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Climate Adaptation: Building resilience through structural transformation

Pranab Mukhopadhyay

Professor of Economics
Goa Business School,
Goa University, India
pm@unigoa.ac.in

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About the COVID-19 Response and Recovery project

This paper is an output from the project "Response and Recovery: Mobilising financial resources for development in the time of COVID-19", which is co-ordinated by the Debt and Development Finance Branch of UNCTAD and jointly implemented with ECA, ECLAC and ESCAP. This project is one of the five UN Development Account short-term projects launched in May 2020 in response to the COVID-19 crisis.

The project aims to enable low-income and middle-income developing countries (LICs and MICs) from Africa, Asia-Pacific, and Latin America and the Caribbean to diagnose their macro-financial, fiscal, external financial and debt fragilities in the global context, and design appropriate and innovative policy responses to the COVID-19 pandemic leading toward recoveries aligned with the achievement of the Sustainable Development Goals (SDGs).

Abstract

Climate change has deepened the vulnerability of multiple groups of the population, particularly the poor. The development challenge for low-income countries would be to reduce vulnerabilities – some of which are climate-related. In many instances, the pre-existing vulnerabilities have been aggravated by climate variation.

In this paper, we use a new version of the database from the Global Policy Model (GPM) of the United Nations. It combines longitudinal data of conventional macroeconomic variables with various climate variables. It thus permits us to examine macro-dynamics of income, employment, and distribution within the climate change framework. This paper focuses on a group of thirty countries (G-30 countries) and uses a transition analysis method over 40 years (1978-2018). It attempts to understand the trajectory of different countries based on their geographical location, level of economic development, demographic and climate characteristics.

Adaptation strategies should avoid re-enforcing pre-existing unequal social and economic hierarchies, especially in the context of race and gender. Unless marginalised populations are made partners in the adaptation strategies and made locally relevant, there is a risk of adverse outcomes. A positive intervention by the governments as proposed in the SDGs would help in addressing the racial and gender inequalities that have been historical institutionalised.

Ensuring domestic social safety nets, guaranteeing employment and building green infrastructure would help them transform structurally to sustainable paths. Unfortunately, development expenditures are the first items that get reduced in fiscal restructuring. New investments must be planned in a manner that ensures a non-declining intertemporal trajectory of comprehensive wealth. International cooperation is critical not only for development and economic reasons but also for ecosystem and biodiversity conservation.

Keywords: Spatial development challenges, Green structural transformation, climate change, adaptation.

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Climate change will add in a significant way to the existing developmental challenges that most lower-middle-income and poor countries have faced (IPCC, 2014a). Macroeconomic simulations suggest that damages caused by climate change would have a downward impact on aggregate demand (through reduced profitability, investment) and employment (Rezai et al., 2018). If anthropogenic pressures continue to increase, there could be catastrophic impacts on human wellbeing if we cross certain "tipping points" (Westley et al., 2011).

While there is a near-global consensus that there is a need for climate change action, there have been protracted international debates on achieving cooperation. While climate economics was devoted mainly to mitigation in the earlier years (Nordhaus, 1977), it has since engaged with other issues, including adaptation (Vale, 2016). The earth's systems already have to deal with the early effects of climate change. It is quite evident that mitigation efforts may not be adequate in the short run.

1.1 The Paris Agreement and NDCs

The most recent Paris Accord of 2015 was adopted by 196 Parties (https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement). The main objective of the Paris Accord was to achieve a (1) ceiling of 2 degrees centigrade compared to pre-industrial levels and (2) "climate neutral" status by 2050. While setting the global target, this Accord left it to individual nations to decide on their own feasible targets and strategies through Intended Nationally Determined Commitments based on the principle of "common but differentiated responsibilities and respective capabilities." On finalisation of the national commitments, these were submitted to the UNFCCC as the Nationally Determined Commitments (NDCs) to be reviewed every five years starting in 2023. At the time of writing this paper, 190 parties had already submitted their first NDCs, and eight parties had submitted their second NDCs (https://www4.unfccc.int/sites/ndcstaging/Pages/Home.aspx). Achieving the NDC targets poses multiple challenges and involves lifestyle changes at the household level and production transitions to low carbon methods for industries, among others (Vrontisi et al., 2020).

Since there are no accountability mechanisms in the Paris Accord, one way to trigger NDC commitment compliance by developing countries is for developed countries to signal in their NDCs the extent of funding they will make available for climate finance (Pauw et al., 2019). However, there remains a gap between the projected need and the committed funds (Buchner et al., 2019). Apart from the NDCs, member countries of the UN are also committed to achieving the Sustainable Development Goals (SDGs), many of which deal with reducing vulnerability apart from Goal 13 on climate action (UN, 2015).

1.2 SDGs and NDCs

The fulfillment of NDC commitments and SDG targets by less developed countries (LDCs) and Small Island Developing States (SIDS) is particularly challenging. It may be contingent on receiving international cooperation by way of finance, technology transfer, and capacity building (Pauw et al., 2020). Such cooperation would help developing countries plan their strategies to overcome climate vulnerabilities more effectively. The term vulnerability in this paper is broadly defined as the proneness of a natural or social system to be displaced to an inferior position (including welfare, health, income) by an event or a process (sequence of events). Such displacements may occur due to climate or non-climate-related processes. Climate change may compound existing vulnerabilities and therefore leading to cascading effects, remedied to which would not lie in the domain of climate solutions alone.

Researchers have identified regions (Watson et al., 1998) that will be most adversely affected by climate change – labelled as "hot spots" (Schleussner et al., 2018). Two approaches have been adopted to identify these locations – (a) which region is most vulnerable (Malone & Engle, 2011) and (b) which region will see the most change in climate variables (Giorgi, 2006). While the latter is important from the point of view of spatial climate assessments, the former will be of greater concern to those studying impacts on human well-being due to climate change.

One of the direct consequences of climate change has been the increased frequency of extreme events and increased intensity of extreme weather events (Frame et al., 2020). A recent review comparing disaster events over four decades (UNDRR & CRED, 2020) found that the last two decades have seen a near doubling of disasters and the economic costs of disasters compared to the earlier two decades. The impact on livelihoods due to extreme events is particularly worrisome. Notably, the report points out that floods (44%, and associated with it, landslides, 5%) and storms (28%) are the two most frequently reported climate disasters globally. These are followed by heatwaves (6%), droughts (5%), and wildfires (3%). Floods affected the largest number of people (41%), followed by droughts (35%) and storms accounted for the largest number of deaths due to climate-related events. The top ten countries that reported disasters in the last two decades are (China, the USA, India, Philippines, Indonesia, Japan, Viet Nam, Mexico, Bangladesh and Afghanistan, in decreasing order). While China's major problem was floods, for India, it was drought. This suggests that climate-related events have varied impacts depending on what we are focusing on -- the type of event, the number of deaths, people affected, among others.

We examine the growth and development challenges of countries ranging from low to high-income countries in the context of climate change. Many of these countries have sections of the population that are already vulnerable due to poverty and lack of social security, uncertain employment, which continue to be development challenges. Their vulnerability would be particularly exacerbated by climate change. The rural economy becomes risk-prone with agricultural unsustainability, and urban areas fail to provide employment and social safety nets to migrant workers. The poor in developing countries face the risk of receding government involvement from the economic and social sphere, thereby accelerating inequality. Such economic and political trajectories would further reduce the

possibility of the economy's autonomous structural transformation without endangering the profit-wage shares.

These three factors (climate change, urbanisation, and migration), in addition to technology, have been seen as the most significant factors impacting inequality (UN DESA, 2020). Inequality between countries has reduced over time but has steadily increased within countries and among income deciles. This has social and economic implications which have a direct bearing on sustainability. This could imply increasing vulnerability of groups that are getting economically, socially, and politically marginalised, a process exacerbated by climate change (Olsson, 1993).

1.3 Market failures and fiscal policy

Environmental management failures are typically attributed to the failure of either the market or the government (Hepburn, 2010). However, governments are answerable to their citizens, and most countries have internal mechanisms for course correction when governments deviate significantly from national priorities. Markets on their own are rarely known to have the ability to correct failures in allocation, especially when it deals with equity. Therefore, market failure is a serious problem associated with environmental management and achieving environmental sustainability (Rosenbloom et al., 2020). This creates the need for state intervention, both in environmental management and addressing vulnerability, especially for marginalised groups (Rosewarne, 2010). One of the direct ways to achieve this, especially in developing countries, would be to ensure guaranteed employment, food security and access to affordable public health by the state (Osberghaus et al., 2010). This would help build resilience against loss of livelihood, especially during disasters that are likely to increase in frequency with climate change.

An employment guarantee policy would have multiplier effects on the economy resulting in robust demand-driven growth (Patnaik, 2005). Climate proofing of the economy would require a structural transformation with investments in green sectors. It would need switching to non-fossil fuel production and low-emission industrial strategies on the one hand (Gallagher & Kozul-Wright, 2019) to expanded irrigation networks and guaranteed minimum income for farmers on the other. This may be a pathway for balanced growth and reduced inequality and rural indebtedness. All of this would require a planned development strategy that would use the climate change challenge as an opportunity to meet the economic and social needs of low-income countries. Typically, with growing international trade in goods and services and liberal, volatile international financial flows, the independence of small nation-states to pursue an independent fiscal and monetary policy is fast receding (Izurieta et al., 2018). The pressure of financing climate change adaptation may further reduce this fiscal space for developing countries for other (non-climate) developmental actions.

When developing countries attempt to finance climate change adaptation by borrowing internationally at market rates, their macroeconomy becomes vulnerable. The known macroeconomic threats are exposure to exchange rate shocks and volatile capital flows (Bhaduri, 2009). The borrowing for adaptation would then have to be in addition to financing needs of existing current account deficits. This makes developing economies vulnerable to pressure from international capital to remove capital controls leading to a loss of national autonomy in domestic monetary and fiscal policy (Patnaik, 2011). Under these circumstances, developing country governments would be left with little fiscal

independence to pursue their national developmental agenda or pursue adaptation measures optimally. This necessitates the need for international cooperation that would make it possible for developing nations to maneuvre their fiscal balance to meet their national developmental needs and international climate commitments. It has been pointed out that a rising gap on the current account could have an impact on domestic deficits (Rakshit, 2009). This is in contrast to the proposition that the cause of rising current account deficits may be domestic deficits. Therefore, opening up of trade controls, especially financial controls, can impose trade-offs for national governments and limit their freedom to choose national priorities, and allocate development funds to meet both the NDC targets and the SDG goals.

1.4 SIDS and climate change

The need for such policy cooperation is even more important for the Small Island Developing States (SIDS). The UN has treated such nation-states as a separate group that will face the most significant impact of climate change, including sea-level rise, tropical cyclones, and marine heatwaves (Thomas et al., 2020). The ethical dilemma for the rest of the world remains that these island states, home to about 65 million people, have the lowest ecological footprint contributing to climate change. Nevertheless, they will be the frontline of climate change damages with varying abilities to mitigate or adapt to climate change. This group geographically is spread over three regions the (i) the Caribbean; (ii) the Pacific; and (iii) the Atlantic, Indian Ocean, Mediterranean and South China seas (AIMS) and are considered one of the hot-spots for climate change.

1.5 Gender impacts

Climate change is expected to have a heterogeneous impact with respect to gender. Existing gender gaps in wealth (Deere et al., 2013; Frémeaux & Leturcq, 2020), employment (WB, 2014), education (Buchmann et al., 2008), family decisions (Mossman, 1994), health services (Shaw et al., 2017), political representation (Childs & Lovenduski, 2013; Kenworthy & Malami, 1999), and gender violence (Garcia-Moreno & Watts, 2011), among others, are expected to be amplified by climate change due to multi-layered social hierarchies. The need for state intervention to remedy such gaps and international cooperation to build resilience will have an added dimension when discussing gender issues.

The rest of the paper is organised as follows. We describe the scope of the study and the data sources in the next section 2. In section 3, we describe the socio-economic and climate vulnerabilities that different regions face. We discuss these vulnerabilities in the context of geographical location and look at linkages between them. In section 4, we discuss the development and growth challenges that currently exist. We conclude in section 5 with a discussion on some of the potential policy interventions that can address the dual challenges of development needs and climate change adaptation which may seem contradictory in certain situations.

2. Scope and Methods

2.1 Data

In this paper, we use a new version of the database from the Global Policy Model (GPM) of the United Nations (Cripps et al., 2010). This new version combines longitudinal data of conventional macroeconomic variables with various climate variables. It thus permits us to examine macro-dynamics of income, employment, and distribution within the climate change framework.

There are three popular ways in which countries are classified (Nielsen, 2011). The World Bank (WB) classifies countries by per capita income (World Bank, 2020). The International Monetary Fund (IMF) classifies countries by per capita income and trade and financial openness (IMF, 2021). The United Nations (UN) classifies based on income, health, and education (UN, 2020). The WB classifies countries into four groups -- high-income countries, upper middle income, lower middle income and low-income countries. The IMF classifies countries into two groups – advanced economies and non-advanced economies (emerging market and developing economies). The UN classifies countries into three groups, developed economies, economies in transition and developing economies. The WB offers a little more heterogeneity than the IMF and UN classification and uses a single variable (income) that is easily understood even outside academic and policy domain. Despite the limitation of income as a single indicator of development (UNDP, 2019), for the limited purpose of this paper, we have used this variable to group countries.

2.2 Scope of the study

This paper focuses on a group of thirty countries (for convenience called the G-30 countries) similar to McKinley (2021). The G-30 is a cluster of countries across all continents representing different development status, income levels, and geographic locations (high income – Australia (AU), Canada (CA), Chile (CL) France (FR), Germany (DE), Italy (IT), Japan (JP), South Arabia (SA), South Korea (KR), United Kingdom (UK), United States of America (US),,; upper middle income -- Argentina (AR), Brazil (BR), China (CN), Ireland (IR), Mexico (MX), Russia (RU), Turkey (TR), South Africa (ZA); lower middle income -- Bangladesh (BD), Democratic Republic of Congo (CD), Egypt (EG), Indonesia (ID), India (IN), Nigeria (NG), Philippines (PH), Pakistan (PK), Viet Nam (VN); and low income -- namely Ethiopia (ET) and Tanzania (TZ). These countries differ not only in their income but also in their spatial, climatic, demographic, and development status.

2.3 Transition dynamics method

Our study uses a transition analysis method suggested by Quah (1993, 1997), which examines the distribution of countries in multiple phases of their progression. It checks whether a country that started in a particular cohort ends with the same cohort is relatively worse or better off. This analysis uses the Markov process as a distribution dynamic framework to map the transition of economies and is popular in growth convergence studies (Maasoumi et al., 2007). We rely on a graphical representation for the transition analysis through the paper to keep the arguments accessible to a non-technical audience. The two periods that we compare are 1978 and 2018. Although data for many variables are available from 1975, however, we have used 1978 as the initial year for our analysis to round off a four-decade change analysis given that the most recent actual data available is for 2018.

We use the US per capita income (PCI) of 1978 (US $30646 at US $2015 PPP) as the benchmark for change as it was the highest PCI during that period (apart from Saudi Arabia). We refer to this as the aspirational PCI for all other countries (except SA). SA, whose PCI was already higher than that of the USA in 1978, is an outlier and an oil exporter. We have therefore not used Saudi Arabia for comparative purposes here. All monetary values are normalised for 2015 prices in US $ purchasing power (PPP) terms to allow for comparability (UN DESA, 2010, updated version).

3. Development challenges and Geography

3.1 Spatial Vulnerability

Climate change will have differentiated impacts on different countries -- depending on their geographical location, their per capita income, level of development, demographic characteristics, among other characteristics.

It is well-recognised among economists now that space matters in economic outcomes (Krugman, 1991). Climate science too confirms that geographical location is an essential determinant of the nature and extent of the impact of climate change (Husnain et al., 2018). It would therefore be a natural extension to ask how geographical location impacts economic outcomes in the context of climate change (Arnell et al., 2019).

Let us start by placing countries with respect to their distance from the equator with a separation at the Tropic of cancer and Tropic of Capricorn. It has been pointed out that weather patterns and ecosystems differ between the tropic and temperate zones (Welcomme & Berkowitz, 1991). Since countries lie on either side of the equator, for convenience, we have taken the absolute difference in latitude (so all distances are positive). Further, some countries are spread over many latitudes and may have both tropical and temperate weather in different parts. We have taken the capital as the central location and accordingly determined its location.

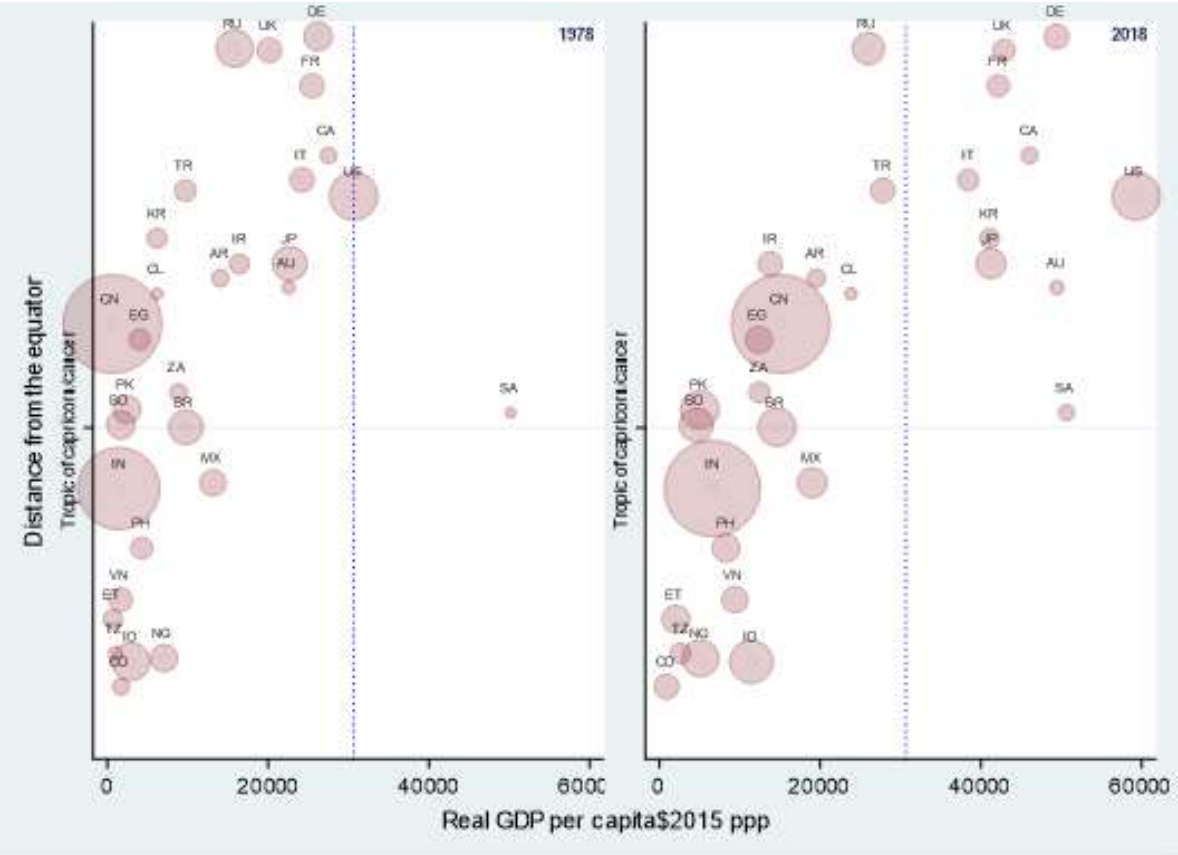
We start by plotting a scatter of distance (vertical axis) and PCI (horizontal axis) for the start year (1978) and end year (2018) for comparison **(Figure 1)**. There are two reasons why this mapping has important implications in the context of climate change. First, temperatures in the tropics are expected to rise slower than in the polar zones (IPCC, 2014a). However, the adverse impact on human populations will be much greater in tropical regions due to complex climate dynamics and exposure of populations.

This implies that heatwaves and droughts will become more prevalent in the tropics. Consequently, it will have direct adverse impacts on the population residing in the tropics and increase their vulnerability and adaptation costs. For urban populations, climate-induced mortality and morbidity are attributed to heat waves and heat islands (Campbell et al., 2018; Wong et al., 2013).

Over these forty years, there has been considerable growth in PCI for most countries under consideration. By 2018, many countries have achieved and overtaken the aspirational PCI. Interestingly, none of these countries belong to the tropics. They all belong in the temperate zone. However, one must add that not all countries in the temperate zone have achieved the aspirational

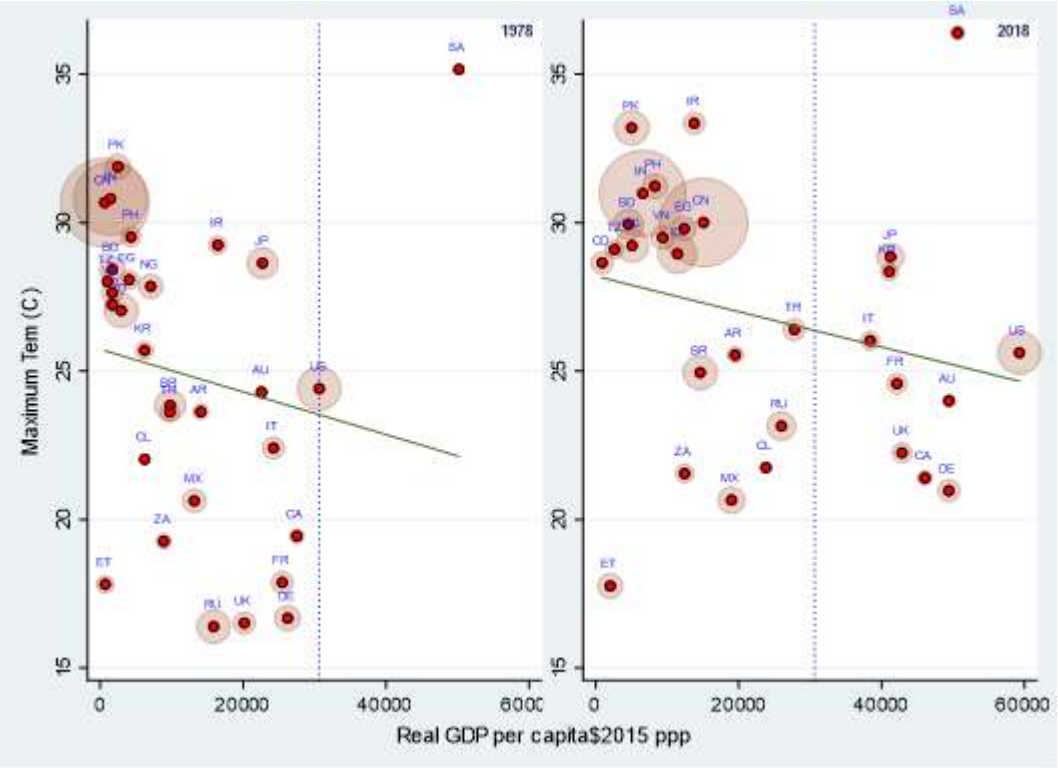
PCI yet.

Figure 1: Distance from the Equator and PCI



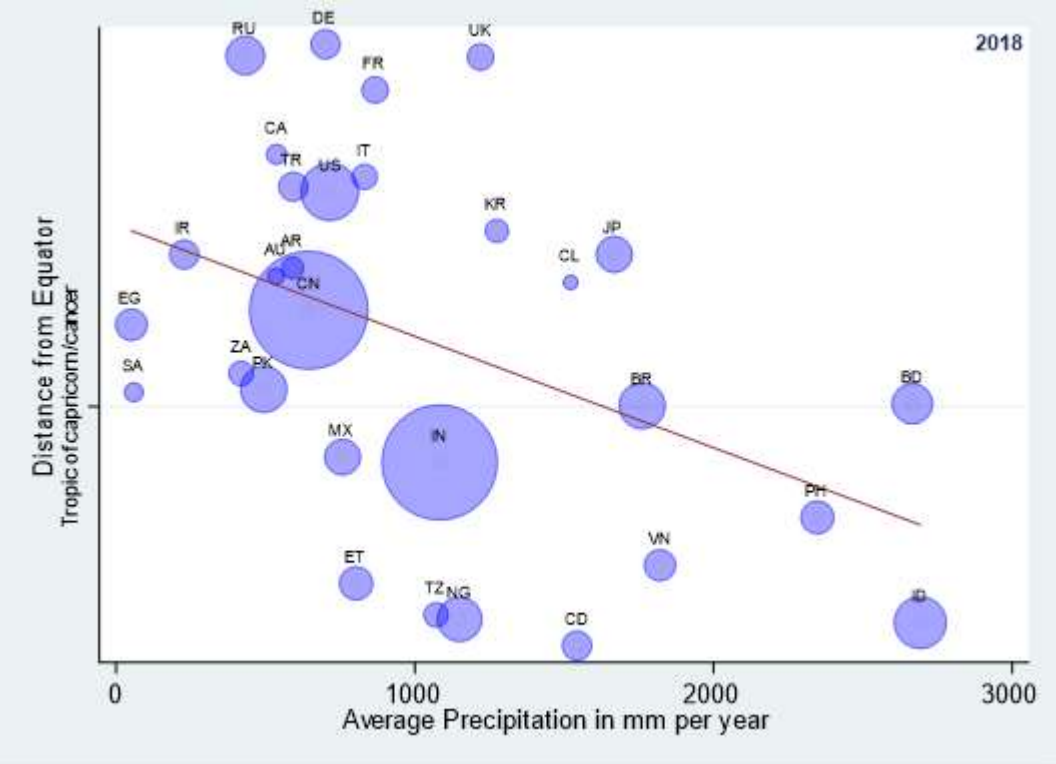
This trend is reflected in the relation between PCI and maximum temperatures. If we compare the 1978 and 2018 scatter plots (**Figure 2**), we find that countries with lower maximum temperature forged ahead in the last 40 years in comparison to others among G-30 countries. No country with a maximum above 30C has reached the aspirational PCI yet. Since climate change is expected to raise temperatures, relatively hot countries will face a greater challenge in ensuring healthy working spaces (ILO, 2019; Kjellstrom et al., 2016). It will lead to a larger burden of mortality and morbidity as well as add to the costs of adaptation. On the production front, maintaining efficient work conditions, productivity and growth would be a challenge for these countries.

Figure 2: PCI and Maximum Temperatures



There is another aspect of weather that is impacted by climate change -- precipitation. Extreme rainfall events would lead to two diverse outcomes -- the lack of it will lead to droughts (and heatwaves, forest fires), and the excess of it would cause flooding and landslides (IPCC, 2014b; Tabari, 2020). While it may seem that drought and flooding events would be spatially distanced but there is increasing evidence that the contrary may be true. Marengo et al. (2020) provide evidence from Sao Paulo of a shift in weather patterns and temporal dynamics (also called the inter-annual variability) with a bunching of high precipitation days and a more extensive duration of zero precipitation days. This is not unique to Sao Paulo and is observed in different parts of the world. It has implications for agricultural productivity and sustainability in many countries, as evidenced in the high PCI countries like the USA (Shortridge, 2019), low PCI countries like Ethiopia (Asfaw et al., 2018), and Lower Middle PCI like India (Kulkarni et al., 2020). If we examine the scatter plot of countries linking distance from the equator with the average annual precipitation of 2018, we find that countries have a weak inverse relationship between the two **(Figure 3**). It is also found that countries in warmer climatic zones are likely to experience greater variation in precipitation (Pendergrass et al., 2017)**.**

Figure 3: Distance from the Equator and Average Annual precipitation



In order to complete the hydrological cycle, we should also look at the effect of climate change, especially, global warming on ocean circulation systems and geography, which is equally complex (Abraham et al., 2013). There are predictions that the Gulf Stream, which brings warmth to Europe, may weaken and could cause (a) more storms (both frequency and intensity) and severe winters in the UK, (b) heatwaves to Europe and (c) sea-level rise in the eastern coast of the USA, among other impacts (Caesar et al., 2021; Thornalley et al., 2018).

Therefore, the challenges that geographical location poses for human wellbeing are not unidirectional and heterogeneous. We next look at the sector that is most directly dependent on climatic conditions, namely agriculture.

3.2 Agriculture and Food Security

Food security has been a major concern in developing countries. This arises from two different but not unrelated axes in both urban and rural regions. One is driven by market-oriented fiscal restructuring in the economy. The rural peasantry and small farmers get disenfranchised by (a) reduced budgetary support (by way of removing input subsidies, offering floor support prices for agriculture, public investment in irrigation, among others) (Mishra, 2020) (b) trade liberalisation, which increases the volatility of agricultural prices and puts pressure on domestic agricultural prices and farm incomes (Patnaik, 2002), and (c) corporatisation of farming (Lobao & Stofferahn, 2008; Lyson & Welsh, 2005). Restrictions on access to minor forest produce to meet conservation targets would also affect access to food for forest-dependent communities (Guha, 1994). What affects all rural households is the loss

of their production base due to reduced natural capital (Wynants et al., 2019). This could occur for multiple reasons (Kareiva et al., 2011), including land use land cover changes (Yan et al., 2009).

Trade liberalisation, especially in developing countries, also impacts the industrial structure, ownership, labour market, and wages (Acosta & Montes-Rojas, 2014). It is typically accompanied by the dismantling of labour laws and informalisation of production (D'souza & Naik, 2018; Ghosh, 2021) on the pretext to achieve cost reduction and trade competitiveness (Chandrashekhar & Pal, 2006). A phenomenon often described as a "race to the bottom" (Taylor & Ömer, 2019). A consequence of these processes is wage suppression in urban production sectors, loss of formal regular urban industrial employment, increasing the vulnerability of the urban poor (UNCTAD, 2006). Such policies are often accompanied by a dismantling of the public distribution system, reduction in social security expenditures, limiting the access to health and education for the urban poor (Ghosh & Chandrasekhar, 2009). The failure of governments to provide social safety nets to the marginalised in both rural and urban is part of the development crisis that precedes the challenge of climate change (Bhaduri, 2006). The adverse implications of such policies are not limited to the global south but also affect the developed countries (Kiefer & Rada, 2015).

The other axis of food security concerns comes from factors that are global and climate-related. Agriculture is very sensitive to climatic conditions (Zilberman et al., 2004). Global warming is expected to have a differential impact, with some areas in temperate zones likely to gain ("carbon fertilisation effect"). There is debate on the potential gains due to carbon fertilisation effect as there is counter-evidence that suggests that the gains may not be universal (Fan et al., 2020).

Mendelsohn (2014) finds that in parts of Asia, a 1.5C rise in temperature could lead to a loss of one-fifth of the net crop revenue, especially in South Asia. A 3C rise would be even more damaging and geographically widespread. It has also been suggested that the commonly used weather variables in predicting agricultural productivity, namely temperature and precipitation, may be missing out on other factors like humidity and wind speed which may lead to biased findings. (P. Zhang et al., 2017) find that when additional variables are included in the analysis, China is likely to see a dramatic decline in yield of rice (36%), wheat (18%), and corn (45%) before this century is out.

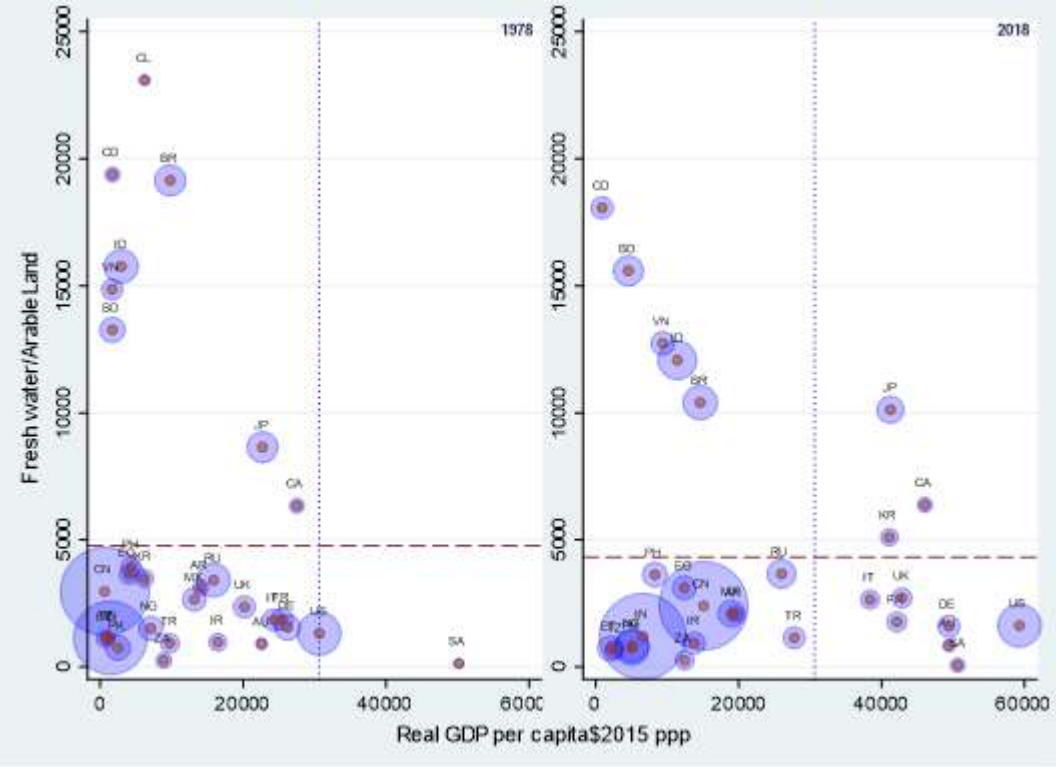
There are multiple confounding issues here. First, many regions (Mujumdar et al., 2020; Zhao et al., 2020) face both droughts and floods in succession and sometimes in the same year. Such changes are partly being attributed to a natural process. However, some of it is linked to climate change and anthropogenic intervention by way of land-use change and urbanisation. We discuss this in more detail later in this study.

3.3 Rural Challenge

The development challenge has been conceived by many as the equitable transformation from a low PCI, primarily agriculture-based economy, to a high PCI, primarily industrial society. While some countries hoped to leap-frog their development trajectory from an agriculture-based economy to a service-based economy, the experience of many countries has shown that it was a strategy that did not deliver (Rakshit, 2007; Tejani, 2016). In some instances, the growth of urban centres is driven by the rural-urban wage gap, with the urban centre being seen as a growth nucleus (Zhang & Song, 2003).

However, in many instances, this migration itself reflects the rural crisis and a shifting of the burden of vulnerability from the rural to the urban (Deotti & Estruch, 2016). There are distressing reports that in some cases the distress levels have reached such levels that small farmers and agricultural labourers have committed suicide (Nagaraj et al., 2014; Singh et al., 2021). Therefore, no matter how much infrastructure is planned in urban areas, till the rural crisis is addressed, particularly in developing countries, they will continue to face the challenge of managing urbanisation.

Figure 4: Ratio of freshwater availability per unit of arable land and PCI



We examine the change in the availability of freshwater per unit of arable land over the period under study **(Figure 4)**. The horizontal red lines represent the average freshwater per unit of arable land during the respective years (average calculated excluding CL as it was an outlier).[1] There were no countries in 1978 who had both a high PCI and high freshwater availability with respect to arable land. By 2018, there were three countries in this quadrant (Japan, Canada and Korea. In 1978, there were no countries in the south-east quadrant (except SA). By 2012, most developed countries had moved to this quadrant indicating the structural transformation that they had been through in this period.

[1] The average freshwater availability per unit of arable land in 1978 was 4773 mm/ha and in 2018 it was 4320 mm/ha.

3.4 Migration as an Adaptation strategy

The process of rural-urban migration is well-studied in economics, where the poor move to urban and peri-urban areas to escape rural poverty and seek a better living. It finds a central theme in the Lewis model and the much-debated enclosure movement in Britain and subsequently in other European nations.

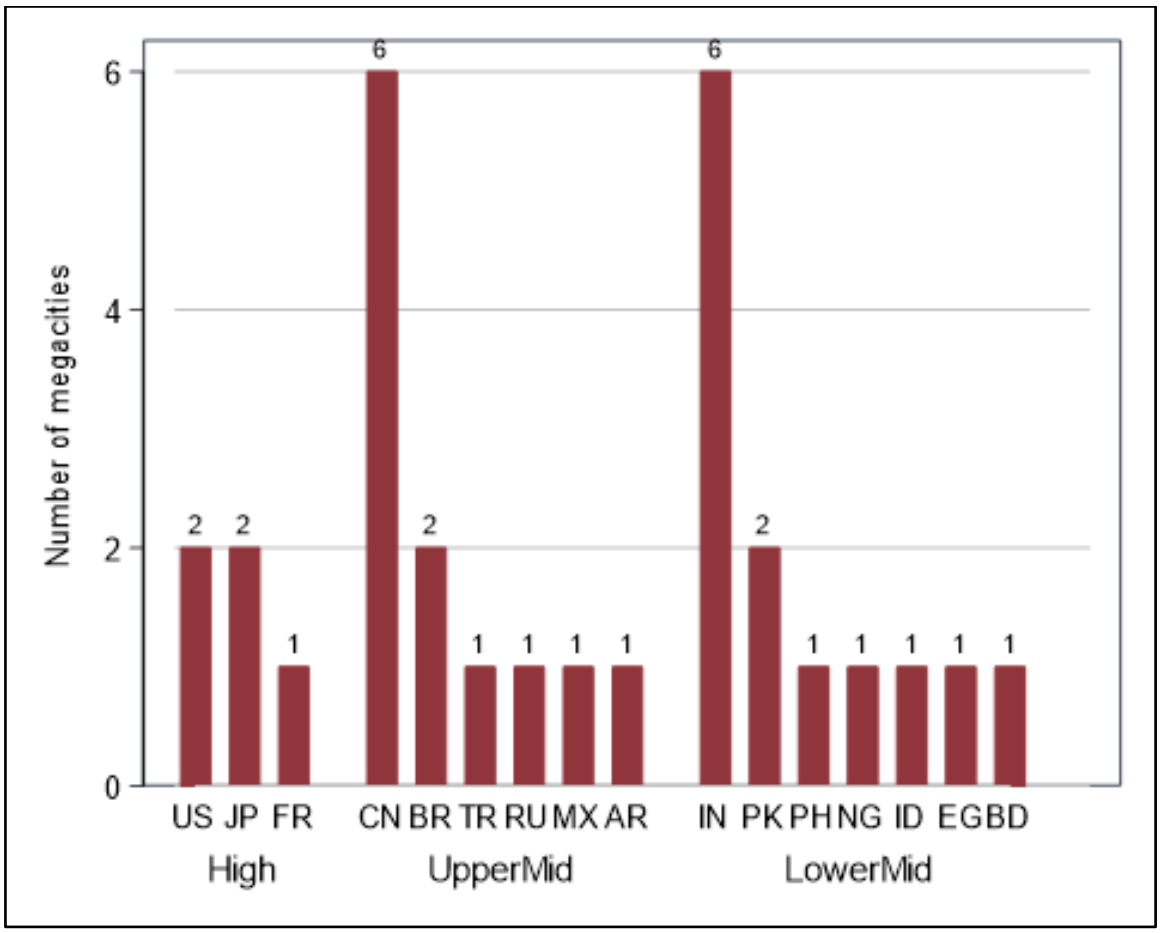
Apart from the migration induced by rural agricultural depression and dispossession, there is also an emerging category of human displacement labelled as climate migrants (also sometimes referred to as climate "refugees") both within nations as well as across nations (Marotzke et al., 2020). Rural-urban migration, as well as international migration, is seen as an adaptation strategy to cope with climate change (McLeman & Hunter, 2010). However, as we have seen in the recent Covid in 2020 lockdown over many months, migrant labour was made unwelcome in their workplace and had to walk back thousands of kilometres over weeks with no transport available even within countries (Bhagat et al., 2020). This is a situation that could happen during extreme climate events too. In such situations, already vulnerable populations could be at higher risk.

Already, 56% of the world's population lives in urban geographies, and this is projected to increase to 68% by 2050 (https://stats.unctad.org/handbook/Population/Total.html). The developing economies currently have 51% living in urban areas and are projected to go up to 65% (by 2050). Developed countries are already at 81% and are projected to reach 88% (by 2050).

3.5 The Challenge of urbanisation

There are 34 megacities (population more than 10 million) in the world (as of 2020) (https://www.worlddata.info/megacities.php). China and India have six each, and the USA, Japan (among the developed and high countries) and Brazil (among the developing and upper-middle-income countries), and Pakistan (among the developing and lower-middle-income countries) have two each **(Figure 5).** Five other countries from the lower middle income, four from the upper-middle, and one from the high-income countries have one megacity each.

Figure 5: Distribution of megacities (2020)



Source: https://www.worlddata.info/megacities.php

This adaptation strategy in developing countries brings with it its own challenges. Urban infrastructure is grossly inadequate for day-to-day living in terms of health, drainage, drinking water, clean air.

Figure *6* presents the share of the urban population and the PCI of G-30 countries and demonstrates that across the board, urbanisation has been rising. The figure juxtaposes the status of 1978 against that of 2018. Each year is split into four quadrants -- on the x-axis, it levels with the US PCI in 1978 (at US $2015 PPP), and on the vertical axis, it levels with 50% (just as an equal marker for half proportion).

The countries in the 3rd quadrant (south-west, SW) have low income and low urban populations, and in contrast, those in the first quadrant (north-east, NE) have high income and high urban populations. The countries in the 2nd quadrant (northwest NW) have a high urban population but a lower income than the US PCI in 1978. Contrarily, countries in the 4th quadrant (south-east, SE) have a high urban population but a lower income than the US PCI in 1978. This quadrant represents the collection of countries that have high PCI but low urban populations. This is an empty set both in 1978 and 2018. We could take this observation as implying that, as of the current state of technology, it is a near impossibility to achieve high PCI but manage to do it with low urbanisation.

In 1978 only one country was in the NE quadrant -- Saudi Arabia. As we have explained earlier, this country is an exception. There are no countries in the NE quadrant. All countries (except Saudi Arabia) are below the US PCI of 1978. One group is in the NW quadrant, and another is in the SW quadrant with China and India, both low in the SW quadrant.

In 2018, the picture changed significantly. The spread of countries is larger. Ten countries now are in the NE quadrant, nine countries are in the SW quadrant, and the remaining eleven are in the NW quadrant. These are Argentina, Brazil, Chile, China, Indonesia, Ireland, Mexico, Nigeria, Russia, Turkey and South Africa. Of these seven countries (AR, BR, CN, ID, MX, RU, NG) had at least one megacity in 2020. The urban infrastructure in most countries is incapable of handling the rising anthropogenic pressure and is a challenge for urban sustainability. These countries will need support to sustain their rising urban populations, and the urban poor are most vulnerable here.

Figure 6: Share of Urban Population and PCI

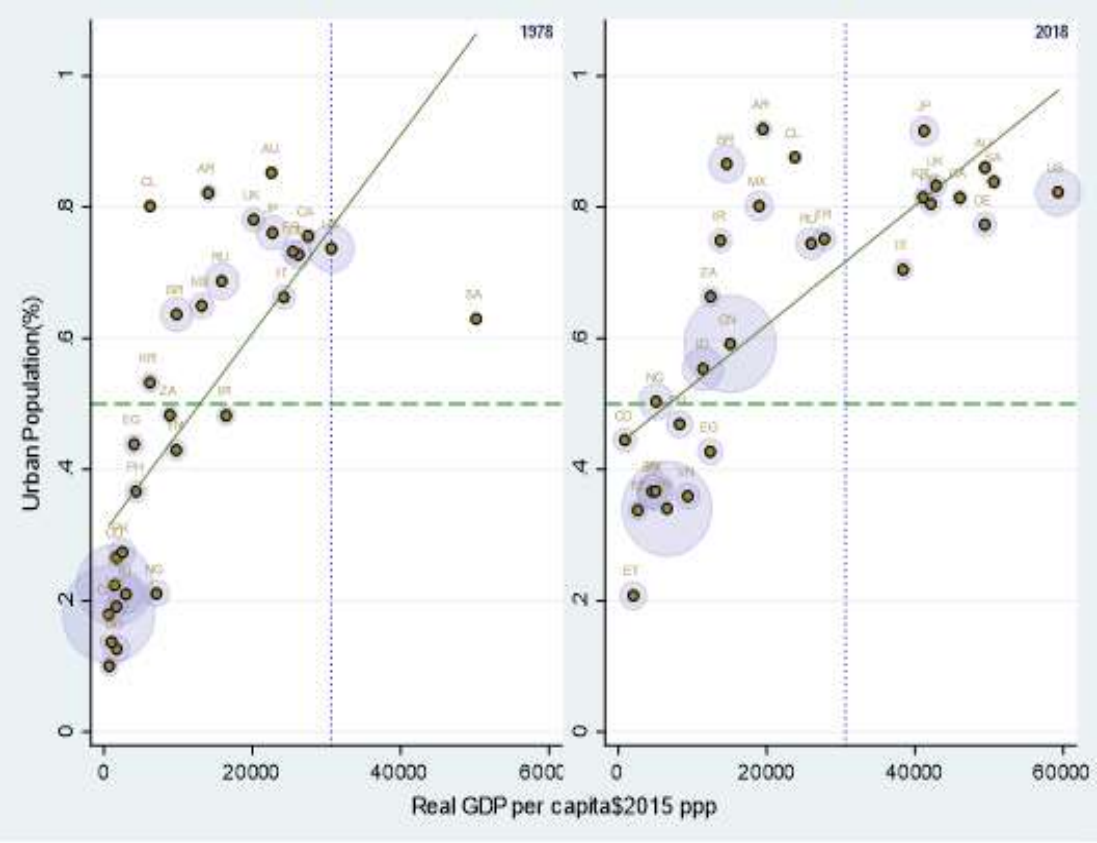


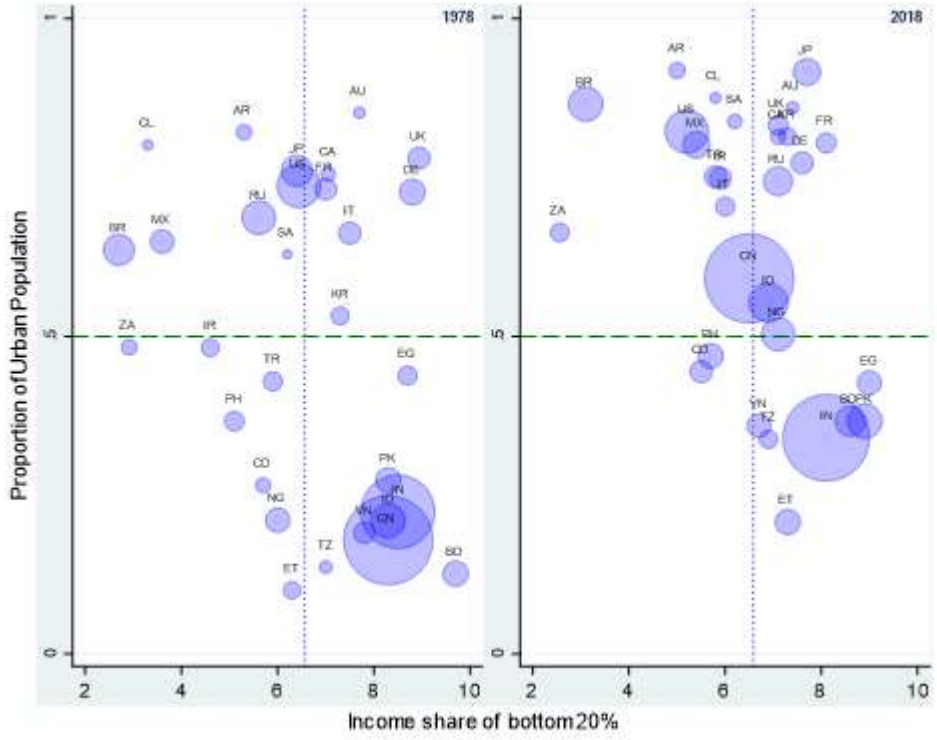
Figure 7, we present the graph showing the share of the urban population and the share of income of the bottom 20%. We briefly discuss the trajectory over the four decades (1978-2018), Again the X-Y space has been divided into four quadrants for analytical convenience.[2] In 1978, there were countries spread over all the four quadrants. The NE represents the space where there is high urban concentration and a greater share of the bottom 20% of the population in income share. The SW

[2] The average IYB2 in 1978 was 6.564919 and in 2018 was 6.585311. These values have been used to make the groups for the respective years.

represents low urban concentration and also a low share for the bottom 20%. In the NW quadrant are those countries that have a high urban population but a low share in income for the bottom 20%. In the SE quadrant are those that have a low urban population and a higher share for the bottom 20%.

In 1978, there were seven countries in the SW quadrant (CD, ET, IR, NG, PH, TR, ZA) and eight in the NW quadrant (AR, BR, CL, JP, MX, RU, SA, US). By 2018, only two remained in the SW quadrant (CD, PH), but the NW quadrant had eleven countries now (adding CN IR IT, TR, ZA to). While IR, TR, and ZA moved up from low urban to the high urban category but still maintaining a below-average share of income in the bottom 20%, CN moved from SE to NW, and IT moved from NE to NW. This suggests there was a rise in urbanisation in CN but also a decline in the share of the bottom 20%. For IT, even though it maintained high urban levels, its share of the bottom 20% fell below the average of the G-30 countries for that year.

Figure 7: Share of Urban Population and share of bottom 20% in income



The improvement in urban living conditions in the high-income countries and the upper-middle-income countries has come at a considerable cost. One of the biggest challenges of urbanisation is organising transport. Air pollution studies show the high contribution of fossil fuel-based transport vehicles in cities where mass transit has not switched to cleaner fuel. Most developing countries face this challenge.

3.6.1 Air pollution

Two decades back (Mage et al., 1996) projected that air pollution levels in megacities would worsen considerably (especially in those located in developing countries) if mechanisms to control air pollution were not put in place. There is now consistent evidence that with climate change the allergic and respiratory diseases are on the rise, especially in urban areas (Patella et al., 2018). The rapid urban growth in China and India, the two most populous countries in the world, is a matter of global concern. The 47 out of the 50 urban centres of the worst polluted cities and towns (PM2.5) were from China and South Asia (Bangladesh, India and Pakistan) (https://www.iqair.com/us/world-most-polluted-cities). Delhi which is the second-largest megacity in India, reported the worst ambient air quality (PM2.5) in 2019.

A Global Burden of Disease 2019 study on India suggests that air pollution (in morbidity and mortality) accounted for nearly 18% of the deaths in 2019, translating into an economic loss of US$ 26·5 per capita and a GDP to the tune of US$ 36,804 million (Pandey et al., 2021). Delhi's and the Gangetic plain's problem is further compounded by annual crop residue burning in the neighbouring states adding to the effect of the city's own emissions (Jethva et al., 2019; Kulkarni et al., 2020). Interestingly, the COVID lockdown period offered scientists an opportunity for a natural experiment for air quality research. Over a three-month period (in early 2020) of lockdown, air quality (PM2.5) showed an improvement of about 65% in India and China, suggesting the possibility of curbing air pollution in urban areas (Agarwal et al., 2020). It demonstrated that it is possible to reduce certain emissions rapidly. However, it would require strategic urban planning for urban land use and transport services.

One way to explain this rising pollution in developing countries would be on the lines of the pollution haven hypothesis (Copeland & Taylor, 1994; M. S. Taylor, 2005), which suggests that it is a direct consequence of polluting industries migrating to the global South. Rising environmental regulation in developed countries pushes them to regions where governments are more accommodative of pollution. In such countries, policymakers treat the rising pollution as a trade-off with higher growth. Although (Grossman & Helpman, 2001) provide counter arguments claiming that trade liberalisation does not increase pollution, the weight of evidence suggests otherwise (Wood et al., 2020). Countries importing pollution-intensive products may insist on strong linkages between trade policies (Copeland, 2000). The opposite will hold true for countries undertaking the import of pollution-intensive goods. They would want unfettered free trade.

3.6.2 Water supply and Drainage

Urban centres in developing countries face the unique challenge of providing drinking water and drainage, especially during extreme climate events. The problem of urban water supply has been a concern for urban planners. Rapid urbanisation has left large segments (about 150 million globally) of the population with day-to-day water shortages (McDonald et al., 2011).

As the precipitation patterns deviate from historical climate regimes and the frequency and intensity of extreme precipitation changes, the pressure on urban drainage infrastructure will grow (Kourtis & Tsihrintzis, 2021). These will particularly affect large urban agglomerations (Dale, 2021) though rural regions too will be affected. Hill regions and coastal regions are, particularly at risk. In hill regions, these result in flash floods, landslides, avalanches, dam bursts (Penna et al., 2013) and can devastate human habitations -- lives, houses and infrastructure rapidly (Kundzewicz et al., 2014). In coastal regions, these events, combined with sea-level rise, high-tide events, and storm surges which can cause widespread damages to life and property (Hallegatte et al., 2013).

Part of the problem planners face is the wide range of predictions with respect to precipitation. If the volume of water needing drainage is difficult to predict, it would be even more difficult to plan infrastructure needs effectively (Filho et al., 2019). Sometimes, local governments in developing countries may not even be aware that there is adequate willingness to pay for urban infrastructure by residents (Mahaprashasta et al., 2021). The reasons for under-investment in public drainage are multiple but often boil down to lack of political will to support public investment or uncertainty about financing options. It is essential, therefore, to examine the trajectory of public investment in the adaptation challenges for climate change. That is the subject matter of the next section.

4. Linking economic development and climate change adaptation

The experience of the last four decades suggests that geographical location and economic transition have placed many countries in the tropics at the juncture where climate change exposure places an additional layer of vulnerability to pre-existing development challenges. The rural poor in the equatorial and tropical regions will have to adapt to variability in precipitation, rising temperature (higher frequency of droughts and floods), which will add a layer of risk for agricultural output. Migration to urban centres would be a natural process in the hope that they would find stable employment and a better living environment. However, due to the informalisation of the production process, lack of urban infrastructure, poor public health, sanitation, and education, they will find it hard to overcome the livelihood challenges that they were hoping to escape by migration. Given the “jobless” growth that the service sector-led strategy has resulted in, unemployment and stagnant wages are likely to add to the challenges that the urban poor will face.

4.1. Role of fiscal policy

The role that governments can play here is significant. We are aware that while the market would respond to many of the climate change adaptation needs of consumers who have the ability to pay. The poor and the marginalised will continue to have to rely on non-market solutions. There is evidence that various community-led initiatives can provide relief by building trust (Dasgupta, 2010) and social capital (Ostrom, 1994). Collective action in managing common property can provide adaptation solutions that provide hope for climate adaptation (Haque et al., 2021). However, community action is often localised and may take long periods to replicate in heterogeneous institutional settings. The probability of success is greater when there is a helpful hand from national governments or international agencies.

Under these circumstances, the primary responsibility for accelerating climate change adaptation has to come from government intervention. There is a need for large-scale public investment in infrastructure. The failure of the market to respond to these social needs is well-known even in advanced economies (Samuelson, 1954). Governments, therefore, have to re-strategise their fiscal policy if they are to avoid climate calamities like the Covid pandemic has shown the complete lack of public health preparedness globally.

The uncertainty in weather patterns, temperature, precipitation, extreme events due to climate change implies that there will be large uncertainties even in economic processes. Here too, the optimal solution cannot be market-based for multiple reasons – markets for such risks may not exist, and when they do, they are often iniquitous and have meagre coverage (Virk & Atun, 2015). Governments, on the other hand, are able to bear the risk at much lower social costs (Arrow & Lind, 1970).

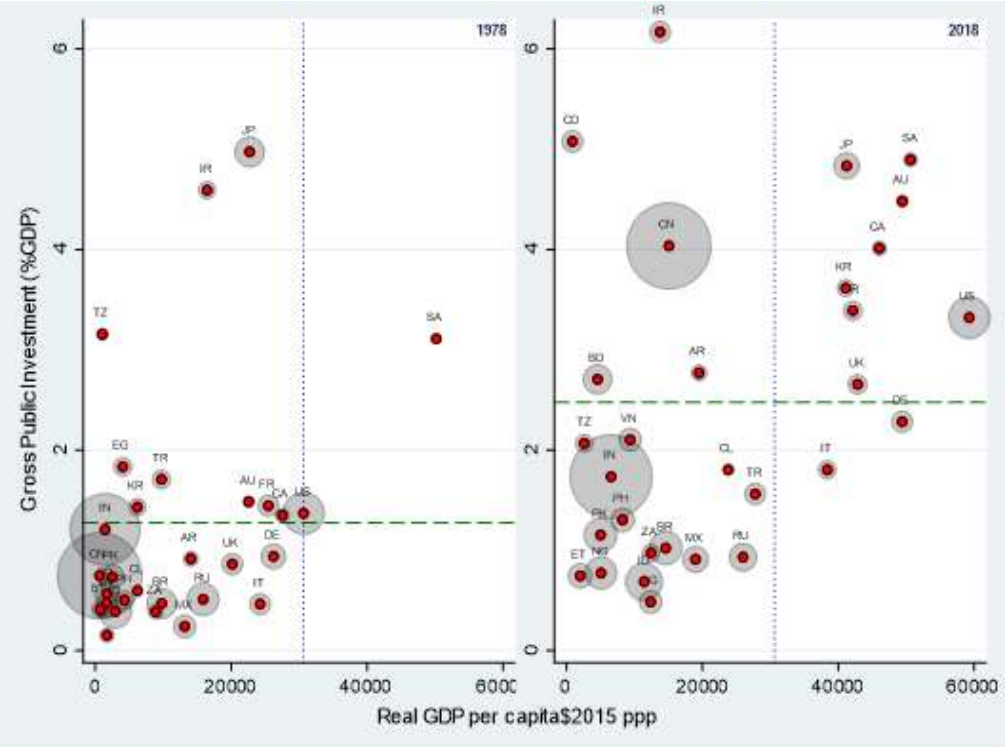
Public investment in economies with elastic labour supply is expected to have multiplier effects and not encounter problems of "crowding out" or long-term inflation (Izquierdo et al., 2019; Pradhan et al., 1990). Contrarily, public investment is known to have "crowding in" effects in less developed economies (Karun et al., 2020) as it expands the market for private producers and increases consumption by putting income in the hands of the poor (whose marginal propensity to consume is higher). Thus, it addresses the issue of aggregate demand and employment that is a first-level challenge of development.

We now look at the level of public investment in these G-30 countries and examine how this has changed in the last four decades **(Figure 8)**. Once again, the scatter diagram has been created in the form of a quadrant for comparative purposes.[3] The green horizontal line represents the average GCF/GDP in each year for the G-30 countries. The countries above the green line spend more than the average, and the countries below the green line spend less than the average. The average itself has

[3] The average AIG per GDP in 1978 was 1.276422 and in 2018 was 2.477021. These values have been used to make the groups for the respective years. Nigeria was not included in the calculation of the mean in 1978 as it had an outlier value of capital formation (10.81%).

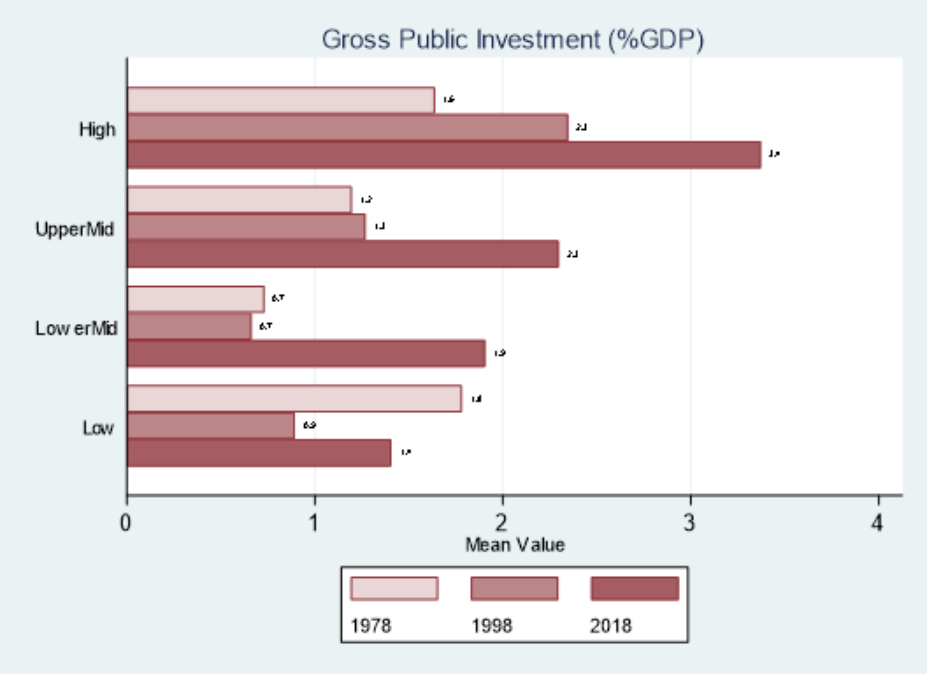
gone up over the period, as evident from the Figure. Eighteen countries were spending below the average, and twelve were spending above the average in 1978. In 2018, fourteen countries were spending above the average and 16 were below the average. The countries that made the transition from below the average (in 1978) to above the average (in 2018) are AR, BD, CD, CN and UK. The countries that receded from above the average (in 1978) to below the average (in 2018) are EG, NG, TR and TZ. The rest of the countries did not change their relative position vis-a-vis the average. The countries that remained below the average in both years (1978 and 2018) are CL, DE, ET, ID, IN, IT, MX, PH, PK, RU, VN and ZA. Only DE in this group belongs to the High PCI group. The two low PCI countries in this group are ET and TZ, while ET stayed below the average (in both the years), but TZ receded from being above average in 1978 to being below average in 2018.

Figure 8: Government Gross capital formation (% of GDP) and PCI



The GCG/GDP has grown (between 1978-2018) for all groups except the Low-income group (ET and TZ) **(Figure 9)**. This would be a concern as these countries urbanise for reasons discussed earlier. The effectiveness of public investment has been a matter of long-standing debate in the literature. In a recent review, (Izquierdo et al., 2019) found that the multiplier effect of public investment is much higher in countries that have lower initial stock of public capital (as a proportion of GDP). Low PCI countries fall in this bracket and therefore are likely to gain with increased public investment.

Figure 9: Government Gross Fixed Capital Formation (% of GDP): Group means



Note: NG is excluded from this analysis being an outlier

Not only has public-funded capital formation been of interest, but so has the government consumption expenditures. Government consumption (spending on goods and services) forms the other important component of aggregate demand under the control of public policy. This captures the commitment of the state to provide essential services to its citizens. When we look at the disaggregated picture, we find that while high and upper-middle PCI groups managed to increase their government consumption marginally. In contrast, lower and middle-income countries had reduced their spending as a proportion of GDP **(Figure 10)**.

This has important implications for demand management in economies that are struggling to improve their employment levels as well as the provision of essential services to the poor. Lower government consumption expenditure translates into lesser public medical and educational services, reduction in anti-poverty and employment schemes, pension provisions, all of which have adverse impacts on the poor (Kangas & Palme, 2000). Lower government expenditure is indicative of a decline in welfare expenditure overall. These services are expected to be provided by the private sector. It typically leads to a trajectory where the poor fall into the trap of cyclical poverty, ill-health and growing inequality (Banks et al., 2017).

It also indicates lost opportunities to boost aggregate demand by pursuing a consumption-led growth trajectory in a system where labour supply is elastic. A common concern from conservative policy-makers invokes the problem of financing such expenditures. The argument that higher government expenditure would lead to higher deficits is on weak grounds in labour surplus economies even if one were not to invoke the balanced budget multiplier. The need for using fiscal policy to expand the welfare state would become even more imperative under the threat of climate change. There are two

kinds of choices that policy-makers are often faced with. One envisages a small government, low taxes, low government expenditure, and a narrow welfare footprint. Often this institutional setup is driven by the argument that fiscal deficits and public debt have to be kept in check to keep investor confidence buoyant (Wolfson, 2000).

The alternative Keynes-Kalecki inspired policy-making could achieve the same small fiscal deficit and low public debt objective if policy-makers chose the alternative of a large government, high government expenditure financed by high taxes. High taxes become politically challenging to implement, and there are "leakages" for various reasons that are well-known in the literature. Alternatively, an expansionary public expenditure could be financed by raising the threshold of fiscal deficits and public debt on principles of "functional" finance (Lerner, 1943), as has been done in many advanced countries during their period of expansion. The additional debt could potentially be adjusted in the long run when the rate of growth exceeds the real interest and the burden of interest and debt declines over growth cycles (Taylor et al., 2012). This would achieve a larger welfare state without affecting the inter-temporal profile of debt. In times of climate change, with the urgent need for adaptation action, these are choices that governments need to consider when market-based options seem unclear.

Figure 10: Government Consumption expenditure (% of GDP): Group means

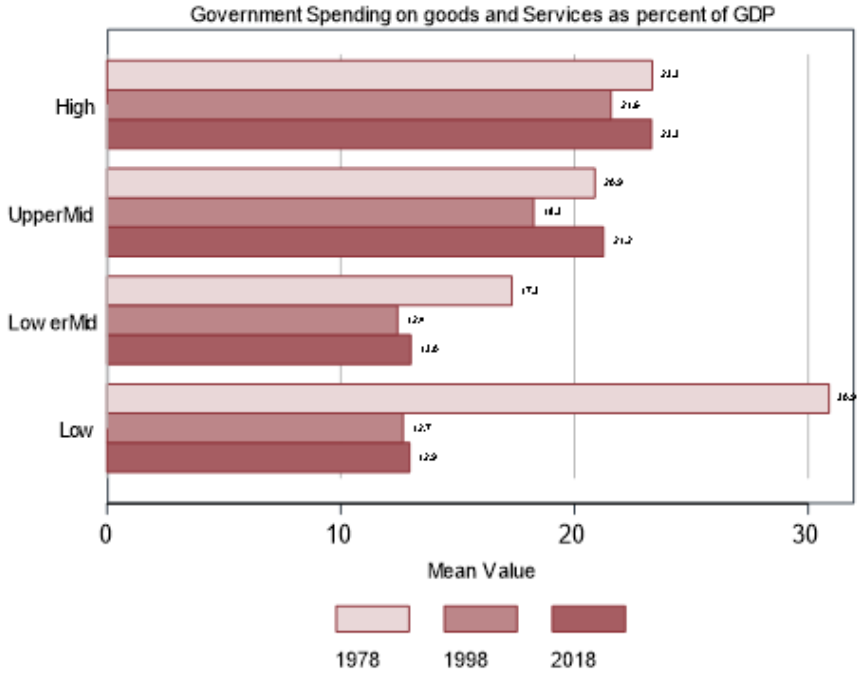
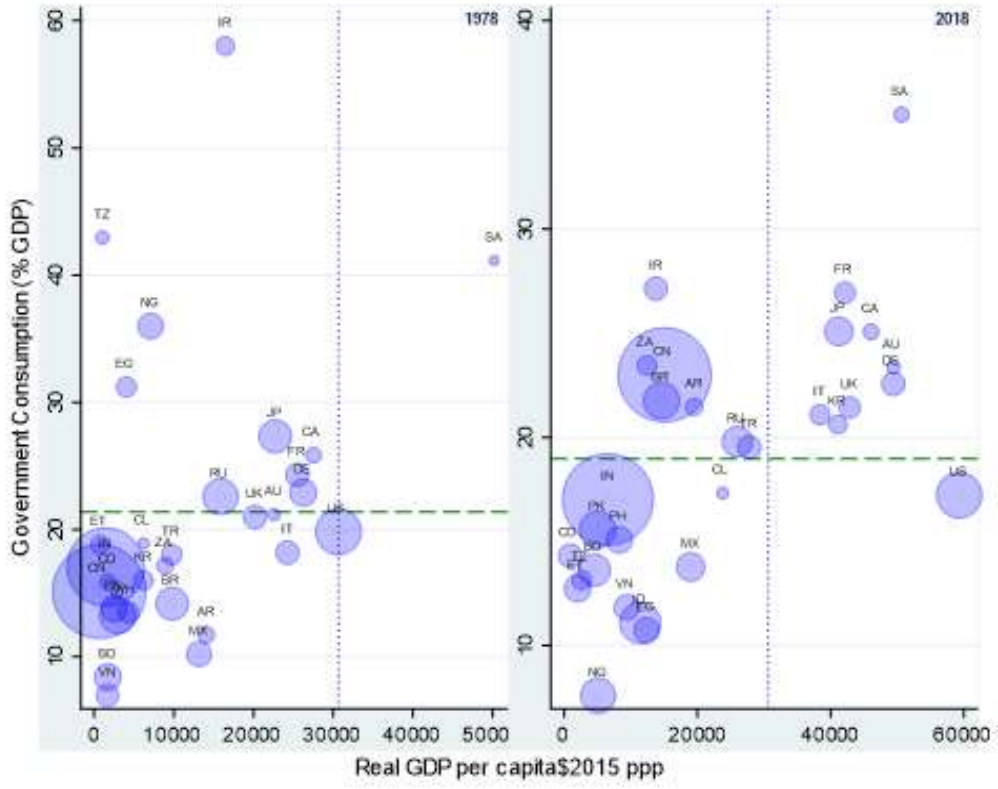


Figure 11: Government consumption and PCI



In 1978, five countries were spending more than 30% of the GDP on government consumption **(Figure 11)**. In 2018, there is only one -- Saudi Arabia. In 1978, eight countries were spending between 20% to 30%. In 2018, there were thirteen. In 2018, all countries spending more than 20% had a high or upper-middle PCI. In 1978, there were two lower-middle (EG, NG) and one low PCI (TZ) country that spent more than 20%. There is only one country whose income is higher than the US 1978 PCI who spent less than 20% of its GDP on government consumption -- it was the USA (which has the highest PCI).

As we have indicated earlier, government intervention in the economy has a direct impact on employment. The workforce participation rate is an important indicator of economic empowerment, especially from a gender perspective. Women's participation in the paid workforce has had increased over time (Alonso-Almeida, 2014) but continues to be significantly unequal (WEF, 2021). The female workforce participation varies across countries and in recent years has even declined in some countries contrary to expectation (Dubey et al., 2017). These are matters of social and economic concern and in need of policy intervention.

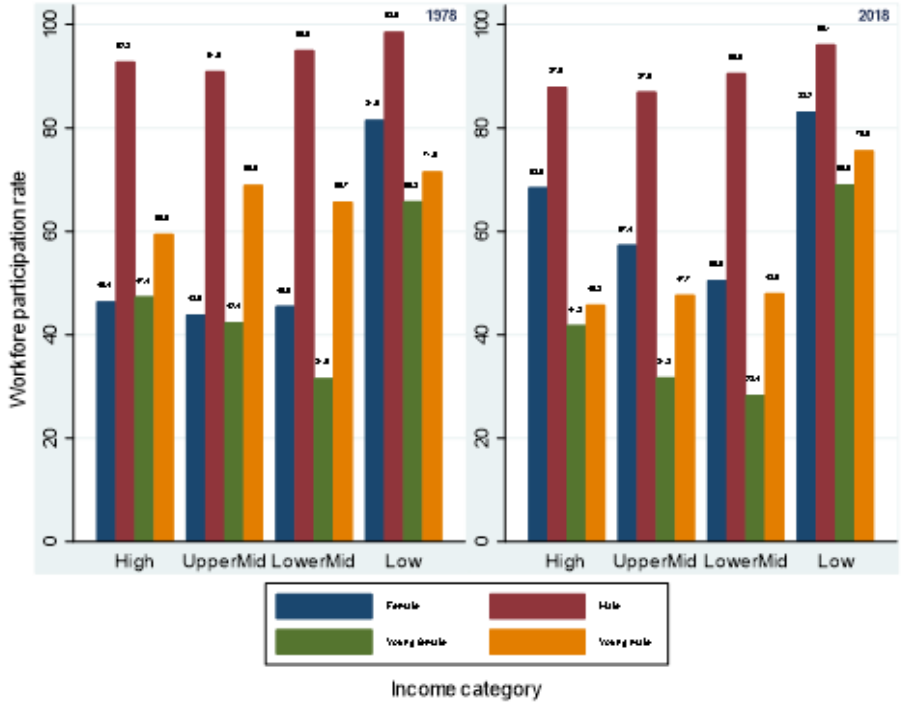
It has been pointed out that these numbers under-represent women's contribution to the economy as they leave out their contribution to unpaid work (Hirway & Jose, 2011; Lahoti & Swaminathan, 2016). Even after one accounts for these unseen contributions, the persisting gender gap in the paid workforce is a worrying factor as it has implications for women's employment choices and economic

empowerment (Cornwall & Rivas, 2015), gender equality (Blau et al., 2012) and is known to impact on violence against women (Aizer, 2010). Climate change is expected to have additional adverse impacts on women's empowerment (Denton, 2002), including violence (Sekhri & Storeygard, 2014).

The state can play a transformative role by focusing on women's empowerment through multiple strategies (Duflo, 2012) to address the gender gaps as part of the climate adaptation strategy. Women's empowerment would have important contributions to building climate resilience in the long run (Alston, 2013; Chirambo, 2017). Ensuring that the girls child does not drop out of school and gains the skills to participate in the paid workforce would help in increasing human capital accumulation, productivity and have a positive impact on long term growth (Agénor & Canuto, 2015). By making it legally possible for women to have equal rights to inheritance (Roy, 2015), governments can ensure that women are able to have some assets to adapt to climate change (Goh, 2012). This would also help in consumption smoothing in case of extreme events. A guaranteed employment programme would help women build their own assets, and access to public health would have inter-generational health benefits (Watts et al., 2019). Needless to say, there cannot be a one policy fits all approach and must be nuanced as per national needs (Arora-Jonsson, 2011).

In this context, we next look at the workforce participation rate disaggregated by gender over the last four decades.

Figure 12: Workforce participation rate and PCI



The story on the employment front (measured with the workforce participation rate WFP) is mixed **(Figure 12).** The adult female workforce participation rate (NLNWF) is lower than male (NLNWM) in all categories of PCI and in both years. Having said that, we observe that NLNWF is higher for all categories in 2018 in comparison to 1978, so that should be good news for gender empowerment. However, the young female participation rate is lower than the adult one in all PCI groups in 2018. This matches the comparison between adult male and young male participation rate. The gender gaps in employment have been cause for concern in the feminist and developmental literature, as discussed earlier. The persistent employment gap has been seen as a consequence of labour market discrimination. This has been all-pervasive, whether it is measured by wage differentials (O'Neill, 2003), employment gaps (WB, 2014), political representation (Omvedt, 2005), corporate leadership (WEF, 2021), among others.

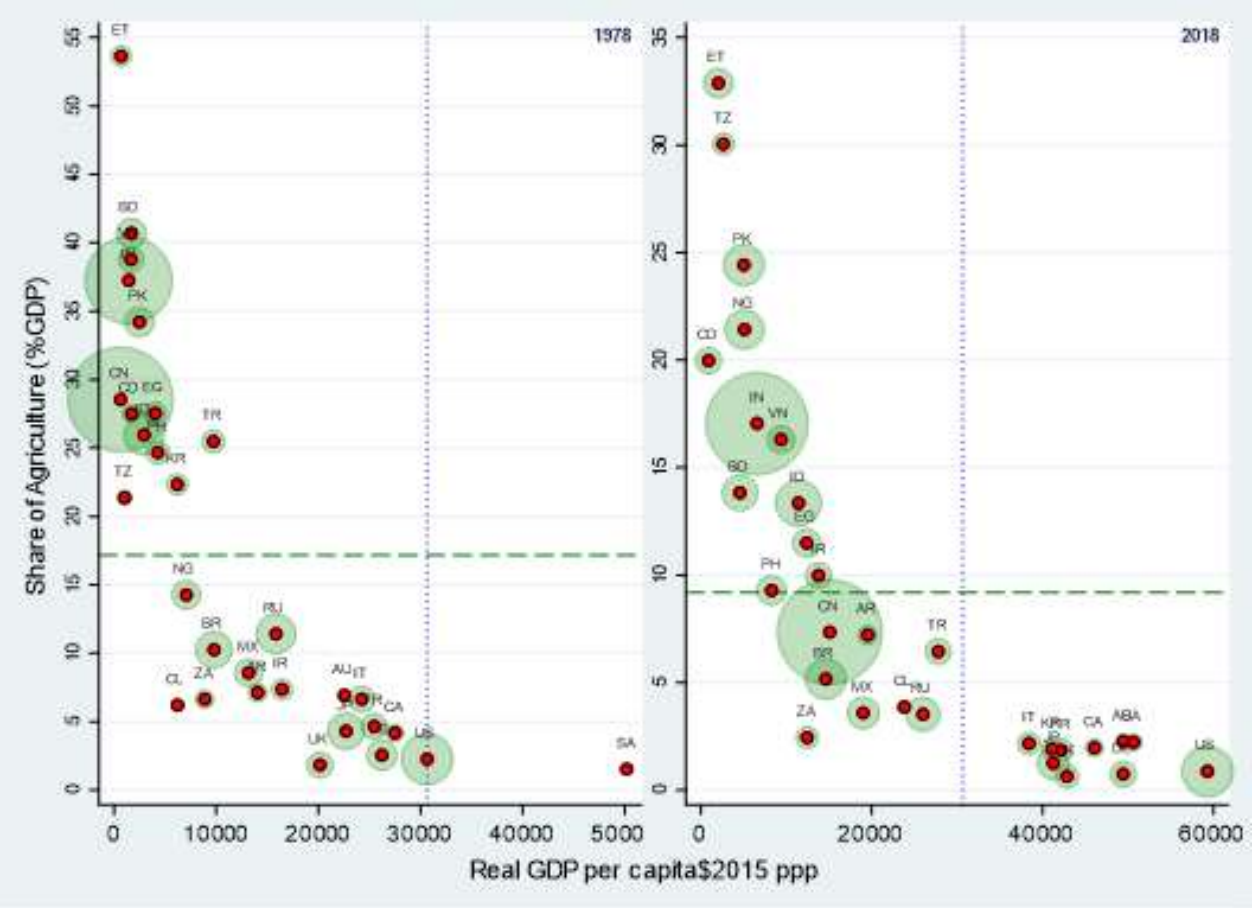
Progressive states have taken multiple pathways to address these gaps – either by way of legislation or by moral suasion. Many countries have experimented with political representation in elected government as well as corporate boards mandatory by reserving seats for women. There is evidence that this has given greater voice to women in decision-making and led to sustainable outcomes (Bose & Das, 2018; Matsa & Miller, 2013; Valls Martínez et al., 2020).

4.2 Structural change as a pathway to climate adaptation

In light of the discussion above, it is crucial to understand that state intervention could enhance aggregate demand and incomes in the economy. However, to meet the ecology-economy balance for sustainable development, there is a need for a planned structural transformation. This would help developing countries avoid the trap of rural unemployment and agrarian distress due to climate change and the informalisation of urban economic processes. Countries that relied on service sector-led growth have found that this has neither addressed issues of employment (especially educated unemployed) nor has it moved the economy to sustainable growth. In contrast, they have led to "jobless" growth, growing insecurity in the labour market and wage depression.

As evident from the trajectory of developed countries (discussed below), there is a need for better planned industrial expansion. However, in the context of climate change, this will have to be low-carbon green technology-based growth. While the growth of the primary sector (agriculture, fisheries) would be necessary as a supportive sector, the structural transformation that developing countries would have to rely on for sustainable development is industrialisation based on green technologies. The service sector would play an important role, but current evidence suggests that a development strategy based on services is fragile, as has become evident during the current pandemic (https://www.unwto.org/tourism-and-covid-19-unprecedented-economic-impacts).

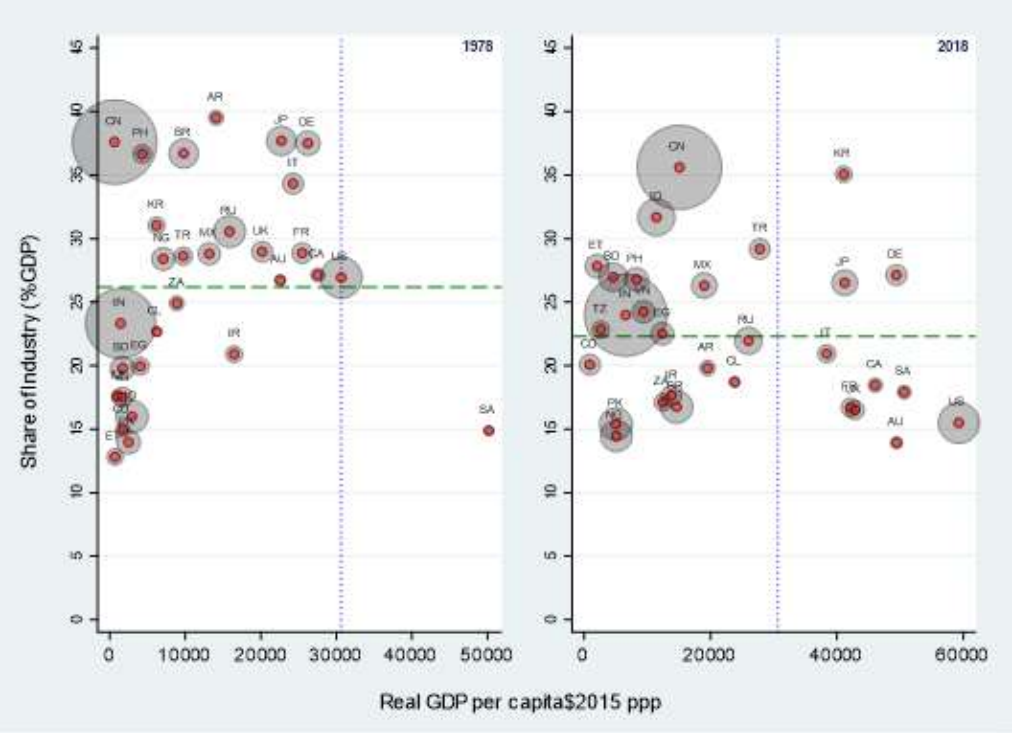
Figure 13: Share of agriculture in GDP and PCI



We look at the structural change over the last four decades, starting with agriculture. In **Figure 13**, we display the scatter plot between the share of agriculture in GDP for 1978 and 2018. The average share was 17.16% in 1978, and it came down to 9.18% in 2018. If we look at the trajectory of all countries, we find that in 1978 only seven countries had share less than 5%. By 2018, 14 countries had a share below 5%. There is of course, a clear downward slope to the scatter in both years. In 1978, there were 13 countries with a share above 20%, but by 2018 there were only 4%. The growth of PCI is strongly and negatively correlated to the share of income coming from agriculture. In some ways, this is also reflective of the crisis of agricultural growth and prices.

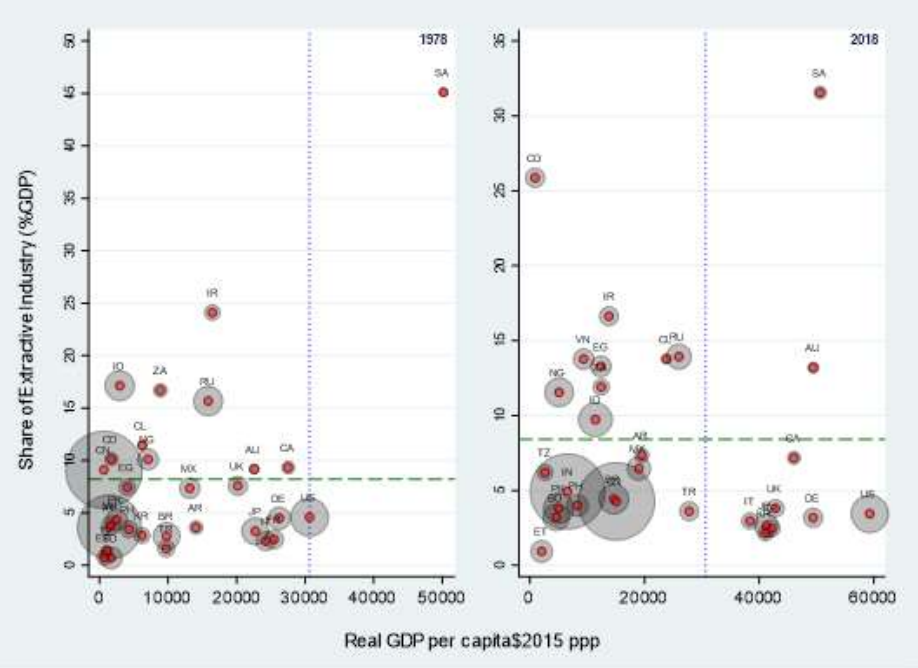
The share of industries, on the other hand, has also come down a little bit over the last four decades **(Figure 14)**. Three countries have moved into the first quadrant (more than average industrial share and above the US's 1978 income, namely JP, DE and KR. While JP and DE have been in the high PCI group for some time now, KR is a new entrant. China still has some way to go, but it has kept industry share above 35% but moved closer to the US 1978 PCI. India has moved from below the G-30 average to above the G-30 average in 2018.

Figure 14: Share of industry in GDP and PCI



What has also been under discussion is the role of the extractive industry in climate change adaptation. The mitigation efforts focused on reducing emissions have been arguing that extractive industries have a larger ecological footprint than conventional industries.

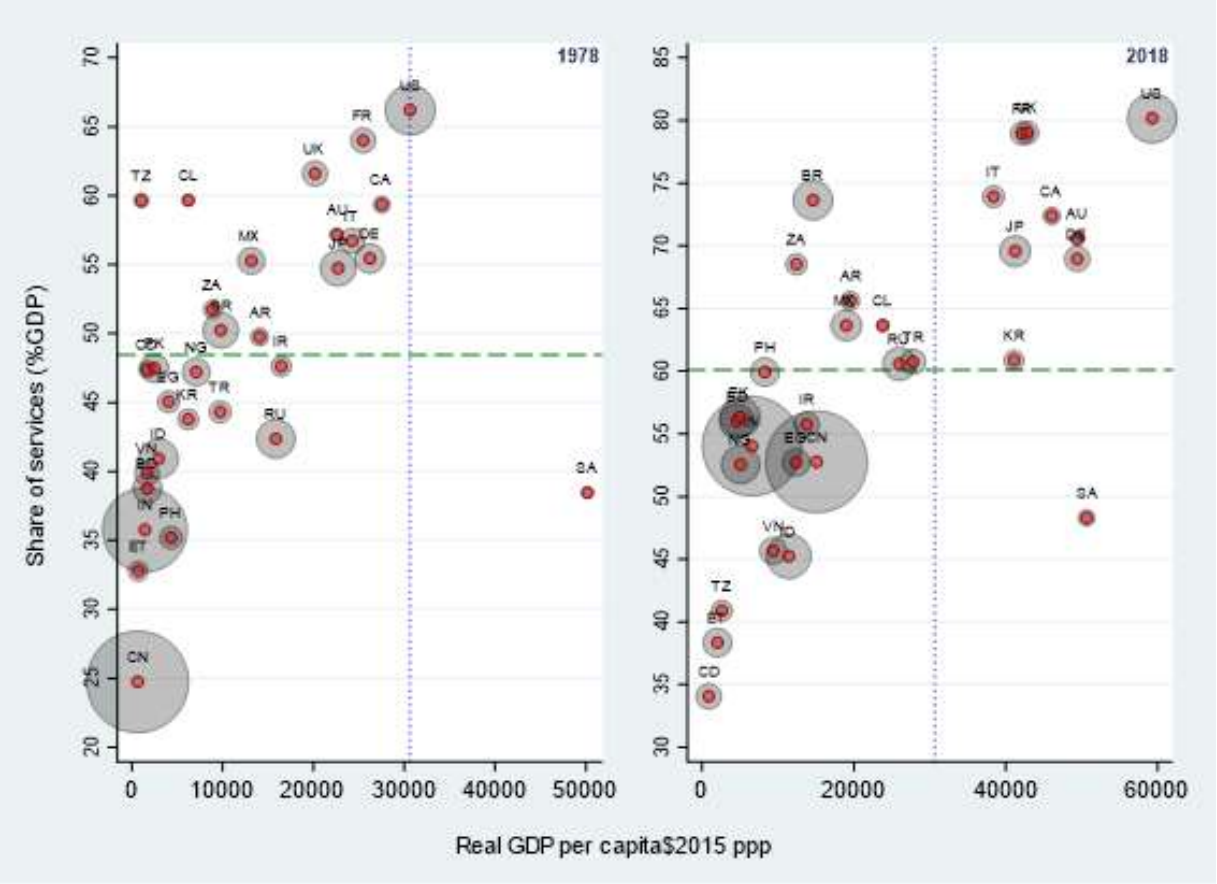
Figure 15: Share of extractive industries in GDP and PCI



The share of extractive industries in GDP has only marginally increased (8.2% in 1978 and 8.4% in 2018, **Figure 15**). SA continues to be the country with the highest share of GDP coming from extractive industries though its own share in the GDP has declined from about 45% to a little above 30%. CN has seen a rapid decline in its share of extractive industry contribution but that has not affected its growth trajectory. In contrast, CO has seen a rapid rise in its share of extractive industries, but it has not transformed into significant development outcomes. Australia, on the other hand, has witnessed a significant rise in its share but also its income.

The most significant structural transformation that has taken place is in the growth of the service sector. In **Figure 16** below, we present the scatter plot of the share of services with PCI for the two periods. The rapid rise in the share of services of the high PCI countries is evident below.

Figure 16:Share of services in GDP and PCI



The world average share has gone up from below 50% to above 60% in four decades. While the US has gone up from about 65% to 80%, China has gone up from 25% to above 50% and India from about 35% to about 55%.

5. Discussion

Climate change has deepened the vulnerability of multiple groups of the population, particularly the poor, those exposed to weather changes both from extreme events caused damages as well as livelihood loss (IPCC, 2018). The well-being of these groups can be enhanced sustainably by increasing their adaptive capacity (Alston, 2013; UNEP, 2021). This would require a upgradation of their socio-economic condition, a combined effort or endogenous adaptation efforts and state support to make a structural transformation feasible.

Human-nature interactions occur at multiple levels and in multiple ways in a complex social-ecological system (SES) context (Ostrom, 2009). There is a large consensus that sustainability would require adjustments either within the social-ecological system (SES) or change the framework of relationships itself (Barnes et al., 2020). It has been pointed out that adaptation intervention, especially externally funded intervention, should be done with sensitivity; otherwise, they may exacerbate existing vulnerabilities. (Eriksen et al., 2021) argue that unless marginalised populations are made partners in the adaptation strategies and made locally relevant, there is a risk of adverse outcomes. The creation of green infrastructure can lead to climate injustice as the poor are evicted from urban spaces in the name of climate adaptation (Anguelovski et al., 2019). The relationship between urbanisation and development is neither simple nor linear. It depends on a multiple set of factors, including supportive infrastructure investment (Turok & McGranahan, 2013). However, rapid urban infrastructure has not kept pace with rapid urbanisation in most developing countries and there is urgent need for fresh investments and expansion of public services.

The pathway to sustainable development would lie in overcoming existing development gaps of unemployment, lack of public services (health, education, transport), agriculture (including irrigation and farm prices), urban infrastructure, affordable housing which help reduce vulnerability of the maginalised groups. Unfortunately, development expenditures are the first items that get reduced when there is fiscal restructuring (Chakraborty & Dash, 2017).

The SIDS regions need special attention as they will be at the forefront of sea-level rise and extreme weather events (Petzold & Magnan, 2019; Robinson, 2020). They will have to reorganise their economic strategies including tourism that forms a major income source for many of these regions (Pratt, 2015). They will need support for infrastructure and technology to undertake robust adaptation measures without significantly disturbing the sensitive ecosystems in these regions and social relations that have sustained their lives.

A large part of the adaptation process will involve new infrastructure projects. However, there is a need for sensitivity in planning large scale infrastructure projects if these disturb the ecosystem services significantly (Bebbington et al., 2020). The tropical countries are some of the most species-rich regions (Brown et al., 2020; Trew & Maclean, 2021). The need to protect biodiversity for human well-being cannot be over-emphasised (Dasgupta, 2021). International cooperation is critical not only for development and economic reasons but also for ecosystem and biodiversity conservation. Climate

change will cause the relocation of many species geographically (Titley et al., 2021). This may involve species migration across national borders. Ecological conservation would then require greater coordination and cooperation in addition to economic development efforts. In developing countries, there continue to be significant segments of the population who meet their consumption needs and drive their livelihood directly from nature (Angelsen et al., 2014). Therefore, the new investments must be planned in a manner that ensures a non-declining intertemporal trajectory of comprehensive wealth (Arrow et al., 2012; UNDP, 2010).

There is a concern that macroeconomic analysis at the country level often overlooks what happens within the country, especially the poor, who are more vulnerable than the average citizen (Hallegatte et al., 2013). A growing literature documents the conflicts arising from increased extractive demand for resources that form the survival base for many communities (Martinez-Alier, 2002). These conflicts evolve due to multiple reasons including either different notions of sustainability, inadequate sharing of resource rents, and lack of community participation in development dialogue (Scheidel et al., 2018). When the development process is participative and there is community involvement in planning and implementation, they lead to stable and sustainable outcomes (Haque et al., 2021; Ostrom, 1994). There is a need for development dialogue with citizen groups when planning for social transformation and climate adaptation. These will allow policy intervention that takes into account specificities and people's aspirations in different regions.

Adaptation strategies should avoid re-enforcing pre-existing unequal social and economic hierarchies, especially in the context of race and gender. The gap in wealth, education, health and role in decision-making (WEF, 2018) could be a continuing barrier to adaptation to climate change (Jerneck, 2018). Identities, whether it is race or gender, are sites of social allocation of power and control (West & Zimmerman, 1987). It is anticipated that climate change will have heterogenous impacts on different groups (Nursey-Bray, 2015). A positive intervention by the governments as proposed in the SDGs would help in addressing the racial and gender inequalities that have been historical institutionalised.

Adaptation for sustainability cannot succeed without changes in consumer behaviour. We are aware that there are two types of dynamics at work as far as consumer behaviour is concerned. On the one hand, there is a demand from conscious consumers for green products that have triggered intense effort to find low-carbon production technologies and thereby reduce emissions. On the other hand, it is the effort to achieve higher income that will bring with it demand for more commodities and potentially greater emissions. The latter outcome is often referred to as the "rebound effect", especially in the context of energy (Colmenares et al., 2020). An important connect to aggregate emission reduction strategy is a change in consumption behaviour (Bjelle et al., 2021). There are many ways to alter consumption behaviour -- persuasion, consumer sensitisation (awareness), administration diktat, incentive, to name a few. While no single strategy would work everywhere, each country would have to find the appropriate combination of strategies depending on the country conditions.

The challenge for developing countries to undertake climate change adaptation would be to reduce vulnerabilities – some of which are climate-related. Some are pre-existing ones that have been aggravated by climate variation. In a global macroeconomic landscape where finance capital is

increasing its control over macroeconomic policy in developing countries, the global effort must focus on strengthening the domestic capabilities of developing nations to transform and leapfrog to a green economy structurally. This would be possible only if developed countries agree on technology transfer to aid robust industrial growth. However, that would only be a partial solution that may temporarily reduce emissions. For a sustainable solution, the global macroeconomic framework would have to overcome conservative policies of "sound finance" and accommodate greater fiscal independence for developing countries to fund domestic social safety nets, provide guaranteed employment and build green infrastructure.

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