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DEBATE

Relevance of population mobility for climate change mitigation

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ABSTRACT Population mobility and immobility are depicted prominently in the climate change adaptation literature either as maladaptation, or failure to adapt, or as a key strategy for adaptation in place or elsewhere. On the other hand, the relevance of population mobility in the context of climate change mitigation has not been highlighted to the same extent as, for example, population growth and fertility. And yet, as the outcomes of people moving around – sometimes in unexpected ways because of local combinations of policies, contexts and shocks – population mobility patterns, trends and levels could both facilitate and constrain climate change mitigation efforts. In this brief note, I suggest that climate change mitigation strategies and actions need to take into account their potential interactions with population mobility because it is a key component of population growth, population distribution and urbanisation trends, as well as a potential contributor to behavioural change.

KEYWORDS Climate change mitigation • Population mobility • Migration policies • Mitigation policies • Population dynamics

There is a growing consensus on the significance of population trends for climate change mitigation (Jiang and Hardee, 2011; Dodson et al., 2020; Muttarak, 2021). But while population mobility and immobility[2] are depicted prominently in the climate change adaptation literature either as "maladaptation", or failure to adapt, or as a key strategy for adaptation in place or elsewhere (e.g., Hoffmann et al., 2020; McLeman et al., 2021; Boas et al., 2022), their relevance in the context of climate change mitigation has not been highlighted to the same extent as that of other population processes (such as population growth and fertility), even though mobility trends are vital for understanding regional and sub-regional population trends (Deuster et al., 2023).

In this brief note, I look at the relevance of population mobility trends for climate change mitigation efforts, suggesting ways in which mobility could influence mitigation strategies, and highlighting potential feedbacks.

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2 Population mobility includes internal, international, long-term and temporary moves, regardless of motivations (see McAuliffe and Triandafyllidou, 2021, pp. 342–343).

Meanings of mitigation: interventions, actions and behaviour

The Intergovernmental Panel on Climate Change (IPCC, 2022a, p. 1808) defines *mitigation of climate change* as "a human intervention to reduce emissions or enhance the sinks of greenhouse gases". The design of these interventions and the selection of options require an understanding of *mitigation behaviour*, or human actions that directly or indirectly influence mitigation (IPCC, 2018, pp. 551), including the actions of individuals, communities, local organisations, governments and international organisations. Mitigation strategies or interventions may include plans or efforts to encourage changes in these behaviours, and thus to transform or modify human actions, in ways that contribute to climate change mitigation (IPCC, 2022a). This focus on human behaviour links the mitigation of climate change to population mobility trends, which are themselves the outcomes of human decisions, actions and conduct.

There are several *mitigation options* (i.e., technologies, processes or practices that reduce GHG (greenhouse gas) emissions or enhance sinks) that are implemented through *mitigation measures*, such as renewable energy (RE) technologies, waste minimisation processes or public transport commuting practices. Table 1 lists selected categories of

Table 1 Mitigation strategies and options, and potential links to mobility flows (selection)

Mitigation strategies/options	Links to mobility flows
Conventional mitigation technologies: focus on reducing fossil fuel-based CO_2 emissions, transition to renewable sources (wind, solar, geothermal energy) on the demand and the supply sides	Internal (urban-rural) and international (South-North) migration flows could alter the energy demand and the supply profiles of the receiving and the sending areas by changing the size and the composition of the population, which could, in turn, increase the demand for renewable energy options (e.g., fuel switching), or reduce the attractiveness of certain areas for renewable energy suppliers.
Geoengineering techniques: negative emissions technologies aiming to capture and sequester atmospheric carbon in order to reduce carbon dioxide levels (carbon sequestration in agriculture, afforestation, reforestation, etc.)	Managed retreat, rural-rural migration and rural population displacement are potential outcomes of changes in land use to accommodate negative emissions technology projects.
Geoengineering techniques of radiative forcing: alter the earth's radiative energy budget to stabilise or reduce global temperatures (space mirrors, cirrus cloud thinning, stratospheric aerosol injection)	Population displacement due to reduced habitability in the target areas is a possible outcome related to, for example, impacts on the hydrological cycle.
Potential mitigation options across the consumption domains of food (e.g., dietary changes), housing (e.g., renewable energy), industry, transport (e.g., living car-free) and other consumption sectors	Migration flows (internal and international) could influence consumption preferences by altering the size and the composition of the population. Alternative transportation options could modify commuting patterns and local residential patterns.

Sources: based on Fawzy et al. (2020), Ivanova et al. (2020), Ginty (2021), Sovacool (2021), IPCC (2022b)

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mitigation strategies (Fawzy et al., 2020; Ivanova et al., 2020; Ginty, 2021; IPCC, 2022b), and looks at how mobility flows could either affect the strategies or be the result of their implementation.

Population mobility trends: magnitude, geography and selectivity

Despite the widespread policy and media focus on international migration, the vast majority of movers remain within their countries' boundaries. The number of international migrants has been estimated at around 280 million in 2020, or 3.6% of the world's population (McAuliffe and Triandafyllidou, 2021, pp. xii). The numbers for internal migration are more uncertain and debatable: some sources have estimated the total number of internal migrants at around 763 million in 2005, or 12% of the world's population, although in some countries the share of internal migrants in the population could be as high as 20% (UNESCO, 2018, pp. 13).

High-income countries are among the main destinations of international migration flows, and migration is an important contributor to population growth in these countries (United Nations Department of Economic and Social Affairs, Population Division [UN DESA], 2022). For internal migration flows, urban areas are the preferred destinations. Overall, the higher the level of urbanisation in a country, the lower the contribution of internal migration to population growth in urban areas; however, urbanisation processes and trajectories differ across countries (Menashe-Oren and Bocquier, 2021).

Population mobility is a highly selective process. In general, younger, more educated and higher skilled individuals are more likely than others to move, but there are, of course, differences in the characteristics of movers by region and type of flow (international vs internal, or seasonal vs permanent). In some contexts, women make up a large proportion of the movers (e.g., Guallar Ariño, 2023); while in others, education is negatively correlated with the probability of migration (e.g., Rendall and Parker, 2014). There are also contexts (e.g., Central American flows to the United States) where the proportion of unaccompanied children has recently been increasing (Rosenblum and Ball, 2016). Cumulative causation could lessen migration selectivity (Lindstrom and Ramirez, 2010).[3]

Because of this highly selective character, population mobility contributes not only to changes in population size and distribution in the sending and the receiving areas, but also to changes in the composition of the population by age, sex and educational status (among other demographic characteristics) in both areas (Rodríguez-Vignoli and Rowe, 2018; McAuliffe and Triandafyllidou, 2021).

At any given time, worldwide shocks could quickly affect population mobility trends. The effects of the COVID-19 pandemic and related measures and policies (including border closings, stay-at-home orders and travel restrictions) on all forms of mobility were

3 In migration studies, cumulative causation refers to the process through which "each act of migration alters the social context within which subsequent migration decisions are made, typically in ways that make additional movement more likely" (Massey et al., 1993, pp. 451). Cumulate causation facilitates mobility by, for example, lowering the relative costs of migration as more people in the community have migratory experience and can provide information and support (Lindstrom and Ramirez, 2010, pp. 4).

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widespread in 2020, 2021 and even 2022, reducing the scale of international migration; stranding passengers and migrants (McAuliffe and Triandafyllidou, 2021; UN DESA, 2022; González-Leonardo et al., 2023); and even reversing flows from cities to rural areas in some countries (Baumeister, 2020; Rowe et al., 2023). However, COVID-19 restrictions did not prevent major displacements and refugee flows due to conflict, violence, socio-political instability and environmental events (Internal Displacement Monitoring Centre and Norwegian Refugee Council, 2021).

Linking population mobility trends and climate change mitigation

Figure 1 displays the correlations between CO_2 emissions and GDP per capita (A); emissions and net migration (B); and emissions and urbanisation (C). There are large differences in emissions per capita across high-, medium- and low-income countries, and, overall, emissions per capita and GDP per capita are positively correlated (A). There is also a positive correlation between emissions per capita and net international migration rates, as migrants tend to move from the Global South to the Global North (international migration); in other words, from areas with lower emissions per capita to areas with higher emissions per capita. Similarly, higher urbanisation rates (used here as a proxy for internal migration) are positively correlated with CO_2 emissions (C).

In this context, population mobility could influence the reduction of GHG emissions (the main objective of climate change mitigation) in at least two ways:

(a) Population mobility alters the population size, growth and distribution trends in both the origin and the destination areas. In particular, it could lead to increases in population in areas where aggregated consumption and GHG emissions are already higher (e.g., large cities, high-income countries) (Morris, 2021; Jiang and Hardee, 2011; Liang et al., 2020). On the other hand, by reducing population growth in the origin areas, mobility could eventually reduce the emissions footprints of these areas. Liang et al. (2020, pp. 12534) summarised this point: "The developing regions are generally the net exporters of immiCO_2, while the developed regions mostly act as net importers of immiCO_2".[4] A critical caveat of these arguments is that they are based on the assumption that migrants follow the same emission and consumption patterns as non-migrants (Liang et al., 2020, pp. 12536), or that the populations in the sending and the receiving areas are homogenous in terms of their emissions and consumption patterns (Connolly et al., 2022). A similar argument could apply to urban and rural areas that are, respectively, the receiving and the sending areas of internal migration flows. In general, urban areas have larger carbon footprints than rural areas (e.g., Connolly et al., 2022; IPCC, 2022b; Sethi and Puppim de Oliveira, 2015), and rural to urban mobility could ultimately affect a country's aggregated carbon emissions footprint (Long et al., 2022, pp. 10). However, this overall positive relationship

4 Liang et al. (2020, pp 12534) define *immiCO_2* as those "CO_2 emissions caused by international migration".

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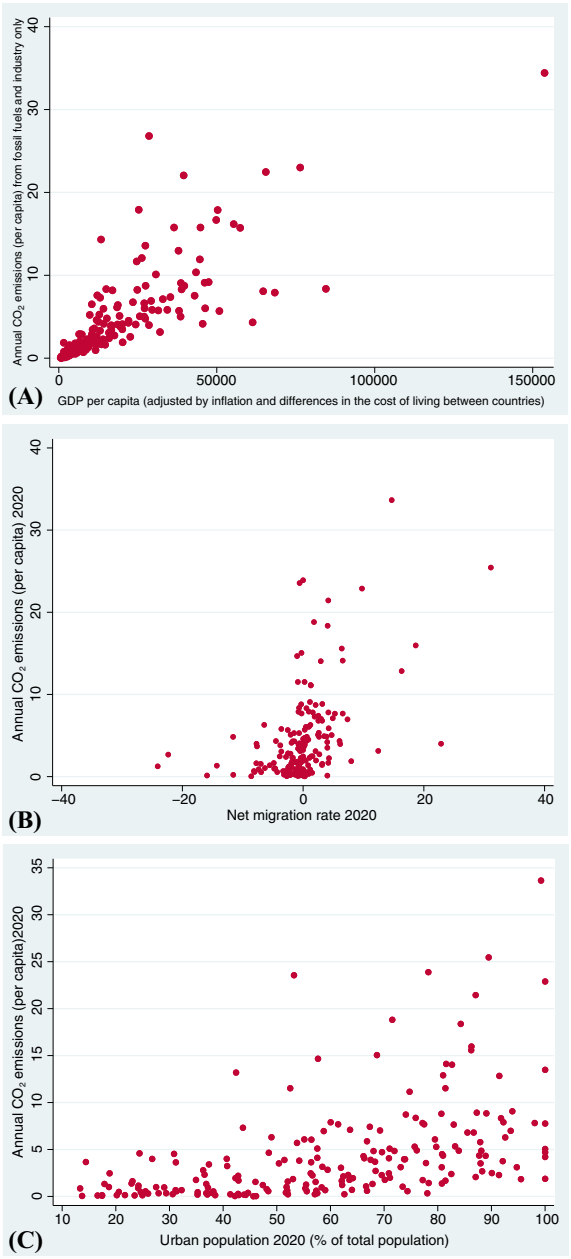
Figure 1 CO_2 emissions and GDP per capita by country, 2018 (A); CO_2 emissions per capita and net migration rate by country, 2020 (B); and CO_2 emissions per capita and proportion of urban population, 2020 (C)



Sources: (A) own elaboration based on Morris (2021, Fig. 2) and data from Our World in Data; (B) and (C) own elaboration based on data from Our World in Data (https://ourworldindata.org/grapher/co2-emissions-vs-gdp)

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between urbanisation and emissions can vary depending on the level of economic development and the form of urban settlement expansion (low, medium or high density) (Seto et al., 2010; Luqman et al., 2023). How rapidly a city expands in terms of population and area, and how concentrated or dispersed this growth is, are relevant factors in determining the city's current and future role in the emissions of the country where it is located. The large body of existing literature on residential mobility and commuting (not covered in this brief article) – including transportation options and choices (active travel, public transportation, private car) – could provide valuable insights into this relationship (see, for example, Brand et al., 2021).

(b) Population mobility could help to facilitate or to restrict behavioural change through its effects on the demographic composition of the populations in the receiving and the sending areas, which could, in turn, influence consumption and emissions patterns, based on the premise that the sending and the receiving areas differ in terms of their emissions per capita and consumption structures (Jiang and Hardee, 2011). Modification of consumption trends is an important strategy for mitigation because a large proportion of global GHG emissions is related to household consumption (Ivanova et al., 2020). Due to its selectivity, population mobility may, for example, rejuvenate urban areas while accelerating ageing in rural places. These changes could influence mitigation efforts because the consumption structures of the younger and the older populations differ. What is important for mitigation is how different the consumption patterns are in the sending and the receiving areas, and the extent to which migrants adopt new behaviours. The integration of immigrants in their host communities, as well as the environmental attitudes and values and the normative landscape of these communities, could be critical factors in determining whether more or less environmentally-friendly behaviours are maintained or adopted (Head et al., 2019; Romero et al., 2018). Moreover, whether migration is mainly long- or short-term and the migrants' ages could be relevant for understanding environmental consciousness (Hunter, 2000). Migrants' remittances also deserve attention (e.g., Benveniste et al., 2022), including not just financial, but also social remittances (Levitt and Lamba-Nieves, 2011). Remittances could promote behavioural changes in the areas of origin by either facilitating or constraining mitigation strategies, such as those related to changes in consumption patterns and structures. However, social remittances go both ways, as migrants arrive at their destination with their norms, practices, identities and social capital (Levitt and Lamba-Nieves, 2011), which could influence those around them (other migrants or non-migrants), including their mitigation behaviour related to emissions and consumption.

Equity, justice and policy matters

In this note, I looked at the ways that population mobility, as a key component of population trends, may shape emissions, consumption and mitigation behaviour, thereby facilitating or constraining mitigation strategies, options and policies. As people move within or between countries looking to improve their wellbeing or to escape conflicts, violence or disasters,

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population mobility needs to be acknowledged as a relevant factor in mitigation policies, not only at the national level, but also at the global level, for example, when setting global CO_2 mitigation targets (Liang et al., 2020).

The Global Compact for Migration recognises that migration is an inherent part of globalisation, and is essential for "connecting societies within and across all regions" (United Nations. General Assembly [UNGA], 2018, p. 3). It also calls for countries to "minimise the adverse drivers and structural factors that compel people to leave their country of origin" (UNGA, 2018, p. 9), including by implementing plans for mitigation of and adaptation to climate change.

At the same time, some mitigation plans, strategies and policies (such as negative emissions technologies based on the expansion of biofuels and carbon forests, geoengineering and solar engineering) could unintentionally result in forms of maladaptation that increase vulnerability and lead to displacement or forced migration (Ginty, 2021, pp. 1–2; see also Vigil, 2015; Sovacool et al., 2022; Aldy et al., 2021). Mitigation policies may have impacts on more disadvantaged groups (Hallegatte and Rozenberg, 2017), and mobility could be one of the responses to these effects.

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