

Diana Reckien, Felix Creutzig, Blanca Fernandez Milan, Shuaib Lwasa, Marcela Tovar-Restrepo, Darryn McEvoy, David Satterthwaite

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Climate Change, Equity and Sustainable Development Goals: An Urban Perspective

Diana Reckien^{1,*}, Felix Creutzig^{2,3}, Blanca Fernandez Milan^{2,3},
Shuaib Lwasa⁴, Marcela Tovar-Restrepo⁵, Darryn McEvoy⁶, David
Satterthwaite⁷

Abstract

Climate change is acknowledged as the largest threat to our societies in the coming decades, affecting large and diverse groups of residents in urban areas in this century of urbanization. The focus of climate change impact discussions conceivably shifts to who in cities will be affected how by climate change, bringing the urban equity question to the forefront and co-aligning with a set of key Sustainable Development Goals. Here we assess how climate change events may amplify urban inequity. We find that heat waves, but also flooding, landslides, and even mitigation and adaptation measures affect specific population groups more than others. As underlying sensitivity factors we consistently identify socio-economic status and gender. We synthesize the findings with regard to equity types, meaning outcome, procedural and context-related equity, and suggest solutions for avoiding increased equity and justice concerns as a result of climate change impacts, adaptation and mitigation.

Keywords: Equity, Environmental Justice, Equality, Climate Change, Impacts, Adaptation, Mitigation, Assessment, Gender, Women, Socio-economic, Poverty, Low-income.

^{1*}(Corresponding author) University of Twente, Department of Urban and Regional Planning and Geo-Information Management

²Mercator Research Institute on Global Commons and Climate Change Berlin

³Technical University Berlin, Department of Economics of Climate Change

⁴Makerere University Kampala, Department of Geography

⁵Columbia University, Graduate School of Architecture, Planning and Preservation

⁶RMIT University, Civil, Environmental and Chemical Engineering

⁷International Institute for Environment and Development

1. Introduction

Cities are melting pots of people with diverse backgrounds, cultures and positions within social and economic networks. In addition to these intra-city diversities cities differ with respect to their political and economic functions, development stages, locations and climates. As climate change becomes an increasingly pressing issue, the question of how these urban diversities interact and cities react to climate change becomes an increasingly important issue demanding systematic investigations (Reckien et al. 2014, Creutzig et al. 2015, Reckien et al. 2015, Shi et al. 2016). Arguably, the most important issue deals with the question of *who* will be impacted by climate change, and *how* to address co-occurring injustices and underlying equity concerns.

WHO: There are two main distributional categories of climate change and cities. First, a number of climate hazards, from heat waves, to flooding, landslides, and droughts impact urban populations differently, depending on a number of economic, social and individual factors. Second, while high-income cities, mostly in the North, have contributed most to climate change, it will be cities in the low-income countries, mostly in the South, that might be impacted most. HOW: Like climate change-related impacts and risks affect urban populations differently, so do measures of mitigation and adaptation to climate change. This is especially pronounced in cities where people of different abilities, resources and coping capacities concentrate. Adaptation and mitigation policies may affect vulnerable populations proportionately stronger if not properly designed and therefore manifest inequities and inequalities in cities. However, if properly designed—addressing the concerns of the most vulnerable urban populations—policy measures can alleviate burden and reduce equity concerns of climate change. It is the main goal of this article to review the impact of climate change and related adaptation and mitigation policy measures on equity concerns in cities.

Addressing equity and equality issues has reached overarching global importance, documented not only by the recent advancements of the UNFCCC negotiations towards a post-Kyoto Agreement in Paris, but also by the Sustainable Development Goals (SDGs). Sustainable development is a global focus reasoned by the observation that the substantial progress towards a number of the Millennium Development Goals (MDGs) was not universal, nor the benefits evenly shared (WEDO and REDD+SES 2013, United Nations 2015, Bundesministerium für Arbeit und Soziales 2013). It is also documented that reaching the goal of gender equality was missed (United Nations 2015). Wide gaps remain in women's access to paid work in at least half of all world regions (UN Women's Major Group 2014, UN Women's Major Group 2015). In this paper we argue that equity issues caused by climate change impacts, adaptation and mitigation in cities (Revi et al. 2014, IPCC 2014) closely interact with reaching a number of the SDGs.

It is the interface of climate change and cities with equity and equality that we examine by focusing on the unequal impacts of climate change, adaptation and mitigation on people in poverty and on women. We proceed as follows: We first provide crucial background by disentangling various equity perspectives and introducing climate change and equity concerns in cities (Section II). We then shortly explain the type of research and assessment done (Section III). We then systematically summarize differential impacts of a number of climate hazards on urban populations, as well as the differential outcomes of mitigation and adaptation policies on certain groups, particularly on women and the poor (Section IV). We finally summarize our findings and highlight policy implications for addressing climate change in cities related to the SDGs (Section V).

2. Background

In this section we shortly explain the main types, domains and principles of equity as distinguished in the climate change literature. The main types are used as a framework to return to in the conclusion and summary of the article. We then shortly introduce how aspects of climate change impact, adaptation and mitigation relate to equity concerns.

2.1 Equity types, domains, and principles

Promoting equity is an implicit (and sometimes explicit) goal of many local and regional climate initiatives (McDermott and Schreckenber 2009), aiming at current and future generations. However, it is often unclear which type of equity concern is being referred to. Commonly three types are identified:

1. Outcome-based/ distributive/ consequential equity, relating to the consequences of a policy, action or developmental trend; e.g. equity in the distribution of costs and benefits or in privileges and burdens; between women and men or between households; between urban districts (including peri-urban districts), or generations of urban residents;

2. Process-oriented/ procedural equity, referring to the impartiality and fairness in the process of delivering and administering the justice, such as access to decision making processes (Metz 2000, McDermott, Mahanty, and Schreckenber 2011);

3. Contextual equity, linking the first two dimensions by taking into account pre-existing political, economic and social conditions (McDermott and Schreckenber 2009).

To operationalize equity concerns McDermott, Mahanty, and Schreckenber (2011) relate the three content-related types to three parameters: the targets (and scale) of equity, the goals of equity, and the process of setting targets and goals. Operationalization is further based on principles and indicators, of which a large

number have been proposed (Metz 2000, Klinsky and Dowlatabadi 2009, Cazorla and Toman 2000). The large number of principles converge to a limited set of equity domains (Table 1, based on (Kallbekken, Sælen, and Underdal 2014)).

Table 1: Commonly applied equity domains in international climate change mitigation efforts. Domains are distinguished by causes versus consequences and costs versus benefits.

Focus on	Object to be allocated on basis of ...	
	Costs (obligations)	Benefits (rights)
Causes of the problem	I) Moral responsibility (“guilt” in having caused the problem)	III) Previous contributions (to providing the benefits under consideration)
Consequences of the solution	II) Capabilities (capacity to contribute to problem solving)	IV) Need for (or right to) the outcome to be achieved, i.e. goods or services of a policy

Support for equity domains, principles and indicators differ between countries (Shukla 1999, Kallbekken, Sælen, and Underdal 2014) and potentially even more between regions and cities—underlining the need for consideration of procedural and contextual equity. For example, among delegates to the UNFCCC climate change negotiations the ‘polluter pays’ principle (example of I) had most support in a short- term perspective, i.e. ≤ 20 years. This was followed by ‘the exemption of the poorest’ (II) and ‘ability to pay’ (II). An ‘egalitarian’ principle (equal mitigation pledges) was not supported by many and even more objected to the ‘sovereignty’ principle, i.e. the full right and power to decide on its mitigation pledges (Kallbekken, Sælen, and Underdal 2014, Lange et al. 2010).

Stressing the need for consideration of process-related equity and inclusion of related stakeholders, for example, even within the UNFCCC gender balance and women’s participation on boards and bodies is highly unequal. Women’s rights groups have made important contributions to the UNFCCC, including several decisions stating the need of women’s participation in UNFCCC thematic areas and their right to decide on mitigation, adaptation, climate change finance, technology and capacity-building. However, so far only resolutions regarding adaptation have included robust gender-sensitive language. Few decisions on mitigation refer to gender, with no guiding mandate for gender-sensitive mitigation actions (see (WEDO 2014)).

2.2 Equity and climate change impacts and risk, adaptation and mitigation

Equity, equality and environmental justice issues first entered the debate on climate change when it was recognized that countries that historically have contributed least to global warming might be impacted the most by climate change in the future (UNDP 2004, Revi et al. 2014). Consequently, initial discussions revolved around mitigation responsibility and pledges. It is now recognized that impacts are also increasing in high-income countries due to, e.g., supply chain interdependencies

(Nabangchang et al. 2015), which broadens the discussions. Metz (2000) stresses that the climate change equity discussions should not only consider mitigation, but also take account of impact and adaptation. This is of particular importance for urban areas, as it is at local and regional scales where differential impacts and adaptation needs will unfold. However, impacts and risks of climate change are reduced by adaptation and mitigation, hence all three dimensions play a role for cities.

Impacts of climate change differ across (Fig. 1) and also within cities. The latter are caused by intrinsic, person-related characteristics determining a person's sensitivity and extrinsic, location-specific conditions determining the exposure to a climate or weather event. Intrinsic and extrinsic characteristics interact, influencing where people live and how sensitive they are to climate change impacts. However, it is not just the most susceptible that are impacted; regularly occurring events can also gradually undermine the resource base of more resilient groups in society, ultimately leading to increases in the scale and depth of urban poverty overall (Tyler and Moench 2012, Tompkins et al. 2013).

High exposure and sensitivity to climate impacts often coincide with low adaptive capacity (Mearns and Norton 2010). In that respect it is important to recognize the current vulnerability of many cities in low- and middle-income nations and their inhabitants and their limited capacity to adapt to a changing climate (Revi et al. 2014). Such differential vulnerability may be attributed to deficiencies with respect to the quality, location and access of and to infrastructure and housing, availability of social services and facilities, opportunities and access to education, effectiveness of planning systems; as well as the lack of resources and low levels of community adaptive capacity (Taylor 2013, Revi et al. 2014, Sen 1999). Adaptive capacity can be eroded over time through repeated coping and 'risk accumulation processes' (Satterthwaite et al. 2007, Rodin 2014), with knock-on effects for chronic poverty (UNISDR 2009).

Mitigation issues are a concern of contemporary urban planning, too, as the contribution of Greenhouse gases emissions (GHGs) of urban areas to the global total is estimated at between 37% and 49% (Seto et al. 2014)— although principally from cities in middle and high-income nations. Some cities have shown farsighted leadership in setting targets and devising and implementing plans to reduce GHG emissions (Reckien et al. 2014) but it is important to evaluate such commitments with respect to the distribution of the benefits and burdens. Curbing GHG emissions should be central for high-income residents; whereas greater, sustained and affordable access to energy and electricity are often of key importance for low-income residents. In order to ensure the resilience of communities in the future, considerations of equity need to be central to all three domains—impacts and risks, adaptation, and mitigation—of the contemporary urban climate change debate.

Box 1: Explanation of important gender concepts

Sex is a biological term and indicates the physical differences between women and men, based on their sexual and reproductive functions. **Gender** refers to the socially constructed differences between women and men. It involves gender identities and attributes, roles and relationships, including power relations. Gender roles vary substantially across different cultures and societies and shape the gender division of labor, the access, use, control and property of assets, goods and opportunities. These can be used as an analytical tool to analyze social processes and be changed over time. Gender roles cause that women spend more hours in the household and the community sphere, performing reproductive and care-work that is not paid or under-paid. For example: women work two-thirds of the world working hours yet they receive only 10% of the world's income. Of the 550 million low-paid workers in the world, 330 million (60%) are women. In Pakistan in 2001, women owned less than 3% of the plots, even though in most cases, legal regulations allowed them to own land (GGCA 2009).

Gender equality means that women and men have equal conditions for realizing their full human rights and the equal valuing by society of both the similarities and differences between women and men, and the varying roles that they play.

Gender equity is the process of being fair to women and men. To ensure fairness, measures must often be available to compensate for historical and social disadvantages that prevent women and men from otherwise operating on a level playing field.

Gender sensitive is to take into consideration socio-cultural norms and discriminations in order to acknowledge the different rights, roles & responsibilities of women and men in the community and the relationships between them. Gender sensitive policy, program, administrative and financial activities, and organizational procedures will: differentiate between the capacities, needs and priorities of women and men; ensure that the views and ideas of both women and men are taken seriously; consider the implications of decisions on the situation of women relative to men; and take actions to address inequalities or imbalance between women and men.

Gender mainstreaming is the process of assessing the implications of any planned action for women and men, in all areas and at all levels, and as a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies in political, economic and social spheres so that women and men benefit equally and inequality is not perpetuated. The ultimate goal is gender equality. Gender mainstreaming was formally introduced at the Fourth World Conference on Women in Beijing 1995; ECOSOC: 'Resolution 1997/2' and 'Resolution 1998/34'.

3. Methods

This study is a review of the current scientific knowledge on climate change impacts, mitigation and adaptation in urban areas and their relation to equity and environmental justice issues. Data included in the review comprise scientific publications controlled by commercial publishers, such as scientific journal papers,

but also a limited number of grey literature, such as reports or working papers. We try to maintain a balance in looking at cities in low-, medium- and high-income countries.

The main part of the review draws from an international assessment exercise on climate change and cities—the Assessment Report for Climate Change in Cities 2 (ARC3.2)—and its chapter 4 „Climate Change Interactions with Equity and Environmental Justice“ (Reckien et al. 2015). Here, we extend the mentioned piece of research by focusing and reflecting on the relation of climate change impacts, adaptation and mitigation policies and the equality of gender (see Box 1 for gender-related terms) as well as the distribution of poverty in cities. For the full description of findings including other aspects of climate change and equity in cities see Reckien et al. 2016.

4. Findings

4.1 Equity in urban climate change impacts

4.1.1 Common equity concerns related to CC impacts

Gradual changes in climate and extreme weather events pose risks to urban residents (Adelekan 2010, Fuchs 2010) that are influenced by following factors: 1) physical exposure determined by the location of a community, 2) urban development processes that ‘construct risk’ (Eiser et al. 2012, McBean 2012), 3) the social, economic and demographic characteristics of urban populations (Barrios, Bertinelli, and Strobl 2006), and 4) a number of institutional, power and governance aspects at play (Bulkeley et al. 2009, UN-Habitat 2008b, a). Most of these factors are closely related, and play out in low, middle and high-income nations as well as in large, medium and small cities (Adelekan 2012, Awuor, Orindi, and Adwera 2008, Fuchs 2010).

There is evidence that impacts of both gradual climate change and extreme weather events disproportionately affect people with low incomes and low social status (Reckien, Wildenberg, and Bachhofer 2013, Reckien 2014, Bartlett et al. 2009), especially women (Bartlett et al. 2009, Hardoy and Pandiella 2009). But regularly occurring events like droughts and floods have also gradually undermined the resource base of better-off groups (Tyler and Moench 2012, Tompkins et al. 2013). Evidence shows that in cities such as Cairo, Alexandria (Hereher 2010), Rio de Janeiro (de Sherbinin and Hogan 2011), and Dhaka (Khan et al. 2011, Fuchs 2010) residents with low social status and low incomes characteristically inhabit areas more exposed to climate risk. The risks of low-income residents are also related to high population densities and poor quality buildings (UNISDR 2009), the lack of risk-reducing infrastructure and services (Revi et al. 2014), and the failure to draw or implement lessons from previous disasters (Singh and Fazel 2010).

Together with governance and management shortfalls, this has resulted in the accumulation of risk over time (Annez, Buckley, and Kalarickal 2010, David and Enarson 2012), documented by records of increasing disaster losses in cities from mega-debris flows, floods, earthquakes, and tsunamis and, in the last two decades, tropical storms (Allen 2006, Rao 2013).

Fig. 1 shows that many large cities across the world are located in middle and low-income nations. The current rate of warming in these regions is moderate, but warming is expected to continue entailing large anticipated risks in the future. Additionally, many of the cities in middle- and low-income nations experience high growth rates, i.e. increasing the risks for even more residents in the future.

Specific equity concerns

Heat-related equity concerns

Heat-related impacts are one of the main hazards associated with climate change in cities. Two dynamics converge: 1) the global increase in average temperature and 2) the urban heat island effect, i.e. the temperature gradient between dense human built environments and rural environments around the city. These dynamics can be beneficial when reducing the mortality and morbidity risks of cold temperatures, but result in heightened morbidity and mortality during periods of excessive heat or heat waves (White-Newsome et al. 2009, Kinney 2012). Heat waves pose a major climate-related risk: more fatalities—as one measure of impact—occur as a result of heat waves than other climate hazards such as floods and hurricanes (Satterthwaite et al. 2007, Klinenberg 2003).

Heat waves in cities can cause increased morbidity and mortality rates (Kinney 2012) as a result of direct heat stress and other indirect effects. Direct heat stress is particularly harmful when night-time temperatures are high, which prevents the human body from resting, repose and regeneration (Amengual et al. 2014). Indirect effects on health arise principally through the interaction of heat and other environmental factors, particularly air and water pollution (Petkova et al. 2013, Petkova, Gasparrini, and Kinney 2014).

Heat-related risk might be expected to impact all citizens equally. However, heat-related risk is stratified across the population and is linked to both ‘intrinsic’ person-specific characteristics and ‘extrinsic’ socio-economic factors. Extrinsic factors refer to social, environmental and location-specific characteristics, such as socio-economic status, living and working conditions.

Intrinsic factors: Intrinsic factors include various physiological attributes, of which age, female sex, and pre-existing medical condition have been identified as main factors (Fernandez Milan and Creutzig 2015, Reckien et al. 2015) in a meta-analysis of 18 recent studies. A study probing the age factors suggests that physical fitness is the underlying variable explaining the age effect. Women may be more

heat intolerant than men due to potential physiological and thermoregulatory differences (referring to aspects of sex) (Druyan et al. 2012, Racine et al. 2012). However, women may also typically experience more exposure to heat than male residents, due to the time spent in interior spaces undertaking reproductive labors such as cooking in informal settlements, that do not have adequate air flow or air-conditioning (referring to aspects of gender) (Jabeen 2014). In terms of medical status, vulnerability to heat waves is higher in people who are less mobile and confined to bed (e.g., (Vandentorren et al. 2006)). People suffering from cardiovascular diseases are also at relatively higher risk (Tran et al. 2013, Nitschke et al. 2013).

For the extrinsic factors, lower socio-economic status (using a deprivation index based on a series of components, namely education, occupation, unemployment, number of household members, overcrowding and household ownership) and education levels increase relative vulnerability to heat stress. Heat also disproportionately impacts socio-economically disadvantaged households because of their residence in areas with less access to urban green infrastructure and their reduced ability to fund, maintain, and develop private green space. The existence of open spaces and waters are risk-reducing environments, as they cool their immediate surroundings. Unsurprisingly, people living in inner cities are therefore generally more at risk than those living in the suburbs.

Precipitation-related equity concerns

Precipitation-induced hazards may occur as a result of a surplus of rain in short timeframes, such as those connected to inland flooding and landslides, and to a lack of sufficient precipitation potentially causing drought. Inland flooding can occur on a massive scale, e.g. of watersheds—as in Pakistan in 2010 (Atta ur and Khan 2013), Australia in 2011 (Coumou and Rahmstorf 2012), and Thailand in 2011 (Komori et al. 2012)— but localized flash floods can also cause substantial damage and threaten health, lives, and livelihoods as the case in Kampala, Uganda (Sliuzas et al. 2013, Sliuzas, Flacke, and Jetten 2013). In many cities, informal settlements have been developed on flood plains that experience frequent flooding or on steep slopes affected by landslides (Dodman 2013, Carcellar, Co, and Hipolito 2011, Moser and Stein 2011, Hardoy and Pandiella 2009, Douglas et al. 2008, UNISDR 2009, 2011). Insufficient or delayed precipitation also severely impacts mostly low-income populations by way of water shortages, generating crop failures and subsequent food price increases.

Inland flood risk in cities of low- and middle-income countries stems from a number of factors: impermeable surfaces that lead to rapid run-off; the general scarcity of parks and other green spaces to absorb such flows; inadequate drainage systems that are quickly overwhelmed by storm water; and/ or the ill-advised development of housing on marshlands and other natural buffers (Jha, Bloch, and Lamond 2012, Revi et al. 2014). The urban poor are highly affected due to locating in these environmentally riskier areas and lack of risk reducing measures in the

neighborhoods. The exposure to flood risks associated with living close to urban rivers and canals is in many instances a consequence of the on-going pressure for land in fast-growing cities and can be attributed to a lack of tenure security for the urban poor. Given the proximity to waterways, the urban poor risk the loss of their homes to flooding and are often displaced leading to disruption of livelihoods and social support networks (Hardoy and Pandiella 2009). Other indirect effects are related to unsanitary conditions and health risk, e.g. when hazardous materials contaminate flood waters and spill into open wells, elevating the risks of water-borne, respiratory, and skin diseases (Ahern et al. 2005, Kovats and Akhtar 2008, Haines et al. 2013). Outbreaks of cholera, dysentery and diarrheal diseases, Acute Respiratory Infections (ARI), dengue, and malaria are all reported to occur largely in cities with dense low-income neighborhoods (Akanda and Hossain 2012, Khan et al. 2011, Kovats and Akhtar 2008) following intense and excessive rainfall. In turn, diseases may increase the amount of care work and number of unpaid hours women have to spend taking care of sick children and elderly. In many occasions women have to quit their paid jobs to cope with these sanitary and health emergencies (GGCA 2009, Dankelman 2010, Tovar-Restrepo 2010).

The poor in Asian cities deserve particular attention, and if simply as a matter of scale: Asia is the most populated continent; and an estimated 28.6% or 506 million people in Asia live in sub-standard housing or slums (2010), which are often found along a city's rivers and canals (Taylor 2013). The percentage of urban residents living in sub-standard housing in Africa is higher (37.5%), but in total this affects smaller numbers (211 million people) (UN-Habitat 2010, p.32).

Excessive rainfall is a crucial risk factor and has been associated with triggering landslides, which have not yet received as much attention as flooding and coastal hazards, perhaps because these are highly localized events. Despite the recording of these events in international disaster databases, attention usually shifts away from extreme rainfall to geophysical causes of landslides as soon as response programs get underway and rescue efforts are called off. As noted by Cepeda et al. (Cepeda et al. 2010, p.2) "landslides are usually not separated from other natural hazard triggers, such as extreme precipitation, earthquakes or floods in the natural disaster databases. This underestimation contributes to reducing the awareness and concern of both authorities and general public about landslide risk". Yet in many countries and cities, landslides (individually and in combination) present significant threats to human well-being. In general, rainfall triggered landslides are the product of a combination of geo-hydrological and locational factors in mostly mountainous cities. Geo-hydrological factors include intensity of precipitation; locational factors include slope, rock strength, rock susceptibility to fracturing, soil moisture, and vegetation cover (Cepeda et al. 2010). However, whether landslide risk affects mostly low-income or other income groups strongly depends on a number of factors, as seen in El Salvador, Nepal and Sri Lanka (NGI 2012). After civil conflict in these countries rapid, uncontrolled migration from rural to urban centres led also well-off

residents to move to hazardous (and non-occupied) urban areas, with entailing consequences for landslide impacts.

Men and women may experience migration and displacement in different ways. After periods of excessive rain and damages to house and property evidence suggests that women migrate to urban centers, starting a new life but also facing security risks, lack of skills to access the labor market or lack of linguistic skills related to the dominant language, e.g. in Colombia. After periods of drought men have been documented to leave in the quest to make money in urban or more prosperous areas, while women stay put to look after the property, facing challenges of food security and water scarcity (Tovar-Restrepo and Irazábal 2014).

Storm surge and coastal flooding related equity concerns

Storm-related hazards (hurricanes and storm surges) are associated with precipitation-related hazards and constitute a major risk to urban populations. (Tropical) storms often lead to excessive precipitation in addition to gusty winds. In affected coastal regions storms lead to inundation of low elevation coastal zones with differential impacts. The poor settlements are often impacted severely due to inadequate infrastructure protecting the neighborhoods. The impacts differ also among women and men. As women are present in greater numbers in the urban informal economic sector and home-based businesses, extreme weather may therefore impact their living space and income source at the same time. The loss of small productive assets such as sewing machines may permanently affect their livelihoods (GGCA 2009, Dankelman 2010). Coastal flooding can also be caused by excessive rainfall inland with subsequent flooding in river deltas downstream due to heightened river levels. In Ganges-Brahmaputra and Zambezi deltas, multiple risks of storm surges and inland river flooding severely affect the cities and settlements within the deltas (Lwasa 2015).

Moreover, global warming induced sea level rise, combined in places with subsidence of coastal land, and increasing storm intensity have combined to put large and growing coastal populations at risk from the rise in sea levels as well as storm surges. Recent examples of coastal flood disasters include the flooding caused by Hurricane Katrina in 2005 in New Orleans, Cyclone Nargis in 2008 in southern Myanmar, Hurricane Sandy in 2012 in New York, and Super Typhoon Haiyan in 2013 in the Philippines (Temmerman et al. 2013). Wave heights reached up to 10 meters during Hurricane Katrina (Fritz et al. 2007) and to almost 4 meters above normal tide levels during Hurricane Sandy (Blake et al. 2013, McGranahan, Balk, and Anderson 2007).

Urban dwellers are highly exposed to the risks of cyclones and storm surges compared to rural villagers because urbanites are more likely to live on or near the coast. Cities and towns account for nearly two of every three residents of coastal areas world-wide (McGranahan et al. 2005, McGranahan, Balk, and Anderson 2007). In Asia, 18% of the population lives in the low elevation coastal zone—the

highest percentage across all world regions; 12% of the urban land in Asia is at low elevation and near the coast (McGranahan, Balk, and Anderson 2007). Many of Asia's largest cities are located in coastal areas that are at risk of sea level rise, heavy rainfall (e.g. monsoon-related) or cyclones, leading to storm surge and flooding. Mumbai saw massive floods in 2005, as did Karachi in 2007 (World Bank 2008, Kovats and Akhtar 2008). Flooding and storm surges also threaten coastal African cities, such as Port Harcourt and Lagos in Nigeria (de Sherbinin et al. 2014, Güneralp, Güneralp, and Liu 2015). Similar vulnerabilities affect Mombasa in Kenya (Douglas et al. 2008, Awuor, Orindi, and Adwera 2008) and various cities in Latin America (Hardoy and Pandiella 2009, Revi et al. 2014).

4.2 Equity in urban climate change adaptation

Equity and environmental justice issues related to climate change adaptation include inequalities in the capacity to cope and adapt (Dodman 2013, Hardoy and Pandiella 2009), mainly arising from 1) failure to adapt (no adaptation) or 2) inadequate adaptation or 3) maladaptation to climate change among and within urban centers.

Differentials in the scale and nature of risks *among* settlements relate to the extent of infrastructure (piped water, sanitation, effective drains, all-weather roads and paths) and services provision (including health care and emergency services), as well as housing options available for low income groups (see for example, Krishna, Sriram, and Prakash 2014). The lack of risk-reducing infrastructure is often underpinned by a lack of capacity within urban governments to address the large infrastructure and service deficits (Parry et al. 2009). Figure 1 highlights the wide variation in urban areas' adaptive capacity (Revi et al. 2014), depicted by the proxy 'national income'. In low-income and many middle-income nations, most urban authorities have very small budgets and even less investment capacity (UCLG 2014). At the other end of the spectrum are urban centers with universal provision for risk reducing infrastructure (such as piped treated water and adequate drainage) and services (like enforcement of buildings standards for structural safety) and active climate change adaptation policies, but these cover a very small proportion of the world's urban population. In these cities in high-income countries, development has greatly reduced risk from extreme weather—though, the infrastructure, services, important institutions and financial systems (Satterthwaite 2013) are not provided as a response to climate change and are therefore not 'adaptation' per se. This, however, is not to claim that all inequalities in risk are addressed—as work on environmental justice in high-income nations and their cities has shown (Schlosberg and Collins 2014).

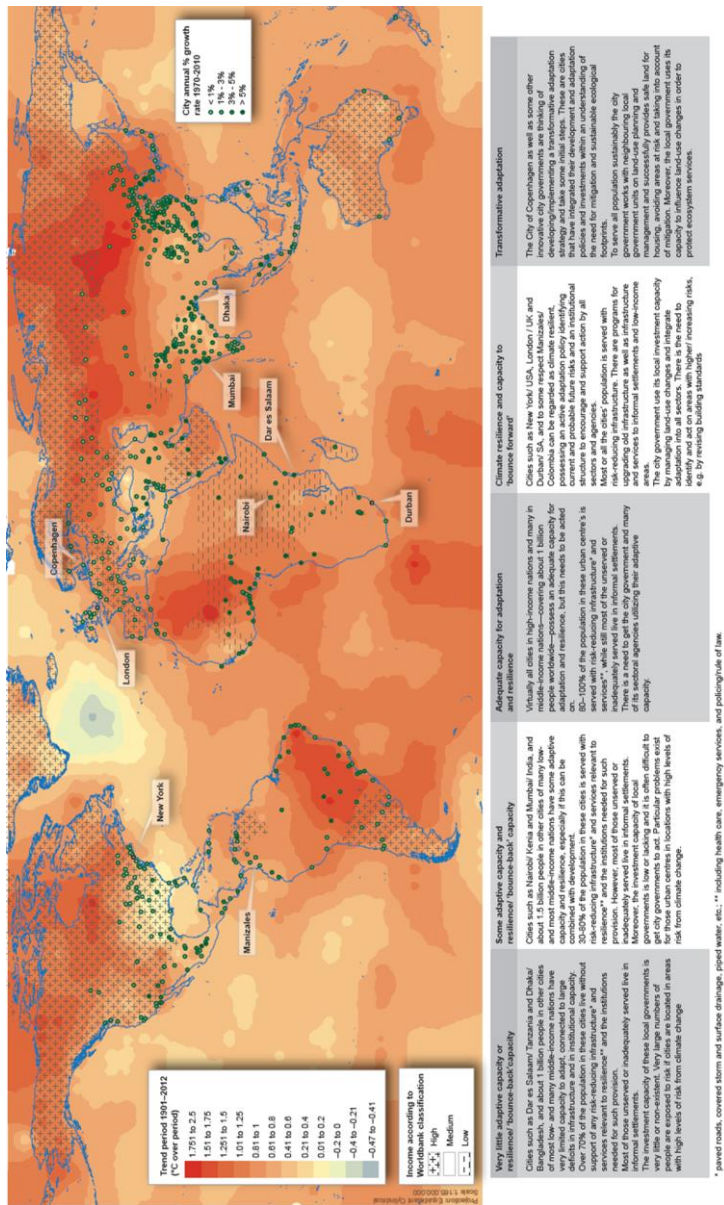


Figure 1: Location and annual growth rates (1970–2010) of large urban agglomerations in low-, medium- and high-income countries against the background of recently observed temperature change. Insets describe the spectrum of adaptive capacity in urban centers across the globe. Many cities with the highest population growth rates are located in low- and middle-income nations with generally low (national) adaptive capacity. This means that an increasing number of people are put at risk of future climate change with generally little structural or formal support to adapt. However, cities with the highest population growth rates are also located in areas of moderate recent temperature increase. Yet, under these conditions city authorities are struggling to provide basic infrastructure and institutional services of support during and after climate change impacts and weather extreme events to their residents. A projected increase in climate change impacts will very likely aggravate the situation. Source: own draft; Data: (Revi et al. 2014)

Within cities in low- and most middle-income countries, differentials in risk also arise from inadequate or no infrastructure and services in certain urban areas, mostly evident and documented in informal settlements (Revi et al. 2014, Dodman and Satterthwaite 2009, UN-Habitat 2013). Risks from extreme weather in many informal settlements are further magnified by their location on dangerous sites—especially in flood plains and alongside rivers, or on steep slopes (Hardoy, Mitlin, and Satterthwaite 2001, Hardoy and Pandiella 2009, Dodman 2013). Housing development on dangerous sites is nurtured by a range of factors, including inappropriate building regulations and land use/ zoning practices that increase the cost and restrict the supply of affordable housing plots (Aylett 2010, Lwasa and Kinuthia-Njenga 2012, Lwasa 2012). Unclear property rights and land tenure also contribute (Bartlett 2011, Busck et al. 2006), as documented in cities like Nairobi, Dar es Salaam, Dhaka, Dakar, Maputo, Manila and Kolkata (Jenkins 2000, Owens 2010, Rao 2013, Roy 2009).

Risk differentials within cities also emerge in relation to age, sex/ gender and health status (Bartlett 2008), which can be socially constructed as in the case of discrimination. For example, with regard to gender discrimination (Dankelman et al. 2008). an analysis of the impacts of floods in Lagos in 2011 revealed the differentials in vulnerability among low-income women created by the intersection of gender relations and gender roles in household structure, occupation, and access to health care (Ajibade, McBean, and Bezner-Kerr 2013). Focusing on process-oriented equity differentials in risk also arise from the lack of voice for particular groups (for instance those living in informal settlements) and the lack of accountability to them by government agencies (Bulkeley, Edwards, and Fuller 2014, Adger 2013). It is thus relevant to consider the extent to which adaptation measures acknowledge these differentials and take action to reduce them.

It is not only the lack of government capacity that underpins lack of attention to climate change adaptation but also deliberate choices by city or national governments (Bulkeley, Edwards, and Fuller 2014), as documented by Thailand's flood crisis in 2011. Mitigating flood damage in the central districts by diverting flood waters to other areas heightened the disproportionate impact on communities outside the defenses (Nabangchang et al. 2015). The refusal to address risks to poor and politically under-represented groups in urban areas is often also related to the low priority that national governments and international agencies have previously given to such equity issues.

Changes in land-use planning and regulatory frameworks are an important part of adaptation to climate change, as are fiscal incentives and infrastructure investments that respond to current and projected future climate risks. Land use planning and management should play critical roles in ensuring there is sufficient land for housing that avoids dangerous sites and in protecting key ecological services and systems.

There is also growing awareness of the need for gender-sensitive adaptation processes and intersectional analyses in order to develop inclusive, contextually-specific interventions and policies (Alston 2013, Sultana 2013, Kaijser and Kronsell 2014). Differentiated gender needs and roles are often missed out in displacement or re-location plans, usually lacking planning for the access to community services and child-care facilities. Another aspect relates to women's non-access to secure land tenure in many low- and medium-income countries. Secure land tenure determines the eligibility for financial credits or subsidies, which is needed to increase the adaptive capacity during post-disaster recovery stages. Moreover, in post-disaster camps and temporary accommodations women often face serious risks of sexual harassment and violence (Tovar-Restrepo and Irazábal 2014, Dankelman et al. 2008).

Those who live in settlements on dangerous sites without risk-reducing infrastructure and services often take measures to reduce risk to their household, homes and assets—especially in informal settlements or urban centers where there is no government interest or adaptive capacity (Revi et al. 2014). Such measures can make an important contribution towards reducing risk, but cannot provide the network infrastructure on which local adaptation measures depend (e.g., water abstraction and waste-water treatment plants, water, sewer, and drainage mains). However, an important lesson of these experiences is that the adaptive capacity, resilience and bounce-back capacity of communities can be sustainably increased by providing appropriate support for community-based initiatives. Support should preferably include economic incentives for residents—thereby framing adaptation measures as economic opportunities for low- and middle-income households. Women should be part of community efforts, since women are key agents of change (Dankelman 2010, GGCA 2009, UNDP 2009, UNISDR 2009).

Adaptation practices should also align with mitigation concerns to prevent maladaptation. For example, the choices made in the management of flood waters in and around Bangkok could be considered as an example of maladaptive practice as it protected the wealthy and placed an increasing burden on the more vulnerable in society (McEvoy et al. 2014). Other maladaptive practices relate to constraining land supplies, forcibly resettling people in areas far from their employment—or evicting people with no compensation—and pushing up land and housing costs. Forced evictions constitute gross violations of human rights as they indirectly and directly violate the full spectrum of civil, cultural, economic, political and social rights—and will not equally reduce vulnerabilities. Maladaptation leads to further impoverishment of vulnerable groups, often in the name of 'development', e.g. expansion of roads and highways and other measures to reduce infrastructure deficits.

4.3 Equity in urban climate change mitigation

We here focus on the sectors most relevant to urban mitigation, including spatial planning, accessibility and transport-related aspects, waste management and renewable energy. So far high-income countries led the urban mitigation agenda having emitted the largest share of urban emission on a per capita basis, and having more often the means to act. Cities in low- and middle-income countries face very different challenges to those in high-income ones; only a few cities include mitigation actions into city plans (Hardoy and Ruete 2013, Roberts 2010, Roberts and O'Donoghue 2013, Roberts et al. 2012, Seto et al. 2014). Spatial planning policies in cities of low- and middle-income countries are often outpaced by rapid population growth and constrained city budgets inadequate to meet the ensuing need for expanded infrastructure and service provision (Bartlett et al. 2009, UCLG 2014, Parry et al. 2009).

In cities of high-income countries, urban mitigation strategies are often based on anti-sprawl policies aiming at changing low-density development, the conservation of open spaces, the enhancement of mixed land use, walkable neighbourhoods, and low-carbon construction standards (Wilson, Hutson, and Mujahid 2008). These measures have been implemented to make public transportation and other services based on economy of scale profitable, thereby securing the services for all income households, and particularly the poor, while also reducing transport-related GHG emissions from transit. However, these principles can have negative side effects for low-income households if not properly designed. Anti-sprawl policies are criticized for pushing up housing prices with subsequent displacement of low-income residents (Addison, Zhang, and Coomes 2013, Burton 2000, Cox 2008, Ewing et al. 2014, Wendell 2011, Bradshaw et al. 2005, Golubchikov and Deda 2012), a process referred to as “environmental gentrification” (Checker 2011, Curran and Hamilton 2012, Jennings, Gaither, and Gragg 2012, Johnson-Gaither 2011, Todes 2012). Densification may curtail access to (well-maintained) public facilities, including transportation, or reduce open and green space. As access to green space often negatively correlates with racial/ ethnic and socio-economic characteristics, a reduction of green space may exacerbate existing inequalities (Burton 2000, Schindler and Caruso 2014, Dempsey, Brown, and Bramley 2012, Newman 1972, Dai 2011, Joassart-Marcelli 2010, Joassart-Marcelli, Wolch, and Salim 2011). There is no consensus on the burden shifts of fiscal anti-sprawl policies (Burton 2000, Sharpe 1982, Smyth 1996), but taxing new developments to cover infrastructure-related costs seem to imply a lower burden for low-income groups than other instruments that mandate which areas can be developed and under which conditions (Bento, Franco, and Kaffine 2011, 2006, Brueckner 1997).

The enhancement of public and private transportation is a frequent mitigation strategy in cities, which typically bring good to all and particularly the low-income households. To optimize the equity outcomes of such investments, special attention should be given to the changes on the affordability of housing and transportation for

lower-income groups. Similarly, transit-oriented development (TOD), i.e. the improvement of access to public transportation, has positive socio-economic effects for the residents and communities, as it brings a larger area of land into the employment catchment area (Brand and Dávila 2011, Cerdá et al. 2012), but it can also have negative effects on low-income groups via decreased housing affordability (Deng and Nelson 2010, Deng and Nelson 2011, Zhang and Wang 2013, Smith and Gihring 2006). Low-income groups may be forced to migrate to other locations with limited access to transportation but more affordable housing (Boarnet 2007, World Bank 2012, Deng and Nelson 2011, Munoz-Raskin 2010, Zhang and Wang 2013). Another aspect relates to transportation fares, which usually require high up-front costs to access discounts, e.g. through the purchase of a periodic transit pass. This may oblige low-income households to purchase short-term passes, sometimes up to three times more expensive than longer-term ones (Nuworsoo, Golub, and Deakin 2009, Schweitzer 2011). Increases in the costs of transfers or the removal of unlimited-use passes also affects lower-income riders, women, youth, and minorities, as these groups generally make more trips and transfer more frequently than others (Chen et al. 2013, Nuworsoo, Golub, and Deakin 2009, Levy 2013). Gender-based violence, harassment, and crime in public transport are also sources of concern and should be addressed through gender-sensitive transportation-based mitigation actions—but not by reducing public transportation (Maffii, Malgieri, and Bartolo nY, Levy 2013, Clarke 2012). In cities like Vienna, Berlin and Malmo, transit-planning interventions are designed from a gender-sensitive perspective. General improvements on safety are achieved by participative planning with focus groups, wider pavements, pedestrian-friendly traffic lights, and safe crossings, among others (Maffii, Malgieri, and Bartolo nY).

Private transportation improvement actions show contradictory equity outcomes, mainly due to the range of policy options available (Schweitzer 2011). Registration fees based on emissions rates typically affect low-income drivers more than those based on distance travelled, because they drive vehicles that pollute more per mile than those owned by wealthier groups of the society (Dill, Goldman, and Wachs 1999, Walls and Hanson 1999, Fullerton, Devarajan, and Musgrave 1980, Bento et al. 2005). High Occupancy Toll (HOT) lanes tend to be progressive, especially when alleviating congestion on the unpriced lanes (Altshuler 2013), but they may also pose barriers to affordable mobility, depending on the transit provision (Schweitzer 2011). Area-based schemes tend to perform better in terms of equity effects than speed limit or cordon-based schemes (Bureau and Glachant 2011, Maruyama and Sumalee 2007, Eliasson and Mattsson 2006, Wang 2013, Schweitzer 2011). In middle- and low-income countries, congestion charges are mostly progressive, as car drivers tend to belong to the more affluent half of the population.

In many low- and middle-income countries waste picking constitutes the major re-use and recycling business, thereby helping to avoid substantial GHG emissions (King and Gutberlet 2013). Though being sustainable and inclusive, it may face strong opposition from authorities (Chen et al. 2013, Hayami, Dikshit, and Mishra

2006, Hunt 1996). When improved waste collection becomes a public priority, pickers are often displaced (Ahmad et al. 2006, Betancourt 2010, Medina 2008, Rouse and Ali 2001, Scheinberg and Anschütz 2006, Wilson, Velis, and Cheeseman 2006), regardless of their environmental contribution and the subsequent social impacts (Baud et al. 2001, Huysman 1994, Moreno-Sánchez and Maldonado 2006). However, some progressive cities have devised contractual arrangements for waste-pickers to support waste management services, such as in Kampala, Uganda (Fergutz, Dias, and Mitlin 2011, Kareem and Lwasa 2011, Vergara and Tchobanoglous 2012, Storey et al. 2013).

Finally, regarding broad-scale renewable energy schemes, these may also lead to unequal burden shifts when investments are put to the consumer, because low-income households often contribute a larger fraction of their disposable income to energy and other housing costs, compared to higher-income households (Earl and Wakeley 2009, Perry, Rosewarne, and White 2013). Renewable energy schemes should be implemented with caution of this effect.

5. Conclusions and policy recommendations

In this paper we reviewed the interactions of climate change with equity and equality in urban areas, drawing on the evidence base of how climate change impacts, adaptation and mitigation affect low-income residents and women. We argued that acting on climate change impacts in urban areas by way of poverty- and gender-sensitive adaptation and mitigation actions will be a promising pathway to simultaneously contribute to meeting multiple SDGs.

As we have seen, climate change interacts with differential exposure to risk, preparedness and coping capacities as well as recovery capabilities from climate change impacts. Low-income residents and women are often particularly affected by climate change, but also by adaptation and mitigation policies (Chen et al. 2005, UNIFEM 2008). Studies have impressively shown that poverty and gender are related (Brady and Kall 2008), not only in low- but also in high-income countries as, e.g., documented for affluent democracies since the mid of the last century (Brady and Kall 2008). It has further been shown that reducing the feminization of poverty will not naturally result from reducing overall poverty. Studies therefore suggest that extensive welfare measures, i.e. large social security transfers are needed in order to reduce female poverty (Brady and Kall 2008). In order for climate change impacts, adaptation and mitigation policies not to increase inequalities in urban areas, our study suggests focusing on the impact and needs of the most vulnerable and particularly on women and women living in poverty. Poor women in particular are disproportionately affected by climate change impacts, while too few adaptation measures are directly benefitting them and too few mitigation measures respect their concerns.

For adaptation this means foremost to address infrastructure and service insufficiencies in low-income neighborhoods and communities, to build up institutions and governance options including financing to do so. It also means to grant women full access to decision making processes, thereby making them active parts of climate change governance.

For mitigation, spatial planners should be aware of and attempt to lower possible negative side-effects of compact city spatial planning models on low-income neighborhoods and ethnic communities, e.g. by using social policy to cap accommodation prices and rents for households in need. Related to public transport, it seems important to reduce out-of-pocket fees, provide unlimited-use passes for public transportation, and prioritize women's perspectives in public transport schemes. Table 2 and 3 summarize our policy recommendations to foster poverty reduction and gender equality through climate change adaptation and mitigation actions in cities.

Table 2: How climate change in and across cities relates to poverty eradication/reduction. Note: We here refer only to outcome-based equity aspects, process-related and contextual aspect are omitted. LIC - Low-income countries; MIC - Middle-income countries; HIC - High-income countries.

Considering equity concerns for POVERTY ERADICATION		SOLUTIONS
Outcome/ distribution-related equity concerns		
<p>Outcome-based equity concerns relate to an increase in climate risks and impacts of climate change in urban areas, as well as adaptation and mitigation measures that are dis-respective of their effects on the urban poor, e.g. via:</p> <p>Heat: mostly affecting elderly and women (LIC, MIC, HIC);</p> <p>Floods: mostly relating to poor and marginalized groups (in LIC & MIC) via high exposure and low coping;</p> <p>Landslides: impacting various income groups (MIC, LIC & MIC) via high exposure & low protection;</p> <p>Storm surge: affecting poor and marginalized group (HIC, LIC & MIC) via high exposure & low protection, but also better-off households in HIC.</p> <p>Within cities low-income neighborhoods and households often occupy high-risk areas at high densities.</p>	<p>Adaptation:</p> <p>Target protecting the most vulnerable of urban societies making it the primary goal of adaptation options;</p> <p>Provide sufficient infrastructure and services in all urban neighborhoods and work against the deliberate neglect of authorities to do so (mainly MIC and LIC);</p> <p>Align adaptation with adequate financial and institutional support, particularly in LIC and MIC.</p> <p>Mitigation:</p> <p>Prevent a disproportionate impact on the urban poor, e.g. by way of changes of housing affordability, costs and access to transportation;</p> <p>Exonerate or compensate low-income communities, cities or regions (across and within countries).</p>	
Process-related equity concerns		
<p>Process-based equity concerns relate to the access, role and power of low-income households in formal and informal decision-making processes. Low-income households may not be familiar with formal decision making and power structures, which may translate into less access and understanding of risks and preparedness information. This may lead to informal structures that are misused, e.g. by slum lords—particularly for newly arrived migrants.</p> <p>Process-based equity concerns across countries and cities relate to the access, role and power of cities with large numbers of low-income residents within their countries (and low-income countries within international governance and policy structures), e.g. the access, role and power of low-income countries and cities within the UNFCCC decision making processes.</p>	<p>Adaptation and mitigation:</p> <p>Form supportive institutions and governance structures to cater for the urban poor and newly arrived migrants in cities, including the failure to address the malpractices of “slum lords”;</p> <p>Foster accepting and hearing the voice of cities with large numbers of low-income population in national (and international) decision making processes.</p>	
Contextual equity concerns		
<p>Contextual equity concerns relate to the locations, densities and problem-constellations of high-risk areas in cities, which may differ across geographies, culture and countries. Across cities, poverty and equity concerns relate to cities that are situated in risk zones, and the differentials in adaptation and mitigation capacity of cities in low- and middle-income countries. Climate change may affect these cities via:</p> <p>Increased average temperatures for continental cities;</p> <p>Increased sea level rise and storm surge for coastal cities;</p> <p>Higher risk levels for cities situated at large rivers (and deltas).</p> <p>Increased damage levels in cities where building regulations and standards are not implemented or enforced.</p>	<p>Support and increase enforcement of building standards (most in MIC and LIC);</p> <p>Adapt buildings standards to new threats, where needed;</p> <p>Exonerate or compensate low-income communities, cities or regions, to be able to meet their adaptation challenges;</p> <p>Support cities in LIC and MIC, in particular.</p>	

Table 3: How climate change in and across cities relates to gender equality.

Considering equity concerns for GENDER EQUALITY	SOLUTIONS
Outcome/ distribution-related equity concerns	
<p>Outcome-based equity concerns regarding gender are shaped by direct and indirect impacts of climate change on women and girls, e.g. via:</p> <p>Heat: Heat stress affects women more than men;</p> <p>Floods/ Landslides/ Storm surge lead to reduced or no access to potable water, drainage and sanitation facilities in cities, women:</p> <p>Face loss of income from their home-based activities and often water-based economic activities like cleaning, washing clothes or cooking food products, particularly in informal settlements.</p> <p>Have to spend more hours fetching water from water trucks or tanks.</p> <p>Face malnutrition or low calorie intake especially in older women and young girls because gendered diet hierarchies and the reduction in food supply or increase in food prices.</p> <p>Face the risk of infections as they overwhelmingly take care of children, old and sick family and community members, who tend to suffer diarrheal, respiratory and other health problems.</p> <p>Are more vulnerable to losing their jobs given that they need to devote more time to non-paid care-work.</p>	<p>Adaptation:</p> <p>Reduce ex-ante vulnerabilities of women;</p> <p>Ease women’s income opportunities and home-based businesses;</p> <p>Value and adequately pay care-work and female income options;</p> <p>Align measures with adequate financial and institutional support for women, particularly in LIC and MIC;</p> <p>Mitigation:</p> <p>Address gender-based violence, harassment, and crime through gender-sensitive mitigation actions, e.g. in transportation.</p>
Process-related equity concerns	
<p>Process-based equity concerns within cities relate to differentiated gender roles among women and men. Women who do not speak the dominant language have less access and understanding of risks and preparedness information.</p> <p>Process-based equity concerns across countries and cities relate to the discrimination of women with respect to access to technologies, education, and income opportunities, particularly in LIC and MIC. Also, because women in LIC and MIC have less access to secure land tenure, they lack access to financial credits or subsidies, important in climate change recovery stages.</p>	<p>Adaptation and mitigation solutions:</p> <p>Involve women in leadership roles in community processes and local climate change politics, as women are recognized as key agents of change.</p> <p>Increase women participation in (inter-)national political decision-making processes, including the UNFCCC.</p>
Contextual equity concerns	
<p>Contextual equity concerns in cities regarding gender mainly relate to strongly diverging roles of women and men in different cultures, and high-, medium or low-income nations. Women from low- and middle-income countries living in poverty are typically more vulnerable to climate change impacts than men because of the discrimination they face with respect to wealth and capital goods, health, access to technologies, education, services and information, and opportunities to generate financial and productive assets.</p>	<p>Take into account gender roles and women’s needs</p> <p>Challenge traditional gender roles and recognize and balance care work between men and women;</p> <p>Value paid income options for women.</p>

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