatures have increased by 1.1°C since 1850–1900 as a result of human activity, mostly through greenhouse gas emissions. CO_2, methane, and nitrous oxide are the main causes of this warming, which has a negative impact on economies, human health, food security, and water security. Despite making the least contribution to climate change, vulnerable communities bear the brunt of its effects. GHG concentrations, especially CO_2, are rising to previously unheard-of levels, aggravating social and environmental problems. For well-informed policy decisions that address poverty and environmental issues, it is essential to incorporate environmental indicators into multidimensional poverty measurements. Achieving the SDGs, which connect environmental sustainability with social and economic development, depends on these issues.

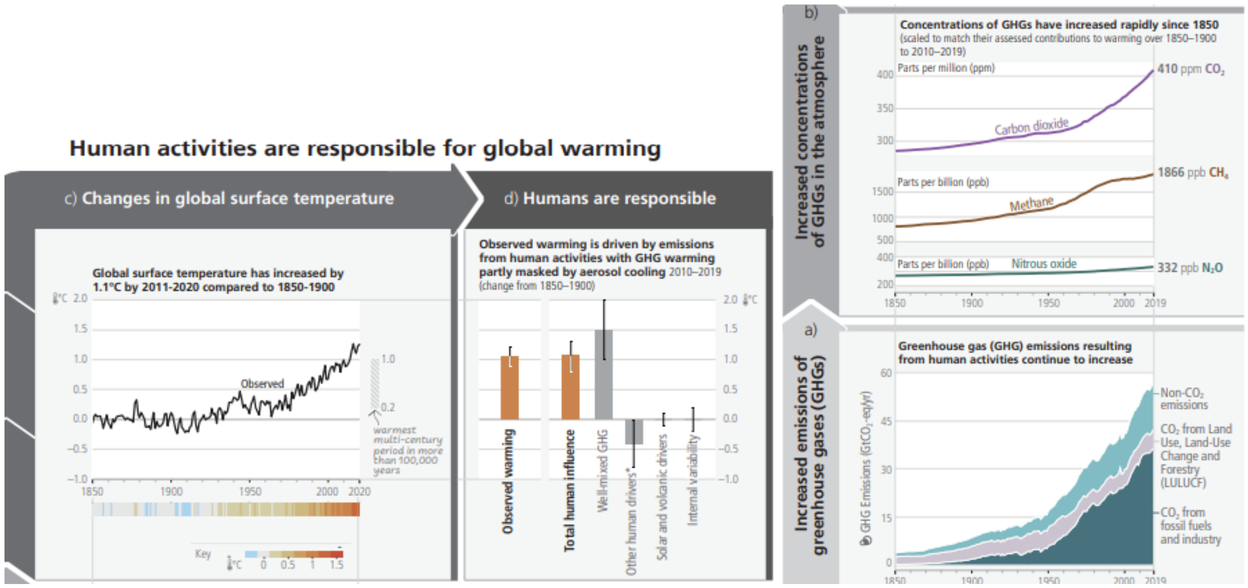


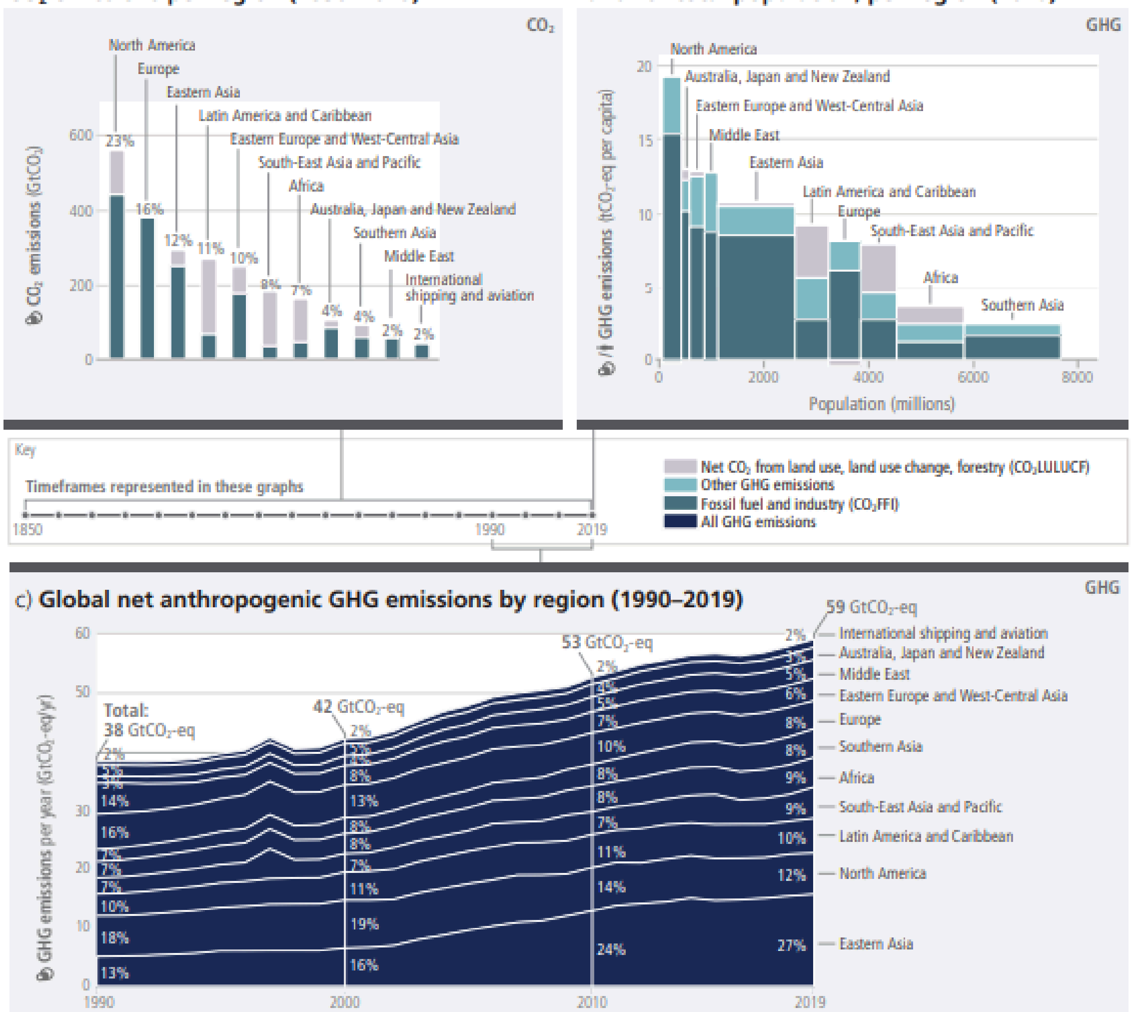
Figure 2.2 from the IPCC Sixth Assessment Report (AR6) provides a detailed breakdown of global greenhouse gas (GHG) emissions across regions, showing their contribution to the total cumulative production-based CO2 emissions from 1850 to 2019. Here's a summary of the key panels in the figure:

1. **Panel (a)**: Displays the historical cumulative net anthropogenic CO2 emissions per region from 1850 to 2019, including both CO2 emissions from fossil fuel combustion (CO2-FFI) and land-use, land-use change, and forestry (CO2-LULUCF). The uncertainty in CO2-LULUCF emissions is highlighted, with a ±70% confidence interval.
2. **Panel (b)**: Shows the distribution of regional GHG emissions in 2019 on a per capita basis, broken down into CO2-FFI, net CO2-LULUCF, and other GHG emissions (such as methane, nitrous oxide, and fluorinated gases). The area of the rectangles in this panel represents the total emissions for each region, taking into account population size.
3. **Panel (c)**: This panel visualizes global net anthropogenic GHG emissions by region over the period 1990–2019, presented in GtCO2-equivalent per year (GWP100-AR6). It shows the percentage contribution of each region to total GHG emissions during this time, noting a spike in 1997 due to CO2-LULUCF emissions from forest and peat fires in Southeast Asia.
4. **Panel (d)**: Focuses on population, GDP per person, and emission indicators in 2019, along with production-based and consumption-based CO2-FFI data. Consumption-based emissions refer to emissions released in the production of goods and services consumed by a region, excluding international shipping and aviation.

Emissions have grown in most regions but are distributed unevenly, both in the present day and cumulatively since 1850

a) **Historical cumulative net anthropogenic CO_2 emissions per region (1850–2019)**

b) **Net anthropogenic GHG emissions per capita and for total population, per region (2019)**



d) **Regional indicators (2019) and regional production vs consumption accounting (2018)**

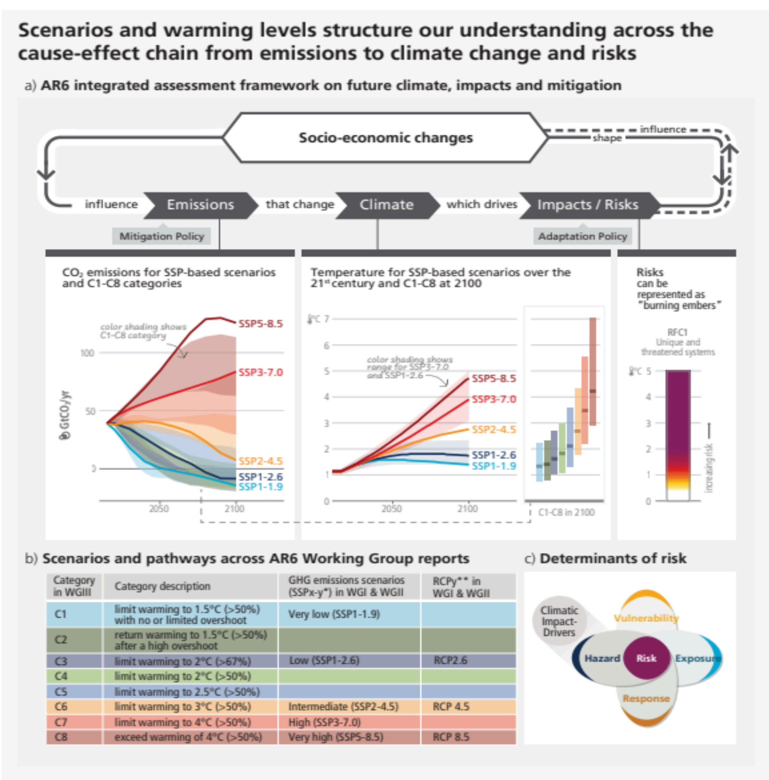
	Africa	Australia, Japan, New Zealand	Eastern Asia	Eastern Europe, West-Central Asia	Europe	Latin America and Caribbean	Middle East	North America	South-East Asia and Pacific	Southern Asia
Population (million persons, 2019)	1292	157	1471	291	620	646	252	366	674	1836
GDP per capita ($USD1000_{PPP}$ 2017 per person) [1]	5.0	43	17	20	43	15	20	61	12	6.2
Net GHG 2019 [2] (production basis)										
GHG emissions intensity (tCO_2-eq / $USD1000_{PPP}$ 2017)	0.78	0.30	0.62	0.64	0.18	0.61	0.64	0.31	0.65	0.42
GHG per capita (tCO_2-eq per person)	3.9	13	11	13	7.8	9.2	13	19	7.9	2.6
CO_2FFI, 2018, per person										
Production-based emissions (tCO_2FFI per person, based on 2018 data)	1.2	10	8.4	9.2	6.5	2.8	8.7	16	2.6	1.6
Consumption-based emissions (tCO_2FFI per person, based on 2018 data)	0.84	11	6.7	6.2	7.8	2.8	7.6	17	2.5	1.5

[1] GDP per capita in 2019 in USD2017 currency purchasing power basis.
[2] Includes CO_2FFI, CO_2LULUCF and Other GHGs, excluding international aviation and shipping.

The regional groupings used in this figure are for statistical purposes only and are described in WGIII Annex II, Part I.

The atmosphere, seas, and land have all unquestionably warmed as a result of human activity, and several elements of the climate system have seen previously unheard-of changes. It draws attention to the following:

- **Ocean Warming:** 91% of the heat in the climate system comes from warming in the upper ocean (0-700 m) worldwide since the 1970s. Human activity has been the main cause of this.
- **Sea-Level Rise:** Between 1901 and 2018, the global sea level rose by 0.20 meters, with the rate of rise accelerating in recent decades. Since at least 1971, human activity has most likely been the primary cause of this acceleration.
- **Glacier Retreat and Ice Loss:** Since the 1990s, glacier retreat has most likely been caused by human-induced climate change, and since the late 20th century, the Arctic sea ice has been declining.
- **Climate Extremes**: Extreme weather events, such as heatwaves, heavy rainfall, and droughts, have become more frequent and intense since the 1950s. Marine heatwaves, in particular, have doubled in frequency since the 1980s. Human activities are very likely responsible for most of these changes.
- **Ecosystem Impacts**: Climate change has caused severe damage to ecosystems, leading to irreversible losses in some cases. Species are shifting to new geographic areas due to heat extremes, and ecosystems like glaciers, permafrost areas, and wetlands are undergoing irreversible changes.



Insufficient funding, a lack of political frameworks, and a lack of incentives are the main causes of the financial gap in addressing climate change for both mitigation and adaptation. Actual financial flows, especially for climate adaptation, fall short of the global target of $100 billion annually. Investments from the public and private sectors continue to prioritize fossil fuels over climate action. There is an urgent need for large investments in both mitigation and adaptation, as adaptation funding is much less than what is needed, particularly in developing nations. Barriers like inadequate regulatory frameworks, misaligned capital allocation, and a lack of institutional capacity locally further aggravate this problem. Therefore, overcoming these financial obstacles and guaranteeing sufficient funding, particularly for the most vulnerable regions, are essential to effective climate action.

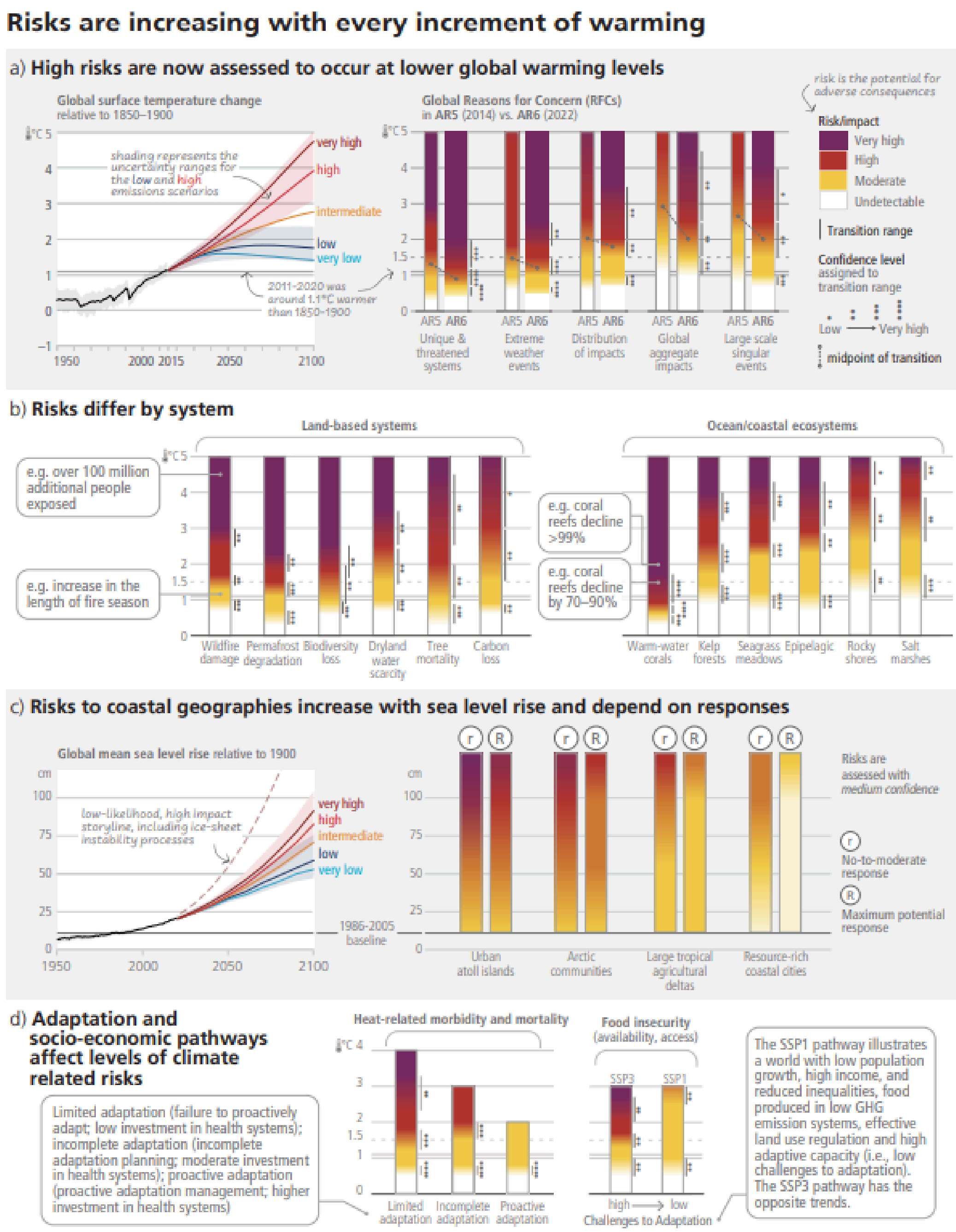
Socioeconomic trends that are used in climate modeling to forecast future greenhouse gas emissions, climate impacts, and adaptation measures are referred to as SSPs (Shared Socio-economic Pathways). A particular amount of radiative forcing (watts per square meter, or Wm2) predicted for the year 2100 is linked to each SSP. SSP scenarios range from low (SSP1-1.9) to high (SSP5-8.5) emissions, where "y" is the amount of radiative forcing.

The AR5 RCP (Representative Concentration Pathways) scenarios, on the other hand, resemble SSPs but differ from them. Though they differ in how they handle particular greenhouse gases and their concentration trajectories, they are both based on radiative forcing levels. Therefore, when compared to RCPs with the same labels, the SSPs typically project higher radiative forcing.

These scenarios form the basis for climate models assessing future warming, risks, and mitigation options. Additionally, the concept of **limited overshoot** refers to exceeding 1.5°C of global warming by up to 0.1°C (moderate overshoot) or 0.3°C (high overshoot) for a few decades before eventually stabilizing.

Long-Term Climate and Development Futures-

Future warming will be driven by future emissions and will affect all major climate system components, with every region experiencing multiple and co-occurring changes. Many climate-related risks are assessed to be higher than in previous assessments, and projected long-term impacts are up to multiple times higher than currently observed. Multiple climatic and non-climatic risks will interact, resulting in compounding and cascading risks across sectors and regions. Sea level rise, as well as other irreversible changes, will continue for thousands of years, at rates depending on future emissions. (high confidence)

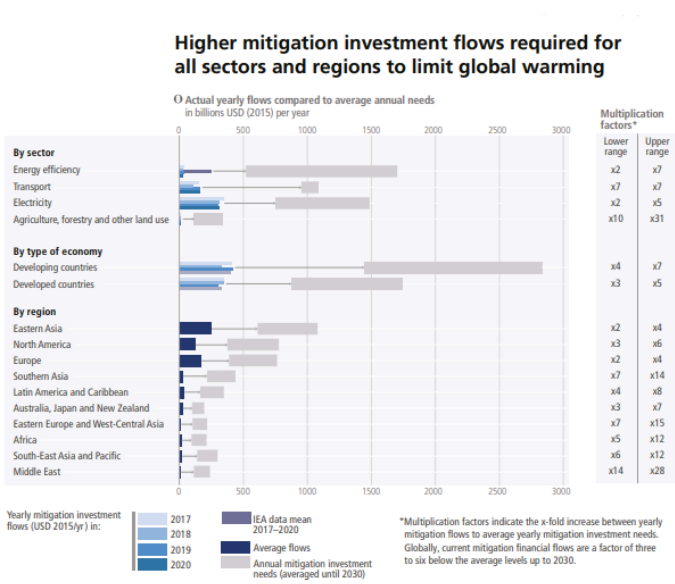


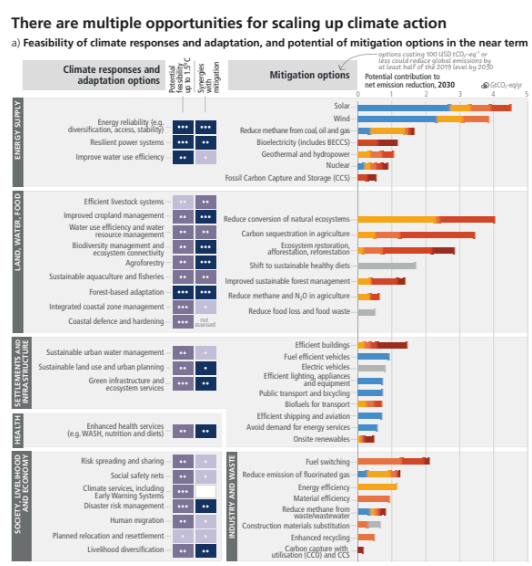
The likelihood and risks of abrupt and irreversible climate changes increase with higher global warming levels, with significant impacts on biodiversity and ecosystems. For example:

1. **Species Extinction and Ecosystem Loss**: As global temperatures rise, the risk of species extinction and irreversible biodiversity loss increases, particularly in sensitive ecosystems like **coral reefs** (very high confidence), **Arctic regions** (high confidence), and **tropical forests**. Tipping points for large-scale events, like **ice sheet instability** or tropical forest loss, are expected between **1.5°C to 2.5°C** of warming, transitioning to **very high risk**

beyond **2.5°C to 4°C**. These changes are expected to be abrupt at regional scales and irreversible over decadal to century timescales (high confidence)

2. **Sea-Level Rise**: Sea-level rise is considered unavoidable due to the ongoing deep ocean warming and ice sheet melt, continuing for centuries to millennia. The projected rise in global mean sea level will continue through the 21st century, with a significant increase in extreme sea-level events due to relative sea-level rise. By **2100**, regions that experienced extreme sea-level events once per century are expected to face such events at least annually. If warming is sustained between **2°C and 3°C**, the **Greenland** and **West Antarctic** ice sheets could be lost almost completely over several millennia (limited evidence). This would result in a significant rise in sea levels, with projections ranging from **2 to 6 meters** for a **2°C** warming scenario over the next **2000 years**
3. **Deep Uncertainty and High-Impact Outcomes**: The likelihood of **low-likelihood, high-impact outcomes** increases with higher global warming. Warming levels beyond the assessed **very likely range** for a given emissions scenario could lead to regional changes greater than anticipated. For instance, **global sea level rise** could exceed **2 meters** by **2100** under a **high emissions scenario (SSP5-8.5)**, and may even exceed **15 meters** by **2300** due to uncertainties in ice-sheet processes.





To achieve rapid reductions in greenhouse gas emissions, energy systems must transition to net-zero CO2 solutions, reducing fossil fuel use and implementing carbon capture technologies. Key strategies include widespread electrification, renewable energy adoption, and energy efficiency. Major cost-effective options include solar, wind, and methane emissions reductions. For industrial emissions, efficiency, electrification, and low-emission fuels are crucial, while cities can reduce emissions through integrated planning, low-carbon buildings, and sustainable transport. Adaptation strategies are also vital, addressing climate impacts on energy systems, industries, and urban infrastructures

The breakdown of mitigation investment flows and needs until 2030 highlights key areas such as energy efficiency, transport, electricity, and agriculture, forestry, and land use. It shows the disparity between current investment flows (2017-2020) and the necessary future investments across sectors and regions. For example, investment flows in energy efficiency, transport, and electricity are compared to the required levels of mitigation investment, which are significantly higher, reflecting the gap that needs to be closed. These figures provide insight into the scale of investment needed for a transition to a low-carbon economy.

On the broader issue of innovation, international cooperation is crucial, but it must be tailored to local value chains, ensuring capacity building and equal partnerships. However, technological innovation can have trade-offs such as increased environmental impacts, social inequalities, and reliance on foreign technology. Digitalization, while promoting energy efficiency, can lead to higher consumption and electronic waste, so policies need to address these negative effects.

The integration of climate adaptation and mitigation, focusing on ecosystem resilience and human well-being, offers numerous benefits. For example, sustainable land-use strategies can reduce emissions while benefiting biodiversity, food security, and ecosystem services. Coordination of mitigation and adaptation strategies across sectors like agriculture, land use, and urban planning can also have cascading effects, leading to substantial environmental and socio-economic benefits. Integrated policy approaches that consider equity, gender equality, and justice will be key in realizing these benefits.

MPI With Environmental Factor

The integration of environmental indicators into poverty measurement is essential for developing a more comprehensive understanding of poverty and its drivers. Currently, various countries incorporate specific environmental indicators into their national Multidimensional Poverty Indices (MPIs). These include factors like **proximity to green spaces** (Nigeria, El Salvador), **proximity to natural disaster high-risk zones** (The Dominican Republic, Chile), and **proximity to sources of pollution** (The Dominican Republic). These indicators reflect environmental deprivations that extend beyond the household level, indicating how the environment can impact an individual's or household's well-being.

The need to refine and standardize environmental indicators across regions remains critical. Context-specific factors significantly influence how environmental deprivations are measured. For instance, indicators related to pollution or natural disaster risks may be more relevant in some regions than others. This emphasizes the importance of identifying environmental indicators that can be universally applicable while maintaining relevance to local conditions. For example, incorporating an indicator of **preparedness for extreme natural events** could provide valuable insights into a household’s or individual’s resilience to climate change, an issue increasingly significant across the globe.

In the process of advancing these environmental indicators, there is also a push to harness **emerging geospatial datasets** to calculate more accurate environmental deprivation measures at the individual or household level. These datasets can be essential in providing real-time, location-specific data that is aligned with other dimensions of poverty. However, these efforts require **extensive research** and **stakeholder consultations** to ensure that deprivation thresholds are well-defined across various contexts.

A key recommendation is to not let the pursuit of perfection hinder the exploration of new domains of human development, such as environmental deprivations. Existing data sources, like **DHS (Demographic and Health Surveys)**, can provide a foundation for these new indicators. By making small adjustments or additions to the questions in these surveys, researchers can begin to collect more relevant data on environmental factors without significantly increasing survey length or complexity.

This approach could be instrumental in not only expanding the **Multidimensional Poverty Index** to include new environmental dimensions but also in ensuring the index captures **moderate poverty** across regions, providing a clearer picture of the challenges faced by a broader segment of the population.

Integrating emerging dimensions of poverty, such as the **digital divide** and **environmental vulnerabilities**, into existing measurement frameworks presents both opportunities and challenges. Here's how these aspects can be addressed:

1. The Digital Divide:

The digital divide, particularly regarding access to technology and the internet, is a dimension that can be measured more directly through household surveys. For example, existing surveys like the **Demographic and Health Surveys (DHS)** already include questions on **cell phone ownership** and **internet access**, which can be used to gauge the digital divide. Integrating questions about internet use and access, especially with a gender focus (e.g., comparing access for women and men), could help track how digital inequalities contribute to broader poverty measures.

Given the increasing importance of digital access in modern economies, this dimension can be more feasibly included in national surveys, with clear definitions and thresholds. Key considerations for integrating the digital divide into poverty measures include:

- Ensuring **actionable** indicators that governments can use to develop policies (e.g., internet access as a basic service or a tool for economic advancement).

- Ensuring **representative** data that can be disaggregated by region, gender, and socioeconomic status to highlight the varying impacts across different groups.

2. Environmental Vulnerabilities:

Measuring **environmental vulnerabilities** is more complex due to the difficulty in directly linking household deprivations (such as crop loss or income loss) to environmental factors like climate change or natural disasters. A **household survey** could ask about environmental-related hardships, but these questions often reflect perceptions rather than direct causality.

To capture environmental vulnerabilities more accurately:

- **Overlaying geospatial data** (such as changes in temperature, tree cover, or proximity to natural disaster zones) with household-level survey data can provide a clearer picture of the role of environmental factors in poverty. For example, measuring how climate patterns correlate with household-level deprivations can help in understanding the broader environmental context.
- **GPS data** can be valuable for matching environmental data with household locations, though its use must be handled with care to maintain **confidentiality**. However, since this raises concerns about data sensitivity, appropriate **data protection measures** need to be in place, such as displacement of GPS coordinates to ensure privacy.

The integration of environmental vulnerabilities into poverty measurement frameworks is challenging, but the combination of **survey data** and **geospatial indicators** could help provide a more comprehensive understanding.

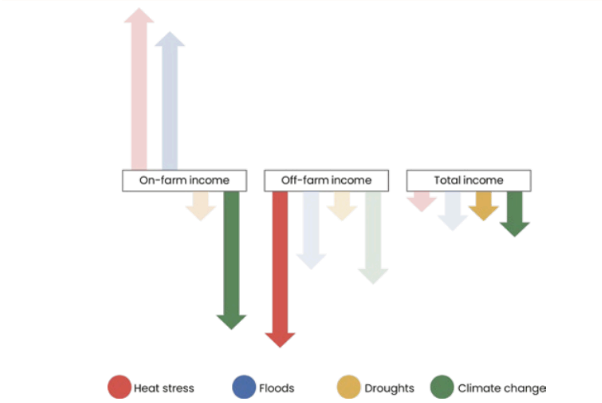
3. Prioritizing Survey Questions:

Given the limited space in household surveys and the competition for inclusion of new indicators, it's crucial to prioritize questions that are both actionable and meaningful. This means:

- Ensuring that indicators are **relevant** and aligned with **policy needs**. Questions should be focused on dimensions that have a direct impact on policy making and poverty reduction, not merely aspirational data points.
- Ensuring **feasibility**, i.e., that the data collected can be disaggregated and used across various contexts and populations.

Focus on India

The relation between climate stressors and incomes of poor Indian households



Characteristics of poor and better-off Indian households

	Full sample (1)	HHs in poverty (2)	Better-off HHs (3)	Difference (2)-(3)
Household characteristics				
HH size	5.58	5.20	5.75	-0.56***
Female HH head	0.09	0.09	0.09	-0.00
Age head	51.07	49.08	51.97	-2.89***
HH head years of education	4.75	2.87	5.60	-2.73***
Social protection	0.46	0.50	0.44	0.07***
Agricultural endowments				
Cultivated land area, in ha	0.63	0.47	0.71	-0.24***
Livestock owned (TLU)	1.12	92.00	1.16	-0.14***
Agricultural expenditure	146.88	92.00	171.83	-79.83***
Income variables				
On-farm income	987.45	789.23	1 077.54	-288.31***
Off-farm income	873.52	656.30	972.25	-315.95***
Total income	1 885.17	1 462.05	2 077.48	-615.43***
Income diversification	0.52	0.49	0.53	-0.04***
Observations	11 572	3 616	7 956	11 572

Note: All income variables are measured in USD per adult equivalent (OECD) and adjusted to 2011 purchasing power parity (PPP) (World Bank). TLU = Tropical Livestock Unit.

Source: authors' elaboration, based on own calculations.

The analysis highlights key characteristics that differentiate poor households from better-off ones, showing the various factors contributing to their vulnerabilities, especially in the context of agriculture, income generation, and climate stressors:

1. **Youth and Education**: Poor households typically have younger heads and less education. The lack of education correlates with a lower capacity to adapt to climate-related shocks. This emphasizes the need for educational interventions to boost adaptive capacity.
2. **Agricultural Assets**: Poor households have significantly smaller land holdings and fewer livestock, critical assets for resilience. Limited investment in agricultural inputs such as improved seeds and fertilizers reduces their productivity, making them more vulnerable to shocks.
3. **Income and Diversification**: Poor households rely more on precarious off-farm income and have less diversified sources of income. This lack of diversification exposes them to greater financial risks during climate events, underscoring the need for income diversification strategies.
4. **Social Protection**: Despite having lower incomes, poor households often rely on social protection programs, which can be crucial in buffering the effects of climate change. Expanding such programs could provide more robust protection against climate stressors.

Policy Recommendations:

1. **Anticipatory Social Protection**: Expanding programs that can be scaled up in anticipation of extreme weather events could prevent more people from falling into poverty during such crises.

2. **Workforce Diversification**: Supporting off-farm employment through vocational training and mentorship can enhance skills, making workers more adaptable to diverse economic opportunities.
3. **Gender Equality**: Addressing gender barriers, particularly in non-farm employment, by using transformative methodologies can help women participate more fully in the economy.
4. **Group-Based Agricultural Extension**: Participatory, group-based approaches can help farmers collaborate on shared challenges, reducing individual risk and promoting collective resilience.
5. **Technology Access**: Supporting access to climate-resilient agricultural technologies can boost productivity and help farmers adapt to changing environmental conditions.

Environmental MPI Indicator for Measuring Poverty:

1. **Air Quality & Pollution:**
   Indicator: % of the population exposed to harmful air pollution (PM2.5 above WHO thresholds).
   Justification: Poor air quality leads to health issues, exacerbating poverty, especially in urban areas (WHO, 2023).
2. **Access to Clean Water:**
   Indicator: % of households with access to safe drinking water.
   Justification: Lack of clean water directly impacts health and economic productivity (UNICEF, 2020).
3. **Deforestation & Land Degradation:**
   Indicator: % of households in areas with significant deforestation or soil degradation.
   Justification: Loss of agricultural productivity and food insecurity due to environmental degradation (FAO).
4. **Climate Change Vulnerability:**
   Indicator: Households in areas prone to extreme weather events (floods, droughts).
   Justification: Extreme weather exacerbates poverty by threatening livelihoods, housing, and food security (IPCC).
5. **Waste Management & Sanitation:**
   Indicator: % of population with access to improved sanitation.
   Justification: Poor sanitation leads to disease outbreaks, contributing to poverty cycles (World Bank).

The formula for MPI could be extended as:

MPI=1d∑i=1n(Dimension 1)i×(Dimension 2)i×⋯×(Environmental Dimension)where:

- **d** is the number of dimensions (4 in this case)
- **i** represents individuals in the sample
- Each dimension's value (including the environmental one) is quantified on the basis of available data.

Formula:

eMPI=1/5(A1+A2+A3+A4+A5)
Where A_1–A_5 represent each of the environmental factors. This composite index captures environmental poverty and can guide actionable policy for improving living conditions.

By integrating these factors, the Environmental MPI provides a comprehensive assessment of how environmental vulnerabilities intersect with poverty, aiding in targeted development efforts.

Justification:

1. **Relevance**: The factors selected are directly correlated with environmental poverty and are widely recognized by global organizations such as the **UN**, **WHO**, **FAO**, and **World Bank** as major contributors to poverty. The multidimensional nature of poverty is well-reflected by these indicators, which combine both health-related and livelihood-related environmental factors.
2. **Actionability**: Each of these indicators is actionable. Governments and policymakers can use them to identify key areas where interventions are needed. For instance, access to clean water can be improved through infrastructure investments, while air quality can be managed through stricter pollution controls.
3. **Global Comparability**: The use of globally recognized datasets like satellite data for deforestation and air quality measurements ensures that the **eMPI** can be applied across countries and regions, allowing for **cross-national comparisons**. This helps in targeting international development goals, especially those related to **SDGs (Sustainable Development Goals)** such as **SDG 6 (Clean Water and Sanitation)** and **SDG 13 (Climate Action)**.
4. **Disaggregation**: The index allows for the disaggregation of data by subpopulations (e.g., by gender, rural/urban areas, income levels) to highlight specific vulnerabilities within different demographic groups. For example, women in rural areas often face more limited access to clean water, so this could be reflected in the indicator for targeted action.
5. **Long-Term Impact**: By including these environmental factors, the **eMPI** provides a way to track long-term environmental impacts on poverty and development. Monitoring these

factors can help anticipate and mitigate future poverty risks due to environmental degradation and climate change.

Example Workflow in Python:

1. **Data Collection**: Using internet sources (like WHO, World Bank, or satellite data).
2. **Preprocessing**: Cleaning and normalizing the environmental data.
3. **Integrating Environmental Data**: Merging environmental indicators with existing MPI data.
4. **Calculating the Expanded MPI**: Using Python code to compute the final MPI score

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