# Climate Change Strategy for Urban Planning and Urban Development Sector in the State of Qatar

# 4 STRATEGY REPORT

# Executive Summary

## Introduction

GHD Global Pty Ltd (GHD) has been engaged by the Urban Planning Department of the Ministry of Municipality and Environment (MME) to develop a "Climate Change Strategy (CCS) for Urban Planning and Urban Development Sector in the State of Qatar". This report comprises Stage 4 of the CCS – Strategy development and action plans.

Qatar has seen immense growth in industry, population and size of urban settlements over the last 30 years. This has been driven by the oil and natural gas reserves that have been developed, contributing to one of the highest per capita Gross Domestic Product (GDP) in the world (Forbes, 2012). In response to this growth, a number of documents have been developed to guide and manage the impacts associated with these changes, including:

- Qatar National Vision 2030 (QNV 2030)
- Qatar National Development Strategy 2011-2016 (QNDS 2011-2016)
- Qatar National Masterplan (QNMP)

One aspect identified in multiple plans was the potential impact of climate change on Qatar. This has led Qatar to undertake studies to understand the impacts and challenges associated with climate change.

The primary objective of this CCS is to address how urban planning and urban development can be managed to mitigate climate change and reduce its impacts. The focus on urban planning and development is achieved by concentrating on aspects directly or indirectly related to spatial land use in Qatar that influence or can be impacted by climate change.

This report comprises the deliverable for Stage 4 of the Project and presents climate change mitigation and adaption measures for Qatar in relation to urban planning and the associated action and implementation plans.

## Greenhouse gas emissions

According to the United Nations Climate Change Secretariat (UNFCC, 2015), Qatar had the highest per-person $CO_2$ emissions in the world in 2014. The World Resources Institute reported Qatar as emitting 106.02 million tonnes CO2 equivalent in 2010 and 85.25 million tonnes CO2 equivalent in 2012, of which 93% was carbon dioxide, 5% was methane, and the rest was nitrous oxide and fluorinated gases (World Resources Institute, 2014).

An estimate of greenhouse gas emissions by activity was compiled during Stage 3 of this project using data from Kahramaa (utility provider) and publicly available emissions inventories. This review established a baseline of 14.7 metric tonnes $CO_2$ equivalent per capita.

The 2012 per capita GHG emissions for Gulf countries published by World Resources Institute revealed that Qatar also had the highest per capita GHG emissions from transportation. Based on the 2014 data, private passenger vehicles including taxis and motorcycles contributed approximately 99% of the transportation GHG emissions.

## Implications of climate change in Qatar

### Sea level rise

Of the Middle East and North Africa (MENA) countries, Qatar is the most vulnerable to sea level rise and associated flooding, as a 1-m rise in sea level (predicted for 2100) would affect about 3% of its area, while a 3-m rise would affect 8%. A flood study was completed for Qatar, which modelled flooding under various climate change scenarios with varying levels of rainfall intensity, sea level rise and storm surge. The study identified that around one third of all other land use areas was projected to be affected. Depending on the land use type, the economic, social and environmental impacts would vary, although the flood modelling projected that much of Qatar's critical infrastructure would be affected by a base case flood including power and water supply infrastructure as well as emergency services and hospitals. Within Doha City Centre, the modelled flood simulations projected that a number of areas are projected to be inundated by up to 2 m of water.

Sea level rise is a function of a combination of factors, mainly thermal expansion of the oceans and an increase in loss of land ice (glaciers and ice sheets). As the response times for each of these drivers varies significantly, sea levels will be rising for hundreds if not thousands of years irrespective of mitigation of carbon emissions in the coming decades (Clark et al, 2016). As there are reinforcing factors driving the changes, sea levels will rise at an exponential rate during this period. The only uncertainty is the rate of rise, and the ultimate equilibrium global sea level. Accordingly, land that is considered presently vulnerable (i.e.in the period to 2100) will almost certainly be eventually inundated.

### Increasing temperatures

The IPCC expects temperatures in Middle Eastern countries (including Qatar) to rise by about 2°C in the next 15-20 years, and by more than 4 °C by the end of the century. Recent modelling work reported in *Nature Climate Change* suggests that:

*"By the end of the century, annual wet bulb temperatures in Doha will exceed 35°C several times in the 30 years, and the present-day 95th percentile summer (July, August, and September) event becomes approximately a normal summer day."*

35°C is the threshold wet bulb temperature beyond which any exposure for more than six hours would be intolerable for most humans, resulting in hyperthermia which becomes a medical emergency requiring immediate treatment to prevent disability or death. In the current climate, the wet bulb temperature rarely exceeds 31°C.

In urban areas, increasing temperatures will be exacerbated by heat island effect intensified in:

- Built-up areas, particularly roads
- Inland areas compared with those nearer the sea (coastal areas)
- Areas with higher population densities

The areas assessed to be particularly affected by the heat island effect were Doha and Al Rayyan municipalities, with six areas noted to be affected in each, while Al Daayen and Umm Slal included one area each. Increased heat can result in critical human health issues as well as impacts to biodiversity and an increase in GHG emissions due to increased power requirements.

## Socio-economic implications

The predominant effects of climate change in Qatar are associated with increasing temperatures and rising sea levels. Without adequate mitigation or adaptation measures, these effects will have a gradually increasing adverse consequence for society, the economy and the environment (Table IV-1).

**Table 1-1: Effects and implications of climate change**

| Effect | Increasing levels of: | Implications | | |
|---|---|---|---|---|
| | | Social | Economic | Environmental |
| Increasing temperatures | Heat stress | Public health | Reliability of infrastructure | Species resilience |
| | Cooling energy | - | Cost of energy | Increased emissions |
| Rising sea levels | Flooding and inundation | Public safety | Damage / loss of land and assets | Ecosystem damage |
| | Loss of habitat | Amenity | | Reduced biodiversity |

With the current global policy settings, climate change will continue for the foreseeable future and the social, economic, and environmental consequences will worsen. It is clear that the social, economic, and environmental costs of not acting will be extremely high, and therefore significant investment in reducing the risks is warranted.

## Existing Climate Change Management in Qatar

A number of studies and initiatives addressing climate change have been undertaken by the community and private entities in Qatar. For example, 'A climate change and temperature warning in Qatar' study was undertaken by Qatar University's Social and Economic Survey Research Institute (SESRI). From the different studies and initiatives, it can be surmised that there is a general acknowledgement and understanding of climate change and its effects in Qatar by its citizens and commercial entities. However, knowledge of certain impacts and how they may be mitigated seems limited.

# Climate Change Strategy framework

The Strategy is structured through the establishment of a hierarchical framework comprising a set of specific actions delivering outputs, which contribute to higher level objectives aimed to achieve the overall vision of the strategy (Figure VI.1).

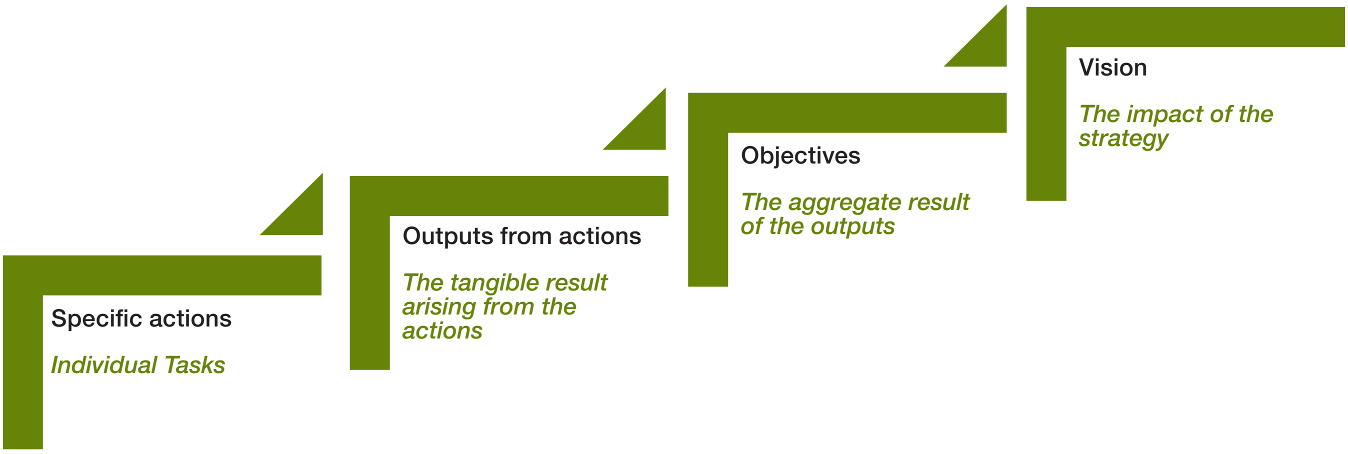


*Figure 1.1: Hierarchical framework of the Climate Change Strategy*

A vision statement for the Climate Change Strategy (CCS) for Urban Planning and Urban Development in Qatar was developed by reviewing existing climate change policy statements in the QNDF, QNV2030 and other Qatari planning framework documents. The vision statement sets the overall course for the CCS.

*"Urban development in Qatar will progressively reduce average per capita greenhouse gas emissions and be resilient to the potential impacts from climate change"*

The objectives for the CCS are set out in Figure VI.2.

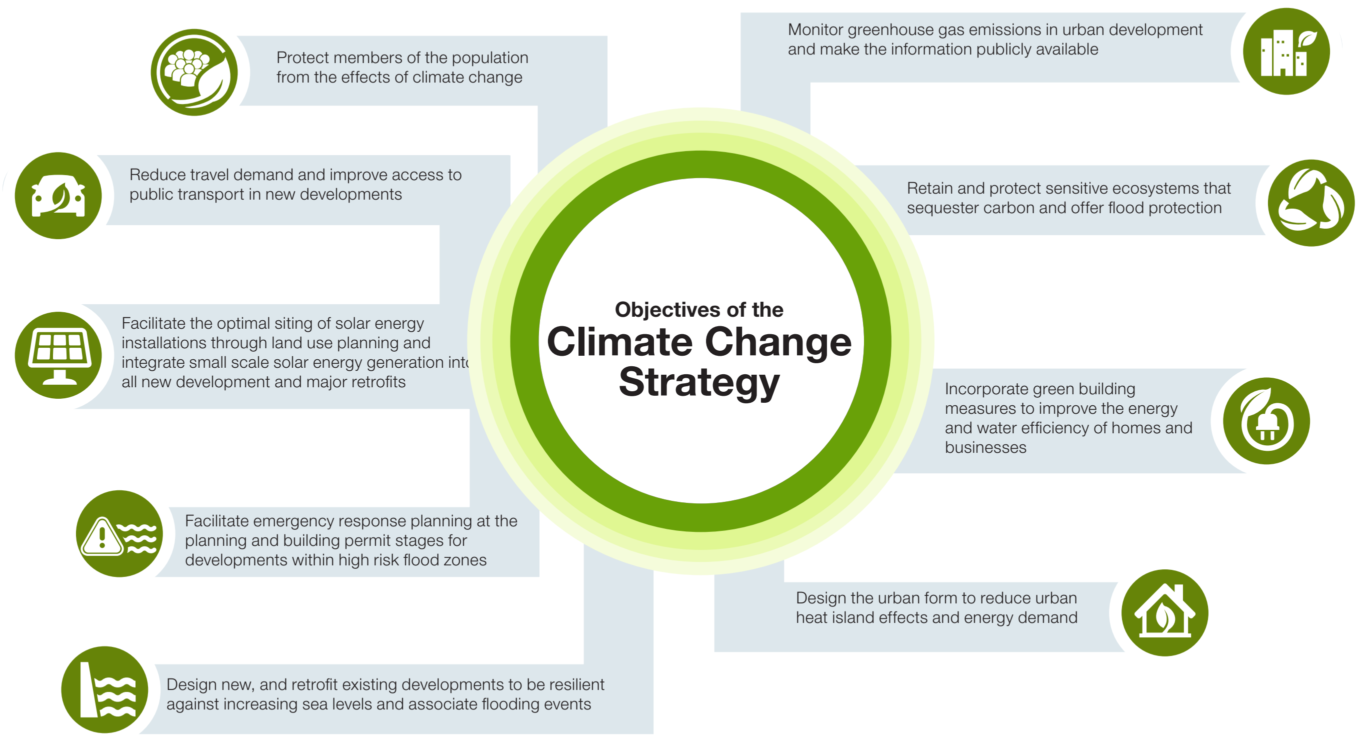


*Figure 1.2: CCS Objectives*

Specific actions have been identified which are intended to achieve outputs that, taken together will meet the objectives. These are summarised in the following sections.

# Summary of Action Plan

## Responding to Sea Level Rise and Flooding

Sea level rise is a function of a combination of factors, mainly thermal expansion of the oceans and an increase in loss of land ice (glaciers and ice sheets). As the response times for each of these drivers varies significantly, sea levels will be rising for hundreds if not thousands of years irrespective of mitigation of carbon emissions in the coming decades. The only uncertainty is the rate of rise, and the ultimate equilibrium global sea level. Accordingly, land that is considered presently vulnerable (i.e.in the period to 2100) will almost certainly be eventually inundated.

A number of initiatives are proposed to address the threats arising from long term sea level rise and associated risks.

### *SL 1: Establish Vulnerable Coastal Zone to communicate risk and regulate development*

In order to reduce the risk to property over the long term, new developments should be avoided in areas currently identified in the Coastal Flooding Maps (CFMs) as vulnerable, defined as having a 1% Annual Exceedance Probability (AEP) of flooding conditions occurring under Scenarios 6 (the 'worst case' scenario), which takes into account changes in rainfall intensity, sea level rise, and storm surge. The 1% AEP mapping should be used to produce a boundary within which there is a presumption against new development (Avoidance), with certain exceptions (such as temporary development, necessary and strategic defence or industrial installations). This land should be identified in the Municipality Spatial Development Plans (MSDPs) as the Vulnerable Coastal Zone (VCZ) with development restrictions. The actual boundaries of the VCZ should be based on the 1% AEP contour but will need to be rationalised to reflect the features of the natural and built environment.

### *SL 2: Update planning, policy and regulatory framework documents to address flood risk in vulnerable coastal areas*

MSDPs, where necessary, should be revised to require a Coastal Flood Risk Assessment that incorporates flood mapping. Any facilities within the VCZ or high risk areas landward of the VCZ should be required to adopt flood accommodation measures.

### *SL 3: Develop a framework to evaluate protection vs retreat options*

In areas with higher than acceptable risks (i.e. within the VCZ) some aspects of climate adaptation cannot be adequately managed through flood accommodation measures.

It is recommended that planning authorities should evaluate the social, economic and environmental cost: benefit of structural coastal protection measures vs strategic retreat. Such an evaluation can involve formal cost benefit studies or multi-criteria analysis of the options. This option evaluation process will identify:

- Whether interim protection measures are justifiable in each coastal management unit
- Where they are justifiable, the nature and timing of the works

In order to conduct studies on specific parts of the coast it will be necessary to designate coastal management "units" which separate the coast into sections that exhibit similar coastal processes and morphology. It will also be necessary to prepare a compendium of coastal protection measures appropriate to Qatar conditions.

### *SL 4: Develop a framework for the strategic retreat from vulnerable land*

Strategic retreat involves the safe removal or relocation of development, assets and settlements from encroaching shorelines, or areas vulnerable to flood or sea level rise, allowing the water to advance unimpeded. It involves abandoning, demolishing or moving existing buildings and infrastructure to higher ground. It also includes prohibiting new development in areas likely to be inundated.

There may be potential for compensation claims to be made where private land will be affected by erosion and inundation. Acquisition of land, through compulsory acquisition or market purchase can be explored for private land located within an identified area where a retreat strategy applies.

In new coastal development areas, the release of private land should consider leasehold rather than freehold sale, to avoid future pressures and costs to protect private coastal land.

In all instances, an effective and appropriate planning response is to place a notification on title on all affected landholdings, informing landholders of the status of the land being located within a vulnerable coastal area which has a retreat strategy applicable to it. This ensures all existing and potential land holders are aware of the risks, and assists to avoid an assumption that the land value will be retained in perpetuity through coastal protection works.

### SL 5: Implement emergency management measures

It is recommended that a flood Emergency Management Plan (EMP) be required from developers so that flood risk for each development within high risk flood zones is managed. Preparing a flood EMP enables strategic decisions about where, what and how to develop, while reducing residual risk to an acceptable level.

An EMP sets out the prevention, preparation, response, and recovery arrangements and the responsibilities of individuals, agencies and organisations with regards to these functions.

## Responding to Increasing Temperatures

Densely built inner city and urban areas have a propensity to store large amounts of heat because the density of buildings, networks of asphalt streets and concrete or stone paving and prevalence of concrete and steel, means they have a high thermal mass. These locations are often several degrees warmer than surrounding low density suburbs and rural countryside. The initial results of the Qatar University 'hot spot' study identify areas particularly prone to the heat island effect.

A number of initiatives are proposed to address the threats arising from increasing temperatures and the associated heat island effect.

### UH1: Improve green space in areas vulnerable to the Heat Island Effect

Green areas reduce the impact of hot days and the urban heat island effect through evaporative cooling and by providing shade. Opportunities exist to expand green areas through the greening of parking lots, developing green corridors along roads and pavements, and increasing publicly accessible green space.

### UH2: UH2: Ameliorate the Urban Heat Island Effect

It is proposed to integrate the Global Sustainability Assessment System (GSAS) Heat Island Effect Calculation into the building permit application process. The GSAS calculation computes pre and post albedo values (the ratio of solar energy reflected off a surface to incident solar energy) which determines the potential heat island effect due to the proposed development.

The adoption of design measures that incorporate a range of interventions aimed at passively cooling buildings (i.e. without the use of air conditioning) is proposed. Measures also include the adoption of traditional Middle Eastern architectural design practices.

Light coloured pavements if installed in public spaces and near roads will help to reflect heat rather than absorb it. This generally involves the use of concrete rather than bitumen, topping asphalt with a light-coloured aggregate, or applying a light-coloured overlay to existing pavement.

Measures to reduce energy use within buildings can also reduce the build-up of heat in the buildings and help to keep them cool. These measures include LED lighting, occupancy sensors and smart controllers for air conditioning.

### UH3: UH3: Introduce shading requirements

Shading systems such as awnings, sails, pergolas, photovoltaics as shading, arcades over pavements, public spaces and parking areas are an easy way of reducing the ground temperature and improving the amenity of an area for pedestrians. It is proposed to require shading of 60 % - 70% of hardscaped pedestrian pathways and parking areas, and 25% - 30% of hardscaped common areas.

### UH4: UH4: Support urban canyons and street orientation

'Cool islands' in urban areas can be formed by street canyons or narrow streets and tall buildings, especially if shade trees are also present. It is proposed to promote 'urban canyons' in city centres through the optimization of building heights, street widths, setbacks and site coverage, and to orient streets to allow penetration of cool coastal breezes.

### UH5: UH5: Develop a heat wave emergency response plan

For instances of extreme heat, it is necessary to develop a response plan that will reduce illness and death in the community due to heat stress, particularly among older people, children and other vulnerable groups. Given the increasing potential for extreme heat to occur in Qatar, heat-wave response planning is critical.

It is proposed that an emergency response plan is developed for cases of heat waves, which includes preparedness / preventive action, monitoring and communication, and a plan of action during the emergency.

## Reducing Greenhouse Gas Emissions

The key objective of the emission mitigation measures proposed are to place Qatar in a Leadership position, in the region, on tackling the issue of climate change.

Measures to mitigate greenhouse gas emissions include interventions to reduce the sources of emissions, or enhance carbon sequestration.

A range of measures has been identified to improve GHG mitigation in the land use sector in Qatar involving: reducing travel demand, improving energy and water efficiency, reducing the embodied energy of development, and promoting renewable energy.

### *GE1: Develop GHG emission inventory and benchmarks*

It will not be possible to measure the success of the CCS without a reasonably accurate measurement of GHG emissions from the built environment. Stage 5 of the present Project involves the development of a tool to estimate and predict GHG emissions from the built environment.

It is proposed to develop a consumption-based GHG emissions inventory for the built environment based on international best practice, devise emissions indicators appropriate for use in monitoring domestic GHGs, establish benchmarks and prepare and publish an annual report outlining consumption-based emissions and key metrics.

### *GE2: Create higher densities and mixed use to reduce travel demand*

Compact urban areas with high densities reduce the distance between land uses and make walking and cycling feasible alternatives to vehicle travel, while improving the feasibility of public transport. Locating different types of land uses near each other and within smaller development blocks reduces the need to travel because services are within walking or cycling distance of each other.

It is proposed to require compact, mixed use development in city centres and inner suburbs at the densities necessary to promote public transport use, integrate walking, cycling and public transport networks into existing mega-projects and require higher residential density targets for new development.

### *GE3: Improve walkability*

Reducing the demand for car travel requires the provision of appropriate public transport, walking and cycling facilities.

It is proposed to develop a street design code that stipulates walkability requirements within higher residential density centres and mixed use zones, and progressively upgrade existing areas for compliance with the street design code, where possible.

### *GE4: Create Transit Oriented Development*

Transit Oriented Development (TOD) is the creation of compact, walkable, pedestrian-oriented, mixed-use communities centred around high quality public transport systems.

It is proposed to establish mixed use zones within 480 m of the planned stations of the Doha Metro, and create a zone a further 480 m from this radius for medium density and other uses that would benefit from proximity to rail stations, including park and ride facilities. It is also proposed to require public facilities (e.g. town/district centres, parks, schools, sports clubs) to be accessible by walking, cycling or public transport.

### *GE5: Introduce parking restrictions*

Studies have determined that “higher motoring and parking costs will be more effective than well-intended urban design strategies at creating the kinds of urban densities needed for cost-effective transit services”. In other words, car drivers with established patterns of transport are likely to need disincentives to driving as well as incentives to switch from their cars to other transport modes.

It is proposed to introduce parking fee minimums, require companies to provide the minimum number of parking spaces necessary for their workforce, stipulate parking maximums for development in zones with good public transport and incorporate the final stipulations from the Qatar Parking Master Plan within the MSDP Zoning Regulations.

### *GE6: Improve energy efficiency in new development*

Qatar’s Vision 2030 and the Qatar National Development Strategy 2011-2016 aim to reduce the energy intensity of the economy through awareness campaigns, standardisation and shutdowns. By far the most cost-effective mitigation action is the avoidance of emissions through energy efficiency measures.

It is proposed to mandate a minimum of GSAS Level 2 energy performance for all new development.

### GE7: Improve water efficiency

Qatar has very limited potable water resources and consequently the country largely relies on desalination plants, which are highly energy intensive. Therefore reducing water consumption will also reduce Qatar's GHG emissions.

It is proposed to mandate a minimum of GSAS Level 2 water performance for all new development, require major industrial and agricultural developers to prepare water efficiency plans, require the use of certain water efficient irrigation practices and mandate the use of native and drought-tolerant species.

### GE8: Increase the use of recycled water in new development

By requiring the reuse of water in future developments, demand for water resources would decrease.

It is proposed to incentivise or require new developments to incorporate wastewater recycling facilities for the production of greywater or recycled wastewater for non-drinking purposes such as watering street trees or irrigation.

### GE9: Improve the energy and water efficiency of retrofitted development

Retrofitting of existing buildings offers the possibility of making them more energy and water efficient. Some measures include; improved insulation, LED lighting and lighting controls, more efficient cooling systems, photovoltaics and water efficient fixtures and fittings.

### GE10: Reduce the embodied energy of development

'Embodied energy' is the energy needed, directly or indirectly, in constructing and demolishing a building. Embodied energy can account for up to half of a building's lifetime $CO_2$ emissions. As such, retrofitting a building to extend its life is often more energy-efficient than constructing a new building. Using recycled/reused building materials is also a way of reducing embodied energy.

It is proposed to require developers to consider retrofit/ refurbishment over new build, demonstrate how they will minimize their use of virgin materials, and recycle the maximum amount of the building materials.

### GE11: GE11: Design for structure reuse

The embodied energy of development is also reduced by ensuring that buildings, or at least their component materials are adaptable and can be disassembled. Designing buildings for re-use or re-purposing (so-called 'adaptive reuse) is one way of achieving this objective, and ensuring their components can be re-used is another.

It is proposed to require developers to produce designs that facilitate the re-purposing of the building and reuse of their components.

### GE12: GE12: Plan for large scale renewable energy production

As Qatar's heavy use of fossil fuel-generated power is a primary contributor of greenhouse gas emissions, transitioning to renewable energy has the potential to significantly reduce Qatar's greenhouse gas emissions over time. The Qatar National Vision 2030 establishes a 20% renewable energy target by 2024.

It is proposed that MME identify and reserve possible sites for medium to large-scale photovoltaic energy developments near high voltage infrastructure, and depict them on the MSDP zoning maps.

### GE13: GE13: Increase onsite renewable energy in new development

As Qatar has some of the best solar insolation characteristics in the world, and is a manufacturer of solar technology, new developments can play an important role by simultaneously supporting local industry and reducing emissions by mandating solar Photo Voltaic (PV) in new developments.

It is proposed to require all new developments and major retrofits to produce at least 20% of their energy needs from on-site renewable energy, that all roofs be capable of supporting solar PV panels, and protect solar access for rooftop solar PV. An additional requirement is to ensure that there are no planning or design restrictions that will prevent the installation of small-scale renewable energy systems, and alternatively provide regulatory incentives for the installation of onsite renewable energy systems.

## Protecting Biodiversity

The rich biodiversity of the Arabian Gulf includes dozens of mammal species, hundreds of bird species, and scores of amphibian and reptile species; and highly productive coastal habitats, including intertidal mudflats, seagrasses, algal beds, mangroves, and coral reefs, and a variety of fish species. Climate change is a major threat to the retention of this biodiversity.

Ecosystems such as mangroves, rawdah, wadis, urban parks, sea grass communities and coral reefs provide important ecological services. These include the provision of food, soil formation, and nutrient cycling. Mangrove forests and seagrass communities are also highly productive carbon sinks with production rates equivalent to tropical humid forests.

### *PB1: Introduce buffer zones to protect sensitive ecosystems*

Sensitive ecosystems include Protected Areas, mangroves, coral reefs, sea grasses, and other habitats that are not formally protected but are of ecosystem importance. Buffer zones around sensitive habitats help to protect these ecosystems from the impacts of development which include dust, noise, light, recreational disturbance, and run off.

It is proposed to commission a study into appropriate buffer zones and migration corridors for Qatar's Protected Areas and mangroves. As an interim measure, it is recommended to prohibit development within 250 m of Protected Areas, mangroves, seagrass and coral reefs.

### *PB2: Introduce environmental offsets*

An environmental offset compensates for unavoidable impacts on valuable species and ecosystems. It is proposed that an environmental offset should be required as a condition of approval when any development is likely to result in a significant residual impact on valuable species and ecosystems, especially on mangroves, seagrass and coral reefs.

# Implementation of the CCS

An implementation framework has been developed which, for each of the specific actions:

- Establishes the mechanism of implementation, including the relevant standard / code / policy that is related to the specific action
- Sets out the approximate timeframe for implementation, defined as: Immediate, Short term (2 – 5 year) or Long term (>5 year)
- Outlines the proposed performance indicator
- Where appropriate, describe the targets related to performance indicators
- Identifies the parties mainly responsible for this output, and those whose assistance will be required
- Provides an indication of the resource implications of the actions; defined as: Low cost, Medium cost, or High cost

## Change Management

The change management process is the sequence of steps or activities that a team or project leader follow to apply changes in order to drive individual or entity transitions and ensure the project meets its intended outcomes.

The two key challenges involved in the implementation of the CCS will be:

- Getting stakeholders/agencies/communities on board and ensuring their understanding of the objectives and the specific actions relevant to them
- Achieving the cooperation of stakeholders/agencies/communities in successfully progressing the actions

The change management process should incorporate engagement with:

- Government Agencies
  - The Urban Planning Department – as the entity mainly responsible for implementation
  - Other departments within the Ministry of Municipality and Environment whose participation is required, i.e. the Infrastructure Planning Department, the Public Parks Department, the Building Permit Complex, and the Laboratories and Standardization Affairs Department
  - Other government agencies whose participation and cooperation is required, i.e. Ashghal, Kahramaa, and the Ministry of Interior
- Development Community
  - The private development community, i.e. developers, construction firms, and consultants
- The public

## Monitoring and Evaluation

An outline monitoring and evaluation (M&E) plan has been developed that describes how the program works, including the indicators, who is responsible for collecting them, and how the data will flow through the organisation. The core of the M&E plan is the logical framework , which summarises the key elements of the strategy, identifies indicators, and the means by which verification will be achieved.

Indicators, and where applicable benchmarks and targets, have been developed for each level of the framework hierarchy. Where information is not presently available or sufficient to establish benchmarks / targets for some of the quantitative indicators, specific actions have been proposed as part of the implementation process to establish these.

## Implications of implementing the CCS

A qualitative assessment of the consequences of the CCS implementation of each specific action has been undertaken in respect of the resource implications for MME.

The resource implications for implementation of the CCS are considered to be relatively modest, and the effort for most actions can be absorbed within the agency, albeit with additional staff and / or external consultancy support.

The direct social impacts of the CCS are overwhelmingly positive, particularly in respect of the reduced risk of health and safety impacts arising from flooding and heat stress.

The direct economic consequences are also mainly positive, with reduced costs of energy and water accruing to households and businesses. However some resistance from developers to these (and any new) measures is to be expected as some will increase construction costs, while savings accrue to owners and occupiers. A rational approach to the retreat from vulnerable coastal land will also yield positive economic benefits as losses of land value will be offset by avoided costs of flood damage and relocation of assets over time as sea levels rise.

The direct environmental consequences are also mainly positive as the CCS will lead to protection and / or reinstatement of threatened coastal ecosystems, and reduced pollution.

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# Acronyms and abbreviations

| Acronym / abbreviation | Definition |
|---|---|
| AAP | Area Action Plan |
| AEP | Annual Exceedance Probability |
| ARI | Average Recurrence Interval |
| Ashghal | Public Works Authority |
| CCIAT | Climate Change Impact Assessment Tool |
| CCS | Climate Change Strategy |
| CFR | Coastal Foreshore Reserve |
| CO2 | Carbon Dioxide |
| CO2e | CO2 equivalent |
| DDG | Developers Drainage Guide |
| DFE | Defined Flood Events |
| DFL | Defined Flood Level |
| EIA | Environmental Impact Assessment |
| EMP | Emergency Management Plans |
| FHO | Flood Hazard Overlay |
| FIFA | Fédération Internationale de Football Association |
| GCC | Gulf Cooperation Council |
| GDP | Gross Domestic Product |
| GFA | Gross Floor Area |
| GHD | GHD Global Pty Ltd |
| GHG | Greenhouse Gas |
| GIS | Geographical Information System |
| GORD | Gulf Organisation for Research and Development |
| GSAS | Global Sustainability Assessment System |
| ICZMP | Integrated Coastal Zone Management Plan |
| IDRIS | Inner Doha Re-Sewerage Implementation Strategy |
| IPCC | Intergovernmental Panel on Climate Change |
| IPD | Infrastructure Planning Department |
| KAHRAMAA | Qatar General Electricity and Water Corporation |

| Acronym / abbreviation | Definition |
|---|---|
| kg | Kilogram |
| LCA | Life Cycle Assessment |
| MCA | Multi-criteria Analysis |
| MDPS | Ministry of Development Planning and Statistics |
| MENA | Middle East and North Africa |
| MME | Ministry of Municipality and Environment |
| MMUP | Ministry of Municipality and Urban Planning |
| MSDP | Municipal Spatial Development Plan |
| Note: Table continued on next page. | |
| MtCO2e | Million tonnes CO2 equivalent |
| NOAA | National Oceanic and Atmospheric Administration |
| NPRP | National Priorities Research Program |
| PMF | Probable Maximum Flood |
| PV | Photo Voltaic |
| QCS | Qatar Construction Specifications |
| QEERI | Qatar Environment and Energy Research Institute |
| QGBC | Qatar Green Buildings Council |
| QHDM | Qatar Highway Design Manual |
| QIDMP | Qatar Integrated Drainage Master Plan |
| QNDF | Qatar National Development Framework |
| QNDS | Qatar National Development Strategy |
| QNFSP | Qatar National Food Security Programme |
| QNMP | Qatar National Master Plan |
| QNV2030 | Qatar National Vision 2030 |
| QSAS | Qatar Sustainability Assessment System |
| QSDDM | Qatar Sewerage and Drainage Design Manual |
| QU | Qatar University |

| Acronym / abbreviation | Definition |
|---|---|
| SESRI | Qatar University's Social and Economic Survey Research Institute |
| SLR | Sea Level Rise |
| sq km | Square Kilometre |
| TOD | Transit Oriented Development |
| TSE | Treated Sewage Effluent |
| UAE | United Arab Emirates |
| UDC | United Development Company |
| UHI | Urban Heat Island |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNFAO | United Nations Food and Agriculture Organisation |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UPD-MME | Urban Planning Department – Ministry of Municipality and Environment |
| US EPA | United States Environmental Protection Agency |
| VCZ | Vulnerable Coastal Zone |
| WHO | World Health Organisation |
| WMO | World Meteorological Organization |

# Definitions

| Term | Definition |
|---|---|
| Vision | The vision statement sets the overall course for the Climate Change Strategy for Urban Planning and Urban Development in Qatar. |
| Objectives | The Objectives set the general direction of how the issues pertaining to climate change applicable to the urban planning and urban development sector in Qatar will be addressed. |
| Specific Actions | The tangible results (mitigation/adaptation measures) arising from the objectives. |
| CCD – Cooling degree days | A CDD is defined as the difference between the daily mean temperature and a base outdoor temperature at which indoor cooling would start to be required. |
| RCP 4.5 | RCP 4.5 is defined as the representative concentration pathways (RCPs) adopted by the IPCC for its fifth Assessment Report of 2013. RP4.5 assumes that greenhouse gas emissions peak around 2040 and then decline. |
| RCP 8.5 | RCP8.5 assumes that emissions continue to rise throughout the 21st century and represents the 'business as usual' scenario. |
| Storm surge | The storm surge is the increase in wave height expected during storms. |
| Total flooding | Area flooding in total under the worst-case scenario simulation. |
| Incremental flooding | Difference in areas flooded under worst-case scenario versus the base case simulation. |
| Passive Cooling | Passive cooling is used to describe cooling without the use of electricity. When discussing passive cooling in this report, we also include measures that use electricity but that are much more energy-efficient than air conditioning, e.g. fans and night-time heat flushing. |
| Mitigation | An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2001a). |

| Term | Definition |
|---|---|
| Adaptation | Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001a). |
| Annual Exceedance Probability (AEP) | The chance of a flood of a given size exceeding in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 $m^3/s$ has an AEP of 5%, it means that there is a 5% chance (1 in 20 chance) of a 500 $m^3/s$ event being exceeded in any one year (see ARI). |
| Average Recurrence Interval (ARI) | The likelihood of occurrence, expressed in terms of the long-term average number of years, between flood events as large as or larger than the design flood event. For example, floods with a discharge as large as or larger than the 100-year ARI flood will occur on average once every 100-years. ARI is related to AEP and Odds of Flooding as follows: ARI in years equals the reciprocal of AEP expressed in terms of chance. For example, a 1% AEP flood has a chance of occurrence in any year of 0.01, and an associated ARI of 100 years. The Odds of Flooding are equal to the ARI in years. Therefore, the 100 year ARI flood is also the 100:1 flood (see also Annual Exceedance Probability). |
| Vulnerable Coastal Zone (VCZ). | Areas that have a 1% Annual Exceedance Probability (AEP) of flooding conditions under the 'worst-case' scenario, which takes into account changes in rainfall intensity, sea level rise and storm surge. |

| Term | Definition |
|---|---|
| Defined Flood Events (DFE), Defined Flood Level (DFL) and Freeboard level | Design levels includes Defined Flood Events (DFE), Defined Flood Level (DFL) and Freeboard level. These levels determine the flood extent in a particular area and the resulting recommended building floor levels and appropriate design responses. Definitions should be standardised across all levels of government to ensure consistency.<br>A DFE is the flood event selected for the management of flood hazard for the location of specific development as determined by the appropriate authority. It is a flood of known magnitude or average recurrence interval, or a historic event, which is selected for land use planning, emergency planning and engineering design purposes. Note that the design flood does not define the maximum extent of land liable to flooding, which is defined by the Probable Maximum Flood (PMF).<br>DFE is illustrated with Flood hazard mapping, including SLR estimates, shows the extent, depth, velocity and hazard of flooding. This mapping is an important tool for the preparation of flood management plans, emergency management plans and planning and building controls.<br>The DFE may be based on a number of flood events (high, med, low) with differing resulting DFLs for different types of development e.g. DFL lower for industrial development than residential DFL. The DFL is the flood level associated with a DFE relative to a specified datum. The DFL plus the freeboard determines the extent of the flood hazard area.<br>Freeboard is a factor of safety above DFL, used in relation to the setting of floor levels, and levee heights. It is usually expressed as a height above the DFL. Freeboard tends to compensate for flood prediction uncertainties and for factors which increase flood levels, such as a wave action, localised hydraulic effects, settlement of levees. It should not be relied upon to provide protection for events larger than the DFE. |

# 1

# Introduction

# 1 Introduction

GHD Global Pty Ltd (GHD) has been engaged by the Urban Planning Department of the Ministry of Municipality and Environment (MME) to develop a "Climate Change Strategy (CCS) for Urban Planning and Urban Development Sector in the State of Qatar". This report comprises Stage 4 of the CCS – Strategy development and action plans.

## 1.1 Project Description

Qatar has seen immense growth in industry, population and size of urban settlements over the last 30 years. This has been driven by the oil and natural gas reserves that have been developed, contributing to one of the highest per capita Gross Domestic Product (GDP) in the world (Forbes, 2012). In response to this growth, a number of documents have been developed to guide and manage the impacts associated with these changes, including:

- Qatar National Vision 2030 (QNV 2030)
- Qatar National Development Strategy 2011-2016 (QNDS 2011-2016)
- Qatar National Masterplan (QNMP)

One aspect identified in multiple plans was the potential impact of climate change on Qatar. This has led Qatar to undertake studies to understand the impacts and challenges associated with climate change.

The primary objective of this CCS is to address how urban planning and urban development can be managed to reduce the impact of climate change. The focus on urban planning and development is achieved by concentrating on aspects directly or indirectly related to spatial land use in Qatar that influence or can be impacted by climate change.

## 1.2 Project Scope

The CCS for urban planning and urban development in the State of Qatar comprises the following stages:

- Stage 1: Inception
- Stage 2: Data and information collection and assessment
- Stage 3: Situation analysis
- Stage 4: Strategy development and action plans (**this report**)
- Stage 5: Climate Change Impact Assessment Tool (CCIAT)

The process for delivery of the other stages is detailed in the Project Method Statement (GHD Ref: 75/11199/102227).

## 1.3 Purpose of this Document

This report comprises the deliverable for Stage 4 of the Project and presents climate change mitigation and adaption measures for Qatar in relation to urban planning and climate change with associated action and implementation plans. The measures and plans in this document have been prepared to address the issues raised during Stage 3 of the study, whereby an analysis of the climate change situation in Qatar was undertaken and a risk assessment of the issues completed to prioritize actions.

## 1.4 Structure of the Document

The structure of this document follows the outline provided in Figure 1.1.

| | | |
|---|---|---|
| 01 | Introduction | This section provides Project background, defines the scope, states the purpose of this document, and provides a summary of the structure of the document. |
| 02 | Climate Change Strategy Approach | This section provides a summary of the findings from Stage 3 of the Project, where an analysis of the current situation in Qatar in relation to urban planning and climate change was undertaken.<br>The vision and objectives for the Climate Change Strategy are also presented in this section. |
| 03 | Responding to Sea Level Rise and Flooding | This section provides the context of sea level rise and flooding as a result of Climate Change and identifies adaptation measures to respond and achieve the set objectives. |
| 04 | Responding to Increasing Temperatures | This section provides the context of increasing temperatures as a result of Climate Change and identifies mitigation and adaptation measures to respond and achieve the set objectives. |
| 05 | Reducing Greenhouse Gas Emissions | This section provides the context of greenhouse gas emissions in relation to urban planning in Qatar and identifies mitigation and adaptation measures to respond and achieve the set objectives |
| 06 | Protecting Biodiversity | This section provides the context of the ecosystems and protected areas in Qatar and identified adaptation measures to reduce the impact on these sensitive ecosystems from Climate Change. |
| 07 | Implementation Framework | This section provides the details of how the mitigation and adaptation measures specified in this document can be implemented, monitored, and evaluated. |
| 08 | Gap Analysis | This section presents the gap analysis undertaken as part of Stage 3 of the Project and identifies which strategies proposed in this report fill the identified gaps. |
| 09 | References | This section provides a list of all the articles, journals, papers, technical and scientific reports referenced during the development of this document. |

*Figure 1-1: Structure of the document*

# 2

# Climate Change Strategy Approach

# 2 Climate Change Strategy Approach

## 2.1 Climate Change Situation in Qatar

The Stage 3 report prepared for this Project presents an analysis of the current situation in Qatar in relation to urban planning and climate change. The Stage 3 report investigated and addressed the following:

- The nature of land use and developments together with a review of the current and potential future population
- Climate change impacts
- Risk assessment of climate change
- Existing climate change management

A summary of the findings for each of the above aspects is provided in the following sub sections.

### 2.1.1 Land Use and Population

An assessment of the existing and projected future land uses and population for Qatar was undertaken. Currently, desert is the most dominant land use (82%), although there has been rapid urbanisation since 2008. The majority of the population reside on the coast, focussed in Doha and Al Rayyan municipalities, with Doha comprising the most densely populated municipality by a large amount, although it also comprises the smallest municipality. Urban sprawl is considered to be one of the key current issues, resulting in large areas of low-density residential areas, which is land-intensive. Another key issue is major infrastructure projects being completed in isolation to national urban planning, meaning that the majority of Qatar's new developments are located on or in proximity to the low lying coastline and the required climate change mitigation and adaption measures are not or may not be implemented.

The projected dominant land use for 2032 is desert, followed by the newly classified 'Environmental Conservation Zone / Agricultural and Green Areas', 'Special Development Areas', 'Transportation and Utility (Roads)', 'Industrial', 'Residential', 'Special Use', 'Parks and Recreation', 'Mixed use', and 'Commercial' zones. Low density residential land use would outweigh proposed medium and high density residential, which could exacerbate the current urban sprawl issue.

The projected average future population (2032) for Qatar is 2.1 million, while the projected maximum density scenario is 3.2 million. An overall reduction in population size is projected, which is potentially attributed to the expected reduction in migrant workers once the major infrastructure projects currently under construction in advance of the 2022 FIFA World Cup are completed (QNMP).

### 2.1.2 Climate Change Impacts in Qatar

Of the Middle East and North Africa (MENA) countries, Qatar is the most vulnerable to sea level rise and associated flooding, as a 1-m rise in sea level would affect about 3% of its area, while a 3-m rise would affect 8%. A flood study was completed for Qatar, which modelled flooding under various climate change scenarios with varying levels of rainfall intensity, sea level rise, and storm surge. In general, low intensity floods of short duration (typically less than a day) with shallow flood depths (typically < 0.5 m) were projected for Qatar. This flooding would be spread out; primarily due to the flat nature of the terrain. The study found that the majority of the land that is projected to be flooded is desert, with 83% of the total projected inundated area comprising this land use. However, around one third of all other land use areas was projected to be affected. Depending on the land use type, the economic, social and environmental impacts would vary, although the flood modelling projected that much of Qatar's critical infrastructure would be affected by a base case flood including power and water supply infrastructure as well as emergency services and hospitals. Within Doha City Centre, the modelled flood simulations projected that a number of areas are projected to be inundated by up to 2 m of water.

With regards to temperature rise, the IPCC expects temperatures in Middle Eastern countries (including Qatar) to rise by about 2°C in the next 15-20 years, and by more than 4°C by the end of the century. In urban areas, this will be exacerbated by heat island effect intensified in:

- Built-up areas, particularly roads
- Inland areas compared with those nearer the sea (coastal areas)
- Areas with higher population densities

The areas assessed to be particularly affected by the heat island effect were Doha and Al Rayyan municipalities, with six areas noted to be affected in each, while Al Daayen and Umm Slal included one area each. Increased heat can result in critical human health issues as well as impacts to biodiversity and an increase in GHG emissions due to increased power requirements. With regards to GHG emissions, the 2012 per capita GHG emissions for Gulf countries published by World Resources Institute revealed that Qatar had the highest per capita GHG emissions from power and transportation categories. Based on the 2014 data, private passenger vehicles including taxis and motorcycles contributed approximately 99% of the transportation GHG emissions. This data demonstrates the need for public transportation to lower GHG emissions.

### 2.1.3 Risk Assessment

A number of key issues were highlighted during the review of climate change impacts in Qatar. Each of these key issues were then assessed via a risk assessment to categorize the risk level, which ranged from low to extreme. During the development of the CCS objectives, an evaluation and assessment was undertaken of the issues identified in Stage 3. The issues have been categorized based on the common key elements (e.g. Sea Level Rise (SLR), Urban Heat Island (UHI), Greenhouse Gas (GHG), and Protecting Biodiversity (PB)). A summary of the Risk Assessment undertaken during Stage 3 along with the key element associated with each issue is provided in Table 2-1 for reference.

The detailed Risk Assessment is available in the Stage 3 Report (Table 5-5, p. 105). For the assessment undertaken in Stage 3, the worst-case scenario conditions were chosen as they represent the extreme scenario and provide a conservative approach for planning. The specifies of the scenario is as follows:

- Future climate era: 2100
- Change in rainfall intensity by IPCC Representative Concentration Pathways (RCP) 8.5: + 30%
- Tide conditions: Mean higher high water (MHHW)
- Sea level rise (m) above IPCC RCP 8.5: +0.98
- Storm surge (m) above IPCC RCP 8.5: +0.5
- Resultant sea level (m): MHHW + 1.48

The above scenario, in addition to an average recurrence interval (ARI) design storm event of 1 in 100 years, also takes into account changes in rainfall intensity, sea level rise and storm surge.

Table 2-1: Summary of Risk Assessment

| ID | Identified Issue | Risk | Key Element | | | |
|---|---|---|---|---|---|---|
| | | | SLR | UHI | GHG | PB |
| I-1 | Al Shamal has isolated scattered mangrove communities along the coast that are threatened by sea level rise. | High | X | | | X |
| I-2 | Roughly 33% of Al Shamal is projected to flood under the 100 yr ARI climate change scenario. | High | X | | X | |
| I-3 | Al Shamal Police Station would be completely inundated with up to 0.75 m flood levels. | High | X | | | |
| I-4 | Roughly 37% of Al Shahaniya would flood under the 100 yr ARI climate change scenario. | High | X | | | |
| I-5 | Al Shahaniya Health Centre would be flooded in parts up to 0.3 m. | Moderate | X | | | |
| I-6 | Dukhan Health Centre would be flooded in parts up to 0.2 m. | Low | X | | | |
| I-7 | Al Kisah appears to be significantly warmer compared to other areas. | High | | X | | |
| I-8 | Simaisima has a small isolated mangrove colony which is constrained by urban development. | High | | | | X |
| I-9 | Approximately 33% of Al Daayen could flood as a result of the 100 yr ARI climate change scenario | High | X | | | |
| I-10 | Al Daayen health centre would be flooded up to 0.2 m. | Low | X | | | |
| I-11 | Al Rayyan (especially Al Waab, New Industrial Area, Mebaireek, and Muaither) appears to be significantly warmer compared to other areas. | Extreme | | X | | |
| I-12 | Al Gharaffa and Madinat Khalifa areas show a general trend of higher temperatures when compared to other areas in Qatar. | High | | X | | |
| I-13 | Approximately 33% of Al Rayyan could flood under the 100-yr ARI climate change scenario. | High | X | | X | |
| I-14 | Al Rayyan Health and Paediatrics Centre would be flooded in parts up to 0.2 m. | Low | X | | | |
| I-15 | Dr Ayad Al Shakarchi Medical Centre would be flooded in parts up to 0.5 m. | High | X | | | |
| I-16 | The Al Khor mangrove forest is constrained by urban development in the southern and eastern sections. | High | | | | X |
| I-17 | Seagrass communities offshore of Al Khor will be threatened by rising sea levels. | High | X | | | X |
| I-18 | Approximately 39% of Al Khor and Al Thakhira could flood under the 100 yr ARI climate change scenario. | High | X | | X | |
| I-19 | Most of Ras Laffan Industrial City is projected to be flooded to > 2.0 m. | High | X | | | |
| I-20 | Al Khor Medical Centre would be flooded up to 0.2 m. | Low | X | | | |

| ID | Identified Issue | Risk | Key Element | | | |
|---|---|---|---|---|---|---|
| | | | SLR | UHI | GHG | PB |
| I-21 | A number of areas within Doha are assessed to be significantly warmer compared to other areas, including the industrial area, garden city, Madinat Khalifa and Ferej Al Ali. | Extreme | | X | | |
| I-22 | Salwa road notably shows the heat island effect due to a combination of larger areas of impermeable surfaces. | High | | X | | |
| I-23 | Hamad International Airport shows the heat island effect due to the large area of impermeable surface and heat from airplanes. | High | | X | | |
| I-24 | The mangroves north of the Pearl and at Katara Cultural Village have no potential to expand or grow landward in response to sea level rise. | High | X | | | X |
| I-25 | Roughly 33% of Doha municipality would flood under the 100 yr ARI climate change scenario. Particularly significant flooding is expected at the airport and to a lesser extent at Souq Waqif area. | High | X | | X | |
| I-26 | Al Emadi Hospital and Airport Health Centre would be flooded up to 0.2 m. | Low | X | | | |
| I-27 | HC Heart Hospital, West Bay Health Centre and Al Jazeera Medical Centre would be flooded in parts up to 0.5 m. | High | X | | | |
| I-28 | Aster Hospital, Dr. Ayad Al Shakarchi Medical Centre and Icon Medical Centre would be flooded in parts from 0.2 m up to > 1.0 m. | High | X | | | |
| I-29 | Former Civil Defense Wadi Al Sail would be flooded in parts up to 0.75 m. | High | X | | | |
| I-30 | The mangroves at Mesaieed and Al Wakrah have no potential to expand or grow landward in response to sea level rise. | High | X | | | X |
| I-31 | Roughly 33% of Al Wakrah would flood under the 100 yr ARI climate change scenario. | High | X | | X | |
| I-32 | Roughly 10% of the municipality would be subject to major flooding of up to 2 m over large areas of Mesaieed industrial city and to the south of Mesaieed. | High | X | | X | |
| I-33 | Al Wakra Health Centre would be flooded in parts up to 0.3m. | Moderate | X | | | |
| I-34 | KIMS Qatar Medical Centre would be flooded in parts up to 0.2 m. | Low | X | | | |
| I-35 | Umm Slal Muhammed area shows higher temperatures compared to other areas in Doha. | High | | X | | |
| I-36 | Roughly 31% of the municipality would flood under the 100-yr ARI climate change scenario. | High | X | | X | |
| I-37 | Al Kharaitiyat Medical Centre would be flooded in parts up to 0.2 m. | Low | X | | | |

The following risk levels were designated for the 37 identified issues evaluated:

- The majority (71%) were evaluated to be high risk and therefore require intervention in the short term. These issues mainly corresponded to flooding and sea level rise impacts to municipalities and critical infrastructure.
- Two issues were evaluated to be an extreme risk, both of which related to temperature as a result of the projected increase in temperatures combined with the heat island effect. These two issues would require urgent intervention.
- Two issues were assessed to have moderate risk, associated with the projected flooding of health centres to depths of < 0.5 m. These items can be addressed in the longer term.
- Seven issues (18%) were evaluated as low risk, which related to critical infrastructure experiencing 100-yr ARI flooding at less than or equal to 0.2 m. These items, along with the moderate risk category, can be addressed in the longer term.

#### 2.1.4 Existing Climate Change Management in Qatar

A number of studies and initiatives addressing climate change have been undertaken by the community and private entities in Qatar, which were reviewed as part of this study. For example, 'A climate change and temperature warning in Qatar' study was undertaken by Qatar University's Social and Economic Survey Research Institute (SESRI). From these studies and initiatives, it can be surmised that there is a general acknowledgement and understanding of climate change and its effects in Qatar by its citizens and commercial entities. However, knowledge of certain impacts and how they may be mitigated seems limited. This may negatively affect the support of changes introduced by the government in terms of development controls, funding direction and actions required of the community itself.

There is an opportunity for the outcomes of this study to encourage the preparation of an education campaign to increase awareness and support of new climate change management and mitigation measures that may be adopted by the MME. It may also lead to innovative solutions implemented by the private sector and community groups.

Further, a review of existing planning frameworks, policies, action plans, strategies, guidelines and applicable international treaties and conventions was undertaken to understand the limitations of the current planning framework and interventions in comparison to identified key climate change issues in Qatar. From a review of a range of framework documents, it is clear that a role exists for intervention from the urban planning and development sector in the form of policy and guideline development that assists in addressing and responding to the various climate change impacts experienced in Qatar. Notably, with regards to the urban heat island effect, urban design also has a role in influencing design outcomes that serve to mitigate against such impacts in the public realm.

The next steps for the CCS are to develop Qatar's climate change strategy and specific actions which have been presented in this report.

### 2.2 Vision

The vision statement sets the overall course for the Climate Change Strategy for Urban Planning and Urban Development in Qatar. The vision statement was developed by reviewing existing climate change policy outcomes in the QNDF, QNV2030, and other Qatari planning framework documents.

The Vision for the Climate Change Strategy for Urban Planning and Urban Development in Qatar has been defined as *"Urban development in Qatar will progressively reduce average per capita greenhouse gas emissions and be resilient to the potential impacts from climate change"*

#### 2.2.1 Objectives

The Objectives set the general direction of how the issues identified as part of the Issue Prioritization, in Stage 3 of the Project (Table 5-7, p. 98), will be addressed. The objectives are presented in Figure 2.1.

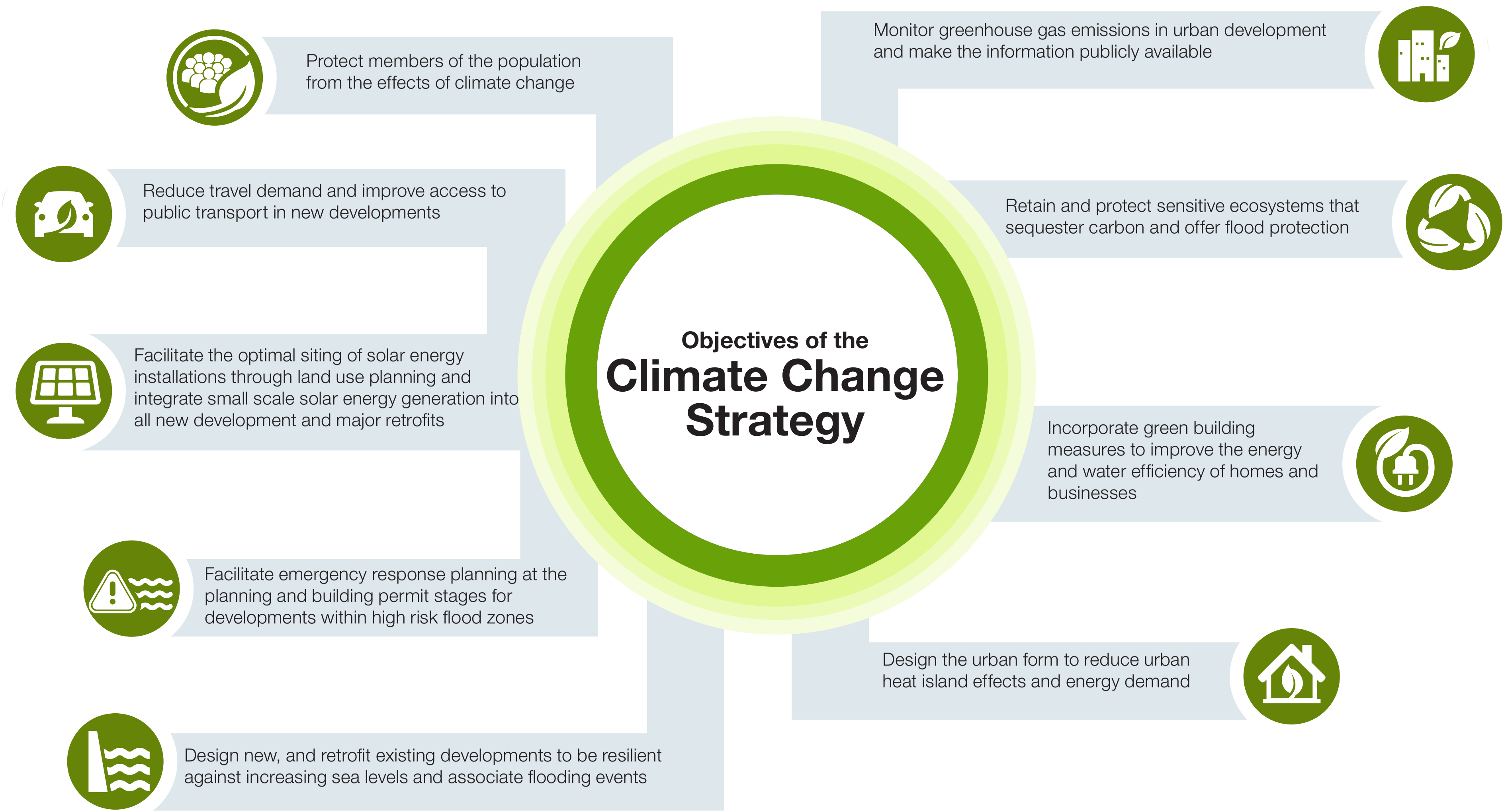
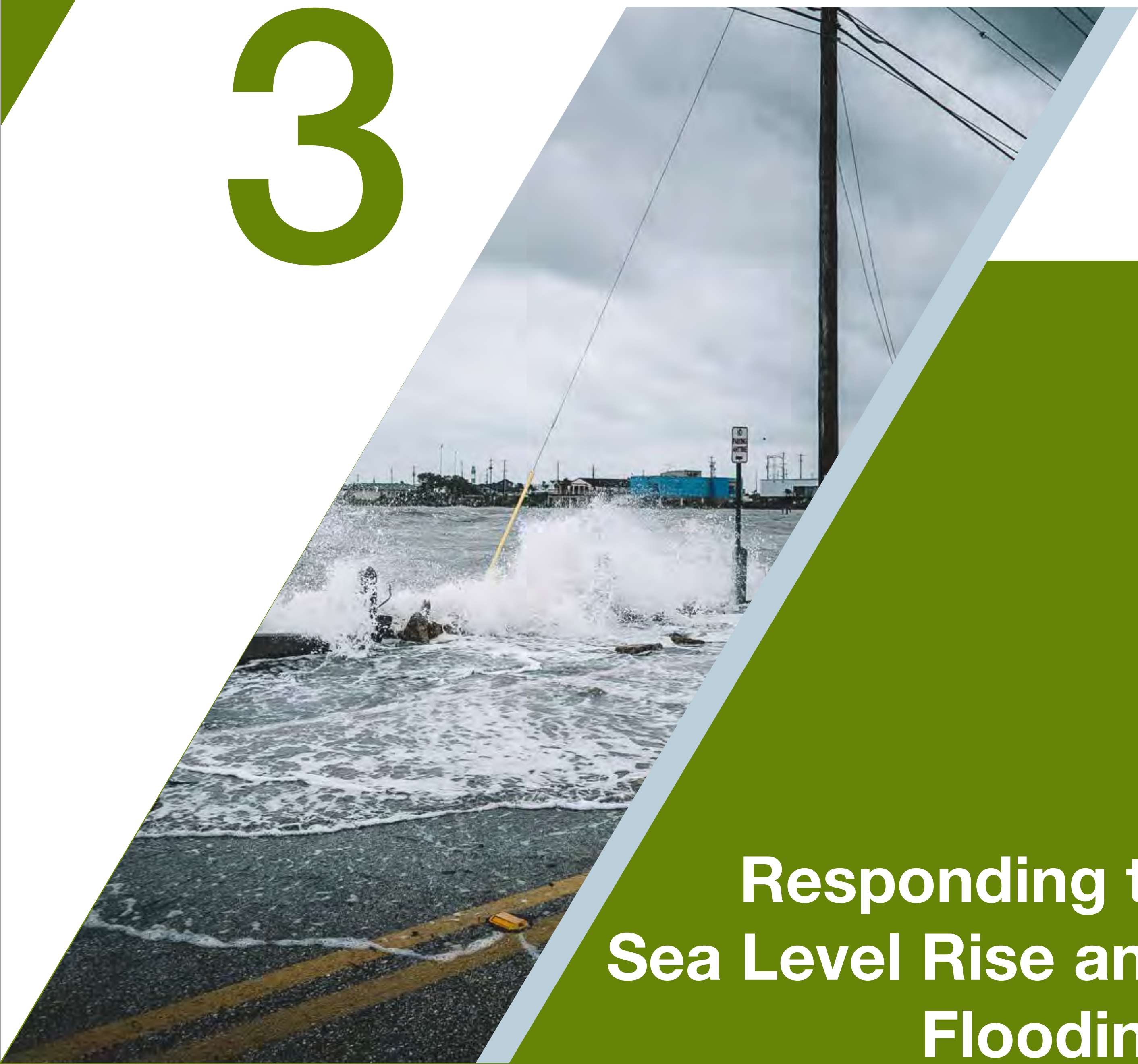



*Figure 2-1: Climate change strategy objectives*

# 3



# Responding to Sea Level Rise and Flooding

# 3 Responding to Sea Level Rise and Flooding

## 3.1 Context

Several published studies identify the potential impacts of climate change on sea level rise (SLR) and associated risks in the Gulf Region (Dasgupta et al, 2007; El Raey, 2010). The 2009 Report of the Arab Forum for Environment and Development on the Impact of Climate Change on Arab Countries (AFED, 2009), describes the risk as follows:

*"Of the Middle East and North Africa (MENA) countries, Qatar is the most vulnerable to sea level rise and associated flooding, as a 1-m rise in sea level would affect about 3% of its area, while a 3-m rise would affect 8%."*

The Climate Change and Sea Level Rise Study prepared for the Integrated Coastal Zone Management for the State of Qatar (MME, 2014a) concluded:

*"Most of the systems affected by coastal flooding are expected to experience a medium impact level due to changes in flooding level produced by climate change at horizon year 2040. High impacts due to changes in flooding level by 2100 under the two RCPs are projected for all the socio-economic and natural systems."*

The flood study completed for Qatar by GHD assumes sea levels rise accord with the global sea level rise projections by 2050 (0.37 m) and 2100 (0.98 m) (MME, 2016a). Sea level rise is a function of a combination of factors, mainly thermal expansion of the oceans and an increase in loss of land ice (glaciers and ice sheets). As the response times for each of these drivers varies significantly, sea levels will be rising for hundreds if not thousands of years irrespective of mitigation of carbon emissions in the coming decades (Clark et al, 2016). As there are reinforcing factors driving the changes, sea levels will rise at an exponential rate during this period. The only uncertainty is the rate of rise, and the ultimate equilibrium global sea level.

Accordingly, land that is considered presently vulnerable (i.e.in the period to 2100) will almost certainly be eventually inundated. Although measures to protect assets or accommodate flooding within that zone may be socially and economically feasible, these should be considered interim measures leading to strategic retreat of vulnerable coastal land.

The recommendations in this section reflect the underlying reality of long term sea level rise, and its implications for new and existing development in Qatar.

## 3.2 Measures to Achieve Plan Objectives

The Climate Change Strategy objectives applicable to 'responding to sea level rise and flooding' are:

- Protect members of the population from the effects of climate change
- Design new, and retrofit existing developments to be resilient against increasing sea levels and associate flooding events
- Facilitate emergency response planning at the planning and building permit stages for developments within high risk flood zones

Flood resilient design and managing coastal development are available interventions within Qatar's planning framework. However, implementation mechanisms are lacking for these processes. There is an overall lack of emergency planning policy or guidelines.

The gaps in existing planning frameworks, policies, action plans, strategies, guidelines and applicable international treaties and conventions in relation to SLR and flooding were identified in Stage 3 of the Project (Table 6-4 of the Stage 3 Report, p. 123). These gaps have been addressed as part of measures proposed in the following sections.

## 3.3 Adaptation Measures

In broad terms, the adaptation measures available to authorities to address sea level rise and associated risks are usually described as a hierarchy, as illustrated in Figure 3.1.

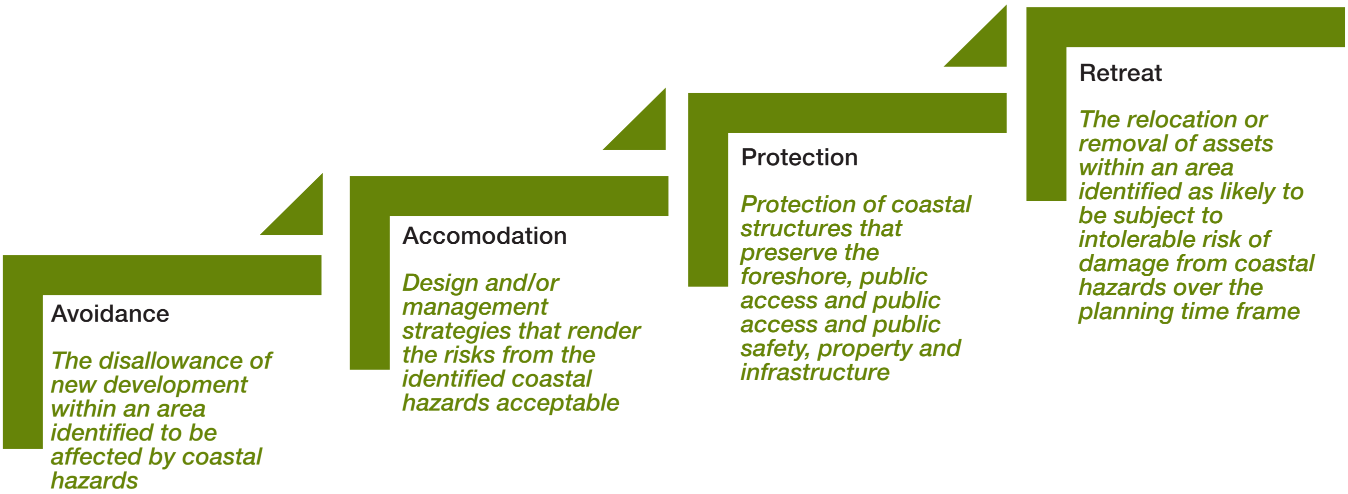



*Figure 3-1: Climate Change Adaptation Hierarchy*

Although all of these measures are categorised as climate change *Adaptation* measures, some actions (e.g. the preservation of coastal vegetation otherwise lost) do contribute to carbon sequestration and therefore double as *Mitigation* measures.

The measures proposed in the following sub-sections ultimately aim at protecting life, ensuring the provision and access to emergency services, minimizing damage and ensuring maintained operation of critical services.

### 3.3.1 Establish Vulnerable Coastal Zone to communicate risk and regulate development

It is recommended that Coastal Flood Risk Assessments are carried out for all areas vulnerable to the effects of sea level rise, including the requirement to carry out flood mapping as described below.

The proposed approach to planning for sea level rise and associated risks is based on utilisation of coastal flooding maps (CFMs) to be developed, building on the previous work in the ICZMP study (MME, 2014a) and the Flood Hazard Overlay (FHO) developed as part of the Qatar Flood Study. A summary of the FHO and the details of the climate change scenarios utilised in its modelling assessment are provided in Appendix A.

The CFMs should identify land that is at risk of coastal flooding from extreme water level events arising from Scenario 6 in the Qatar Flood Study (worst-case scenario), i.e.:

- Future climate era: 2100
- Change in rainfall intensity by IPCC RCP 8.5: + 60%
- Tide conditions: Mean higher high water (MHHW)
- Sea level rise (m) above IPCC RCP 8.5: +0.98
- Storm surge (m) above IPCC RCP 8.5: +0.5
- Resultant sea level (m): MHHW + 1.48"

The above scenario, in addition to an average recurrence interval (ARI) design storm event of 1 in 100 years, also takes into account changes in rainfall intensity, sea level rise, and storm surge.

**Output SL1:**

**Establish Vulnerable Coastal Zone to communicate risk and regulate development**

SL1-1. Utilize the 1% AEP mapping to identify the Vulnerable Coastal Zone (VCZ).

SL1-2. Develop regulations for VCZ to prohibit new development (with certain exceptions).

SL1-3. Update the existing and future zoning maps to incorporate VCZ as an overlay.

SL1-4. Continually update the 1% AEP contour as new sea level rise projections are made available with IPCC releases.

An example of such a map is included as Figure 54 of the Climate Change and Sea Level Rise ICZMP report, and repeated below as Figure 3.2.

SLR 2100 RCP8.5

*Figure 3-2: Projected coastal flooding of Doha area by 2100*

The CFMs should include contours that depict the boundaries of land at 1%, 2% and 10% probability of such high water level events being exceeded in any one year, known as the Annual Exceedance Probability (AEP)[1].

The CFMs should be used to as part of the broader scale land use planning and management decisions such as DC2 referral assessment and conditions, land use zoning amendments, infrastructure planning, and structural mitigation implementation. Accordingly, regular updating of the CFMs with new climate data and estimates will be crucial to the efficacy of ongoing planning measures.

The proposed approach utilises the CFMs to establish vulnerable coastal zones for application to both new and existing development.

A summary of the process to undertake a coastal flood risk assessment using the CFM is provided as Figure 3.3. Details for the establishment of the vulnerable coastal zone (VCZ) are provided below.

In order to reduce the risk to property over the long term, new developments should be avoided in areas currently identified in the CFMs as vulnerable, defined as having a 1% Annual Exceedance Probability (AEP) of flooding conditions occurring under Scenarios 6 (the 'worst-case' scenario), which takes into account changes in rainfall intensity, sea level rise, and storm surge. The 1% AEP mapping should be used to produce a boundary within which there is a presumption against new development (*Avoidance*), with certain exceptions (such as temporary development, necessary and strategic defence or industrial installations). This land should be identified in the Municipality Spatial Development Plans (MSDPs) as the Vulnerable Coastal Zone (VCZ) with the development restrictions described above. The actual boundaries of the VCZ should be based on the 1% AEP contour but will need to be rationalised to reflect the features of the natural and built environment.

This approach will require a continual updating of the CFMs and the 1% AEP contour to take into account the changes to projections of rainfall intensity, sea level rise, and storm surge. It is recommended that these updates align with future IPCC releases. The next main assessment report (AR6) report is expected to be released sequentially between 2020/2021 and a Synthesis Report in 2022.

The VCZ within the MSDPs should be reviewed regularly, e.g. at 5 year intervals, and if necessary, updated. If new sea level rise estimates are not available at the time of the analysis it will be necessary to extrapolate from the previous assessments.

Over time, new development that occurs adjacent to, and landward of the VCZ, will fall within the VCZ and become subject to the arrangements for existing development.

The VCZ would also apply to planning regulations for existing development within that zone. Land owners within the VCZ should be advised that their land is vulnerable to erosion and / or flooding in the next 100 years and that relocation or removal of assets

1 AEPs of 1%, 2% and 10% are approximately equivalent to Annual Recurrence Intervals (ARIs) of 100, 50 and 10 years respectively.

may eventually be required (*Retreat)*. Land owners should be advised by their respective municipality to take precautions to accommodate an increasing frequency of erosion and / or flooding events (*Accommodation*). Any such facilities should be required to adopt the flood accommodation measures in Section 3.3.2. Some discretion in applying this requirement will be necessary, e.g. for facilities nearing the end of their design life and those deemed to present low risk to property or people.

*Buffers*

Buffers limit the proximity of new construction to natural coastal features (e.g. mangroves). They also protect surface waters from pollution, assist to protect structures from flooding or erosion, and preserve sensitive ecosystems and shoreline amenities. In this context, a buffer zone will operate in conjunction with the VCZ, providing an additional requirement to limit development where necessary.

Designing an effective buffer zone can be a complex process which relies upon many factors, including the characteristics, type, environmental values, location, surrounding land uses, and the current and future stressors and impacts on the coastal zone.

Separation distances from the natural coastal features should not be adopted as absolute criteria, but rather as indicative distances which may be adjusted having regard to specific site circumstances. Requirements may be assessed on a site-by-site basis during the Building Permit Process along with standard buffer distance requirements to give general guidance to new development.

Further discussion and recommendations in respect of buffer zones around sensitive habitats and protected areas is presented in Section 6.3.

### 3.3.2 SL2: Update planning, policy and regulatory framework documents to address flood risk in vulnerable coastal areas

It is recommended that the MSDPs, where necessary, are revised to require a Coastal Flood Risk Assessment (some already call for this) and it is envisaged that this will incorporate the flood mapping described in the previous section.

As set out in Section 3.3.1, it is recommended that there is a presumption against new development within the VCZ (i.e. within the 1% AEP contour), except for special conditions such as temporary development, necessary and strategic defence or industrial installations. Any such facilities should be required to adopt the flood accommodation measures detailed in the following subsections.

These regulatory measures should also apply to high risk areas landward of the VCZ identified in the Risk Assessment (e.g. where the consequence of the hazard is sufficiently serious).

In addition, these requirements are applicable to retrofitting existing development within the VCZ, including emergency service facilities. Some discretion in applying this requirement will be necessary, e.g. for facilities nearing the end of their design life and those deemed to present low risk to property or people.

A summary of the process to undertake a coastal flood risk assessment is provided as Figure 3.3.

**Output SL2:**

**Update planning, policy and regulatory framework documents to address flood risk in vulnerable coastal areas**

SL2-1. Require Coastal Flood Risk Assessments.

SL2-2. Adopt measures to improve flood resilience in developments and buildings.

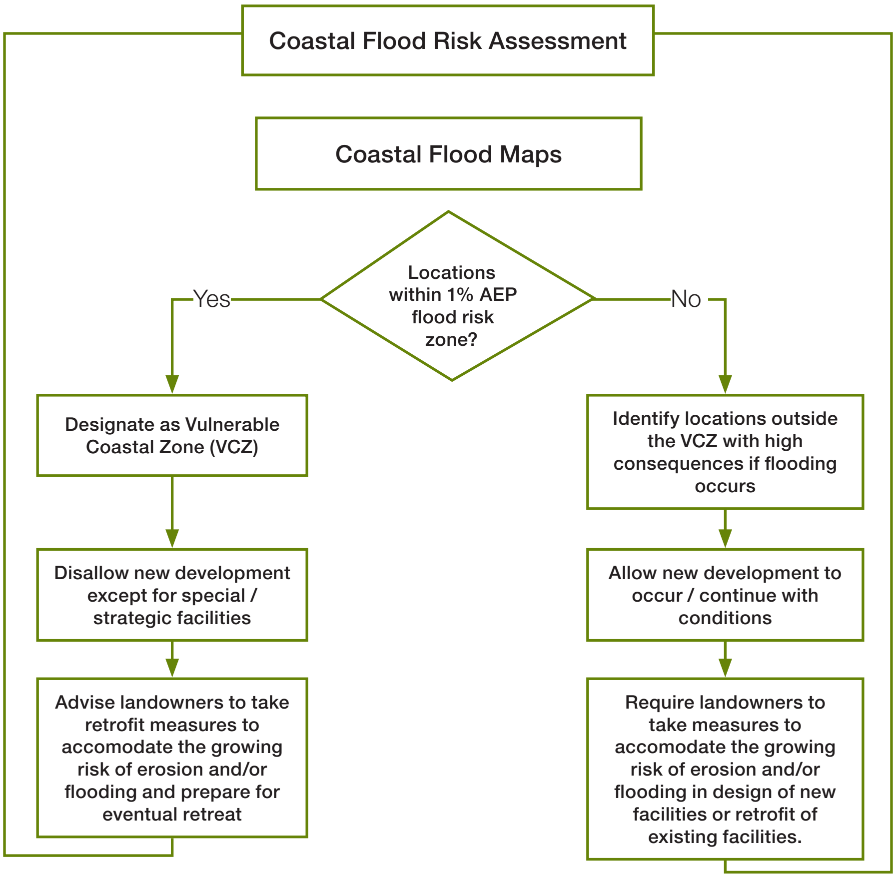



*Figure 3-3: Process of undertaking a Coastal Flood Risk Assessment*

### *Plans, Regulations and Standards*

A number of planning and policy frameworks within the existing Qatari system provide suitable vehicles for the introduction of management measures to address SLR issues.

Planning controls provide the most comprehensive measures to regulate future development and its vulnerability to climate change hazards. They provide clear guidance to authorities as to how flood/SLR mitigation and management should be factored into a building approvals/permitting and future planning, and provide policy support for these decisions.

Planning controls and regulations to reduce risk can also impose unavoidable additional costs at the initial building stage. However, requiring developers in low-lying areas to construct on pier and-joists rather than slab-on-ground (for example), would be offset by avoidance of considerable potential future costs.

Table B-1 in Appendix B defines potential regulatory recommendations within the SLR hazard area.

### *Revise existing and future Municipal Spatial Development Plans (MSDPs)*

MSDPs define the land uses / Zonings in Qatar and show where development will occur and where it will be restricted. They represent a key tool in the implementation and coordination of SLR adaptation measures across Qatar. However, many of the MSDP and Area Action Plam (AAP) statements regarding climate change are drafted in tentative language, with no clear indication of when and how they will be implemented.

Currently, when flooding is addressed in the planning framework, it is primarily in the context of flooding from sea level rise, not rainfall events. The response to flooding is a restriction on development within a given distance from the coast (with no explanation of how that distance has been determined) and/or that developers should "apply the precautionary approach" without specifying what this process involves.

The plans also have consistent gaps in their coverage of SLR considerations, relating to:

- Areas prone to flooding
- Sustainable drainage systems
- Protection of mangroves
- Emergency planning
- Support for vulnerable residents
- Implementation and monitoring

Each gap in the plan has potential to lead to a future climate change impact, and MSDPs should be revised to cover these issues.

In order to close the gaps presented in Table 6-4 of the Stage 3 Report (p. 123), and to ensure that land use zoning appropriately considers flood/SLR hazard, and appropriate types of development are permitted in the flood/SLR hazard zone and/or planning for open space in flood prone areas; a number of recommendations to amend MSDPs are proposed in Table B-2 in Appendix B.

### 3.3.3 SL3: Develop a framework to evaluate protection vs retreat options

In areas where the CFMs identify important assets at 2% AEP or greater risk of flooding, planning authorities should evaluate the social, economic and environmental cost : benefit of structural coastal protection measures vs strategic retreat.

The 'likelihood' of these parts of the coast becoming eroded and / or inundated (without intervention) will eventually be 'certain'. The only uncertainty relates to when this will occur. As no protection measures can be devised that remain effective for hundreds to thousands of years, any coastal protection works that are undertaken cannot be considered permanent. The logical conclusion is that the feasibility and cost of continuing protection will become untenable, and eventual retreat is therefore inevitable.

This means that the losses (land value) and costs (disruption to operations) associated with retreat are common to all possible measures taken in the foreseeable future. The various adaptation measures (accommodate or protect or combination thereof) will have a finite effective life and therefore only serve to delay these losses and costs, albeit considerably in some cases. To be financially preferable, the capital and ongoing costs of these measures must be less than the benefit obtained by delaying the inevitable losses and costs of eventual retreat. This test is relatively straightforward using discounted cash flow techniques.

The option analysis (including but not limited to financial costs) should therefore compare the following alternatives:

**Output SL3:**

**Develop a framework to evaluate protection vs retreat options**

SL3-1. Identify specific coastal management units within MSDPs to facilitate coastal process analysis.

SL3-2. Undertake a socio economic cost : benefit assessment of structural coastal protection measures vs strategic retreat for important assets within the Coastal Risk Zone.

SL3-3. Develop a compendium of coastal protection measures for vulnerable areas of the coastline to be used in the evaluation of options.

- Retreat when risk become unacceptable
- Interim protection incorporating a range of short to long term protection measures that delay (but eventually lead to) retreat.
- In order for coastal protection works to be appropriate, there needs to be sufficient benefit to justify at the cost and other consequences of the works. As noted above, the financial equation is the comparison between:
  - The capital and ongoing costs (including decommissioning) of these measures
  - The benefits obtained by delaying the losses and costs of eventual retreat

Of course there are non-financial costs and benefits, and accordingly it may be preferable to use multi-criteria analysis (MCA) to rank the retreat and one or more interim coastal protection options, with 'costs' as one criterion (derived from a discounted cash flow calculation) combined with social and environmental criteria. This process will preliminarily identify:

- Whether interim protection measures are justifiable in each coastal management unit
- Where they are justifiable, the nature and timing of the works

There are many factors to consider in undertaking such an evaluation including the effect of coastal structures on overland flow paths, cumulative environmental impacts (i.e. impacts that may accumulate from the gradual addition of coastal structures over time), and loss of foreshore amenity.

In order to conduct studies on specific parts of the coast it will be necessary to designate coastal management "units". These units need to separate the coast into sections that exhibit similar coastal processes and morphology. Secondary considerations are surface drainage catchments and the nature of the coastal built form. Coastal Flood Risk Assessments will provide the necessary information to establish Defined Flood Level (DFL) in each coastal management unit. IPD should determine DFL and associated Freeboard on a case by case basis (i.e. area and development type) based on the flood mapping.

Any coastal protection works (e.g. sea walls, groynes, beach nourishment) which are additional to existing structures will influence coastal processes, particularly sediment transport, on adjacent parts of the coast. Any prospective interim protection works derived from the process described above (i.e. consideration of individual coastal units) will therefore need to be reviewed in light of potential cumulative effect. This iteration will lead to a conceptual plan for the protection of certain areas of the coastline, including measures such as beach nourishment, dune rehabilitation and beach access controls, where they are justified through the option evaluation process.

To avoid ad-hoc construction of structural protections which may not be economically optimal or environmentally acceptable, there should be a presumption against land owners constructing their own protective structures, save for government and or essential coastal industrial facilities (e.g. those requiring seawater intakes).

Where the present risk is deemed unacceptable within the current planning horizon, it is envisaged that the conceptual coastal protection measures identified will form the basis of a program of detailed design and implementation by Ashghal. Where the risks are deemed to be presently low, the concepts will remain provisional until they fall within the planning horizon when they will be re-evaluated. The proposed near and long term measures will also inform the development of a funding strategy for the works.

Where the cost : benefit analysis identifies retreat as the preferred option, landowners should be required to relocate and remove assets from the subject land within a reasonable period of time[2] and continue to take precautions against extreme events in the meantime. This requirement also needs to apply to public utility assets such as roads, water and wastewater, power and gas infrastructure which are affected by inundation.

The retreat process should be invoked by changing the land use zoning to Coastal Foreshore Reserve (CFR) within MSDPs, which may require the MME to acquire the land under its powers to expropriate land 'in the public interest'. This process will facilitate municipalities protecting and / or restoring coastal vegetation (such as mangroves) to allow their landward migration to preserve biodiversity, attenuate erosion and flooding events, and contribute to carbon sequestration. Temporary uses can also be considered such as community, recreational and retail facilities, subject to adequate accommodation measures being taken (See Section 3.3.2).

Where the cost : benefit analysis identifies coastal protection measures as the preferred option, these constructions (which may comprise seawalls, levees, groynes, and beach nourishment etc.) should be undertaken by Ashghal and have a specified design life (e.g. 50 years) after which it is presumed they will be removed. Landowners within the VCZ whose assets are protected by coastal protection structures should be advised of their design life and to take precautions against the residual risk of extreme events (e.g. overtopping, damage or failure of structures in a design exceedance event). Should it be viable to retain or upgrade coastal structures at the end of their initial design life, they can be retained to offer protection beyond that date.

The proposed process is described in the flowchart in Figure 3.4.

This process essentially codifies a strategic retreat from vulnerable coastal zones, while retaining economic and social uses of the land for as long as they are safe and feasible.

2 A reasonable period of time to relocate assets depends on the nature and scale of the assets, and the availability of alternative sites, and should be determined on a case by case basis.

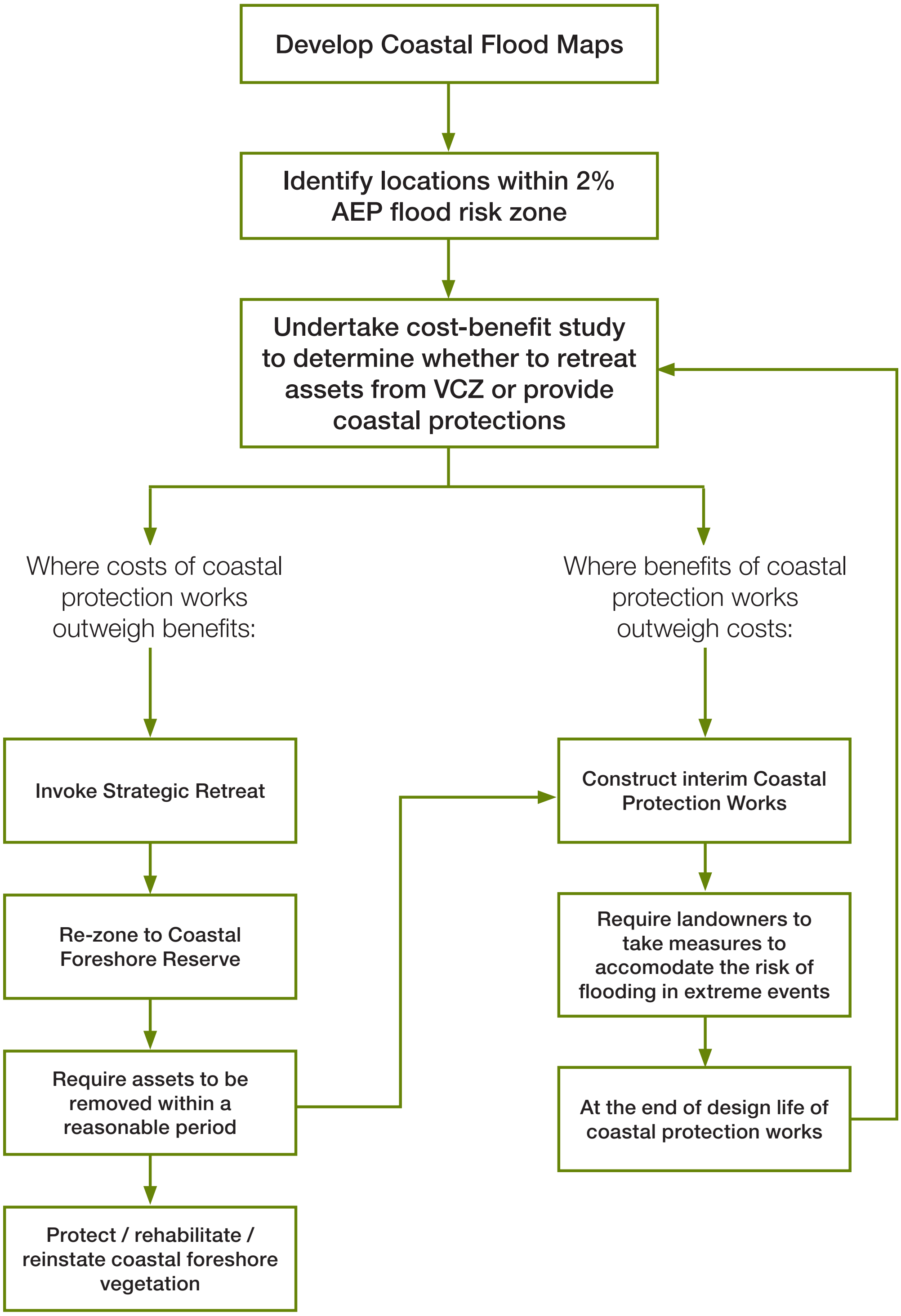



*Figure 3-4: Process to evaluate protection vs retreat options*

### 3.3.4 SL4: Develop a framework for the strategic retreat from vulnerable land

Strategic retreat involves the safe removal or relocation of development, assets and settlements from encroaching shorelines, or areas vulnerable to flood or sea level rise, allowing the water to advance unimpeded. It involves abandoning, demolishing or moving existing buildings and infrastructure to higher ground. It also includes prohibiting new development in areas likely to be inundated.

Once a strategic decision to retreat has been made, additional responses are necessary to manage the infrastructure and financial impacts. Some preliminary responses may include the following options dependent on the primary issues relevant to the location:

- Strategic withdrawal of utilities/infrastructure
- Notifications on title

#### *Strategic Withdrawal of Utilities/Infrastructure*

Over time, strategic planning for utilities and infrastructure can identify ways to relocate and decommission infrastructure in areas at risk as assets become ready for renewal. With sufficient lead in, infrastructure providers are able to consider the level of maintenance, upgrade, and renewal that is appropriate in areas of coastal risk.

New infrastructure should be located outside areas of coastal risk, commensurate with asset lifetimes. Alternative servicing strategies for coastal developments, such as design and installation of infrastructure perpendicular to the coast, can enable staged decommissioning of infrastructure assets over time, as risks are realised.

For infrastructure that may already be located within an identified future retreat location, not allowing for any future upgrading or installation of new infrastructure. The installation of infrastructure is to be limited to areas outside the identified risk zone, and preferably perpendicular to the coast, as opposed to parallel, where possible.

**Output SL4:**

**Develop a framework for the strategic retreat from vulnerable land**

SL4-1. Update the planning regulations to specify that new infrastructure should be located outside areas of coastal risk and any future upgrade or installation of new infrastructure within areas of coastal risk should be prohibited.

SL4-2. Consider leasehold rather than freehold sale in new coastal development areas, to avoid future pressures and costs to protect private coastal land.

SL4-3. Place a notification of title on all affected landholdings, informing landholders of the status of the land being located within a vulnerable coastal area.

SL4-4: Include a mechanism to facilitate long-term strategic retreat from vulnerable coastal land in the next iteration of the QNDF, including the establishment of Coastal Foreshore Reserves.

#### *Notification on Title*

In all instances, an effective and appropriate planning response is to place a notification on title on all affected landholdings, informing landholders of the status of the land being located within a vulnerable coastal area which has a retreat strategy applicable to it. This ensures all existing and potential land holders are aware of the risks, and assist to avoid an assumption that the land value will be retained in perpetuity through coastal protection works.

### 3.3.5 SL5: Implement emergency management measures

#### *Flood Emergency Management Plan*

It is recommended that a flood Emergency Management Plan (EMP) be required from developers so that flood risk for each development within the high risk flood zone (Appendix A) is managed. Managing flood risk is generally simpler in new development areas. Preparing a flood EMP enables strategic decisions about where, what and how to develop, while reducing residual risk (i.e. the risk left after management measures are put in place) to an acceptable level.

An EMP sets out the prevention, preparation, response and recovery arrangements and the responsibilities of individuals, agencies and organisations with regards to these functions. The components of a flood emergency management plan is provided in Table 3-1.

**Output SL5:**

**Implement Emergency Management Measures**

SL5-1. Require a Flood Emergency Management Plan for each development within the high risk flood zone.

SL5-2. Require new and upgraded emergency facilities and services, development to be designed according to the Defined Flood Level (DFL).

SL5-3. Ensure new and existing facilities or services can operate at the required capacity during a Probable Maximum Flood (PMF).

Table 3-1: Components of a flood emergency management plan

| | |
|---|---|
| **Preparedness** | Flood prevention and recovery should be an ongoing process. The following steps should be undertaken for preparedness :<br>• Identify and contact authorities and agencies responsible for monitoring of water-level or rain intensity (forecasting and monitoring service)<br>• Determine the lead time available to implement the flood plan<br>• Identify alternative supply routes, suppliers and storage areas<br>• Identify equipment, stock and material, which could potentially be affected by roof damage-induced flooding<br>• Identify below-ground structures potentially exposed to flood water<br>• Conduct regular training exercises with participation of local emergency services<br>• Engage with suppliers and contractors on potential assistance required during and after flood occurrence (e.g. post flood repairs). |
| **Response / plan of action** | Responding to floods and providing emergency and immediate relief services. A range of strategies are available, including:<br>• Safe evacuation of people<br>• Maintain a detailed log of events (diary or log book)<br>• Keep stakeholders informed of situation<br>• Prepare for safe shut-down of operations<br>• Managing utilities (e.g. power, water) to ensure continued service |

Source: Zurich, 2016

### *Location of Emergency Facilities*

Emergency planning is an important climate change adaptation measure. In Qatar, the likelihood of climate change related risks and emergencies (the population or essential infrastructure being affected by extreme heat or flooding – both SLR and extreme rainfall events) is high, so the importance of emergency planning is also high. The location of all emergency facilities should be included in the MSDP Community Facility's Master Plan.

One element of emergency planning is the safe location of emergency facilities. Such facilities include hospitals, emergency services facilities, designated emergency operations centres, communications facilities, and police and ambulance services. Critical facilities should ideally be located in areas not subjected to flooding and should be able to operate during a flood event. Aged care and disabled facilities should generally be located in areas where the individuals can be readily evacuated to dry land.

Hospitals are a particular concern because it is difficult to evacuate patients in case of an emergency, and because flooding could lead to problems requiring medical help. Hospitals and primary health centres would need to be accessible (the access routes to the site should not be flooded) in order to be used in an emergency. Police stations are also a concern because police would be needed in case of climate change related emergencies.

In considering applications for new and upgraded emergency facilities and services, development should be designed according to the Defined Flood Level (DFL). Where such a requirement cannot be achieved, measures should be taken to ensure the facility or service can operate at the required capacity during a Probable Maximum Flood (PMF).

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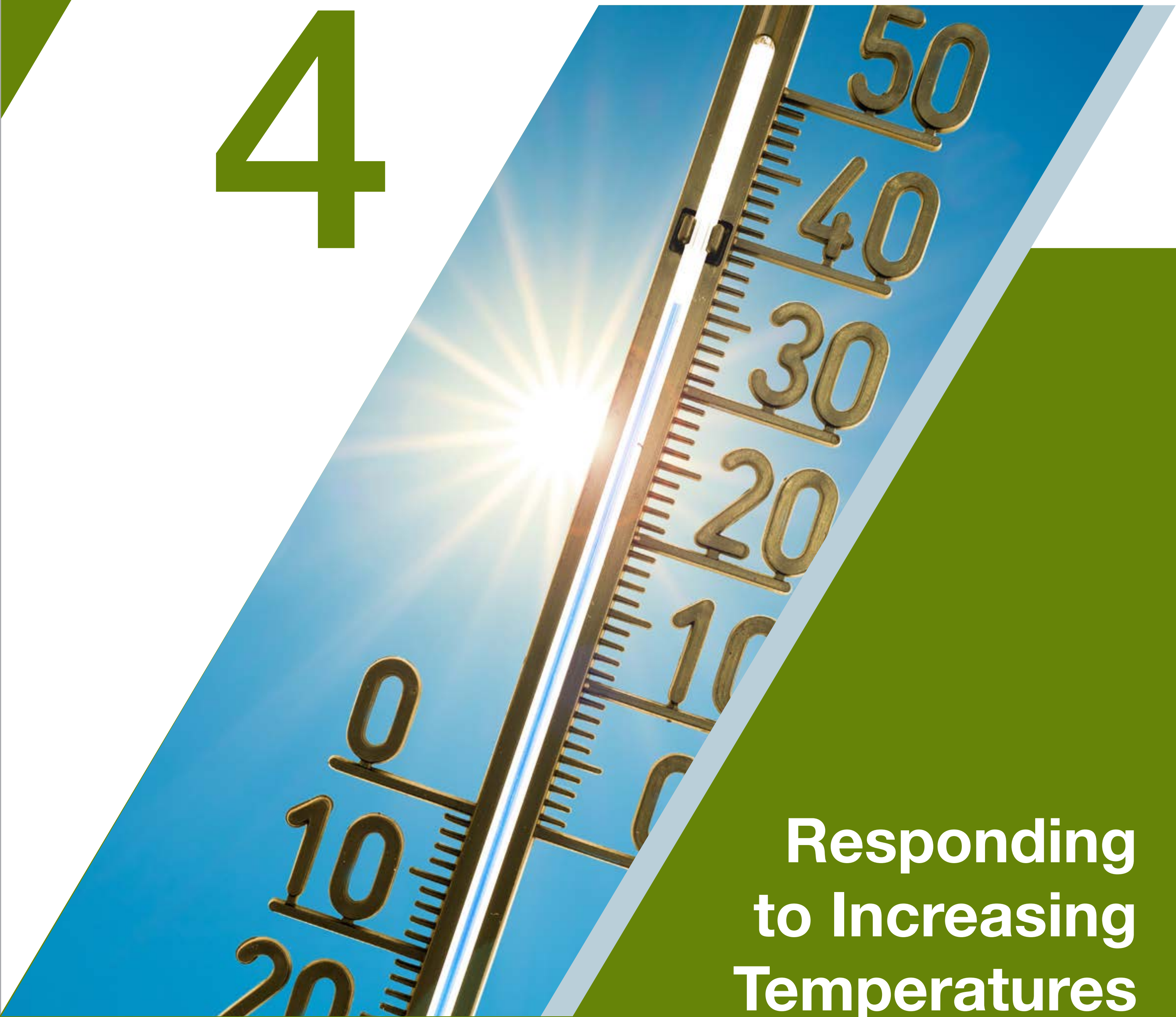



# Responding to Increasing Temperatures

# Responding to Increasing Temperatures

## 4.1 Context

Maximum temperatures in the summer in Qatar are already near 50 °C. As a result of climate change, the IPCC expects temperatures in Middle Eastern countries, including Qatar, to rise by about 2 °C in the next 15-20 years, and by more than 4 °C by the end of the century.

The IPCC suggests that summer months are likely to experience a temperature increase of close to 6 °C and the winter months close to 2.2 °C. Under the higher scenario (6 °C), much of the summer months would be ‘very hot’, with daily maximum averages close to the highest recorded temperatures to date. Even under the lower scenario (2.2 °C), the proportion of summer days that are projected to be ‘hot’ and ‘very hot’ would be much greater than currently experienced (Lelieveld et al., 2016). Figure 4.1 depicts long-term mean and maximum temperatures in Qatar if temperatures increase by 2.2 °C and 6 °C.

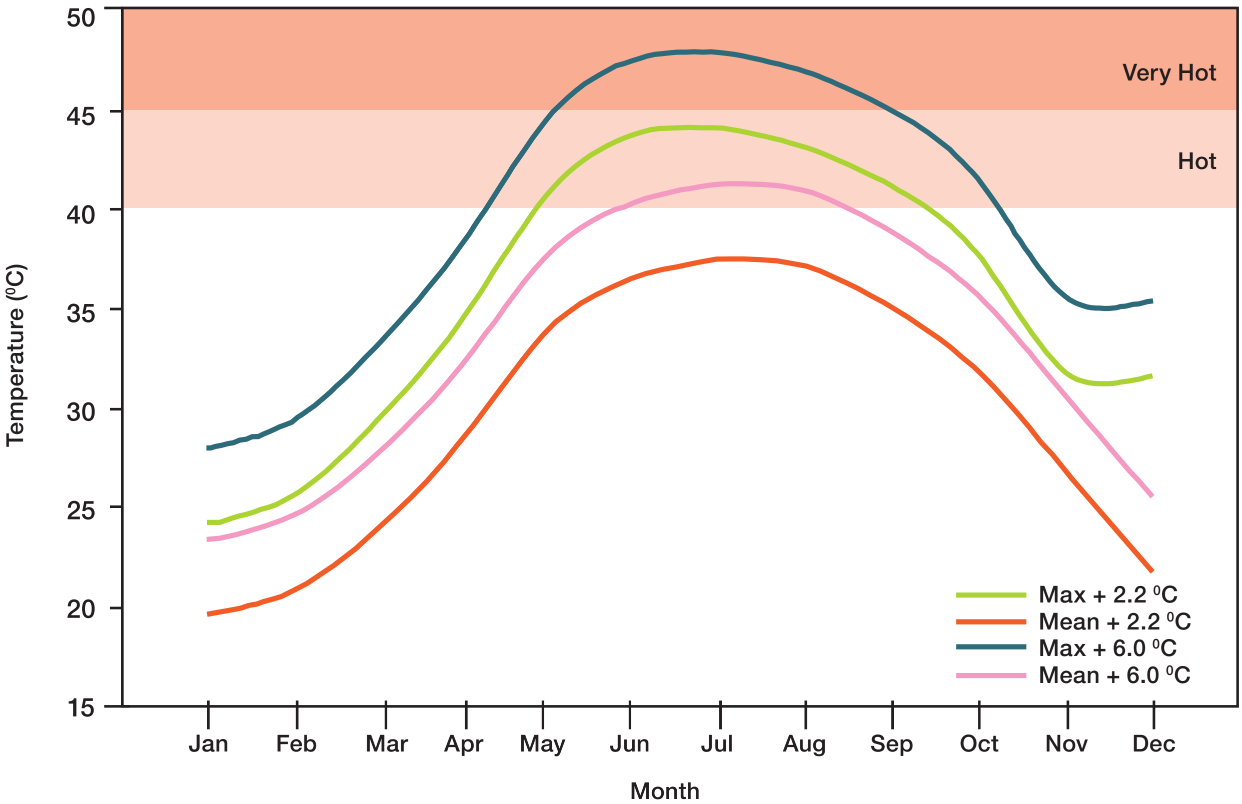



*Figure 4-1: Mean and maximum long-term temperatures in two climate change scenarios: an increase by 2.2 °C and 6 °C*

More recent modelling work reported in *Nature Climate Change* (Pal and Elfatih, 2015) suggests that

*“By the end of the century, annual wet bulb temperatures in Doha will exceed 35°C several times in the 30 years, and the present-day 95th percentile summer (July, August, and September) event becomes approximately a normal summer day.”*

35°C is the threshold wet bulb temperature beyond which any exposure for more than six hours would be intolerable for most humans, resulting in hyperthermia which becomes a medical emergency requiring immediate treatment to prevent disability or death. In the current climate, the wet bulb temperature rarely exceeds 31°C.

The increased temperatures will increase the requirements for air conditioning, the country’s reliance on electricity, and associated emissions of greenhouse gases with the present energy generation mix. In the case of power outages, or an inability to adequately cool buildings during summer months, or where people are otherwise exposed to prolonged hot temperatures (e.g. construction workers), this could lead to severe health problems including death from heat stroke.

## 4.2 The Heat Island Effect

Densely built inner city and urban areas have a propensity to store large amounts of heat because the density of buildings, networks of asphalt streets and concrete or stone paving and prevalence of concrete and steel, means they have a high thermal mass. These locations are often several degrees warmer than surrounding low-density suburbs and rural countryside. This temperature difference is larger at night because rural areas cool while dense urban environments remain relatively warmer. Such environments also lack natural cooling mechanisms such as vegetation or surface water. In the presence of high moisture levels, vegetation plays a dominant role in surface cooling through evaporation and latent heat removed from soils and evaporation from plants (known as transpiration) (Kinney et al, 2003).

The urban topography, which is the relative height of buildings and width of the spaces between them, can worsen the situation by limiting natural breeze. Urban areas also release large amounts of heat from vehicles and buildings that add to the warming. These localised, densely built, urban environments therefore appear as islands of heat on temperature maps or aerial infrared thermographs, and hence the effect has been called the Urban Heat Island (UHI) effect.

As UHI's are characterized by increased temperature, they can potentially increase the magnitude and duration of heat waves within cities. UHI prevents night time temperatures from cooling down and so restricts night time recovery from heat stress. This impact is location dependent and the effect on humans is more pronounced for people who are not acclimated to hot weather conditions.

Hot days and heat islands are self-reinforcing phenomena, with people more likely to increase air conditioning and water usage, which in turn uses more energy and increases the heat island effect. Heat islands also exacerbate the effects of hot days. Figure 4.2 depicts the influence of the built form on UHI effects.

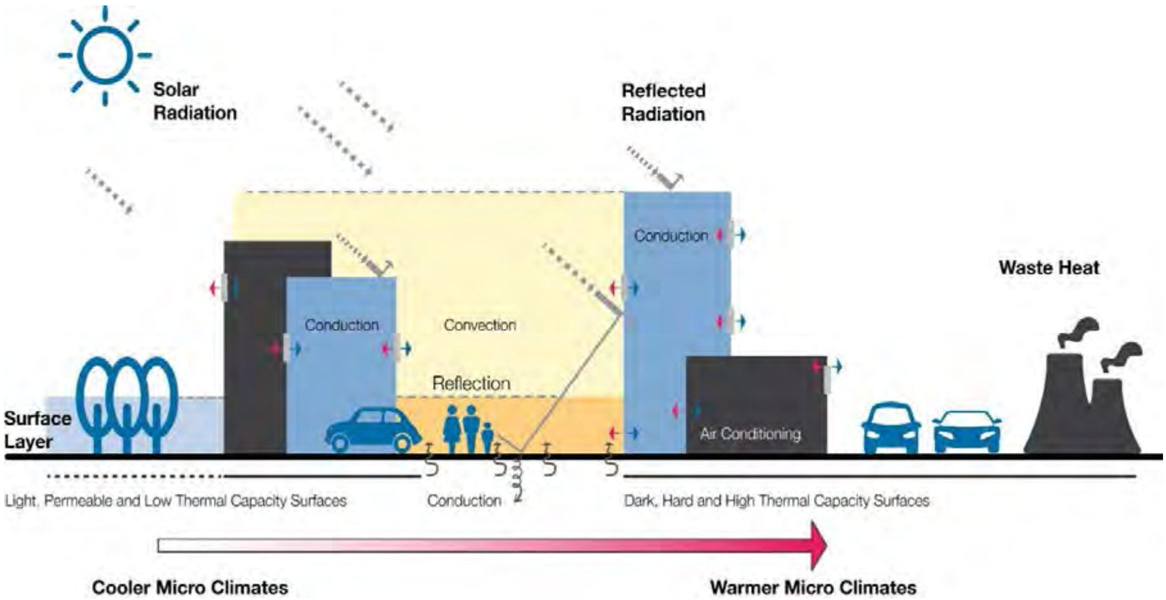



*Figure 4-2: Factors increasing and decreasing the Urban Heat Island Effect*

Source: Own illustration, adapted from Sharifi, 2013

Key factors influencing the heat island effect include:

- Percentage of impervious / dark surfaces
- Industrial activity
- Vehicular activity
- Building height - a high height / width ratio reduces exposure of surfaces to direct solar radiation (Barkarman et al, 2015)
- Inland development locations not accessible by sea breezes

## 4.3 Measures to Achieve Plan Objectives

The Climate Change Strategy objectives applicable to 'responding to increasing temperatures' are:

- Protect members of the population from the effects of climate change
- Incorporate green building measures to improve the energy and water efficiency of homes and businesses
- Design the urban form to reduce urban heat island effects and energy demand

Partial mitigation measures in terms of shading, sea breeze permeability, and an aim to reduce large impervious areas are available interventions within Qatar's planning framework. However, the effectiveness of these partial mitigation measures depends on their inclusion in zone codes with specifics of implementation detailed within the codes. The gaps in existing planning frameworks, policies, action plans, strategies, guidelines and applicable international treaties and conventions in relation to UHI were identified in Stage 3 of the Project (Table 6-4 of the Stage 3 Report, p. 123).

The implementation of the mitigation and adaptation measures proposed in the following sections ultimately aim at ensuing people's comfort and increasing energy efficiency which will also reduce GHG emissions.

Increased temperatures and the heat island effect can be addressed by the urban planning sector through policy intervention, design guidelines and regulations, and developing masterplans that support:

- Locating new development in cooler microclimate locations
- Implementing cool urban design
- Incorporating passive cooling in building design
- Providing for cool green areas

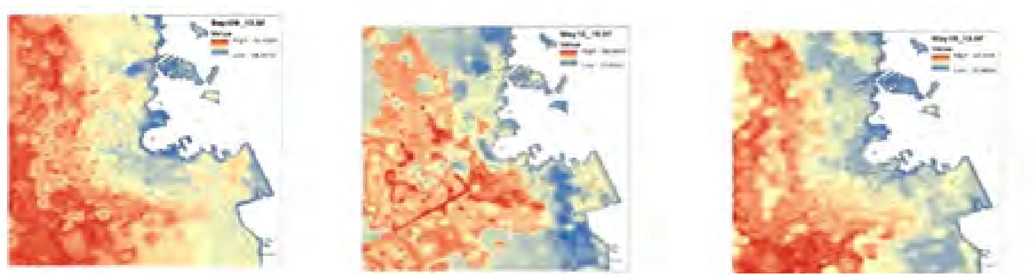
Many of these interventions will also result in reductions in energy use and therefore GHG emissions.

## 4.4 Mitigation Measures

Mitigation measures that can effectively respond to increasing temperatures in the urban planning and urban development sector are detailed in the following sub sections.

### 4.4.1 UH1: Improve green space in areas vulnerable to the Heat Island Effect

Through the use of thermal imaging as a tool, areas experiencing UHI, or 'hot spots' were measured as part of the Qatar University UHI study by Makido et al. (2015 and 2016). Using this technique, the hot spots within Doha on three different days at different times were measured as shown in Figure 4.3. Note that the figures depict warmer and cooler areas, not absolute temperatures.



8 Sep 14, 1pm | 12 May 15, 7pm | 15 May 15, 1pm

*Figure 4-3: Heat Island Effect in Doha*

Source: NPRP research (#5-074-5-015) granted by QNRF

From the initial results of the Qatar University study, areas particularly prone to the heat island effect were identified in Stage 3 of the Project (Table 4-15 of the Stage 3 Report, p. 81). The areas identified include:

- Al Rayyan and particularly the Doha industrial area, probably because of its distance from the sea and lack of sea breezes
- Al Gharafa/Madinat Khalifa and Umm Slal Muhammed areas which are quite densely built-up
- Salwa Road and to a lesser extent other large roads, possibly because of tarmac and warming by vehicles

- The airport, possibly because of heat from the planes and the large areas of tarmac absorbing heat during the day.

The study is currently underway and the final results of the study are not yet available at this stage.

Upon finalization of the study, it's recommended to utilize the results to identify existing areas prone to the heat island effect, agree on the factors that contribute to the heat island effect, and general a hot spot map. The hot spot map shall be overlaid over the future zoning MSDP maps. Subsequently, the appropriate measures as detailed in the following sub sections can be adopted to reduce heat island effect.

### *Vegetation around buildings*

A number of studies have demonstrated the importance of vegetation and green spaces in countering the urban heat island effect (Heisler et al., 1994; Taha et al., 1996; McPherson et al., 2005; Solecki et al., 2005).

Green areas reduce the impact of hot days and the urban heat island effect through evaporative cooling and by providing shade.

For optimal cooling of buildings using vegetation, the vegetation planted around a building must protect it from solar radiation (INSPQ, 2009). In order to maximise the shade on a building, trees should be located on the east, southeast, southwest and west facades (Oliva and Courgey, 2006).

**Output UH1:**

**Improve green space in areas vulnerable to the Heat Island Effect**

UH1-1. Utilize the finalized Qatar University UHI ongoing study to determine areas subject to the heat island effect and generate a hot spot map.

UH1-2. Overlay the hot spot map over future zoning maps to identify the need for any additional publicly accessible green space. Reallocate land use (if needed) and ensure the implementation of the green space.

UH1-3. Incorporate requirements for vegetation around buildings, in parking lots and around roads and pavements.

### *Greening of parking lots*

Parking lots paved with asphalt, contribute to the UHI effect (Rosenzweig et al., 2005). An effective way to reduce the heat stored in these asphalt surfaces is to plant vegetation around the perimeter and within the parking lots. This will result in the paved surface being shaded, which will also protect the pavement from thermal variations and extend its life (INSPQ, 2009).

### *Green corridors*

Green corridors can be provided along roads and pavements, to provide shading, increase evaporative cooling and make a more pedestrian-friendly environment.  This is already proposed in the Downtown Doha Area Action Plan (AAP) (Figure 4.4) Existing trees that are important for shade, biodiversity or the landscape should be protected while new plantings should be suitable to arid desert environments.

### *Green open space*

The World Health Organisation (WHO) and United Nations Food and Agriculture Organisation (UNFAO) suggest that there should be a minimum of 9 $m^2$ of green open space per city dweller. Other world cities have between 10% and 45% of publicly accessible green space, compared with a Qatar average of 1.78% provided for by the MSDPs.

Although Qatar cannot be expected to meet the same standard of publically accessible green space compared to other liveable cities due to its arid desert climate and the scarcity of water, the green open spaces that it can provide can be effectively planned and located to serve multiple functions; which include the provision of green open space and alleviating the UHI effect.

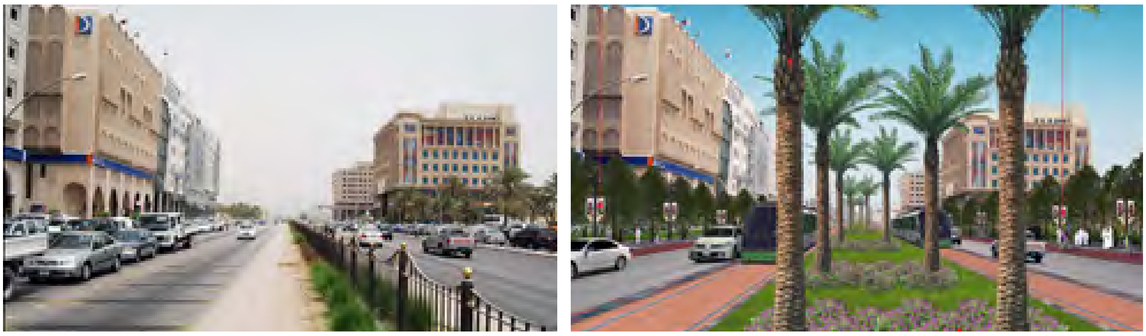


*Figure 4-4:  Green corridors with more planting and shading*

Source: Downtown Doha AAP, MME

The hot spot map to be generated following the completion of QU UHI study can be utilised to determine whether the proposed green areas are best located to reduce the urban heat island effect.

### 4.4.2 UH2: Ameliorate the Urban Heat Island Effect

#### *Increasing Surface Albedo*

The Global Sustainability Assessment System (GSAS) has a Heat Island Effect Calculation that computes two albedo values, one for pre-development and the other for post-development. The albedo value is the ratio of solar energy reflected off a surface to incident solar energy in an urban fabric (GSAS, 2015). This calculation is used to compute and determine the potential heat island effect due to the proposed development. This calculation would be beneficial in the building permit application stage, where the MME would be able to determine which developments would further contribute to the heat island effect. If the development is found to additionally contribute to the existing heat island effect, a range of mitigation measures proposed in this report (in the following sub sections), could be implemented to reduce the effect. The proposed process is illustrated in Figure 4.5.

**Output UH2:**

**Ameliorate the Urban Heat Island Effect**

UH2-1. Integrate the GSAS heat island effect calculation in the building permit application stage to determine the potential heat island effect of the proposed development.

UH2-2. Require all new developments to include applicable and cost-efficient passive cooling measures.

UH2-3. Require major building retrofits to adopt passive cooling measures to the extent that they are cost-effective.

UH2-4. Require the utilization of light colored pavements for roads and parking areas.

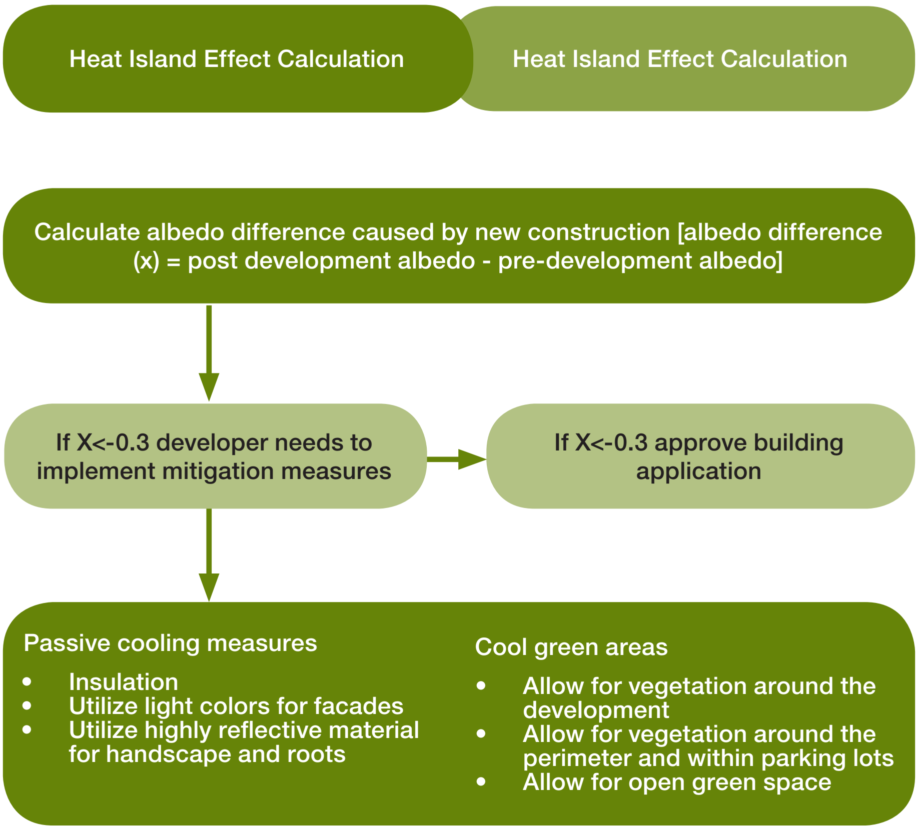



*Figure 4-5: Process of undertaking the heat island effect calculation in the building permit application stage*

*Passive Cooling*

Traditional Middle Eastern architectural design practices incorporate a range of interventions aimed at cooling buildings without the use of air conditioning. Combining these techniques with modern technologies; passive cooling interventions are generally the cheapest and most environment-friendly way of dealing with a hot climate and of not adding to the urban heat island effect. These passive cooling measures are listed below and illustrated in Figure 4.6.

- interior and exterior insulation with double glazing of windows to keep cool air inside
- solar control window films
- reflective or light-colored facades/cladding and roofs
- daylight pipes to offer better heat insulation properties and have the advantage of providing natural light and of saving energy
- ventilation/flushing measures (wind/cooling tower, night time ventilation / heat flushing, windows that can be opened)

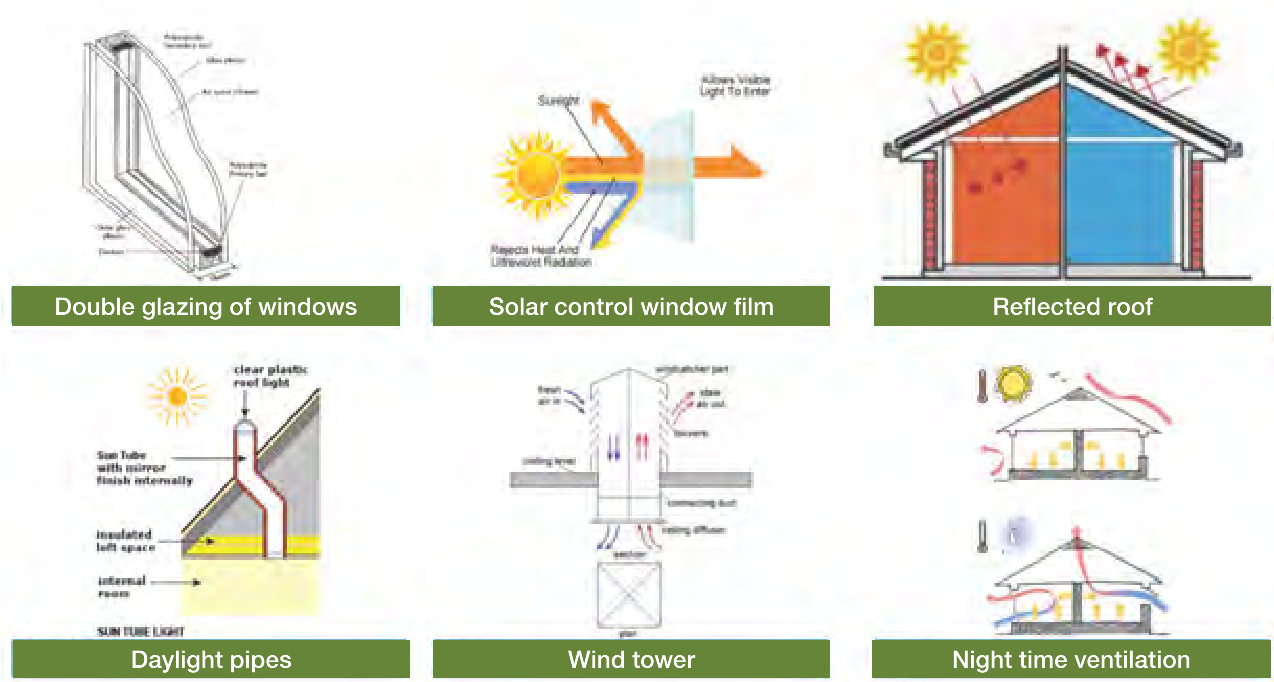



*Figure 4-6: Passive cooling measures*

Cool / Reflective roofs use highly solar reflective material to reflect light and absorb less heat. The cooling capacity of cool roofs is diminished by weathering and dust; however, washing restores their reflective capacity. A core issue with cool roofs is the potential for bouncing light onto taller buildings, which results in the taller building warming. Consequently, it would be more beneficial to use cool roofs on shorter buildings or in areas where roof height is uniform.

*Light Coloured Pavements*

Light coloured pavements if installed in public spaces and near roads will help to reflect heat rather than absorb it. This generally involve the use of concrete rather than bitumen, topping asphalt with a light-coloured aggregate, or applying a light-coloured overlay to existing pavement. Concrete is known for its longevity and durability. However, it is more expensive than bitumen, it takes considerably longer to cure, and can crack on very hot days. Light-coloured pavements could also require maintenance to ensure their reflectivity is maintained.

A number of these above listed practices are incorporated periodically into Qatar's current regulatory framework, specifically within the MSDP's and the Built Environment Section of the QNMP (particularly BE6 and BE10). For consistency, all the MSDPs could be amended so as to all include all of these principles.

*Energy Efficiency*

Furthermore, measures to reduce energy use within buildings can also reduce the build-up of heat in the buildings and help to keep them cool. These measures include:

- LED lighting with smart controller systems
- Occupancy sensors
- Smart controllers and heat pumps for air conditioning

A study suggested that retrofitting buildings with efficient lighting, HVAC optimisation, and heat reflective paint could reduce energy use in buildings by up to 50% (Alkhateeb E et al.,2016). Another similar study found a 16% energy reduction when an office building was retrofitted with an air economiser, night purging, occupancy sensors, lighting scheduling, and cooling of condenser air by condensate drain (Itani T et al., 2013).

Energy efficiency standards and requirements are also discussed in Sections 5.4.6 and 5.4.9.

## 4.5 Adaptation measures

Adaptation measures that can effectively respond to increasing temperatures in the urban planning and urban development sector are detailed in the following sub sections.

### 4.5.1 UH3: Introduce shading requirements

Urban and landscape design of the public realm plays an important role in mitigating the impact of hot days and the heat island effect, making areas more comfortable and walkable.

Shading systems such as awnings, sails, pergolas, photovoltaics as shading, arcades over pavements, public spaces and parking areas are an easy way of reducing the ground temperature and improving the amenity of an area for pedestrians (Figure 4.7).

*Figure 4-7: Shading systems*

For consistency and in accordance with the requirements stipulated within GSAS, the following minimum shading requirements should be mandated within the MSDP Zoning Regulations for all developments in urban areas:

- 60 % to 70% of hardscaped pedestrian pathways and parking areas should be shaded
- 25% to 30% of hardscaped common areas should be shaded

A shading analysis should be undertaken as part of the development assessment process, prior to the DC 2 submission, to ensure that the minimum shading requirement is met.

*Figure 4-8: Example of a shaded 'urban canyon'*

*Figure 4-9: Typical street section in West Bay*

### 4.5.2 UH4: Support urban canyons and street orientation

Increasing building height in city centres can help to create shaded 'urban canyons' (Figure 4.8). Several studies have found that 'cool islands' in urban areas can be formed by street canyons or narrow streets and tall buildings, especially if shade trees are also present (Bahi, H et al, 2016 and Johansson E and R Emmanuel, 2006). The creation of 'urban canyons' is promoted within the West Bay AAP as follows:

*"The photograph (of a typical street in West Bay (Figure 4.9) is a particularly unfriendly pedestrian environment that is unsafe and unprotected from sunlight for pedestrians. Instead, buildings in West Bay should have consideration of the human scale and provide a building height to street width ratio that is broadly in proportion to the height of human beings so as not to overdominate the space."*

This promotion of 'urban canyons' is not being implemented or enforced; either in west bay or in any other city centres. Figure 4.9 illustrates how the streets in west bay are excessively wide and there is little defintion to the street edge at the human scale, notable by lack of pedestrians.

Some AAPs currently incorporate the above mentioned principles on a sporadic basis. For consistency, all MSDPs, AAPs and design guidelines should stress these principles and encourage their implementation.

### 4.5.3 UH5: Develop a heat wave emergency response plan

For instances of extreme heat, it is necessary to develop a response plan that will reduce illness and death in the community. At present, Qatar does not have emergency planning at the national or local level. Given the increasing potential for extreme heat to occur in Qatar, heat-wave response planning is critical. There is no universally accepted definition of a heat wave, as a range of factors (e.g. demographics, urban form, and acclimatisation) will result in the same temperature having considerably different impacts based on the community. However, heatwaves are generally accepted to be the minimum temperature over a prescribed duration that may impact the health of a community.

Similar problems may occur where there is no heat wave but if there is a power outage on a hot day. Hot days can trigger power outages because the increased use of air conditioning can overload the electricity system.

**Output UH5:**

**Develop a heat wave emergency response plan**

UH5-1. Develop an emergency response plan for cases of heat wave, which includes preparedness / preventive action, monitoring and communication, and a plan of action during the emergency.

Heatwaves and pro-longed power outages on hot days require emergency response planning as they increase the incidence of illness and death, particularly among vulnerable groups. Those particularly vulnerable to heatwaves include:

- older people (65 years and older)
- children (<5 years old)
- pregnant and nursing mothers
- people with diabetes, heart disease, kidney disease or mental illness
- people with a disability
- migrants and those who are not acclimatised
- people who work outside

Heatwave response planning can generally be broken into the three components described in Table 4-1. Additionally, the World Meteorological Organisation (WMO) and World Health Organisation (WHO) have developed guidance on the development of heatwave warning systems (WMO and WHO, 2015). These guidance measures can be a valuable source to the development of a comprehensive heatwave response plan.

**Table 4-1: Components of a heatwave response plan**

| | |
|---|---|
| **Preparedness / preventive action** | Planning and raising community awareness of heatwaves. At a high level, this stage involves:<br>coordinating service providers heatwave response planning (e.g. hospitals, emergency services, power and water providers)<br>preparing or identifying cooling centres (i.e. areas that will provide a cool environment, particularly in cases of energy blackouts)<br>educating health professionals about appropriate medical responses<br>identifying vulnerable individuals<br>A core component of this stage is ensuring that the community is aware of the risks and management of heatwaves. Education and awareness should target vulnerable groups. |
| **Heat wave warning system** | Forecasting and monitoring of high temperatures should be undertaken by the Qatar Meteorology Department. In the event of an expected heat wave:<br>The citizens should be alerted and informed about the expected danger.<br>Inform citizens about where they can obtain and reference the 'Heatwave Action /Emergency Plan'<br>Additionally, an administrative crisis management plan for instances of heat waves should be developed and made publically available |
| **Response / plan of action** | Responding to heat waves and providing emergency and immediate relief services. A range of strategies are available, including:<br>Relocating vulnerable people if necessary<br>Undertaking heat checks on vulnerable populations<br>Increasing the number of emergency services<br>Managing utilities (e.g. power and water) to ensure continued service. |

Source: modified from Victoria State Government, 2015

# 5

# Reducing Greenhouse Gas Emissions

# 5 Reducing Greenhouse Gas Emissions

## 5.1 Context

According to the United Nations Climate Change Secretariat (UNFCC, 2015), Qatar had the highest per-person CO2 emissions in the world in 2014. In most developed western countries consumption based emissions exceed production emissions due to the emissions embedded in imports. The opposite is the case in Qatar because much of Qatar's emissions are effectively embedded in the exported hydrocarbons, meaning the real domestic emissions intensity is significantly overstated by merely dividing annual national production emissions by the population. As such, the key objective of the emission mitigation measures proposed are to place Qatar in a Leadership position, in the region, on tackling the issue of climate change.

An estimate of greenhouse gas emissions by activity was compiled during Stage 3 of this project using data from Kahramaa (utility provider) and publicly available emissions inventories (Section 4.3 of the Stage 3 Report, p. 81). This review established a baseline of 14.7 metric tonnes CO2 equivalent per capita[3]. Water and power account for the vast majority (72%) of emissions, followed by transportation (18%), as shown in Figure 5.1.

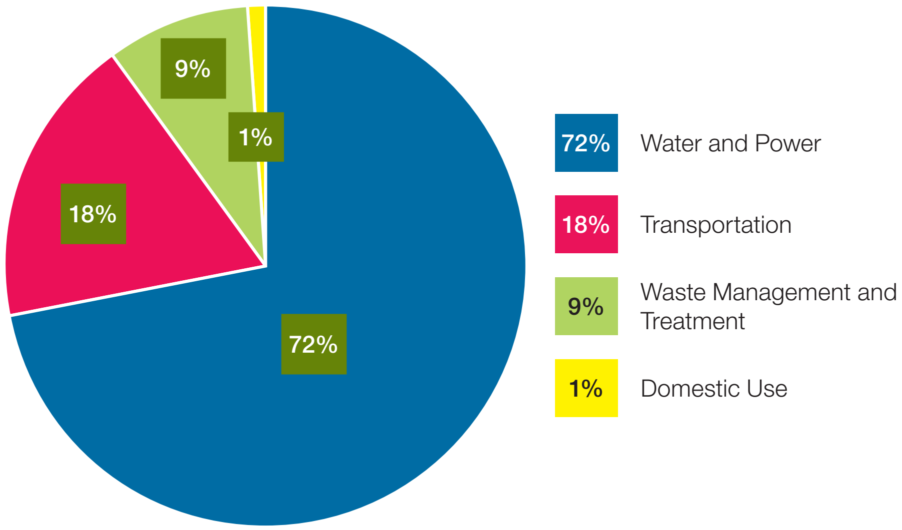



*Figure 5-1: Emissions by activity*

## 5.2 Greenhouse Gas Effect

Greenhouse gases can be defined as gases that trap heat in the atmosphere. The majority of these gases occur naturally, although there are also artificial greenhouse gases such as fluorinated gases. These greenhouse gases allow short-wave energy from the sun to reach and heat the Earth's surface. About half of this energy, in the form of longer-wave (infrared) energy, is emitted back to the atmosphere (NOAA, 2017). Greenhouse gases and water vapor absorb this infrared radiation, resulting in heat being trapped in the atmosphere and re-radiated to the earth's surface, which is the process known as the greenhouse effect. The greenhouse effect can therefore be defined as the warming of the Earth, which is responsible for global warming, now commonly referred to as climate change.

Greenhouse gas concentrations have been increasing in the atmosphere over recent centuries due to an increase in global population and associated increase in fossil fuel consumption since the industrial revolution (NOAA, 2017). Assessments by the Intergovernmental Panel on Climate Change (IPCC) suggest that the earth's climate has warmed 0.85 °C, from 1880 to 2012, and that greenhouse gas emissions from anthropogenic impacts is likely a dominant cause (US EIA, 2016).

3 This consumption based calculation is much lower than the per capita production based emissions, which were approximately 39 metric tonnes CO2 equivalent per capita in 2014 (http://cait.wri.org/historical).

The increase in global temperatures has a range of impacts on society and the environment, including the following:

**Agriculture:** Increasing temperatures and CO2 levels can make it difficult to grow some crops, raise livestock, and catch fish. This may affect food security at a local, regional, and global level.

**Energy:** Increasing temperatures are likely to increase energy demands whilst affecting the ability to produce electricity and deliver it reliably (UC, 2014).

**Coasts:** Climate change is causing sea level rise, changes in the frequency of storms, increases in precipitation and warmer ocean temperatures, which are affecting coasts. These impacts can worsen shoreline erosion, flooding, and water pollution. In addition, increasing $CO_2$ levels cause oceans to absorb more gas and become more acidic.

**Ecosystems:** Warming of land and oceans due to climate change causes changes in the timing of seasonal life cycle events of flora and fauna species, forces species to migrate to different areas, disrupts food web distributions, increases the risk of pathogens and diseases and increases the risk of species extinction.

**Water Resources:** Climate change is likely to increase water demand whilst decreasing water resources. In addition, water quality can be affected due to an increase in runoff. Heavy precipitation can increase the amount of sediment, nutrients, pollutants, and waste entering freshwater systems (US EPA, 2017).

All of these affect society through adverse impacts to human health, infrastructure, transportation systems, energy and food, and water supplies.

### 5.2.1 Integrating land use and transport planning

The relationship between transportation and the spread of urban settlements is interactive (Mehrota et al, 2011). The building of railroads and highways has influenced urban development, and conversely the growth of urban areas has influenced the development of road, air, and rail networks that facilitate travel within and across urban areas (Chomitz and Gray, 1996 ). As urban areas become vulnerable to climate change, addressing transportation issues in adaption and mitigation involves addressing the interactions between the sector and land use in cities (Mehrota et al, 2011).

There is evidence that more effective planning is needed to achieve sustainable mobility and integrating land use and transport planning is the strongest and most effective long-term strategy to improve transport energy efficiency. (Inturri G and Ignaccolo M, 2016). The energy efficiency of a conventionally propelled car is very low with only an average of 13% of the energy consumed being utilized to drive the wheel. The remaining 87% is dissipated in the engine, transmission, vehicle accessories, and when the engine is idling (Schafer et al, 2009). The occupants of a car contribute 6% to the total weight of the vehicle. Consequently, only 1% of the fuel energy is utilized to transport the occupants (Inturri G and Ignaccolo M, 2016). This is essentially why transportation policies aim at reducing the need to travel while also promoting public transport, walking, and cycling.

The mitigation measures proposed in Section 3.4.2 focus on measures that concentrate on spatial planning and transport systems to reduce the need to travel and ultimately reduce GHG emissions.

### 5.2.2 Existing and proposed energy regulation

The “Electricity and Water Consumption Rationalization Law” 2009 sets out a program to:

- **Develop the technical specifications for thermal insultation and power-saving measures in residential building as well as commercial, industrial, and investment facitilities**
- **Update the technical specifications of electricity and water internal installations**
- **Upgrade the audit methods to reduce power and water loss in customer premises with high consumption**
- **Develop and update technical specifications and standards for instruments, tools and equipment used in electricity and water installations and link them to the specifications for granting building permits.**

Kahramaa now requires all developments (in urban areas) to comply with Tarsheed (the National Program of Conservation and Energy Efficiency). Developers are required to submit forms that demonstrate that their projects achieve certain levels of energy and water use efficiency (Meier, 2012).

A related but separate development involves the Gulf Sustainability Assessment System (GSAS). GSAS was developed by the Gulf Organisation for Research and Development (GORD) by drawing best practices from building rating systems used regionally and internationally while addressing the specific social and cultural needs and environment of the region. GSAS is one of the most comprehensive schemes in the world, covering:

- **The full life cycle of construction: design, construction and operation**
- **The full range of construction scales: urban design, infrastructure and buildings**
- **The full range of construction types: District & Infrastructure, Residential, Commercial, Sports, Healthcare, Railways, PArks, Light Industry, Education, Mosques, Workers' Accommodation and Neighbourhoods**

The GSAS categories cover the full range of impacts associated with the built environment, and several that are specifically relevant to mitigation of greenhouse gases:

**Urban Connectivity**

Consists of factors associated with the urban environment such as zoning, transportation networks and loadings. Loadings on the urban environment include traffic congestion and air, noise, and light pollution

**Energy**

Consist of factors associated with the energy demand of buildings, the efficiency of energy delivery, and the use of fossil energy sources that result in harmful emissions and pollution

**Water**

Consists of factos associated with water consumption and its associated burden on municipal supply and treatment systems.

**Materials**

Consists of factors associated with materials extraction, processing, manufacturing, distribution, use/re-use, and disposal

Although GSAS is not mandatory at this stage, it has been voluntarily adopted by the developers of large projects:

- (Lusail Real Estate Development Company) for all developments in Lusail City (currently under construction)
- UDC (United Development Company)  for all developments in the Pearl

The formal adoption of GSAS for new development in Qatar offers a major opportunity to mitigate greenhouse gas emissions. These opportunities are identified in section 5.4.1.

### 5.2.3 Baseline Emissions

An extensive and comprehensive data collection and data assessment was undertaking during Stage 2 of the Project. Stage 2 established baseline information for the Project. However, due to the limited data available on GHG emissions from the urban planning and urban development sector in Qatar, baseline emission factors for all categories of land use could not be developed. In particular, emission factors for residential zones are based on the population present in those zones. Based on regression analysis performed by GHD, there is no correlation between the type of zone and the population density – thus, it is only possible to estimate emissions for residential zones based on the population density or population present in a zone. Additional refinements could be made if electricity usage, transportation, waste, and water data (in that order) is available for specific types of residential zones.

To develop emission factors for other zones and land use categories, the following information would be useful: typical industrial activities that occur in various industrial zones; shipping volumes by different industry, zone, or district across different shipping methods (e.g. truck, rail); electricity usage by different zone or district; waste production and content mix by different zone or district; and water usage by different zone or district.

Emission factors were developed for land use categories where possible (Table 5-1). Baseline emissions were developed based on information available from Kahramaa, the Ministry of Development Planning and Statistics (MDPS), the International Energy Agency (IEA), the International Gas Union, US EPA emission factors, and IPCC publications.

These emission factors are specific to the environmental conditions and circumstances in Qatar. Local climate conditions, living standards, and construction practices mean that GHG emissions cannot be directly compared to other regions. For example, due to Qatar's hot climate, electricity usage for air conditioning is significantly higher, and could not practically be lowered to the same levels as countries in Western Europe or North America. Thus, it is most pragmatic to benchmark future GHG emissions in Qatar against a baseline of current GHG emissions in Qatar, rather than a target based on emissions in other countries.

With the goal of future GHG reductions in mind, these baseline emission factors can be considered as the acceptable upper threshold for GHG emissions from future land use changes.

Details of how the emission factors were developed are provided in the following sub-sections.

**Table 5-1: Area-based emission factors for land use categories**

| Land Use Category | Emission Factor (kg $CO_2e/yr/m^2$) |
|---|---|
| Community Facility Zone | 42.94 |
| District Centre | 42.94 |
| Environmental Conservation Zone | – |
| Green Belt Zone | – |
| High Density Residential Zone | – |
| Large Format Retail Zone | 42.94 |
| Logistics/Distribution/Warehousing Zone | 42.94 |
| Low Impact Industry Zone | 213.27 |
| Low-Density Residential Zone | – |
| Note: Table continued on next page | |
| Low-Medium Density Residential Zone | – |
| Medium Density Residential Zone | – |
| Medium-High Density Residential Zone | – |
| Metropolitan Centre | 42.94 |
| Open Space and Recreation Zone | – |
| Residential Tower Zone | – |
| Rural/Desert Zone | 0.21 |
| Sports Zone | 42.94 |
| Tourism Zone | 42.94 |
| Town Centre | 42.94 |

In addition to the emissions expected from certain land uses, there are emissions associated with day-to-day activities of individuals. These per-capita emissions account for 8.14 tonnes of $CO_2$ per capita per year, which need to be considered in overall emissions. In residential areas, the primary driver of greenhouse gas emissions is the population count, rather than population density or zone area.

To calculate the expected GHG emissions for a particular area, three pieces of information are required: the emission factor fromTable 5-1, the estimated area of that particular land use, and the total population of residents that will live in that area. The total annual emissions are then equal to:

$$\text{Emissions (tonnes } CO_2 \text{ e)} = \frac{\text{(Emission factor from Table 5 – 1)} \times \text{(Area in } m^2\text{)}}{1{,}000} + 8.14 \times \text{Population}$$

For example, on average, expected emissions for rural/desert zones are 0.21 kg $CO_2e$ per year per $m^2$ plus 8.14 t $CO_2$ per year per resident. For a 10,000 $m^2$ zone with a population of 100, the expected annual emissions are 816.1 tonnes $CO_2e$ per year:

$$\frac{0.21 \times 10{,}000 m^2}{1{,}000} + 8.14 \times 100 \text{ people} = 816.1 \text{ tonnes } CO_2 \text{ e /year}$$

### *Residential Emission Factor Development*

Residential emission factors were developed based on a variety of collected data, and were broken down into emissions associated with five categories:

1. Water consumption (0.31 metric tons $CO_2e$ per capita per year)
2. Electricity consumption (3.74 metric tons $CO_2e$ per capita per year)
3. LPG consumption (0.13 metric tons $CO_2e$ per capita per year)
4. Transportation (2.68 metric tons $CO_2e$ per capita per year)
5. Waste (1.27 metric tons $CO_2e$ per capita per year)

Total emissions associated with residential areas were 8.14 metric tons $CO_2e$ per capita per year. Further details about supporting information for each category are provided below.

### Water Consumption

GHG emissions for residential water consumption were developed based on information available from Kahramaa, internal GHD research, US EPA emission factors, and IPCC publications. Per-capita annual water consumption (Kahramaa) was multiplied by the electricity required to produce the water (GHD). The resulting electricity usage was then multiplied by the grid emission factor (Kahramaa), speciated into separate greenhouse gases using natural gas emission factors (US EPA), and converted to $CO_2e$ using global warming potentials (IPCC).

### Electricity Consumption

GHG emissions for electricity consumption were developed based on information provided by Kahramaa, US EPA emission factors, and IPCC publications. Per-capita annual electricity consumption (Kahramaa) was multiplied by the grid emission factor (Kahramaa). This value was then speciated into separate greenhouse gases using natural gas emission factors (US EPA), and converted to $CO_2e$ using global warming potentials (IPCC).

### LPG Consumption

GHG emissions for LPG consumption were developed based on information from the Ministry of Development Planning and Statistics (MDPS), the International Energy Agency (IEA), the US EPA, the International Gas Union, and the IPCC. Total LPG consumption for residential use (IEA) was divided by the estimated population of Qatar (MDPS) to obtain per-capita LPG consumption for residential use. This value was then converted to the appropriate units (International Gas Union) and speciated greenhouse gas emissions were calculated using LPG emission factors (US EPA). These were then converted to $CO_2e$ using global warming potentials (IPCC).

### Transportation

GHG emissions for transportation were developed based on information from the Qatar Environment and Energy Research Institute, MDPS, and IPCC. The total distance travelled by various types of passenger vehicles (Qatar Environment and Energy Research Institute) was multiplied by emission factors for each type of vehicle (Qatar Environment and Energy Research Institute). These values were then converted to $CO_2e$ using global warming potentials (MDPS) and divided by the estimated population of Qatar (MDPS) to obtain per-capita GHG emissions.

### Waste

GHG emissions from waste were developed based on two subcategories:

1. Solid waste disposal
2. Wastewater handling

Specific details for the two categories are provided below.

### Solid Waste Disposal

GHG emissions from solid waste disposal were developed based on information from the Qatar Environment and Energy Research Institute, MDPS, and IPCC. The average domestic waste generation (Qatar Environment and Energy Research Institute) was multiplied by the estimated population of Qatar (MDPS). This value was then used with the IPCC waste model to estimate per-capita GHG emissions.

### Wastewater Handling

GHG emissions from wastewater handling were developed based on information from the Qatar Environment and Energy Research Institute, IPCC, and MDPS. These emissions were separated into three categories:

1. Methane emissions from domestic wastewater treatment calculated using equation 6.1 of 2006 IPCC Guidelines, using data from the IPCC and the Qatar Environment and Energy Research Institute
2. Nitrous oxide emissions from wastewater effluent calculated using equation 6.9 of 2006 IPCC Guidelines, using data from the IPCC and the Qatar Environment and Energy Research Institute
3. Fugitive methane emissions from sludge processing and disposal or recycling calculated using equation 1 of Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories – Background Paper, $CH_4$ and $N_2O$ Emissions from Waste Water Handling (IPCC)

### *Other Emission Factor Development*

### Commercial

Commercial zones include the following land use categories:

1. Sports
2. Community Facility
3. Metropolitan Centre
4. Logistics
5. Tourism
6. District Centre
7. Town Centre
8. Large format retail

Emission factors for these zones were developed based on the estimated electricity and water usage as obtained from the International Energy Agency and the Ministry of Development Planning and Statistics. These values were converted to $CO_2e$ values similar to the residential factor development process. The resulting value was then divided by the total land area of those uses based on GIS information.

### Industrial

Emission factors for the low impact industry zone were developed based on the estimated electricity and water usage as obtained from the International Energy Agency and the Ministry of Development Planning and Statistics. Electricity usage associated with steel and aluminium production was disaggregated from the total electricity usage, as these activities are unlikely to occur in low impact industry zones. These values were converted to $CO_2e$ values similar to the residential factor development process. The resulting value was then divided by the total land area of industrial uses based on GIS information.

### Rural/Desert

Emission factors for the rural/desert zone were developed based on the estimated agricultural water usage as obtained from the Ministry of Development Planning and Statistics. This values was converted to $CO_2e$ values similar to the residential factor development process. The resulting value was then divided by the total land area of this land use based on GIS information.

## 5.3 Measures to Achieve Plan Objectives

The Climate Change Strategy objectives applicable to 'reducing greenhouse gas emissions' are:

- Protect members of the population from the effects of climate change
- Reduce travel demand and improve access to public transport in new developments
- Facilitate the optimal siting of solar energy installations through land use planning and integrate small scale solar energy generation into all new development and major retrofits
- Monitor greenhouse gas emissions in urban development and make the information publicly available
- Incorporate green building measures to improve the energy and water efficiency of homes and businesses

This section proposes urban development and planning actions to reduce greenhouse gas emissions in Qatar. The actions comprise:

- Reducing energy and water use: reducing embodied energy, increasing energy efficiency, increasing water efficiency
- Reducing the need to travel: location of housing in relation to other land uses, links to public transport, high quality walking and cycling environment, parking management and other disincentives to car use
- Renewable energy production: large-scale and household scale renewables

## 5.4 Mitigation Measures

Mitigation measures that can effectively reduce greenhouse gas emissions in the urban planning and urban development sector in Qatar are detailed in the following sub sections.

### 5.4.1 GE1: Develop GHG emission inventory and benchmarks

It will not be possible to measure the success of the CCS without a reasonably accurate measurement of GHG emissions from the built environment. Stage 5 of this Project involves the development of a tool to estimate and predict GHG emissions from the built environment.

In Qatar's National Emission Inventory (1995-2015) report, Mohammed (2016) identifies many deficiencies in data collection and sharing that inhibits efforts to understand the full extent of GHG emissions in Qatar.

Mohammed's inventory is constructed on a similar basis to other national reports, namely emissions related to the point of production by sector: agriculture, electricity / water, industrial, natural gas, oil, transport and waste. However, he notes:

*"Production-based emission inventories are often misleading, especially, where the domestic consumption of locally produced emission-intensive products is minimal. Using a conventional approach such as per capita emissions to gauge the country's status is evasive. In countries with high levels of export volume, it is appropriate to use consumption-based emissions to determine their accurate contribution to global emissions."*

**Output GE1:**

**Develop and publish a GHG emission inventory and benchmarks**

GE1-1. Develop a consumption-based GHG emissions inventory for the built environment based on international best practice.

GE1-2. Devise emissions indicators appropriate for use in monitoring domestic GHGs and establish benchmarks.

G1-3. Prepare and publish an annual report outlining consumption-based emissions and key metrics.

In most developed western countries consumption based emissions exceed production emissions due to the emissions embedded in imports. The opposite is the case in Qatar because much of Qatar's emissions are effectively embedded in the exported hydrocarbons, meaning the real domestic emissions intensity is significantly overstated by merely dividing annual national production emissions by the population. MME's initiative to prepare a tool to estimate emissions from the built environment in Qatar is consistent with Mohammed's call for a consumption-based emissions account system. Similar recommendations are made by David and Caldeira (2010).

Until the gaps identified in Mohammed's report are resolved, any emissions inventory will be inaccurate. However, the inventory provides a basis for estimating consumption based emissions from the built environment. The development of the tool will require the development of a consumption-based emissions inventory (CBEI) along the lines of that used widely in the United States to track household consumption emissions. A toolkit has been developed as part of the Urban Sustainability Directors Network's suite of Innovation Products (2016), which provides a good basis for development of a similar tool in Qatar. This tool estimates emissions from consumption, i.e.

***Emissions from consumption (Ec) = emissions from local production (Ep) – emissions embedded in exports (Ee) + emissions embedded in imports (Ei)***

To develop consumption based emissions it will be necessary to:

- disaggregate Qatar's production emissions into those embedded in domestic consumption and those exported
- use the emissions inventories of other countries to assess emissions embedded in imports

The CBEI methodology determines consumption based emissions for a range of household consumption categories. However, the Qatar consumption inventory needs to address emissions for all forms of development and therefore will need to go beyond the household. It is envisaged that emissions for these uses are disaggregated by Construction, Maintenance, Energy use, Water, Waste. This will require the emission intensity of electricity production and any direct combustion of other fossil fuels such as natural gas or biomass. The feasibility of preparing an inventory of this level of complexity will depend on the information available.

The essential metrics derived from the inventory and which will be used as emission indicators are provided in Table 5-2.

Table 5-2: Emissions indicators

| Total $CO_2$-e emissions | / person pa<br>/ m2 pa |
|---|---|
| Household $CO_2$-e emissions | / person pa<br>/ m2 pa |
| Retail $CO_2$-e emissions | / m2 pa |
| Commercial $CO_2$-e emissions | / m2 pa |
| Infrastructure $CO_2$-e emissions | / unit of domestic consumption (e.g. kWh) |
| Transportation $CO_2$-e emissions | / km travelled |

The initial inventory developed will provide benchmarks for each of these indicators. In the meantime it is recommended that the reference benchmarks established in the GSAS framework are used (Table 7-1).

The consumption based emissions inventory and key metrics should be produced annually, published by MME and communicated to local and international audiences. The results should be produced in a manner that clearly identifies changes from year to year and therefore facilitates monitoring of emissions over time.

### 5.4.2 GE2: Create higher densities and mixed use to reduce travel demand

Transport is a major generator of greenhouse gases in Qatar. Where trips are short, for instance in compact urban areas with high densities, walking and cycling are feasible alternatives, while the bus or train is appropriate for longer journeys. Urban planning and development interventions that support a shift away from car use and towards walking, cycling and public transport are discussed in the following sub-sections.

Measures such as limiting urban footprints by promoting dense developments is a feasible urban design intervention, which if implemented, can reduce GHG emissions.

Dense developments have a smaller footprint and use less energy than detached dwellings as apartments essentially act as insulation for each other.

Locating different types of land uses near each other and within smaller development blocks reduces the need to travel because services are within walking or cycling distance of each other. Figure 5.2 shows examples of 'coarse grained' development of large blocks of single land use that encourages travel by car, and 'fine grained' multi-use development that encourages walking and cycling. A key to encouraging fine grained development is to increase development density and hence reduce the distance between land uses.

The London Master planning Checklist for sustainable transport (Taylor and Sloman, 2008) suggests that:

- New development should be built to high density levels with a minimum net density of 100 dwellings (approximately 250 people) per hectare
- Development in locations close to excellent public transport should be built to net densities of above 200 dwellings per hectare.

**Output GE2:**

**Create higher densities and mixed use to reduce travel demand**

GE2-1. Require compact, mixed use development in city centers and inner suburbs (excluding Qatar Housing Areas) at the densities necessary to promote public transport use.

GE2-2. Require central and inner development sites to achieve a mixed use (i.e. residential and non-residential uses), with non-residential uses on the ground floor.

GE2-3. Integrate walking, cycling and public transport networks into existing mega-projects.

GE2-4. Implement higher residential density targets for new development.

GE2-5. Require new development to be sequenced, such that with development further from existing urban areas is permitted only after areas nearer the existing urban areas have been developed.

*Figure 5-2: Coarse-grained development that encourages car use (left), and fine-grained development that encourages walking and cycling (right)*

The Guidelines for Providing Access to Public Transportation Stations in the United States (Coffel, 2012) suggests building densities that support good quality public transport, as shown in Table 5-3.

**Table 5-3: Land use and development density**

| Location type | Typical distance from city center (km) | Typical net residential density (people per km²) | Primary mode of arrival to the train, bus rapid transit, or ferry station |
|---|---|---|---|
| Central business district | 0 – 3 | NA | Pedestrian |
| Central city | 3 - 16 | 3200 – 8000 | Pedestrian, bus |
| Inner suburbs | 16 - 24 | 1600 – 2400 | Park & Ride, bus |
| Outer suburbs | 24 - 40 | 1000 – 1600 | Park & Ride |

Source: Transportation research board (2012)

The policies in Qatar's MSDPs generally support compact, mixed-use development and 'fine grained' planning, as well as promoting city centres, town centres and district centres that are easily accessible from residential areas. However, none of the policies specifies a level of density that would support a 'compact urban area' approach and the zoning plans seem inconsistent with this vision. There is an inconsistency in the plans by aiming for a 'compact city' model but also specifying Qatari style housing.

The existing MSDPs allocate about 80% of future development as low density residential zones, at 1-60 persons/ha, on par with the least dense 'executive home' model provided in Figure 5.3. Doha municipality currently has an average density of 46 persons/ha or 4600 persons/km². However, none of the other municipalities achieves this net density.

An additional, more recent problem has been the development of mega projects inconsistent with urban planning regulations and frameworks, which has resulted in districts that are spatially fragmented to the extent that they require private vehicles to access them.

Development in Qatar should be phased in order to reduce the overall development footprint and need to travel, consequently reducing GHG emissions. Currently, much of the development in Qatar is piecemeal, with large vacant areas present between developed areas. This form of sprawl development makes for a disjointed townscape and increases the need to travel.

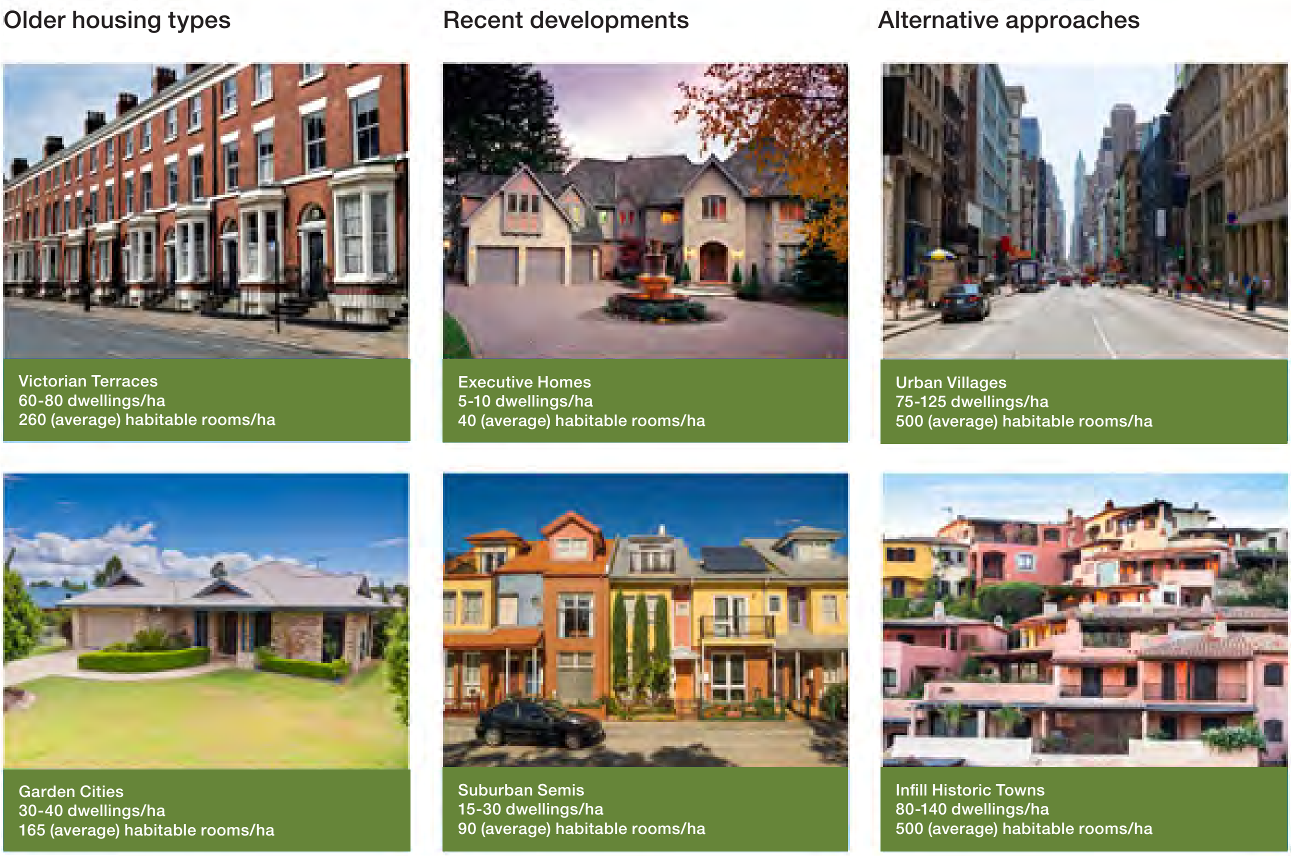



*Figure 5-3: Alternative approaches to density*
Original graphics credit: CABE (2005)

### 5.4.3 GE3: Improve walkability

Reducing the demand for car travel requires the provision of appropriate public transport, walking and cycling facilities. While providing these facilities is not within the remit of the MME, it is possible to ensure good access to those that are provided. In this regard, the London Master planning Checklist (Taylor and Sloman, 2008) recommends the following links between development and transport:

- Location of new developments
  - Not close to motorways, or high-speed dual carriageway roads
  - Within walking distance of major public transport links
  - Adjacent to or within urban centres rather than smaller freestanding towns
- Local facilities and jobs
  - Residential developments should include or be closely associated with facilities that are used on daily basis – i.e. shops selling food and fresh groceries, newsagents, open space with children's play area, post offices and cash points, nursery and primary schools, eating and drinking places, supermarkets, and secondary schools
  - Larger residential development should also include or be close to facilities which can capture a large proportion of trips locally – i.e. medical centres, chemists, community centres
  - Residential developments should include or be close to as wide a range of shops and facilities as possible
  - The local centre with shops and facilities should be within walking distance (480 m) of all residences.

**Output GE3:**

**Improve walkability**

GE3-1. Develop a street design code that stipulates walkability requirements (guided by GSAS criterion S.6 Walkability) within higher residential density centers and mixed use zones.

GE3-2. Progressively upgrade existing areas for compliance with the street design code, where possible.

Further, the area around public transport hubs (Metro stations and bus stations) should typically be built to a high density and contain a variety of uses (see Figure 5.4), including goods and service providers and open space. This encourages access to public transport by walking and cycling (in contrast to park and ride sites for example), thus reducing dependence on private vehicles and the associated carbon footprint.

A street design code should be developed and incorporated into the MSDPs that stipulates walkability requirements (e.g. safe and attractive sidewalks of appropriate width and shading (Section 4.5.1)) within higher residential density, centre and mixed use zones. Existing areas can be progressively targeted for upgrading for compliance, where possible. Guidance for these measures can be sourced from the GSAS criterion S.6 Walkability.

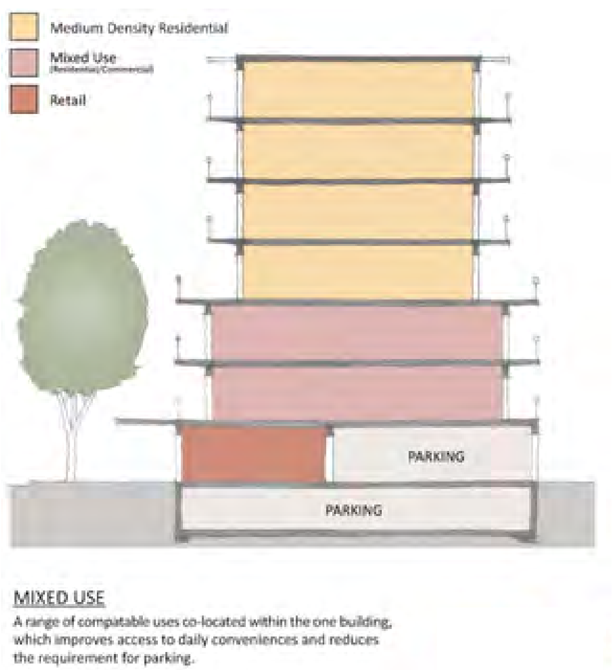



*Figure 5-4: Cross section of mixed use development appropriate for near public transport hubs*

### 5.4.4 GE4: Create Transit Oriented Development

The MSDPs generally support transport-development links. For instance, the Al Rayyan MSDP promotes transit oriented development, especially around public transport hubs and aims to facilitate a modal transfer to a high quality public transport system. The Umm Slal MSDP requires development of a choice of metro stations on the Metro Green Line, strategically located in close proximity to the mixed use centers. Other strategies outlined within the MSDPs include:

- Park and Ride sites integrated with proposed public transport stations and centre developments
- Restructuring of the highway/ street systems to meet Transit Oriented Development (TOD) requirements
- Shared Parking Rates for Mixed Use Centres within the Qatar Parking Master Plan. Once completed, rates will be included within these regulations

However the Al Shamal MSDP states that the low population density in the northern Cities does not provide a sufficient threshold for an economic and efficient public transport network to be established, and only supports inter-city coaches. Further, in Al Shamal, services that would ideally be reached by young people on foot or on bikes (the Al Shamal Park, Shamal Model School and Al Shamal Sports Club) are all on the outskirts of town, accessible only by vehicles on large roads (Figure 5.5).

**Output GE4:**

**Create Transit Oriented Developments**

GE4-1. Establish mixed use zones within 480 m of the planned stations of the Doha Metro. Create a zone a further 480 m from this radius for medium density and other uses that would benefit from proximity to rail stations, including park and ride facilities.

GE4-2. Require public facilities (e.g. town/district centers, parks, schools, sports clubs) to be accessible by walking, cycling or public transport following the guidance of the GSAS criterion (UC.5 Intermodal Connectivity).

*Figure 5-5: Examples of services that currently cannot be easily reached by walking and cycling*

As such, mixed used zones should be established within walking distance (max. 6 minutes walking with walking speed of 80 m/ minute, which translated to 480 m (GSAS, 2015)) of planned Doha metro stations.

### 5.4.5 GE5: Introduce parking restrictions

A study into public transport (Cervero and Guerra, 2011) suggested that:

*"It is unlikely that 'liveability enhancements' like streetscape improvements and greening of transit corridors will be sufficient… More than likely, external factors like higher motoring and parking costs will be more effective than well-intended urban design strategies at creating the kinds of urban densities needed for cost-effective transit services in the U.S.".*

In other words, car drivers with established patterns of transport are likely to need disincentives to driving as well as incentives to walk, cycle, and take public transport to switch from their cars to other transport modes. Generally, this means making car access more expensive, less convenient, and slower in comparison to access by walking, cycling, and public transport. This can be achieved by making centres accessible only to walking and cycling, where possible.

Some of the MSDPs already do this to a certain extent. For instance:

- Al Daayen MSDP: *"In key activity nodes… the capacity for private cars should be reduced in favour of public transportation, pedestrian facilities and an enhanced public realm"*
- Al Shamal MSDP*: "… low traffic speeds within residential streets. Car parking on pavements should be prohibited… With greater densities, services in walkable distance, local bus services and a pedestrian friendly environment, the number of parking spaces can be reduced in time."*

**Output GE5:**

**Introduce parking restrictions**

GE5-1. Introduce parking fee minimums to reduce parking occupancy, which in turn will minimize cruising for parking spaces.

GE5-2. Require companies to provide the minimum number of parking spaces necessary for their workforce.

GE5-3. Stipulate parking maximums for development in zones with good public transport.

GE5-4. Incorporate the final stipulations from the Qatar Parking Master Plan within the Zoning Regulations.

However the MSDPs offer few specific requirements (e.g. 'the number of parking spaces can be reduced in time' gives no assurance about levels of reduction or when this will happen). Other MSDPs (e.g. Umm Slal, Al Rayyan) identify heavy reliance on cars as a problem, but make no specific requirements to reduce the problem.

Parking is a particular problem for urban development as it decreases the potential for urban density and therefore decreases transit ridership, while encouraging private vehicle use. Qatar is currently preparing the *Qatar Parking Master Plan,* which will incorporate measures to reduce private vehicle use and increase public transport patronage. It is recommended that the following parking restrictions be included within the document:

1. Parking fee minimums to reduce parking occupancy, which in turn will minimise cruising for parking spaces
2. Workplace levies imposed by municipalities on companies that provide over a certain number of parking spaces for the size of their workforce
3. Stipulate parking maximums for development in zones with good public transport.

### 5.4.6 GE6: Improve energy efficiency in new development

**Output GE6:**

**Improve energy efficiency in new development**

GE6-1. Mandate a minimum of GSAS Level 2 energy performance for all new development.

Qatar's Vision 2030 and the Qatar National Development Strategy 2011-2016 aim to reduce the energy intensity of the economy through awareness campaigns, standardisation and shutdowns. Despite this, Qatar is expected to have growing energy consumption and has only a limited framework for improving energy efficiency.

By far the most cost-effective mitigation action is the avoidance of emissions through energy efficiency measures. In the residential sector, energy is used for space cooling (and limited heating), hot water and the operation of appliances. Best practice building design is capable of dramatically reducing the energy demand of houses, as demonstrated by Qatar's first 'Passivhaus' project (Khalfan et al, 2015). This project incorporated a 'super insulated envelope with no thermal bridges, mechanical ventilation with heat recovery, low air leakage rates, solar water heating, photovoltaic panels, high performance glazing and high efficiency A/C and lights', and achieved adequate thermal comfort with very little cooling energy.

The World Bank (2016) suggests that Qatar has the potential to achieve 41% energy savings in its industrial sector (the second highest of 12 MENA countries), and 14% in its residential sector by 2025. Suggested planning measures include:

- Mandating commercial and industrial facilities to install efficient lighting and equipment
- Introducing standards and regulations to ban the use of energy-inefficient lighting and enforcing regulations where they have been adopted
- Developing mandatory regulations and enforcing building energy codes in existing and new residential buildings (Qatar has already introduced standards for air conditioners)

Further, energy use can also be reduced by up to 30% through education and behaviour change programs (Lopes, Antunes, & Martins, 2012), supported by smart metering, which enables users to view their energy consumption.

The MSDPs for Al Rayyan and Doha include in their planning objectives *"promote energy and transport efficient urban developments to reduce the impact on the environment"*. The Doha MSDP also refers to *"the construction of innovative, energy efficient buildings"*. All of the MSDPs include the wording *"Develop buildings that are sustainable, address QSAS standards, and respond to the climate taking inspiration from historic Islamic architecture"*.

However, none of the MSDPs or AAPs explain how energy efficiency should be achieved and how QSAS or GSAS standards should be addressed. Further, QSAS/GSAS is currently a good-practice standard rather than a mandatory requirement.

In order to ensure greenhouse gas is addressed appropriately in Qatar's planning framework, more comprehensive regulations are required. Although Kahramaa now requires some developments to comply with certain standards, Tarsheed (the National Program of Conservation and Energy Efficiency), these requirements only apply to development in urban areas and are prescriptive rather than performance based.

Rather than formalise further, more stringent prescriptive approaches in (e.g. a design code), the mandatory adoption of GSAS offers the opportunity to achieve superior energy performance within an existing compliance framework.

The scheme has its own regulated approach to audit, evaluation and certification meaning that it provides an opportunity to adopt it in whole or part through reference to its requirements within planning and building approval processes.

The adoption of GSAS should however require minimum performance in respect of energy. This could be achieved by requiring a minimum of Level 2 performance for the energy criteria, i.e.:

- E.1 Energy Demand Performance
- E.2 Energy Delivery Performance
- E.3 Primary Energy Sources
- E.4 $CO_2$ Emissions and Offset

### 5.4.7 GE7: Improve water efficiency

Qatar has very limited potable water resources and consequently the country largely relies on desalination plants, which are highly energy intensive. Therefore reducing water consumption will also reduce Qatar's GHG emissions. At present, Qatar has a limited regulatory framework for managing and reducing water consumption, although a Qatar *National Water Policy* is currently under preparation, which will establish an integrated system of quality requirements, discharge controls and incentives for conservation.

Water consumption in Qatar is over 300 litres / day / person, making it the largest per capita user of water in the world. A Qatari home using 2,000 litres per day of water requires over 3,000 kWh/year of energy at the desalination plant. Water consumption represents one of the largest uses of energy in Qatari buildings. Desalination adds at least one kWh for every 200 litres of water consumed (Meier, 2012).

At the residential and commercial level, new developments can be made more energy and water efficient by requiring them to include water efficient fixtures (including toilets, tapware, showerheads, and garden irrigation systems).

As for energy, GSAS should be adopted and require minimum performance in respect of water. This could be achieved by requiring a minimum of Level 2 performance for the water criteria, i.e.:

- W.1 Water Efficiency
- W.2 Water Consumption and Reuse

In industry and agriculture, optimised water usage technology should be required, such as the use of subsurface drip irrigation. Some jurisdictions also require industrial users to prepare water efficiency plans that identify where they can make water savings.

The MDSPs have identified large areas of greenspace for future development. In order to ensure these areas do not also result in the excessive use of water, restricting planting to species that are adapted to an arid environment should be considered. This would reduce water consumption in addition to providing essential habitat for regional avian and fauna species.

**Output GE7:**

**Improve water efficiency**

GE7-1. Mandate a minimum of GSAS Level 2 water performance for all new development.

GE7-2. Require major industrial and agricultural developers to prepare a water efficiency plan showing how they will minimise water use in line with world's best practice. The plans should be updated yearly within the Qatar National Water Policy (this will require the Qatar National Water Policy to be amended).

GE7-3. Require the use of certain water efficient irrigation practices and provide planning incentives (e.g. grants for water efficient systems).

GE7-4. Mandate the use of native and drought-tolerant species.

### 5.4.8 GE8: Increase the use of recycled water in new development

Re-used water can be divided into the following water categories:

- Greywater (residential and commercial water from laundry, bathroom, taps and showers)
- Industrial greywater (slightly polluted water than can be reused in manufacturing)
- Sewage effluent, which can be treated and used for irrigation.

By requiring the reuse of water in future developments, demand for water resources would decrease. For new development, implementation requirements may be as part of the DC 1 and DC 2 building approvals process. Further regulations may be incorporated into the Qatar Construction Specifications (QCS).

**Output GE8:**

**Increase the use of recycled water in new development**

GE8-1. Incentivize, or require new development to incorporate wastewater recycling facilities. Incentives may include the development of a market for the use of greywater / recycled wastewater, such as watering street trees or irrigation.

### 5.4.9 GE9: Improve the energy and water efficiency of retrofitted development

Many old buildings in Qatar are of poor quality so retrofitting offers the possibility of making them more energy efficient. Retrofitting of existing buildings can include insulation, LED lighting and lighting controls, more efficient cooling systems and photovoltaics. Larger regeneration projects offer the possibility of upgrading the entire building stock. Itani et al. (2013) found that for an office building in Lebanon, night purging (flushing air out of a building at night when temperatures are below 21C) saves 20% on cooling costs; and an air economizer which takes in air from outside when it is cooler saves 15% on cooling costs. These technologies have payback periods of 6 – 8.5 years.

**Output GE9:**

**Improve the energy and water efficiency of retrofitted development**

GE9-1. Mandate a minimum of GSAS Level 2 energy performance for retrofits of selected building types / floor area.

The GSAS schemes include a certification for existing buildings, and this should be adopted to ensure the energy and water performance of these buildings is improved over time. Discretion will be necessary as to which buildings this requirement applies to ensure that the benefits are commensurate with the costs incurred.

### 5.4.10 GE10: Reduce the embodied energy of development

'Embodied energy' is the energy needed, directly or indirectly, to deliver a good or service (Cleveland & Morris, 2009). In urban development terms, it can mean the energy of producing and transporting building materials and the energy used in constructing and demolishing (but not operating) the resulting building. Embodied energy can account for up to half of a building's lifetime $CO_2$ emissions (Institution of Civil Engineers, 2015). As such, retrofitting a building to extend its life is often more energy-efficient than constructing a new building. Using recycled/reused building materials is a key way of reducing embodied energy, as can be seen in Figure 5.6.

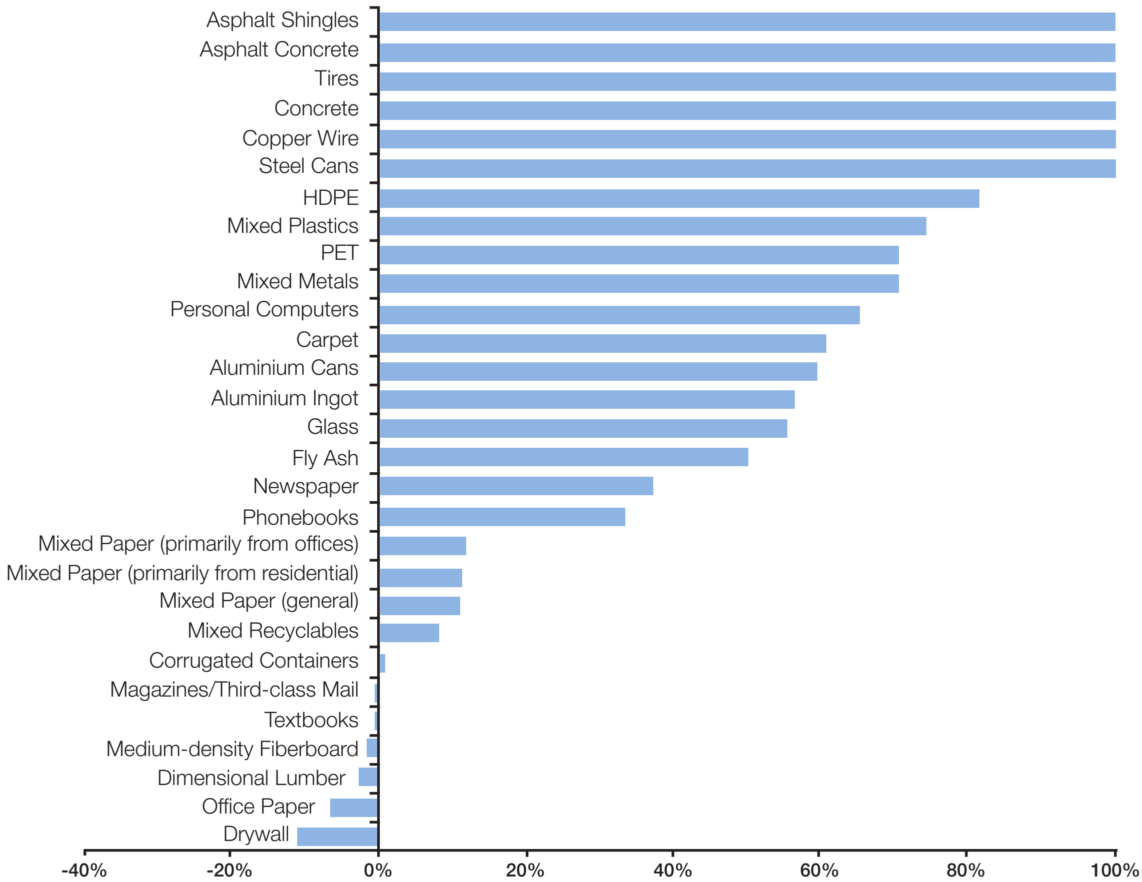
**Output GE10:**

**Reduce the embodied energy of development**

GE10-1. Require developers to consider retrofit/ refurbishment over new build, particularly if the existing building is relatively energy efficient.

GE10-2. Require developers of new developments and major retrofits to demonstrate how they will minimize their use of virgin materials.

GE10-3. Require developers of retrofit or upgrades to previously developed sites to recycle the maximum amount of the previous building materials.




Note: Positive numbers indicate GHG benefits attributable to energy savings from recycling; negative numbers indicate that additional energy GHG emissions result from energy required for recycling, compared to landfilling. This figure excludes materials in WARM for which recycling is not a viable end-of-life management option.

*Figure 5-6: Greenhouse gas benefits from recycling relative to landfilling*

Source: US Environmental Protection Agency (2015)

The incorporation of recycled materials in new and retrofit development is contingent on local availability of the materials themselves. It is beyond the remit of MME to develop the recycling industry in Qatar, and it is recognised that the limited availability of appropriate recycled materials will affect the viability of increasing their use.

These actions can be progressed through application of the GSAS Materials category, specifically:

- M.1 Regional Materials
- M.2 Responsible Sourcing of Materials
- M.3 Recycled Materials
- M.4 Materials Reuse
- M.7 Life Cycle Assessment (LCA)

The embodied energy of development is also reduced by ensuring that buildings, or at least their component materials are adaptable and can be disassembled.

**Output GE11:**

**Design for structure reuse**

GE11-1. Require developers to produce designs that facilitate the re-purposing of the building and reuse of their components in line with the measures included in GSAS.

### 5.4.11 GE11: Design for structure reuse

Designing buildings for re-use or re-purposing (so-called 'adaptive reuse) is one way of achieving this objective, and ensuring their components can be re-used is another. Buildings should be designed to facilitate their adaptation or disassembly through measures such as:

- Using simple open-span structural systems and standard size, modular building components and assemblies
- Using durable materials that are worth recovering for reuse and/or recycling
- Minimizing the use of different types of materials and making connections visible and accessible
- Using mechanical fasteners such as bolts, screws and nails instead of sealants and adhesives
- Planning for the movement and safety of workers to allow for safe building adaptation, repair and disassembly
- A guide for designing for reuse is available through the US EPA (US EPA, 2017) and the issues are included in the GSAS framework

The measures included in GSAS, sspecifically M.5 Structure Reuse; and M.6 Design for Disassembly should be mandated.

### 5.4.12 GE12: Plan for large scale renewable energy production

**Output GE12:**

**Plan for large scale re-newable energy production**

Identify and reserve possible sites for medium to large-scale photovoltaic energy developments near HV infrastructure, and depict them on the zoning maps.

As Qatar's heavy use of fossil fuel-generated power is a primary contributor of greenhouse gas emissions, transitioning to renewable energy has the potential to significantly reduce Qatar's greenhouse gas emissions over time. In addition, investment and development of renewable energy would increase Qatar's energy security and resilience by widening its electricity offer and increasing its capacity for future energy export and related revenues.

The *Qatar National Vision 2030* establishes a 20% renewable energy target by 2024. In practice, most or all of this would come from photovoltaics since Qatar's wind speeds are generally considered insufficient for economically efficient wind energy. Additional supporting regulatory frameworks need to be established to support this ambitious goal.

Qatar Solar Energy (QSE, 2017) was established as a nationally important initiative and has been producing solar technology since 2014 at their facilities in Al-Rayyan.

A 200 megawatt solar power project is being developed by Qatar Electricity and Water Company and Qatar Petroleum and is due to be operational by 2020 (Clean Technica, 2017). Other large-scale renewable projects have recently been built in other MENA countries, confirming that this should also be feasible in Qatar. The unit cost of photovoltaics are decreasing worldwide (MENA New Energy, 2017), making them increasingly cost-efficient.

The development of large-scale photovoltaic energy development ('solar farms') could be facilitated by having appropriate sites for solar farms identified in the MSDPs, located near High Voltage (HV) infrastructure. Of the MSDPs reviewed (Al Daayen, Al Rayyan, Al Shamal, Doha, Umm Slal), none mention renewable energy. Table 5-4 shows solar farm criteria used in the UK, adapted to the Qatar context. Criteria used elsewhere (Georgiou and Skarlatos, 2016) have included the requirement to be placed at least:

- 50 metres from primary and secondary roads
- 200 metres from nature conservation sites or urban zones
- 100 m from surface waters
- 200 m from the shoreline or archaeological sites
- 2000 m from airports.

**Table 5-4: Criteria for locating a solar farm (ESGP, 2014)**

| Criteria | Parameters (adapted to the Qatar context) |
|---|---|
| Flooding | Must be outside the 1-in-20 year flood zone |
| Land use / designation | Must be outside of built up areas or Protected Areas |
| Land type | Rural/desert, Green Belt, Transportation and Utility, Vacant, Landfill (Environmental Protection Agency guidance document (2013) available on 'Best Practices for Siting Solar Photovoltaics on Municipal Solid Waste Landfills' |
| Public access | Not accessible to the public |
| Aspect | Level or sloping south / SE / SW |
| Shading | Not shaded (e.g. by residential or industrial development) |
| Solar radiation | Must receive at least 1050 kWh/m2 of solar radiation |
| Grid connection | Must be within 1 km of existing high voltage power distribution lines |
| Access | Access for vehicles for construction |

### 5.4.13 GE13: Increase onsite renewable energy in new development

Possibly the most effective way of encouraging building-scale renewables in houses and commercial premises is to have a generous feed-in tariff, namely a long-term contract that pays householders for the renewable energy they produce. The price of solar panels has fallen sharply in response to this high demand. However, feed-in tariffs are outside the remit of the MME.

The MME can, however, require all developments, or developments over a given size to include renewables. The UK 'Merton Rule' requires new developments (all types of buildings) of 1000 $m^2$ or more to generate at least 10% of their energy needs from on-site renewable energy equipment.

The cost of solar Photo Voltaic (PV) is now sufficiently low that it can be considered as merely an additional building component. In Australia some 16% of houses have installed solar PV systems, and in some states the percentage is as high as 25%. The unit costs will continue to fall with additional research and development, and efficiencies of scale.

As Qatar has some of the best solar insolation characteristics in the world, and is a manufacturer of solar technology, new development can play an important role simultaneously supporting local industry and reducing emissions by mandating solar PV in new development.

**Output GE13:**

**Increase onsite renewable energy in new development**

GE13-1. Require all new development and major retrofits of 1,000 m2 or larger to produce at least 20% of their energy needs from on-site renewable energy. Review and increase this target over time as the unit cost of solar PV installations falls.

GE13-2. Require that all roofs be capable of supporting solar PV panels.

GE13-3. Require achievement and protection of solar access for rooftop solar PV, including building and roof orientation.

GE13-4. Ensure that there are no planning or design restrictions that will prevent the installation of small-scale renewable energy systems.

GE13-5. Provide regulatory incentives for the installation of onsite renewable energy systems.

# 6

# Protecting Biodiversity

# 6 Protecting Biodiversity

## 6.1 Context

The rich biodiversity of the Arabian Gulf includes dozens of mammal species, hundreds of bird species, and scores of amphibian and reptile species; and highly productive coastal habitats, including intertidal mudflats, seagrasses, algal beds, mangroves, and coral reefs, and a variety of fish species. Climate change is a major threat to the retention of this biodiversity.

Ecosystems such as mangroves, rawdah, wadis, urban parks, sea grass communities and coral reefs provide important ecological services. These include the provision of food, soil formation, and nutrient cycling.

Mangroves provide a habitat for a wide range of species, serve as breeding grounds for Qatar's commercial fisheries stock, and act as natural coastal defences. Seagrass communities stabilise the nearshore seabed against wave action, provide a nursery for commercial fisheries and are an important food source for the threatened green turtle and dugong (Erftemeijer, 2012).

Mangrove forests and seagrass communities are also highly productive carbon sinks with production rates equivalent to tropical humid forests (Alongi, 2012, Fourqurean et al, 2012). Although mangroves account for only approximately 1% of carbon sequestration by the world's forests, as coastal habitats they account for 14% of carbon sequestration by the global ocean. A net loss of mangrove forests will therefore contribute to greenhouse gas emissions. Protecting and restoring mangroves and seagrass communities and the ecosystem complexes they comprise therefore contributes to both mitigation of, and adaptation to climate change.

Qatar's indigenous plants and animals are adapted to tolerate heat and drought. However, the increased number of hot days, extreme weather events and sea level rise associated with climate change will increasingly stress their ability to survive. This will exacerbate the existing impacts from urban development and habitat fragmentation. Many species will adapt by either remaining where they are or moving northward (or inland for those at risk of sea level rise), but the more sensitive and less adaptable species would be more affected and may die out. Rare, patchy or unique habitats are likely to show a change in species composition, with more robust and adaptable species becoming more prevalent.

About 29% of Qatar has been designated as Protected Areas and development is prohibited within them. With increasing urban development, smaller protected areas are at risk from development pressures on their edges.

In Qatar, the rate of SLR coupled with the constrained location of mangroves, and rapid development will limit the landward migration of mangroves as a result of climate change. The expected temperature increase, as a result of climate change, has the potential to limit mangrove growth as photosynthesis ceases when leaf temperatures exceed 38 – 40 °C (Clough et al. 1982).

The mangroves at Al Thakhira are particularly vulnerable to flooding and sea level rise, with those at Mesaieed also being affected by nearby large scale construction activities (MME, 2017). Salinisation of previously fresh groundwater due to rising sea levels is also an issue for coastal, estuarine and near shore plant and animal communities whose ecological function has some dependence fresh groundwater.

Qatar's coral reefs are at the far end of the water temperatures in which they can survive, with many communities dying off due to the coral bleaching events occurring in 1996, 1998, 2002 and 2012 (Hume et al, 2013). These bleaching events ultimately reduced living coral to 1 percent in shallow areas, which has lead to decreasing fish stocks and species richness (Riegl, 2002).

## 6.2 Measures to Achieve Plan Objectives

The Climate Change Strategy objective applicable to 'protecting biodiversity' is:

- Retain and protect sensitive ecosystems that sequester carbon

This section of the report proposes urban development and planning actions to protect biodiversity in Qatar.

## 6.3 Adaptation and Mitigation Actions

### 6.3.1 PB1: Introduce buffer zones to protect sensitive ecosystems

Sensitive ecosystems include Protected Areas, mangroves, coral reefs, sea grasses, and other habitats that are not formally protected but are of ecosystem importance.

Buffer zones around sensitive habitats (Figure 6.1) help to protect these ecosystems from the impacts of development which include dust, noise, light, recreational disturbance and run off. The buffer zones can also act as additional nesting or feeding areas for mobile species such as birds and mammals. As such, development within 250 m of Protected Areas, mangroves, seagrass and coral reefs should be prohibited.

In particular, retaining a natural shoreline is important to allow marine ecosystems and adjacent fresh groundwater dependent ecosystems to move landwards as the coastline recedes. The construction of 'hard' engineering structures prevents this occurring and will lead to the loss of ecosystem integrity, as sea levels rise and the original habitat is lost.

**Output PB1:**

**Introduce buffer zones to protect sensitive ecosystems**

PB1-1. Commission a study into appropriate buffer zones and a need for migration corridors for Qatar's Protected Areas and mangroves.

PB1-2. As an interim measure, prohibit development within 250 m of Protected Areas, mangroves, seagrass and coral reefs.

PB1-3. Include requirements in the MSDPs to identify and protect the buffer zones from any future development.

PB1-4. Provide a minimum of 250 m width 'escape routes' from Protected Areas. Where this is not possible due to existing development, provide a continuous wildlife corridor that is as wide as possible.

Buffer elements can be defined as natural or artificial features, or management activities within a buffer that protect the protected area from direct pressures. Buffer elements are site-specific and as a result, further assessment is required to define appropriate buffer locations and sizes in Qatar.

Under development pressure, exacerbated by climate change, new areas will be required to allow terrestrial species and habitats to move as a biodiversity retention response. Wildlife corridors will be needed to enable this movement.

A 'way out' of development from land based Protected Areas of at least 250 m width is proposed, heading north or west, to allow for migration of plants and animals out of the area, to areas that will remain undeveloped. These escape routes should be continuous, with indigenous plants. Where existing development encroaches on the 250 m buffer or prevents migration (especially on the northern side of ecosystems which is the direction in which they are most likely to travel in response to climate change) the closest alternative possible should be provided, i.e. continuous unbuilt areas that are as wide as possible (adjacent to pavements, through public spaces etc.), with indigenous plants, which would allow wildlife to migrate.

Where roads form a barrier to migration; notably at Um Warn, Al Wusail, Um Al Amad and Al Sheehaniya; green bridges or underpasses are ways of allowing migration, as illustrated in Figure 62. The suitable location of these green bridges will have to be assessed and land will have to be allocated by the MME for their construction. Coordination will be required between Ashghal and the MME for the development of the green bridges and their continued maintenance.

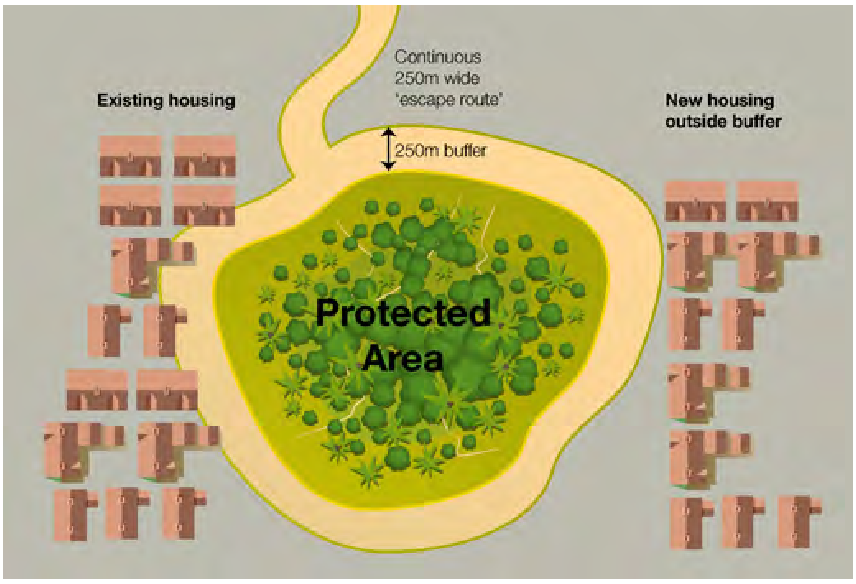



*Figure 6-1: Management of protected areas*

*Figure 6-2: Example of green bridges*

### 6.3.2 PB2: Introduce environmental offsets

An environmental offset compensates for unavoidable impacts on valuable species and ecosystems.

An environmental offset should be required as a condition of approval when any activity (in this instance, an activity specifically related to development) is likely to result in a significant residual impact on valuable species and ecosystems.

Additionally, a conservation outcome should be achieved by the environmental offset. Essentially, the status quo should be maintained as if the development and offset had not occurred (State of Queensland, 2017).

**Output PB2:**

**Introduce environmental offsets**

PB2-1. Require environmental offsets for unavoidable development impacts on protected areas and biodiversity (especially on mangroves, seagrass and coral reefs).

A conservation outcome can be achieved through a range of actions (State of Queensland, 2017) such as:

- Improving existing habitat for the impacted valuable species or ecosystem
- Creating new habitat for the impacted valuable species or ecosystem where it will maintain its viability
- Reducing threats to the impacted valuable species or ecosystem
- Preventing the imminent loss of an impacted valuable species or ecosystem
- Preventing the imminent loss of the habitat for an impacted valuable species or ecosystem

# 7

# Implementation Framework

# 7 Implementation Framework

The strategy is structured hierarchically as a series of specific actions that contribute to defined deliverables (referred to here as outputs), which together are aimed at achieving objectives, which over time will achieve the vision.

This section of the report describes the delivery model for implementing the strategy, including a set of tables in Sections 7.1- 7.4 that:

- Summarise the specific actions set out in Section 7.3 to Section 7.6
- Describe the output that results from completion of the suite of specific actions
- Identify the parties mainly responsible for this output, and those whose assistance will be required
- Establishes the mechanism of implementation, including the relevant standard / code / policy that is related to the specific action
- Sets out the approximate timeframe for implementation, defined as:
  - Immediate: Actions that are key to understanding and reducing risks and easy to implement
  - Short term (2 – 5 year): Actions that require some additional research, or implementation after 'Immediate ' actions
  - Long term (>5 year): Actions that will not likely be completed in the first QNDF planning cycle
- Outlines the proposed performance indicator for the output, noting that:
  - These relate to the specific suite of actions described in the table
  - The indicators set out in Sections 7.1- 7.4 are related to the completion of the task (specific actions)
  - Measurable Performance indicators for the whole CCS, as per the Strategy hierarchy detailed in 7.6.1, are set out in 7.6.2
- Where appropriate, describe the targets related to performance indicators, noting that:
  - The highest level targets require the development of a consumption based emissions inventory to establish appropriate benchmarks (see Section 7.3.1)
  - Targets for building performance are based on the GSAS reference values
- Provides an indication of the resource implications of the actions:
  - Low cost: actions that can be completed in house with the expertise available in the MME
  - Medium cost: actions that can be completed in house in coordination with other agencies but could potentially require additional resources and expertise
  - High cost: actions that will require a specialist to be implemented and will require additional resources

The stakeholder engagement necessary to explain and promote the strategy is described in Section 7.5 and a monitoring and evaluation framework is set out in Section 7.6.

A summary of all the actions and references to the section in the report in which they are discussed is provided in Appendix C.

## 7.1 Responding to Sea Level Rise and Flooding

The implementation framework for all the specific actions related to responding to sea level rise and flooding are detailed in this sub section.

### 7.1.1 SL1: Establish Vulnerable Coastal Zone to communicate risk and regulate development

| Output from actions | SL1: Establish Vulnerable Coastal Zone (VCZ) to communicate risk and regulate development |
|---|---|
| Specific Actions | **SL1-1:** Utilize the 1% AEP mapping to identify the Vulnerable Coastal Zone (VCZ).<br>**SL1-2:** Develop regulations for VCZ to prohibit new development (with certain exceptions).<br>**SL1-3:** Update the existing and future zoning maps to incorporate VCZ as an overlay.<br>**SL1-4:** Continually update the 1% AEP contour as new sea level rise projections are made available with IPCC releases. |
| Mechanism | Overlay on existing and future Zoning maps (SL1-3) |
| Implementation responsibility | MME-UPD |
| In coordination with | MME-IPD (SL1-1 and SL1-4) |
| Timeframe | Immediate |
| Resource implications | Low cost (SL1-1, SL1-2)<br>Medium cost (SL1-3, SL1-4) |
| Performance Indicator | Establishment of a VCZ |

### 7.1.2 SL2: Update planning, policy and regulatory framework documents to address flood risk in vulnerable coastal areas

| Output from actions | SL2: Update planning, policy and regulatory framework documents to address flood risk in vulnerable coastal areas |
|---|---|
| Specific Actions | **SL2-1.** Require Coastal Flood Risk Assessments.<br>**SL2-2**. Adopt measures to improve flood resilience in developments and buildings.<br>Table B-1 in Appendix B defines potential regulatory recommendations within the SLR hazard area. |
| Mechanism | MSDPs |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-BPC (SL2-1)<br>MME-IPD and Ashghal (SL2-2) |
| Timeframe | Immediate (SL2-1)<br>Short term (SL2-2) |
| Resource implications | Low cost (SL2-1)<br>Medium cost (SL2-2) |
| Performance Indicator | Regulations in place requiring coastal flood risk assessments |

### 7.1.3 SL3: Develop a framework to evaluate protection vs retreat options

| Output from actions | SL3: Develop a framework to evaluate protection vs retreat options |
|---|---|
| Specific Actions | **SL3-1.** Identify specific coastal management units within MSDPs to facilitate coastal process analysis.<br>**SL3-2**. Undertake a socio economic assessment including the evaluation of the cost : benefit of structural coastal protection measures vs strategic retreat for land within the Coastal Risk Zone.<br>**SL3-3**. Develop a compendium of coastal protection measures for vulnerable areas of the coastline to be used in the evaluation of options.<br>A number of recommendations to amend MSDPs are proposed in Table B-2 in Appendix B. |
| Mechanism | QNDS |
| Implementation Responsibility | MME-IPD and MME-UPD (SL3-1, SL3-2, and SL3-3) |
| In coordination with | Ashghal (SL3-1, SL3-2, and SL3-3) |
| Timeframe | Short term |
| Resource implications | Low cost (SL3-1)<br>Medium cost (SL3-2 and SL3-3) |
| Performance Indicator | Preparation and implementation of a cost : benefit methodology and compendium of coastal protection measures for vulnerable areas |

### 7.1.4 SL4: Develop a framework for the strategic retreat from vulnerable land

| Output from actions | SL4: Develop a framework for the strategic retreat from vulnerable land |
|---|---|
| Specific Actions | **SL4-1**. Update the planning regulations to specify that new infrastructure should be located outside areas of coastal risk and any future upgrade or installation of new infrastructure within areas of coastal risk should be prohibited.<br>**SL4-2**. Consider leasehold rather than freehold sale in new coastal development areas, to avoid future pressures and costs to protect private coastal land.<br>**SL4-3.** Place a notification of title on all affected landholdings, informing landholders of the status of the land being located within a vulnerable coastal area.<br>**SL4-4:** Include a mechanism to facilitate long-term strategic retreat from vulnerable coastal land in the next iteration of the QNDF, including the establishment of Coastal Foreshore Reserves. |
| Mechanism | QNDF and MSDP Zoning Regulation<br>Note: The next revision of the QNDF should consider including specific requirements of climate change mitigation and adaptation outcomes. |
| Implementation Responsibility | MME-IPD and MME-UPD (SL4-1)<br>MME-UPD (SL4-2 and SL4-3) |
| In coordination with | MME-BPC (SL4-2 and SL4-3)<br>Ashghal (SL4-3) |
| Timeframe | Short term |
| Resource implications | Low cost (SL4-1, SL4-2 and SL4-3) |
| Performance Indicator | Planning policies and regulations in place to implement strategic retreat within identified areas of coastal risk |

### 7.1.5 SL5: Implement emergency management measures

| Output from actions | SL5: Implement Emergency Management Measures |
|---|---|
| Specific Actions | **SL5-1.** Require a Flood Emergency Management Plan for each development within the high risk flood zone.<br>**SL5-2.** Require new and upgraded emergency facilities and services, development to be designed according to the Defined Flood Level (DFL).<br>**SL5-3.** Ensure new and existing facilities or services can operate at the required capacity during a Probable Maximum Flood (PMF). |
| Mechanism | All MSDPs and MSDP Zoning Regulations |
| Implementation Responsibility | MME-UPD (SL5-1)<br>MME-IPD and MME-UPD (SL5-2)<br>MoI and MME-UPD (SL5-3) |
| In coordination with | MME-BPC (SL5-1)<br>Ashghal and MoI (Civil Defence) (SL5-2) |
| Timeframe | Short term |
| Resource implications | Low cost (SL5-1)<br>Medium cost (SL5-2 and SL5-3) |
| Performance Indicator | Regulation in place requiring a flood emergency management plan for each development within the high-risk flood zone |

## 7.2 Responding to Increasing Temperatures

The Implementation framework for all the specific actions related to responding to increasing temperatures are detailed in this sub section.

### 7.2.1 UH1: Improve green space in areas vulnerable to the Heat Island Effect

| Output from actions | UH1: Improve green space in areas vulnerable to the Heat Island Effect |
|---|---|
| Specific Actions | **UH1-1.** Utilize the finalized Qatar University UHI ongoing study to determine areas subject to the heat island effect and generate a hot spot map.<br>**UH1-2**. Overlay the hot spot map over future zoning maps to identify the need for any additional publicly accessible green space. Reallocate land use (if needed) and ensure the implementation of the green space.<br>**UH1-3**. Incorporate requirements for vegetation around buildings, in parking lots and around roads and pavements. |
| Mechanism | Include requirements in all MSDPs, Future Zoning MSDP maps, and the Urban Design Compendium<br>Utilization of 'hot spot' overlay to determine areas subject to the heat island effect |
| Implementation Responsibility | MME-UPD |
| In coordination with | QGBC and QU (UH1-1)<br>MME-PPD (UH1-2 and UH1-3) |
| Timeframe | Short term |
| Resource implications | Low cost (UH1-1, UH1-2 and UH1-3) |
| Performance Indicator | Establishment of a hot spot map for Qatar |

### 7.2.2 UH2: Ameliorate the Urban Heat Island Effect

| Output from actions | UH2: Ameliorate the Urban Heat Island Effect |
|---|---|
| Specific Actions | **UH2-1**. Integrate the GSAS heat island effect calculation in the building permit application stage to determine the potential heat island effect of the proposed development.<br>**UH2-2**. Require all new developments to include applicable and cost-efficient passive cooling measures.<br>**UH2-3**. Require major building retrofits to adopt passive cooling measures to the extent that they are cost-effective.<br>**UH2-4**. Require the utilization of light colored pavements for roads and parking areas. |
| Mechanism | Include requirements in all MSDPs, Qatar Construction Specification, and Highway Design Manual (UH2-4)<br>Utilization of 'hot spot map' to track the management of heat island effect at hot spot zones |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-BPC (UH2-1, UH2-2, and UH2-3)<br>Kahramaa (UH2-3)<br>MoTC (UH2-4 and Highway Design Manual)<br>MME-LSA (Qatar Construction Specification) |
| Timeframe | Immediate (UH2-1)<br>Short term (UH2-2, UH2-3, and UH2-4) |
| Resource implications | Low cost (UH2-1, UH2-2 and UH2-3)<br>Medium cost (UH2-4) |
| Performance Indicator | Adopt GSAS minimum requirement, -0.3 ≤ Albedo Difference (Post-development Albedo – Pre-development Albedo) < -0.2 |

### 7.2.3 UH3: Introduce shading requirements

| Output from actions | UH3: Introduce shading requirements |
|---|---|
| Specific Actions | **UH3-1**. Require shading of 60 % - 70% of hardscaped pedestrian pathways and parking areas, and 25% - 30% of hardscaped common areas. |
| Mechanism | Include shading requirements in the Urban Design Compendium |
| Implementation Responsibility | MME-UPD and MME-BPC |
| In coordination with | MME-BPC and Ashghal (UH3-1) |
| Timeframe | Immediate |
| Resource implications | Low cost (UH3-1) |
| Performance Indicator | Shading requirements incorporated within the Urban Design Compendium |

### 7.2.4 UH4: Support urban canyons and street orientation

| Output from actions | UH4: Create urban canyons and improve street orientation |
|---|---|
| Specific Actions | **UH4-1**. Improve the 'urban canyons' in city centers through optimization of building heights, street widths, setbacks and site coverage.<br>**UH4-2**. Orient streets to allow penetration of cool coastal breezes where feasible. |
| Mechanism | Include requirements in all MSDPs (UH4-1)<br>Include requirements in Urban Design Compendium (UH4-2)<br>Utilization of 'hot spot' overlay to determine areas subject to the heat island effect |
| Implementation Responsibility | MME-UPD and MME-BPC |
| In coordination with | N/A |
| Timeframe | Short term |
| Resource implications | Low cost (UH4-1 and UH4-2) |
| Performance Indicator | MSDP requirements in place to create urban canyons and optimal street orientation where practical and possible |

### 7.2.5 UH5: Develop a heat wave emergency response plan

| Output from actions | UH5: Develop a heat wave emergency response plan |
|---|---|
| Specific Actions | **UH5-1.** Develop an emergency response plan for cases of heat wave, which includes preparedness / preventive action, monitoring and communication, and a plan of action during the emergency. |
| Mechanism | N/A |
| Implementation Responsibility | MME-UPD |
| In coordination with | Ministry of Public Health and the Civil Defence Council (UH5-1) |
| Timeframe | Short term |
| Resource implications | Low cost (UH5-1) |
| Performance Indicator | Publically available heat wave emergency response plan in place for Qatar |

## 7.3 Reducing Greenhouse Gas Emissions

The Implementation framework for all the specific actions related to greenhouse gas emissions are detailed in this sub section.

### 7.3.1 GE1: Develop and publish a GHG emissions inventory and benchmarks

| Output from actions | GE1: Develop and publish a GHG emissions inventory and benchmarks |
|---|---|
| Specific Actions | **GE1-1**. Develop a consumption-based GHG emissions inventory for the built environment based on international best practice.<br>**GE1-2**. Devise emission indicators appropriate for use in monitoring domestic GHGs and establish benchmarks.<br>**GE1-3**. Prepare and publish an annual report outlining consumption-based emissions and key metrics. |
| Mechanism | In conjunction with the tools to be developed in Stage 5 of the CCS<br>A new process introduced by the MME (Section 5.4.1) |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-CCD and MME-BPC (GE1-1, GE1-2 and GE1-3) |
| Timeframe | Short term |
| Resource implications | Medium cost (GE1-1, GE1-2 and GE1-3) |
| Performance Indicator | Consumption based emissions inventory developed<br>Annual Report published and communicated to local and international audiences |

### 7.3.2 GE2: Create higher densities and mixed use to reduce travel demand

| Output from actions | GE2: Create higher densities and mixed use to reduce travel demand |
|---|---|
| Specific Actions | **GE2-1**. Require compact, mixed use development in city centers and inner suburbs (excluding Qatar Housing Areas) at the densities necessary to promote public transport use.<br>**GE2-2**. Require central and inner development sites to achieve a mixed use (i.e. residential and non-residential uses), with non-residential uses on the ground floor.<br>**GE2-3**. Integrate walking, cycling and public transport networks into existing mega-projects.<br>**GE2-4**. Implement higher residential density targets for new development.<br>**GE2-5**. Require new development to be sequenced, such that with development further from existing urban areas is permitted only after areas nearer the existing urban areas have been developed. |
| Mechanism | Include requirements in the MSDP Zoning Regulations and Urban Design Compendium |
| Implementation Responsibility | MME-UPD |
| In coordination with | Mowasalat and QRail (GE2-1)<br>MME-BPC (GE2-3, GE2-4 and GE2-5) |
| Timeframe | Short term |
| Resource implications | Low cost (GE2-1, GE2-2 and GE2-5)<br>Medium cost (GE2-3 and GE2-4) |
| Performance Indicator | Higher residential density targets in place for new developments |

### 7.3.3 GE3: Improve walkability

| Output from actions | GE3: Improve walkability |
|---|---|
| Specific Actions | **GE3-1**. Develop a street design code that stipulates walkability requirements (guided by GSAS criterion S.6 Walkability) within higher residential density centers and mixed use zones.<br>**GE3-2**. Progressively upgrade existing areas for compliance with the street design code, where possible. |
| Mechanism | Include requirements in the MSDP Zoning Regulations and Urban Design Compendium |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-BPC |
| Timeframe | Short term |
| Resource implications | Medium cost (GE3-1 and GE3-2) |
| Performance Indicator | Walkability requirements (guided by GSAS criterion) incorporated into the MSDP Zoning Regulations and Urban Design Compendium |

### 7.3.4 GE4: Create Transit Oriented Development

| Output from actions | GE4: Create Transit Oriented Development |
|---|---|
| Specific Actions | **GE4-1**. Establish mixed use zones within 480 m of the planned stations of the Doha Metro. Create a zone a further 480 m from this radius for medium density and other uses that would benefit from proximity to rail stations, including park and ride facilities.<br>**GE4-2**. Require public facilities (e.g. town/district centers, parks, schools, sports clubs) to be accessible by walking, cycling or public transport following the guidance of the GSAS criterion (UC.5 Intermodal Connectivity). |
| Mechanism | Include requirements in all MSDPs and Urban Design Compendium |
| Implementation Responsibility | MME-UPD |
| In coordination with | QRail (GE4-1 and GE4-2)<br>MoTC (GE4-2)l |
| Timeframe | Short term |
| Resource implications | Medium cost (GE4-1)<br>Low cost (GE4-2) |
| Performance Indicator | Requirement for Public Transport Accessibility (PTAL) GSAS minimum score incorporated in selected MSDP areas |

### 7.3.5 GE5: Introduce parking restrictions

| Output from actions | GE5: Introduce parking restrictions |
|---|---|
| Specific Actions | GE5-1. Introduce parking fee minimums to reduce parking occupancy, which in turn will minimize cruising for parking spaces.<br>GE5-2. Require companies to provide the minimum number of parking spaces necessary for their workforce.<br>GE5-3. Stipulate parking maximums for development in zones with good public transport.<br>GE5-4. Incorporate the final stipulations from the Qatar Parking Master Plan within the Zoning Regulations. |
| Mechanism | Qatar Parking Master Plan, MSDP Zoning Regulations, and Urban Design Compendium |
| Implementation Responsibility | MME-UPD |
| In coordination with | MoTC |
| Timeframe | Short term |
| Resource implications | Low cost (GE5-1, GE5-2, GE5-3 and GE5-4) |
| Performance Indicator | Parking restrictions incorporated for selected areas within the Qatar Parking Master Plan and MSDP Zoning Regulations |

### 7.3.6 GE6: Improve energy efficiency in new development

| Output from actions | GE6: Improve energy efficiency in new development |
|---|---|
| Specific Actions | **GE6-1**. Mandate a minimum of GSAS Level 2 energy performance for all new development. |
| Mechanism | Building Permit Application Process (GE6-1)<br>Qatar Construction Specification<br>Urban Design Compendium |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-BPC and Kahramaa (GE6-1)<br>MME-LSA (Qatar Construction Specification) |
| Timeframe | Short term |
| Resource implications | Low cost (GE6-1) |
| Performance Indicator | Maximum MJ / m2 / year energy requirements mandated within the Qatar Construction Specifications |

### 7.3.7 GE7: Improve water efficiency

| Output from actions | GE7: Improve water efficiency |
|---|---|
| Specific Actions | **GE7-1**. Mandate a minimum of GSAS Level 2 water performance for all new development.<br>**GE7-2**. Require major industrial and agricultural developers to prepare a water efficiency plan showing how they will minimize water use in line with world's best practice. The plans should be updated yearly within the Qatar National Water Policy (this will require the Qatar National Water Policy to be amended).<br>**GE7-3**. Require the use of certain water efficient irrigation practices and provide planning incentives (e.g. grants for water efficient systems).<br>**GE7-4**. Mandate the use of native and drought-tolerant species. |
| Mechanism | Building Permit Application Process (G7-1)<br>Qatar National Water Policy<br>Qatar Construction Specification<br>Urban Design Compendium |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-PPD and Kahramaa (GE7-3 and GE7-4)<br>Kahramaa (GE7-2 and Qatar National Water Policy)<br>MME-LSA (Qatar Construction Specification) |
| Timeframe | Short term |
| Resource implications | Low cost (GE7-1 and GE7-4)<br>Medium cost (GE7-2 and GE7-3) |
| Performance Indicator | Maximum kL / $m^2$ / year water requirements mandated within the Qatar Construction Specifications<br>Requirements in place requiring water efficiency plans for major industrial and agricultural developers |

### 7.3.8 GE8: Increase the use of recycled water in new development

| Output from actions | GE8: Increase the use of recycled water in new development |
|---|---|
| Specific Actions | **GE8-1**. Incentivize, or require new development to incorporate wastewater recycling facilities. Incentives may include the development of a market for the use of greywater / recycled wastewater, such as watering street trees or irrigation. |
| Mechanism | Qatar National Water Policy<br>Qatar Construction Specification |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-PPD (GE8-1)<br>Kahramaa (GE8-1 and Qatar National Water Policy)<br>MME-LSA (Qatar Construction Specification) |
| Timeframe | Short term |
| Resource implications | Medium cost (GE8-1) |
| Performance Indicator | Proportion of recycled water to total water use in new developments |

### 7.3.9 GE9: Improve the energy and water efficiency of retrofitted development

| Output from actions | GE9: Improve the energy and water efficiency of retrofitted development |
|---|---|
| Specific Actions | **GE9-1**. Mandate a minimum of GSAS Level 2 energy performance for retrofits of selected building types / floor area. |
| Mechanism | Qatar National Water Policy<br>Qatar Construction Specification<br>Urban Design Compendium |
| Implementation Responsibility | MME-UPD |
| In coordination with | Kahramaa (GE9-1 and Qatar National Water Policy)<br>MME-LSA (Qatar Construction Specification) |
| Timeframe | Long term |
| Resource implications | Low cost (GE9-1) |
| Performance Indicator | Energy and water performance requirements in place for retrofitted developments. |

### 7.3.10 GE10: Reduce the embodied energy of development

| Output from actions | GE10: Reduce the embodied energy of development |
|---|---|
| Specific Actions | **GE10-1**. Require developers to consider retrofit/ refurbishment over new build, particularly if the existing building is relatively energy efficient.<br>**GE10-2**. Require developers of new developments and major retrofits to demonstrate how they will minimize their use of virgin materials.<br>**GE10-3**. Require developers of retrofit or upgrades to previously developed sites to recycle the maximum amount of the previous building materials. |
| Mechanism | Urban Design Compendium |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-BPC (GE10-1, GE10-2 and GE10-3) |
| Timeframe | Short term |
| Resource implications | Low cost (GE10-1, GE10-2 and GE10-3) |
| Performance Indicator | Life Cycle Assessments (LCA) requirement in place for new developments and retrofits |

### 7.3.11 GE11: Design for structure reuse

| Output from actions | GE11: Design for structure reuse |
|---|---|
| Specific Actions | **GE11-1**. Require developers to produce designs that facilitate the re-purposing of the building and reuse of their components in line with the measures included in GSAS. |
| Mechanism | Urban Design Compendium |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-BPC (GE11-1) |
| Timeframe | Short term |
| Resource implications | Low cost (GE11-1) |
| Performance Indicator | Re-purposing and reuse requirements in place for new developments |

### 7.3.12 GE12: Plan for large scale renewable energy production

| Output from actions | GE12: Plan for large scale renewable energy production |
|---|---|
| Specific Actions | **GE12-1**. Identify and reserve possible sites for medium to large-scale photovoltaic energy developments near HV infrastructure, and depict them on the zoning maps. |
| Mechanism | All MSDPs |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-IPD and Kahramaa (GE12-1) |
| Timeframe | Short term |
| Resource implications | Medium cost (GE12-1) |
| Performance Indicator | Large scale renewable energy site selection process in place |

### 7.3.13 GE13: Increase onsite renewable energy in new development

| Output from actions | GE13: Increase onsite renewable energy in new development |
|---|---|
| Specific Actions | **GE13-1**. Require all new development and major retrofits of 1,000 $m^2$ or larger to produce at least 20% of their energy needs from on-site renewable energy. Review and increase this target over time as the unit cost of solar PV installations falls.<br>**GE13-2**. Require that all roofs be capable of supporting solar PV panels.<br>**GE13-3**. Require achievement and protection of solar access for rooftop solar PV, including building and roof orientation.<br>**GE13-4**. Ensure that there are no planning or design restrictions that will prevent the installation of small-scale renewable energy systems.<br>**GE13-5**. Provide regulatory incentives for the installation of onsite renewable energy systems. |
| Mechanism | QNDF and Urban Design Compendium<br>Note: The next revision of the QNDF should consider including specific requirements of climate change mitigation and adaptation outcomes. |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-IPD and Kahramaa (GE13-1, GE13-4 and GE13-5)<br>Kahramaa (GE13-1, GE13-2, GE13-3, GE13-4 and GE13-5) |
| Timeframe | Long term |
| Resource implications | Low cost (GE13-4)<br>Medium cost (GE13-1, GE13-2, GE13-3 and GE13-5) |
| Performance Indicator | Onsite renewable energy production requirement in place for new developments |

## 7.4 Protecting Biodiversity

The Implementation framework for all the specific actions related to protecting biodiversity are detailed in this sub section.

### 7.4.1 PB1: Introduce buffer zones to protect sensitive ecosystems

| Output from actions | PB1: Introduce buffer zones to protect sensitive ecosystems |
|---|---|
| Specific Actions | **PB1-1**. Commission a study into appropriate buffer zones and a need for migration corridors for Qatar's Protected Areas and mangroves.<br>**PB1-2**. As an interim measure, prohibit development within 250 m of Protected Areas, mangroves, seagrass and coral reefs.<br>**PB1-3**. Include requirements in the MSDPs to identify and protect the buffer zones from any future development.<br>**PB1-4**. Provide a minimum of 250 m width 'escape routes' from Protected Areas. Where this is not possible due to existing development, provide a continuous wildlife corridor that is as wide as possible. |
| Mechanism | All MSDPs |
| Implementation Responsibility | MME-UPD |
| In coordination with | MME-BPC (PB1-2 and PB1-3) |
| Timeframe | Short term (PB1-1, PB1-3 and PB1-4)<br>Immediate (PB1-2) |
| Resource implications | Low cost (PB1-2 and PB1-3)<br>Medium cost (PB1-1 and PB1-4) |
| Performance Indicator | Interim buffer zones incorporated in MSDPs |

### 7.4.2 PB2: Introduce environmental offsets

| Output from actions | PB2: Introduce environmental offsets |
|---|---|
| Specific Actions | **PB2-1.** Require environmental offsets for unavoidable development impacts on protected areas and biodiversity (especially on mangroves, seagrass and coral reefs). |
| Mechanism | QNDF<br>Note: The next revision of the QNDF should consider including specific requirements of climate change mitigation and adaptation outcomes. |
| Implementation Responsibility | MME-UPD |
| In coordination with | N/A |
| Timeframe | Long term |
| Resource implications | Medium cost (PB2-1) |
| Performance Indicator | Requirements for environmental offsets incorporated in the QNDF |

## 7.5 Change Management Process

The change management process is the sequence of steps or activities that a team or project leader follow in order to drive individual or entity transitions and ensure the project meets its intended outcomes. Specifically for this Strategy, the intended outcomes are the implementation of the specific actions summarized and detailed within Sections 7.1, 7.2, 7.3 and 7.4.

The change management process should incorporate engagement with:

- Government Agencies
  - The Urban Planning Department – as the entity mainly responsible for implementation
  - Other departments within the Ministry of Municipality and Environment whose participation is required (i.e. internal stakeholders), i.e. the Infrastructure Planning Department, the Climate Change Department, the Public Parks Department, the Building Permit Complex, and the Laboratories and Standardization Affairs Department
  - Other government agencies whose participation and cooperation is required, i.e. Ashghal, Kahramaa, and the Ministry of Interior
- Development Community
  - The private development community, i.e. developers, construction firms, and consultants
- The public

**Implementation recommendation SE1:**

**Develop an effective change management process to communicate and promote the CCS.**

SE1-1. Communicate the context, purpose and content to all staff within MME.

SE1-2. Establish an Implementation Working Group to coordinate implementation within MME and other government agencies / committees.

SE1-3. Engage the development community to ensure there is awareness and support for the proposed changes to policy and regulation. Provide a communication platform (e.g. online portal) for the development community to raise their concerns and questions.

SE1-4. Engage the public to ensure there is awareness and support for the proposed changes to policy and regulation. Provide a communication platform (e.g. online portal) for the public to raise their concerns and questions.

### 7.5.1 Challenges of CCS Implementation

The key challenges that will be faced during the CCS implementation from parties the MME need to engage with, for the strategy to be ultimately successfully implemented are detailed below.

*Key Challenges from other departments within the Ministry of Municipality and Environment (i.e. Internal Stakeholders)*

The following key challenges that the MME will potentially face from other departments within the MME during the implementation of the CCS:

1. Bureaucracy: There is a potential for established bureaucratic norms to hinder information sharing between government departments.
2. Resistance to change in process: There is potential for resistance from the staff to the change in process. Established processes will be changed with the implementation of the CCS e.g. new evaluation processes for the Building Permit Complex.
3. Resource Allocation: There is potential for staff to be unavailable or busy with other tasks. This can slow down the implementation process.
4. Capability and Competency: Some of the tasks might require specialization that is beyond the staff's capability. This will require capacity building and additional training for the successful implementation of the CCS.

*Key Challenges from other government agencies*

The key challenge that the MME will potentially face from other government agencies during the implementation of the CCS is 'Resistance to process of change'. There is potential for resistance from the staff to the change in process. Established processes will be changed with the implementation of the CCS e.g. new energy efficiency requirements will require coordination with Kahramaa. There is potential to face resistance from the staff to the process of change.

### *Key Challenges from the Development Community*

The following key challenges that the MME will potentially face from the development community during the implementation of the CCS:

1. Resistance due to additional cost and work: There is potential to face resistance from the development community regarding the implementation of the CCS, as this will lead to additional costs and work for the developers. This can be managed by training programs to inform developers of the ultimate result of implementing the new requirements.
2. Communication Protocol: There is a non existent communication channel between the development community and the MME. This will delay the implementation process.

### *Key Challenges from the Public*

The following key challenges that the MME will potentially face from the public community during the implementation of the CCS:

1. Limited public engagement: There is limited public engagement regarding any changes in legislation and policies.
2. Communication channel: There is no channel presently available for the public to voice their concerns and opinions regarding the CCS. This could also resultantly limit public engagement, further hindering implementation.
3. Resistance due to lifestyle change: There is potential to face resistance from the public as the implementation of the CCS could potentially have an impact to the people's lifestyle e.g. resistance to use public transportation as individual vehicles are heavily relied upon.
4. Signalling strategic retreat from vulnerable coastal land may adversely affect property values: There is a potential for strong community backlash against retreat, and pressure for government to build coastal protection structures. It will be necessary to communicate the inevitability of long term sea level rise to counter this pressure.

The change management process for these different entities, government agencies, development community, and the public which will help to address the key challenges of implementation are detailed in Sections 7.5.2, 7.5.3 and 7.5.4 respectively.

### 7.5.2 Engaging government agencies

As the agency with the prime responsibility for implementation of the CCS, it is essential that MME-UPD communicate its context, purpose and content to all management and staff. This process will commence with the presentation of the CCS and the action plans to MME-UPD and nominated stakeholders in a workshop environment.

The key steps involved in engaging government agencies are:

- CCS Launch Statement
- Establishment of Implementation Working Group (IWG)

Details of the keys steps are detailed in this section.

### *CCS Launch Statement*

In order to ensure support within MME, and across the government, there should be a statement from the MME, launching the CCS and urging cooperation across MME for its implementation. The statement, and a more detailed description of the CCS should be widely communicated across the departments of MME. The statement should align the CCS closely with Chapter 6 of the existing Qatar National Development Strategy (QNDS) *Sustaining the environment for future generations*. This chapter includes aspirations for an effective response to climate change, and the CCS should be characterised as a component of the QNDS.

### *Establishment of Implementation Working Group (IWG)*[4]

It is recommended that the department establish an Implementation Working Group (IWG) with senior management leadership to guide the implementation process, including the responsibility for coordination with other agencies. The makeup of the IWG should reflect the nature of the recommended actions, i.e. it should include those with the appropriate background and responsibility are tasked with taking action related to each of the core areas of the CCS, i.e. sea level rise and flooding, increasing temperatures, reducing emissions and protecting biodiversity.

4 A *Planning Legislation Project* is currently underway and under finalization. The development of a Climate Change Strategy is a direct Project output. This section is dependent on the results of the *Planning Legislation Project* and will be updated upon its completion and finalization.

The IWG should include personnel from other MME departments with a significant role in implementation, i.e. the Climate Change Department, the Infrastructure Planning Department, the Public Parks Department, the Building Permit Complex, and the Laboratories and Standardization Affairs Department. Consideration should also be given to personnel from outside the government to participate in the IWG as advisors. There are a number of academics and consultants with relevant expertise and experience in Qatar on issues of importance to the CCS.

### Roles and Responsibilities of the IWG

The roles and responsibilities of the IWG are stated below, but not limited to:

- Ensuring that all staff are informed about the context, purpose and content of the CCS
- Ensuring that staff directly responsible for implementing actions are cognisant of the entire CCS and the role of others in the department
- Provide staff training and capacity building
- Providing a forum to ensure that the implementation team consults widely within the department to ensure corporate knowledge and expertise is fully utilised, including testing the proposed actions to minimise unintended consequences

The IWG leadership will also need to engage with MME's senior management to communicate the CCS intent and action plan to other departments within MME, and to nominate managers to responsible for liaising with the IWG, and ensuring coordination between departments.

With the support of the Minister's office, other relevant government agencies and working committees also need to be engaged, in particular: Ashghal, Kahramaa, Ministry of Transport and Communication and the Ministry of Interior. A similar, but more limited process of communication should be undertaken with relevant staff in these teams.

In particular, the cooperation of those entities required to implement changes to design guidance, policy and regulation is critical to the successful implementation of the CCS. The IWG leadership will need to work closely with the management of those groups to ensure the importance of their participation is understood, and that the necessary resources are deployed.

### Training and Capacity Building

An important role of the IWG is to facilitate the necessary training and capacity building for MME staff. The role of capacity building is to enhance the ability of individuals to achieve their organisation's objectives through improved knowledge and competencies. To successfully implement the CCS, MME staff will need capacity building that addresses climate change as a subject as well as the role of MME, their department, and their own role. Accordingly, a tailored program will be required involving both inter and intra departmental sessions, developed in consultation with the MME Human Resources Department under the purview of the IWG. The program will need to include content that improves the knowledge of staff about climate change, as well as identifying their role in implementing the CCS recommendations.

Ministry wide:

- Climate change science in general, and implications for Qatar specifically
- Economy-wide mitigation and adaptation challenges for Qatar
- The CCS project (all stages)
- Key findings from Stages 3 and 4 of the project, including the identified key challenges

Within departments:

- Objectives and actions relevant to the department
- Identified implementation challenges
- Proposed organisational responsibilities within the department

For the individual:

- Specifically tailored professional development / training as required to:
  - appreciate the context and purpose of the CCS
  - play their role in the implementation

The content of the Stage 3 and 4 CCS reports can provide much of the material for the program, complemented by the large number of references cited in the reports. It is particularly important that local research and analysis carried out in the Gulf region and Qatar specifically is used in the program, and where possible local academics and consultants assist MME to deliver the program.

The recommendations of the CCS relate broadly to mitigating climate change through emission reductions, and adaptation to increased temperatures and rising sea levels. These three broad themes should be reflected, as appropriate and relevant, for each audience.

### 7.5.3 Engaging the development community

Implementation of the CCS will have a significant impact on the development community in Qatar, including developers, contractors, consultants, and academics. A program of engagement through media statements, workshops and a dedicated website should aim to ensure there is a clear understanding of the context, purpose and content of the CCS.

The development community should be made aware of all the proposed changes to policy, regulation and design guidance and the likely timeframe for their introduction. They should also be consulted during the process of drafting the changes. Consideration should be given to the establishment of an advisory group comprising prominent members of the development community to facilitate this engagement.

### 7.5.4 Engaging the public

Communicating to the public the scientific consensus on climate change, and the actions to be taken to mitigate its progress and adapt to its effects is critical to the success of any government strategy. Although the CCS is an important component of a national response to climate change, it does not represent all that needs to be done, e.g. in the energy, industry and agricultural sectors. Accordingly, the CCS cannot, in isolation, be the basis for a major national public climate change campaign.

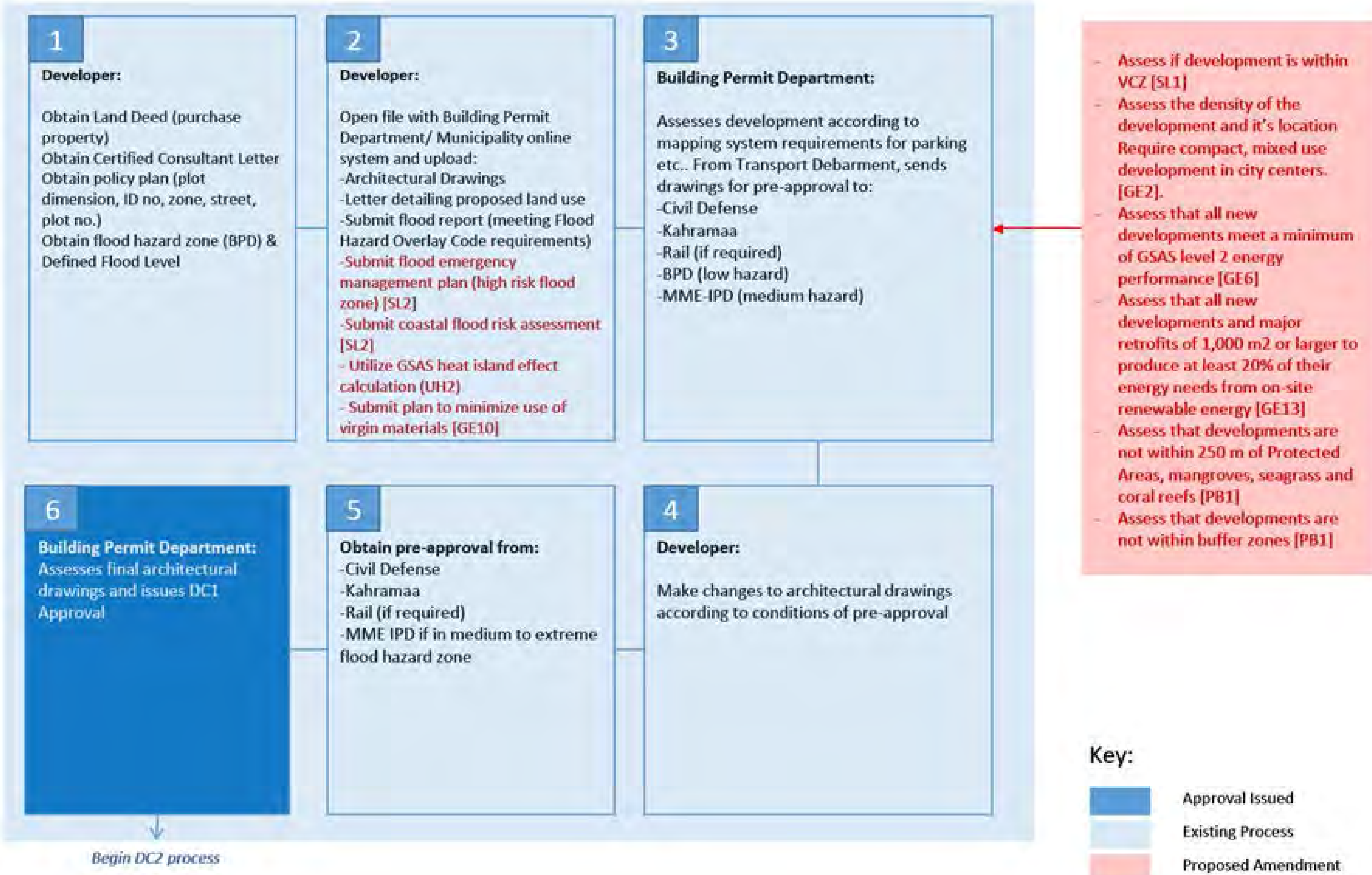
However, the proposals for action in the CCS can be effectively communicated to the public. Issues such as improving energy and water efficiency, using recycled water, promoting public transport and restricting parking require public support to succeed. Obtaining support requires communication about the need for, and objectives of the proposed changes.

It is recommended that a limited public information campaign involving media and website content is mounted to communicate those elements of the CCS most relevant to the public. Such a campaign is best timed to coincide with the introduction of changes to policies, regulation and design guidance. Consideration should be given to whether such a campaign is best targeted at the public in general, or whether more geographically discrete engagement (e.g. in MSDP areas) is likely to be more effective.

### 7.5.5 Process Mapping (Qatar Building Permit System)

An assessment of the Qatar Building Permit System (the DC1 and DC2 process) was undertaken to depict the interventions and proposed amendments, that are included within this Stage 4 report, to the existing building permit process. The specific action codes have been used for each amendment for the ease of the reader. The existing process depicted includes the recommendations that have also been made within the Flood Study for Qatar.

The existing process map of the Qatar Building Permit System and the proposed amendments are presented in Figure 7.1.


1
Developer:
Obtain Land Deed (purchase property)
Obtain Certified Consultant Letter
Obtain policy plan (plot dimension, ID no, zone, street, plot no.)
Obtain flood hazard zone (BPD) & Defined Flood Level
2
Developer:
Open file with Building Permit Department/ Municipality online system and upload:
-Architectural Drawings
-Letter detailing proposed land use
-Submit flood report (meeting Flood Hazard Overlay Code requirements)
-Submit flood emergency management plan (high risk flood zone) [SL2]
-Submit coastal flood risk assessment [SL2]
- Utilize GSAS heat island effect calculation (UH2)
- Submit plan to minimize use of virgin materials [GE10]
3
Building Permit Department:
Assesses development according to mapping system requirements for parking etc.. From Transport Debarment, sends drawings for pre-approval to:
-Civil Defense
-Kahramaa
-Rail (if required)
-BPD (low hazard)
-MME-IPD (medium hazard)
- Assess if development is within VCZ [SL1]
- Assess the density of the development and it's location Require compact, mixed use development in city centers. [GE2].
- Assess that all new developments meet a minimum of GSAS level 2 energy performance [GE6]
- Assess that all new developments and major retrofits of 1,000 m2 or larger to produce at least 20% of their energy needs from on-site renewable energy [GE13]
- Assess that developments are not within 250 m of Protected Areas, mangroves, seagrass and coral reefs [PB1]
- Assess that developments are not within buffer zones [PB1]
4
Developer:
Make changes to architectural drawings according to conditions of pre-approval
5
Obtain pre-approval from:
-Civil Defense
-Kahramaa
-Rail (if required)
-MME IPD if in medium to extreme flood hazard zone
6
Building Permit Department:
Assesses final architectural drawings and issues DC1 Approval
Begin DC2 process
Key:
Approval Issued
Existing Process
Proposed Amendment

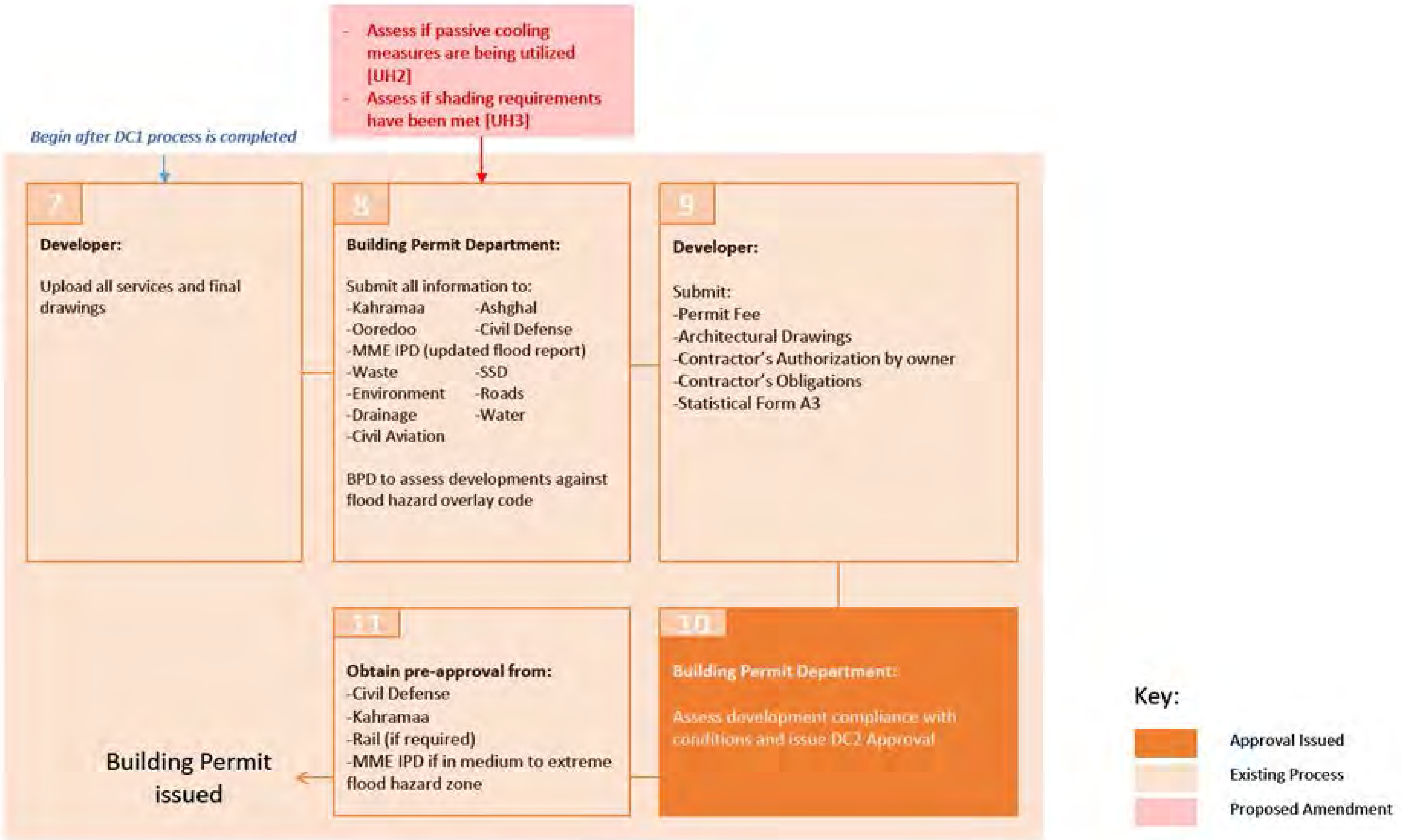



*Figure 7-1: Proposed amendments to the Qatar Building Permit System*

## 7.6 Monitoring and Evaluation

Tracking the implementation of the strategy outlined in this report will require a formal plan. A monitoring and evaluation (M&E) plan describes how the program works, including the indicators, who is responsible for collecting them, and how the data will flow through the organisation. The following sections establish the core elements of the M&E plan.

### 7.6.1 The CCS framework

The core of the M&E plan is the logical framework[5], which summarises the key elements of the strategy, identifies indicators, and the means by which verification will be achieved.

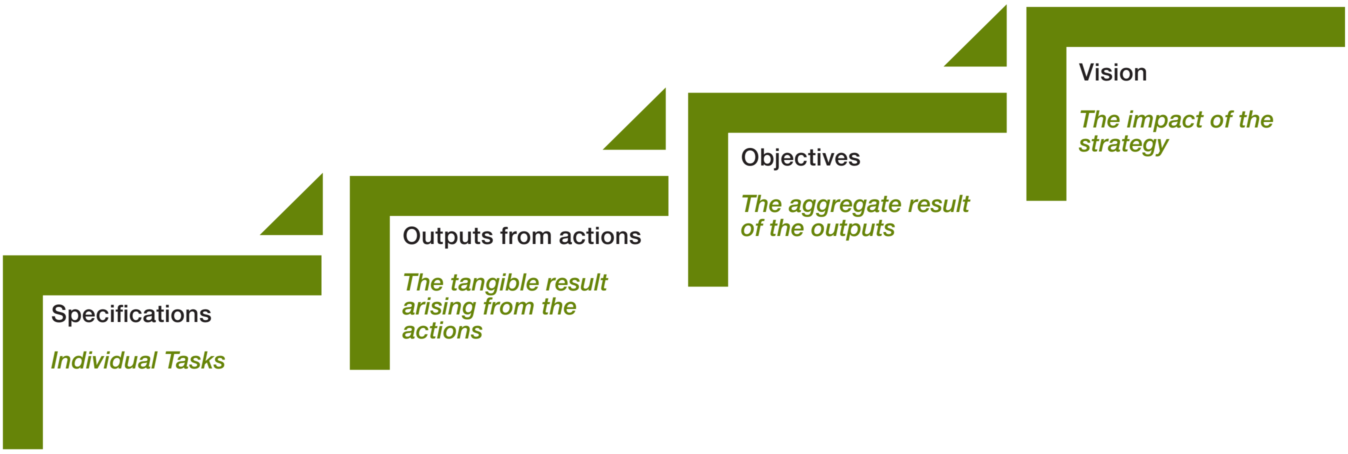



*Figure 7-2: The Logical Framework*

The framework seeks to establish the logical chain of causality in the program (vertical logic) described in Figure 7.2, i.e.

- If the assumed inputs are provided, the actions can be progressed
- if actions are completed, the outputs will be produced
- if outputs are produced, then objectives will be achieved
- if objectives are achieved, then the vision will be realised

The core elements of the framework are set out in Figure 7.3 which establishes the hierarchy within the strategy.

5 The description of the approach presented here is derived from the Australian Government's guidance document "The Logical Framework Approach".

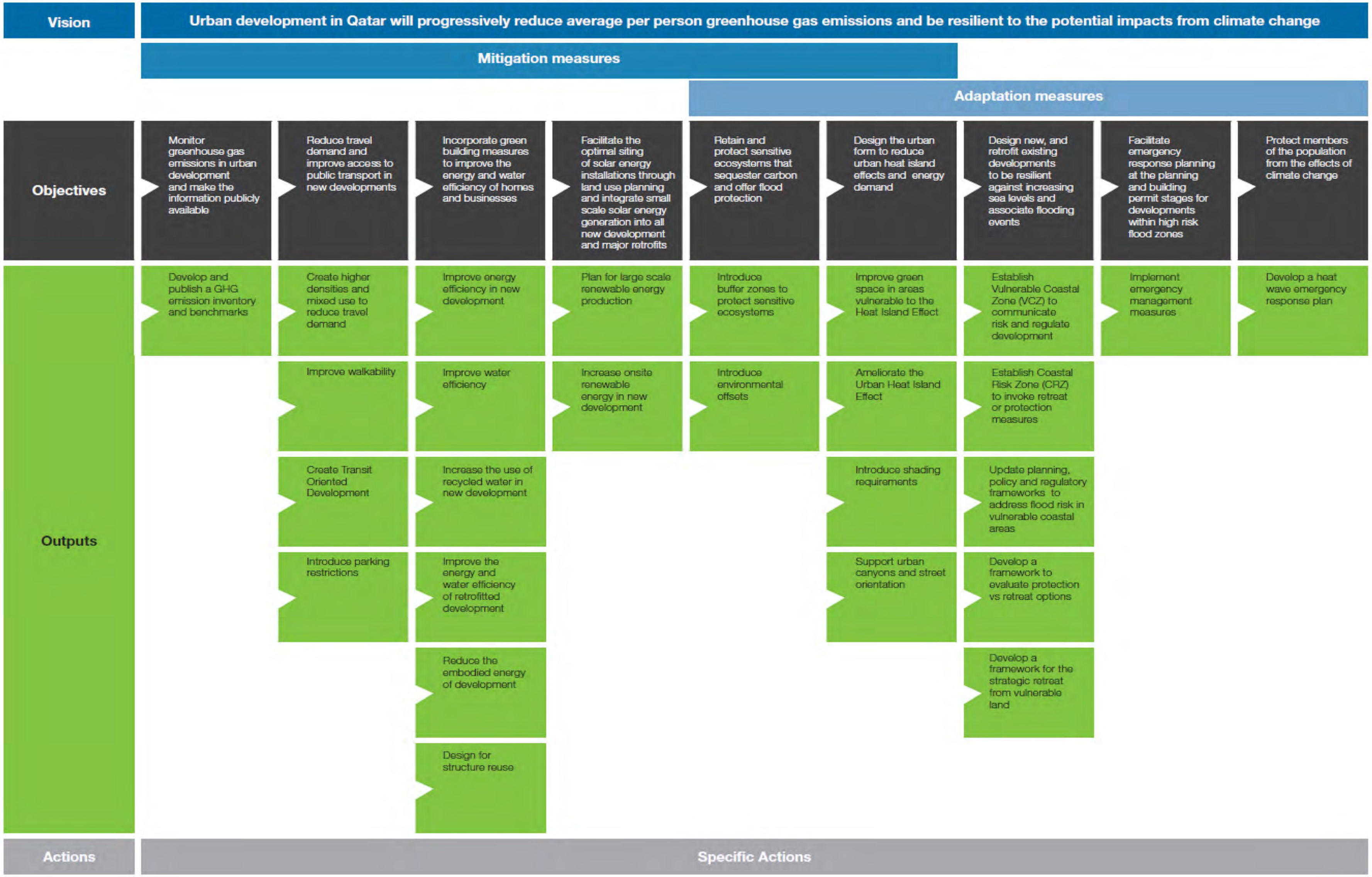



*Figure 7-3: Hierarchy within the CCS*

### 7.6.2 Indicators, benchmarks and targets

The indicators in Table 7-1 are metrics against which the vision and objectives can be evaluated. The indicators assess the degree to which intended results are being achieved. The indicators specified in Table 7-1 offers a consistent way to measure progress towards the CCS vision and objective.

In the absence of available data for the indicators specified in Table 7-1, the first year of monitoring data will be used to establish the baseline. This baseline data can then be used to set meaningful and realistic targets depending on the trend observed in the data. The targets in Table 7-1 set the initial steps of establishing where reduction and increase is required.

The benchmarks in Table 7-1 are to provide reference and guidance to the MME in setting the targets based on best practice (locally and internationally). Table 7-1 should be revisited after year 1 of monitoring when sufficient baseline data is available and a suitable assessment can be made to define the target.

The following sub sections provide additional details on the indicators, benchmarks and targets.

#### *Indicators*

Indicators have been selected to meet the following criteria:

Specific – Key indicators need to be specific and to relate to the conditions the activity seeks to change.

Measurable – Quantifiable indicators are preferred because they are precise, can be aggregated and allow further statistical analysis of the data. However, process indicators may be difficult to quantify in certain instances, and qualitative indicators have also be used.

Attainable – The indicator (or information) must be attainable at reasonable cost using an appropriate collection method.

Relevant – Indicators should be relevant to the management information needs of the people who will use the data. Indicators have also be selected to meet the management and informational needs of all partners to implementation.

Timely – Information on an indicator needs to be collected and reported at the right time to influence many management decisions.

Indicators, and where applicable benchmarks and targets, have been developed for each level of the framework hierarchy, this has been tabulated and provided in Table 7-1.

Where information is not presently available or sufficient to establish benchmarks / targets for some of the quantitative indicators, specific actions will be proposed as part of the implementation process to establish these.

#### *Benchmarks*

As part of the benchmarking exercise, the following hierarchy was followed as the process of establishing relevant benchmark guidelines:

- Local standards
- International Standards and Guidelines
- Best practice/Standards from other countries

A literature review was undertaken following the hierarchy established above. Benchmarks were selected based on internationally accepted practices and guidelines. A summary of the relevant benchmarks for each level of the framework hierarchy is summarized in Table 7-1. The benchmarks in Table 7-1 are to provide reference and guidance to the MME in setting the targets based on best practice (locally and internationally).

The benchmarking process and details of the analysis are provided as Appendix E.

#### *Targets*

Interim targets have been established as summarized in Table 7-1. These targets will be reviewed and revised upon the implementing of the CCS monitoring programme, as baseline data becomes available.

Table 7-1: Indicators, benchmarks and targets

| | Statement | Indicator(s) | Benchmarks | | | Target |
|---|---|---|---|---|---|---|
| | | | Local Standard | International Standards and Guidelines | Best Practice / Standards from other countries | |
| **Vision** | Urban development in Qatar will progressively reduce average per capita greenhouse gas emissions and be resilient to the potential impacts from climate change | Percentage decrease in average consumption based greenhouse gas emissions per capita per year | N/A | Multi-regional input-out (MRIO) analysis | There are sever MRIO databases and models with functionality to estimate consumption based emissions. Some of the most widely used databases are:<br>• Eora<br>• Global Trade Analysis Project (GTAP)<br>• World Input-Output Database (WIOD)<br>• Global Resource Accounting Model (GRAM) | Year on year reduction |
| | | Reduction in monetary value of property damages attributable to climate change | N/A | The Economics of Global Climate Change (2015) | Estimating monetary damages from flooding in the United States under a changing climate (Wobus et al. 2014) | Year on year reduction |
| **Objective 1.** | Design new, and retrofit existing developments to be resilient against increasing sea levels and associate flooding events | Reduction in number of incidences of flood impact on properties and infrastructure | N/A | N/A | Urban Flood Impact Assessment: A state of the art review (Hammond et al, 2013) | Year on year reduction |
| **Objective 2.** | Facilitate emergency response planning at the planning and building permit stages for developments within high risk flood zones | Percentage of developments within high risk zones with emergency response plans | N/A | Disaster and Emergency Planning for Preparedness, Response, and Recovery (Alexander D, 2015) | Producing Emergency Plans (FEMA, 2008) | Progressing towards 100% of developments within high risk zones to have emergency response plans in place |
| **Objective 3.** | Design the urban form to reduce urban heat island effects and energy demand | Cooling energy demand per $m^2$ per year | GSAS Design Guidelines (2015)<br>GSAS Reference: Residential: 85 KWh/m2 pa Commercial: 95 kWh/m2 pa | N/A | N/A | To meet 70% of GSAS reference. |
| **Objective 4.** | Protect members of the population from the effects of climate change | Percentage of population affected annually by extreme weather events | N/A | N/A | N/A | Year on year reduction |

| | Statement | Indicator(s) | Benchmarks | | | Target |
|---|---|---|---|---|---|---|
| | | | Local Standard | International Standards and Guidelines | Best Practice / Standards from other countries | |
| **Objective 5.** | Monitor greenhouse gas emissions in urban development and make the information publicly available | Continuous public reporting of consumption emissions (emission indicators provided in Table 5-2) | N/A | Guide for Designing Mandatory Greenhouse Gas Reporting Programs (Singh et al, 2015) | Regulation EU No. 525/2013 on a mechanism for monitoring and reporting GHG emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC (EC, 2017) | - |
| **Objective 6.** | Reduce travel demand and improve access to public transport in new developments | Reduction in total km travelled per capita per year | N/A | For Future Inland Transport Systems (ForFITS) User Manual (UNECE, 2017) | N/A | Year on year reduction |
| | | Percentage increase in public transport services available | N/A | N/A | Guidelines for Planning for public transport in developments (TIHT, 1999) | Year on year increase |
| **Objective 7.** | Incorporate green building measures to improve the energy and water efficiency of homes and businesses | Percentage of new development to be GSAS certified | GSAS Design Guidelines (2015) | N/A | Estidamaa (The Pearl Rating System) (UPC, 2017) | All new developments to be GSAS certified at a minimum of 2 star rating. |
| **Objective 8.** | Facilitate the optimal siting of solar energy installations through land use planning and integrate small scale solar energy generation into all new development and major retrofits | Percentage increase in solar generation capacity in new development/ major retrofits | N/A | N/A | Planning guidance for the development of large scale ground mounted solar PV systems (Bre, 2017) | Percentage increase in new buildings with solar panel installations which can produce at least 20% of their energy needs. |
| **Objective 9.** | Retain and protect sensitive ecosystems that sequester carbon | Number and area of protection zones for sensitive ecosystems | N/A | N/A | Guidelines for the selection of protected ecological areas (Beechey, 1989) | No reduction in number and area of protection zones for sensitive ecosystems |

### 7.6.3 Means of Verification

The different means (and effort) of collecting information will need to be carefully considered when the CCS is implemented. The Logframe matrix is a useful analytical and presentational structure for systematically identifying and assessing appropriate 'means of verification' for each indicator that is chosen.

The following are key considerations in reviewing indicators and establishing the means by which verification will be achieved:

- how should the information be collected, e.g. sample surveys, administrative records, national statistics?
- what source is most appropriate? e.g. Who should be interviewed? Is the information already being collected? Is the source reliable?
- who should do it? e.g. MME staff, an independent team?
- when and how often should the information be collected, analysed and reported? e.g. monthly, annually?
- what formats are required to record the data being collected?

**Implementation recommendation SE2:**

**Develop an effective change management process to communicate and promote the CCS.**

SE2-1. Review indicators and establish their means of verification.

SE2-2. Develop a plan for monitoring the progress of implementation, including information to be collected and responsibilities for reporting.

SE2-3. Establish a plan for internal evaluation of the success of the program in achieving the CCS objectives.

### 7.6.4 Monitoring

The IWG will need to establish a program of monitoring to ensure the CCS is being implemented in accordance with management's intentions. The key questions are:

- What information is required to confirm progress?
- How will the information be collected?
- Where will the data / information be stored?
- Who will be responsible for interpreting the data and reporting to the IWG?
- What is the appropriate interval between reports (which may vary for different stages of implementation)?
- What resources are required to monitor the implementation program?

### 7.6.5 Evaluation

The purpose of evaluation is to determine the effectiveness of the implementation program in achieving the program objectives. Evaluation should be conducted at identified milestones during the implementation process, and on completion. These milestones should align approximately with the suggested timelines for implementation for each of the actions as set out above.

Common evaluation questions include the following:

- How well was the program designed and implemented?
- To what extent did the program meet the overall program objectives?
- Was there any significant change and to what extent was it attributable to the program?
- How valuable are the outcomes to the organisation, other stakeholders, and participants?
- What worked and what did not?
- What were unintended consequences?
- Was the project cost effective?
- Is the change self-sustaining or does it require continued intervention?
- To what extent has the project led to the long-term behaviour change?

## 7.7 Socio-Economic Analysis

### 7.7.1 Implications of climate change

The Stage 3 report (summarised in Section 2.1) identifies the likely impacts of climate change in Qatar. Further commentary is provided on these issues in the sections above on sea level rise and flooding (Section 3.1), increasing temperatures (Section 4.1), and biodiversity (Section 6.1). The predominant effects of climate change in Qatar are associated with increasing temperatures and rising sea levels. Without adequate mitigation or adaptation measures, these effects will have a gradually increasing adverse consequence for society, the economy and the environment (Table 7-1).

**Table 7-2: Effects and implications of climate change**

| Effect | Increasing levels of: | Implications | | |
|---|---|---|---|---|
| | | Social | Economic | Environmental |
| **Increasing temperatures** | Heat stress | Public health | Reliability of infrastructure | Species resilience |
| | Cooling energy | - | Cost of energy | Increased emissions |
| **Rising sea levels** | Flooding and inundation | Public safety | Damage / loss of land and assets | Ecosystem damage |
| | Loss of habitat | Amenity | | Reduced biodiversity |

Some of these effects give rise to reinforcing feedbacks that will worsen climate change impacts under business as usual. Increasing temperatures will result in higher consumption of electricity (for cooling) and water, leading to higher emissions and consequently higher temperatures. Any loss of coastal mangroves due to sea level rise will increase coastal erosion, which will exacerbate flooding risk even under business-as-usual assumptions.

The impacts are interrelated, with all social and environmental impacts having an economic effect and vice versa. In considering the socio-economic impacts, it is important to be mindful of the dynamics of climate change. The effects of climate change will increase for as long as the concentration of atmospheric $CO_2$ continues to rise. Although the Paris Agreement could go some way to obtaining national commitments to reduce emissions, these are not sufficient to reduce atmospheric $CO_2$ concentrations in absolute terms. Therefore, there is no way to determine when global temperatures will stabilise, and therefore the final cumulative effects of climate change.

With the current policy setting, climate change will continue for the foreseeable future and the social, economic and environmental consequences will worsen. The risks set out in Section 2.1.3, (many of which are already high or extreme) can therefore be considered certain to increase. In the 2009 report of the Arab Forum for Environment and Development (AFED, 2009) Tolbar and Saab state that sea level rise, of 1 m, would reduce GDP by 2% in Qatar. If it assumed that this would occur incrementally over the balance of the century, the cumulative monetary value of these losses would be around QR 1,570 bn with a present value of around QR 70 bn. If impacts other than sea level rise are included, and a monetary value placed on the social and environmental impacts, these figures would increase by several times. It is clear that the social, economic and environmental costs of not acting will be extremely high, and therefore significant investment in reducing the risks is warranted.

### 7.7.2 Implications of implementing the CCS

A qualitative assessment of the consequences of the CCS implementation of each specific action has been undertaken in respect of the resource implications for MME and this is included as Appendix D. A summary of the assessment, together with the direct social, economic, and environmental consequences of implementation, is provided in Table 7-3.

**Table 7-3: Qualitative socio-economic analysis**

| Output from actions | Resource implications for MME | Direct consequences | | |
|---|---|---|---|---|
| | | Social | Economic | Environmental |
| SL1: Establish Vulnerable Coastal Zone (VCZ) to communicate risk and regulate development | Low-medium cost | Reduced risk of property loss and injury | Reduced opportunities for new development | |
| SL2: Establish Coastal Risk Zone (CRZ) to invoke retreat or protection measures | Low-medium cost | - | - | Protection / reinstatement of coastal vegetation |
| SL3: Update planning, policy and regulatory framework documents to address flood risk in vulnerable coastal areas | Low-medium cost | - | Some additional costs for owners | |
| SL4: Develop a framework to evaluate protection vs retreat options | Low-medium cost | - | Optimal economic decision-making | Protection: Loss of coastal habitat<br>Retreat: Retention of coastal habitat |
| SL5: Develop a framework for the strategic retreat from vulnerable land | Low cost | - | Loss of land and asset value | Protection / reinstatement of coastal vegetation |
| SL6: Implement Emergency Management Measures | Medium cost | - | Additional cost of flood protection measures | |
| UH1: Improve green space in areas vulnerable to the Heat Island Effect | Low cost | Reduced incidence of heat stress | Some loss of floor space | Additional habitat |
| UH2: Ameliorate the Urban Heat Island Effect | Low-medium cost | - | Reduced energy costs | - |
| UH3: Introduce shading requirements | Low cost | - | - | - |
| UH4: Create urban canyons and improve street orientation | - | - | - | - |
| UH5: Develop a heat wave emergency response plan | Low cost | - | Some additional health system costs | |
| GE1: Develop and publish a GHG emission inventory and benchmarks | Medium cost | Increased awareness | | - |
| GE2: Create higher densities and mixed use to reduce travel demand | Medium cost | - | Improved development returns | Reduced levels of pollution |
| GE3: Improve walkability | Medium cost | Health benefits | Improved retail exposure | |
| GE4: Create Transit Oriented Development | Low-medium cost | Improved access and local work opportunities | Investment in transport infrastructure | |
| GE5: Introduce parking restrictions | Low cost | Inconvenience for car owners | | - |

| Output from actions | Resource implications for MME | Direct consequences | | |
|---|---|---|---|---|
| | | Social | Economic | Environmental |
| GE6: Improve energy efficiency in new development | Low cost | Improved levels of thermal comfort | Reduced energy costs and investment | |
| GE7: Improve water efficiency | Low-medium cost | - | Reduced energy & water costs and investment | |
| GE8: Increase the use of recycled water in new development | Low-medium cost | - | Higher unit water costs and investment | |
| GE9: Improve the energy and water efficiency of retrofitted development | Low cost | Improved levels of thermal comfort | Reduced energy costs and investment | |
| GE10: Reduce the embodied energy of development | Low cost | - | Potentially higher material costs | Reduced waste to landfill |
| GE11: Design for structure reuse | Low cost | More flexible buildings | Economic efficiency gains | |
| GE12: Plan for large scale renewable energy production | Medium cost | - | New investment opportunities | |
| GE13: Increase onsite renewable energy in new development | Medium cost | - | Lower life cycle energy costs | |
| PB1: Introduce buffer zones to protect sensitive ecosystems | Low-medium cost | - | Some loss of land for development | Retention of habitat |
| PB2: Introduce environmental offsets | Medium cost | - | - | Reduced loss of habitat |

As identified in Table 7-3, the resource implications for implementation of the CCS are considered to be relatively modest, and the effort for most actions can be absorbed within the agency, albeit with additional staff and / or external consultancy support.

The direct impacts of the CCS are overwhelmingly positive to society in general, particularly in respect of the reduced risk of health and safety impacts arising from flooding and heat stress.

The direct economic consequences are also mainly positive, with reduced costs of energy and water accruing to households and businesses. However some resistance from developers to these (and any new) measures is to be expected as some will increase construction costs, while savings accrue to owners and occupiers.

A rational approach to the retreat from vulnerable coastal land will also yield positive economic benefits as losses of land value will be offset by avoided costs of flood damage and relocation of assets over time as sea levels rise. However, the impact on individual owners of land that will be lost and assets that will have to be relocated, remains potentially significant, irrespective of the net long term economic benefit to society. Policies to ameliorate or offset the costs to individual landowners will need to be developed to reduce these negative consequences, and so improve support for the implementation of the CCS.

The direct environmental consequences are also mainly positive as the CCS will lead to protection and / or reinstatement of threatened coastal ecosystems, and reduced pollution.

### 7.7.3 Quantitative socio-economic analysis techniques

It is recognised that in further consideration of some of the recommended measures, more formal analysis may be necessary to ensure optimal cost-effectiveness is achieved.

The available techniques include:

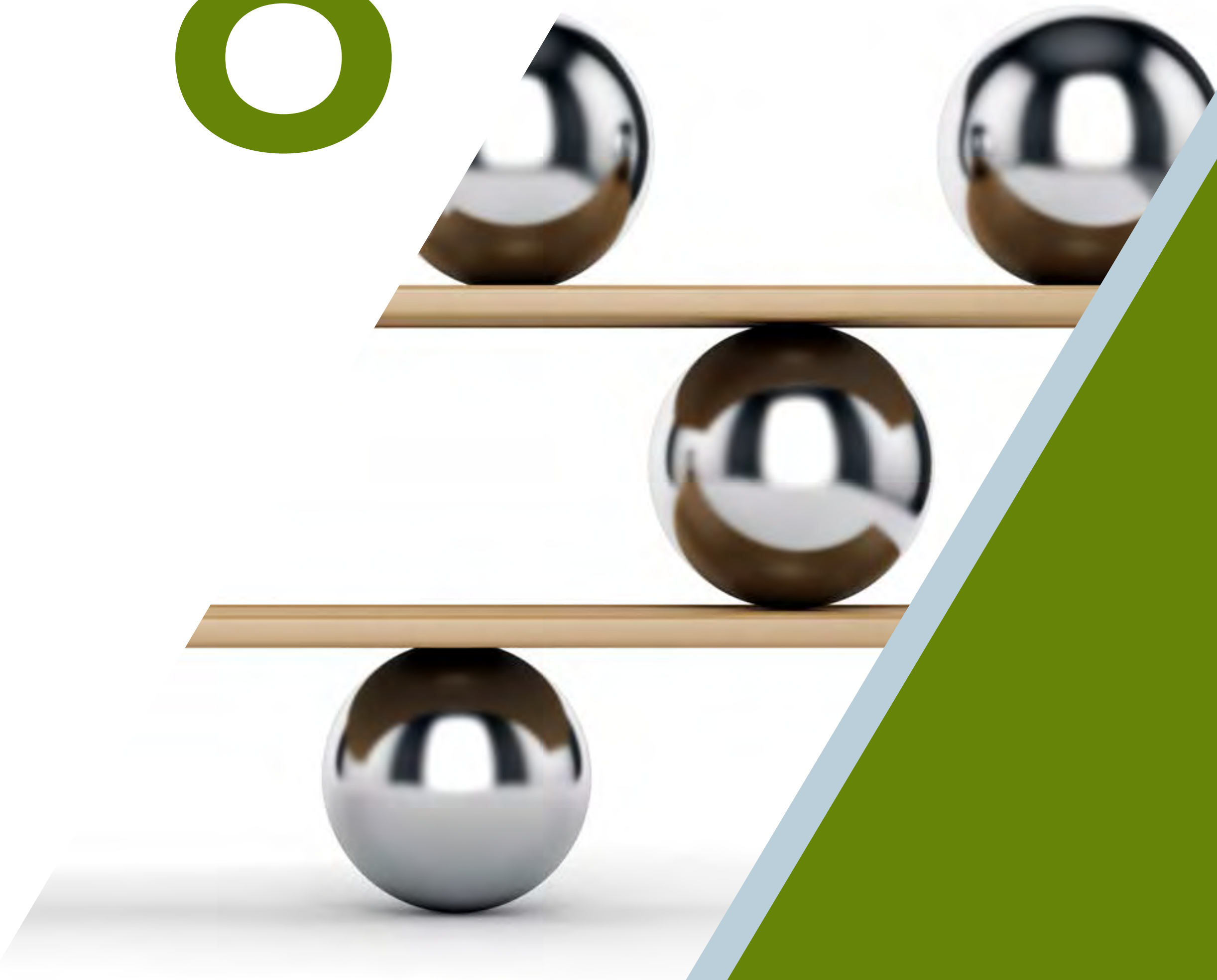
**Cost-benefit analysis (CBA)**: In principle, a CBA values all the effects of both the reference scenario (often do nothing) and of the proposed measure or measures. The measure(s) should only be implemented if the present value of the benefits exceeds the present value of the costs, so that the measure yields a socio-economic profit. When comparing several measures, the measure yielding the highest socio-economic return should be chosen. One difficulty with utilising CBA in a climate context is the need to monetise non-market social and environmental criteria (e.g. environmental value of mangroves).

**Cost-effectiveness analysis (CEA)**: A CEA measures the costs relative to a desired effect (e.g. net costs per tonne of carbon emission reduction). A CEA is especially suited for calculating how society can most cost-effectively achieve a given target within e.g. the climate area.

**Multi-criteria analysis (MCA)**: Multi-criteria analysis establishes preferences between options by reference to an explicit set of objectives that the decision making body has identified, and for which it has established measurable criteria to assess the extent to which the objectives have been achieved. MCA covers a broad range of techniques for comparing impacts in ways which do not involve giving all of them explicit monetary values, although they may include data from cost-effectiveness or cost-benefit analyses. The techniques are in many respects an 'alternative' to defining monetary values for all the major costs and benefits when this is impractical.

The multi-criteria analysis technique, involving social, economic and environmental criteria, is considered to be the most appropriate methodology for such evaluations, with actual economic costs incorporated through conventional discounted cash flow approaches. Such an approach is recommended to address decisions around whether / when to introduce coastal protections and further detail on the methodology in set out in Section 3.3.3.

# 8



# Gap Analysis

# 8 Gap Analysis

The analysis undertaken in Stage 3 (Situation Analysis Stage) ascertained gaps where further interventions were required based on an inventory of existing climate change interventions (management strategies, measures, codes) in Qatar (Table 6-4 of the Stage 3 Report, p. 123). The gaps identified formed the basis for the development of the mitigation and adaptation measures developed in this stage of the Project.

Table 8-1 sets out:

- the gap identified in Stage 3
- the Climate Change issue relevant to the gap
- how each gap has been addressed in this report

Table 8-1: Gap analysis

| Climate change issue | Category of Interventions | Current mitigation | Gap identified at Stage 3 | Where gap is covered in this report |
|---|---|---|---|---|
| General climate change risks and responses | Overall policy commitments | Partial through Qatar National Vision 2030, QNDS, MSDPs; negligible through the Constitution of Qatar 2004 and QNMP: primarily generic statements rather than detailed proposals.<br>MSDPs define a development approval process, however in practice, it is unclear how this process is implemented in determining development outcomes or setting zoning regulations. | QNDS needs to translate general principles from the Constitution and Qatar National Vision into actions.<br>QNMP and MSDPs need climate change related policies | This report comprehensively covers this gap in respect of the issues that can be addressed within the land use planning sector. |
| | Mechanisms to incentivise developers to integrate climate change response into development proposals | Partial mitigation through MSDP policies on open space (provision of smaller spaces and plazas, developer contributions for provision of open space); negligible mitigation through QNDF and MME Intended Nationally Determined Contributions which highlight the importance of renewables. | Explore tools for identifying and quantifying potential climate change and other environmental impact offsets and requiring developers to implement or pay for these (where they cannot design the impacts out in the first place, which is preferable). | This gap has been addressed by the following Specific Actions that design out environmental impacts from new and existing developments:<br>• Specific Action UH2: Covers ameliorating the urban heat island effect. This requires all new developments to include passive cooling measures and mandates developments to be retrofitted cost effectively to be more efficient in terms of energy consumption.<br>• Specific Actions GE6, GE7, GE8, GE9, GE10 and GE11 cover improving energy and water efficiency of new and retrofitted development, minimizing material use, and the utilization of recycled water in new development.<br>• Specific Actions PB1 and PB2 prohibits development within buffer zones of sensitive ecosystems and requires environmental offsets for unavoidable development impacts.<br>• Specific Action GE5 covers reducing parking occupancy by introducing parking fees and stipulating parking maximums. |
| Heat island effect | Shading | MSDP transport policies require 70% of car parking spaces to be shaded; residential policies promote housing types that provide shade and soft landscaping; and open space policies require minimum grassed and landscaped areas and 60% of pedestrian pathways to be shaded. QNDP requires provision of attractive shaded walking and cycling areas. | Ensure that shading measures are specified in the zone requirements and QNDF | This gap has been addressed by Specific Action UH3 that requires 60-70% of pedestrian pathways and parking areas, and 25-30% of hardscaped common areas to be shaded. |

| Climate change issue | Category of Interventions | Current mitigation | Gap identified at Stage 3 | Where gap is covered in this report |
| --- | --- | --- | --- | --- |
| | Sea breeze permeability | Partial mitigation through some MSDPs' policies on Centres Hierarchy/ Open Space | Not in all MSDPs and implementation not clear- how will sea breeze be harnessed through design. Needs specifications in codes. | This gap has been addressed by Specific Action UH4 that covers street orientation and building heights to allow for urban canyons and the penetration of cool coastal breezes. |
| | Reduce large impervious areas | QNDF and MSDP residential policies promote tall buildings, hierarchy of mixed-use centres, lot consolidation etc. | Needs explicit policies to ensure master planning, density, massing is used to minimise and protect from solar gain. | This gap has been addressed by the following Specific Actions:<br>• Specific Action UH2 requires light coloured pavements for roads and parking areas.<br>• Specific Action UH1 discuss the need for publicly accessible green areas to help reduce the heat island effect.<br>• Specific Actions GE2, GE3, GE4 and GE5 improve higher density, mixed use and connected development which will reduce large impervious areas. |
| Sea level rise and other flooding due to climate change | Sea level rise | Integrated Coastal Zone Management Plan discusses possible interventions but does not specify actual measures; the QNDF and MSDPs mention flood problems but do not propose concrete actions | No climate change hazard mapping. No translation of possible measures into concrete actions with a plan for resourcing and implementing them. | This gap has been addressed by the following Specific Actions:<br>• Specific Actions SL1 and SL2 which defines the criteria to identify the VCZ<br>• Specific Actions SL2 and SL3 proposes planning and regulatory amendments to address flood risk, and development of frameworks to evaluate protection vs retreat options and strategic retreat from vulnerable land.<br>• Climate Change hazard mapping is being undertaken as part of the Qatar Flood Study project. |

| Climate change issue | Category of Interventions | Current mitigation | Gap identified at Stage 3 | Where gap is covered in this report |
|---|---|---|---|---|
| | Avoid new development in flood risk zones and protect vulnerable development (move it out of flood risk zones) | Qatar National Vision 2030 and QNDS recognise the risk but do not translate this into concrete actions. The Qatar Integrated Drainage Master Plan 2013 aims to reconcile future population and urban development, with climate change being an input to the multi-criteria analysis it uses. QNDF policy ENV4 and emerging National Coastal Zone Management Plan prohibit development in Coastal Zone Protection Areas and areas subject to erosion, flooding, storm surge or sea level rise.<br>A National Coastal Zone Management Plan is being prepared which will not allow development in or near the Coastal Zone Protection Area. Interim Coastal Zone development Guidelines ensure that permitted activities require permission from the MMUP and MME.<br>The Coastal Protection Overlays control the type and scale of development within the coastal area | Qatar Integrated Master Plan 2013 does not describe any process of testing individual locations or capacities against possible climate change scenarios. There is also no specific mention of how climate change impacts may be taken into account in the projections for demand.<br>QNDF could be clearer about levels of risk and timescales. | This gap has been addressed by the following Specific Actions:<br>• Specific Actions SL1, and SL4 make provision for the process of protecting existing vulnerable development from flooding and invoking retreat from vulnerable coastal land.<br>• Specific Actions SL3 covers the requirements for a cost: benefit assessment for coastal protection measures vs. strategic retreat<br>• Specific Actions SL5 requires a flood emergency management plan for all developments within the high-risk flood zone. |
| | Flood-resilient design (e.g. habitable rooms on upper floors, flood protection measures) | Qatar Highway Design Manual (QHDM) sets requirements for the level of flood protection. Qatar Sewerage Drainage Design Manual 2006 provides guidance on the level of flood protection to be applied and the design standards to be used for surface water drainage systems. Interim Advice Notes regarding future proofing of rural roads are applied only on a case by case basis. QNDF calls for infrastructure vulnerable to flooding to be identified and protected.<br>ICZMP proposes measures to support and protect coastal ecosystems and heritage sites/assets from increased flooding and storms, and provides for mitigation and retreat. | The QHDM and Sewerage Drainage Design Manual set good standards, but their effectiveness of implementation is unclear.<br>The QNDF needs an implementation mechanism.<br>Confirmation of the effectiveness of the ICZMP is needed | This is outside the remit of the UPD Department within the MME.<br>This gap to be addressed as part of the Qatar Flood Study Project in collaboration with Ashghal. |
| | Emergency planning | Negligible mitigation through the QNDF which discusses emergency response facilities but not in the context of climate change | Overall lack of emergency planning policy or guidelines. | This gap has been addressed by the following Specific Actions:<br>• Specific Action SL5 requires the development of a Flood Emergency Management Plan and identifies flood hazard design requirements for emergency facilities and services<br>• Specific Action UH5 requires the development of a heat wave emergency response plan |

| Climate change issue | Category of Interventions | Current mitigation | Gap identified at Stage 3 | Where gap is covered in this report |
|---|---|---|---|---|
| Impact of climate change on environmental assets | Protect and enhance open spaces and green spaces, protection from inappropriate development, promotion of biodiversity conservation | Interim Open Space and Recreational Facilities Development Guidelines promotes a network of green spaces. QNMP protects green areas, and sees them as a way of improving amenity and encouraging walking and cycling; the AAPs help to implement this.<br>QNDF introduces Green Belts and Environmental Protection Areas, and protects them from development and inappropriate use. QNDS acknowledges strains on biodiversity by climate change.<br>MSDPs restrict development in aquifer protection zones, Environmental Protection Areas, wadi and rodah; and aim to contain growth within defined urban boundaries. They promote parks within walking distance and the use of road and utility corridors as green corridors.<br>ICZMP describes Qatar's protected area framework but does not refer to climate change. | The Interim Open Space Guidelines need to mention how open spaces can mitigate or adapt to climate change.<br>The QNDF should look for opportunities to help wildlife respond to climate change.<br>The MSDPs provide good general statements of principle but their effectiveness depends on the Open Space and Recreation Strategy.<br>The ICZMP recommendations include constraints on development, but these need to be applied in spatial planning. | This gap has been addressed in the following Specific Actions:<br>• Specific Action PB1 prohibits development within 250 m of Protected Areas, mangroves, seagrass and coral reefs and makes provision for wildlife corridors and 'escape routes'<br>• Specific Action PB2 requires offsets for unavoidable impacts on biodiversity. |
| | Landscaping | QNDF recommends use of indigenous species in the design of open spaces. MSDP Mixed Use Residential Zone and Residential Zones 1-6 require minimum landscaping of 20-30%. | Unclear whether the QNDF recommendation is a mandatory requirement.<br>MSDPs do not specify planting requirements for other zones, nor of drought-tolerant species. | This gap has been addressed by Specific Action GE7 that requires the use of native and drought-tolerant plant species be mandated. |
| | Mangroves | ICZMP describes the relocation of seagrass and mangroves as mitigation for construction projects. | ICZM is unclear about how to decide whether relocation is appropriate, how much relocation of what quality would constitute success etc. | This gap has been addressed in the following Specific Actions:<br>• Specific Action PB1 prohibits development within 250 m of Protected Areas, mangroves, seagrass and coral reefs<br>• Specific Action PB2 requires offsets for unavoidable impacts on biodiversity. |

| Climate change issue | Category of Interventions | Current mitigation | Gap identified at Stage 3 | Where gap is covered in this report |
|---|---|---|---|---|
| | Groundwater | Dewatering Permit details parameters required to obtain a dewatering permit, including limit for discharged water into the marine environment.<br>The Utilities section of MSDPs promotes sustainable drainage techniques, and the use of wadi and rodah to manage stormwater. The Natural Environment section states that all development within the Northern Aquifer must be connected to a reticulated sewage system and no groundwater extraction is permitted without permission from MME. | The Dewatering Permit is not directly related to climate change.<br>MSDP effectiveness depends on inclusion of requirements into zone codes (e.g. what sustainable drainage technique, how it will be implemented etc.)<br>Shallow groundwater quality requires better monitoring of the development industry and enforcement of development and environmental permit approval conditions. | This is outside the remit of the UPD Department within the MME.<br>This gap to be addressed as part of the Qatar Flood Study Project in collaboration with Ashghal and Environmental Affairs Department within MME. |
| Other | Energy use | MSDPs' Natural Environment sections discuss the need for a step change in recycling through the introduction of recycling facilities, awareness programmes and incentive schemes. | Identified need for increase in recycling but not evident in zone requirements. | This gap has been addressed by Specific Action GE10 which sets requirements for consideration of re-purposing of buildings over new build to reduce embodied energy, minimization of the use of virgin materials and recycling of building materials. |
| | Renewable energy | Qatar National Vision 2030 sets a goal of 20% renewable energy by 2024. | QNV needs to be put into action | This gap has been addressed by Specific Action<br>GE13 which requires that new development and major retrofits should produce at least 20% of their energy needs from on-site renewables, and that various plans support and incentivise the development of renewable energy. |
| | Water use | QNDS states that Qatar will enact a Qatar National Water Policy establishing an integrated system of quality requirements, discharge controls and incentives for conservation.<br>MSDPs' Utilities sections propose new desalination facilities; identify potential shortfalls in servicing new transport systems and increasing water consumption; and discuss the use of recycled water for irrigation of street trees and farming. | No strategies to address increasing water consumption. Identifies need for providing sustainable alternative water supplies by no process for action. | This gap has been addressed by Specific Actions<br>GE6, GE7, GE8 and GE9 which promote minimum standards of water efficiency for new developments and major retrofits; make provision for major industrial and agricultural developers to prepare a water efficiency plan; require water efficient irrigation practices; and require the incorporation of recycled water in new development. |

| Climate change issue | Category of Interventions | Current mitigation | Gap identified at Stage 3 | Where gap is covered in this report |
|---|---|---|---|---|
| | Promotion of walking and cycling | The QNDF aims to enable pedestrian-prioritized streets that are well-shaded by trees and buildings.<br>MSDPs promote a shift away from the car and towards public transport and walking; encourage the provision of parks that are accessible through walking/cycling; and state the Local Centres should be within a convenient walking distance for residents (generally 400m).<br>National Bicycle Master Plan is an overarching strategy for enhancing routes and facilities for cyclists. It requires developers to provide facilities for cyclists. Interim Advice Note 11 on cycleway design is applied on a case by case basis. | The QNDF needs implementation mechanisms.<br>The MSDPs set good statements of principles but need to be implemented, e.g. in zone requirements.<br>Zoning requirements should reflect the National Bicycle Master Plan. | This gap has been addressed by Specific Actions GE2, GE3, and GE4 which place requirements for development to promote walking and cycling. |
| | Public transport/ TOD | QNMP, MSDPs and AAPs support improvements in public transport. The AAPs in particular orient development closely around, and supporting, public transport stations.<br>MSDPs aim to facilitate a modal transfer through provision of a high quality public transport system, and to cluster community facilities and promote higher residential densities within and around centres.<br>The Doha and Al Rayyan MSDPs discourage sprawling retail corridors, and require improvements to public transport facilities. The employment sections of MSDPs note that outside of the Centres and the major precincts, the location of future employment development will be restricted in order to create a more transit oriented urban structure.<br>National Parking Master Plan (currently under preparation) will provide a package of measures including demand management and wider use of public transport services. | Good general statements, require implementation mechanism | This gap has been addressed by the following Specific Actions:<br>• Specific Action GE2 promotes ways of reducing the need to travel.<br>• Specific Action GE4 promote mixed use zones near Doha Metro stations and specifies that MSDPs and AAPs should include a requirement to make public facilities accessible by public transport as well as walking/cycling. |
| | Disincentives to car use | QNMP aims to reduce the attractiveness of automobile use, for instance through slower speeds and increasingly limited parking provision. | The QNMP needs implementation mechanisms. | This gap has been addressed by Specific Action GE4 which makes provision for measures to reduce parking by private cars through the Qatar Parking Master Plan and zoning regulations. |

| Climate change issue | Category of Interventions | Current mitigation | Gap identified at Stage 3 | Where gap is covered in this report |
|---|---|---|---|---|
| | Building design, development pattern and public realm | QNDF states that risks from climate change impacts should be evaluated and mitigation measures developed. The QNMP promotes dense, compact settlements but also low-density Qatari homes.<br>MSDPs promote high quality design of the urban realm to ensure better responses to the climate, and to provide a continuous active street connection between shops and the public domain. Commercial corridors should reflect the desert environment and climate.<br>Qatar Construction Specifications 2014 address minimum construction standards. Global Sustainability Assessment System promotes consideration of the causes and impacts of climate change in the siting, design and construction of development projects. Discharge Permit Application Form 2016 requires all development to connect to the TSE/wastewater drainage network. Cooling or industrial uses require MME approval.<br>Urban Design Compendium (in preparation) will outline preferred design outcomes for the public realm. Green Building Council guidelines aim to reduce the impact of buildings on the environment, including energy efficiency, environment-friendly materials etc.; however they are not mandatory and are not well implemented. | Reduce QNMP emphasis on low density<br>The Qatar Construction Specifications do not provide specifications for building design in climate change risk areas, or promotion of heat control, shade etc.<br>The Global Sustainability Assessment System is used only for a limited range of projects.<br>Need to ensure that the Urban Design Compendium includes factor concerned with climate change | This gap has been addressed by the following Specific Actions:<br>• Specific Action GE6 (new development) and GE9 (retrofits) requires achievement of GSAS energy and water standards with Level 2 minimum performance.<br>• Specific Action GE2 promotes compact, mixed used developments and prevents non-complying development and urban sprawl though the implementation of targets and sequential development requirements. |

# 9

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# 9 References


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# Appendices

# Appendix A – Summary of FHO

## A.1 Flood Inundation Mapping

As part of the Qatar Flood Study (GHD, 2016), a digital flood mapping portal was developed to illustrate the extent and nature of flood risk across Qatar for a range of design flood events (ranging from small to large). The portal enables the user to zoom in on any location and visualise/query the magnitude of the flood level, depth, velocity or hazard at any given location in Qatar (including coastal areas) for a range of design flood events (DFE).

The flood mapping tool provides Qatar authorities with information that assists decision makers in the development application and approvals process including: DC2 referral assessment and conditions, land use zoning amendments, infrastructure planning, structural mitigation implementation etc.

The flood mapping portal includes a special flood mapping layer titled ‘Flood Hazard Overlay’. This layer illustrates the degree of flood hazard experienced across Qatar in a 1% AEP (1 in 100 year) design flood event. The overlay classifies flooded areas into zones of low, medium, high or extreme flood hazard in accordance with the criteria provided in Table A-1.

Table A-1: Flood Hazard overlay categories

| | Low Hazard | Medium Hazard | High Hazard | Extreme Hazard |
|---|---|---|---|---|
| **Depth (m)** | <0.30 | 0.31 to 0.60 | 0.61 to 1.20 | >1.2 |
| **Velocity (m/s)** | <0.38 | 0.39 to 0.80 | 0.81 to 1.50 | >1.5 |
| **Depth x Velocity (m2/s)** | <Medium | D+0.64*V <0.82 | D+0.69*V <1.38 | >High |
| **Typical means of egress** | Sedan | Sedan early, but 4WD or trucks later | 4WD or large trucks. | Large trucks. |

## A.2 Flooding Under Future Climate Scenarios

As part of the Qatar Flood Study, seven potential future climate scenarios were assessed as tabulated in Table A-2.

Table A-2: Climate change scenarios used in the Qatar Flood Study

| Scenario | Future Climate Era | Change in Rainfall Intensity (5 year ARI) | Change in Rainfall Intensity (100 year ARI) | Tide Conditions Relative to Qatar National Datum (QND95) | Sea Level Rise (m) | Storm Surge (m) | Resultant Sea Condition (m QND95) |
|---|---|---|---|---|---|---|---|
| Scenario 1 (base case) | 2100 | + 0% | + 0% | Mean higher high water (MHHW)* | + 0.00 | + 0.00 | MHHW |
| Scenario 2 | 2050 | + 10% | + 10% | | + 0.37 | + 0.50 | MHHW + 0.87 |
| Scenario 3 | 2100 | + 20% | + 20% | | + 0.98 | + 0.50 | MHHW + 1.48 |
| Scenario 4 | 2100 | + 30% | + 30% | | + 0.98 | + 0.50 | MHHW + 1.48 |
| Scenario 5 | 2100 | + 40% | + 50% | | + 0.98 | + 0.50 | MHHW + 1.48 |
| Scenario 6 (worst case) | 2100 | + 60% | + 60% | | + 0.98 | + 0.50 | MHHW + 1.48 |
| Scenario 7 | 2050 | No rain (tide only) | No rain (tide only) | | + 0.37 | + 0.50 | MHHW + 0.87 |
| Scenario 8 | 2100 | No rain (tide only) | No rain (tide only) | | + 0.98 | + 0.50 | MHHW + 1.48 |

** MHHW tide levels were varies along the Qatar coastline in accordance with MME Hydrographic Department tide tables*

Source: Qatar Flood Study, GHD, MME, 2016a

The base case assessed (Scenario 1) was based on the IPCC RCP 8.5 for an average recurrence interval (ARI) design storm event of 1 in 100 years. This scenario was based on the year 2100 and comprised the standard projected climate change scenario. The other scenarios (Scenario 2 to Scenario 8), in addition to a 1 in 100 year design storm, also take into account changes in rainfall intensity, sea level rise and storm surge. The worst-case conditions (Scenario 6) were chosen for climate change assessment as they represent the extreme scenario and provide a conservative approach for planning purposes.

It is noted that the rainfall intensity increases adopted for Scenarios 5 and 6 are consistent with the future climate rainfall scaling factors of 1.4 (for 2 year to 10 year ARI design events) and 1.5 (for 100 year ARI design events) as recommended in the Qatar Rainfall Runoff Technical Report (COWI, 2017).  It is noted that these scaling factors are also likely to be adopted in the Qatar Highway Design Manual (QHDM) and represent a 'conservative' year 2100 rainfall scenario.

# Appendix B – Regulatory Recommendations within SLR Hazard Area

Table B-1: Proposed regulatory recommendations within the SLR hazard area (flood hazard zone or coastal hazard zone)

| Regulation | Detail | Implementation – Relevant Standard/ Code/Policy |
|---|---|---|
| Review level of risk to existing coastal infrastructure and prioritise protection/ upgrades/ relocation. | • Review and amend standards to provide future protection of coastal infrastructure where appropriate.<br>• Review and implement options to address both sea water incursion and rising ground water salinity levels | • ICZMP<br>• MSDPs |
| Adopt minimum setback and buffer requirements | • Refer to Section 3.3.1 and 6.3.1 for further detail | • All MSDPs<br>• Building Permit Process |
| Re-zone areas of high hazard risk to restrict development | • Development should not be undertaken in the high or low hazard areas unless it is in accordance with the requirements of a SLR/ Flood Hazard Overlay Code (MSDP)<br>• Assess alternate location for the development on the subject site, that is of a lesser hazard<br>• Prevent new development in high hazard area and plan for a phased withdrawal of residential and commercial development in that area | |
| Development for certain uses must comply with the minimum flood planning levels | • Adopt a standard DFL / freeboard level for new development in risk areas. Where existing buildings cannot be raised to comply, further flood resilient design elements should be retrofitted to mitigate flood impacts. | |
| Adopt freeboard / minimum habitable levels for new buildings | • Minimises the risk to people from flood hazard.<br>• Does not reduce the ability of evacuation resources including emergency services to access and evacuate the site in a flood emergency, with consideration to the scale of the development. | |

| Regulation | Detail | Implementation – Relevant Standard/ Code/Policy |
|---|---|---|
| Offsetting requirements for impacts of SLR/Flood (Refer to Section 6.3) | • Develop a broader systematic, science based, process for defining and implementing offsets for a range of climate change impacts of development.<br>• Levying financial charges as a mechanism to offset climate change impacts, which could provide a significant driver for developers to manage climate change impacts generated by their projects.<br>• Explore tools for identifying and quantifying potential climate change and other environmental impact offsets and requiring developers to implement or pay for these (where they cannot design the impacts out in the first place, which is preferable). | • QNDF |
| Enforce planning and building regulations and requirements | • Adopt a SLR and Flood Hazard Management Plan to:<br>- Ensure compliance with development standards and therefore reduce impacts of flooding<br>- Require regular inspections and audits<br>- Record development details for further information and maintenance purposes<br>- Create awareness of flood hazards and procedures<br>- Require regular review and updates<br>- May require fines or penalties for noncompliance | • Building Permit Process<br>• All MSDP |
| An emergency management plan should be prepared to demonstrate development risk mitigation | • An EMP sets out procedures for evacuation due to flooding may be used. Refer to Section 3.3.5 of this report | • All MSDPs<br>• Building Permit Process |

Table B-2: Proposed MSDP amendments

| Existing MSDP statement regarding impacts of SLR or flooding | Recommendation |
|---|---|
| **Mangrove protection** | |
| Only the **Al Shamal MSDP** mentions mangrove protection:<br>"*The protection and replacement of mangroves can help to simulate biodiversity throughout the coastal area. It is recommended that new mangrove habitats are created to replace the biodiversity value lost through the expansion of the port.*" | All MSDPs should all include strong protective measures for mangroves and specify where new mangrove habitats should be planted, and who is responsible for funding and implementing the planting. |
| **Sea Level Rise** | |
| **Al Shamal and Doha MSDPs:**<br>"*To better understand the potential impacts of sea level rise on the municipality's coastline a Coastal Flood Risk Assessment should be carried out to inform future mitigation measures.*" | Amend text to: "A national Coastal Flood Risk Assessment has been carried out. No new development will be permitted in Zone A. In Zone B, any new development will need to show…" |
| **Al Daayen MSDP:**<br>"*Potential impacts of climate change for the municipality include sea level rise and coastal flooding. Outside the development boundaries of Lusail and Simaisma no development will be permitted within 100 m of the coastline. Within these development boundaries developers should apply the precautionary approach to development adjacent to the coastline*". | Utilize the 1% AEP mapping to identify the VCZ and include as an overlay on existing and future Zoning maps.<br>Undertake a coastal setback study to define appropriate coastal buffer locations and sizes in Qatar (Refer to Section 3.3.1 and 6.3.1) |
| **Doha MSDP**:<br>"*Sea level rise caused by climate change is one of the main threats to the coastline of Doha Municipality as a significant amount of urban development has occurred within close proximity to the coastline.* | |
| **Al Shamal MSDP:**<br>"*Sea level rises caused by climate change is one of the main threats to the coastline of Al Shamal. Low-lying areas on the coast are potentially susceptible to coastal flooding through sea level rise. Urban developments and essential infrastructure, particularly utilities and emergency services should not be located in at risk areas.* | |
| **General statements** | |
| MSDPs should be more robust with respect to flooding, both pluvial and from sea level rise. Consideration should be given to:<br>Identification of land (VCZ) that is prone to the 1% AEP flood<br>Incorporation of buffer and setback requirements to development for coastal and flood prone areas. | |
| In order to ensure that the plans and regulations within the MSDPs are being appropriately implemented, establish a framework for monitoring and for enforcement. | |
| Ensure National Coastal Zone Management Plan (under preparation) incorporates SLR/flood management measures. | |

# Appendix C – Summary of Output from Actions and Reference to Discussion

Table C-1: Summary of Output from Actions and Reference to Discussion

| Aspect | Outputs | Section |
|---|---|---|
| Responding to Sea Level Rise and Flooding | SL1: Establish Vulnerable Coastal Zone to communicate risk and regulate development | 3.3.1 |
| | SL2: Update planning, policy and regulatory framework documents to address flood risk in vulnerable coastal areas | 3.3.2 |
| | SL3: Develop a framework to evaluate protection vs retreat options | 3.3.3 |
| | SL4: Develop a framework for the strategic retreat from vulnerable land | 3.3.4 |
| | SL5: Implement Emergency Management Measures | 3.3.5 |
| Responding to Increasing Temperatures | UH1: Improve green space in areas vulnerable to the Heat Island Effect | 4.4.1 |
| | UH2: Ameliorate the Urban Heat Island Effect | 4.4.2 |
| | UH3: Introduce shading requirements | 4.5.1 |
| | UH4: Support urban canyons and improve street orientation | 4.5.2 |
| | UH5: Develop a heat wave emergency response plan | 4.5.3 |
| Reducing Greenhouse gas Emissions | GE1: Develop and publish a GHG emissions inventory and benchmarks | 5.4.1 |
| | GE2: Create higher densities and mixed use to reduce travel demand | 5.4.2 |
| | GE3: Improve walkability | 5.4.3 |
| | GE4: Create Transit Oriented Developments | 5.4.4 |
| | GE5: Introduce parking restrictions | 5.4.5 |
| | GE6: Improve energy efficiency in new development | 5.4.6 |
| | GE7: Improve water efficiency | 5.4.7 |
| | GE8: Increase the use of recycled water in new development | 5.4.8 |
| | GE9: Improve the energy and water efficiency of retrofitted development | 5.4.9 |
| | GE10: Reduce the embodied energy of development | 5.4.10 |
| | GE11: Design for structure reuse | 5.4.11 |
| | GE12: Plan for large scale renewable energy production | 5.4.12 |
| | GE13: Increase onsite renewable energy in new development | 5.4.13 |
| Protecting Biodiversity | PB1: Introduce buffer zones to protect sensitive ecosystems | 6.3.1 |
| | PB2: Introduce environmental offsets | 6.3.2 |

# Appendix D – Qualitative Consequence Assessment of CCS Implementation

Table D-1: Qualitative Consequence Assessment of CCS Implementation

| Specific Actions | Low cost* | Medium cost* | High cost* |
|---|---|---|---|
| **SL1:** Establish Vulnerable Coastal Zone (VCZ) to communicate risk and regulate development | | | |
| **SL1-1:** Utilize the 1% AEP mapping to identify the Vulnerable Coastal Zone (VCZ) | X | | |
| **SL1-2:** Develop regulations for VCZ to prohibit new development (with certain exceptions) | X | | |
| **SL1-3:** Update the existing and future zoning maps to incorporate VCZ as an overlay | | X | |
| **SL1-4:** Continually update the 1% AEP contour as new sea level rise projections are made available with IPCC releases. | | X | |
| **SL2:** Update planning, policy and regulatory framework documents to address flood risk in vulnerable coastal areas | | | |
| **SL2-1:** Require Coastal Flood Risk Assessments | X | | |
| **SL2-2:** Adopt measures to improve flood resilience in developments and buildings | | X | |
| **SL3:** Develop a framework to evaluate protection vs retreat options | | | |
| **SL3-1:** Identify specific coastal management units within MSDPs to facilitate coastal process analysis | X | | |
| **SL3-2:** Undertake a socio economic cost : benefit assessment of structural coastal protection measures vs strategic retreat for important assets within the Coastal Risk Zone | | X | |
| **SL3-3:** Develop a compendium of coastal protection measures for vulnerable areas of the coastline to be used in the evaluation of options | | X | |
| **SL4:** Develop a framework for the strategic retreat from vulnerable land | | | |
| **SL4-1:** Update the planning regulations to specify that new infrastructure should be located outside areas of coastal risk and any future upgrade or installation of new infrastructure within areas of coastal risk should be prohibited. | X | | |
| **SL4-2:** Consider leasehold rather than freehold sale in new coastal development areas, to avoid future pressures and costs to protect private coastal land. | X | | |
| **SL4-3:** Place a notification of title on all affected landholdings, informing landholders of the status of the land being located within a vulnerable coastal area. | X | | |
| **SL4-4:** Include a mechanism to facilitate long-term strategic retreat from vulnerable coastal land in the next iteration of the QNDF, including the establishment of Coastal Foreshore Reserves. | X | | |
| **SL5:** Implement Emergency Management Measures | | | |
| **SL5-1:** Require a Flood Emergency Management Plan for each development within the high risk flood zone. | X | | |
| **SL5-2:** Require new and upgraded emergency facilities and services, development to be designed according to the Defined Flood Level (DFL). | | X | |
| **SL5-3:** Ensure new and existing facilities or services can operate at the required capacity during a Probable Maximum Flood (PMF). | | X | |
| **UH1:** Improve green space in areas vulnerable to the Heat Island Effect | | | |

| Specific Actions | Low cost* | Medium cost* | High cost* |
|---|---|---|---|
| **UH1-1:** Utilize the finalized Qatar University UHI ongoing study to determine areas subject to the heat island effect and generate a hot spot map. | X | | |
| **UH1-2:** Overlay the hot spot map over future zoning maps to identify the need for any additional publicly accessible green space. Reallocate land use (if needed) and ensure the implementation of the green space. | X | | |
| **UH1-3:** Incorporate requirements for vegetation around buildings, in parking lots and around roads and pavements. | X | | |
| **UH2:** Ameliorate the Urban Heat Island Effect | | | |
| **UH2-1:** Integrate the GSAS heat island effect calculation in the building permit application stage to determine the potential heat island effect of the proposed development. | X | | |
| **UH2-2:** Require all new developments to include applicable and cost-efficient passive cooling measures. | X | | |
| **UH2-3:** Require major building retrofits to adopt passive cooling measures to the extent that they are cost-effective. | X | | |
| **UH2-4:** Require the utilization of light colored pavements for roads and parking areas. | | X | |
| **UH3:** Introduce shading requirements | | | |
| **UH3-1.** Require shading of 60 % - 70% of hardscaped pedestrian pathways and parking areas, and 25% - 30% of hardscaped common areas. | X | | |
| **UH4:** Create urban canyons and improve street orientation | | | |
| **UH4-1.** Improve the 'urban canyons' in city centers through optimization of building heights, street widths, setbacks and site coverage | X | | |
| **UH4-2:** Orient streets to allow penetration of cool coastal breezes where feasible. | X | | |
| **UH5:** Develop a heat wave emergency response plan | | | |
| **UH5-1:** Develop an emergency response plan for cases of heat wave, which includes preparedness / preventive action, monitoring and communication, and a plan of action during the emergency | X | | |
| **GE1:** Develop and publish a GHG emissions inventory and benchmarks | | | |
| **GE1-1:** Develop a consumption-based GHG emissions inventory for the built environment based on international best practice. | | X | |
| **GE1-2:** Devise emission indicators appropriate for use in monitoring domestic GHGs and establish benchmarks. | | X | |
| **GE1-3:** Prepare and publish an annual report outlining consumption-based emissions and key metrics. | | X | |
| **GE2:** Create higher densities and mixed use to reduce travel demand | | | |
| **GE2-1:** Require compact, mixed use development in city centers and inner suburbs (excluding Qatar Housing Areas) at the densities necessary to promote public transport use | X | | |
| **GE2-2:** Require central and inner development sites to achieve a mixed use (i.e. residential and non-residential uses), with non-residential uses on the ground floor | X | | |

| Specific Actions | Low cost* | Medium cost* | High cost* |
|---|---|---|---|
| **GE2-3:** Integrate walking, cycling and public transport networks into existing mega-projects | | X | |
| **GE2-4:** Implement higher residential density targets for new development. | | X | |
| **GE2-5:** Require new development to be sequenced, such that with development further from existing urban areas is permitted only after areas nearer the existing urban areas have been developed. | X | | |
| **GE3:** Improve walkability | | | |
| **GE3-1:** Develop a street design code that stipulates walkability requirements (guided by GSAS criterion S.6 Walkability) within higher residential density centres and mixed use zones. | | X | |
| **GE3-2:** Progressively upgrade existing areas for compliance with the street design code, where possible. | | X | |
| **GE4:** Create Transit Oriented Development | | | |
| **GE4-1.** Establish mixed use zones within 480 m of the planned stations of the Doha Metro. Create a zone a further 480 m from this radius for medium density and other uses that would benefit from proximity to rail stations, including park and ride facilities. | | X | |
| **GE4-2.** Require public facilities (e.g. town/district centres, parks, schools, sports clubs) to be accessible by walking, cycling or public transport following the guidance of the GSAS criterion (UC.5 Intermodal Connectivity). | X | | |
| **GE5:** Introduce parking restrictions | | | |
| **GE5-1:** Introduce parking fee minimums to reduce parking occupancy, which in turn will minimize cruising for parking spaces | X | | |
| **GE5-2:** Require companies to provide the minimum number of parking spaces necessary for their workforce | X | | |
| **GE5-3:** Stipulate parking maximums for development in zones with good public transport. | X | | |
| **GE5-4:** Incorporate the final stipulations from the Qatar Parking Master Plan within the Zoning Regulations. | X | | |
| **GE6:** Improve energy efficiency in new development | | | |
| **GE6-1:** Mandate a minimum of GSAS Level 2 energy performance for all new development. | X | | |
| **GE7:** Improve water efficiency | | | |
| **GE7-1:** Mandate a minimum of GSAS Level 2 water performance for all new development. | X | | |
| **GE7-2:** Require major industrial and agricultural developers to prepare a water efficiency plan showing how they will minimise water use in line with world's best practice. The plans should be updated yearly within the Qatar National Water Policy (this will require the Qatar National Water Policy to be amended). | | X | |
| **GE7-3:** Require the use of certain water efficient irrigation practices and provide planning incentives (e.g. grants for water efficient systems). | | X | |
| **GE7-4:** Mandate the use of native and drought-tolerant species. | X | | |
| **GE8:** Increase the use of recycled water in new development | | | |
| **GE8-1:** Incentivize, or require new development to incorporate wastewater recycling facilities. Incentives may include the development of a market for the use of greywater / recycled wastewater, such as watering street trees or irrigation. | | X | |
| **GE9:** Improve the energy and water efficiency of retrofitted development | | | |

| Specific Actions | Low cost* | Medium cost* | High cost* |
|---|---|---|---|
| **GE9-1:** Mandate a minimum of GSAS Level 2 energy performance for retrofits of selected building types / floor area. | X | | |
| **GE10:** Reduce the embodied energy of development | | | |
| **GE10-1:** Require developers to consider retrofit/ refurbishment over new build, particularly if the existing building is relatively energy efficient. | X | | |
| **GE10-2:** Require developers of new developments and major retrofits to demonstrate how they will minimize their use of virgin materials | X | | |
| **GE10-3:** Require developers of retrofit or upgrades to previously developed sites to recycle the maximum amount of the previous building materials. | X | | |
| **GE11:** Design for structure reuse | | | |
| **GE11-1:** Require developers to produce designs that facilitate the re-purposing of the building and reuse of their components in line with the measures included in GSAS. | X | | |
| **GE12:** Plan for large scale renewable energy production | | | |
| **GE12-1:** Identify and reserve possible sites for medium to large-scale photovoltaic energy developments near HV infrastructure, and depict them on the zoning maps. | | X | |
| **GE13:** Increase onsite renewable energy in new development | | | |
| **GE13-1:** Require all new development and major retrofits of 1,000 m2 or larger to produce at least 20% of their energy needs from on-site renewable energy. Review and increase this target over time as the unit cost of solar PV installations falls. | | X | |
| **GE13-2:** Require that all roofs be capable of supporting solar PV panels. | | X | |
| **GE13-3:** Require achievement and protection of solar access for rooftop solar PV, including building and roof orientation. | | X | |
| **GE13-4:** Ensure that there are no planning or design restrictions that will prevent the installation of small-scale renewable energy systems. | X | | |
| **GE13-5:** Provide regulatory incentives for the installation of onsite renewable energy systems. | | X | |
| **PB1:** Introduce buffer zones to protect sensitive ecosystems | | | |
| **PB1-1:** Commission a study into appropriate buffer zones and a need for migration corridors for Qatar's Protected Areas and mangroves. | | X | |
| **PB1-2:** As an interim measure, prohibit development within 250 m of Protected Areas, mangroves, seagrass and coral reefs. | X | | |
| **PB1-3:** Include requirements in the MSDPs to identify and protect the buffer zones from any future development. | X | | |
| **PB1-:** Provide a minimum of 250 m width 'escape routes' from Protected Areas. Where this is not possible due to existing development, provide a continuous wildlife corridor that is as wide as possible. | | X | |
| **PB2:** Introduce environmental offsets | | | |
| **PB2-1:** Require environmental offsets for unavoidable development impacts on protected areas and biodiversity (especially on mangroves, seagrass and coral reefs). | | X | |

**Notes:**

**Low cost** = Actions that can be completed in house with the expertise available in the MME

**Medium cost** = Actions that can be completed in house in coordination with other agencies but could potentially require external resources and expertise

**High cost** = Actions that will require a specialist to be implemented and will require external resources

# Appendix E – Benchmarking Details

As detailed in Section 7.6.2, a hierarchy was followed to establish benchmarks for each level of the Climate Change Strategy Framework. Benchmarks were selected based on internationally accepted practices and guidelines. The details of the benchmarking exercise are provided in this Appendix. A summary of the benchmarking exercise is provided in Table 7-1.

## Vision Statement

| Vision | Urban development in Qatar will progressively reduce average per capita greenhouse gas emissions and be resilient to the potential impacts from climate change |
|---|---|
| Indicators | VI-1: Percentage decrease in average consumption based greenhouse gas emissions per capita per year<br>VI-2: Reduction in monetary value of property damages attributable to climate change<br>VI-3: Health and safety statistics attributable to climate change |
| Local Standard | VI-1: N/A |
| | VI-2: N/A |
| International Standards and Guidelines | VI-1: Multi-regional input-out (MRIO) analysis |
| | VI-2: The Economics of Global Climate Change (2015) |
| Best Practice / Standards from other countries | VI-1: There are sever MRIO databases and models with functionality to estimate consumption based emissions. Some of the most widely used databases are:<br>• Eora<br>• Global Trade Analysis Project (GTAP)<br>• World Input-Output Database (WIOD)<br>• Global Resource Accounting Model (GRAM) |
| | VI-2: Estimating monetary damages from flooding in the United States under a changing climate (Wobus et al. 2014). |

### Discussion:

*VI-1: Consumption based greenhouse gas emissions per capita per year*

**International Standards and Guidelines**

It is widely accepted that the multi-regional input-out (MRIO) analysis the best approach to estimating consumption-based emissions. Consumption based emissions and MRIO modelling can provide crucial insights in the drivers of carbon leakage and changes in global production more generally (Deloitte Access Economics, 2015).

There are several MRIO databases and models with functionality to estimate consumption based emissions. Some of the most widely used databases are described in the table below (Table E-1).

Table E-1: MRIO databases for consumption-based emissions accounting

| Database | Description | Coverage |
|---|---|---|
| Eora | Records the bilateral economic and emissions flows between 15,000 sectors in 189 countries (26 to 511 sectors per country). Key data sources:<br>74 IO tables from National Statistical Offices, other country data from UN National Accounts Main Aggregates Database<br>Trade data from UN Comtrade and Service trade databases<br>Emissions from Emission Database for Global Atmospheric Research (EDGAR) and IEA | 189 countries with 26-511 sectors<br>1980 to 2012<br>Updated annually with a 2 year lag |
| Global Trade Analysis Project (GTAP) | Public global data base representing the world economy with bilateral trade information, transport and protection linkages. Key data sources:<br>National IO tables submitted by GTAP members<br>Trade data from UN Comtrade UN Service trade databases<br>CO2 derived from IEA energy data | 140 countries with 57 sectors<br>2004, 2007 and 2011<br>Updated every 3 years with a 4 year lag |
| World Input Output Database (WIOD) | Public database time-series of world input-output tables for forty countries worldwide and a model for the rest-of the-world. Key data sources:<br>National IO tables based on supply and use tables from National Accounts<br>Trade data from UN Comtrade, European Commission (Eurostat) and OECD<br>Emissions from Eurostat's environmental accounts | 40 countries plus a 'rest-of-the world' region<br>1995-2011<br>Updates funding dependant (project ended in 2012) |
| Global Resource Accounting Model (GRAM) | Designed to calculate historic data on (not a forecasting model): $CO_2$ emissions and resource use by consuming country and not by producing or extracting country. Key data sources:<br>IO tables published by the OECD<br>Trade data from OECD's Bilateral Trade Database<br>CO2 and energy balances from IEA<br>Raw material data from the Sustainable Europe Research Institute (SERI) Global Material Flows Database for global resource extraction. | 53 countries and 2 'rest-of-the-world' regions with 48 sectors (trade in 25 product groups and 1 service sector)<br>1995 to 2005<br>Currently being updated to 2010 |

Source: Deloitte Access Economics. 2015

## *VI-2: VI-2: Monetary value of property damages attributable to climate change*

### International Standards and Guidelines

Climate change is an issue that embodies issues of externalities, common property resources, public goods, renewable and non renewable resources, and the discounting of costs and benefits over time. It has economic, scientific, political, and technological dimensions. Economic analysis alone cannot adequately respond to a problem of this scope, but economic theory and policy have much to offer in the search for solutions. An effective response to the climate change problem requires much more sweeping action on a global scale than anything so far achieved. Economic policy instruments that have the power to alter patterns of energy use, industrial development, and income distribution are essential to any plan for mitigating or adapting to climate change. Evidence of climate change impacts is already clear, and the issue will become more pressing as greenhouse gas accumulation continues and costs of damages and of climate adaptation rise. The Economics of Global Climate Change by Jonathan M. Harris, Brian Roach and Anne-Marie Codur summarises and identifies the key aspects of Social and Environmental Issues in Economics (Source: The Economics of Global Climate Change (2015).

### Best Practice / Standards from other countries

Wobus et al. 2014. Estimating monetary damages from flooding in the United States under a changing climate estimated the how climate change could affect monetary damages from flooding in the coterminous United-States. Publically available historical flooding and precipitation data was utilized to estimate region-specific logistic regression models of the probability that severely damaging floods will occur under baseline conditions. Future precipitation projects were driven by climate model outputs to estimate the probability that damaging floods could occur under a 'business as usual' climate change scenario.

## Objective 1:

| Objective 1. | Design new, and retrofit existing developments to be resilient against increasing sea levels and associate flooding events |
|---|---|
| **Indicators** | OI1-1: Reduction in number of incidences of flood impact on properties and infrastructure |
| **Local Standard** | OI1-1: N/A |
| **International Standards and Guidelines** | OI1-1: N/A |
| **Best Practice / Standards from other countries** | OI1-1: Urban Flood Impact Assessment: A state of the art review (Hammond et al, 2013) |

## Discussion:

*OI 1-1: No. of incidences of flood impact on properties and infrastructure*

### Best Practice / Standards from other countries

Flooding can cause major disruptions in cities, and lead to significant impacts on people, the economy and on the environment. These impacts may be exacerbated by climate and socio-economic changes. Resilience thinking has become an important way for city planners and decision makers to manage flood risks.

Despite different definitions of resilience, a consistent theme is that flood resilient cities are impacted less by extreme flood events. Therefore, flood risk professionals and planners need to understand flood impacts to build flood resilient cities. This paper presents a state-of-the-art literature review on flood impact assessment in urban areas, detailing their application, and their limitations. It describes both techniques for dealing with individual categories of impacts, as well as methodologies for integrating them. The paper also identifies future avenues for progress in improving the techniques (Hammond et. Al, 2013).

## Objective 2:

| Objective 2. | Facilitate emergency response planning at the planning and building permit stages for developments within high risk flood zones |
|---|---|
| Indicators | OI2-1: Percentage of developments within high risk zones with emergency response plans |
| Local Standard | OI2-1: N/A |
| International Standards and Guidelines | OI2-1: Disaster and Emergency Planning for Preparedness, Response, and Recovery (Alexander D, 2015) |
| Best Practice / Standards from other countries | OI2-1: Producing Emergency Plans (FEMA, 2008) |

## Discussion:

*OI 2-1: No. of incidences of flood impact on properties and infrastructure*

### International Standards and Guidelines

Emergency and disaster planning involves a coordinated, co-operative process of preparing to match urgent needs with available resources. The phases are research, writing, dissemination, testing, and updating. Hence, an emergency plan needs to be a living document that is periodically adapted to changing circumstances and that provides a guide to the protocols, procedures, and division of responsibilities in emergency response.

Emergency planning is an exploratory process that provides generic procedures for managing unforeseen impacts and should use carefully constructed scenarios to anticipate the needs that will be generated by foreseeable hazards when they strike. Plans need to be developed for specific sectors, such as education, health, industry, and commerce.

They also need to exist in a nested hierarchy that extends from the local emergency response (the most fundamental level), through the regional tiers of government, to the national and international levels. Failure to plan can be construed as negligence because it would involve failing to anticipate needs that cannot be responded to adequately by improvisation during an emergency.

Plans are needed, not only for responding to the impacts of disaster, but also to maintain business continuity while managing the crisis, and to guide recovery and reconstruction effectively. Dealing with disaster is a social process that requires public support for planning initiatives and participation by a wide variety of responders, technical experts and citizens. It needs to be sustainable in the light of challenges posed by non-renewable resource utilization, climate change, population growth, and imbalances of wealth.

Although, at its most basic level, emergency planning is little more than codified common sense, the increasing complexity of modern disasters has required substantial professionalization of the field. This is especially true in light of the increasing role in emergency response of information and communications technology. Disaster planners and coordinators are resource managers, and in the future, they will need to cope with complex and sophisticated transfers of human and material resources. In a globalizing world that is subject to accelerating physical, social, and economic change, the challenge of managing emergencies well depends on effective planning and foresight, and the ability to connect disparate elements of the emergency response into coherent strategies (Alexander D, 2015).

### Best Practice / Standards from other countries

The Producing Emergency Plans Guideline by Federal Emergency Management Agency's (FEMA) continues the more than 50-year effort to provide guidance about emergency operations planning to State, Local, Territorial, and Tribal Governments. This Guide provides emergency managers and other emergency services personnel best judgment and recommendations on how to address the entire planning process – from forming a planning team, through writing and maintaining the plan, to executing the plan. It also encourages emergency managers to follow a process that addresses all of the hazards that threaten their jurisdiction through a suite of plans connected to a single, integrated emergency operations plan (EOP). While CPG 101 is the foundation for public sector emergency planning in the

United States, emergency planners in all disciplines and organizations may find portions of this Guide useful in the development of their emergency response plans (FEMA, 2008)

## Objective 3:

| Objective 3. | Design the urban form to reduce urban heat island effects and energy demand |
|---|---|
| **Indicators** | OI3-1: Cooling energy demand per $m^2$ per year |
| **Local Standard** | OI3-1: GSAS Design Guidelines (2015) |
| **International Standards and Guidelines** | OI3-1: N/A |
| **Best Practice / Standards from other countries** | OI3-1: N/A |

## Discussion:

### *OI 3-1: Cooling energy demand per m² per year*

**Local Standards**

The GSAS Design Guidelines provide relevant sustainable strategies that could help mitigate the negative effects of the project. It contains descriptive information for consideration to help attain the specific credit for each criterion in the GSAS categories. These suggestions are in the form of recommended methods, strategies, and technologies. Projects shall consider and assess the potential advantages and benefits of the recommended design guidelines in relationship to the specific goals, requirements and conditions of the project. The manual is intended to be used as a practical resource to supplement the design assessment manual (GSAS Design Guidelines (2015).

## Objective 4:

| Objective 4. | Protect members of the population from the effects of climate change |
|---|---|
| **Indicators** | OI4-1: Percentage of population affected annually by extreme weather events |
| **Local Standard** | OI4-1: N/A |
| **International Standards and Guidelines** | OI4-1: N/A |
| **Best Practice / Standards from other countries** | OI4-1: N/A |

## Objective 5:

| Objective 5. | Monitor greenhouse gas emissions in urban development and make the information publicly available |
|---|---|
| Indicators | OI5-1: Continuous public reporting of consumption emissions (emission indicators provided in Table 5-2) |
| Local Standard | OI5-1: N/A |
| International Standards and Guidelines | OI5-1: Guide for Designing Mandatory Greenhouse Gas Reporting Programs (Singh et al, 2015) |
| Best Practice / Standards from other countries | OI5-1: Regulation EU No. 525/2013 on a mechanism for monitoring and reporting GHG emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC (EC, 2017) |

## Discussion:

### *OI 5-1: Monitoring program in place*

#### International Standards and Guidelines

Over the past decade, greenhouse gas (GHG) reporting programs have emerged at the regional, national, and subnational levels to provide information on emission sources and trends. As more jurisdictions plan to design and implement these programs, this report draws on the experience of 13 existing and proposed programs to guide policymakers and practitioners in developing GHG reporting programs. Businesses, industry associations, civil society, and funding agencies may also find this guide useful in facilitating their participation in the development of a reporting program. GHG reporting programs can be voluntary or mandatory. Unlike a voluntary program (in which participation is voluntary), a mandatory program obligates entities (companies and facilities) to report their emissions at regular intervals. This report focuses on mandatory reporting programs, but much of the information can be applied to the design of voluntary programs. Mandatory reporting programs provide credible information about GHG emissions and their sources, which can help establish a strong foundation to support mitigation policies. These programs also enable governments and industries to understand their emissions-related risks and opportunities so they can efficiently focus on mitigation activities that will produce the greatest GHG reductions. Mandatory reporting programs bring consistency and enhanced accuracy in reporting entity-level emission through rigorous calculation and quality management methods (Singh et al, 2015).

#### Best Practice / Standards from other countries

All EU countries are required to monitor their emissions under the EU's greenhouse gas monitoring mechanism, which sets the EU's own internal reporting rules on the basis of internationally agreed obligations (EC, 2017).

The reporting covers:

- emissions of 7 greenhouse gases (the greenhouse gas inventory) from all sectors: energy, industrial processes, land use, land use change & forestry (LULUCF), waste, agriculture, etc.
- projections, policies & measures to cut greenhouse emissions
- national measures to adapt to climate change.
- low-carbon strategies
- financial & technical support for developing countries, and similar commitments under the 2009 Copenhagen Accord and 2010 Cancún Agreements
- national governments' use of revenues (estimated at around €11bn in 2013) from the auctioning of allowances in the EU emissions trading system (they have committed to spend at least half of these revenues on climate measures in the EU and abroad)

## Objective 6:

| Objective 6. | Reduce travel demand and improve access to public transport in new developments |
|---|---|
| **Indicators** | OI6-1: Reduction in total km travelled per capita per year<br>OI6-1: Percentage increase in public transport services available |
| **Local Standard** | OI6-1: N/A |
| | OI6-1: N/A |
| **International Standards and Guidelines** | OI6-1: For Future Inland Transport Systems (ForFITS) User Manual (UNECE, 2017) |
| | OI6-2: N/A |
| **Best Practice / Standards from other countries** | OI6-1: N/A |
| | OI6-2: Guidelines for Planning for public transport in developments (TIHT, 1999) |

## Discussion:

**International Standards and Guidelines**

ForFITS was developed as a software tool capable to satisfy two sets of key requirements:

- the estimation/assessment of emissions in transport
- the evaluation of transport policies for CO2 emission mitigation.

To achieve these targets, ForFITS evaluates transport activity (expressed in terms of passenger kilometres – pkm, tome kilometres –tkm, and vehicle kilometres – vkm), related vehicle stocks, energy use and CO2 emissions in a range of possible policy contexts.

ForFITS is suitable for the analysis of transport systems having a regional, national and/or local dimension, with a primary focus on national systems.

ForFITS is a sectoral model, covering both passenger and freight transport services on all transport modes (including aviation and maritime transport), but mainly targeting inland transport (especially road, rail, and inland waterways). Pipelines are also considered in the model. Each mode is further characterised in sub-modes (when relevant) and vehicle classes.

Vehicle classes are further split to take into account of different powertrain technologies and age classes. Finally, powertrains are coupled with fuel blends that are consistent with the technology requirements.

ForFITS does not provide information on the evaluation of the overall effects of changes in the transport system on the economic growth (UNECE, 2017).

**Best Practice / Standards from other countries**

Land use planning has a key role in delivering the Governments integrated transport strategy. By shaping the pattern of development and influencing the location, scale, density, design and mix of land uses, planning can help to reduce the need to travel, reduce the length of journeys and make it safer and easier for people to access jobs, shopping, leisure facilities and services by public transport, walking, and cycling. Consistent application of these planning policies will help to reduce some of the need for car journeys (by reducing the physical separation of key land uses) and enable people to make sustainable transport choices. These policies are therefore part of the Governments overall approach to addressing the needs of motorists, other road and public transport users, and business by reducing congestion and pollution and achieving better access to development and facilities. They will also help to promote sustainable distribution. In this way, planning policies can increase the effectiveness of other transport policies and help maximise the contribution of transport to improving our quality of life (Planning Policy Guidance 13: Transport, 2006).

**Additional Details:**

Estimates of vehicle kilometres travelled (VKT) are used extensively in transport planning for allocating resources, estimating vehicle emissions, computing energy consumption, assessing traffic impact and road safety policy.

VKT estimation methods can be classified into two broad categories —traffic measurement methods and non–traffic measurement methods (Kumapley and Fricker 1996). The traffic measurement VKT estimation methods are more preferable than the non–traffic measurement methods, because the former methods are based on actual data for vehicle movement (EPA 1992). Under these two broad categories, there are four basic methods. Traffic measurement methods are of two types, e.g. odometer readings (vehicle-based method) and traffic counts (road-based method), while non–traffic measurement methods consist of household/driver survey method and fuel sales method (Leduc 2008; Azevado and Cardoso 2009)

The total km travelled per capita per year would be recorded or estimated in some form by the MoTC as part of the transportation planning for the country. The data every year would be compared with the baseline to evaluate reduction.

## Objective 7:

| Objective 7. | Incorporate green building measures to improve the energy and water efficiency of homes and businesses |
|---|---|
| **Indicators** | OI7-1: Percentage of new development to be GSAS certified |
| **Local Standard** | OI7-1: GSAS Design Guidelines (2015) |
| **International Standards and Guidelines** | OI7-1: N/A |
| **Best Practice / Standards from other countries** | OI7-1: Estidamaa (The Pearl Rating System – Abu Dhabi, UAE). |

## Discussion:

### Local Standards

The GSAS Design Guidelines provide relevant sustainable strategies that could help mitigate the negative effects of the project. It contains descriptive information for consideration to help attain the specific credit for each criterion in the GSAS categories. These suggestions are in the form of recommended methods, strategies, and technologies. Projects shall consider and assess the potential advantages and benefits of the recommended design guidelines in relationship to the specific goals, requirements and conditions of the project. The manual is intended to be used as a practical resource to supplement the design assessment manual (GSAS Design Guidelines (2015)).

### Best Practice / Standards from other countries

The Pearl Rating System has been introduced to address the need for a regionally relevant system to drive sustainable development that is economically, environmentally, culturally and socially relevant and to align with other important Government initiatives in Abu Dhabi Emirate. All relevant new projects must achieve a minimum 1 Pearl rating to receive approval from the planning and permitting authorities. Government-funded projects must achieve a minimum 2 Pearl rating (UPC, 2017).

## Objective 8:

| Objective 8. | Facilitate the optimal siting of solar energy installations through land use planning and integrate small scale solar energy generation into all new development and major retrofits |
|---|---|
| **Indicators** | OI8-1: Percentage increase in solar generation capacity in new development/major retrofits |
| **Local Standard** | OI8-1: N/A |
| **International Standards and Guidelines** | OI8-1: N/A |
| **Best Practice / Standards from other countries** | OI8-1: Planning guidance for the development of large scale ground mounted solar PV systems (Bre, 2017) |

## Discussion:

**Best Practice / Standards from other countries**

This national guidance provides best practice planning guidance in respect of how large ground mounted arrays are developed setting out planning considerations and requirements (Bre, 2017).

## Objective 9:

| Objective 9. | Retain and protect sensitive ecosystems that sequester carbon |
|---|---|
| **Indicators** | OI9-1: No. and area of protection zones for sensitive ecosystems |
| **Local Standard** | OI9-1: N/A |
| **International Standards and Guidelines** | OI9-1: N/A |
| **Best Practice / Standards from other countries** | OI9-1: Guidelines for the selection of protected ecological areas (Beechey, 1989) |

## Discussion:

**Best Practice / Standards from other countries**

Guidelines for the selection of protected ecological areas provides guidelines for the selection of protected ecological areas developed by the Canadian Council on Ecological Areas (CCEA). Concepts and ideas dealing with the selection and evaluation of protected ecological areas is a dynamic field of

conservation biology that Council intends to review from time to time. In the interim, the guidelines should continue to provide a relevant focus to create a comprehensive network of protected ecological areas (Beechey, 1989).

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Ministry of Municipality
and Environment

# Climate Change Strategy for Urban Planning and Urban Development Sector in the State of Qatar

## Strategy Report