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**SABIN CENTER FOR CLIMATE CHANGE LAW**

# ASSESMENT RUBRIC FOR ADAPTATION: SUSTAINABLE CITIES GOAL 11

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# EXECUTIVE SUMMARY

This year's COP21 in Paris yielded a new climate agreement that has renewed global optimism surrounding greenhouse gas emissions reductions and, more generally, climate change mitigation. However, it is important to recognize and address the impacts of climate change that are already locked in due to past and current emissions. A wide array of climate adaptation strategies will be necessary to protect communities and ecosystems from the worst impacts of climate change, including rising temperatures, rising sea levels, increased frequency of severe weather events, drought, and reduced air quality.

Despite the growing importance of adaptation, there is no existing universal standardized framework for assessing the efficacy of existing and future adaptation projects. Coming to an internationally agreed upon set of indicators and monitoring and evaluation strategies for adaptation should be a priority in the coming years. It is likely that incorporating adaptation into an existing global framework may yield the best results for achieving standardized adaptation assessments in a timely manner.

The Sustainable Development Goals, a set of 17 goals with specific targets aimed at reducing poverty, addressing climate change, and supporting human well-being, are a great example of a universally agreed upon framework into which adaptation could be incorporated. This report aims to analyze Sustainable Development Goal 11: Sustainable Cities, and incorporate climate change adaptation into the language of the targets as well as suggest indicators and monitoring and evaluation strategies that would both achieve the Goal's targets and increase the success and prominence of climate change adaptation.

Nine targets under Goal 11 are included in this report. Within each target, the relevant types of adaptation strategies are outlined, and existing indicators and monitoring and evaluation strategies are listed and described. The report then discusses the current shortcomings within the field of assessing climate change adaptation, and makes concrete and applicable suggestions to improve adaptation assessments. These suggestions come in multiple forms: the rewording or alteration of existing indicators, the proposal of new indicators, changes to existing monitoring and evaluation strategies, the proposal of new monitoring and evaluation strategies, and the repurposing of successful monitoring and evaluation strategies from other fields. Other fields with robust strategies include climate change mitigation, public health, economics, and biodiversity studies. Our suggestions for each target, as well as existing best practices, are outlined in charts that should function as a rubric for assessing climate change adaptations.

Within our research, we found several recurring factors that inhibit the success of adaptation projects. Those challenges include lack of project funding, lack of political will and corruption, lack of data transparency and availability, and lack of cooperation between city and national governments. Although these challenges are complex, we have attempted to outline ways of reducing them. We have also put forth new indicators, which track the allocation of funding and resources, and could push countries to increase their investment in adaptation. Additionally, the Green Climate Fund has the potential to raise funds at the international level, if countries are held accountable for their commitments and a certain proportion of the funding is set aside for adaptation. By tracking the presence of gang lords and local authorities within slums and low socioeconomic areas, nations will be held accountable at the international level for intervening to decrease corruption that hinders adaptation. Data availability can be improved through the use of new technologies including cellular phones and satellite imagery. Not only would this make data more publicly available, it would also provide a streamlined data platform in which organizations could have access to important data in real time. To address the issue of poor cooperation and communication between varying levels of power, we hope that this assessment rubric for climate change adaptation will serve as a framework for standardizing the approach to adaptation and reduce conflicting or inconsistent regulations surrounding adaptation.

Despite the existing challenges that hinder climate change adaptation, it will become increasingly critical in the coming years to ensure that communities are protected against climate change. These challenges can, and must, be overcome. This report is intended as an important first step in bringing adaptation to the forefront of the discussion by incorporating it into a well-established framework like the United Nation's Sustainable Development Goals.

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# INTRODUCTION

Climate change directly and indirectly impacts populations worldwide. Flooding from rising sea levels and drought from temperature increases are only two potential risks. Such environmental changes ultimately affect human health and culture in the form of increased communicable disease and forced migration. Ecosystem services and biodiversity are also jeopardized by climate change, which in turn threatens individuals and the very foundation of human society. Consequently, it is important for humanity to adjust our current lifestyles through adaptation efforts. The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as follows: "Adaptation refers to adjustments in ecological, social or economic systems in response to actual or expected climate stimuli and their effects of impacts. It refers to changes in processes, practices and structures to moderate potential damages to benefit from opportunities associated with climate change." Though there are few systematic monitoring and evaluation processes for adaptation, the Sustainable Development Goals (SDG's) present a reliable framework around which to build solid monitoring and evaluation strategies.

The SDGs are a set of goals and targets agreed upon by the United Nations, attempting to end extreme poverty, promote equitable economic development, and combat climate change on a global level. The SDGs offer major improvements on the Millennium Development Goals (MDGs). The framework for the proposed SDGs addresses key systemic barriers to sustainable development that were neglected by the MDGs. These barriers include inequality, unsustainable consumption patterns, weak institutional capacity, and environmental degradation (ICSU 7). The SDGs have been proposed as part of a new development program aimed at continuing progress towards worldwide adaptation and sustainability for a growing population while battling a changing climate. The United Nations will be participating in the COP21/CMP11 convention in Paris, France in December 2015 to discuss and negotiate the final version of the goals and targets. The SDG proposal currently contains 17 goals with 169 targets encompassing an extensive range of sustainable development issues. These issues include ending poverty in all its forms worldwide, making cities and human settlements inclusive, safe, resilient, and sustainable, and also conserving and protecting oceans, the environment, and all biodiversity with an overall focus on adaptation.

In order to incorporate adaptation into the Sustainable Development Goals, this report has compiled a rubric to evaluate and monitor adaptation indicators. While current indicators for adaptation exist, they often lack specificity or applicability, and suitable monitoring and evaluation strategies are necessary to determine their effectiveness. In this report, we provide an analytical approach to determining best practices for adaptation evaluation by researching international and regional reports from public and private agencies. In dimensions that were lacking substantial indicators, we provided our own suggested indicators based on existing literature. Each metric, though useful in theory, will have to rely on effective national policy frameworks for implementation. In order to address this, we outline certain roadblocks to adaptation and suggest legal and policy frameworks that could be useful in overcoming these challenges and achieving the successful implementation of adaptation strategies. Our report will address these issues through the lens of sustainable cities, as they function as economic and cultural epicenters with the greatest amount of existing adaptation measures to analyze.

Adaptation is becoming an increasingly important method of dealing with climate change risk, especially for developing countries that cannot afford expensive mitigation strategies. The development of indicators for monitoring and evaluating strategies is in its beginning stages. We chose SDG 11: make cities inclusive, safe, resilient, and sustainable, for a number of reasons. Primarily, it addresses multiple crosscutting issues related to adaptation, such as, SDG 3 (public health and well being), SDG 7 (affordable and clean energy), SDG 9 (infrastructure), SDG 13 (environment). As a result, any indicators that we build for SDG 11 will likely be applicable to other goals, and will hopefully be the most useful to policy-makers. Additionally, Goal 11 applies to a large portion of the world's population, as 54 percent of the world's population resides in urban areas. By 2050, the global population is expected to increase to 9.2 billion, of which 6.4 billion are expected to be living in urban areas (*World Urbanisation Prospects: The 2007 Revision*). With such a large portion of the world's population, as we well as economic and cultural resources, being affected, focusing on adaptation measures for SDG 11 will provide potential solutions for a rapidly evolving environment.

Furthermore, Goal 11 directly relates to adaptation, which is the focus of this paper. While other goals and their targets address adaptation, they do not focus on adaptation to the extent that Goal 11 does. Goal 13 arguably emphasizes the issue of adaptation more than Goal 11; however, due to its broad nature, it does not allow for the implementation of practical strategies that can be employed by sustainability practitioners.

# METHODS

Indicators and their associated monitoring and evaluation strategies will differ depending on the scale of analysis—national, regional, global and thematic scales are the most commonly used (SDG framework). In order to build an assessment rubric for urban adaptation, we chose to divide the Goal 11 targets into three thematic categories: economic, social, and infrastructure. By organizing targets thematically, we were able to include indicators and case studies at the urban, national, regional, and global levels. The thematic groups and their included targets are outlined below.

| Economic | Social | Infrastructure |
|---|---|---|
| 11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations | 11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries | 11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums |
| 11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management | 11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage | 11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons |
| 11.a Support positive economic, social and environmental links between urban, per-urban and rural areas by strengthening national and regional development planning | 11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities | 11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials |

**Figure 1.** Division of SDG goal 11 targets into three thematic groups

Targets were assigned a thematic group based on similarity in content and type of evaluation strategies they would require. The economic targets address quantitative monetary impacts of cities; all three social targets are values-based and require qualitative metrics; the infrastructure targets focus on the built environment and require technical analysis. However, overlap between the thematic groups is inevitable due to crosscutting issues including funding, human health, and energy.

Target 11.b is not included in any thematic group. The target is: "By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels." Since it directly relates to expanding adaptation strategies, we felt that there were no specific opportunities to incorporate adaptation into the target. The other nine targets, however, provide opportunities to either expand on or include an adaptation component.

The research for this report was carried out in three phases. The first phase involved researching and tracking existing adaptation projects worldwide, and analyzing the monitoring and evaluation strategies associated with each. The second phase involved identifying and documenting gaps in existing research, as well as gaps in adaptation indicators and monitoring & evaluation. After analyzing the existing information as well as the areas in which research is limited, the third phase included updating and creating new indicators, and identifying existing policy and legal frameworks that could be valuable in monitoring and evaluating the adaptation indicators which we suggest.

# RESULTS

*The following sections contain the results of our literature review, and are organized by thematic group. Within each group, all three targets and their associated adaptations are described, and any existing monitoring and evaluation strategies are explained. The sources in which each indicator were found are listed in the final references of the report. Each target summarizes its content in a chart listing established indicators for existing adaptation projects.*

## ECONOMIC GROUP

The three targets included in the economic group are 11.5, 11.6, and 11.a. Target 11.5 focuses on decreasing the negative economic impacts of natural disasters on urban areas, primarily by preventing human injury and infrastructural damage. Target 11.6 deals with the per capita environmental impact of air pollution, water pollution, and waste systems—6 specific types of adaptation projects are identified and analyzed. Target 11.a attempts to quantify the economic value and impact of urban-rural linkages, describing the adaptations necessary to ensure that connections between urban, peri-urban, and rural areas are not impacted by climate change events.

### TARGET 11.5

Target 11.5 concentrates on minimizing the impacts of natural disasters on people and the economy. In particular, it emphasizes reducing the number of deaths, number of people affected, and GDP losses related to natural disasters. According to the IMF, there were 700 registered natural disasters affecting more than 450 million people between 2010 and 2012. The cost of damages caused by natural disasters has risen from an average of US$20 billion per year in the 1990s to US$100 billion per year in the 2000s (Laframboise, 2012). The United Nations International Strategy for Disaster Reduction (UNISDR) defines a disaster as "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental impacts, which exceeds the ability of the affected community or society to cope using its own resources" (United Nations, 2009). Floods, droughts, heat waves, hurricanes and other super storms, forest fires, earthquakes, and even epidemics can all be considered natural disasters if they result in the kind of destruction outlined by the UNISDR.

Studies conducted by the Intergovernmental Panel on Climate Change (IPCC) suggest that climate change will affect regions differently and make areas more prone to natural disasters in different ways. The IPCC has identified a number of factors that are very likely to impact the Earth's future and potentially lead to disasters if no action is taken to reduce disaster risk. Globally, temperature increases are inevitable, and researchers are fairly certain that the length, frequency, and intensity of warm spells and heat waves will increase by the end of the 21st century. Additionally, the frequency of heavy precipitation is likely to increase, and cyclones will become more intense due to an increase in their wind speeds (Field, 2012). One should note that these are only some of factors mentioned by the IPCC in their Special Report. In general, cities are prone to the greatest amount of economic losses after a natural disaster due to such a high concentration of people and structures, as well as assets within such a small area of land. Within cities, the poor are most vulnerable to these extreme events. They tend to live in areas with low-quality infrastructure easily prone to destruction, and they lack the resources to recover from disasters, such as economic assets, insurance, and legal protection (Field, 2012). Even though cities can be substantially impacted by extreme climate events, they also have the most resources to recover from these events and adapt to reduce the impacts of future events.

Strategies to strengthen resilience against natural disasters and adapt to the effects of climate change can also be thought of as risk reduction practices. From an economic perspective, adaptation strategies can be separated into three different categories for investment: communicative and preparedness strategies, resilient and protective infrastructure, and incentive structures promoting individual implementation of adaptation strategies (Kousky, 2012). Further assessment of individual disaster types is needed in order to identify the appropriate means for adaptation. Not all types of natural disasters are addressed in this report. Instead, examples of the kinds of strategies being implemented in response to different disasters are used to provide readers with a general idea of how the issue is being dealt with in reality.

**Enhanced Communication and Early Warning Adaptations**

Many of the devastating impacts from natural disasters are a result of a lack of preparation and spread of informative messages for natural disasters. While adequate communication and preparation measures have always been necessary, the new circumstances imposed by climate change require more urgent and informative messages to prepare for future disasters. Because climate change has the potential to lead to more frequent and intense extreme events, there is an even greater amount of lives to be saved and destruction to be reduced through early preparation. As part of the International Strategy for Disaster Reduction, the Federal Foreign Office has created checklists for what it has identified as four key elements of successful early warnings in the event of a disaster. The four elements of early warning are: risk knowledge; technical monitoring and warning service; communication and dissemination of warnings; and community response capability ("Developing Early Warning Systems," 2006). The checklists help evaluate the development and refinement of specific warning strategies. Early warnings play a crucial role in preparation for all types of natural disasters and can have a large impact in reducing the overall negative effects of a disaster on people and the economy. For example, a heat wave in France in 2003 led to the deaths of 15,000 people. This great number of deaths can be partly explained by the French government failing to provide adequate warnings on the severity of the heat. Many organizations did not have time to adjust their operations to appropriately respond to the rising temperature, which resulted in a large number of deaths (Kousky, 2012). Advanced warnings allow people to prepare for the approaching event. Japan has implemented early warning systems for earthquakes, tsunamis, and volcanic activity. For example, immediately following an earthquake, the Japan Meteorological Agency (JMA) sends a warning of approaching tsunamis and their estimated heights to the different regions of Japan. Warnings and information are distributed to Japan's citizens through Internet services, which includes mobile phones, and prefectural networks for disaster prevention. When Japan was hit by a magnitude 9.0 earthquake in 2011, the JMA released a warning that allowed at least some people to escape to seek protection and move to higher ground, reducing the overall number of deaths and people affected. Since 2011, Japan has continued to improve its early warning systems for all extreme weather events and natural disasters (Japan Meteorological Agency, 2014). If the appropriate steps are taken after the warning, individuals have the ability to reduce the potential impact of the approaching event on a population and the economy.

**Resilient and Protective Infrastructure Adaptations**

Improving infrastructure resilience and protection against extreme climate events helps reduce the amount of people affected and the economic losses from an event. Natural disasters have the ability to cause major damage to infrastructure and the results can be devastating. In 2008, extreme rainfall was the most significant cause of the failure of dams, accounting for 25% of dam failures worldwide (Field, 2012). Dam failures can lead to flooding of human settlements, reduction or complete loss of water supply, and even death. Investments in infrastructure should be specific to the types of disasters different locations face. Infrastructure can be constructed with the purpose of directly reducing the impacts of a natural disaster or protection and resilience can be incorporated within new and pre-existing infrastructure that serves an area in other ways, like streets and bridges. All types of infrastructure can play a significant part in limiting the risks associated with natural disasters. According to one report citing the Interagency Floodplain Management Review Committee, reservoirs and levees built by the US Army Corps of Engineers prevented an estimated $19 billion in damages from flooding in Missouri and Mississippi within a single year (Kousky, 2012). Because infrastructure can be easily associated with a dollar value, cost-benefit analyses help cities and other localized communities to limit the risks of potential future disasters.

**Individual Incentive Structure Adaptations**

While the government plays a significant role by directly investing in larger adaptive projects, individual citizens also have the ability to make decisions and take action in adapting to climate change and reducing the impacts of natural disasters. Multiple studies have shown that, in general, individuals do not carry out adaptation measures on their own. One study in particular found that out of 1,100 homes along the Atlantic and Gulf Coasts, 83% of homeowners had done nothing to make their homes more resilient to hurricanes and 68% did not have any extra supplies, such as food and bottled water, in preparation for a hurricane (Kousky, 2012). Adaptive strategies, such as raising homes two feet above ground to limit destruction from flooding, can be very beneficial but also costly. Government policy could play a crucial role in reducing the costs of adaptation for individuals, which will also reduce the losses associated with natural disasters.

**Indicators**

The metrics mentioned within Target 11.5 can be used as indicators for the success of adaptation strategies.

The three metrics all have some relation to on one another, so a single adaptive strategy that fits within any one of the three strategy categories may have an effect on all three metrics. For example, the government of Bangladesh built cyclone shelters to reduce the country's vulnerabilities caused by such storms. When Cyclone Sidr hit Bangladesh in 2007, 15% of the population resided in the cyclone shelters. The shelters saved thousands of lives, reduced the number of people affected, and protected valuable livestock, which reduced the storm's impact on the country's economy and GDP (World Bank, 2010). Additionally, these metrics can be examined in more detail according to disaster type, and other applicable subcategories related to individual cities. The table below, Figure 2, outlines a basic structure of Target 11.5's indicators and how the indicators are being measured.

| Category | Indicator | Monitoring & Evaluation |
|---|---|---|
| Reduce Deaths Related to Natural Disasters | # of deaths caused by disaster | ● **Monitoring:** submitted reports of missing or dead persons; hospital records; administrative data (national accounts and statistics)<br>● **Evaluation:** comparisons w/ past records |

| | | |
|---|---|---|
| Reduce Number of People Affected by Disasters | # of people injured as a direct result of a natural disaster | ● **Monitoring:** individual reports of injuries; hospital records of individuals seeking or provided with treatments for injuries caused by disaster; administrative data (national accounts and statistics)<br>● **Evaluation:** comparisons w/ past records |
| | # of people forced to relocate as a direct result of a natural disaster | ● **Monitoring:** individual reports of relocation; public records of a household's relocation for reasons related to the natural disaster; administrative data (national accounts and statistics)<br>● **Evaluation:** comparisons w/ past records |
| Reduce % Economic Losses Relative to GDP | $ value of damages to hard infrastructure and private property caused by a natural disaster | ● **Monitoring:** self-reported damage or destruction of property; administrative data (national accounts and statistics)<br>● **Evaluation:** comparisons w/ past records; comparisons made w/ assumption-based economic models |
| | $ potential value lost due to disruption in the economy caused by the natural disaster | ● **Monitoring:** assumption-based economic models accounting for conditions before and after the disaster; administrative data (national accounts and statistics)<br>● **Evaluation:** comparisons w/ past records and models |

**Figure 2:** chart of indicators and monitoring & evaluation strategies for Target 11.5

**TARGET 11.6**

Target 11.6 aims to reduce the adverse per capita environmental impact of cities, which includes paying special attention to air quality and municipal and other waste management. While greenhouse gas mitigation may play an important role in achieving this target, a variety of adaptation strategies are currently being implemented which also have potential to reduce per capita environmental impact—many of which even offer mitigation co-benefits. Within this target, three types of climate change impacts require the most attention: poor air quality, flooding, and rising temperatures.

**Air Quality Adaptations**

Poor air quality, including fine particle pollution and smog, results in human health costs as well as the costs resulting from reduced ecosystem services—both of which decrease economic efficiency and lead to high environmental impacts from urban areas. Climate change impacts air quality primarily through temperature increases. Higher temperatures result in increased ground-level ozone concentrations (EPA, 2011). Warmer months also see increased levels of smog, which result from the interaction between sunlight and fine particle pollution (EPA, 2011). Therefore, adaptations must be implemented which prevent decreased air quality from locked-in temperature increases. In order to adapt to deteriorating air quality in urban areas, two types of adaptation strategies can be implemented: increased tree cover, which acts as a natural carbon sink, and carbon capture and storage (CCS), a technological carbon sink. While emissions reductions mitigate the effects of climate change, carbon capture and storage functions as an adaptation that traps emissions at the source, therefore requiring no change or reduction in power plant emission rates. CCS projects are not widely used due to high implementation and maintenance costs—there are currently only 15 large-scale projects in operation, 13 of which are located in developed countries (Global CCS Institute, 2015). As a result, urban greening adaptation projects tend to be more widely implemented in both developed and developing countries. In addition to lower implementation costs, urban greening adaptation projects can also be used to address the problem of urban flooding.

Green roof systems require an "extension of the existing roof which involves a high quality water proofing and root repellant system, a drainage system, filter cloth, a lightweight growing medium and plants." (Urbanscape, 2015) Monitoring the progress of green roofs is done by calculating the area of rooftops "greened" as a percentage of total planned acreage/rooftop surface area (Chicago Climate Action Plan, 2010). CCS projects require monitoring over a longer timeframe, and due to the fact that there are multiple stages of project implementation.

Prior to beginning construction, CCS projects fall into the "development planning" stage. This stage involves determining the appropriate type of CCS technology to implement and weighing benefits between different project designs. In the "executive stage," the project begins construction and investment choices are finalized. Once construction is completed, the project is in the "operate stage." (Global CCS Institute, 2015) In addition to monitoring which stage a project is in, the technology must be monitored throughout the duration of its operate stage—the carbon capture and the carbon storage both need particular monitoring. While there are no detailed monitoring procedures, each project must operate under regulatory requirements. Whether a project meets its requirements should be the basis of monitoring the carbon capture component. In order to monitor the carbon storage, Monitoring, Verification, and Accounting (MVA) techniques have been outlined by the Office of Fossil Energy. They are currently testing atmospheric monitoring, remote sensing and near-surface monitoring, subsurface monitoring, and intelligent monitoring networks and protocols to determine the storage efficacy of geological sequestration sites. Evaluation practices are in the developmental stages and not well defined (Office of Fossil Energy).

**Flooding Adaptations**

Climate change results in varying environmental effects depending on the geographical region—while not applicable globally, many coastal and temperate cities will have to adapt to flooding events in the coming years. High influxes of rainwater can easily overload a city's wastewater and stormwater management systems, resulting in water pollution and human health impacts that negatively impact the economy. In order to adapt to increased flooding, green roofs and permeable pavement have been incorporated into city planning, including the Chicago Climate Action Plan. Once again, urban greening offers the most economical solution—green roofs allow for influxes of rainwater to be absorbed and evaporated by soil rather than diverted to stormwater systems, and increased tree cover slows the accumulation of rainwater runoff (Urbanscape, 2015). While implementation costs are comparatively low, the adaptation potential is significantly high—green roofs can prevent up to 50% of annual rainfall volume from reaching a stormwater management system (EPA, 2009).

Permeable pavement, however, offers the ability to adapt streets, alleys, and other surfaces where greening is impractical. Cities like Chicago have used permeable pavement technology as part of their Green Alley initiative—rainwater is filtered through the pavement into the ground rather than collected by the sewer system, and open-bottom catch basins are installed to capture any excess water (Green Alley Program, 2010). In developing countries, lower-cost alternatives for permeable pavement include gravel and shredded rubber. If high albedo materials are used, which reflect more light and absorb less, permeable pavement can also double as an adaptation against rising temperatures and urban heat island effect (Ashley, 2008).

The process of monitoring green roofs for flooding adaptations is the same as outlined for air quality adaptations above. However, evaluation practices differ, as flooding evaluation must determine how successful the green roof and urban greening projects are at preventing storm and wastewater management systems from overloading. A successful example of green roof evaluation comes from the EPA's Office of Research and Development – Water Supply and Water Resources Division. Success of a green roof project was determined by calculating the percentage of annual rainfall volume removed from a roof through retention and evapotranspiration. Results were determined

by comparing the rainfall runoff between a building with a green roof and a building of similar location and matching dimensions with standard asphalt rolled roofing (EPA, 2009). Monitoring permeable pavement projects requires comparing the area of permeable surfaces to the end-of-project goal. Similar to green roofs, evaluation strategies for permeable pavement seek to determine how successful a permeable pavement project is at reducing the influx of rainwater into storm and wastewater management systems. The EPA has also developed an evaluation strategy from its Low-Impact Development Center. A range of different pervious surfaces (including pervious plastic cells, impervious blocks divided by grass, and gravel) were compared to a control stall of traditional asphalt to determine the water percolation benefits of each. The asphalt surface functioned as a baseline value of water runoff (EPA, 2009).

**Rising Temperature Adaptations**

The urban heat island effect is defined as the rise in temperature of a man-made area, resulting in a well-defined area of higher temperatures than surrounding areas (EPA, 2015). A recent study published by Stanford and Berkeley calculates that national GDP is closely tied to temperature—above 13 degrees Celsius, economic activity begins to suffer. Without mitigation and adaptation, climate change could reduce global output by up to 23% compared to baseline by 2100 (Burke, 2015). Since the majority of economic activity centers on urban areas, adapting to higher temperatures will become increasingly important in countries in the tropics, most of which are developing countries in Africa, Southeast Asia and Latin America. Additionally, adapting to rising temperatures will decrease the costs associated with heat-related illness and rising energy demand.

The three most common adaptations for urban temperature increases are green roofs and increased vegetative cover, high albedo concrete, and reflection roof standards. Vegetation cover at the street and roof level reduces temperature in multiple ways—vegetation has a significantly higher albedo than dark asphalt or rooftops, reducing heat build up throughout the day. Additionally, trees offer cooling through evapotranspiration. At the street level, tree cover provides shade, while green roofs insulate buildings from heat and result in lower energy demand—a mitigation co-benefit as well as an adaptation. High albedo concrete reflects more radiation and prevents urban heat island, similarly to high-reflection roofs (Ashley, 2008).

All stages of implementation of an adaptation strategy require monitoring. For urban heat island effect, the initial stage requires determining the areas within a city that are most in need of adaptation—The Chicago Climate Action Plan offers a monitoring strategy for this, using satellite imagery to identify areas of the city which have the highest percentage of low albedo material (both rooftops and street-level). While this technique has not been widely employed, it is a useful tool for determining the best location for rising temperature adaptations: green roofs, high albedo concrete, and reflection roof standards. Monitoring the progress of project implementation is fairly straightforward, and follows the same process as listed in the Air Quality Adaptation section for green roofs: first identify a goal for final acreage of each adaptation, and compare it to completed acreage. Alternatively, satellite imagery can be utilized to determine the percentage increase in green roofs, high albedo concrete, and high reflection roofs (Portland Cement Association).

Evaluation practices for these three adaptation strategies' impacts on temperature are less developed. Urbanscape's proposed indicators (energy performance of green roofs in the summer and winter) are a move in the right direction, connecting the implementation of a green roof with the associated energy demand impacts. However, there are no evaluation strategies in place to determine how much a green roof reduces microclimatic temperature. The same is true of high albedo concrete and reflection roof standards—while the solar reflectance index (SRI) of materials may be monitored overtime, evaluation of the impact on temperature needs to be identified and standardized.

**Indicators**

Based on the three climate events most relevant to target 11.6, there are a total of six adaptation strategies that are currently in the stages of implementation: green roofs, urban greening, Carbon Capture and Storage, permeable surfaces, high albedo concrete, and reflection roof standards. Figure 3 outlines the current theoretical or practiced indicators associated with each adaptation.

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| Green roofs | Percentage of wastewater flows treated to national standards (and reused) | ● **Monitoring:** are of rooftops completed as percentage of total planned green roof area<br>● **Evaluation:** calculating the percentage of annual rainfall volume removed from a roof through retention and evapotranspiration |
| | Mean urban air pollution of particulate matter (PM10 and PM2.5) | |
| | square footage of green roofs planned or completed | |
| | Energy performance of green roofs in summer (cooling effect) | |
| | Energy performance of green roofs in winter (thermal insulation) | |
| Urban greening | Acres of tree canopy added | ● **Monitoring:** satellite imagery to determine area of green space<br>● **Evaluation:** insufficient |
| | Amount of pollution in the air and around the park compared with an area with no urban green spaces in the neighborhood, measured per unit area or volume | |
| | Amount of massive vegetation in the urban green area concerned | |
| Carbon Capture and Storage | Mean urban air pollution of particulate matter (PM10 and PM2.5) | ● **Monitoring:** categorizing projects into development planning, executive, and operate stages<br>● **Evaluation**: MVA techniques including atmospheric monitoring of sequestration sites |
| | CO2 capture capacity (Mtpa) | |
| | Capture type | |

| | | |
|---|---|---|
| Permeable surfaces | Percentage of wastewater flows treated to national standards (and reused) | ● **Monitoring:** square footage of impermeable surfaces converted to permeable surfaces<br>● **Evaluation:** calculating the reduction of rainwater into storm and wastewater management systems through controlled experiments |
| | Percent increase in permeable area per site | |
| | increase of acres of permeable surface area | |
| High albedo concrete | Solar Reflectance Index value | ● **Monitoring:** determine priority areas through satellite imagery<br>● **Evaluation:** insufficient |
| Reflection roof standards | Solar Reflectance Index value | ● **Monitoring**: determine priority areas through satellite imagery<br>● **Evaluation:** insufficient |
| | % of roof covered in high SRI material | |
| | % of roof that is green roof | |

**Figure 3:** chart of indicators and monitoring & evaluation strategies for Target 11.6

**11.a RESULTS**

Target 11.a aims to support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning. Relevant climate change events requiring economic adaptation for successful linkage in urban and rural regions are drought, food insecurity, flooding, natural disasters, climate induced conflict, loss of ecosystem services, externalities which include agricultural runoff and eutrophication, loss of biodiversity, lack of economic development.

The five primary themes that intersect urban and rural regions and will be impacted by these environmental events are migration and resettlement, agriculture and food security, water and sanitation, transportation and family size. Therefore, economic adaptation as it relates to urban-rural linkages will focus on these five targets.

Since in the urban context transportation, resettlement, water and sanitation are covered explicitly in in other sections document focusing on targets 11.2, 11.3, and 11.6, this section will only cover the specific rural adaptations for regions, as an impact urban on regions. Finally, agriculture and food security, are themes that impact urban centers, but are primarily rural in nature, and so the recommendations for these adaptations will be concentrated only in this section.

**Background on Linkages**

Migration and resettlement are the primary concerns for low lying regions, small island nations, and areas inclined to land degradation, drought, sea level rise. These regions will be, and presently are being forced to adapt to climate impacts through a variety of ways. Regions that populations relocate to, which may not already be explicitly defined, will need to anticipate adjustments in the economy and social services.

Agriculture, consumption and food security is important to urban growth since, in order for urbanization to be sustainable, supply of agricultural products is necessary. The complexity of the linkages between rural and urban people and enterprises is encapsulated in the capacity of food producers to adapt to increasing demand in urban centers.

In terms of global water and sanitation, 63 percent of the population uses improved sanitation facilities. Since 1990, 1.8 billion people have gained access to improved sanitation. In urban areas, 8 out of 10 people use an improved sanitation facility, compared to only half of the rural population. However, the number of people without improved sanitation in urban areas has grown by 183 million since 1990, during a time of rapid urbanization (UNICEF, WHO 2012).

Protection, restoration and payment for water-related ecosystem services, including mountains, forests, wetlands, rivers, aquifers and lakes, will benefit many urban regions economically. A well-preserved watershed will save on cost in filtration systems. Further, rural regions that rely on groundwater and other natural sources of drinking water will benefit greatly by urban regions having a functioning water treatment plan. Beyond sanitation, water scarcity will also play a significant economic role in the vitality of the region, as access to water is a limiting factor in agriculture and other pursuits of livelihood. Addressing the links in urban and rural demands for water and sanitation will allow for greater success in adaptation by building a stable system that takes into account local geography, present infrastructure, and a comprehensive understanding of how these regions work together.

Transportation infrastructure and urban to rural planning will shape the resilience of future development. Where people decide to live and how they move spatially affects air quality and quality of living. With an increase of populations moving into urban regions, attention to efficiency of mobility will prove to define success of a region's sustainability in economic, social, and environmental sectors. Climate change is expected to have a further impact on transportation. Sea level rise and regional temperature may change road and rail networks and adaptation planning needs to respond to both urban transportation infrastructure and rural transportation as a conduit to urban centers. As stated previously, this section (11.a) will focus on transport to and from rural regions. For more depth on urban transportation see section on SDG 11.2.

## ADAPTATIONS

### Ecosystem Based Adaptation

Protection, restoration and payment for water-related ecosystem services, including mountains, forests, wetlands, rivers, aquifers and lakes, will benefit many urban regions economically. Ecosystem-based adaptation (EbA) uses biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change at local, national, regional and global levels. A well-preserved watershed, for instance, will save on cost in filtration systems in urban centers, and rural regions that rely on groundwater and other natural sources of drinking water will benefit greatly by urban regions having a functioning water treatment plant**.**

Environmental drivers requiring adaptation include flooding, natural disasters, and loss of ecosystem services and externalities of development. Suggested economic adaptation strategies for developing countries and developed countries are funding for new infrastructure and retrofitting old systems to reduce water waste.

EbA is a co-benefit to mitigation, but is important for adaptation as the preservation of natural systems reduce impacts of climate change relative to no preservation, and in that sense will represent an adaptation. This input will aid in the resilience of certain regions, will prevent a large simultaneous flux of migration, reduce economic shocks associated with resettlement. Mandates for industries pay taxes on externalities to preserve these services should be valuated with the cost of resettlement in mind. Collectively these strategies will help to ensure successful adaptation.

*Monitoring and Evaluation*

The 'Intergovernmental Platform on Biodiversity and Ecosystem Services' (IPBES) purpose is to assess the state of the planet's biodiversity, its ecosystems and the essential services they provide to society.

IPBES provides a mechanism recognized by both the scientific and policy communities to synthesize, monitor and evaluate relevant information and knowledge generated worldwide by governments, academia, scientific organizations, non-governmental organizations and indigenous communities. With this in mind Cambridge Conservation Initiative and Birdlife International have created a toolkit for monitoring and evaluation.

Cambridge Conservation Initiative and Birdlife International Monitoring Points:

*Climate Regulation Services.* Carbon sinks can be estimated using the following methods. One way is to reference o IPCC standard tables. Another way to transfer the values derived from sites with a similar vegetation and climate. And finally, field surveys can be used to quantify the volume of living vegetation in the different habitats. The loss of carbon through disturbances is estimated using as standardized methods. The amount of CO2 and other greenhouse gas emissions are estimated by using IPCC methods depending on the habit type and data is extrapolated based on values per hectare

*Water services.* Data from a water companies can be used to calculate a region's water provisions and a questionnaire survey from residents can also be helpful. Where water services are difficult to measure there are open software tools such as "Costing Nature" web based tool for natural capital accounting and analysing the ecosystem services provided by natural environments created by King's College London (models), AmbioTEK (software), UNEP-WCMC (applications).This provides information on changes in water provisions based on a particular region.

*Harvested wild goods.* The most important harvested wild goods are identified surveys of randomly selected households. Questions regarding the annual amount harvested, the unit value and all related costs and opportunity costs are answered and quantified. The goods that are selected are matched with land cover types and are extrapolated according to average value per hectare.

*Cultivated Goods.* Stakeholder meetings with informed individuals are used to identify the primary goods relevant to the region. Random household surveys are undertaken to quantify the annual amount cultivated, the unit value and all related costs and opportunity costs. The average values per hectare are applied to areas that have been under cultivated.

*Nature-based Tourism and recreation.* Data on the number of visitors to a site can be extracted from published reports on visits to sites and protected areas. Also, a census of visitors over a random selection of days, can then be extrapolated to an annual estimate. To estimate average expenditure (travel, food, other goods, entrance fees) per visit can be deduced from interviews with visitors. The proportion of value coming from nature-based tourism is estimated questions about the alternative state (CCI and BirdLife International, 2011)

**Agricultural Financial and Infrastructural Resilience Adaptation**

Agriculture, consumption and food security for urban dwellers is dependent on security of employment and monetary income, since in the urban context there is greater dependence on the market system for food purchases. Presently many people in urban regions, particularly those in developing countries, have limited purchasing power as their employment tends to be low paying. At the individual level, food security depends the availability of an adequate and sustainable food supply and also the way in which households acquire the needed food. Food insecurity and malnutrition are often higher in urban regions than in rural areas, and the suggested adaptation strategies for urban regions in both developing countries and developed countries, include addressing low and irregular incomes, and inadequate housing and basic infrastructure.

At the rural level, where agriculture is produced, adaptation is focused on financial and infrastructural Resilience as well as preservation of ecosystem services. Households will depend on the farmer's ability to alter agricultural methods, ensuring best practices in advanced agronomic knowledge, resilient crop varieties, and improved storage and distribution channels, and expansion of irrigation infrastructure. Transportation infrastructure will better link farmers to input and output markets.

Adaptation strategy should not only take into account necessary increased food production, but also inequalities of distribution. Urbanization affects all aspects of food production and consumption and a broad approach to food systems is needed to encompass all aspects of food production, storage, distribution and consumption, all of which will be affected by climate change, through growing frequency and severity weather events.

Further adaptation according to this report suggests that smallholders diversify income in other sectors, and having increased access to credit and insurance, and creating weather-indexed insurance products, to ensure financial resilience. In developed countries, the private sector accounts for 55% of total agricultural R&D expenditures where many companies are innovating varieties to adapt to climate change, such as drought-tolerant maize. However, developing countries presently do not have the direct benefits of these outputs (D. Lobell and M. Burke, 2010).

*Monitoring and Evaluation*

To monitor these adaptations there are established frameworks under UN-Habitat and the World Bank using primary data such as satellite imagery, remote sensing, and census data. The data points to be focused on include, which crop varieties are available and if they are resilient varieties, storage and distribution channels, financial mechanisms and farmers access to credit and insurance, including weather indexed-insurance products. And finally, the ratio of land consumption rate to population growth rate, at comparable scale.

**Rural to City Transportation Infrastructure Adaptation**

As populations move from rural regions to urban centers and are subject to climate migration safe, reliable and affordable transportation will be critical. An integrated assessment that accounts for land use, demographic and climatic conditions in the both the urban transportation system and in rural regions, will be necessary for improving livelihoods while promoting resilience to additional environmental shocks. Further, economies depend on the country's transportation system for mobility of products and services like energy, food, manufacturing, and trade. Disruptions to transportation systems will cause large economic and personal losses.

Accessibility, sustainability and resiliency of infrastructure are the two major areas of concern in both developing and developed countries. Primarily in rural regions, accessibility is low and populations are isolated by distance, rugged terrain and poverty from essential services and opportunities like employment, healthcare and education. Climate change will exacerbate loss of pathways, and for this reason an adaptation method could include increasing access to Intermediate means of transport (IMTs). IMTs are lower-tech forms of transportation like hand-carts, bicycle or animal drawn carts, and/or motorcycle-based technologies. These can provide crucial mobility to access markets, healthcare, and schools. Further making credit or building materials more accessible to manufacturers can improve uptake and improve mobility for disadvantaged people. In terms of infrastructure, adaptation to climate change includes building roads and routes. For built roads, adapting specific to engineering include raising, sloping, paving roads; ensuring proper drainage and hydrology; and regular maintenance and management (UN Habitat, 2014).

*Monitoring and Evaluation*

Most methods of M&E are presently developed to address transportation infrastructure in the urban context (for more information please see section 11.2) and methods need to be created to encompass the needs of migrating populations from rural regions. Some methods proposed by International Institute for Environment and Development (IIED), include measuring the percentage of people within 0.5 km of public transit running at least every 20 minutes, access and presence of interstates, roads and rail.

Also, measuring the sustainability and footprint of transportation system and infrastructure and alternative routes to density, that don't force people to choose between being displaced to distant peripheries or being crowded into unhealthy "slums" or apartment blocks. A primary data source is still to be determined, however a potential lead agency would be UN-Habitat. (IIED, 2014)

**Financial and Infrastructural Resilience for Clean Water Adaptation**

Environmental drivers requiring adaptation include flooding, natural disasters, and drought. With that in mind, SDG Goal 6 is to "ensure availability and sustainable management of water and sanitation for all". In the urban to rural context, adaptations to improve water quality include reduction of point and non-point pollution, restoration of ecosystems, increased water-use efficiency, and expansion international and regional cooperation and capacity-building. Additionally, these improvements are not only adaptation strategies, but also mitigation solutions for potential climate events and can have direct market implications for both urban and rural regions.

*Monitoring and Evaluation*

Joint Monitoring of the United Nations Programme for Water Supply and Sanitation (JMP), managed by the World Health Organization (WHO) and United Nations International Children's Emergency Fund (UNICEF), has been the

United Nation's mechanism for monitoring Millennium Development Goal (MDG) 7, target 10, and has had mixed success. Although, MDG water and sanitation targets called for reporting on progress in both rural and urban areas, the regions have very different results.

Measures to be taken include identifying how sanitation and water services can be improved in deprived urban locations that conventional urban piped water and sewer services have not reached. Identifying how effective informal water vendors, private and publicly operated utilities are meeting the needs of low-income residents, and identifying what can be done to improve the often high-priced services they provide, or to shift towards piped systems. Other measures include measuring the proximity to potable water sources based on community enumerations, mapping, documentation of sanitary conditions, and establishing baselines for new or adapted sanitation solutions.

To evaluate the effectiveness on-site compliance inspections and investigations are necessary and a review of permits and other documentation. Data collection, review, reporting, program coordination, for off-site compliance is also necessary as wells as inspector training, credentialing and support

Here is an overview developed by the Joint Monitoring of the United Nations Programme for Water Supply and Sanitation:

*Periurban slums*. The national sample surveys, sometimes provide representative data for a region or province or a city, but the data cannot be broken down to identify the specific needs of locations such as rural villages, small towns or urban slums.Yet such detailed data are needed about the scope of the provisions in each region, to appropriately for investments in drinking water and sanitation systems.

*Time to source.* When the round trip takes more than 30 minutes, people typically retrieve less water than they need to meet their basic requirements.

*Gender disparities.* The study notes that there is little research on gender inequalities and water supply. However there is now evidence that women and girls are the main bearers of water and this interferes with education. (UN Women, 2015)

*Household water treatment* will aid in reducing water-borne diseases. However, measures still need to be taken to create sustainable drinking-water infrastructure to ensure sufficient water supply

(Source: UNICEF/WHO JMP, 2015)

**Climate Resettlement Plan (rural) Adaptation**

One of the more complex adaptation strategies is climate resettlement programs. In the context of climate change migration, once resettlement is necessary it is already is considered a failure to adapt. However, given that the average number of climate displaced person since 2008 is already 22.5 million, and we know that entire regions will continue to have to relocate, and the relocation itself has become the adaptation (Internal Displacement Monitoring Centre, 2015).

So far, multilateral organizations have framed climate relocation as disaster risk reduction (DRR). The Sendai Sendai Framework for Disaster Risk Reduction sets four priorities, which are understanding disaster risk, strengthening disaster risk governance to manage disaster risk, Investing in disaster risk reduction for resilience, and enhancing disaster preparedness for effective and response and to "Build Back Better" in recovery, rehabilitation and reconstruction (UNISDR, 2015).

Framing resettlement solely under DDR is problematic since it doesn't address already present structural difficulties explicitly. Depending on the region structural issues that affect rural to urban growth and resettlement, could include fast population growth, militants, unequal development in the urban and rural regions, insufficient food sources and potable water. Climate change then, is a stress-multiplier of the aforementioned issues and DDR does nothing to address the existing preconditions.

Adaptation methods beyond DDR, that address structural issues include the following:

> *Increased Investment in labor shortage to develop regular pathways of labor mobility.* Attention to the way in which rural populations settle into cities or into new territories, and a strengthening of information on where labor shortages exist will allow for efficiency gains in economic, environmental and social sustainability. (International Labor Organization ILO)

> *Strengthened Resilience Through Education.* Education and training will allow for the ability for an individual to assimilate to new region and ensure labor productivity.

> *Protection of Human rights.* Given the lack of governance and institutional capacity, it will be challenging for many countries to fulfill human rights obligations related to climate change adaptation. (Internal Displacement Monitoring Centre, 2015)

> *Anti-Poverty Programs.* When economies develop and people become wealthier, they are better able to manage risks through adaptation and cope with impacts (World Bank, 2015)

> *Family size reduction through gender empowerment.* A decrease in population growth will allow for efficient uses of resources. There has been a strong correlation between girls' education and empowerment and a decrease in birth rates.

According to International Organization for Migration (IOM), adaptations include "furnishing technical assistance for flood-prone areas; developing regional preparedness strategies and cross-border mobility in drought areas; creating temporary and circular migration schemes; constructing transitional shelters; and providing primary health care to victims in regions struck by disaster" (IOM, 2015).

Lastly, one of the most important issues is establishing which regions people will relocate to. Climate refugees still do not have an appropriate framework, and do not fall under the auspices of Geneva Refugee Convention of 51. With that in mind, The Peninsula Principles address displacement within national boundaries states are obliges to prevent displacement and work to rebuild in a timely fashion. Since this will not be a reality for many nations, the Nansen Initiative attempts to address adaptations for cross-border displacement. The study notes that the recommendations for adaptation have temporal and spatial fixes that are highly dependent on the particular context, and there is no single approach for reducing risks appropriately across all settings (Displacement Solutions, 2013).

Therefore, the recommendations in these reports are both over-inclusive and under-inclusive.

To address the issue of climate resettlement in a pragmatic way, it has been suggested as a thought exercise that countries with the largest concentrations of emissions and spatial capacity, should open borders to those displaced by climate change (Gerrard, 2015). There are of course ethical implications related to this idea, and remedies and compensation on this issue still needs to be discovered.

Following this thought, the concept of a "displacement coordination facility" have been proposed. Under this concept two options are available. One is a new loss and damage mechanism that would (a) assist in developing arrangements for emergency relief; or (b) assist in providing organized migration and planned relocation; or, the second option would be continued implementation of the Warsaw Mechanism. This option would call upon the Executive Committee of the Warsaw Mechanism on Loss and Damage to take the lead in coordinating climate displacement rather than establishing a "displacement coordination facility" (Wentz, Burger, 2015).

Overall, adaptation for resettlement will prove to one of the more difficult issues to resolve in the urban and rural context. With this in mind, addressing structural issues will allow for more resilient communities and is the most defined pathway to ensuring a measure of success.

**Indicators**

Based on the climate events most relevant to target 11.A, there are a total of 6 adaptation strategies that are currently in the stages of implementation: Ecosystem Based Adaptation, Agricultural Financial and Infrastructural Resilience, Rural to City Transportation Infrastructure, Clean Water Financial and Infrastructural Resilience, and Climate Resettlement Plan (rural). Figure 4 outlines the current theoretical or practiced indicators associated with each adaptation.

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| Ecosystem | Proportion of land area covered by forest | • **Monitoring:** Satellite |

| | | |
|---|---|---|
| Based Adaptation | Proportion of fish stocks within safe biological limits | imagery, remote sensing, field data<br>● **Evaluation:** Comparisons with past records |
| | Proportion of total water resources used | |
| | Proportion of terrestrial and marine areas protected | |
| | Proportion of species threatened with extinction | |
| | Proportion of land area covered by forest (FAO) | |
| Agricultural Financial and Infrastructural Resilience | [Ratio of land consumption rate to population growth rate, at comparable scale] – to be developed | ● **Monitoring:** Satellite imagery, remote sensing census data<br>● **Evaluation:** Comparisons with past records |
| | Resilient crop varieties | |
| | Improved Storage and Distribution Channels | |
| | Poor farmer access to credit and insurance: Weather indexed-insurance products | |
| Rural to City Transportation Infrastructure | Percentage of people within 0.5 km of public transit running at least every 20 minutes | ● **Monitoring:** National household census information, Cost-benefit analyses based on road appraisal models such as HDM4 and RED<br>● **Evaluation:** Comparisons with past records |
| | Access and presence of interstates, roads and rail | |
| Financial and Infrastructural Resilience for Clean Water | Proportion of population with access to improved sanitation, urban and rural | ● **Monitoring:** Formulation and implementation of compliance monitoring strategies;<br>On-site compliance inspections, evaluations, and investigations (including review of permits, data, and other |
| | Presence of Run-off and erosion protection | |
| | Presence of eutrophication | |
| | Presence of storm water collection | |
| | Presence of Septic/Wastewater Treatment Systems | |

| | | |
|---|---|---|
| | Presence of Water Filtration System | documentation);<br><br>Off-site compliance data collection, review, reporting, program coordination;<br><br>Oversight, and support inspector training, credentialing and support<br><br>● **Evaluation:** Comparisons with past records |
| | Presence of retrofit and/or built aquifers | |
| | Proportion of population with sustainable access to an improved water source, urban and rural | |
| | [Percentage of wastewater flows treated to national standards, by municipal and industrial source] – to be developed | |
| | Proportion of total water resources used | |
| | Complementary National Indicators:<br><br>Percentage of population reporting practicing open defecation | |
| | Proportion of the population connected to collective sewers or with on-site storage of all domestic waste waters | |
| | Proportion of the flows of treated municipal wastewater that are directly and safely reused | |
| Climate Resettlement Plan (rural) | Percentage of urban population living in slums or informal settlements (MDG Indicator) | ● **Monitoring:** Satellite imagery and census data<br><br>● **Evaluation:** Comparisons with past records |
| | Proportion of population below $1.25 (PPP) per day<br><br>Poverty gap ratio | |
| | Share of poorest quintile in national consumption | |
| | Growth rate of GDP per person employed | |
| | Employment-to-population ratio | |
| | Proportion of employed people living below $1.25 (PPP) per day | |
| | Proportion of own-account and contributing family workers in total employment | |

| | | |
|---|---|---|
| | Proportion of households with access to secure tenure | |
| | Land Use Efficiency [Ratio of land consumption rate to population growth rate, at comparable scale] – to be developed | |
| Family Size Reduction | Birth Rate | • **Monitoring**: Census data<br>• **Evaluation:** Comparisons with past records |
| | Infant Mortality Rate | |

**Figure 4:** chart of indicators and monitoring & evaluation strategies for Target 11.a

**SOCIAL GROUP**

*The following section outlines the various results found during the literature review for each of the three targets 11.3, 11.4, and 11.7 relevant to the thematic social group.*

**TARGET 11.3**

Goal 11.3 focuses on enhancing inclusive and sustainable urbanization and capacities for participatory, integrated and sustainable human settlement planning and management in all countries. This target is explicitly related to adaptation because planning and management are integral steps in achieving a more sustainable urban city. Depending on each city's location, they are subject to several different climate change events such as flooding and drought. For example, climate change can impact participatory processes and sustainability by the displacement of people and the influx and rapid overpopulation of urban areas. Adaptation efforts make a population more resilient towards climate change by planning for these events. Quality of life within these different cultural contexts and human settlement patterns require adaptation strategies specific to each region. More socially inclusive cities are overall healthier and more productive in their economic sectors.

**Policy Adaptations**

Current adaptation strategies are most evident in developed countries which center around frameworks of countries projected goals and climate action plans. For example, Australia has developed an approach to sustainable planning within five metropolitan cities. Australia articulated a framework, identified urban sustainability trends by the UN Habitat, reviewed the metropolitan planning strategies developed by the respective state governments, and established state and federal government's current positions and critique through the Urban Political Ecology (UPE) (Fitzgerald, 2015).

These policy-making frameworks are for the most part recent implementations or projected goals for the countries foreseeable future. Some of these adaptation efforts include: community based adaptation, program and project based adaptation, and national policy initiatives (WRI). These three adaptation efforts work together by using a combination of both local and national frameworks in order to further adaptation. The Principles of Adaptation emphasize results-based management, learning, and flexibility. Specifically, when looking at the social context, it becomes difficult to indicate the progression of success of these frameworks, highlighting the need for quantitative adaptation strategies within this target.

Developing countries have been able to use these frameworks tailored to their own context to increase their overall well-being. “Implementing each village with frameworks according to its specific geographic, environmental, and socio economic context.”. Participation is key to flexibility. This model can be used for adaptation due to climate change (World Resources Institute, 2015).

**Quality of life Adaptations**

Quality of life within growing urban populations has become more of a priority with the influx of people into urban settlements. Variables include climate related amenities such as: precipitation, humidity, and sunshine, as well as environmental concerns such as landfill waste discharges and treatment, storage and disposal sites. This is a particularly effective adaptation strategy when looking at variables that have been caused due to climate change, as well as establishing a baseline for each country to compare its annual quality of life (Blomquist, 1988). Achieving high quality of life has become an increasing challenge in urban areas due to rapid growth and migration. There is a direct correlation between overall quality of life and jobs, families, health, and other qualitative variables. The Quality of Life Index values are calculated using the characteristics of the average household and all 16 amenities included in the empirical analysis. “The index is constructed using preference-based weights, which are the amenity values derived from the hedonic estimation” (Blomquist, 1988). This index looks at a specific amenity variable, establishes a sample mean and unit of measurement for all countries.

With the influx of more people living in urban settlements, it is important to not only look at economic output, but also take into account other aspects of overall human well-being. Prosperity beyond economic growth, including other vital dimensions such as quality of life, adequate infrastructures, equity and social inclusion, productivity, and environmental sustainability are all variables looked at by the UN Habitat. They propose such policies for a prosperous city as being:

1. Effective urban planning and management,
2. Decentralization and appropriate institutions,
3. A system that creates equal opportunities,
4. Civil society participation,
5. A favorable business environment,
6. Adequate infrastructure

The City Prosperity Index, in combination with a conceptual matrix called The Wheel of Prosperity, is used to help with policy determination. (UN Habitat, 2012).

**Quality of Life Indicators**

World Happiness Report uses GDP per capita, healthy years of life expectancy, social support (as measured by having someone to count on in times of trouble), trust (as measured by a perceived absence of corruption in government and business), perceived freedom to make life decisions, and generosity (as measured by donations, adjusted for differences in income), as a way to rank countries on their overall happiness and well-being. The monitoring and evaluation used in The World Happiness Report includes personal evaluation, which may differ amongst and across countries. These calculations are difficult to standardize due the way people choose to rate their own happiness (Helliwell, 2015).

Another example of quality of life indicators is the Urban Inequities survey (UN, 2015). This method measures and identifies sanitation services disaggregating urban water and sanitation service coverage by socio-economic status. Identify needs in terms of access to infrastructure and basic services (water, sanitation, solid waste management and drainage), such as sufficiency, safety and acceptability, affordability and physical accessibility. They also address different components of other human settlements issues such as durable housing, overcrowding, security of tenure, education, employment, social capital, income and expenditure, solid waste management, environment, health, livelihoods, transportation, in short, a comprehensive set of information on a majority of MDG indicators. The exercise involves the use of GIS to identify populations that are not served by water and sanitation facilities (UN, 2015).

Many times the most common indicators used in measurement of quality of life include health and education. There are most available and can be easily measured by surveys including the Demographic and Health Surveys, UNICEF's Multiple Indicators Cluster Surveys, and the World Bank's Living Standards and Measurement Surveys.

| **Adaptation** | **Indicators** | **Monitoring and Evaluation** |
|---|---|---|
| Planning and management Adaptation | Environment Index | ● **Monitoring:** SEMPRe database was created as a method of monitoring and evaluating hard data.<br>● **Evaluation:** One index, incorporating all parameters of urban sustainability. |
| | % recycling | ● **Monitoring:** Organized around three dimensions of adaptation: adaptive capacity, adaptation actions, and sustained development.<br>● **Evaluation:** describe the adaptation context, identify the contribution to adaptation, form an adaptation hypothesis, create an adaptation theory of change, choose indicators and set a baseline, and use the adaptation and M&E system |
| | per capita waste volume | |
| | forest area in a 10km radius | |
| | national heritage area in a 5km radius | |
| | % green energy interest | |
| | transport CO2 emissions | |
| | drinking water NO3 | |
| | electricity CO2 emissions | |
| | level of wastewater treatment | |
| | socio-economic index | |

| | | |
|---|---|---|
| | population density | |
| Adaptive capacity of target groups | increase and diversification of income | |
| | reduction of share of population below poverty line | |
| Sectoral | increased agricultural productivity | |
| | increased water availability | |
| | improved natural resource base | |
| | reduced damage due to floods | |
| Structural impact | # of centrally sponsored and state sponsored schemes | |
| Quality of Life | GDP per capita | ● **Monitoring:**<br>● **Evaluation:** Personal evaluation/ this may differ amongst and across countries. Difficult to standardize the way people rate their happiness |
| | healthy rates of life expectancy | |
| | social support (as measured by having someone to count on in times of trouble) | |
| | trust (measured by a perceived absence of corruption in government and business) | |
| | perceived freedom to make life decisions | |
| | generosity (as measured by donations, adjusted for | |

| | | |
|---|---|---|
| | differences in income) | |
| Further Quality | disaggregates urban water and sanitation service coverage by socio-economic status | ● **Monitoring:**<br>● **Evaluation:** GIS, Demographic and Health Surveys, Multiple Indicators Cluster Surveys, and the World Bank's Living Standards and Measurement Surveys |
| Identify needs in terms of access to infrastructure and basic services (water, sanitation, solid waste management and drainage | safety | |
| | acceptability | |
| | affordability | |
| | physical accessibility | |

**Figure 5:** Chart of indicators and monitoring & evaluation strategies for Target 11.3

**TARGET 11.4**

Target 11.4 addresses the urban scale and the role of municipalities in protecting cultural and natural heritage. Cultural heritage includes anything that has national, cultural or historical significance, such as a national monument like the Lincoln Memorial in Washington D.C., or a historical monument like the Castle Keep in Newcastle Upon Tyne, UK. Natural heritage refers to the biodiversity, such as plants, animal, and ecosystems that have existed and currently exist within a specific location.

It is important to consider the cultural and natural nexus of urban environments, as cities have often been places of commerce and manufacturing, developing in locations suited to economic activity, such as on trade routes or near useful resources. Concentrated populations also produced and continue to produce a diversity of skills and stimulate growth with a diversity of economic activity and knowledge. Cities also have public buildings and spaces for government, organized religion, education, commerce, social interaction, cultural events and public services, which play an important role in providing a focus for citizens and communities (O'Brien *et al.,* 2015). Lozano argues that the city is the realm of high level of culture linked with the most civilized expression of social behavior (O'Brien *et al.*, 2015, adapted from Lozano, 1990). Despite the many problems that cities face such as urban sprawl and insufficient development, many city residents identify strongly with their place of residence and the cultural landmarks it contains (Giddings *et al.*, 2005).

Cultural and natural heritage are very diverse and a variety of strategies will be needed to adapt to climate change. The table below shows the range of threats faced by cultural heritage from climate change, thus calling for rapid adaptation strategies.

| | |
|---|---|
| Precipitation | - many rainwater goods are not capable of handling heavy water and are often difficult to access, maintain and adjust |
| Fluvial Flooding | - can damage heritage as can ground heave and subsidence as water recedes |
| Coastal Flooding and storm surge | - could lead to loss of coastal sites |
| Extreme weather | - problem areas include windows, roofs, awnings, verandas and large trees close to buildings. Ruined building and excavated archaeology would be in danger of wind throw |
| Temperature | -important for visitor comfort, although winter heating would decrease; could lead to a drive to install air conditioning and cooling systems in summer. Deterioration of materials and contents because higher temperature would increase rate of chemical reactions |
| Relative Humidity | - changes to relative humidity could result in new sorts of insects attacking collections |
| Water Table Chemistry | - change can result for a fall in water table height or from seawater incursion. Certain areas may see a change in the pattern of damage from rising damp |

**Figure 6.** Impacts of climate change on cultural heritage**.** Originally adapted from Cassar (2005)

**Proposed Indicators by the United Nation's Sustainable Development Solutions Network (UNSDSN)**

The United Nation's Sustainable Development Solutions Network proposed specific adaptation strategies and indicators to measure these efforts (Figure 7). They include the Hyogo post-2015 framework for disaster risk reduction that seeks to highlight the percentage of cities with more than 100,000 inhabitants that are implementing risk reduction and resilience strategies. The Red List Index is an indicator of the changing state of global biodiversity. It defines the conservation status of major species, and measures trends in extinction risk over time. Also, there is a suggestion that could be assumed to be a measurement of protected areas that are overlaid with indicators of biodiversity such as the Red List Index.

**Hyogo post-2015 Framework for Action (HFA)**

The Hyogo Framework for Action Monitoring and Progress Review facilitates monitoring, evaluating and reporting on the implementation of disaster risk reduction measures at the national, regional and global levels (UNISDR, 2011). Previously, the General Assembly of the United Nations adopted and endorsed the HFA 2005-2015 by the

World Conference on Disaster Reduction in 2005 and was the culmination of a process started in 1990, with the declaration of the International Decade for Natural Disaster Reduction (UNISDR, 2011). The post-2015 framework seeks "to address the need for disaster risk management to be an integral component of development plans and poverty eradication programs" (UNISDR, 2015). To adapt the report's language within the context of cities, cities "must reduce their vulnerabilities and exposure to risk by [incorporating] development mechanisms (such as national public investment planning systems, social protection, and national and local infrastructure investments) to reduce risks and strengthen resilience" (UNISDR, 2015). This is important because reducing disaster risk and reinforcing resilience in cities is increasingly seen as part of a new development paradigm where well-being and equity are core values and human and natural assets central to planning and decision-making.

**Red List Index**

The Red List Index (RLI) illustrates changes in the overall threat status (relative projected extinction risk) for sets of species. For example, an RLI has been calculated for the world's birds for 1988–2004, and a preliminary RLI has been produced for the world's amphibians for 1980–2004 (Butchart *et al.*, 2004, 2005). As well as monitoring global trends for different taxonomic groups, the RLI can be disaggregated to compare trends for suites of species in different biogeographic regions, ecosystems, habitats, or taxonomic subgroups or for species relevant to different international treaties such as the Ramsar Convention on Wetlands (Butchart *et al.*, 2005).

The key strength of the RLI is its geographic representativeness, being based on information for nearly all species in a taxonomic group (Butchart *et al.*, 2006). Its principal weakness is that it has a coarse temporal resolution: species may take some time to change in population size, trend, or range size sufficiently to cross the thresholds to qualify for placement in a higher or lower red-list category. Although population-trend-based indicators show greater sensitivity to status changes, such information tends to be available only for certain types of species in better known and often biodiversity poor regions (Brooks & Kennedy 2004). Hence the RLI and population-trend- based indicators are highly complementary in terms of their geographic representativeness and temporal resolution.

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| Strengthen efforts to protect and safeguard the world's cultural and natural heritage | 11.3. Percentage of cities with more than 100,000 inhabitants that are implementing risk reduction and resilience strategies informed by international frameworks (such as forthcoming Hyogo-2 framework) | • **Monitoring:** none<br>• **Evaluation:** none |
| | Red List Index | |
| | protected areas overlay with biodiversity | |

**Figure 7.** Proposed Indicators for Target 11.4 by the United Nations' Sustainable Development Solutions Network. Source: SDSN, 2015.

**Complementary Indicators**

In conducting an assessment rubric for these proposed indicators and strategies, it was important to assess the literature to see what other adaptation strategies were present that could either enhance or improve upon the suggested indicators. In the literature review there were some strategies and indicators that potentially complement the SDSN indicators. They include the Singapore Index, which serves as a self-assessment tool for cities to benchmark and monitor the progress of their biodiversity conservation efforts against their own individual baselines with 23 indicators that measure native biodiversity in the city, ecosystem services provided by biodiversity, and governance and management of biodiversity (Chan *et al,* 2014). The cultural heritage adaptation forum, which is a dynamic model with individual baselines that can be used by various stakeholders that have an interest in protecting cultural heritage from climate driven hazards (O'Brien *et al.*, 2015). However, it is important to note that the forum assesses the management of adaptation rather than an actual strategy. Specifically, it focuses on processes by which a society or nation perceives, assesses and acts on climate related events and their willingness to learn from them (O'Brien *et al.*, 2015).

**Natural Heritage Adaptation**

It is commonly assumed that cities are devoid of flora and fauna due to impacts of human occupation—but the reality is that many cities retain rich biodiversity-- regardless of geographical location and climate (Chan *et al.,* 2014). The natural heritage in cities is sometimes located within or near biodiversity hotspots, while others are important stopover sites for migratory species. For example, the original habitat of the black lion tamarin, a flagship endangered species endemic to the Atlantic Forest of Brazil, overlays with the location of the country's two most populous cities, Sao Paulo and Rio de Janeiro (Dietz *et al.*, 1994). Therefore, the ecosystem services that urban biodiversity provides to the local area are innumerable and often undervalued. Beyond aesthetics, ecosystems regulate the supply and quality of water, air and soil as well as moderating ambient temperatures. Water supply to urban areas frequently comes from catchment areas within or beyond the city boundaries; these catchment areas are sustained by natural ecosystems that store and purify the water (Chan *et al.*, 2014). Urban greenery replenishes oxygen, sequesters carbon, absorbs solar radiation, reduces air pollution, maintains water balance and regulates surface temperature in urban landscapes through shading and evapotranspiration (Chan *et al,* 2014). Whereas sequestering carbon, reducing air pollution, and maintaining water balance make urban greenery an important adaptation strategy due to its ability to increase resilience of urban ecosystems. Absorbing solar radiation and regulating surface temperature are mitigation co-benefits (Chan *et al.,* 2014). These co-benefits may not directly address cultural and natural heritage, but nonetheless provide benefits that enhance the adaptation strategy. For example, planting urban gardens and trees can empower individuals and build community within urban neighborhoods, thereby enhancing the cultural attributes of the city (Pinceti 2010). Parks and natural areas provide recreational and educational opportunities to residents and contribute towards the livability of a city (Chan *et al.*, 2014). As a result, maintaining biodiversity is an ecosystem based adaptation strategy that makes urban areas more resilient to the effects of climate change.

The most current adaptation measure used by cities to address the importance of urban biodiversity and natural heritage is the Singapore Biodiversity Index (CBI) (Figure 8). Prior to the development of the Singapore Index, existing environmental and sustainability indices for cities and local authorities covered broader environmental issues and if biodiversity was considered, it typically formed only a minor component of the scores (Chan *et al.*, 2014).

The Singapore Index serves as a self-assessment tool for all cities to benchmark and monitor the progress of their biodiversity conservation efforts against their own individual baselines. The CBI encourages cities to complete a baseline assessment of their biodiversity and then monitor this over time. This provides cities with valuable information that they might not otherwise have and can aid in the decision-making process as it helps to identify strengths, weaknesses and trends over time (Figure 8).

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| To benchmark and monitor the progress of a city's biodiversity conservation efforts | Geographical coordinates | ● **Monitoring:** none<br>● **Evaluation:** no evaluation needed; indicator meant to place the city's evaluation for the Index in the proper perspective |
| | Altitude | |
| | Climate: rainfall/ precipitation (range and average) | |
| | Total population and population density | ● **Monitoring:** none<br>● **Evaluation:**no evaluation needed; indicator meant to place the city's evaluation for the Index in the proper perspective |
| | Population of the region (if appropriate) | |
| | Gross Domestic Product (GDP) | ● **Monitoring:** none<br>● **Evaluation:** no evaluation strategy needed; indicator meant to place the city's evaluation for the Index in the proper perspective |
| | Gross National Product (GNP) | |
| | Per-capita income | |
| | Key economic activities, drivers and pressures on biodiversity and culture | |
| | Ecosystems within the city | ● **Monitoring:** none<br>● **Evaluation:** no evaluation strategy needed; indicator meant to place the city's evaluation for the Index in the proper perspective |
| | Species within the city | |
| | Quantitative data on populations of key species of local importance | |
| | Relevant qualitative biodiversity data | |
| | Proportion of Natural Areas in the City | ● **Monitoring:** subsequent applications of the CBI and Adaptation Forum take place every three years to allow sufficient time for changes to have taken effect or the results of biodiversity conservation efforts to materialize<br>● **Evaluation:** CBI, relative to individual city's benchmark, each monitoring measure will range in score from 0-4 points for a maximum score of 40 points |
| | Connectivity Measures | |
| | Native Biodiversity in Built Up Areas (Bird Species) | |
| | Change in Number of Vascular Plant Species | |
| | Change in Number of Bird Species | |
| | Change in Number of Butterfly Species | |
| | Change in Number of Species (any other taxonomic group selected by the city) | |
| | Change in Number of Species (any other | |

| | | |
|---|---|---|
| | taxonomic group selected by the city) | |
| | Proportion of Protected Natural Areas | |
| | Regulation of Quantity of Water | ● **Monitoring:** subsequent applications of the CBI and Adaptation Forum take place every three years to allow sufficient time for changes to have taken effect or the results of biodiversity conservation efforts to materialize<br>● **Evaluation:** CBI, relative to individual city's benchmark, each monitoring measure will range in score from 0-4 points for a maximum score of 16 points |
| | Climate Regulation: Carbon Storage and Cooling Effect of Vegetation | |
| | Recreation and Education: Area of Parks with Natural Areas | |
| | Budget Allocated to Biodiversity | ● **Monitoring:**subsequent applications of the CBI and Adaptation Forum take place every three years to allow sufficient time for changes to have taken effect or the results of biodiversity conservation efforts to materialize<br>● **Evaluation:** CBI, relative to individual city's benchmark, each monitoring measure will range in score from 0-4 points for a maximum score of 36 points |
| | Number of Biodiversity Projects Implemented by the City Annually | |
| | Existence of Local Biodiversity Strategy and Action Plan | |
| | Institutional Capacity: Number of Biodiversity Related Functions | |
| | Institutional Capacity: Number of City or Local Government Agencies Involved in Inter-agency Co-operation Pertaining to Biodiversity Matters | |
| | Participation and Partnership: Existence of Formal or Informal Public Consultation Process | |
| | Participation and Partnership: Number of Agencies/Private Companies/NGOs/Academic Institutions/International Organizations with which the City is Partnering in Biodiversity Activities, Projects and Programs | |
| | Education and Awareness: Is Biodiversity or Nature Awareness Included in the School Curriculum | |

| | | |
|---|---|---|
| | Education and Awareness: Number of Outreach or Public Awareness Events Held in the City per Year | |

**Figure 8.** Singapore Biodiversity Index (CBI) Indicators. Source: Chan *et al.*, 2014.

**Cultural Heritage Adaptation**

Cultural heritage encompasses all contemporary demonstrations and evidences of human creative activity that are inherited from previous generations and considered by communities or society at large to be of value, and therefore to be maintained in the present and transmitted to future generations for their benefit (Roders & van Oers, 2011). Cultural heritage is important as a source of memory and inspiration and contributes to national and local identity (Communities and Local Government, 2009). Tangible cultural heritage includes monuments, groups of buildings, sites and cultural landscapes while intangible cultural heritage includes the practices, representations, expressions, knowledge, skills of communities and groups, and sometimes individuals, as well as the instruments, objects, artifacts and cultural spaces (UNESCO, 1972, 2003).

A Cultural Heritage Adaptation Forum model developed by O'Brien (2015) seeks to develop climate adaptation strategies to reduce climate risk for cultural heritage. O'Brien posits that to have a clear understanding of the existing baseline for cultural heritage it is important start to thinking about future adaptation measures for cultural heritage. His model suggests that various data types should be involved to develop a comprehensive knowledge base (Figure 9). These various data inputs will constantly update what we know about the vulnerabilities and likely impacts on cultural heritage of climate change events.

For example, building resilience of cultural heritage requires identifying its vulnerabilities, hazards and expertise (Figure 9). Vulnerabilities can include "maldevelopment" or "lack of maintenance" that can influence the capacity of cultural heritage to withstand adverse events, such as increased flood risk (O'Brien *et al.,* 2015). Though it is typical in disaster management to consider discrete hazards, the cultural heritage adaptation forum seeks to understand hazards as dynamic and therefore would be reflected as such (O'Brien *et al.*, 2015). Analyzing the expertise available to respond to climate change vulnerabilities and hazards requires building a database on the status of preparedness. From there appropriate adaptation interventions--whether minimal or robust--should be selected after assessing this information and determining priorities within accepted values and norms (O'Brien *et al.,* 2015). In the case with increased flood risk, one might assess whether buildings are wind and water-tight, draining systems are functioning properly and whether there is a flood plan in place. Any sort of adaptation strategy to build resilience to buildings facing such climate hazards would include societal perceptions and stakeholder reactions to build a consensus based on the evidence. In the case study at the end of this section, the Heart of the City Partnership in Newcastle upon Tyne, UK developed a adaptation forum where a broad-based partnership informed by climate science produced successful strategies to protect the city's Castle Keep from the near- and long-term effects of climate change.

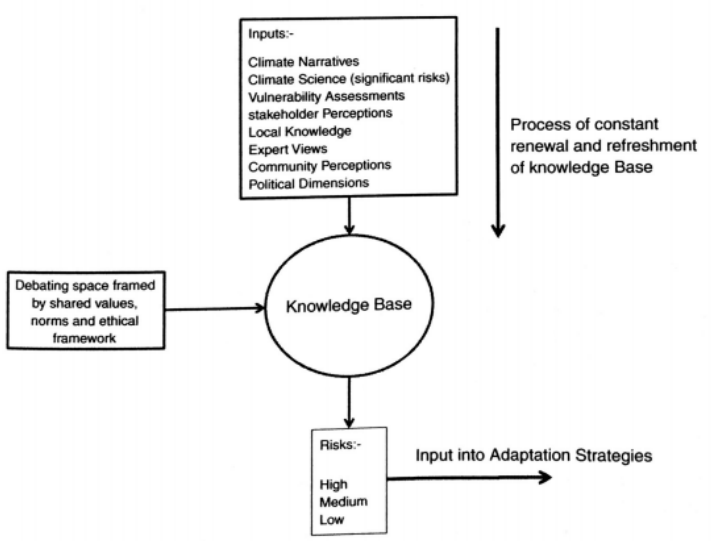


**Figure 9.** Development of a cultural heritage adaptation forum

**Case Study: The Castle Keep, Newcastle upon Tyne, United Kingdom**

The Castle Keep and the Black Gate are iconic structures in the City of Newcastle upon Tyne. It is where the Romans established a small fort to protect a bridge, Pons Aelius, they had built over the River Tyne. After the departure of the Romans, the area became known as Monkchester. Robert Cuthrose, in 1080, as part of his campaign against the Scots built a Motte and Baillie Castle in Monkchester. Therefore the area was renamed "Newcastle upon Tyne" and is the origin of the city's name.

FIGURE 1 THIS IS THE IMAGE SOURCE INFORMATION FOR CITATION PURPOSES: HTTPS://COMMONS.WIKIMEDIA.ORG/WIKI/FILE:NEWCASTLE_SCHLOSS.JPG

The Castle Keep became a significant city landmark and has played a key role in the history of the city. One of the interesting features of the Castle Keep is that it was built with a roof over the main body of the building and on the four turrets where visitors are allowed on to enjoy the cityscape. In 2007 an extreme precipitation event saw the water pool extensively on the roof, such that it flooded down the stairway and into the body of the Castle Keep. By using a *cultural adaptation forum* (with the Heart of the City Partnership) a solution was reached where barriers

were constructed according to meteorological records of the intensity and length of extreme precipitation events experienced in the region. The current solution will be monitored and reassessed over time to ensure that it is fit for purpose as an adaptation measure.

What made this forum work was the idea that broad partnership was a more effective way to arrive at adaptation strategies. Because of the uncertainties in climate change, decision-making can be very problematic. Climate science provides an evidence base for policy-making; however, policy-making—belonging to the realm of social science—is value laden, and neither field can effectively deal with uncertainty. However, evaluating evidence and new knowledge in a democratic forum implied some sort of risk sharing in the decision-making process. Epistemological limits to climate prediction wasn't interpreted as a limit to adaptation, but by placing climate prediction and risk assessment within this forum, it was possible to develop a successful adaptation strategy despite the deep uncertainties of climate change.

*Source: O'Brien, G., O'Keefe, P., Jayawickrama, J., Jigyasu, R. (2015). "Developing a Model for building resilience to climate risks for cultural heritage". Journal of Cultural Heritage Management and Sustainable Development. Vol. 5 No. 2. pp. 99-114.*

**Figure 10** shows the final part of the process. It has been advocated by the climate and disaster communities in the IPCC Special Report "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" (IPCC, 2012). It builds on lessons learned about earlier interventions and their effectiveness, providing flexible adaptation pathways. It also shows that new understanding of risks and vulnerabilities should inform future interventions.

**TARGET 11.7**

"Goal 11.7 is to provide universal access to safe, inclusive and accessible, green and public spaces, particularly for women and children, older persons and persons with disabilities by 2030" (United Nations, 2015).

This target is connected to climate change adaptation in that it is closely linked to people's well being as well as the preservation of nature. In order for people to stay healthy in a changing climate, where issues like heat spells, floods, and other climatic changes favoring diseases become more pronounced, it is necessary that there are accessible, safe and green public spaces. "Accessible, good-quality, well-maintained green spaces and playgrounds … that encourage physical activity and social interactions are key constituents of urban quality of life" (Ludlow, 2009). In other words, a healthy population is equivalent to a more resilient population. Also in terms of climate change, as better health usually translates to being physically and psychologically stronger and therefore more adept at dealing with extreme events. The World Health Organization also "considers urban planning [to be] an important determinant of health, and also economic development — as the attractiveness of a city or town is becoming an increasingly important factor in the decision making process." (Ludlow, 2009). Furthermore, it is a small but relevant step in finding ways of preserving biodiversity in a rapidly urbanizing world. "The consumption patterns and lifestyles related to our quality of life also drive climate change and threaten the ecological, economic and social basis of quality of life in the longer term" (Ludlow, 2009). Consciously maintaining these green spaces can further adaptation by keeping species present that are struggling to cope with the changes. "Continuing growth in mobility generates more noise and air pollution and increasing land consumption has negative impacts on biodiversity and ecosystems" (Ludlow, 2009). Green spaces can also function to soften the effects of flooding or heat by naturally absorbing the water, thereby reducing flooding, while also reducing heat that is usually intense in cities. Furthermore, accessibility also encompasses the idea that these public spaces need to be preserved and maintained in the face of natural disasters and climate change so that they themselves remain protected. Simply implementing or creating these spaces would be limited short term thinking because they have to be able to withstand floods, heat waves, droughts, and other climate related events in order to remain an intrinsically useful adaptation. In order to protect the spaces, similar concepts as outlined in the "infrastructure section" should be taken into consideration.

Permeable concrete could be used as general accessibility paths. Moreover, having an effective irrigation system would reduce the water wasted in terms of droughts. Also, if these public spaces are known to be in regions close to a source of water known to have flooding potential, it is possible to secure the spaces either by specific infrastructure, or through natural barriers. These natural barriers consist of a conscious choice made in the types of plants so that for example trees are planted that are known to be relatively resilient towards flooding events and have strong roots which are able to serve as a natural barrier to flash floods.

**Adaptation Strategies**

Currently, adaptation strategies in response to climate change vary greatly from region to region. Generally developing countries have fewer adaptation strategies for goal 11.7. However, a positive note can be made of Santa Cruz in Bolivia, which has tried to adapt to the rapidly urbanizing region. They have acknowledged the importance of public open green spaces for all strata of society. By doing this they have also acknowledged the different needs of members of society. For example, by posting security guards at the entrances, or installing more lights within the parks, especially women and elderly now feel a lot safer and more comfortable actually using the spaces. Still, as many of the developing countries are lagging behind in adaptation, other concerns take the upper hand, like the provision education and health care. Furthermore, what is rarely taken into account is that "potential accessibility is not the same as usability; therefore, it is extremely important to also consider user preference, perceptions, and potential barriers to access" (Wendel et al., 2012). This means that different members of society have different needs and public spaces need to incorporate this. A park might be beautiful and be clean, safe, and aesthetically pleasing, but a woman with a stroller might simply not be able to access it, if there are only pebbly paths leading into the park. Besides, knowing that preferences and perceptions are of such high importance, "culturally shaped use patterns and behaviors, such as gender roles, greatest use periods, and preferences related to size and amenities, need to be taken into account in the design and distribution of urban green spaces" (Wendel et al., 2012). Also, a generally prevalent pattern is that the lower-income residents tend to have a bigger need for receiving access and assistance in terms of health, through the social, environmental, and economic benefits that public open green spaces have to offer (Wendel et al., 2012). A positive example can be made of Europe, which has outlined goals and initiatives to assist all their cities in reaching targets that embrace "quality of life" standards. These standards include factors like the accessibility and importance of public green spaces. Most of these goals take into account quantity, quality and access of open green spaces in terms of maintenance of the environment and infrastructure/utilities, diversity of nature, low degree of fragmentation, cultural landmarks, air pollution and quietness. Studies have shown that these public green spaces are indeed important for the health of people, especially in the context of a changing climate which is likely to bring about more extreme weather events.

**Public Open Space Accessibility and Quantity**

Indicators that carry a lot of importance consist mainly of factors that are helpful in determining how accessible an open green space is in terms of distance that an individual has to travel, as well as how big the actual green space is. Therefore, in order to assess these two themes, a map needs to be drafted that indicates where the public green spaces are. This would allow for evaluation of the distance needed to be overcome by the different dwelling's inhabitants. These distances can be categorized into different groups which can then be analyzed on the grounds of what kind of public open space it actually is that one is able to access. With this in mind, the public open spaces need to be categorized themselves into size groups, starting from small parks ($\leq$0.3ha) all the way to big regional parks (>4.0 ha). Furthermore the recurring term (SA1) is taken directly from the established framework in Australia. It denotes that "Statistical Area Level 1 (SA1) boundaries" are defined by The Australian Bureau of Statistics (ABS) Australian Statistical Geography Standard (ASGS) (Australian Bureau of Statistics, 2013) as equivalent to an area of approximately 400 persons (Villanueva et al., 2015). This serves as a good baseline in combination with the other indicators, mainly because those broad categories can then be used to analyze how much of the population has access to what kinds of open public spaces, which is especially important in the urban context.

**Monitoring and Evaluation**

Currently there is very little data collected for both monitoring as well as evaluation purposes, which makes it hard to establish baselines. There are however some measurements that have proven successful, even for the more qualitative data. Those include mainly surveys and interviews conducted among the general population. This is currently one of the few ways in which the perceptions and needs of people can be measured in order to get baselines, which in turn allow for future monitoring, evaluation, and comparisons.

Another way that data is currently collected is by implementing research projects that work with GIS and other modelling type software. Sometimes even coupled with satellite information, these computer programs are often used to visually construct the location, quantity, and accessibility of the public open green spaces. These approaches are the most successful ways to gather the relevant quantitative data.

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| Availability of public spaces | Area of public space as a proportion of total city space | ● **Monitoring:** can mostly be done with GIS programs and satellite information to measure the acreage increase in public green spaces compared to residential, commercial, or industrial areas. On the ground surveys and polls are being conducted through community interviews and routine census data collection<br>● **Evaluation**: requires similar computer programs |
| Close access possibility | Proportion of residents within 0.5 km of accessible green and public space | |
| Public open space quantity | % POS area within SA1 | |
| | % POS area of subdivisible SA1 land area | |
| | # of POS available within SA1 | |
| | # POS by size/type within SA1 | |
| Public open space access | Road network distance from SA1 population-weighted centroid to nearest POS border | |
| | 95% of dwellings have access to a local ( ≤0.3ha) park POS ≤400 m | |
| | 95% of dwellings have access to a small (>0.3 to ≤ 0.5 ha) neighbourhood park POS ≤400 m | |
| | 95% of dwellings have access to a medium (>0.5 to ≤ 1.5 ha) neighbourhood park POS ≤ 400 m | |

| | | |
|---|---|---|
| | 95% of dwellings have access to a large (>1.5 to ≤ 2.5 ha) neighbourhood park POS ≤ 800 m | |
| | 95% of dwellings have access to a district (>2.5 to ≤ 4.0 ha) park POS ≤ 800 m | |
| | 95% of dwellings have access to a regional (>4.0 ha) park POS 5 km or 10 km | |
| Public open space quality | A quality (attractiveness) score is assigned to each POS based on its attributes and amenities | |
| Preserving Culture and History | Number of relics of traditional landscapes | |
| | Number of cultivated parks | |
| | Number of old parks | |
| Quietness | Proximity of major roads, airports | |
| | Statistical noise levels | |
| Facilities | Degree of physical access (entrances and paths) | |
| Universal access | Ratio of land consumption rate to population growth rate, at comparable scale | |
| | Area of public space as a proportion of total city space | |
| | Number of street intersections per square kilometer | |
| | Existence and implementation of a national urban and settlements policy framework | |
| Space distribution | The average share of the built-up area of cities that is open space in public use for all | |
| | The average share of the built-up areas of cities in open space in public ownership and use | |
| | Proportion of women subjected to physical or sexual harassment by | |

| | | |
|---|---|---|
| | perpetrator and place of occurrence (last 12 months) | |

**Figure 11:** Chart of indicators and monitoring & evaluation strategies for Target 11.7

**INFRASTRUCTURE GROUP**

*The following section outlines existing metrics and evaluation strategies for infrastructure to mitigate the effects of climate change. These indicators were found through an extensive literature review for each of the three targets listed under the infrastructure theme: 11.1, 11.2, and 11.c. Each of these targets relates to sustainable buildings, construction, and community structures.*

**TARGET 11.1**

Target 11.1 is based on the idea that all people have a fundamental right to shelter. It is a vast and arduous challenge that continues and expands the efforts of MDG 7/11 (ICSU, 56) by expressing the need to provide safe and affordable housing for all. Target 11.1 aims to improve existing infrastructure, focusing on enhancing energy efficiency and building more resilient infrastructure that is adaptable to possible changes in climate. Within this goal falls the important task of upgrading slums and considering approaches for doing so effectively. When considering the potential threats of climate change, those who have successfully improved housing conditions and infrastructure prove to be less vulnerable.

In terms of adaptation, upgrading slums and infrastructure in low-income areas is an adaptation method in and of itself, as resilient infrastructure provides resistance to the effects of climate change, such as warmer temperatures, water shortages, flooding, and rising sea levels. There is never any certainty in where a slum will form; therefore, there is no initial prevention towards one forming in areas susceptible to the effects of climate extremes. If a slum does form on land that is unstable or hazardous, relocation may be the best option. However, more often slums form on well-located land, providing slum dwellers easy access to a city and its opportunities. Because of this it is preferred to upgrade these areas in important locations that provide access to employment opportunities (Cities Alliance, 2014).

**Slum Upgrading**

The concept of slum upgrading evolved out of a period of unprecedented urban growth. People began flooding out of rural areas and into cities without properly planned and managed urban sectors, resulting in backlogs for housing and the growth of urban slums. Climate issues, such as droughts, have forced rural populations to migrate into urban areas, searching for better opportunities offered by cities. The process of upgrading slums engages in physical, social, economic, organizational, and environmental improvements undertaken cooperatively by citizens, community groups, businesses, and local authorities to ensure sustained improvements in the quality of life for growing numbers of residents (UN-Habitat.) Slum upgrading is not limited to any set amount of factors. Each slum is unique and diverse, but two important elements remain consistent for successful upgrading: strong political will on behalf of the government and strong community involvement (Cities Alliance, 2014).

Generally, urban upgrading is about striking a balance between investing in areas that attract investment to the city on a global level and investing in programs that impact the city's citizens so that they can also receive benefits as well. The interconnectivity of these two goals is critical to a successful development strategy of any city. Slum

upgrading is an integrated component of investing in citizens. Residents of a city have a fundamental right to environmental health and basic living conditions. As such, cities must ensure the citizenship rights of the urban poor. Figure 12 provides a list of actions currently being taken to upgrade slums.

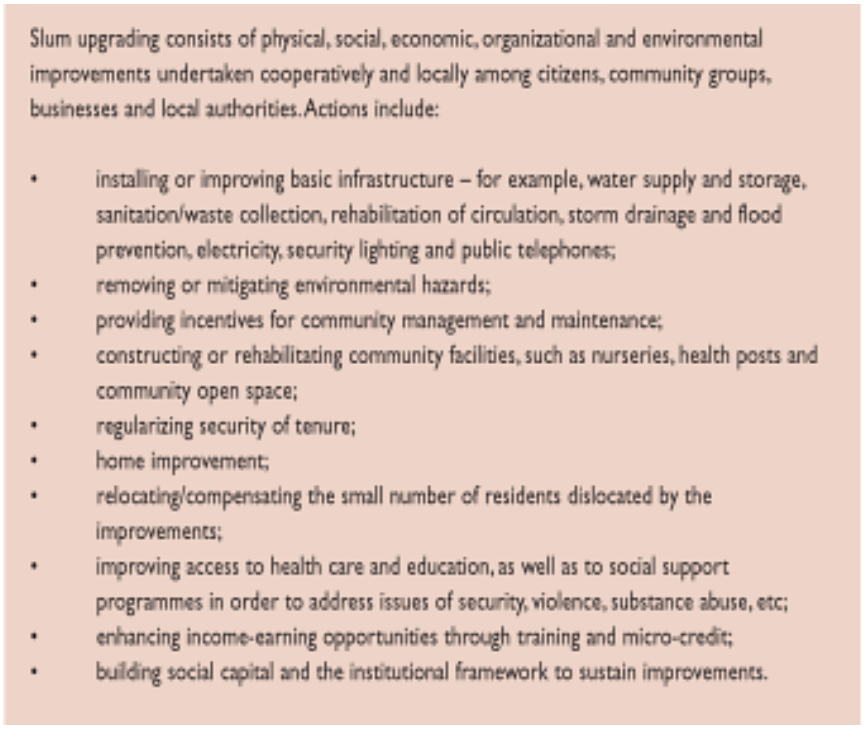


**Figure 12:** Current slum upgrading recommended actions

**Challenges of Slum Upgrading**

There are several cases where slum-upgrading projects have not proven successful. One reason for this failure is that there might be people in the community who believe that they will not qualify for an upgrading program because they are not citizens or residents of the country. This results in inhabitants allowing for the place in which they reside to degrade over time. Furthermore, someone who does not have clear ownership or have secure assets is less likely to be able or inclined to upgrade their property over the long term. A study carried out in Soweto, Kibera showed only 15% of respondents thought better houses were the solution to improving their lives. Instead, the majority was mainly concerned with improving road networks, proper drainage systems, good sanitation, improved security, and better income (Wilson, 2009).

**Warmer Weather Adaptation**

Slums and poor communities' adaptability tends to become more limited as climate change affects human settlements. The context for developing countries as opposed to developed countries is dramatically different in terms of adaptation capabilities. The lack of resources in developing countries restricts their ability to accomplish goals that developed countries easily manage. When it comes to warmer weather adaptations, the ideas of green roofs and natural ventilation are very effective means for reducing heat island effects that come with settlements.

However, when it comes to developing countries and upgrading slums, these options are not as easily achieved. In most cases, slums occupy a minimal amount of a city's overall area while at the same time, as in the of Kibera in Nairobi, Kenya, holding the majority of the city's overall population (African, 2002). With such a large population in such a congested area, the ability to introduce green spaces diminishes. Attempts to introduce green spaces for cooling purposes only stands to displace those who reside in whichever area may be considered for such projects.

**Water Shortages Adaptation**

Many nations currently face the severity of water shortages as urban spaces continue to grow. Much of the intensity of water use is based on the living standards that go beyond what is necessary for basic needs. Therefore, water shortages develop more as a distribution issue than as an availability issue. The majority of fresh water used globally goes into agriculture. This is a necessary, water-intensive evolution, but new practices in agriculture to reduce water usage while still producing the same amount of agricultural product should be implemented. Water shortages occur as an imbalance between availability and demand. Outside of the natural freshwater replenishment systems, rainwater catch basins, if employed in a favorable way, can provide a means of freshwater locally while also not being detrimental to the land.

**Population Monitoring and Adaptation Strategies**

Monitoring population growth and migration is a necessary component in the proper planning of urban developments to prevent the growth and spread of slums. However, it is unclear how many people actually reside in slums. With sporadic organization between slums, there is no census data to document the true population. Without this data it is difficult to determine what is necessary to meet the needs of the population. One monitoring strategy that may be helpful in tracking influxes and migratory patterns of people is the use of mobile telephones. There are particular characteristics around using mobile phones that differentiate it from other forms of technology, namely that mobile phones are portable, ubiquitous, personalized and multi-modal. By monitoring mobile phone usage, patterns can be detected to help determine certain demographic trends, like the movement of people and the locations in which they settle. While not all people of the world own or have access to mobile phones, it is a rapidly growing technology becoming more accessible and affordable for poverty-grieved populations.

**Safe and Affordable Housing**

Given the current policy environment, affordable housing providers interested in expanding financial capability programs should think about alternative approaches to government funding. The ability to provide housing standards that are safe and all-inclusive lies heavily on government and citizen involvement. Many of the issues that come from governments' inability to provide safe and affordable housing stem from economic issues addressed in prior sections. Many developing countries lack the funds necessary to provide this service to their citizens. Beyond initiatives put in place for natural, energy reducing standards, providing safe and affordable housing is a concern that can be best addressed with economic capabilities.

**Monitoring and Evaluation**

One existing gap in the monitoring and evaluation of upgrading slums is the lack of a definitive definition for a "slum." In regards to slum upgrading, monitoring this goal requires aggregating distributed data, including age and gender. Gathering this data can be difficult or near impossible, especially in developing countries facing the biggest challenges involving rapid urbanization or political instability. This is because it is increasingly more difficult to track and monitor the influxes of migrants from rural to urban areas. In order to properly monitor strategies for slum upgrading, the overall population needs to be determined more accurately. Until an overall number of inhabitants

who reside in a given area is known, it is difficult to determine the amount of focus or overall effort needed to upgrade properly.

**Indicators**

Below is a list of indicators as well as monitoring and evaluation strategies that currently exist in order to evaluate the resilience and adaptation capacity of slums and low-income housing. This list was compiled from an extensive literature survey.

| Adaptations | Indicator | Monitoring & Evaluation Strategies |
|---|---|---|
| Warmer Weather | # of buildings designed with natural ventilation | ● **Monitoring:** Reduction in energy costs used for air-conditioning<br>● **Evaluation:** Less energy used during the warmer times of the year. |
| | enhanced amount of landscaping to maximize natural cooling | ● **Monitoring:** Amount of native plants and grassland planted and protected. Natural landscape preservation that allows for natural cooling through shade and wind tunnels<br>● **Evaluation:** Reduced heat island effect. Less energy consumption to run air conditioners during heat waves |
| | termite ranges extending north | ● **Monitoring:** The migration of termites as warmer temperatures stretch north<br>● **Evaluation:** Termite migration north decreases |
| Water Shortages | expansion of new developments in drier regions | ● **Monitoring:** Monitoring urban spread in areas prone to drought<br>● **Evaluation**: Less severe drought impacts on settlements |
| | plans for plumbing systems for graywater separation | ● **Monitoring:** Number of buildings installing water separation devices to recycle graywater<br>● **Evaluation:** Water conservation over time |
| | harvested rainwater | ● **Monitoring:** Number of constructed rainwater catch basins and use<br>● **Evaluation:** Increase in water supply without overly diminishing land infiltration |
| | amount of native plants to avoid over-watering landscapes | ● **Monitoring:** Reducing/limiting the amount of non-native plants in human landscaping<br>● **Evaluation:** Less watering needed for green spaces |

| | | |
|---|---|---|
| Storms, flooding, rising sea level | areas built in flood zones | ● **Monitoring:** The expansion of settlements on to areas at risk for flooding.<br>● **Evaluation:** Less settlements affected by floods |
| | expansion of storm water management capacity | ● **Monitoring:** Number of operating drains and natural water runoff systems<br>● **Evaluation:** Less floods caused by pooling water |
| | ability to rely on natural systems to mitigate natural catastrophe impacts | ● **Monitoring:** Incentives to maintain natural vegetation adapted to the local weather<br>● **Evaluation:** Less surface runoff caused by the clearing of natural vegetation |
| | plans in work for rising sea levels in coastal areas | ● **Monitoring** Construction of resistance measures in flood zones<br>● **Evaluation:** Less destruction during storms |

**Figure 13:** Chart of indicators and monitoring & evaluation strategies for Target 11.1

**TARGET 11.2**

Target 11.2 aims to provide improved access to safe, affordable, and sustainable transport systems for all by 2030 and emphasizes improving road safety, notably by expanding public transportation. This goal prioritizes the needs of those in vulnerable situations, women, children, people with disabilities, and older members of society (United Nations, 2015).

When the UN Millennium Summit established the Millennium Development Goals (MDGs) in 2000, policy makers did not include any goals or targets specifically related to transportation. However, transportation services are essential for meeting many of the goals recognized by the MDGs (Hook). With the incorporation of transportation into the new Sustainable Development Goals (SDGs), policy makers have finally acknowledged transportation's critical contribution in creating a more sustainable and safer world.

Target 11.2 specifically relates to climate change adaptation as it contributes to both the health and safety of commuters and transit users in both developed and developing regions. In the United States for example, transportation is the largest single source of air pollution. In 2013 alone, transportation related vehicles contributed to more than half of the country's carbon monoxide, nitrogen oxides, hydrocarbons, and particulate matter in the atmosphere. This pollution is emitted during operation, refueling, manufacturing, and during the disposal process. Air pollution, especially particulate matter, poses a serious threat to human health and can penetrate deep into the lungs, causing a number of health concerns including aggravated asthma or reduced lung function (UCS, 2014).

Additionally, long-standing transportation infrastructure that has not been properly maintained runs the risk of breaking down, endangering lives, and becoming more vulnerable to destruction from climate related disasters. Public transportation must therefore be restored and maintained. And, local governments should begin shifting public transport's energy use towards more renewable sources in order to mitigate its contributions to pollutants in the atmosphere. As the world begins to adapt to a warming climate and the associated risks of a new environment, transportation must begin to adapt as well. Transportation is soon to become even more essential as populations

begin to cover greater distances due to forced migration from the effects of climate change. Adapting to a changing world must involve both mitigating transportation's contributions to greenhouse gases as well as adapting infrastructure to the potential risks of future disasters. This adaptation will involve improving accessibility, resiliency, and safety for all (DOT, 2014).

**Adaptation Strategies**

Many cities in developing countries are currently implementing new adaptation strategies to prepare their infrastructure for the changing world and its associated climate risks. For example, cities like Bogota, Colombia, have redesigned their public transportation systems to be more cost-effective, efficient, and safer for users and the environment. These changes include the designation of bus-only lanes, the use of fewer but larger transit vehicles, and a more efficient system for paying public transit fares to increase overall efficiency and decrease travel time. These changes have led to other co-benefits such as decreased traffic congestion and the reduction of the city's overall carbon emissions by 60,000 tons per year (Guevara-Stone, 2014).

Developed regions have also begun to assess the criticality of their infrastructure to determine whether they are in need of adaptation. Some cities have begun eliminating roadways in disrepair or abandoning infrastructure that does not play an essential role in emergencies, disaster relief, defense, or health related incidents. By determining the criticality of transportation infrastructure, cities have been able to cut down operation and maintenance costs and devote more of their resources towards upgrading more critical systems (FHA, 2010).

However, quantifying transportation infrastructure's criticality and ability to adapt to future climate risks poses a great challenge as the structural and functional capacity of infrastructure varies greatly across different regions. However, various organizations and municipalities have begun creating metrics to address some of these issues. Through an extensive literature review, a list of existing metrics that relate to target 11.2 and adaptability to climate change have been compiled below. These metrics cover accessibility, structural resiliency, safety, quality of life, and sustainability.

**Accessibility**

While evaluating the accessibility of public transportation, it is important to consider transportation's critical role in both economic prosperity and social equity. Besides providing transport services to the public, this infrastructure plays a crucial role in emergencies as it can aid with the evacuation of populations and provide access to essential services under extreme conditions (DOT, 2014). Transportation must therefore be physically accessible to a majority of the population and reside within walking distance of major residential and economic centers. Metrics for evaluating the accessibility of transportation include quantifying the percent of job opportunities and services within 30 minutes of residential regions and major economic centers or measuring the average door-to-door travel times for commuters. These metrics, by quantifying accessibility through travel time and commuter distance, evaluate transportation's accessibility to members of the population when it is most needed.

However, it is important to consider that transportation might be less available to those in poorer regions where the infrastructure is less established as well as its accessibility to people with disabilities. Effective metrics must consider the percentage of low-income households with access to public transport networks within a 30 minute commute, as well as the percentage of access points to public transport with total accessibility for all, including those who need disability entrances (FHA, 2010).

Similar to transportation's equity of accessibility, it is also essential that transportation be affordable across a wide range of socioeconomic classes. Affordability can be measured by calculating the percentage of household expenditures devoted to public transport and travel costs as well as by polling individuals on their level of satisfaction with transportation expenditures (FHA, 2010).

**Structural Resiliency**

Existing infrastructure across the world has been built under many different design and environmental standards, meaning that each country's vulnerability and resilience to climate risks is extremely varied. As the potential for climate disasters increases, the probability of unexpected infrastructure failures is bound to increase. For example, Superstorm Sandy in 2012 caused significant damage to the subway system in New York City, flooding seven East River subway tubes, two Long Island Railroad tubes between Manhattan and Queens, two vehicular tunnels, one subway bridge, and six bus depots while also funneling in dangerous debris. All of this water and debris then had to be removed and pumped back up to the surface, forcing many workers to navigate the subway tunnels in dangerous conditions (Boissoneault & Johnson, 2013). Though New York City's transportation system has been able to recover from the effects of the Superstorm, other regions might not have the financial means or government support to recover so quickly. Cities around the world, and especially those in vulnerable coastal regions, need to determine if their infrastructure is approaching the end of its service, consider replacing their systems, or abandoning certain structures entirely (DOT, 2014).

In order to assess the structural resiliency of transportation, local municipalities should consider the potential impacts of various climate risks. First, when considering future increases in atmospheric temperatures, infrastructure must be evaluated on its ability to withstand extreme heat, as higher temperatures can buckle rail tracks, break asphalt, or increase the demand for air conditioning and overload a system's power grid (DOT, 2014). Also, as severe weather and precipitation increase, the likelihood of flooding can cause major shutdowns or reductions in the service life of transportation infrastructure. Roadways can be damaged by washouts, landslides, and mudslides, as well as suffer from overload in their drainage systems. Severe precipitation and high wind speeds can ultimately damage bridges, signs, overhead cables, and other tall structures. Each of these events can lead to extreme delays or operator fatigue for those traveling during severe weather. Additionally, it is important to consider rising sea levels and its potential to flood underground infrastructure, destroy coastal roadways, bridges, or airports (DOT, 2014).

Each of these potential risks requires climate-conscious land-use planning, the reinforcement of existing infrastructure, and the relocation or abandonment of at-risk-structures. Local governments also need to ensure provisions for the rapid recovery of infrastructure should disasters arise (DOT, 2014).

In order to monitor and evaluate infrastructures' level of physical resiliency, the total number of investments made in infrastructure maintenance per capita as well as the number of public subsidies used to cover these costs should be monitored. Local governments should measure the cost of tracking potential climate threats and the cost of research and development on renewable technologies, materials, and fuels that could be applied to transportation. Lastly, metrics should take into account the number of new policies and measures enforced to improve the resiliency of public transportation as a whole (FHA, 2010).

**Quality of Life**

While transportation infrastructure must adapt to a changing climate and an increase in climate related disasters, it is important to consider the safety of transportation both in its structural capacity and contributions to quality of life. In order to assess the safety of transportation, we must calculate the number of transport related accidents, fatalities,

and injuries per mode per year. The number of reported incidents related to personal security violations per mode per year should be recorded, and metrics for the number of traffic calming measures on local streets should be observed. Proper and consistent signage is also essential to ensure efficient and effective transportation systems, especially as climate related weather events increase and lead to riskier travel conditions (FHA, 2010 ).

Additionally, vehicle-tracking systems could be installed to ensure that vehicles can be located at all times in case of an emergency. When an incident occurs, knowing the exact location can assist authorities arriving at the scene. If a driver becomes incapacitated it will become especially evident that the vehicle is deviating from its usual course schedule. Lastly, security cameras on vehicles as well as at transit stops could be essential during emergency situations (Truett et al., 2005).

**Sustainability**

As transportation systems continue to grow to keep pace with an increasing population and developing world, cities should ensure that their systems are both economically and environmentally sustainable to guarantee longevity and minimize impacts on health and well being. Because transportation is a significant contributor to greenhouse gas emissions and a major consumer of energy, indicators must include quantifying the amount of resource use, emissions released into the atmosphere, soil, and water, as well as contributions to habitat loss in the regions that transport-structures occupy (Toth-Szabo et al., 2011).

To consider economic sustainability, indicators should measure the productivity and efficiency of transportation. This can be done by evaluating the average freight speed of transportation, the percentage of public transportation keeping timetables, the number of delays due to traffic congestion, or the number of transportation days disrupted by climate related events such as precipitation, sea level rise, and temperature spikes (FHA, 2010). Assessing economic sustainability also includes calculating transportation's benefits to the economy through quantifying the gross value added to public revenue and expenditures as well as its contribution to the growth of employment (FHA, 2010).

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| Accessibility | Physical Accessibility | ● **Monitoring**: % job opportunities and services within 30 minutes travel distance of residents, average door-to-door commute time, average travel time between sustainable transport modes and passenger cars<br>● **Evaluation:** Determine if travel time and accessibility are relatively even across wealthy/poor communities and for those with disabilities. |
| | Equity of accessibility | ● **Monitoring:** % low income residents with access to public transport network within 30 minutes of major employment centers, % of access points to public transport with total accessibility<br>● **Evaluation:** Determine if travel time and accessibility are relatively even across wealthy/poor communities. |

| | | |
|---|---|---|
| | Affordability | ● **Monitoring:** Calculate household travel costs, poll households on satisfaction with how much they spend on travel costs<br>● **Evaluation:** percentage of total family income spent on travel costs and level of satisfaction |
| Resiliency | Resiliency to Temperature Change | ● **Monitoring:** Construction materials' ability to withstand extreme increases in temperature, evaluate peak load of energy grid for transportation system, cost of monitoring potential climate threats<br>● **Evaluation:** The resiliency and capacity of transportation infrastructure to withstand temperature changes and increased use. |
| | Resiliency to Precipitation/Flooding | ● **Monitoring:** # of days systems shut down due to flooding, # formal protocols in place to mobilize cooperation to prepare for emergencies related to infrastructure, cost of monitoring potential climate threats<br>● **Evaluation:** Shut downs and costs due to flooding as well as regional preparedness. |
| Quality of Life | Livability and Safety | ● **Monitoring**: # of transport-related accidents/fatalities/ injuries per mode per year, # of reported incidents of personal security violations per mode per year, % crossing points/bus stops adopted for disabled, % of local streets with traffic calming measures, % public vehicles with safety belt reminders, # vehicles with tracking systems, presence of security cameras on vehicles and transit stops<br>● **Evaluation**: Improved safety and decline in disruptions to quality of life. |
| Sustainability | Operation and Maintenance | ● **Monitoring:** Investments in transport infrastructure maintenance/capita, public subsidies, R&D expenditure on clean transport fuels, total expenditure on pollution prevention and cleanup, # policies/measures taken to improve public transport<br>● **Evaluation:** regional expenditures and upkeep of transportation. |
| | Productivity/Efficiency | ● **Monitoring:** Average freight transport speed, % of public transport keeping timetables, delays due to traffic congestion, # transportation days disrupted by climate related events (precipitation, sea level rise, temperature spikes)<br>● **Evaluation:** Speed, efficiency, and days of transport disrupted. |
| | Benefits to the Economy | ● **Monitoring:** Impacts to public revenue and expenditures, contribution of transport sector |

| | | |
|---|---|---|
| | | to employment growth (# employed)<br>● **Evaluation:** Effects of transport on economy. |
| | Criticality | ● **Monitoring:** Average level of use (Vehicle Miles Traveled or Ridership), freight tonnage or value moved using transport, importance in linking regions or facilitating national trade flows, role in emergencies for evacuating people/getting assistance to a particular region (disaster relief, defense, health care)<br>● **Evaluation:** Importance of infrastructure to economy and emergency systems. |
| | Resource Use | ● **Monitoring:** % of public transport using renewable fuels, consumption of solid raw materials, fuel consumption/vehicle miles traveled/passenger miles traveled, % of transit vehicles using alternative fuels<br>● **Evaluation:** Amount of raw material consumption and transport using renewable resources. |
| | Ecological Intrusion/Habitat loss | ● **Monitoring:** Land take, # of measures taken to preserve habitats<br>● **Evaluation:** proximity of transport infrastructure to designated ecosystems/habitats. |
| | Emissions to the atmosphere | ● **Monitoring:** % contribution of transport to total GHGs, % population living in areas where pollution is higher than air quality standards, % population exposed to exceedances of air quality standards, % population feeling disturbed by pollution<br>● **Evaluation:** total emissions to the atmosphere and public sentiment towards emissions. |
| | Emissions to soil and water | ● **Monitoring:** # of leaks of harmful liquid, solid, or gas substances generated by transportation related incidents, amount of runoff pollution from daily usage of transport infrastructure, wastewater from manufacture/maintenance of infrastructure, discharge of oil/wastewater at sea, annually |

**Figure 14: C**hart of indicators and monitoring evaluation strategies for Target 11.2

**TARGET 11.c**

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Target 11.c is geared toward supporting least developed countries in building sustainable and resilient buildings utilizing local materials by providing financial and technical assistance (Proposal for Sustainable Development Goals). Adaptation is inherent in this target as buildings must be adaptive for them to be sustainable and resilient. A great number of strategies exist for building sustainable and resilient buildings, and many of these strategies have wide-reaching benefits. There are four main climate change impacts affecting this target: flooding, rising temperatures, drought, and extreme weather.

| **Four Climate Threats and the Countries Most At Risk (Strachey, 7)** | |
|---|---|
| **Threat** | **Countries** |
| **Drought** | Chad, Eritrea, Ethiopia, India, Kenya, Malawi, Mauritania, Mozambique, Niger, Sudan, Zimbabwe, Iran |
| **Flood** | Bangladesh, Benin, Cambodia, India, Lao PDR, Mozambique, Pakistan, Rwanda, Vietnam, China, Sri Lanka, Thailand |
| **Storm** | Bangladesh, Haiti, Madagascar, Mongolia, Vietnam, China, Fiji, Honduras, Moldova, Philippines, Samoa, Tonga |
| **Coastal Threats** | Bangladesh, Mauritania, Myanmar, Senegal, Vietnam, China, Egypt, Indonesia, Libya, Mexico, Tunisia, Small Islands, Developing Countries |

**Figure 16:** Table showing four climate threats and the countries most at risk (Strachey, 7)

**Flooding Adaptations**

Flooding caused by sea level rise is one of the most common climate change risks for low-lying areas and coastal regions. According to the IPCC sea levels will rise 0.7-1.0 meters by the end of the century (Gregory, 9), leaving a significant portion of coastal land permanently flooded. As many major cities worldwide are located in coastal regions, it is important for countries to address this issue that threatens coastal buildings. Prevention of flooding impacts on buildings begins with preliminary research into expected sea level rise within regions followed by the creation of floodplain maps and models to predict the severity and locations most prone to flooding in the coming years. Areas of concern must then utilize this information to implement flood-proofing measures. Increasing freeboard requirements, preventing new construction in pre-existing or future flood plains, and retrofitting buildings with sealants and other materials that make structures impermeable to floodwaters have all proven to be effective measures in developed countries. It is important to note that developing countries may not have the same authority over building standards; consequently, these suggested adaptations will prove difficult to implement. In such cases, community education about safe building practices can be used to provide an effective means of ensuring implementation of these strategies. While organizations such as UN Habitat have numerous community education programs, research suggests it is advisable for local and national governments to engage the community in a similar fashion.

Review of literature relating to 11.c revealed that the most popular and efficient method for preventing flooding is simply to not build in floodplains. One notable example of effective floodplain management in a developing country is Kampala, Uganda. Here the city council and the central government have launched campaigns to evict developers

in floodplains (Strachey, 11). The council mitigated future costs of flood damage since there is less human settlement in floodplains. Reports such as "Sustainability Guidelines for Gulf Coast Reconstruction" and the PlaNYC 2014 Progress Report emphasize monitoring the number of buildings present in floodplains while striving to decrease that number from year to year. These sources also stress the importance of raising "freeboard" requirements and planting indigenous trees. Raising freeboard requirements simply involves raising the minimum height of building foundations to protect against floodwaters, while planting indigenous trees helps with drainage and place less of a strain on cities' water supplies (An Introduction to).

In addition to raising freeboard requirements, stilted homes may also protect from flooding and provide opportunities for using locally sourced materials for the main structure (Cities and Development, 2). The efficacy of this measure is demonstrated the case of Korail Bangladesh. Flood protection using locally sourced material is ultimately achieved by elevating the organic and insulated material, protecting it from rot due to water penetration. A final, but essential element of flood proofing, as mentioned before, is the creation of flood maps which inform such government actions as freeboard requirement increases and designation of conservation zones, which serve to prevent construction in floodplains.

**Rising Temperature Adaptations**

The expected increase in the global average for annual temperature is planned to have a devastating impact on the health of individuals—especially those in developing countries, and urban areas. It will also place significant strain on all buildings' atmosphere control systems. It is important to note, however, that in developing countries, many buildings lack central air conditioning. Therefore, it falls upon buildings' physical design to facilitate the circulation of cool air (Golubchikov, 18). Installing energy efficient air conditioning units, in addition to utilizing better insulating materials and building designs that optimize air circulation are help maintain livable conditions within buildings in high temperatures.

Urban areas already experience a "heat island effect." The heat island effect describes an observation that cities tend to be several degrees warmer than nearby rural areas. According to the Environmental Protection Agency, heat islands can cause increased summertime peak energy demand, air conditioning costs, air pollution, GHG emissions, heat-related illness, mortality, and diminish water quality (Heat Island Effect). The urban heat island effect is expected to intensify in the coming years with rising temperatures due to climate change. To promote the proliferation of cooler buildings in warmer urban environments, government-subsidized building retrofitting provides an opportunity for both energy saving and comfort. For example, in Ulaanbaatar, Mongolia, a project that installed better insulation in buildings resulted in a 50-60% reduction in annual energy consumption by retrofitted buildings (Strachey, 23). Additionally, community involvement in greening projects, which would mitigate heat island effect and reduce energy required for maintaining livable indoor temperatures.

The process of designing and building cooler buildings for a warmer world is difficult for governments of countries without the most basic building auditing programs to monitor implementation of adaptive technology. The suggested indicators for monitoring cooling efficiency are therefore, for the most part, rudimental. Worse, they still include requirements for the creation and enforcement of adequate policy prior to delving into specific and more complex requirements, namely "number of buildings built with cooling load avoidance strategies." Some of these requirements include the use of skeletal walls as opposed to monolithic walls makes installing insulation easier in addition to strategic window placement and floor elevation to allow for ventilation (this may also be considered a co-benefit from increased freeboard requirements) (Hannula, Emma-Liisa, 26).

**Drought Adaptations**

Climate change is expected to cause drought in certain countries including Chad, Iran, and India (Strachey, 7). While developed countries may have the financial capital to fund ad-hoc construction of desalination plants and/or other drastic and expensive measures, developing countries have far fewer options. One of these options is simple water conservation. Adaptive buildings, recognizing impending water shortages, should aim to be as water-efficient as possible. To promote building water efficiency, LEED standards, promoted by some US federal agencies, state and local governments encourage installment of flow/flush-control fixtures as well as metering devices. In buildings with no plumbing or a lack of funds for retrofitting, rainwater capture structures and greywater recycling practices are also viable options. Additionally, in many developed countries worldwide, government incentives in the form of subsidies for retrofitting projects and provision of flow/flush-control fixtures have been found to be effective initiatives for water conservation.

Drought conditions expected with climate change require countries to implement water conservation efforts. Buildings themselves, depending on their fixtures and users' knowledge about the importance of limiting consumption, can contribute to the problem of drought. Suggested indicators for adaptive water conservation include presence of policy requiring installation of water efficient fixtures, presence of a water efficiency auditing program, and inclusion of indigenous trees on building sites.

Education is especially important in water conservation in buildings, as it is likely that developing countries lack the resources to install such fixtures. When individuals are aware of the impact of their water use it increases the likelihood that they will take steps to conserve on their own. Indicators such as the presence of public education programs and number of community members involved in greening projects solidly represent environmental awareness in the community, and consequently, measure the likelihood that these community members are working to conserve water.

**Extreme Weather Adaptation**

Climate Change is expected to increase the intensity of storms. The impacts of intense storms on structures are well documented, thus this category of adaptation contains one of the most comprehensive overviews of coping strategies. Some of the most compelling strategies include increasing the number of buildings with passive survivability, increasing building energy efficiency, implementing community education programs, and creating disaster response protocols. Unfortunately, many of these coping strategies are dependent upon the existence of building codes. Developing countries that lack building codes or means of enforcing them must resort to other voluntary measures, mainly community education and government incentives. Additionally, a large part of constructing buildings capable of withstanding natural disasters brought on by climate change involves an understanding of what natural disasters are most probable for particular regions (e.g., hurricanes along the Gulf Coast), and what structures or infrastructure would be affected by the disaster in question. This is another area where thorough research is key to development of effective adaptation strategy.

"However, communicating initiatives when benefits may only be visible in the long term or never—as is the case with avoided disasters—is difficult" (Strachey, 13). To combat this challenge, the document recommends emphasis upon values such as responsibility and vision. Increased storm intensity necessitates a shoring up of building structure. While flood proofing is inherent in this process, energy efficiency, passive survivability, assessment of structural integrity and creation of emergency protocols are also essential. The following measures are effective because they result in structures that are reliable, place a minimal burden on the local electricity grid, and provide shelter during emergencies. Indicators for measuring these qualities in buildings include appropriate raising of freeboard requirements in response to floodplain maps, noting whether there is an inventory of best practices for enhancing climate resilience in at-risk areas (which contributes to reliable and consistent implementation of resiliency strategies), counting the number of buildings which utilize energy efficiency measures (including all

LEED certified structures), counting the number of buildings designed for passive survivability, and the number of buildings audited for distress or decline.

**Monitoring and Evaluation**

In many cases, developing countries lack building codes in the first place. This makes establishment and enforcement of building codes a priority before any additional adaptation measures. Many indicators outlined simply aim to determine whether a country has implemented a particular building or construction policy relating to adaptation within the goal 11c. These indicators include presence of auditing programs, size of zoning departments, and presence of zoning authorities.

**Cooperation Between Countries for Safe Buildings**

*"Local governments can partner with NGOs, academia, and the private sector to achieve climate goals.*"

(Strachey, 27)

In Sorsogon City in the Philippines, a vulnerability assessment within the city shared with offices of national government helped address the city's climate change concerns (Strachey, 23). Similar cooperation measures in other cities may prove equally effective in tandem with foreign aid.

(Aerial view of Durban)

**Case Study of Durban (EThekwini Municipality)**

Durban has already implemented specific adaptation measures within several sectors of their municipalities. These adaptation plans have been created within local and national authorities, driven by the goals and political leadership of the local authority itself. This adaptation plan is sector-oriented and made by local authorities for Durban. They address several projects for single urban adaptation issues and utilize an iterative process of adaptation to be accomplished between 2070-2100.

The head of the city's Department of Environmental Management initiated action on climate change. In this sense Durban demonstrates how individuals may use both their external networks and their knowledge of internal institutional mechanisms for promoting adaptation planning initiatives within their administrations.

Though Durban's first attempt at total adaptation overhaul failed, a second attempt with sector-specific plans that address health, water, and disaster management sectors (spurred local action) has gained general acceptance. These plans align adaptation measures with existing business plans, development objectives, funding, and skills. Early warning systems and ensured resiliency are built into the construction process to reduce the probability of infrastructure failure and enhance recovery after an extreme event...Designated a disaster management unit for this.

The activities in Durban are heavily focused on the involvement of local authorities' officials and staff in order to integrate climate adaptation into local public policies. Additionally, Durban conducted research on climate projections to inform their action (based on research undertaken by the University of Pretoria, University of KawZula Natal-Pietermartizburg, and the University of Cape Town + The South African Navy) (sea level rise).

This research gave rise to many adaptation policies that are resilience-focused interventions aimed at improving development and service delivery objectives.

With regard to foreign aid, Durban opted for participation in Cities for Climate Protection and other financial aid campaigns for adaption in developing countries.

Challenges faced by the plan are listed on pages 19-20 of Conceptualizing Urban Adaptation to Climate Change Findings from and Applied Adaptation Assessment Framework and include the lack of buildings codes.

**Figure 17:** Case Study of Ethekwini Municipality, South Africa. (Johnson and Breil)

**Indicators**

The four potential climate impacts linked to target 11.c have a wide range of adaptation strategies, but some of the most common and feasible are listed in the table below.

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| Universal | Presence of national climate change adaptation programs | ● **Monitoring**: Documentation submissions<br>● **Evaluation**: Subsidizes local climate change adaptation plans |
| | Presence of local zoning authority | ● **Monitoring**: Local to national government communication<br>● **Evaluation**: Indicates preliminary steps toward regulating building adaptation strategy |
| | Size of local zoning department | ● **Monitoring**: Number of personnel<br>● **Evaluation**: Indicates strength of efforts toward regulating building adaptation strategy |
| | Presence of auditing program | ● **Monitoring**: communication with local authorities<br>● **Evaluation**: Indicates preliminary steps toward enforcement of adaptive building codes |
| | Use of life cycle assessment | ● **Monitoring**: Presence of the term in construction documents<br>● **Evaluation**: Indicates consideration for long-term ecological impacts of materials choice in building practices |
| | Presence of local and national public education programs for water conservation, flood proofing, prevention of urban heat island effect, and natural disaster preparedness | ● **Monitoring**: Note presence and usership<br>● **Evaluation**: Presence indicates public involvement in resilience, may contribute to more resilient buildings in locations without building codes/ enforcement |
| | Presence of matrix assessment and mapping tools | ● **Monitoring**: note presence<br>● **Evaluation**: Presence Indicates |

| | | |
|---|---|---|
| | | thoroughness of government planning for cc risks |
| | Implementation of Bio-climatic design measures | • **Monitoring**: Presence of standard building practice using passive solar design, raised flooring for ventilation, consideration of local wind patterns<br>• **Evaluation**: Indicates regional sensitivity to climate change impacts |
| Flood Proofing | Number of buildings present in floodplains | • **Monitoring**: Count number of buildings present in floodplains<br>• **Evaluation**: Lower number indicates resilient zoning practices |
| | Elevated housing/ freeboard requirement | • **Monitoring**: Higher freeboard requirements and number of steel-reinforced stilted housing projects.<br>• **Evaluation**: Higher number indicates resilient zoning practices when in areas prone to flooding |
| | Number of indigenous trees planted on building site | • **Monitoring**: Note presence in construction records<br>• **Evaluation**: Increased number indicates flood preparedness |
| | Existence of flood maps | • **Monitoring**: Note presence/stage of development<br>• **Evaluation**: Presence indicates preliminary research into cc impacts |
| | Existence of reliable sea level rise model | • **Monitoring**: note presence and improvement efforts<br>• **Evaluation**: Presence indicates preliminary research into climate change impacts |
| | Community members' involvement in greening projects | • **Monitoring**: number of community members involved in greening projects<br>• **Evaluation**: Presence indicates public involvement in resilience, may contribute to more resilient buildings in locations without building codes/ enforcement |
| | Presence of publicly owned conservation zones | • **Monitoring**: note area covered relative to flood zone area<br>• **Evaluation**: Presence indicates government efforts to prevent building in at-risk zones. |
| Building Cooling | Use of green roofs | • **Monitoring**: number of buildings using green roofs (via. construction documentation or manual counts)<br>• **Evaluation**: Increased number indicates |

| | | |
|---|---|---|
| | | preparedness for increased heat island effect |
| | Presence of cool roof requirement | • **Monitoring**: note presence in local/national government<br>• **Evaluation**: Increased number indicates government planning for increased heat island effect |
| | Use of cooling-load avoidance strategies | • **Monitoring**: number of buildings built<br>• **Evaluation**: Increased number indicates preparedness for increased heat island effect |
| | Implementation of climate zone-specific building practices | • **Monitoring**: note implementation of practices examples outlined in Going Green (UN Habitat Doc.) (e.g., Compact, inward facing housing oriented for minimum surface exposure to sunlight.)<br>• **Evaluation**: Indicates sensitivity to varied climate change impacts |
| Water Conservation | Zoning policy that requires installation of water and energy efficient technology | • **Monitoring**: Note presence of policy<br>• **Evaluation**: Presence of policy means conservation of water resources and conservation of energy reducing strain on grid. |
| | Presence indigenous trees planted on building site | • **Monitoring**: track quantity over time (construction plans and audits)<br>• **Evaluation**: Increased number indicates flood preparedness |
| Natural Disaster Preparedness | Equip homes with renewable electricity or heat generating units | • **Monitoring**: number of homes (construction documentation)<br>• **Evaluation**: The more homes with this technology, the less strain on power grid and more reliable it will be in cases of weather emergencies |
| | Number of zero net energy buildings | • **Monitoring**: number of homes (construction documentation)<br>• **Evaluation**: The more homes with this technology, the less strain on power grid and more reliable it will be in cases of weather emergencies |
| | Number of affordable housing units preserved or added | • **Monitoring**: number of homes (construction documentation)<br>• **Evaluation**: Greater number means better protection for the urban poor |
| | Elevated housing/ freeboard requirement | • **Monitoring**: note presence in flood risk areas |

| | | |
|---|---|---|
| | | • **Evaluation**: Higher freeboard requirements and number of steel-reinforced stilted housing projects. (Higher number indicates resilient zoning practices when in areas prone to flooding) |
| | Presence of inventory of best practices for enhancing climate resilience in at-risk areas | • **Monitoring**: note presence<br>• **Evaluation**: Indicates general preparedness of city for impacts (includes construction practices) |
| | Buildings designed with passive survivability | • **Monitoring**: number of buildings<br>• **Evaluation**: Increased number indicates disaster preparedness |
| | Buildings regularly assessed for conditions of distress or decline | • **Monitoring**: number of buildings assessed, development of zoning programs<br>• **Evaluation**: Larger number indicates government efforts to identify present condition of building resilience within city |

**Figure 18:** Chart of indicators and monitoring & evaluation strategies for Target 11.c

# DISCUSSION

*This section includes a comprehensive discussion of each thematic group's findings and includes current best practices, proposals for new indicators, alterations of existing indicators, and suggestions to improve monitoring and evaluation strategies. All suggestions and alterations are demarcated in red texted within the assessment charts.*

### ECONOMIC GROUP

*This section outlines the comprehensive discussion for all targets under the economic theme: 11.5, 11.6, 11.a.*

### TARGET 11.5

Understanding the level of success of different adaptation methods reaches far beyond Target 11.5's metrics. Accounting for the number of deaths, number of people affected, and the economic losses caused by a natural disaster is crucial, but these numbers are difficult to use as a measure of success. The impact of natural disasters can vary greatly and lead to discrepancies in conclusions made by comparing these numbers. The Federal Emergency Management Agency (FEMA) makes this point evident in a discussion assessing the impacts of climate hazards. FEMA states the impacts of climate-related disasters can be distinguished according to six characteristics, "… speed of onset, availability of perceptual cues (such as wind, rain, or ground movement), the intensity, the scope, and the duration of impact, and the probability of occurrence" (Emergency Management Institute, 2006). Variations in these characteristics can lead to significant differences in the effects from similar types of events. A small flood one year may cause the same amount of damage and affect the same amount of people as a very severe flood in a future year after the city has implemented a number of adaptation strategies. According to the numbers, the adaptation strategies did not limit the damage caused by floods; however, if one were to incorporate the differences in the severity of the floods, then the adaption strategies could be seen as having a positive impact on the city's resilience and ability to adapt.

Additionally, Target 11.5 lacks any discussion on funding for adaptation strategies that focus on reducing the impacts of natural disasters. From an economic standpoint it would be beneficial to incorporate some metrics on the amount of funds being allocated towards such strategies. However, this would also acquire additional analysis of an area's needs and vulnerabilities to identify a specific dollar amount or percentage to dedicate to such strategies. Ultimately, I believe the indicators used for the sustainable development goals in relation to adaptive strategies should provide a clear and obvious picture of the level of success of a city's actions. In particular, Target 11.5 requires greater analysis of the natural disaster itself in order to understand the disaster's destruction.

**Monitoring and Evaluation**

While identifying methods of measurement for Target 11.5's indicators is somewhat simple, actually collecting the relevant information and data can be extremely difficult. Effective and successful adaptation strategies are those that address local issues; however, the related data needed for monitoring and evaluating different strategies tends to be available on a national level instead of a local one (Field, 2012). Even in a report on natural disasters from the International Monetary Fund, the economic impacts of disasters were written about on a national level. The report summarizes the impacts of different disasters on a country's total GDP and government stability (Laframboise, 2012). It neglects the impact on local governments and communities who were likely to be affected very differently. Also, developing countries in particular do not usually have the resources or organization for accurate data collection in the wake of a natural disaster. They lack the financial and technical support needed to implement the systems for adequate data collection (Badiee, 2004). Some organizations attempting to monitor and evaluate the cities in developing and developed countries rely on remote data from satellites. After an earthquake in East Japan caused a tsunami in March 2011, Polarimetric Synthetic Aperture Radar (SAR) analysis was used to assess the damage. From space and air crafts, the Polarimetric SAR radar system provided images and mapping of the affected areas that were used to identify flooded areas to send aid to and estimate the extent of damage to buildings and other built-up structures (Chen, 2012). Polarimetric SAR allowed researchers to gather more data and observe the effects of the earthquake and tsunami on a more local level. While the information provided by satellites is valuable, it is not as reliable on its own to capture the complete effect of a disaster on a society.

A lack of data points or cases is another difficulty with monitoring and evaluating strategies. Additionally, because no natural disaster is the same as another and can have high degrees of variability, comparisons can be very difficult to make and base improvements on. The success of an adaptation strategy cannot be measured based only on the impacts it has on reducing damages from natural disasters. Researchers must also account for the specific characteristics of a disaster and the potential damage it could have caused without the implementation of a particular strategy. The IPCC developed a 7-step framework to test the adaptation strategies before their implementation through a number of modeling techniques that incorporate environmental, economic, social, and legal factors (Carter, 1994). The models help identify suitable adaptation strategies to meet different objectives; however, the accuracy of predictions from such models, like all models, is limited.

**Indicators**

The table below (Figure 19), shows the list of indicators for Target 11.5 with suggested improvements for the monitoring and evaluation methods for certain indicators. The language of Target 11.5 identifies clear indicators, so no other indicators were added. However, as discussed earlier in this section, local governments should consider expanding upon this list in relation to the specific adaptation strategies relevant to their local needs and vulnerabilities. This includes adding information about funding structures and accounting for the intensity and other details of past disasters to make more accurate comparisons after future disasters and extreme climate events.

| Category | Indicator | Monitoring & Evaluation |
|---|---|---|
| Reduce Deaths Related to Natural Disasters | # of deaths caused by disaster | • **Monitoring:** submitted reports of missing or dead persons; hospital records; administrative data (national accounts and statistics)<br>• **Evaluation:** comparisons w/ past records |
| Reduce Number of People Affected by Disasters | # of people injured as a direct result of a natural disaster | • **Monitoring:** individual reports of injuries; hospital records of individuals seeking or provided with treatments for injuries caused by disaster; administrative data (national accounts and statistics)<br>• **Evaluation:** comparisons w/ past records |
| | # of people forced to relocate as a direct result of a natural disaster | • **Monitoring:** individual reports of relocation; public records of a household's relocation for reasons related to the natural disaster; administrative data (national accounts and statistics)<br>• **Evaluation:** comparisons w/ past records |
| Reduce % Economic Losses Relative to GDP | $ value of damages to hard infrastructure and private property caused by a natural disaster | • **Monitoring:** self-reported damage or destruction of property; administrative data (national accounts and statistics); remote satellite data showing images of destruction and assessing the value of the destruction pictured<br>• **Evaluation:** comparisons w/ past records; comparisons made w/ assumption-based economic models |
| | $ potential value lost due to disruption in the economy caused by the natural disaster | • **Monitoring:** assumption-based economic models accounting for conditions before and after the disaster; administrative data (national accounts and statistics)<br>• **Evaluation:** comparisons w/ past records and models |

**Figure 19:** chart of new indicators and suggestions for monitoring and evaluation strategies for Target 11.5

**TARGET 11.6**

A significant gap in monitoring temperature-related adaptations is the lack of indicators concerning urban heat island effect. While green roofs, for example, have indicators regarding air pollution, there is no established measure to track a city's success in reducing its temperature. This may be an area in which new indicators need to be developed. However, the majority of gaps associated with the outlined adaptation strategies concern evaluation. In order to achieve target 11.6, benefits from adaptations need to be converted into monetary values. Yet, there is no standardized way of converting air quality improvements, reduced flooding, or temperature decreases into monetary values—without this step added to evaluation practices, it will be difficult to assess the net economic value of a project.

Additionally, baselines are not well established for many of the listed adaptation projects, and no examples of moving baselines exist in the literature, despite the fact that climate change will require continuously updated and accurate projections of future climate. For this reason, baselines need to be determined and used to track the success of a project, and in some cases, short and long-term time horizons should have different evaluation practices and indicators to account for the long-term nature of the adaptation strategies.

In order to adequately incorporate adaptation into the language of target 11.6, certain existing indicators should be altered, new indicators be added, and repetitive indicators be eliminated.

**Altered Indicators**

As an addition to the working SDG indicator for wastewater management (percentage of wastewater flows treated to national standards and reused), It may be advisable to add a prefacing component: Percentage of rainfall entering storm and wastewater management systems. By including this component, target 11.6 will be now be able to assess the success of various adaptation projects in reducing the initial influx of water, rather than solely focusing on water once it has reached the wastewater system.

Additionally, the green roof indicator "square footage of green roofs planned or completed" ought to read "urban green roof area as a percentage of total urban roof area." By converting the indicator from a total area to a percentage, cities of different sizes can more easily be compared to determine progress. The same should be done for urban greening project indicators; instead of measuring the acres of tree cover added, the indicator should be acres of tree cover as a percentage of total urban acreage. Urbanscape's green roof indicators should also be altered (energy performance of green roofs in the summer and in winter) by combining them into a single indicator of net annual green roof energy performance.

While not widely applicable yet, urban CCS projects should have a standardized set of indicators to determine their impact in an urban setting. The current indicator used by the Global CCS Institute is "CO2 capture capacity (Mtpa)". If this indicator were changed to "urban CO2 capture capacity as a percentage of total urban CO2 emissions," it could be applied to specific cities and urban areas. This indicator would only be relevant for large-scale CCS projects located within city boundaries.

**New Indicators**

Due to the lack of metrics for measuring urban heat island effect, an indicator must be added. The suggestion for an urban heat indicator is "the difference in degrees between urban temperature to surrounding rural temperature." High ratios would indicate a more extreme heat island effect, while low ratios would suggest that the temperature within the urban area is not substantially different from that of its surroundings. This indicator would function at the city scale; however, it is also necessary to have a temperature indicator at the project scale.

Borrowing the language of the URGE indicator on air pollution, an indicator tracking temperature increases could be added: "temperature of the air above the urban green area compared to an area with no urban green spaces in the neighborhood, measured in degrees Celsius." In addition to providing information on specific project success, this indicator allows different types and styles of urban green projects (high tree cover vs. low tree cover, for example) to be compared. A complete list of the updated and new indicators is shown below in Figure 20.

**Monitoring and Evaluation**

Monitoring and evaluating these indicators will require updating existing strategies as well as repurposing strategies from other development and scientific fields. The use of satellite imagery and tracking should be utilized in order to track the land and roof cover changes that are associated with most of the listed adaptations: green roofs, urban greening, high albedo concrete, and reflection roof standards. Satellite imagery provides a cheap, globally available

alternative to counting or tracking progress from the ground—it requires less labor, and is more accurate in determining square footage and change over time.

However, the most significant changes need to be applied to the evaluation process associated with these adaptations. In order to determine the economic benefit that reduced, temperature, flooding, and air pollution have on an urban area, improvements need to be converted to monetary values.

While this has not been done for adaptation in the past, it has been done for mitigation strategies. The Clean Air Task Force provides a useful example of how to convert reduced fine particle pollution into a concrete economic benefit. Once the amount of pollution reduction is calculated, it is converted into a direct health improvement cost. This is done using the Abt Software tool, which calculates health benefits from epidemiological studies. The health improvements are then assigned specific economic values, which are used to calculate total monetary savings due to pollution emission reductions. This strategy was used to calculate benefits associated with NOx, SO2, and mercury reductions—this model could be used to measure the monetary benefits of adaptation strategies as well, calculating the health benefit of green roofs or carbon capture and storage.

Additionally, if the model were altered to take water pollution as an input rather than air pollution, it could evaluate the economic impact of improved human health associated with flooding adaptations like permeable pavement. The same could be done for temperature related adaptations and heat-related illness. If this type of epidemiological model were to be adapted in these ways, it would be possible to not only determine the air, water, and temperature improvements associated with an adaptation, but also the economic and environmental impact per capita that target 11.6 is attempting to measure. Below is an updated indicator table, with altered and new indicators included.

| Adaptation | Indicator | Monitoring and Evaluation |
|---|---|---|
| Green roofs | Percentage of rooftop rainfall diverted from wastewater management systems, & resulting wastewater flows treated to national standards | • **Monitoring**: area of rooftops completed as percentage of total planned green roof area<br>• **Evaluation:** calculating the percentage of annual rainfall volume removed from a roof through retention and evapotranspiration, and using modeling software to convert avoided flooding into net economic benefits from both avoided human health costs and avoided human productivity costs<br>• **Evaluation**: calculating the avoided temperature increases caused by the green roof, and using modeling software to convert avoided temperature increases into net economic benefits from both avoided human health costs and avoided human productivity costs |
| | square footage of green roofs planned or completed | |
| | Mean urban air pollution of particulate matter (PM10 and PM2.5) | |
| | Urban green roof area as a percentage of total urban roof area | |
| | Net annual green roof energy performance | |

| | | |
|---|---|---|
| | | |
| | the ratio of urban temperature to surrounding rural temperature | |
| Urban greening | Acres of tree cover as a percentage of total urban acreage | • **Monitoring**: satellite imagery to determine area of green space<br>• **Evaluation:** calculating the temperature differential between urban green spaces and other areas<br>• **Evaluation**: Calculating the amount of water diverted from stormwater systems from green spaces, and using modeling software to convert avoided flooding into net economic benefits from both avoided human health costs and avoided human productivity costs |
| | Amount of pollution in the air and around the park compared with an area with no urban green spaces in the neighborhood, measured per unit area or volume | |
| | Temperature of the air above the urban green area compared to an area with no urban green spaces in the neighborhood, measured in degrees Celsius | |
| | the ratio of urban temperature to surrounding rural temperature | |
| Carbon Capture and Storage | Mean urban air pollution of particulate matter (PM10 and PM2.5) | • **Monitoring**: categorizing projects into development planning, executive, and operate stages<br>• **Evaluation**: MVA techniques including atmospheric monitoring of sequestration sites<br>• **Evaluation:** Effect on urban co2 emissions and air quality |
| | Urban CO2 capture capacity as a percentage of total urban CO2 emissions (Mtpa) | |
| Permeable surfaces | Percentage of surface rainfall entering wastewater management systems & resulting wastewater flows treated to national standards (and reused) | • **Monitoring:** square footage of impermeable surfaces converted to permeable surfaces<br>• **Evaluation:** calculating the reduction of rainwater into storm and wastewater management systems through controlled experiments |
| | Percent of urban surface area covered by permeable surfaces | |
| High albedo concrete | Solar Reflectance Index value | • **Monitoring**: determine priority areas through satellite imagery<br>• **Evaluation**: determining the temperature decreases compared to high albedo concrete scenario |
| | Percent of urban concrete that is high albedo | |
| | the ratio of urban temperature to surrounding rural temperature | |

| | | |
|---|---|---|
| Reflection roof standards | Solar Reflectance Index value | • **Monitoring**: determine priority areas through satellite imagery<br>• **Evaluation:** determining the amount of reflected radiation and the resulting avoided temperature decreases and energy savings, and ano convert avoided temperature increases into net economic benefits from both avoided human health costs and avoided human productivity costs using modeling software t |
| | Percent of city roofs covered in high SRI material | |
| | The ratio of urban temperature to surrounding rural temperature | |

**Figure 20:** Chart of new indicators and monitoring & evaluation strategies for Target 11.6

**TARGET 11.a**

Target 11.a is not covered under the framework of the MDG's, however there is some synergy with MDG Goal 7 which is to "Ensure Environmental Sustainability". There is also some overlap in terms of affordable transport systems (SDG 11.1) and with resettlement in urban regions (SDG 11.3).

So far there is very little definition on how this target should be executed. It would be helpful to define ways to integrate target 11.a with the other targets, within SDG goal 11 to deal explicitly with finance and urban planning, and how regional and local governments may work in concert with national level development planning. Further, since the other targets within goal 11 are explicitly urban, then target 11.a would be the optimal category to include mention of poverty and inequality in the peri-urban and rural context, as it impacts urban centers, which so far seems to be lacking.

Resources, geography and local customs will vary greatly depending on the region and nation and these differences will need to be considered as the indicators are developed. Depending on the reach of this target, which definition appears to still be in progress, the gaps in this particular target could be ameliorated by having a more succinct purpose. Moreover, the adaptation strategies recommended work to define ways to integrate target 11.a as it relates to the other targets of SDG 11 and focus on issues of finance and urban planning. Further, these recommendations are intended to address the areas of potential intersection within development planning at both the national and local level. As noted above, suggested adaptations are Ecosystem Based Adaptation, Agricultural Financial and Infrastructural Resilience, Rural to City Transportation Infrastructure, Financial and Infrastructural Resilience for Clean Water, Climate Resettlement Plan (rural) and Family size reduction.

Cooperation between regions who have access to watersheds and those who lack natural sources is a gap for clean water. Also, since energy is a limiting factor in many situations, ensuring that there is inexpensive and clean energy to operate filtration and desalination water treatments will be important.

Attention should be placed on ecosystem based adaptation (EbA). Presently, a large gap in preserving ecosystems is the illegal and legal trade of threatened species. The United Nations Convention on the International Trade of Endangered Species (CITES), does not account for the loss of ecosystem services when species are traded and the regulation in this area is flawed. Further, the legal trade of threatened and endangered species, and wildlife products, creates a loophole for the illegal trade of species. This leads to increased armed-conflict, and the trade of species is linked to the illegal arms and drug trade, and general lawlessness. Therefore, a legal mechanism to address

enforcement across multiple levels, including local, national and inter- and intra- national is necessary. A well-preserved ecosystem is important for adaptation as the preservation of natural systems reduce impacts of climate change such water filtration, seed dispersal and other services, but will also serve as a co-benefit of mitigation by maintaining important carbon sinks.

Further, in terms of climate resettlement, EbA will aid in the resilience of certain regions and thereby preventing a large simultaneous flux of migration to urban or peri-urban regions, and reduce the economic shocks associated with resettlement. Specific attention should be put on identifying regions for climate resettlement and establishing funding for emergency assistance, job training, housing. Human rights will need to be addressed and given the logistical difficulties of resettlement, is at risk of being ignored all together. Institutions and nations that are receiving climate refugees should be working on remedies for assimilating people and nations that have been traditionally disenfranchised. More research on regions with labor shortages should be done in order to increase mobility pathways. Adaptation funding for migration and Intended Nationally Determined Contributions (INDC's) need to significantly increase. "Estimates of global adaptation costs (ranging from US$70 billion-$100 billion per year) are likely to be a significant underestimate, particularly in the period after 2030" (UNEP/DTU, 2015).

| **Adaptation** | **Indicators** | **Monitoring and Evaluation** |
|---|---|---|
| Ecosystem Based Adaptation | Proportion of land area covered by forest | • **Monitoring:** Satellite imagery, remote sensing, field data, CITES Trade Database, Interpol data<br>• **Evaluation:** Comparisons with past records |
| | Proportion of fish stocks within safe biological limits | |
| | Proportion of total water resources used | |
| | Proportion of terrestrial and marine areas protected | |
| | Proportion of species threatened with extinction | |
| | Proportion of land area covered by forest (FAO) | |
| | Number of illegal wildlife products confiscated | |
| | Proportion of threatened species being legally traded under CITES | |
| | Number of threatened species poached | |
| Agricultural Financial and Infrastructural Resilience | [Ratio of land consumption rate to population growth rate, at comparable scale] – to be developed | • **Monitoring:** Satellite imagery, remote sensing census data<br>• **Evaluation:** Comparisons with past |
| | Resilient crop varieties | |

| | | |
|---|---|---|
| | Improved Storage and Distribution Channels | records |
| | Poor farmer access to credit and insurance: Weather indexed-insurance products | |
| Rural to City Transportation Infrastructure | Percentage of people within 0.5 km of public transit running at least every 20 minutes | • **Monitoring:** National household census information, Cost-benefit analyses based on road appraisal models such as HDM4 and RED<br>•<br>• **Evaluation:** Comparisons with past records |
| | Access and presence of interstates, roads and rail | |
| | Ratio of travel time/cost for rural to urban areas | |
| | Percentage of people with access to Intermediate means of transport (IMTs) | |
| | Percentage of people traveling to urban regions from rural regions | |
| Financial and Infrastructural Resilience for Clean Water | Proportion of population with access to improved sanitation, urban and rural | • **Monitoring:** Formulation and implementation of compliance monitoring strategies; On-site compliance inspections, evaluations, and investigations (including review of permits, data, and other documentation); Off-site compliance data collection, review, reporting, program coordination; Oversight, and support inspector training, credentialing and support<br>• **Evaluation:** Comparisons with past records |
| | Presence of Run-off and erosion protection | |
| | Presence of eutrophication | |
| | Presence of storm water collection | |
| | Presence of Septic/Wastewater Treatment Systems | |
| | Presence of Water Filtration System | |
| | Presence of retrofit and/or built aquifers | |
| | Proportion of population with sustainable access to an improved water source, urban and rural | |
| | [Percentage of wastewater flows treated to national standards, by municipal and industrial source] – to be developed | |
| | Proportion of total water resources used | |

| | | |
|---|---|---|
| | Complementary National Indicators:<br><br>Percentage of population reporting practicing open defecation | |
| | Proportion of the population connected to collective sewers or with on-site storage of all domestic waste waters | |
| | Proportion of the flows of treated municipal wastewater that are directly and safely reused | |
| | [Reporting of international river shed authorities on transboundary river-shed management] - to be developed | |
| | [Indicator on Integrated Water Resources Management (IWRM)] - to be developed | |
| | [Indicator on participation of local communities for improving water and sanitation management] -to be developed | |
| Climate Resettlement Plan (rural) | Percentage of urban population living in slums or informal settlements (MDG Indicator) | • **Monitoring:** Satellite imagery and census data, Happiness Index<br><br>• **Evaluation:** Comparisons with past records |
| | Proportion of population below $1.25 (PPP) per day<br><br>Poverty gap ratio | |
| | Share of poorest quintile in national consumption | |
| | Growth rate of GDP per person employed | |
| | Employment-to-population ratio | |
| | Proportion of employed people living below $1.25 (PPP) per day | |
| | Proportion of own-account and contributing family workers in total employment | |
| | Proportion of households with access to secure tenure | |
| | Land Use Efficiency [Ratio of land consumption rate to population growth rate, at comparable scale] – to be | |

| | | |
|---|---|---|
| | developed | |
| | Percentage of funding for adaptation | |
| | Percentage of population currently displaced | |
| | Number of people with access to education | |
| | Number of people with access to employment | |
| | Percentage of population that has access to legal residency outside of vulnerable regions | |
| Family Size Reduction | Birth Rate | • **Monitoring**: Census data<br>• **Evaluation:** Comparisons with past records |
| | Infant Mortality Rate | |

**Figure 21**: Chart of new indicators and monitoring & evaluation strategies for Target 11.a

**SOCIAL GROUP**

*The following section includes the discussion section for each target within the social thematic group, based on the previously outlined results found during the literature review.*

**TARGET 11.3**

**Discussion**

Target 11.3 is not explicitly mentioned in the MDG's, however it does relate to Goal 7: "Ensure Environmental Sustainability" (source). The main difference between the current SDG indicators and indicators proposed in this report has been the addition of "quality of life" indicators. It is important when looking at the urbanization of cities and ratio of people to land, to focus heavily on the social implications. Possible proposed indicators should take into account context when assessing the indicators, as well as proposing a way to evaluate citizen's quality of life using technology such as smartphones in order to collect real-time, accurate data. The lack of this kind of platform remains a large gap within this target. Looking at a framework that is all encompassing such as the SEMPr database, which was used to incorporate several different aspects of urban sustainability and quantifying these into hard data could be suggested.

**Gaps**

Gaps for this target include the need for a streamlined data platform, which can collect accurate, current and quantitative data and be shared amongst and across countries. There is also a need to define universal terms, such as "slum," while taking into account their socio-economic and regional context in order to properly respond.

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| Planning and management Adaptation | Environment Index | ● **Monitoring:** SEMPRe database was created as a method of monitoring and evaluating hard data.<br>● **Evaluation:** One index, incorporating all parameters of urban sustainability. |
| | % recycling | ● **Monitoring:** Organized around three dimensions of adaptation: adaptive capacity, adaptation actions, and sustained development.<br>● **Evaluation:** describe the adaptation context,identify the contribution to adaptation, form an adaptation hypothesis, create an adaptation theory of change, choose indicators and set a baseline, use the adaptation and M&E system |
| | per capita waste volume | |
| | forest area in a 10km radius | |
| | national heritage area in a 5km radius | |
| | % green energy interest | |
| | transport CO2 emissions | |
| | drinking water NO3 | |
| | electricity CO2 emissions | |
| | level of wastewater treatment | |
| | socio-economic index | |
| | population density | |
| Adaptive capacity of target groups | increase and diversification of income | |
| | reduction of share of | |

| | | |
|---|---|---|
| | population below poverty line | |
| Sectoral | increased agricultural productivity | |
| | increased water availability | |
| | improved natural resource base | |
| | reduced damage due to floods | |
| Structural impact | # of centrally sponsored and state sponsored schemes | |
| Quality of Life | GDP per capita | • **Monitoring:** Conduct quality of life surveys that incorporate a baseline and context within regions. Also, the use of smartphone technology in order to obtain data.<br>• **Evaluation:** Personal evaluation/ this may differ amongst and across countries. Difficult to standardize the way people rate their happiness<br>• Establish Indicator that can help measure how climate change impacts quality of life. |
| | healthy rates of life expectancy | |
| | social support (as measured by having someone to count on in times of trouble) | |
| | trust (measured by a perceived absence of corruption in government and business) | |
| | perceived freedom to make life decisions | |
| | generosity (as measured by donations, adjusted for differences in income) | |
| Further Quality | disaggregates urban water and sanitation service coverage by socio- economic status | • **Monitoring:** Smartphone technology and data platforms that make this information accurate and accessible.<br>• **Evaluation:** GIS, Demographic and Health Surveys, Multiple |
| Identify needs in terms of access to | safety | |

| | | |
|---|---|---|
| infrastructure and basic services (water, sanitation, solid waste management and drainage | acceptability | Indicators Cluster Surveys, and the World Bank's Living Standards and Measurement Surveys |
| | affordability | |
| | physical accessibility | |
| 11.3 by 2030 enhance inclusive and sustainable urbanization and capacities for participatory, integrated and sustainable human settlement planning and management in all countries | [Ratio of land consumption rate to population growth rate, at comparable scale] – to be developed | • **Monitoring:** Streamline a framework which can be adapted to specific countries<br>• **Evaluation:** Establish a baseline for each country in order to track success of planning.<br>• Establish more quantitative indicators. |
| | Domestic revenues allocated to sustainable development as percent of GNI, by sector | |
| | Number of street intersections per square kilometer | |
| | Existence and implementation of a national urban and settlements policy framework | |
| Efficient land use | "Ratio of land consumption rate to population growth rate" with further research as in France's proposal to also address the issue of "quality of life" | • **Monitoring:** Establish baseline of land consumption/population growth in order to mark growth<br>• **Evaluation:** Ratio of land consumption rate to population growth rate |

**Figure 22:** chart of new indicators and monitoring & evaluation strategies for Target 11.3

**TARGET 11.4**

**Gaps**

This target, and current adaptation strategies to address this target, falls short on specificity. For example, this target doesn't explicitly state which roles municipalities must take in protecting cultural and natural heritage. This can lead to a redundancy and/or omission of key monitoring and assessments parameters, making achieving this target difficult. The focus on cultural and natural systems doesn't address the role of public space in cities. Though the CBI

addresses this point, current suggested indicators do not include such. Also, improved protection will be difficult to monitor outside nationally-determined indicators, specific powers and resources for local government. This means that even if effective adaptation strategies exist, current governance and policy could impede progress.

**Discussion**

The Singapore Index encourages cities to complete a baseline assessment of their biodiversity and then monitor this over time. As a tool this provides cities with valuable information that they might not otherwise have and can aid in the decision-making process as it helps to identify strengths, weaknesses and trends over time. Brussels has found the Singapore Index to be useful in identifying gaps in the local biodiversity management strategies, and it has led to an improvement in the data collection system (Honnay *et al.*, 2003).

The Index also serves as a valuable method of awareness raising allowing cities to mobilize their citizenry in efforts to protect and enhance locally important populations of species and ecosystems. Scientific evidence indicates that where local people are involved in monitoring and data collection, better policy outcomes are often the case (Danielsen *et al.,* 2010).

The CBI has also been instrumental in helping local, national and regional government departments to exchange information and ideas on measuring biodiversity. This creates a new network of policy actors around the issue of biodiversity and further embeds the idea into policy discourse. There has been growing participation of NGOs, universities and consultancy firms that have benefited from biodiversity policy in the cities that applied the Index by presenting new policy opportunities that might not have readily existed without the synergies created by the networks involved in data collection. For example, in Lisbon, Portugal, the application of the Singapore Index led to the development of a Local Biodiversity Strategy and Action Plan. It has also been creatively used in Singapore by city planners in the master planning of new districts and the Building and Construction Authority in their Green Mark for Districts scheme. Here the Index helped to create new networks of actors who came together to formulate policies that would not have been possible otherwise.

**Suggested/Additional Adaptation Strategies**

The monitoring of this target may be challenging as it will require accessing disaggregated data and information which is challenging in some countries; and indicators—like the Red Index—at the urban level may not be relevant at the national level (Hsu *et al.,* 2014). New metrics are needed for institutional development for inclusive and multidimensional planning and management–as the Hyogo-2 framework is an insufficient assessment indicator. New metrics are also needed to measure the efficiency of inclusive and equitable policies towards adaptation to climate change and resiliency to disasters, which is currently not included in the suggested indicators (Hsu *et al.* 2014).

Establishing a Cultural Heritage Adaptation Forum as a modifying addition to the suggested indicators recognizes the unique nature of cultural and natural heritage and that it is necessary to establish a process where learning takes place, and that learning will be able to inform the adaptation process. Therefore, modifying the current suggested indicators with elements from the Singapore Biodiversity Index with this debating space is beneficial for climate adaptation. Despite the conflicts and uncertainties, it can help to develop effective adaptation strategies that are crucial for the protection of cultural and natural heritage.

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| Strengthen efforts to protect and safeguard the world's cultural and natural heritage | 11.3. Percentage of cities with more than 100,000 inhabitants that are implementing risk reduction and resilience strategies informed by international frameworks (such as forthcoming Hyogo-2 framework) using the Singapore Biodiversity Index (CBI) as a baseline assessment tool | • **Monitoring:** Initial and subsequent applications of the CBI and Adaptation Forum take place every three years to allow sufficient time for changes to have taken effect or the results of biodiversity conservation efforts to materialize<br>• **Evaluation:** CBI: 23 indicators that measure native biodiversity in the city, ecosystem services provided by biodiversity, and governance and management of biodiversity. Each indicator is assigned a scoring range between zero and four points, with a total possible maximum score of 92 points |
| | Cultural Adaptation Forum to refresh knowledge base | |
| | Red List Index to identify biodiversity and conservation risks and assess current conservation efforts using the CBI | |
| | Assess protected areas overlay with biodiversity using the CBI | |

**Figure 23.** Suggested Indicators and Monitoring/Evaluation Strategies for Target 11.4. This table builds upon existing suggested indicators as proposed by the UN with updated suggested indicators (insert citation). The CBI and Cultural Heritage Adaptation Forum can enhance existing indicators to cover current gaps in monitoring and evaluation.

**TARGET 11.7**

**Gaps**

The main gap in adaptation to climate change in the context of accessible green spaces is that most of the developing world is focusing on other goals. Even if the focus includes goal 11.7, it is difficult to adapt pre-existing urban areas to include accessible green spaces, simply because there might either be a lack of available area, or depending on the way the cities are built, accessibility itself might be the problem.

Existing indicators focus very much on the actual green public spaces themselves but neglect the accessibility aspect. Especially for disabled, elderly, and children, indicators must consider the possible obstacles these more vulnerable groups face. This is also shown by the fact that the Millennium Development Goals did not include the topic of accessible public green spaces, unless goal 7 which outlines the idea of ensuring environmental sustainability is taken very loosely to include any green space as a positive sign. But even so, nothing in the indicators outlined to go along with goal 7 can be directly linked to target 11.7. Furthermore, even if the public green spaces are accessible for these groups, it is sometimes unclear that the spaces themselves can accommodate

them. Therefore facilities such as restrooms, benches, and water fountains are necessary in making it possible for everyone to make use of public green spaces. Furthermore, especially considering climate change, shaded areas are also very important due to the dangers of heat that can greatly affect those more vulnerable groups. Moreover, there needs to be a measure of safety as people, especially weak or vulnerable ones, will only utilize green public spaces if they can feel safe.

Monitoring can be challenging because accessibility is hard to measure. Indicators often change from city to city, especially as both geographical and climatic conditions change, as well as with the change of social factors such as standards of living, the cultural norms, and the perceptions of people. These changing circumstances also make it demanding to have a proper baseline for possible measurements. Furthermore, there is a lack of quantitative data, while qualitative data might be easier to obtain, but harder to evaluate, especially on a global and long-term scale. The complexity of establishing valuable baselines also makes it hard to develop a timeframe in which a comprehensive evaluation can be made. Even if baselines are set, it is still difficult to grasp why individuals might not make use of public green spaces, which can happen for a variety of reasons. Also, since climate change is the essential concept against which evaluation should function, it is exactly the kind of unpredictability of certain climatic events that might make evaluation difficult. For example, a public green space might be perfectly accessible for someone in a wheelchair for eight months of the year, but this person might suddenly face an increased amount of obstacles if there is a particularly rainy year, because his usual route becomes flooded, or muddy, for example. On the other hand, technological advances can be used to bridge these gaps. Mobile phones can be used to obtain real life data from people trying to access these green public spaces. Furthermore, modern computer simulations from GIS and similar modeling tools should be utilized to clearly evaluate the location of the spaces. Furthermore, computer software can be used to closely model what kind of open spaces are accessible to what proportion of the population, thereby creating an important tool for planning and management. This also includes noting possible obstacles or making predictions and future models of climate change influence on the particular region. Furthermore, satellite imagery should be used to evaluate the biodiversity, or more exactly, the growth and development of plant coverage over the years for the green spaces. This would provide valuable information about how all of those factors play together in combining the accessibility aspect with climate change events.

Additionally, the climate change impact on the public open spaces themselves should be assessed because they hold an intrinsic value to both adaptation and resilience to climate change. Indicators should include factors like the number of times more than 20% of the open space was flooded, and the percentage of public open space lying below sea-level, in order to set baselines to monitor and evaluate vulnerability to increased rainfall and flooding events. Further indicators should include the percentage of trees and other greens that are dead because of heat, and the amount of water used for irrigation purposes, as a baseline for assessing heat waves.

<table>
<tr><th>Adaptation</th><th>Indicators</th><th>Monitoring and Evaluation</th></tr>
<tr><td>Availability of public spaces</td><td>Area of public space as a proportion of total city space</td><td rowspan="4"><ul><li>Monitoring: can mostly be done with GIS-like programs and satellite information. Also on the ground surveys and polls are being conducted</li><li>Evaluation: requires similar computer programs</li></ul></td></tr>
<tr><td>Close access possibility</td><td>Proportion of residents within 0.5 km of accessible green and public space</td></tr>
<tr><td rowspan="2">Public open space quantity</td><td>% POS area within SA1</td></tr>
<tr><td>% POS area of subdivisible SA1 land area</td></tr>
</table>

| | | |
|---|---|---|
| | # of POS available within SA1 | |
| | # POS by size/type within SA1 | |
| Public open space access | Road network distance from SA1 population-weighted centroid to nearest POS border | |
| | 95% of dwellings have access to a local ( ≤0.3ha) park POS ≤400 m | |
| | 95% of dwellings have access to a small (>0.3 to ≤ 0.5 ha) neighbourhood park POS ≤400 m | |
| | 95% of dwellings have access to a medium (>0.5 to ≤ 1.5 ha) neighbourhood park POS ≤ 400 m | |
| | 95% of dwellings have access to a large (>1.5 to ≤ 2.5 ha) neighbourhood park POS ≤ 800 m | |
| | 95% of dwellings have access to a district (>2.5 to ≤ 4.0 ha) park POS ≤ 800 m | |
| | 95% of dwellings have access to a regional (>4.0 ha) park POS 5 km or 10 km | |
| Public open space quality | A quality (attractiveness) score is assigned to each POS based on its attributes and amenities | |
| Preserving Culture and History | Number of relics of traditional landscapes | |
| | Number of cultivated parks | |
| | Number of old parks | |
| Quietness | Proximity of major roads, airports | |
| | Statistical noise levels | |
| Facilities | Degree of physical access (entrances and paths) | |
| Universal access | Ratio of land consumption rate to population growth rate, at comparable scale | |
| | Area of public space as a proportion of total city space | |

| | | |
|---|---|---|
| | Number of street intersections per square kilometer | |
| | Existence and implementation of a national urban and settlements policy framework | |
| Space distribution | The average share of the built-up area of cities that is open space in public use for all | |
| | The average share of the built-up areas of cities in open space in public ownership and use | |
| | Proportion of women subjected to physical or sexual harassment by perpetrator and place of occurrence (last 12 months) | |
| Obstacles | # of impassable obstacles for disabled, elderly, and children (steps/stairs, bridges, streets without crossing, steep inclines/declines, gravelly paths) | • **Monitoring**: again should use GIS-like programs, satellite imagery and information, as well as include on the ground surveys which also involve using new technologies like mobile phones.<br>• **Evaluation**: needs to set baselines and thereby monitor progress by evaluating the changes throughout time |
| Facilities | # of restrooms/per 500m^2 (equipped for disabled and babies) | |
| | # of benches/resting opportunities per 500m^2 | |
| | # of water fountains per 500m^2 | |
| Flooding | # of times more than 20% of the open space was flooded | |
| | % of public open space lying below sea-level | |
| Heat waves | % of shade available per 500m^2 | |
| | % of trees and other greens dead because of heat | |
| | amount of water used for irrigation | |

| | | |
|---|---|---|
| | purposes | |
| Crime and safety | Average ratio of crimes/visitor | |

**Figure 24:** Chart of new indicators and monitoring & evaluation strategies for Target 11.7

**INFRASTRUCTURE GROUP**

*The following section includes the discussion section for each target within the infrastructure thematic group, based on the previously outlined results found during the literature review.*

**TARGET 11.1**

With the pressing issues of a changing climate, slums in urban areas are particularly susceptible. Increasing populations in developing countries have led to rapid expansion. Much of this expansion has at times caused members of poor societies to be overlooked or forgotten. The existence of slums forms its own topic in the discussion of climate change, as crumbling infrastructures and unhealthy populations who are constantly exposed to unsanitary conditions are those most susceptible to climate catastrophes. Wealthy countries have the funds to battle the symptoms of climate change rather than the sources that still affect developing countries. There are not many monitoring and evaluation strategies specific to slum upgrading, but efforts towards upgrading slums that do occur should be noted and monitored to detail the effectiveness over time.

For safe and affordable housing, indicators for Target 11.1 show that there are multiple steps being taken to make existing housing adaptable while creating new affordable homes built with adaptation in mind. Older structures should be upgraded and refurbished with materials and appliances that are more energy efficient. As the majority of energy is still created from burning fossil fuels, the less energy used results in less greenhouse gas emissions. This is becoming much easier in developed countries. For new constructions, energy efficiency standards should be met and innovative ideas on smarter buildings should be used. These ideas involve natural ventilation, water separation and recycling, and overall improvements to increase adaptation and energy efficiency.

Though this target is split between providing safe and affordable housing for all and upgrading slums, these two goals are linked. Among the many things slums lack, safe and affordable housing is one of them. Slums are in a unique position though. They are settlements that tend to be affected most by climate change; however, their layouts tend to be clustered, providing resistance to implementing green spaces. Additionally, with limited law enforcement, slums fall under pockets of authority headed by gang lords and drug traffickers, causing a presence of fear that halts advancement strategies. There tends to be an overall feeling of mistrust engrained in slum dwellers. The goal of providing safe and affordable housing to all cannot be met until all slums dissipate and become nonexistent.

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| Warmer | number of buildings designed | • **Monitoring**: Reduction in energy costs used |

| | | |
|---|---|---|
| Weather | with natural ventilation | for air-conditioning<br>● **Evaluation:** Less energy used during the warmer times of the year. |
| | enhanced amount of landscaping to maximize natural cooling | ● **Monitoring**: Amount of native plants and grassland planted and protected . Natural landscape preservation that allows for natural cooling through shade and wind tunnels<br>● **Evaluation:** Reduced heat island effect. Less energy consumption to run air conditioners during heat waves |
| | termite ranges extending north | ● **Monitoring**: The migration of termites as warmer temperatures stretch north<br>● **Evaluation:** Termite migration north decreases |
| Water Shortages | expansion of new developments in drier regions | ● **Monitor:** Monitoring urban spread in areas prone to drought<br>● **Evaluate**: Less severe drought impacts on settlements |
| | plans for plumbing systems for graywater separation | ● **Monitoring**: Number of buildings installing water separation devices to recycle graywater<br>● **Evaluation:** Water conservation over time |
| | harvested rainwater | ● **Monitoring**: Number of constructed rainwater catch basins and use<br>● **Evaluation:** Increase in water supply without overly diminishing land infiltration |
| | amount of native plants to avoid over-watering landscapes | ● **Monitoring**: Reducing/limiting the amount of non-native plants in human landscaping<br>● **Evaluation:** Less watering needed for green spaces |
| Storms, Flooding, Rising Sea Level | areas built in flood zones | ● **Monitoring**: The expansion of settlements on to areas at risk for flooding.<br>● **Evaluation:** Less settlements affected by floods |
| | expansion of stormwater management capacity | ● **Monitoring**: Number of operating drains and natural water runoff systems<br>● **Evaluation:** Less floods caused by pooling water |
| | ability to rely on natural systems to mitigate natural catastrophe impacts | ● **Monitoring**: Incentives to maintain natural vegetation adapted to the local weather<br>● **Evaluation:** Less surface runoff caused by the clearing of natural vegetation |

| | | |
|---|---|---|
| | plans in work for rising sea levels in coastal areas | • **Monitoring**: Construction of resistance measures in flood zones<br>• **Evaluation:** Less destruction during storms |

| | | |
|---|---|---|
| Population | Percentage of population that live in urban areas | • **Monitoring**: Past and current census data<br>• **Evaluation:** Fluctuations in population and the appropriate amount of facilities are provided to support overall population needs (i.e. schools, hospitals, housing). |
| | Percentage of urban population that live in low-income areas or slums | • **Monitoring:** Difficult to monitor. Most low-income and slum population data is currently approximated<br>• **Evaluation:** A reduction in size of substandard living conditions. |
| Safety and security | Corruption in the Law Enforcement | • **Monitoring:** Standards of law enforcement are upheld<br>• **Evaluation:** Trust from citizens in law enforcement |
| | Reduction in consumption of and dealing of drugs | • **Monitoring**: Greater presence of police and law enforcement in low-income areas and slums<br>• **Evaluation:** A decrease in crime tied to illegal drugs less fear |
| | Eliminate ganglords | • **Monitoring**: Extortions and illegal control rates preventing residents from access to water or electricity<br>• **Evaluation:** Reduction in fear and greater community member productivity |
| | Reduce overall crime | • **Monitoring**: Greater presence of police and law enforcement<br>• **Evaluation:** Greater community member productivity |
| Guarantee land security for residents | Controls over mass corporation takeover/corporate land development | • **Monitoring**: Gentrification and land seized by real estate developers for corporations<br>• **Evaluation:** Less poor forced from their homes and displaced and less land seized |

**Figure 25:** chart of new indicators and monitoring & evaluation strategies for Target 11.1

**TARGET 11.2**

While evaluating existing indicators for target 11.2, it becomes evident that these indicators could be more effective if they were refined, applied to a wider range of regions, and supported by increased governmental aid and policies. Current working indicators for target 11.2, as outlined by the Sustainable Development Solutions Network, are fairly poor and include only the following indicators (SDSN, 2015):

| Target | Indicators |
|---|---|
| **11.2** By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons | Existence and implementation of a national urban and settlements policy framework |
| | Road traffic deaths per 100,000 population |
| | Access to all-weather road (% access within [x] km distance to road) |
| | Percentage of people within 0.5km of public transit running at least every 20 minutes |

**Figure 26:** chart of Sustainable Development Solutions Network Indicators

Though the above metrics provide a good baseline for both developing and developed regions, they are hardly extensive enough to truly determine the actual sustainability of public transportation or it ability to adapt to climate change. However, indicators provided by other governmental sources and private organizations are much more extensive, though they still hold significant gaps. For example, rarely do existing metrics for target 11.2 specify how transportation infrastructure can be retrofitted and prepared for each specific climate risk. Monitoring and evaluating these risks might include integrating more sustainable construction materials or increasing research and funding of new materials. Clearly more research needs to be done on the process of sustainable transport construction.

Additionally, one major gap in the monitoring and evaluation of this target is a standardized definition of major urban areas and economic centers. It is difficult to quantify accessibility or criticality to important regions without knowing the exact definition of what is considered critical. There needs to be an established definition of an urban area, such as a region or town including a population of at least 250,000 inhabitants. However, this could mean that certain monitoring and evaluation strategies might not apply to developing countries or regions with smaller populations whose own major urban areas or economic centers would not fall under the standard definition. Therefore, perhaps these targets should indicate whether they apply specifically to developing or developed regions and offer targets and evaluation strategies accordingly.

In addition, it is interesting to note that the two most sustainable, affordable, and accessible forms of transportation are not included in target 11.2 or existing monitoring and evaluation strategies: walking and cycling. Shorter distances could easily be walked or cycled if safe and comfortable infrastructure were provided and encouraged. Some potential indicators for walking and cycling might include calculating the percentage of separate walking paths in the whole transport network, the percentage of walking and biking paths illuminated in the whole network, and the number of bicycle parking spots per capita (ICSU, ISSC, 2015).

Lastly, it is important to consider potential changes to law and policies that could stimulate the success of target 11.2 and adaptation. Without policies that urge the use of renewable energies, discourage the use of personal vehicles, and fund the redesign of transportation infrastructure in populated cities, important adaptation measures might never

be taken. Local governments need to be encouraged to put greater funding towards the renovation, maintenance, and urban design of transit systems. These changes might end up requiring a shift in budgeting or managerial structure within local governments.

To fill existing gaps in the existing indicators for target 11.2, I propose the following list of indicators that includes both my newly suggested indicators as well as currently existing best practices.

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| Accessibility | Physical Accessibility | • **Monitoring**: % job opportunities and services within 30 minutes travel distance of residents, average door-to-door commute time, average travel time between sustainable transport modes and passenger cars<br>• **Evaluation:** Determine if travel time and accessibility are relatively even across wealthy/poor communities and for those with disabilities. |
| | Equity of accessibility | • **Monitoring:** % Low income residents with access to public transport network within 30 minutes of major employment centers, % of access points to public transport with total accessibility<br>• **Evaluation:** Determine if travel time and accessibility are relatively even across wealthy/poor communities. |
| | Affordability | • **Monitoring:** Calculate household travel costs, poll households on satisfaction with how much they spend on travel costs<br>• **Evaluation:** percentage of total family income spent on travel costs and level of satisfaction |
| | Availability of alternative, greener transportation | • **Monitoring**: % of separate walking paths in whole transport network, % of separate bike paths in whole transport network, % of walking and biking paths illuminated in the whole network, # of bicycle parking spots per capita<br>• **Evaluation**: Increased use of green transportation. |
| Resiliency | Resiliency to Temperature Change | • **Monitoring:** Construction materials' ability to withstand extreme increases in temperature, evaluate peak load of energy grid for transportation system, cost of monitoring potential climate threats<br>• **Evaluation:** The resiliency and capacity of transportation infrastructure to withstand temperature changes and increased use. |
| | Resiliency to | • **Monitoring:** # of days systems shut down due to flooding, # formal protocols in place to mobilize |

| | | |
|---|---|---|
| | Precipitation/Flooding | cooperation to prepare for emergencies related to infrastructure, cost of monitoring potential climate threats.<br>• **Evaluation:** Shut downs and costs due to flooding as well as regional preparedness. |
| | Resiliency of construction materials to climate threats | • **Monitoring**: Vulnerability of construction materials to extreme weather, vulnerability of transport to heavy shaking and movement from earthquakes and storms<br>• **Evaluation**: Amount of new research and funding on more resilient construction materials. |
| Quality of Life | Livability and Safety | • **Monitoring**: # of transport-related accidents/fatalities/ injuries per mode per year, # of reported incidents of personal security violations per mode per year, % crossing points/bus stops adopted for disabled, % of local streets with traffic calming measures, % public vehicles with safety belt reminders, # vehicles with tracking systems, presence of security cameras on vehicles and transit stops<br>• **Evaluation**: Improved safety and decreased disruptions to quality of life. |
| Sustainability | Operation and Maintenance | • **Monitoring:** Investments in transport infrastructure maintenance/capita, public subsidies, R&D expenditure on clean transport fuels, total expenditure on pollution prevention and cleanup, # policies/measures taken to improve public transport<br>• **Evaluation:** regional expenditures and upkeep of transportation. |
| | Productivity/Efficiency | • **Monitoring:** Average freight transport speed, % of public transport keeping timetables, delays due to traffic congestion, # transportation days disrupted by climate related events (precipitation, sea level rise, temperature spikes)<br>• **Evaluation:** Speed, efficiency, and days of transport disrupted. |
| | Benefits to the Economy | • **Monitoring:** Impacts to public revenue and expenditures, contribution of transport sector to employment growth (# employed)<br>• **Evaluation:** Effects of transport on economy. |
| Sustainability | Criticality | • **Monitoring:** Average level of use (Vehicle Miles Traveled or Ridership), freight tonnage or value moved using transport, importance in linking regions or facilitating national trade flows, role in emergencies for evacuating people/getting assistance to a particular region (disaster relief, defense, health care)<br>• **Evaluation:** Importance of infrastructure to |

| | | |
|---|---|---|
| | | economy and emergency systems |
| | Resource Use | • **Monitoring:** % of public transport using renewable fuels, consumption of solid raw materials, fuel consumption/vehicle miles traveled/passenger miles traveled, % of transit vehicles using alternative fuels<br>• **Evaluation:** Amount of raw material consumption and transport using renewable resources |
| | Ecological Intrusion/Habitat loss | • **Monitoring:** Land take, )# of measures taken to preserve habitats<br>• **Evaluation:** proximity of transport infrastructure to designated ecosystems/habitats |
| | Emissions to the atmosphere | • **Monitoring:** % contribution of transport to total GHGs, % population living in areas where pollution is higher than air quality standards, % population exposed to exceedances of air quality standards, % population feeling disturbed by pollution<br>• **Evaluation:** total emissions to the atmosphere and public sentiment towards emissions. |
| | Emissions to soil and water | • **Monitoring:** # of leaks of harmful liquid, solid, or gas substances generated by transportation related incidents, amount of runoff pollution from daily usage of transport infrastructure, wastewater from manufacture/maintenance of infrastructure, discharge of oil/wastewater at sea, annually used road salt/snow days<br>• **Evaluation:** total emissions to soil/water and public sentiment towards emissions. |
| | Institutional capacity for adaptation strategies | • **Monitoring**: # of subsidies and funds available to help transportation shift to renewable energy sources, # grants available for research into greener transportation, # of staff in local government devoted to the improvement of sustainable transportation<br>• **Evaluation**: Increased funding, subsidies, and government involvement in adaptation strategies. |

**Figure 27** chart of new indicators and monitoring & evaluation strategies for Target 11.2

**TARGET 11.c**

**Existing Indicators**

The objective of SDG 11.c is addressed in part in MDG 8, Global Partnership for Development, specifically 8B which aims to address the special needs of least developed countries. There are countless potential indicators for adaptive infrastructure. Those that were selected were the most common and the most feasible for implementation in developing countries. While developed countries' measures for adaptive infrastructure were used, it is important to note that there is a dearth of adaptive infrastructure in developing countries to begin with, and both developed and

developing nations are affected climate impacts, though perhaps to different degrees. The suggested indicators were meant as improvements on the current working SDG indicator, which is, "11.4. Presence of urban building codes stipulating either the use of local materials and/or new energy efficient technologies or with incentives for the same" (SDG Indicator). This suggested indicator only recognizes the fact that there are often no building codes in developing countries, and poses no additional solutions, let alone adaptation-specific ones.

**New Indicators**

The ICSU Review of Targets for the Sustainable Development Goals claim that SDG 11.c's focus on local material over-simplifies the urban challenges to attaining SDG 11. They go on to say that it places too much emphasis on material as opposed to other issues relating to sustainable cities. However, considering the dearth of information on specific building materials and methods in least developed countries, research suggests this concern is well-founded and may pave the way for a better system of sourcing local and sustainable materials in the construction process.

The suggested indicators below explore alternatives to building codes for the construction of adaptive buildings in developing countries. Some of these alternatives involve community education and involvement, promotion of voluntary adoption of green building practices, and implementation of other government measures to disincentivize building in floodplains. A major challenge to monitoring and evaluation is the fact that many of the suggested indicators—including freeboard requirements and energy efficiency—lack numerical specificity. This is because the degree to which they can be implemented varies by geographic location. One mode of tracking the efficacy of countries' adaptation strategies would be to count the number of adaptive strategies adopted from year to year. For example, efficacy could be tracked by counting the number of new policies relating to flood proofing implemented in a country each year.

Ideally, buildings would utilize universal baselines for features necessary for adaptation such as insulation and materials sourcing, but in the absence of such baselines a full inventory of adaptive strategies coupled with effective monitoring and region-specific considerations for their implementation could be the most effective means of tracking the realization of goal 11c. In addition to all this, there is a lack of discussion on proven methods for widespread construction of naturally-cooling buildings, wind-proofing, and finding local sources for building materials independent of public policy in developing countries.

**Additional Indicators**

The following indicators are meant to fill some lesser gaps in the suggested indicators.

| Adaptation | Indicators | Monitoring and Evaluation |
|---|---|---|
| Flood Proofing | Annual monetary cost of damage caused by flooding | • **Monitoring**: Measured through business and household surveys and compared from year to year.<br>• **Evaluation:** A reduction in annual cost (assuming same number of flooding events) indicates flood-proofing measures are working (this is monitoring and evaluation) |
| Building | Building interior temperature | • **Monitoring:** install thermostats within buildings and require regular audits of indoor temperature in buildings |

| | | |
|---|---|---|
| Cooling | relative to outdoor temperature (ratio) | • **Evaluation:** Provides a baseline for comparison of cooling efficiency of building. The lower the ratio, the more efficient the building's natural cooling capacity, created baseline policy for livable buildings, tracks implementation of policy for cooler and more energy efficient buildings, an increased number of buildings using such standards indicates a positive trend toward achieving cooler buildings, enables tracking of cool buildings in developing countries |
| | Presence of baseline for livable building interior temperature | • **Monitoring:** track presence in building codes including a provision on baseline livable temperature<br>• **Evaluation:** increased number of localities with baseline temperature requirements indicates efforts to control heat island effect's human impacts |
| | Presence of insulation standards (emphasis on sourcing safe, reliable, and locally sources insulation) | • **Monitoring:** track presence in building codes including a provision on effective insulation material<br>• **Evaluation:** increased number of localities with insulation standards indicates efforts to control heat island effect's human impacts |
| | Presence of requirement for documentation of naturally cooling building design | • **Monitoring:** track presence in building codes including a provision on design to facilitate cooling<br>• **Evaluation:** increased number of localities with building cooling standards indicates efforts to control heat island effect's human impacts |
| Water Conservation | Number of buildings utilizing efficient flow/flush fixtures | • **Monitoring:** Implement auditing programs<br>• **Evaluation:** Though it may be difficult to monitor owing to lack of auditing programs, a larger number reflects significant water savings, higher number demonstrates the overall need for water conservation standards, higher number shows level of water conservation, lower number from year to year (with population constant and conservation and education initiatives in place) indicates impact of water conservation efforts |
| | Number of buildings utilizing greywater for non-consumptive purposes | • **Monitoring:** Implement auditing programs<br>• **Evaluation:** Increased number of buildings utilizing greywater means reduced use of potable water increasing resilience to drought |
| | Total consumption of water resources per urban area | • **Monitoring:** Implement auditing programs<br>• **Evaluation:** Provides standard of comparison for determining the efficacy of water efficiency measures. |

| | | |
|---|---|---|
| | Number of buildings with operational plumbing systems | • **Monitoring:** Implement auditing programs<br>• **Evaluation:** Increased number of buildings with plumbing systems provides standard of comparison for regional performance in implementing efficient flow/flush fixtures |
| Natural Disaster Preparedness | Presence of programs for educating the public about natural disaster protocols (including local availability of passive survivability structures) | • **Monitoring:** Track number of programs from year to year on local, state, and national scales<br>• **Evaluation:** Increasing number of public education programs indicates public involvement in overarching adaptation strategy for natural disasters, higher number indicates higher structural resilience to high wind speeds that come with intense storms |
| | Number of structures wind-proofed | • **Monitoring:** Implement auditing program<br>• **Evaluation:** Resilience to high windspeeds is critical to building adaptive infrastructure. Increased number of wind-proofed structures demonstrates overall building resilience in LDCs. |

**Figure 28:** Chart of new indicators and monitoring & evaluation strategies for Target 11.2

# CONCLUSION

### Economic Group

The economic thematic group comprised of targets 11.5, 11.6, and 11.a, attempts to address the quantitative, monetary impacts of climate change on cities. The types of goals derived from the targets intend to limit economic costs and support economic growth while adapting to climate change. Target 11.5 focuses specifically on the direct impacts of natural disasters on the economy. Target 11.6 also looks at the costs of environmental impacts, but instead, it concentrates on environmental issues like air quality and waste management. Target 11.a aims to support economic growth through development planning that supports the relationship between urban and rural areas. There are a variety of adaptation strategies and indicators that can be implemented within all three targets in order to monitor and evaluation the progress of climate change adaption strategies in areas around the world. Unlike target 11.6 and 11.a, Target 11.5 specifies metrics within the language of the target itself, such as number of deaths caused by disaster and % economic losses relative to GDP, to track the progress of adaptation strategies. Target 11.6 and 11.a are geared more towards tracking the progress of specific strategies, rather than identifying a broader indicator to track the progress of all strategies, like Target 11.5. Target 11.6 focuses on adaptation strategies, like green roofs, urban greening, Carbon Capture and Storage, and reflection roof standards. Target 11.a's strategies center around ecosystem protection, agricultural resilience, and migration. Together, each target attempts to better the economy and reduce economic losses, given the potential impacts of climate change on urban societies.

Because of the significant gaps in economic capacity between developed and developing countries, achieving economic-related goals will necessarily require varying amounts of effort and financial assistance. While it may be challenging for developing countries to construct and evaluate climate change adaptations on their own, international economic policies and funding programs need to be strengthened to allow developed countries to

contribute to other nation's adaptation efforts. Funding for adaptation strategies for both developing and developed countries are included within the Green Climate Fund, which is a fund within the framework of the UNFCCC founded as a mechanism to assist developing countries in adaptation and mitigation practices to counter climate change and intends to raise $100 billion per year in climate financing by 2020. This figure is based on cost estimates by the World Bank, however the true costs are likely to be much higher than this (Nature, 2015).

Although the GCF is intended to be divided equally between mitigation and adaptation projects, private finance still favors mitigation measures over adaptation. One reason for this is adaptation strategies tend to be complex, specialized to the location, and requires detailed local knowledge, which can lead to prohibitive transaction costs. Another reason is that some adaptation strategies do not yield a large enough global social return, and primarily benefits an individual country's economy, which no single private sector entity can or should be responsible for, such as ecosystem restoration. Further, private finance is biased towards wealthier developing countries with better investment prospects, leaving the poorest marginalized people struggling to meet essential adaptation. Therefore, despite mechanisms like the GCF, public funds will still play an important role in financing adaptation (Oxfam, 2013).

An important step in ensuring the funds are utilized and directed appropriately is to establish transparency measures within the fund, and to hold nations accountable for following through on their commitments. In addition to this existing framework, multiple nations have individually pledged funds to help climate-impacted nations cope. However, funds need to be partitioned to ensure that a certain amount is allotted for adaptation. Additionally, it will become increasingly important to establish city or nation specific financial plans that include both short term and long-term adaptation investment costs.

Securing funding is a necessary first step in ensuring that adaptation projects are implemented and are effective. If the necessary monetary requirements are met, then many of the indicators suggested by the economic group would useful for several other Sustainable Development Goals. Goal 7, for example, focuses on affordable and clean energy. Through building and monitoring green roofs for flooding and temperature adaptations, it is also possible to monitor energy efficiency gains that would be applicable to achieving goal 7. Additionally, many of the Ecosystem Based Adaptations proposed under target 11.a could also serve as indicators for Goal 13: Climate Action. EbA strategies, in addition to making communities more resilient, necessarily require the conservation of biodiverse and threatened ecosystems. Therefore, our findings indicate that economic health and environmental health are not at odds with each other, and, in fact, are mutually causal.

## Social Group

The social group discussed targets 11.3, 11.4, and 11.7 which all deal with the more qualitative and value based side of goal 11. Target 11.3 deals with the preservation and protection of human and natural heritage, 11.4 looks at sustainable human settlement planning and management, while target 11.7 takes into account the accessibility to open green spaces. Many of the aspects involved these targets largely depend on human perceptions and cultural influences, rather than exclusively monetary or industry related values. This also comes with the price that it is challenging to find variables and indicators that can be used as baselines and further be monitored and evaluated.

But the SDG suggested indicators for Goal 11—as they currently stand—have as their focus a specific dimension of the social whole. This is not a problem so long as it is acknowledged. However, what we attempted here goes much further. We recognized that problems arose when the social whole is oversimplified or misrepresented. When discussing mitigation and adaptation strategies to address climate change in urban environments, the social is usually considered a subset or subsystem of a primarily understood intersection between the economic market and

the ecosphere it impacts. Thus, the social is treated as an extra domain—supposedly very important but, in practice, thought of as an extra consideration—that doesn't quite fit into the domain of economics. The problem here is that the current SDG suggested indicators fail to adequately address the complex whole of human engagement.

Within the social group there were several overlapping challenges within all targets. The first gap is the need for a streamlined data platform that collects quantitative and real time data. This data could possibly be collected using smartphone technology. In areas in which this technology is still not widespread, cell phones could be given specifically to data collectors in order to equip them with a new methodology for reporting real-time data. Within this gap there is a need in extending the transparency within countries to maximize its usefulness. Another overarching gap is the role of public green spaces within cities, and identifying their importance culturally, as well as how they can be affected by climate change. Overall the need for health and well-being of people within urban cities cannot be overlooked and is necessary when planning for an influx of population due to climate migration. These challenges are necessary in identifying what legal frameworks can be implemented to alleviate these gaps.

However, in a broader sense these targets could be used as a guideline in several SDG's, for example Goal 3, which deals with exactly with the issue of health and wellbeing. Having recognized the importance of the often-neglected social aspects within Goal 11, it has become increasingly striking that there is a close link between many of the other SDG's and that this should be used as an advantage by multiple use of similar indicators in overarching different goals and targets.

### Infrastructure Group

The Infrastructure group encompassed SDG targets 11.1, 11.2, and 11.c. Each of these targets was grouped under the infrastructure theme because they incorporated goals related to buildings, construction, and the social and physical structures of communities. These targets considered the use of building materials and could be monitored with the establishment of building codes and policy interventions. The infrastructure targets also focused on adaptation strategies that would positively impact vulnerable and developing communities, while simultaneously organizing and educating community members through public sustainability programs. The economic and infrastructure themes are closely related. Each of the selected goals for either theme contributes to the accomplishment of at least one within the other. For example, Goal 11.5 of the economic theme which is to significantly reduce the number of deaths and the number of affected people as well as economic losses caused by natural disasters with special attention to poor and vulnerable people is codependent upon the accomplishment of goals 11.1, 11.2, and 11.c which deal with slum upgrading, provision of adequate transportation resources, and safe and resilient buildings. Though the social group has a less harmonious linkage to infrastructure as it concerns the preservation of historic and cultural landmarks, there are elements of the theme, such as the imperative to install accessible green spaces (11.7), which offer adaptation strategies with crosscutting benefits for the infrastructure theme.

In general, there was not an overwhelming amount of material on reliable methodology for gathering data through community surveys, and collaborations with local institutions. These targets also lacked a comprehensive definition of what is considered a developed or developing region (11.1, 11.2), or provided an exclusionary definition of a developing region (11.c). Consequently it is difficult to pose strategies for monitoring adaptation strategies without knowledge of which regions they should be applied to. In particular, phrases such as "slum," "major urban areas," "economic centers," and "sustainable and resilient buildings" muddle the discourse on adaptation methodology when considered across a wide range of regions with different developing and economic capacities. To circumvent this issue, we have posed strategies that address issues of climate change impact and examined a wide range of countries as opposed to those categorized as developed and developing. The latter method yielded particularly rewarding results as some of the adaptation monitoring and evaluation strategies implemented in developing

countries were simple enough to be implemented across the entire socioeconomic spectrum of countries. For example, having governments discourage the development of infrastructure in floodplains.

Many of the factors that hinder the success of adaptation strategies for this theme involve deficient funding and political will. There is also the general issue of poor resource availability and access in addition to research and development. Research and development is especially important for determining necessary building materials in order to guarantee that infrastructure is built and sourced sustainably. With regard to resource access and availability, many regions lack trade opportunities, linkage to international trade systems, and policies that allow for the import of materials that are necessary for the construction of advanced sustainable buildings. For example, in order to build resilient stilted housing to withstand flooding, it is necessary to use steel as a base material for the stilts for durability. In poorer regions, this kind of material may not be affordable or readily available.

A final hindrance for achieving adaptation measures is rapid population growth. This is a trend that is not predicted to slow, and it is getting increasingly difficult to keep up with and support a continuously growing world population. Developing regions also often suffer from an unhealthy, malnourished population, a lack of education, human rights violations, and stable political leadership that may place the upkeep and maintenance of infrastructure at a secondary level to other concerns.

**Comprehensive Conclusion**

This report aims to cover the current state of adaptation assessment, as well as suggest changes that are necessary to building a more universal, standardized, and implementable set of global indictors for climate change adaptation. Despite the challenges outlined above which can make the implementation of adaptation difficult, the suggestions made in this report also intend on reducing these roadblocks through increased monitoring and evaluation of crime, corruption, funding channels and data availability. However, we predict that further legal mechanisms may be needed in order to assist countries in making meaningful progress toward adaptation. Adaptation is critical for both urban and rural areas—as a further area of study, it is suggested that indicators for rural areas are examined to determine if they match or conflict with the indicators proposed in this report. However, building an assessment rubric for cities may be more critical in the coming years, considering current trends in urban migration and growing urban populations. Building an assessment rubric for urban climate change adaptation will make the majority of global population more resilient, safe, and sustainable.

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