MEGACITIES, CLIMATE VULNERABILITY AND ENVIRONMENTAL DISPLACEMENT: INTERDEPENDENT CHALLENGES

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KEYWORDS

Human Mobility; Social Resilience; Ecosystem Services; Climate Change; Migration; Sea Level Rise.

ABBREVIATIONS

CO_2 Carbon Dioxide

GCC Global Climate Change

GHG Greenhouse Gases

IPCC Intergovernmental Panel on Climate Change

IDMC Internal Displacement Monitoring Centre

IPCC Intergovernmental Panel on Climate Change

MEA Millennium Ecosystem Assessment

IOM International Organization for Migration

UN United Nations

UNEP United Nations Environment Programme

UNFCCC United Nations Framework Convention on Climate Change

UN-HABITAT United Nations Human Settlements Programme

UNHCR United Nations Refugee Agency

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ABSTRACT

Climate change and urbanization are the biggest challenges to be faced by humanity. Between 1950 and 2005, global carbon emissions from fossil fuel burning increased by almost 500% while the level of urbanization increased from 29% to 49%. Urban growth is one of the main factors that cause the increase of natural habitat loss on the planet, which affects the capacity of ecosystems to meet the vital needs of millions of people, including the growing number of international migrants, who are strongly directed to urban areas. Considering the trend of intensification of the effects of climate change, this study assesses the interdependence between urbanization, climate vulnerability and environmental displacement in the megacities of the world, based on the simulation of sea level rise in megacities. Although climate change is a global issue, it is also a local concern, since urban areas play a crucial role in the climate change scenario. As migration policies and urbanization are considered separately, megacities are spaces of high vulnerability, notably given the effects of climate change, and demand the development of coordinated responses to tackle them.

1 INTRODUCTION

The world has experienced an intense process of urbanization in the last 50 years, with the concentration of 55% of the global population living in urban areas. The rapid growth of the population and the accelerated process of urbanization have enabled unprecedented development in the number of megacities – urban spaces that concentrate more than 10 million inhabitants. With only two megacities in 1950 (London and New York), the year 2020 congregates 33 megacities with a projected addition of 10 by 2030. The cities configure centers of social, economic and political activity that attract internal and international migrants. The displacement of people from rural to urban areas, between urban settlements of different sizes, and from one country to another will continue to affect the demographic distribution, within and outside national borders (United Nations, 2018; 2019; Rigaud et al., 2018).

Complex and interconnected environmental changes, such as droughts and floods, overexploitation of resources and climate change, are factors that contribute to increased rural-urban and cyclical human mobility within countries and across borders, with a focus on the impact of climate change on resource-dependent livelihoods and food insecurity (IOM, 2019). Migration in response to environmental factors or as a result of climate change demonstrates a tendency to intensify and ranges from gradual displacements motivated by slow-moving environmental changes to mass displacements caused by sudden disasters (IPCC, 2014a; United Nations, 2018). Due to the global realities of ageing societies, slow and uneven economic growth across regions and countries, and environmental and climate instability, large-scale migration to urban centers is inevitable (IOM, 2015).

Considering the increasing intensification of the climate change effects, this study addresses the interdependence between urbanization, climate vulnerability and environmental displacement in megacities. It briefly discusses the socio-environmental consequences of global air pollution and urbanization as a vector of change in ecosystem services. The relationships between human mobility, climate change and megacities are dealt herewith, with the characterization of current incoming migratory flows to these large settlements that will turn into outgoing flows as a result of sea level rise.

2 METHODS

The database used for the analysis of the themes related to “urban mobility”, “megacities” and “climate change” was built between 1st and 24th of June, 2020, by systematically compiling the records from Web of Science (2020). Web of Science provides a large number of peer-reviewed documents at different subscription levels. Restricted access granted to academics of the University of São Paulo (USP) allowed access to the selection of documents corresponding to “article” and “review” published from 2015 to 24th of June, 2020. Firstly, we retrieved records with the term “megacity*” or “mega city*” as a topic – more specifically, when these terms appeared either in the title, abstract or as keywords. The data collected from Web of Science resulted in 3,528 records for the conditions specified in the first research. We applied a new search to this result, for the descriptors related to climate change (334 records), refined by the descriptors “human mobility” (1 record); “migration” (9 records); “displacement” (3 records). We then analyzed and systematized the information, correlating bibliography, official documents on international migration and internal displacement, megacities and climate change.

We used the platform Resource Watch (2020), which presents hundreds of data groups about the state of resources and people on the planet, enabling the visualization of global challenges. We used the platform while taking into account information of the document “World Urbanization Prospects 2018 Highlights” (Population Division of the UN Department of Economic and Social Affairs, 2019) and the most optimistic scenario of sea level rise presented in the IPCC projections (2014). We evaluated the impact of this aspect of the climate change on megacities, from the interactive map with the areas flooded by different values of sea level rise, and correlated the results with the megacities that are destinations of international migration (IOM, 2015).

3 RESULTS

GLOBAL AIR POLLUTION AND SOCIO-ENVIRONMENTAL CONSEQUENCES

Global climate change (GCC) consists of a change in climate that can be directly or indirectly attributed to human activity that modifies the composition of the world's atmosphere, and that is added to the change caused by natural climate variability observed over comparable periods (UNFCCC, 1992; Luca et al., 2020). Global warming is a direct result of the increase in atmospheric concentrations of greenhouse gases (GHG), and it is extremely likely that more than half of the increase in global temperature between 1951 and 2010 was caused by the influence of man-made activities (IPCC, 2014b).

The projections point out that the average global surface temperature will continue to increase throughout the 21st century, and will most likely be above 1.5 ^{o}C by the end of the century. Even if GHG emissions were to stop immediately, many aspects of the GCC would last for many centuries and more than 20% of the emitted carbon would remain in the atmosphere for over a thousand years until it is re-absorbed and fixed again in the surface (IPCC, 2014a). In recent decades the GCCs have had direct impacts on natural and human systems on all continents and oceans, with changes in precipitation and melting of snow and ice; changes in geographic distribution, seasonal activities and migratory routes; changes in the abundance of land, freshwater and marine species; loss of crop yields, and ocean acidification. In the period of 2014-2018 the global average temperature rose to 1.04 ^{o}C above the pre-industrial baseline – the warmest 20 years have occurred in the last 22 years, the last four being the warmest of all (IPCC, 2018).

Concerns about climate changes have increased the interest in measures to reduce GHG levels, among which vegetation plays an important role because of its capacity to absorb atmospheric carbon. At the same time, the intense process of urbanization and metropolization is characterized by generating economic benefits, intense population flow and building densification, as well as increasing the

temperature in urban centers and loss of ecosystem services that are fundamental to life and well-being in these large urban settlements.

MEGACITIES, ECOSYSTEM SERVICES AND CLIMATE CHANGE

The ecological characteristics, functions or processes that contribute directly or indirectly to human well-being are defined as ecosystem services (MEA, 2003; Costanza et al., 1997; Anderson et al., 2019; Geijzendorffer et al., 2017). Although there is an increasing demand for these services, there is also an increasingly strong degradation of the ecosystems' capacity to provide them, which directly affects human well-being and has impacts on safety, material assets necessary for a healthy living, health, social and cultural relations (MEA, 2003; 2005).

In 1997, ecosystem services were estimated at US$ 33 trillion/year, while in 2011 they were estimated to a total of US$ 125 trillion/year, considering only updates in service values. Land-use change corresponded to the loss of US$ 4.3 to US$ 20.2 trillion/year in ecosystem services for the period of 1997-2011 (Costanza et al., 1997; 2017).

Urbanization is a direct vector of change in ecosystems, being responsible for the loss of 190 thousand km^2 of natural habitats on the planet, between 1992 and 2000 – which is equivalent to 16% of all that was suppressed in the period. If the same rates of urban growth are maintained, the trend is the loss of up to 290,000 km^2 in 2030, with humid forests being particularly affected. Globally, more people live in urban areas. If in 1950 30% of the world's population was urban, in 2018 this rate was 55%, with 66% of the world's population projected to be living in urban areas by 2050 (McDonald et al., 2018; United Nations, 2018).

Worldwide urban population growth has been rapid since 1950 – an increase from 741 million to 4.2 billion people in 2018. As the planet continues to urbanize, sustainable development is increasingly dependent on the successful management of urban growth, mainly due to the strong trend of pressure and suppression of natural ecosystems, which harbor important biodiversity and provide significant ecosystem services for their populations. The United States, Brazil, Nigeria and China will be the countries with the greatest loss of native ecosystem areas for urbanization in the next decade (> 10,000 km^2) (McDonald et al., 2018; United Nations, 2019). In practice, urbanization refers to the increase in the percentage of population living in urban areas, the growth related to the number of urban residents, the size of cities and the total area that is occupied by urban settlements (United Nations, 2019).

More than half of the world's population lives in urban environments and 13% of the urban population lives in megacities – urban centers with over 10 million inhabitants. In 1990 there were 10 cities with more than 10 million inhabitants that were home to 7% of the global urban population. In 2018 this number of megacities tripled to 33 and their population represents 13% of the world's urban inhabitants. Megacities are concentrated in only 20 countries and it is projected that 10 more cities will join the group of megacities between 2018 and 2030 (two in Africa; seven in Asia and one in Europe) (United Nations, 2019).

While megacities offer financial, social and cultural opportunities for their inhabitants, they also generally present problems related to inadequate land use, precarious infrastructure, water scarcity, poor sanitation, air pollution, traffic in excess, with significant social, economic and environmental challenges expressed in pockets of wealth and poverty in their territory. In many developing countries, especially in sub-Saharan Africa, urbanization does not necessarily translate into economic growth, promoting the emergence of poor megacities (Castells-Quintana and Wenban-Smith, 2019).

Urbanization and climate change are the greatest challenges to be faced by humanity. In the period from 1950 to 2005, global carbon emissions from fossil fuel burning increased by almost 500% while urbanization increased from 29% to 49%. Even though climate change is a profound global issue, it is also a local issue, as urban areas play a crucial role in the framework of climate change. Urban areas

of the planet account for 71% to 76% of global energy end-use and carbon dioxide emissions. At the same time, they correspond to high concentrations of assets and financial infrastructure and human contingent activities that are vulnerable to climate change. Hundreds of millions of people in urban areas are likely to be affected by rising sea levels and rainfall, more frequent and stronger floods, cyclones and storms, and more extreme heat and cold periods (UN-Habitat, 2016; 2019).

Together with population growth, population ageing and international migration, urbanization constitutes one of the four demographic megatrends. The connection between urbanization, international migration and climate change stands out. As cities are configured as major internal and international migrant gateways and destinations, migration needs to be integrated into the planning and management of cities and urban systems (United Nations, 2019).

Moreover, migration is at the heart of urbanization. The very projection of an increase to 66% of the world's population sheltered in cities is the result of both natural population growth and migratory flows, which include the search for refuge from natural and man-made disasters, flight from violence and persecution or the search for more dignified lives. However, the rapid and intense influx of people into cities, especially when caused by crises, brings challenges for local governments, which need to face pressure on basic services, infrastructure, housing, health and education (United Nations, 2018).

While human activities generate GHG, climate change has a variety of effects on the planet and also causes progressive impoverishment and aggravates local disputes and conflicts. Less resilient populations (with less capacity to adopt alternatives to their traditional productive activities) are more likely to emigrate (Agustoni and Maretti, 2019). The impacts of GCC vary by region and its effect is stronger on the most vulnerable population groups, including those with lower purchasing power.

Megacities and Human Mobility Induced by Climate Change

The relationship between the environment and migration is old; however, the interest in the subject has increased since 1990 due to the consequences of climate changes, natural disasters and environmental degradation affecting human groups, in particular the populations of countries with lower levels of development (IOM, 2017; Pileggi and Sodré, 2020).

A migrant is defined as any person who moves or crosses an international border or within a state outside his or her usual place of residence, regardless of: i) the person's legal status; ii) whether the movement is voluntary or involuntary; iii) what the causes of such mobility are; iv) how long the stay lasts. The following are key concepts about human mobility: i) displacement: situations in which people are forced to leave their homes or places of habitual residence; ii) migration: movements that are predominantly voluntary; and iii) planned relocation: an organized relocation, ordinarily instigated, supervised and carried out by the state with the consent or upon the request of the community (United Nations, 2020), with emphasis on the complex relationship between environmental and geopolitical variables, as determining factors for migrations.

Nowadays, climate and environmental migrations are characterized, above all, by being short distance with a strong impulse component and mainly in the south-south direction. Thus, there is an urgency in the regulation of the issue by the international community (Pileggi and Sodré, 2020). Although international migrations are widely reported by the media and are more directly inserted in the political debate, internal displacements correspond to most of the migration flows, especially when related to the environment (Ionesco, Mokhnacheva and Gemenne, 2016).

The number of international migrants worldwide – people living in a country other than their country of birth – reached 272 million in 2019. Approximately 31% of international migrants worldwide reside in Asia; 30% in Europe; 26% in the Americas; 10% in Africa and 3% in Oceania – international migrants represent 3.5% of the world's population (United Nations, 2020).

At the same time, an increasing number of people are moving within the same country or territory, and thus remaining for short or long periods of time. Although underestimated due to difficulties in their identificDation and monitoring, internal displacement in the 10-year period (2009-2019), added up to 345.3 million, 75% due to disasters (259.7 million) and 25% due to conflict and violence (85.6 million), being important to consider the highly specific nature of each displacement situation (IDMC, 2020) (Table 1).

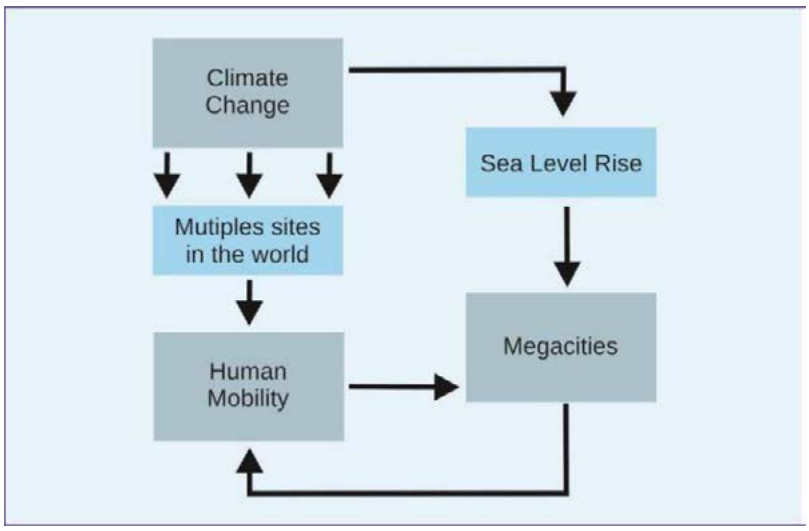
Table 1. New internal displacements in 2019 by conflict, violence and disasters, and by region. *Source*: elaborated based on IDMC (2020).

Region	Conflict, violence	Disasters
The Americas	602,000	1,545,000
Europe and Central Asia	2,800	101,000
Middle East and North Africa	2,566,000	631,000
South Asia	498,000	9,529,000
Sub-Saharan Africa	4.597,000	3,448,000
East Asia and Pacific	288,000	9,601,000
TOTAL	**8,553,800**	**24,855,000**

According to the United Nations Office for Disaster Risk Reduction (UNDRR) we can define disaster as a "*serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts*" (UNDRR, 2021). In 2019, around 1,900 disasters caused 24.9 million new displacements in 140 countries and territories – the highest number since 2012 – and which corresponds to three times the number of displacements caused by conflict and violence in the same period. The disasters affected many communities that were already vulnerable, displacing people with little capacity to recover (IDCM, 2020).

Climate change is a driver of human mobility and will much likely lead to an increase in population displacement. Measures can be taken both to prevent and mitigate displacement in the context of climate, and to implement migration as a planned adaptation and relocation strategy (IPCC, 2014a).

Figure 1. Relation between megacities, climate change and migration.



Scientific research shows that a colossal migration wave tends to occur as a consequence of environmental climate conditions, which has led the international scientific community to experience a rapid growth in the interest on the importance of the connection between migration, climate and environmental change over the past ten years (Maretti et al., 2019; Rigaud et al., 2018). However, in searching the correlation between megacities, climate change and migration in the Web of Science, the return was only 13 records, which highlights a serious knowledge gap.

In this scenario, a more comprehensive evaluation of these correlations is urgent. This analysis must consider the impact of displacement on large urban agglomerations from both international and internal migration, which originates in rural areas impoverished by environmental and climatic factors and natural disasters, and at the same time the impact of climate change on physical infrastructure and human settlements in urban areas (Figure 1).

Phenomena such as rising sea levels, storms, heat stress, extreme precipitation, coastal and inland flooding, landslides, droughts, increased aridity, water scarcity and air pollution will have profound impacts on urban functions, services and infrastructure, with the potential to exacerbate existing tensions (UNEP, 2015).

With a world population of 9.7 billion people, only the 33 megacities concentrate the equivalent of 7% of the planet's population. In order to better understand the relation between megacities, climate change and migration, the future scenario of megacities' jeopardy to sea level rise has been evaluated, in a more optimistic temperature increase scenario, which has among its consequences the sea level rise by 0.5 meters (IPCC, 2014; Resource Watch, 2020). We also identified displacement flows to megacities (IOM, 2015) (Table 2).

Table 2. Megacities, population and impact of the sea level rise. Megacities which are both migrant destinations and affected by the sea level rise are highlighted in red. *Source*: elaborated based on Resource Watch (2020); United Nations, (2019); IPCC (2014b); IOM (2015).

Urban Agglomeration	Population (2018)	Country	Migration destinations	Impact of the Sea Level Rise
Tokyo	37 468 000	Japan	YES	Affected
Delhi	28 514 000	India	YES	Not affected
Shanghai	25 582 000	China	YES	Affected
São Paulo	21 650 000	Brazil	YES	Not affected
Ciudad de México (Mexico City)	21 581 000	Mexico	YES	Not affected
Al-Qahirah (Cairo)	20 076 000	Egypt		Not affected
Mumbai (Bombay)	20 076 000	India	YES	Affected
Beijing	19 618 000	China	YES	Not affected
Dhaka	19 578 000	Bangladesh		Affected
Kinki M.M.A. (Osaka)	19 281 000	Japan		Affected
New York-Newark	18 819 000	USA	YES	Affected
Karachi	15 400 000	Pakistan		Affected
Buenos Aires	14 967 000	Argentina	YES	Affected
Chongqing	14 838 000	China		Not affected
Istanbul	14 751 000	Turkey	YES	Affected
Kolkata (Calcutta)	14 681 000	India	YES	Affected
Manila	13 482 000	Philippines	YES	Affected
Lagos	13 463 000	Nigeria		Affected
Rio de Janeiro	13 293 000	Brazil	YES	Affected
Tianjin	13 215 000	China		Affected
Kinshasa	13 171 000	D.R. of the Congo	YES	Not affected
Guangzhou, Guangdong	12 638 000	China	YES	Affected
Los Angeles-LB-Santa Ana	12 458 000	USA	YES	Affected
Moskva (Moscow)	12 410 000	Russian Federation	YES	Not affected
Shenzhen	11 908 000	China	YES	Affected
Lahore	11 738 000	Pakistan		Not affected
Bangalore	11 440 000	India		Not affected
Paris	10 901 000	France	YES	Not affected
Bogotá	10 574 000	Colombia		Not affected
Jakarta	10 517 000	Indonesia	YES	Affected
Chennai (Madras)	10 456 000	India		Affected
Lima	10 391 000	Peru		Affected
Krung Thep (Bangkok)	10 156 000	Thailand		Affected

The results are alarming: the projection shows that 63%, or 21 megacities, will be affected, with implications for a population totaling 342.58 million people. Of the 33 megacities, 21 are configured as international migration destinations. Of these 21 megacities that receive large flows of international migrants, 12 will be affected by rising sea levels, and it is important to note that the effects of the GCC on coastal systems, in addition to the accelerated rise in sea levels, include more severe tropical cyclones and an irregular and intense climate.

The results presented in Table 2 allow us to infer that the question is not whether there will be an impact on the relation between megacities and migration as a result of climate change events, but when this will occur and what measures are being taken to address this problem. Without taking into account the large coastal cities, which will also be affected by the sea level rise, with only the 12 megacities that are at the same time configured as international migration destinations and which will be affected by the accelerated sea level rise, the impact of the climate change consequences will be felt by more than 182 million people.

It is also necessary to consider the interaction of GCC with other forces of global change that are as synergic threats to the natural and human systems in the coastal zones. They include: degradation of ecosystems, scarcity of resources (especially energy), and population growth. While migration towards the coast during the 20th century has enabled the emergence of coastal megacities, it is very likely that migration flows away from these megacities will intensify throughout the 21st century – more than 10 million people are displaced from coastal areas each year due to storms and flooding (Day and Rybczyk, 2019).

Thus, while these spaces continue to attract movement in their direction, they will become reverse flow territories, expelling millions of people to other regions. The discussion necessarily encompasses the role and infrastructure available in temporary shelters that end up being permanent spaces in inadequate conditions to sustain life. Currently, more than 6.6 million refugees live in camps (4.6 million in planned/administered camps and about 2 million in self-established camps). Although these shelters are a vital survival mechanism in times of humanitarian crisis and displacement, they result in a series of problems, including aid dependency, precariousness and isolation (UNHCR, 2020).

Understanding these inbound and outbound flows, the level of impact of GCC over megacities, and planning housing structures and other arrangements at the scale of the issue is fundamental to mitigate the impact of displacement, which necessarily encompasses the development of urban systems suitable for receiving these mobile human contingents.

CONCLUSIONS

Environmental displacements are a major challenge for society and one of the most relevant obstacles on an international political agenda, although international legislation applied to the theme of refugees does not consider the situation of those affected by relevant environmental disturbances. In the same way, although the number of vulnerable people affected by climate change is high and growing, the debates – both academic and political – on the connection between climate change, human mobility and megacities result in a limited discussion of the problem, which generally disregards interconnections and unequal power relations at local, regional and global scales regarding mobility at the transnational level and at the internal level. By camouflaging an existing problem, this framework can prevent the adoption of appropriate public policies to address it and make it impossible to correctly inform the processes of environmental mobility and the inclusion of those affected in new contexts.

The simulation with the 33 megacities of the world shows that 21 will be directly affected in whole or in part, that is, they will lose territory which will cause deep human displacement and significant

loss of ecosystem services. The 12 megacities that will not be affected by the 0.5 m rise in sea level are likely to receive population contingents from nearby coastal areas, neighboring countries and landlocked island countries. Investments in reducing greenhouse gas emissions, adaptation, and increasing resilience are urgently needed to reduce these effects – avoiding these large projected migrations is urgent and necessary.

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