Da Nang City Climate Action Plan

A conceptual framework for sectoral climate actions

Sustainable Future Pathway Travel Guide

Ministry of the Environment

Prepared by:

Miho Kamei[1], Anh-Tuan Nguyen[2], Louise Guibrunet[3], Marinella Davide[4], Pamela Fennell[5], Peter Jones[5], Le Hoang Son[2], Alejandro Rivero[6], Lili Boenigk[7], Laureline M. Josset[7], Perrine Hamel[8], Kathryn Davies[9], Thi-Ha-Thanh Mac[2], Nguyen Dang Mau[10], Dam Viet Bac[10]

[1] Institute for Global Environmental Strategies (IGES)

[2] The University of Da Nang, University of Science and Technology

[3] National Autonomous University of Mexico (UNAM)

[4] Euro-Mediterranean Center on Climate Change (CMCC)

[5] University College London (UCL)

[6] Rosario Castellanos University

[7] Columbia University

[8] Nanyang Technological University (NTU)

[9] Tufts University

In collaboration with:

Da Nang City, Department of Natural Resources and Environment (DONRE)

[10] Vietnam Institute of Meteorology, Hydrogy, and Climate Change (IMHEN)

Supported by :

Ministry of the Environment, Japan (MOEJ)

Da Nang City Climate Action Plan, 2nd Edition, Published by IGES in 2023.

Recommended citation:

Kamei, M., Nguyen, A.T., Guibrunet, L., Davide, M., Fennell, P., Jones, P., Hoang Son, L., Rivero-Villar, A., Boenigk, L., Josset, L., Hamel, P., Davies, K., Mac, T.H.T., Nguyen Dang, M., and Dam Viet, B (2023) Da Nang City Climate Action Plan - A conceptual framework for sectoral climate actions. IGES. Hayama

Photo credits: Da Nang city & The University of Da Nang
All graphics were created by Miho Kamei (IGES) (including the front page)

Da Nang City
Climate Action Plan

A conceptual framework for sectoral climate actions

Foreword

Da Nang City has become the fastest growing city in Vietnam in recent years with a projected increase in urban area and population in line with rapid economic growth. In the face of climate change, one of the greatest challenges humanity has ever faced, the government of Vietnam announced its commitment to net zero emissions by 2050 at COP26 to meet the target set by the Paris Agreement in 2015. In line with this national vision and the recently approved Da Nang City 10-Year Environmental Plan, it is increasingly important to formulate Local Climate Change Action Plans (LCCAP) with concrete reduction targets in major sectors in Da Nang City. As Da Nang is currently in a significant urban and economic transition phase, long-term visions for sustainability and carbon neutrality should be integrated into an actual development plan. The national government established its National Determined Contribution (NDC) in 2015, and this was revised in 2022 (Viet Nam NDC, 2022). Vietnam's NDC contains key mitigation and adaptation strategies and targets. Thus, Da Nang's future environmental perspective is in line with adaptation concerns, while further concrete targets for mitigation must be set in each sector and strategies developed for contributing to the national NDC targets and National Climate Change Strategies to 2050. Moreover, as Da Nang is a growing economy with a rapidly increasing population, decisions made now will have a strong influence on the future direction in basic infrastructure, local economy, and well-being. The comprehensive LCCAP is part of the fundamental climate change strategy incorporating mitigation and adaptation measures and strategies aiming to support knowledge and actions by key stakeholders for tackling local climate concerns.

This report outlines the conceptual fremawork of Da Nang's sectoral climate actions. This conceptual framework of climate action for Da Nang City mainly focuses on mitigation and adaptation measures. Local resilience and living quality measures are further components which can also achieve socioeconomic sustainability beyond the climate mitigation targets. These are interlinked with SDGs targets such as reducing poverty and social inequality, as well as increasing health and well-being. This climate action plan aims to be oriented towards the local context, and interlinked with urban development master plans. Da Nang's sectoral climate action plan aims to communicate with local residents including young students and children who will be in charge of future socio-economic development in the next decades. Therefore, this sectoral climate action plan sets out fundamental thinking and approaches in each sector so that each citizen can take action. Feedback from Da Nang's residents and visitors would be greatly appreciated to improve the contents and suggest further real actions which can be practically implemented. Finally, this climate action plan hopes that all citizens can gain basic knowledge about the dangers facing our planet due to the threat of climate change and then understand what is urgently needed, and what we ourselves can do today.

Contents

1. Da Nang Climate Change: Long-term Strategies and Motivation

Da Nang City has become the fastest growing city in Vietnam in recent years. Da Nang is one of the five central jurisdictions, and is also the socio-economic center of Vietnam. Situated on the central coast of Vietnam, Da Nang has developed tourist attractions such as beach resorts, and its international airport also functions as a gateway to world heritage sites.

Da Nang currently has a population of 1.1 million and is home to about 270,000 households. About 88% of the population lives in urban areas, and the remaining 12% lives in rural areas. The population density is about 900 people/km^2. Many citizens live in residential areas comprised of two to five storey buildings. The population density in the suburbs (rural areas) is about 180 people/km^2. In Da Nang, the formulation of a master plan for the medium-to-long term (2025 to 2045) is currently underway in parallel with the 10-year environmental plan.

It is increasingly important to formulate a Local Climate Change Action Plan (LCCAP) with concrete reduction targets for major sectors in Da Nang in line with the recently approved Da Nang City 10-Year Environmental Plan. As Da Nang is currently in a significant urban and economic transition phase, long-term visions for sustainability and carbon neutrality should be integrated into the actual development plan.

The national government of Vietnam established its National Determined Contribution (NDC) in 2015, and this was revised in 2020 and 2022 (Vietnam NDC, 2020, 2022). Vietnam's NDC contains key mitigation and adaptation strategies and targets, with a BAU (Business As Usual) scenario forecasting up to 2030 based on actual values in 2014. According to this forecast, there will be significant increases in the energy sector, and these are expected to more than triple compared to 2014. Based on this BAU forecast, the NDCs set a target of reducing GHGs by a total of 15.8% compared to BAU by 2030. It also aims for a 43.5% reduction with international support (Vietnam NDC, 2022)

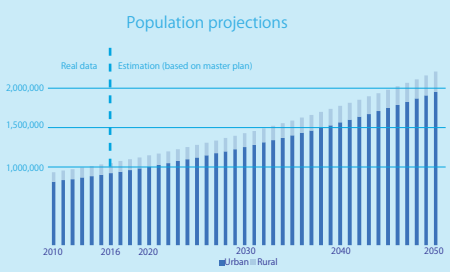
Vietnam announced ambitious national targets towards net zero emissions at COP26 in 2021 in Glasgow, and to achieve these, comprehensive action packages for both mitigation and adaptation are significantly important specifically for cities such as Da Nang, which have seen recent growth and development. While the introduction of efficient technology and renewable energy is very promising, region-specific measures for adapting to rising sea levels and an increase in natural disasters is also a pressing issue. In particular, there is concern that the impacts of climate change may cause enormous damage to agricultural production and increase local risks to human security.

Da Nang's Sustainable Future Long-term Visions

Socioeconomic features

- Population is projected as constantly increasing by 2050 associated with the growth in both urban and rural. (BAU)

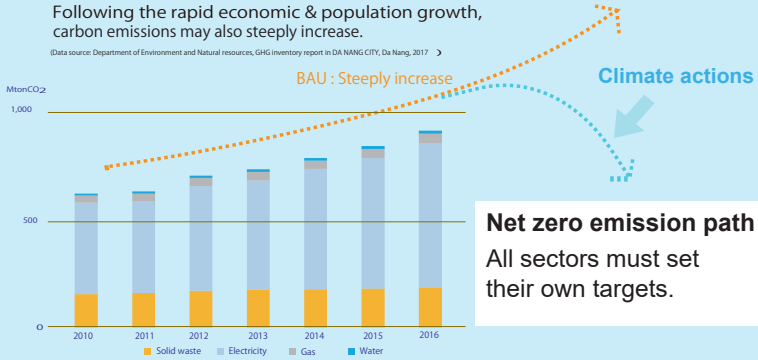
(Data source: Adjustment of the Da Nang City Master Plan to 2030, with a vision to 2045, 2020)



Carbon emissions (Graph shows carbon emissions from households)

Following the rapid economic & population growth, carbon emissions may also steeply increase.

(Data source: Department of Environment and Natural resources, GHG inventory report in DA NANG CITY, Da Nang, 2017)

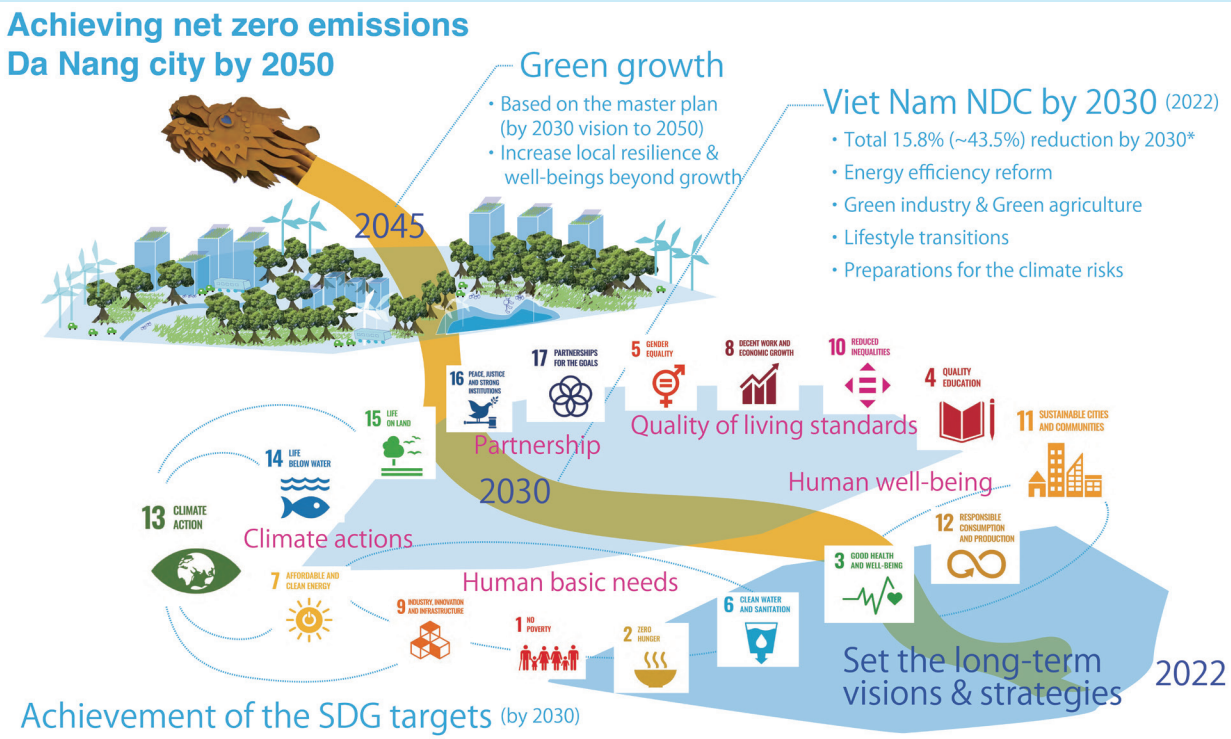


Net zero emission path

All sectors must set their own targets.

Da Nang's future environmental perspective has been incorporated into adaptation concerns (Da Nang City, 2021), while further concrete targets should be set for mitigation in each sector. Strategies are required so as to fully contribute to national NDC targets as well as National Climate Change Strategies to 2050. Moreover, as Da Nang is a growing economy with a rapidly increasing population, decisions made now will have a strong influence on the future direction in basic infrastructure, local economy, and well-being. The comprehensive local climate action plan comprises a set of fundamental climate change strategies, including mitigation and adaptation measures and strategies aiming to support knowledge-sharing and actual actions by key stakeholders to tackle local climate concerns. This climate action plan for Da Nang City focuses on sectoral mitigation and adaptation measures and aims to set concrete targets and action plans specifically for the key sectors. However, as these plans include long-term sustainable development strategies for Da Nang, all related sectors will also be integrated as key components of the overall climate action plan in the future. The achievement of SDGs targets is also an important policy target to increase overall quality living standards while maintaining the security of human basic needs and tackling social equity issues.

Achieving net zero emissions Da Nang city by 2050



* Viet Nam NDC (2022) states that Vietnam will reduce its total GHG emissions by 15.8% compared to the BAU scenario which is base year in 2014. The total contribution 15.8% can be increased by up to 43.5% compared to the BAU with international support. The implementation of NDC is in line with net zero target indicated in the National Climate Change Strategies to 2050.

2. Current Risks

Current risks facing Da Nang include sea level rise and more frequent flooding due to an increase in rainfall in recent years. Climate change has obvious impacts in Vietnam in the form of more natural disasters which cause serious damage to local residents and their economy.

1. Da Nang's status under the risks of climate change

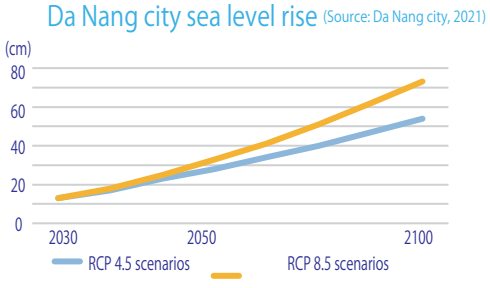
Vietnam has been heavily affected by the impacts of climate change. It is projected that the annual average temperature may increase by 1.9 – 4.0 C by the end of the 21st century according to the climate scenario. Sea levels may also rise by around 53 – 75 cm, in addition to an increase in rainfall by 5-20% (Ministry of Natural Resources and Environment, 2016). Over the past few years, due to the impact of climate change, the frequency and intensity of natural disasters has increased, causing much loss and damage to people and assets, as well as to the economic, cultural, and social infrastructure.

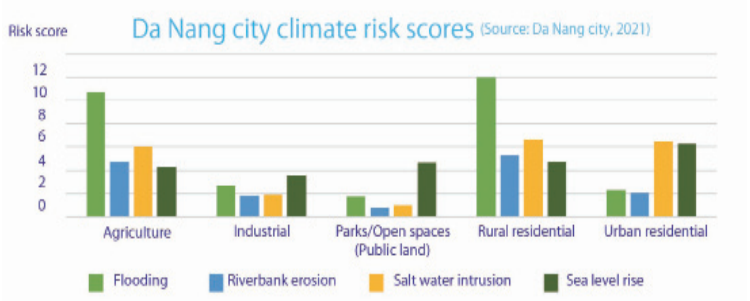
Da Nang City has also been impacted by the rise in sea levels. In recent years, coastal erosion in Da Nang has become more serious. There is a more frequent threat of sea level rise to residential areas and infrastructure along the coast. Additionally, with its location downstream of the Vu Gia - Thu Bon river, Da Nang is particularly vulnerable to the effects of storms and floods in the context of climate change.

The topography of the city incorporates both coastal plain and mountainous areas. High and steep mountainous regions are concentrated in the west and northwest. There are many mountain ranges stretching to the sea, and a number of low hills interspersed with narrow coastal plains.
There are many agricultural, industrial, service, military, residential land and functional areas in the city. Near the Han River and Cu De River, the topography of the seabed is complicated and creates a number of shallow beaches (riverbeds). The offshore estuary area is generally inclined to the northeast. The distance of isometric lines is quite regular.

In recent years, floods have increased and are more difficult to predict, becoming a growing concern for local residents. The water flows rapidly and deepens, and it takes a long time to recede after a flood, as was the case in the historic flood in December 2018 in Da Nang due to heavy rains. In addition to natural disasters, there is growing pressure on the urban water supply. Drought, saline intrusion in rivers, and river water exploitation cause pressure on socio-economic areas such as tourism development, environmental sanitation, and disease outbreaks.

(All contents from 'Action Plan on response to climate change of Da Nang City', 2022)





(Both figures from 'Action Plan on response to climate change of Da Nang City', 2022)

2. Major natural disasters in recent times in the city

According to statistics, the types of natural disasters that are likely to have a direct impact on and affect Da Nang City are floods, inundation, flash floods, landslides, land subsidence due to rain or flood currents, storms, and pressures, tropical depression, strong winds at sea, rising water, drought, heat, saltwater intrusion, landslides, riverbank and coastal erosion, heavy rain, natural forest fires, cyclones, lightning, and hail. At present, the city is also at risk due to many other dangerous types of natural disasters such as heavy rain, landslides, and urban flooding. Out of these, the greatest damage is still caused by: storms, floods, inundation, urban inundation, flash floods, landslides, droughts and forest fires.

3. Damage caused by natural disasters in recent years and main natural disaster risks

a) Summary of damage caused by natural disasters

According to statistics from 1998 until now, the city has been affected by 39 storms, 16 tropical depressions and 57 floods, killing 219 people, injuring 226 people, sinking 175 boats, and damaging infrastructure. Agriculture and infrastructure were severely damaged. Total damage was estimated at more than 10,000 billion VND. In particular, there were floods in 1998, 1999, 2007, 2009, and several storms, including the storm No. 6 in 2006 (Hurricane Xangsane), the storm No. 9 in 2009 (Hurricane Ketsana) and the storm No. 11 (Nari) in 2013 made direct landfall on the city, causing heavy damage to people and property of the State and People.

b) Major natural disaster risks of Da Nang city

Looking at the history of natural disasters and damage, natural disasters can cause risks of death and injury, damage, collapse of houses, roof collapse of houses, landslides of riverbanks, coastlines, dike systems, and embankments. damage to canals, damage to irrigation works, damage to industrial parks, damage to transportation systems, power grids, infrastructure, offices, damage and disruption to tourism industry activities, damage to agricultural production, urban greenery, as well as causing environmental pollution after natural disasters.

4. Areas at risk of being affected by natural disasters

Based on topographical characteristics, natural disaster characteristics and damage caused by natural disasters, it is possible to analyze and identify areas frequently affected by each type of natural disaster in the city to administrative level.

a) Areas affected by storms, tropical depressions and strong winds at sea:

Storms and tropical depressions in Da Nang usually occur in the period from May to December, mainly in October and November. Storms and tropical depressions are often accompanied by heavy rain. Therefore, in addition to strong winds, the mainland is also affected by floods and inundation. Affected areas include:

- The entire East Sea region including Hoang Sa island district and coastal areas are affected by three main types of natural disasters, namely storms and tropical depressions; strong wind at sea;
- The mainland and island area includes eight districts, namely Hai Chau, Thanh Khe, Lien Chieu, Cam Le, Son Tra, Ngu Hanh Son, Hoa Vang and Hoang Sa island district with 56 communes and wards. The extent of the impact varies from region to region and gradually decreases further away from the coast.

b) Areas affected by floods and inundation:

From September to December every year is the rainy season in Da Nang, and heavy rain is concentrated from October to December. There are three types of weather that cause floods in the city, which are:

- When there is a storm, a tropical depression makes landfall or directly affects such as moving along the coast, or making landfall in the north of Quang Nam province, in the south of Thua Thien Hue province. There are often heavy rains before and after storms and tropical depressions.
- When there is a strong northeast monsoon, it is combined with the circulation of storms and tropical depressions. This is a weather pattern that tends to cause heavy rain and major floods on the mainland.
- When the tropical convergence band is active in the south of the East Sea, and at the same time in the north, there is a monsoon or northeast wind that is active and moves to the south. This weather pattern often causes heavy rain, lasting for many days.

c) Areas affected by heavy rain and local flooding:
The whole city, in particular:
- Riverine areas in districts: Cam Le, Ngu Hanh Son, Lien Chieu and Hoa Vang districts flooded residential areas along the river and low-lying areas.
- Urban centers of districts: flooding low-lying and low-lying areas, areas where urban drainage systems have not yet been ensured. Through aggregated data, the city currently has 10 points of frequent flooding and about 20 points of local flooding during intense rain.

d) Areas affected by flash floods, landslides and rocks:
Areas affected by landslides and rocks: The mountainous areas to the west and northwest of the city have complex geomorphology and geology, and mountain slopes are quite steep. When heavy rain occurs for many days, human impacts such as slapping mountains, paving roads, cutting forests, exploiting minerals, cause landslides of hills and slopes in many places. mainly in Hoa Vang district, Lien Chieu district and Son Tra district, including seven communes and wards.

e) Areas affected by riverside landslides:
15 communes and wards with 1,680 households located along Yen River, Cu De River, Tuy Loan River, Qua Giang River, Cau Do River, Vinh Dien River.

f) Areas affected by tsunami and sea level rise:
The entire sea area, Hoang Sa island district and coastal districts: Hai Chau, Son Tra, Ngu Hanh Son, Thanh Khe and Lien Chieu with a total estimated area of 25.56 km^2 , population about 184,000 people.

g) Area affected by drought:
The whole area of Hoa Vang district, Hoa Quy ward, Ngu Hanh Son district, Hoa Tho Tay ward, Cam Le district. The agricultural land area is the most affected.

h) Areas affected by heat, saltwater intrusion:
Saltwater intrusion in rivers: Cau Do, Cu De, Vinh Dien causes a lack of water supply for daily life, production and hot weather affects the whole city.

i) Areas affected by natural forest fires:
Mainly the localities of Hoa Vang, Lien Chieu and Son Tra districts: Hoa Vang district: Hoa Bac, Hoa Phu, Hoa Son, Hoa Ninh communes, Hoa Lien, Hoa Khuong, Hoa Phong, Hoa Nhon; Lien Chieu district: Hoa Hiep Bac ward and Son Tra district: Tho Quang ward.

j) Area affected by cyclones and lightning:
The whole city, mainly Hoa Vang and Lien Chieu districts.

(Source: Vietnam Institute of Meteorology, Hydrology, and Climate Change, 2023)

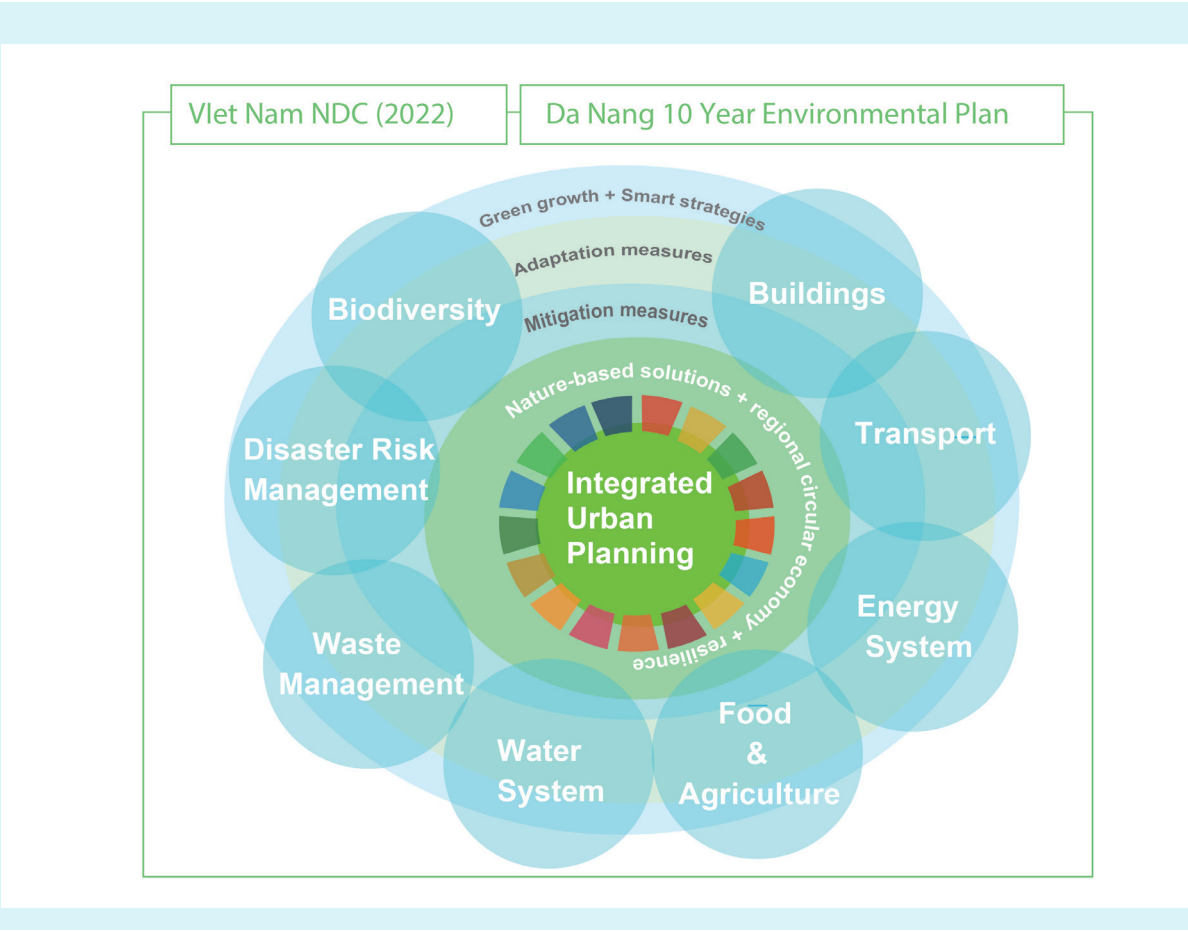
3. Climate Action Plan

Framework and Key Sectors

To realize long-term sustainable visions in Da Nang City, the climate action plan should be interlinked with comprehensive socio-economic key elements. The city's climate action plan consists of mitigation and adaptation strategies, and resilience & living quality indicators.

This report outlines the first conceptual framework of the action plan covering five key sectors: Buildings, Transport, Energy System, Food & Agriculture, Water System, Waste Management, Integrated Urban Planning and SDGs Interactions. Overall key elements, however, include natural ecosystems, and disaster management. These elements play key roles in actions for climate mitigation and adaptation. Specifically, physical infrastructure and basic human needs, energy systems, food & agriculture, and water management are strongly interconnected with local resilience. Buildings, transport and the natural environment are also interlinked with living quality within the framework. All sectors contribute to both mitigation & adaptation measures, while the framework identifies stronger links with each measure.These key indicators should be reflected into the local integrated master plan to be put into place in society. This report firstly focuses on two key sectors: buildings and transport. These sectors have great potential to significantly reduce carbon emissions by 2050. In addition, the energy sector also makes up a large proportion of the city's GHG emissions.

However due to the complexity and lack of inventory data, these sectors are briefly described as having the potential to achieve the carbon neutral society in the long-term as a first step. The food & agriculture sector and the water system generate fewer carbon emissions, but from a sustainable and resilience perspective, these sectors should develop long-term visions and investigate the potential changes to achieve a sustainable society. This local climate action framework has been developed in line with Vietnam's Nationally Determined Contribution (NDC) that was submitted in 2015 and revised in 2020 and 2022 (Viet Nam NDC, 2022), and with reference to the Da Nang City 10-Year Environmental Plan (2021). The report also analyzes SDGs interactions and the impacts of the recent COVID-19 pandemic, by reviewing the city's policy documents and current ongoing projects. Achieving the overall SDGs targets is significantly important for Da Nang and this should be integrated into its current development master plans.



3.1 Buildings

Principles of Climate Action for Buildings

In 2016, the building sector in Da Nang emitted about 1.225 million tons of CO2 equivalent, and this amount is projected to increase 5.0-6.4% annually. Reducing carbon emissions from the building sector is key to Da Nang City meeting its net zero target by 2050. The five principles for action on buildings are set out below.

The implementation of policy strategies is always linked to the laws, regulations and standards that are encouraged as well as mandatory. Therefore, climate actions in the building sector must be motivated by “net zero” emission standards and codes that are guided by what science demands and are consistent across jurisdictions.

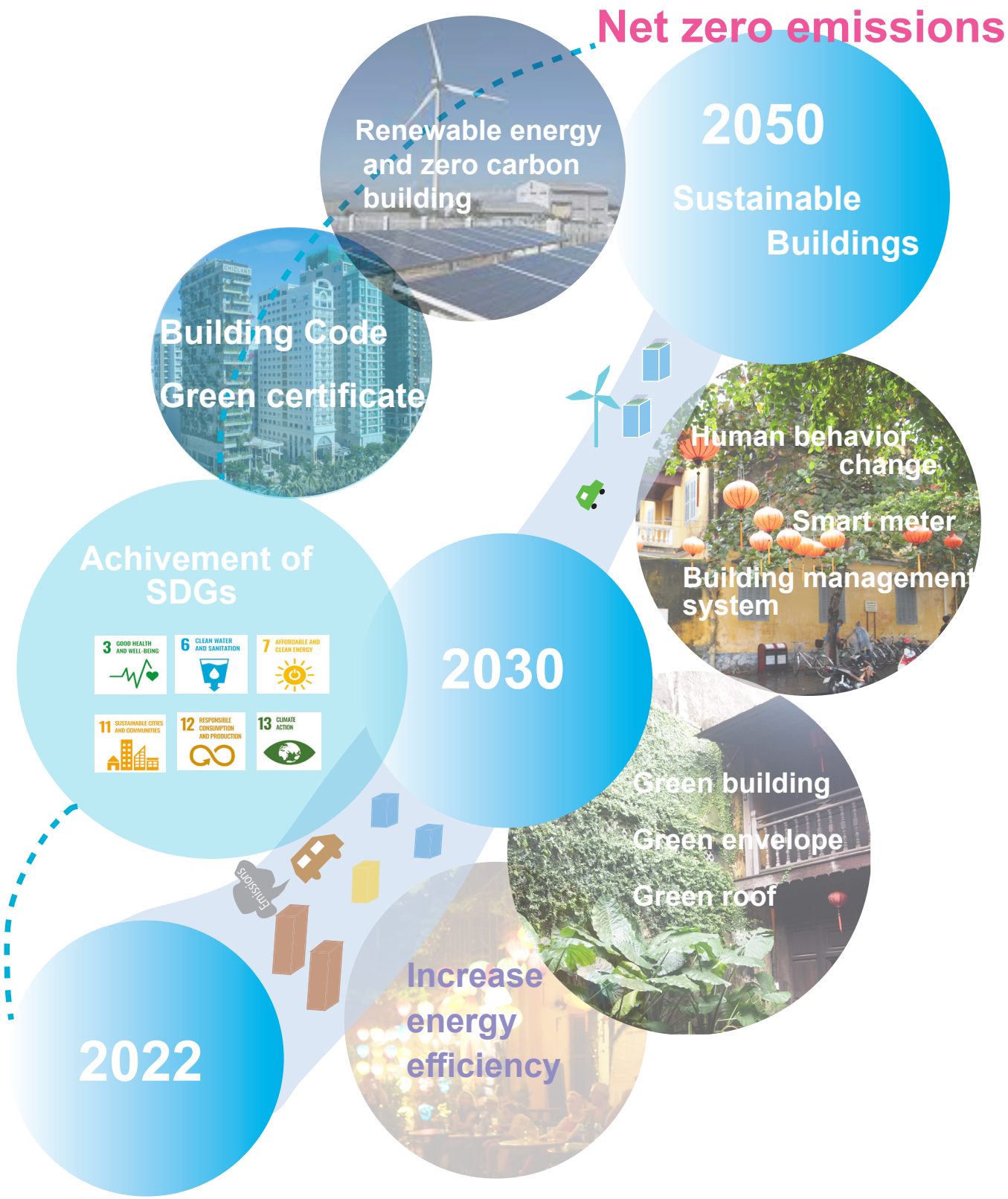
Around two-thirds of the existing buildings will still exist in 2040 and they continue to emit carbon. Therefore, achieving the zero emissions target will require efficient energy upgrades of the existing building stock (increasing energy efficiency, eliminating on-site fossil fuels, and generating and/or procuring 100% renewable energy).

The residential sector accounts for 73.7% of building energy consumption. Therefore, highly effective carbon reduction actions should be focused on this area.

Building emissions policies should be designed to allow a flexible mix of energy efficiency, renewable energy, and electrification, with the goal of enabling every building owner to pursue the solution that most effectively reduces emissions in their building or portfolio.

The process of reducing emissions needs to be linked to a revolution in information-sharing via different information avenues, through which real estate users can share and receive informational net-zero materials, such as case studies, local resources, and other updates.

Pathway to Achieve Sustainable Buildings



3.1.1 Mitigation Measures

Action 1: Reduce total energy use in existing buildings and new energy-efficient buildings

Da Nang's residential sector consumes a high proportion of energy in the building sector. Energy efficiency is recognized as a new economic opportunity as well as a resource efficiency measure to meet the sustainability and climate goals. While building technologies progressed to improve our quality of living, energy demand has steeply increased in cities. Better energy efficiency is one of the priority issues for accelerating climate action. However, enhanced indoor air quality and comfortable space for users are more recent, advanced measures that can be applied to the sustainable building concept. (Houston, 2020). By retrofitting existing building stock or establishing new guidelines for renovations, this goal can be achieved.

Action 2: Reduce climate change impact on buildings by adaptive envelope design measures

Under climate change conditions, buildings are expected to increase energy consumption for cooling to ensure biological comfort inside the buildings. Accordingly, this will increase greenhouse gas emissions, and as a result, the greenhouse effect causing global warming will be even more serious. Studies show that the increase in building energy consumption under the long-term RCP 4.5 climate change scenario will be between 6% and 12%. Meanwhile, the increase corresponding to the long-term RCP 8.5 climate change scenario will be between 12.6% and 22%. Restaurants and hotels are the types of commercial facilities with the most significant increase in emissions, while supermarkets, factories and office buildings have a lower and fairly uniform increase.

Action 3: Establish city energy regulations and benchmarks

Energy codes and regulations can set benchmarks for efficient energy use in new buildings and renovations. These regulations can demonstrate the performance criteria for design, construction, and building components that must be met by energy efficiency measures. Updated national building energy codes QCVN09:2017 (from 2013 to 2017) have increased potential energy savings from 10% to 25% for building occupants. Studies in the US show for each dollar spent on energy code enforcement, there is return on investment from energy savings. In order to achieve these savings, local-oriented benchmarks and regulations have to be established to adapt to the specific culture and climate conditions (Houston, 2020).

Action 4: Reduce energy consumption in the residential sector

The residential sector is a crucial energy consumer in Da Nang, accounting for 73.7% of building energy consumption. There is a huge number of residential buildings in the city and they are managed by the inhabitants of the city. Therefore, solutions in this area need to involve individual residents as they are the ones that will be impacted. The following key measures should be considered:

- Encouraging use of natural ventilation all year. Scientists pointed out that the climate of Da Nang is naturally comfortable for 36.6% of the year, and this can be extended to 58.7% with natural ventilation (Nguyen & Reiter, 2014).
- Building smart meters for households: Consumers will be offered an In-Home Display (IHD) that will provide real time information on their energy use, both in terms of consumption and cost as well as other useful information. Smart meters can result in a reduction of household electricity consumption of between 1.1% and 2.7%. The corresponding reduction in gas consumption can be between 2.2% and 2.8% (Dromacque, et al., 2013).
- New housing should meet the energy efficiency standard and older dwellings should be retrofitted for better energy efficiency (see above-mentioned Action 1).
- Recommendations for choosing energy efficient home appliances: home appliances account for 20% of a household's total electric bill. This can be reduced by 10-50% by using energy efficient appliances (Energysage, 2021). Equipment that has a 4- to 5-star rating according to the energy label established by the Ministry of Industry and Trade should obtain a priority policy in the residential sector.

Action 5: Install on-site renewable production systems (Rooftop PV and solar hot water systems)

The global solar energy market was valued at USD 52.5 billion in 2018 and is projected to reach USD 223.3 billion by 2026, growing at a Compound Annual Growth Rate (CAGR) of 20.5% from 2019 to 2026 (Solar energy market outlook, 2021). Residential solar PV market size is expected to expand. Rooftop PV systems and solar hot water systems may become cheaper due to the rapid increase of users. Based on an estimation from this study (Solar energy market outlook, 2021), around 50% of households and buildings in Da Nang are likely to have installed small rooftop PV systems by 2050, Da Nang could save 3 million tons of CO_2 equivalent by 2050. It is estimated that rooftop solar and power systems may contribute to more than half of Da Nang's total GHG reduction by 2050. Thus, installing on-site renewable energy will play a significant key role in decarbonization measures for Da Nang.

3.1.2 Adaptation Measures

Action 1: Train a workforce that is able to design, build, and operate buildings efficiently

Capacity development for building engineers, architects, and construction engineers is urgently needed to adapt to rapidly increasing climate risks. Flooding, for instance, may increase the risk of damage to machine operation systems which should be moved to higher floors (City of New York, 2013). Potential training opportunities should be provided to the relevant stakeholders in areas such as energy efficiency, building repair & maintenance, and high-performance building construction & design. Further training should cover a benchmarking system, building management system and renewable energy system (Houston, 2020).

Action 2: Invest in stormwater projects in buildings over the span of 20 years

Rainfall in Da Nang is expected to increase due to climate change. Experts have long warned that climate change will affect the intensity and frequency of precipitation. Warmer oceans increase the amount of water that evaporates into the air. These cycles increase the amount of annual rain specifically in coastal areas. However, these phenomena can also increase the opportunity to collect fresh rainwater (USGCRP, 2017). Stormwater harvesting measures can also contribute to multiple objectives, such as reducing contaminated runoff to sensitive waters, promoting groundwater recharge, and non-potable applications such as toilet flushing and irrigation. Stormwater harvesting has been tested in Da Nang to address rising water demands as the population rises and to alleviate freshwater scarcity which has occured frequently in recent years. (McArdle, P; et al., 2011)

Action 3: Implement green building measures to reduce heat island effect and urban temperature

As the annual mean air temperature of a city with one million people or more can be 1.0 – 3.0 °C warmer than its surroundings, under climate change conditions, this difference can be even higher (US EPA, 2017). Green roofs and facades reduce the heat storage capacity of urban surfaces and reduce air temperature, through increased evapotranspiration and shading. Photovoltaic panels (which provide shading for rooftops), increased building heights and outdoor water spraying were also assessed as effective ways of reducing surface temperatures. Increase of green spaces and green roads can provide comfortable shade for all local residents and mitigate the urban heat. Such land use management with nature-based solutions can also increase the local amenity space and improve human health.

Action 4: Adapt well to climate change effect by providing an Urban Adaptation Support Tool

It is necessary to develop a tool to assist cities, towns and other local authorities in developing, implementing and monitoring climate change adaptation plans (for instance, adaptation tool in EU). Such a tool can provide practical guidance and knowledge for stakeholders in Da Nang decision-makers of the city's planning authorities, and practitioners. It would also facilitate easy access to in-depth, expert knowledge and necessary updated data. Such adaptation tools should be established by the public authority with the transparency and reliability that can be maintained by citizen's direct feedback and scientific data.

3.1.3 Synergies with Other Actions and Resilience of Sustainable Buildings

Land use mix and access to public network & green spaces

Sustainable buildings should be connected with effective public transport services within a 5 to15 minutes' walk. Furthermore, public open space is an important factor as a public amenity for all residents and visitors, as well as a way of maintaining local resilience in case of an emergency. Therefore, city planning authorities must be careful to develop neighborhood scale local plans to support public amenities and safe spaces for all residents. Building height, building coverage ratio, and building type (functions) should be identified, while mixed use strategies often provide effective functions for increasing local quality of living space and ensuring the efficiency of local resources (such as food and energy).

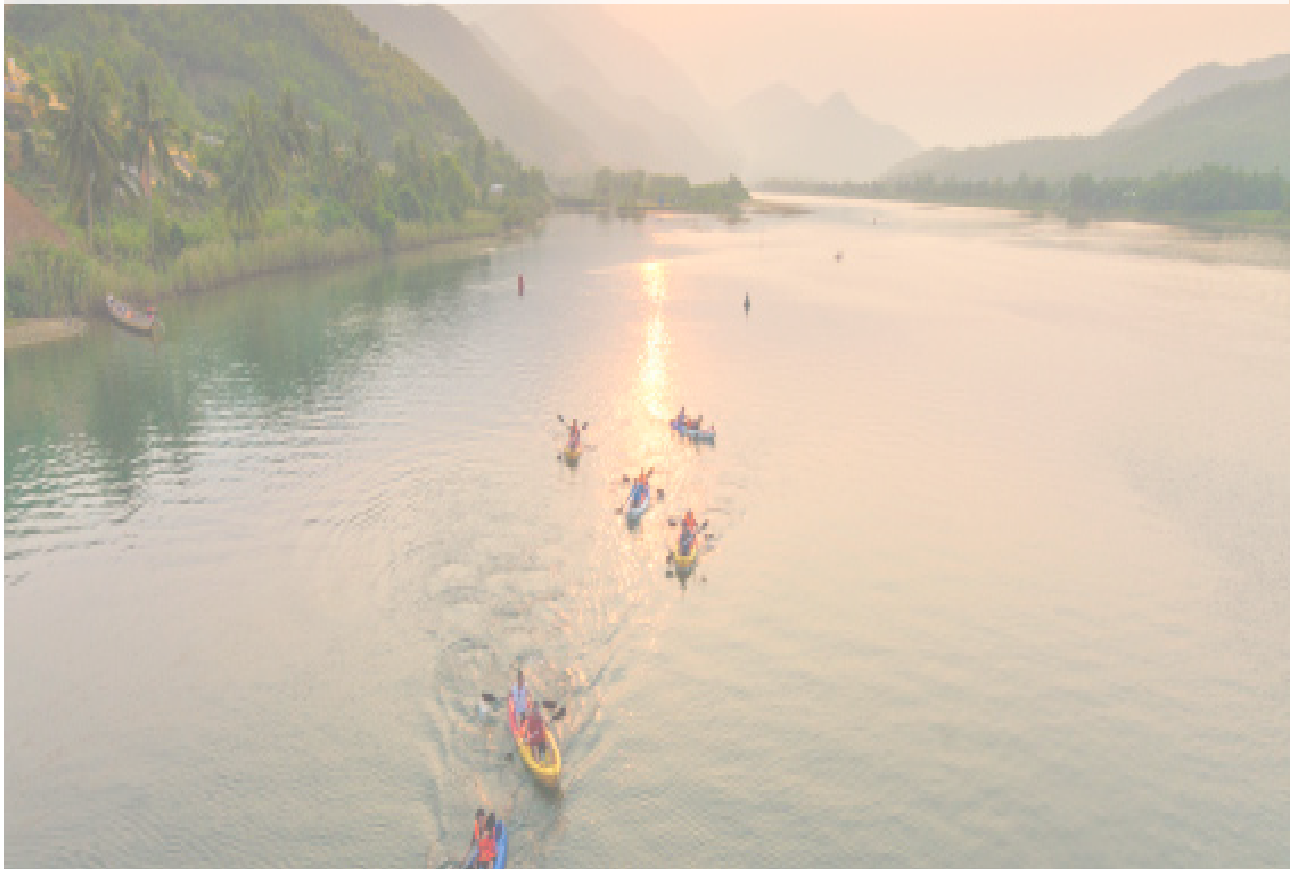
Access to local fresh food production & markets

Sustainable building management can be a part of sustainable local food production through rooftop gardens and vertical farms. There also need to be good links to local food markets (such as morning vegetable markets). Community gardens can be integrated into the local structure plan to develop better human relationships within the neighborhoods which can also enhance the local resilience.

Smart and sustainable regional planning

Smart networks and small-scale micro grid networks have been recognized as being increasingly important for energy-efficient buildings in Da Nang. As the current energy supply comes from outside of the city, one priority for sustainable building management is ensuring resilience in energy and other resources such as water. Therefore, a building mix (functional mix) and block-based area management can play a significant role in future regional sustainability in the building sector. The connection with electric vehicles (as batteries) should also be considered as a combination of localized smart energy system networks.

3.2 Transport



Principles of Climate Action for Transport

The approach to tackling transport-related problems in a city is heavily influenced by its high-level views about the type of city and transport systems that it wants to support. Dealing with climate change requires measures on both mitigation (primarily, reducing carbon emissions) and adaptation (coping with climate change consequences).

The main vision for a carbon neutral transport sector in Da Nang focuses on the increased use of public transit as one of its priorities. Public bus services will continue to play a key role, and will be powered by cleaner fuels (in the short run) and (ultimately) electricity.

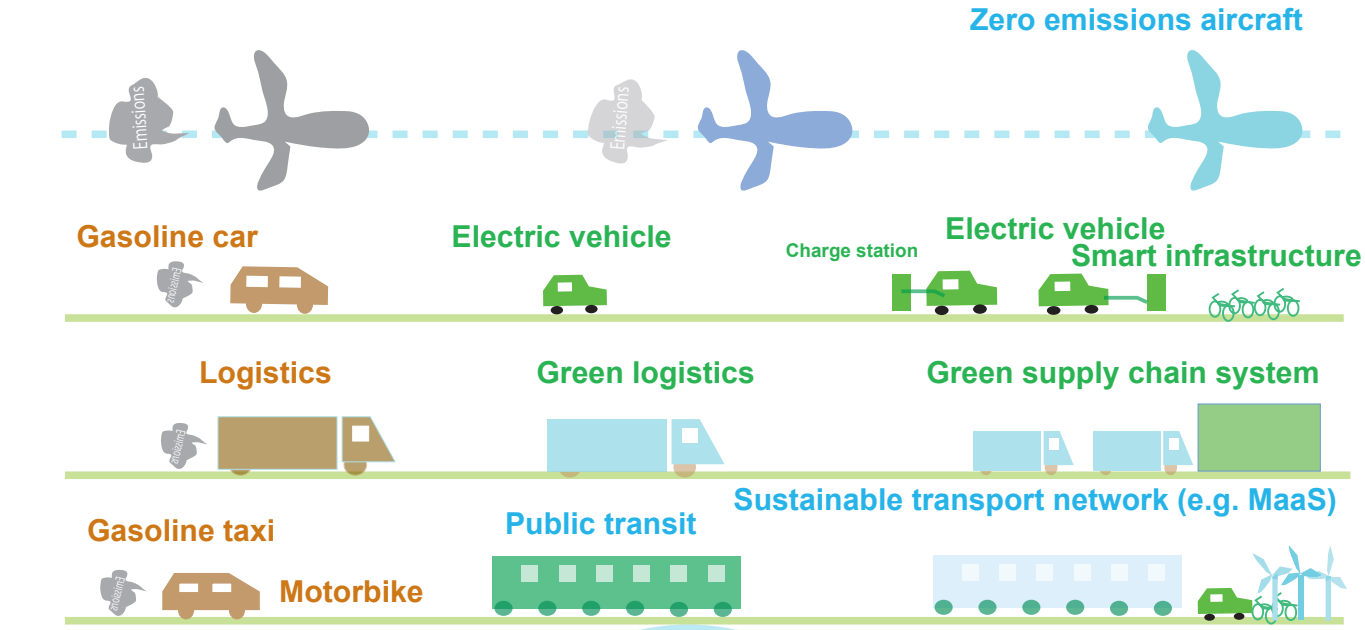
Therefore, electric vehicles (EV) for public transit (bus, taxi, tram (light rail), and water bus, Metro, Bus Rapid Transit (BRT)) should be introduced, targeting 100% of the transport fleet by 2050. Internal Combustion Engine (ICE) private cars and motorbikes should also be replaced by energy efficient electric models with the target of more than 80% by 2050.

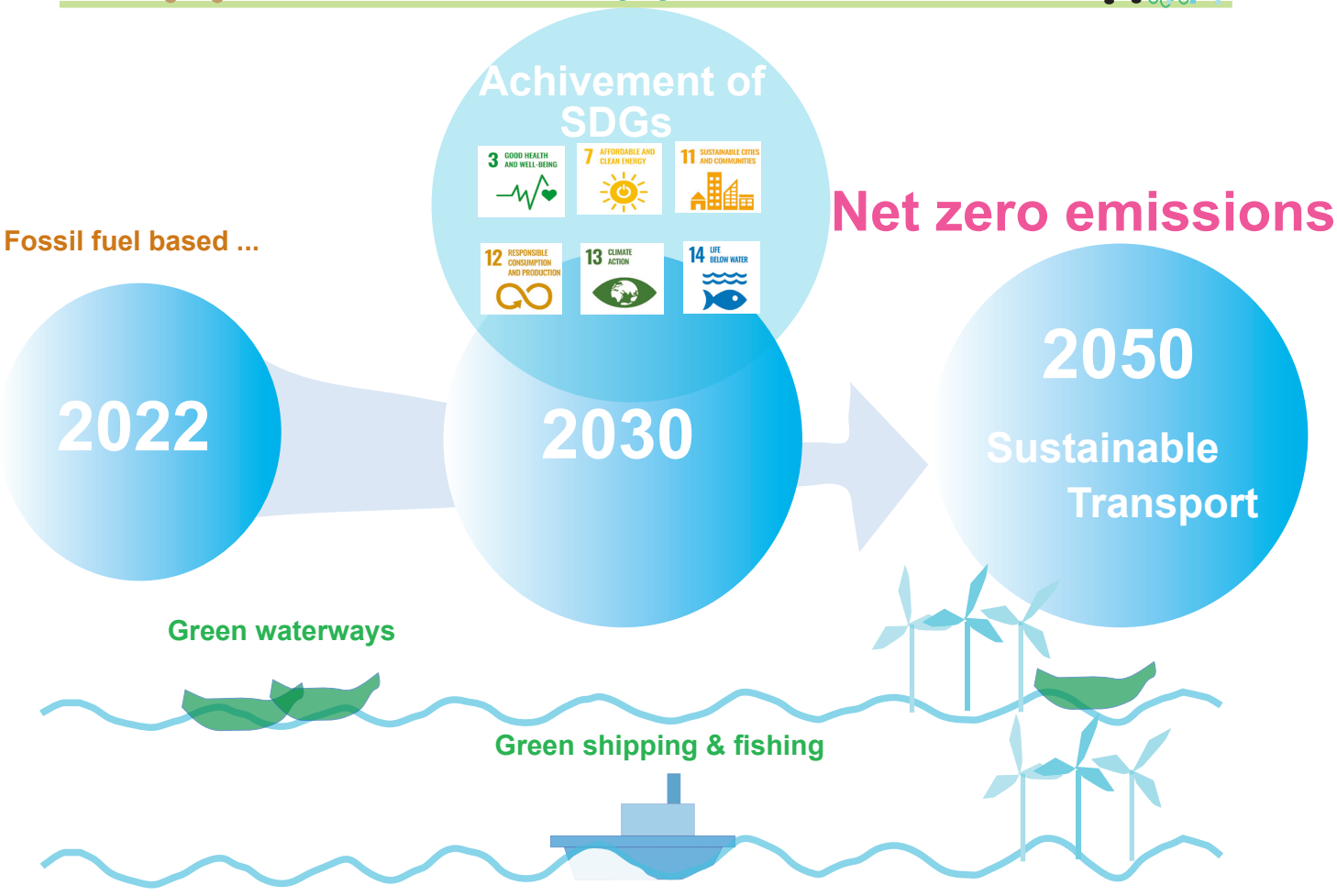
In addition, green logistic strategies should be developed to align with national decarbonization strategies, and promote zero emission freight including longer-distance flows beyond administrative boundaries.

Walking and cycling are also significantly recommended to the communities (both in terms of carbon reduction and public health). The city should develop comfortable pedestrian routes & spaces, and safe & green cycle lane networks, thereby attracting visitors to use these facilities for their city tours in addition to their daily use by local residents.

These improved public policies should be connected with other sustainable development strategies, by effectively managing land use and local urban structure plans to achieve wider sustainability outcomes.

Pathway to Achieve Sustainable Transport





3.2.1 Mitigation Measures

Action 1: Improve and develop public transit services and create effective network systems involving all transport modes

In Da Nang City, around 12% of total GHG emissions comes from motorbikes. Cars and buses emit 2.48% and 2.43% of emissions, respectively. Trucks and vans also emit relatively high emissions at around 18% of the total, contributing to the increase in air pollution. Meanwhile, other transportation systems including railways, waterways and airways account for only 1% of the city's total GHG emissions (World Bank, 2013). Therefore, shifting to more public transport use will significantly contribute to GHG emissions reduction. However, public buses and some waterways are the main public transportation in the city. The city government should put priority on replacing these public vehicles with electric vehicles (EV), and EV charge stations should be created at all necessary points by 2040. A city bike scheme (cycling) can be a part of the green public transport program in the city for both local communities and tourists (this is included in Mitigation Action 4). All these public transport systems should be effectively networked within the city's key nodes using smart technologies (e.g. Da Nang MaaS).

Action 2: Improve traffic flow and reduce congestion

The logistic freight transport sector is one of the highest emitters of GHG at the current level in Da Nang City. Green logistics involving private businesses is one of the key priorities (this is also included in Mitigation Action 5). The city should monitor when time schedules become congested during the daytime and on weekdays, and it could set a congestion charge to mitigate air pollution and GHG emissions from the city centre. In addition, an outer ring road could be developed to divert traffic that is just passing through the city areas. A smart transport network system can monitor the traffic situation and aim for a balance of safe and comfortable traffic flows.

Action 3: Increase EV (and energy stations)

In Da Nang City, more than 30% of total emissions comes from road-based emissions (Da Nang City, 2016). Therefore, replacing vehicles with EV can generate significant GHG reductions and mitigate the air pollution levels. However, the deployment of EV requires energy chargers as a fundamental infrastructure instead of gasoline stations. Capacity of electricity grid to supply EV charging is a key concern.

Action 4: Introducing car-sharing and bike-sharing schemes (lifestyle changes)

Car parking spaces in the city center are limited and the cost of EVs is still not affordable for many residents, so a car-sharing scheme can support the city's green & circular economy strategies under its net zero vision. Such car-sharing and bike-sharing schemes enhance sustainable community networks and support a shift to environmentally-friendly lifestyles. These schemes should be included in local structure plans under the city's revised master plan for 2045.

Action 5: Increase green logistics (within and between cities)

Green logistic programs require major commitment from the private business sector, so city government needs to actively work with all related stakeholders to motivate them to move forward on smart & environmentally-friendly business by 2030. This strongly supports the achievement of SDG9 and SDG12. Cooperation and networking with other business partners beyond the city boundaries are also necessary to achieve the reduction target. This type of collaboration will create new business opportunities and sound business ecosystems beyond sectors through innovative supply chain systems.

3.2.2 Adaptation Measures

Action 1: Implement nature-based solutions for mitigating the heat for public roads and open spaces (Green corridor)

Urban heat island effect in Da Nang City is currently not very serious, but the heat level may increase along with more urbanization and overall global temperature rises over the next few decades. Public roads can increase their green cover with green pedestrian spaces and side gardens & trees. These public trees will effectively create shade during the daytime and can serve as natural thermal barriers. These ecosystem services can also create a wind path and protect the biodiversity network even within the city centre.

Action 2: Create effective buffer spaces for flooding management

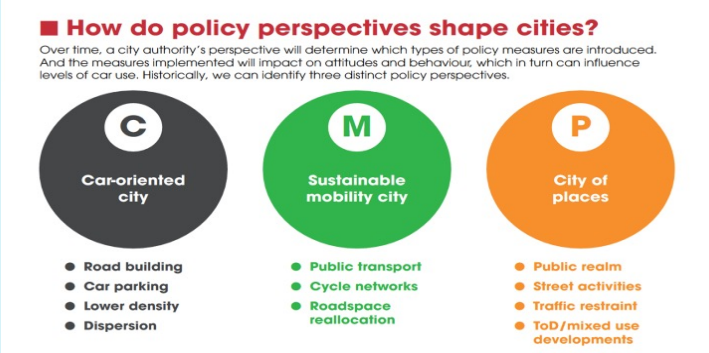
Flooding is one of the most serious natural disasters that occurs annually in Da Nang. As a coastal city, the rise in sea level is also the significant concern that can be seen in future scenarios for the city (Da Nang City, 2021). Public spaces, including transport infrastructure such as coastal roads, can serve as buffer spaces to manage flooding and provide evacuation routes. Therefore, this evacuation route and buffer program should be effectively incorporated in the development master plans. Also a hazard map should be developed as an open data base for all residents.

Action 3: Maintain traffic infrastructure (roads and pavements)

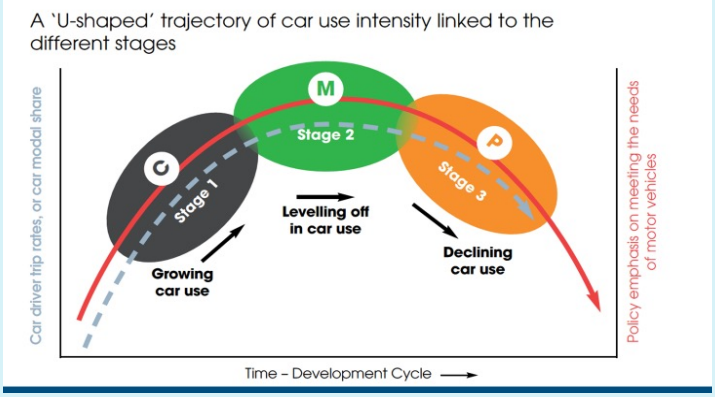
The maintenance of transport infrastructure is necessary for keeping public spaces safe and comfortable. A set of basic maintenance guidelines should be developed to maintain the quality of roads and pavements. Specifically, coastal areas suffer from salt damage due to the sea breeze and this is likely to shorten the lifetime of infrastructure and other transport facilities.

Box: Case study: The EU 'CREATE' project www.create-mobility.eu

The EU 'CREATE' project identified three perspectives that Western European Capital cities adopted at different times, over a 60-year period, each of which had major implications for their transport interventions:
In much of Europe and in parts of the USA, there has been a sequential switch in focus, from accommodating growing car use (car-oriented city), to providing sustainable alternatives (sustainable mobility city) and, most recently, to a 'city of places', involving promoting livability and active traffic restraint.



As a consequence, this has major implications for the levels of car use in cities, as shown below:



3.2.3 Synergies with Other Actions and Resilience of Sustainable Transport

AVOID Strategy
- Substitute digital for physical meetings
- Provide equipment in-home
- Localise facility provision (shorter trips)

Trip-generating sectors: education, health, leisure, retail..

SHIFT Strategy
- Support/encourage shift to sustainable modes
- Consolidation of freight

Governments, transport providers, major trip attractors

IMPROVE Strategy
- Decarbonisation of vehicle fleet
- Increase energy efficiency

Industry, utilities and transport providers

Strategies for carbon reduction are grouped by bodies such as the World Bank into three broad categories:
1. Avoiding the need to travel, by reducing trip lengths and trip numbers – while achieving intended economic and social outcomes;
2. Shifting trips to more sustainable travel modes, by encouraging the use of public transport, walking and cycling, car sharing and micro-mobility modes, and restraining car use;
3. Improving modal performance, by building more fuel efficient vehicles, and electrifying the vehicle fleet.
Some of these strategies interact with others, to support or sometimes weaken the achievement of carbon zero mobility and other high-level urban policy goals. For example, reducing trip lengths not only results in lower fuel consumption, but can make it more attractive to walk or cycle to local destinations, instead of driving. Conversely, electrification of the vehicle fleet will result in much lower operating costs and may encourage car use, thereby contributing to traffic congestion and (to some extent) poor air quality.

Implementation of most of the Avoid-Shift-Improve strategies involves collaborating with other sectors, as illustrated below. Cities rely on the vehicle and supporting industries to provide clean and – increasingly – electric vehicles. Authorities have most influence on Shift strategies, through their support for public transport, walking and cycle networks, their allocation of roadspace (e.g. provision of bus and cycle lanes) and some car restraint policies (e.g. parking controls), but most operations are under private control. Avoid strategies are strongly influenced by the major trip-generating sectors, with the possibility for cities to exercise some direct influence though their land use and spatial planning policies. These might include polices for mixed use rather than zonal land uses and for the 15-minute city, both of which reduce trip lengths and encourage walking and cycling, and public transport use.

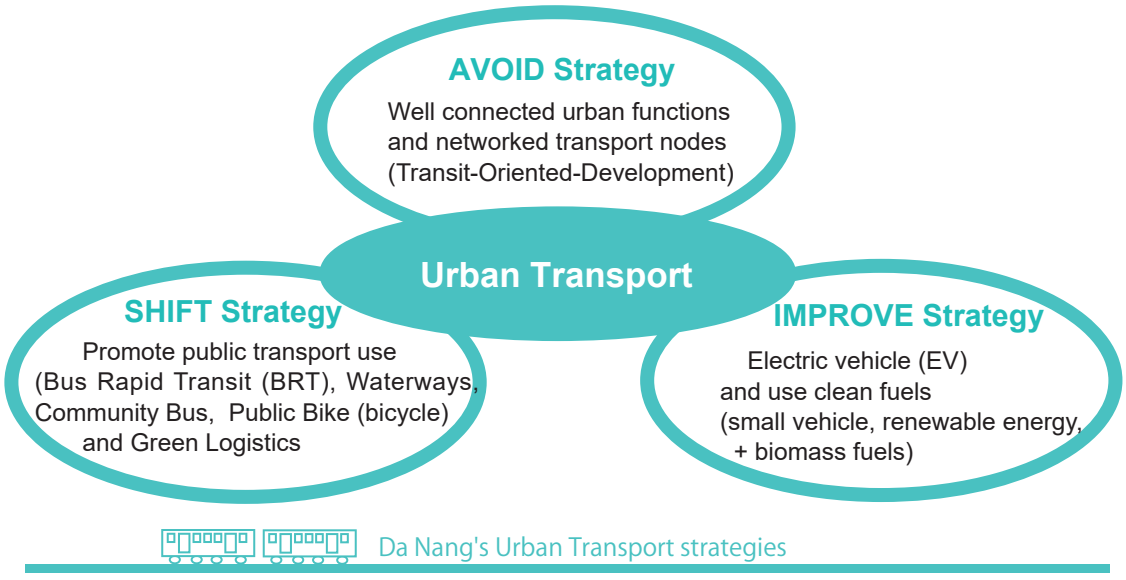


Figure 3.2.1 Transport key strategies adopting to AVOID - SHIFT- IMPROVE framework in Da Nang City
(Authors' development : the figure frame is adoped from Kainuma et al., 2017)

3.3 Energy System

Principles of Climate Action for Energy

In line with a rapidly growing city population and the development of economic activities, deployment of on-site renewable energy and energy efficiency reform in the building, transport, and industry sectors are key for promoting a green economy supported by local energy production from a long-term perspective.

Da Nang City expects to achieve an average 12% GDP growth over the next few decades, which can also create more than 30,000 jobs a year. The speed of growth is higher than the national average in Vietnam. Historically Da Nang's economy was dominated by heavy industry, manufacturing, and construction. However the tourism and service industry has grown significantly and became a major sector in 2006 (World Bank, 2013; UN Habitat, 2019).

This is based on the city's priority with the vision of service-oriented industry strategy along with green growth. The tourism sector is expected to grow faster in coming decades capitalizing on the city's beaches and sea port resources as well as old heritage towns such as Hoi-An and Hue.

Currently, Da Nang's energy system relies almost 100% on supplies from outside the city. The transport and industry sectors are major energy consumers as well as GHG emitters. The industrial and residential sectors dominate electricity use. Therefore, a reduction in demand from factories, hotels, restaurants, and offices for industry and service can make significant impacts on total energy consumption patterns.

Furthermore, the city government should develop an efficient renewable energy deployment program on a city scale, as Da Nang has great potential for utilizing solar PV electricity production with micro grid energy demand management.

Pathway to Achieve Sustainable Energy

3.3.1 Mitigation Measures

Action 1: Install end-use demand energy monitoring and efficient management systems

An energy demand monitoring system should be installed in all buildings, factories, and service facilities to analyze the potential reduction, and support on-site energy balance. Building energy management systems and smart meters can also be installed in offices, restaurants, and hotels. Energy efficient appliances such as LED lighting could be installed in all factories and office buildings which woud have a major impact citywide. Installing small-scale smart grids within industrial parks is the way forward for future potential new technologies to ensure an effective balance between on-site renewable energy and local energy use.

Action 2: Carry out basic reform of energy system reform: set a target to achieve an energy system 100% powered by renewable energy by 2050

Currently, Da Nang's energy supply is 100% imported from outside the city. The city government should set a program to increase renewable energy production within the city to increase energy self-sufficiency and maintain the energy security. The city can develop renewable production in collaboration with neighboring cities to ensure a balance in energy demand management and also adapt to disaster risks caused by climate change. National long-term strategies also highlight a major increase in renewable energy production, so Da Nang can maximize these opportunities and investments, thereby contributing to national renewable strategies and harmonize the city's green growth strategy.

Action 3: Install community based virtual power plant: small-scale smart micro-grid and battery systems

The acceleration of electrification is one of the key components of energy transition to a sustainable energy system globally. Global annual electricity demand increased around 3.0% on average between 1990 and 2019 (IEA, 2020). An increased reliance on renewables such as solar PV and wind power can enable more flexibility for local energy generation and small-scale electricity networks, which can take advantage of decentralized energy distribution. EVs and charging points can operate in a real-time demand response system as a part of a local smart micro grid.

3.3.2 Adaptation Measures

Action 1: Install small-scale battery systems using renewable energy to support the basic needs in case natural disasters occur

Virtual power plants can be utilized as local energy back-up plants when the national energy grid is impacted by disaster and electric supply is stopped. Therefore, such small-scale systems have to be located in important city nodes to ensure effective planning for city-wide disaster risk management that meet human basic needs.

Action 2:Design industrial parks with basic energy backup systems on a local scale

Da Nang City is planning to develop several eco industrial parks. These areas should have disaster evacuation space and facilities which can be supported by local energy production and back-up systems, as well as self-sufficient food and water facilities within the park.

Action 3: Implement water and heat recovery system, rain water collection

Efficient local resource recycling systems are part of a potential adaptation strategy to maintain small-scale water-food-energy management. These can also provide great support in the face of other crises, such as the COVID-19 pandemic, which would be useful in the case of strict lock-downs and the loss of connection with other areas.

3.3.3 Synergies with Other Actions and Resilience of Sustainable Energy

Sustainable energy access for resilient neighborhoods

Increased production of on-site renewables is a priority for both Da Nang City and Viet Nam as a whole. However, new local renewable production also requires the relatively large investment of regional grid network which is connected to the national grid. Small-scale micro grids can be established with smaller initial costs compared to large-scale national planning. These are more flexible and can be a closed system within the local community. These small-scale systems can function as a backup system in case of power shortage caused by disasters.

Energy-food-water and health nexus

Sustainable energy systems can also support access to human basic needs. This is a more ambitious target for Da Nang on its path to achieve the SDGs by 2030. Energy is the basis for daily lives and economic activities as well as for food production. The city should identify local mutual reliance to enhance its resilience to climate risks. Local clean production for energy-food-water systems also improves local and indoor air quality, helping to maintain good human health.

Waste-to-energy

Please see Section 3.6 on waste management (3.6.3 Synergy section)

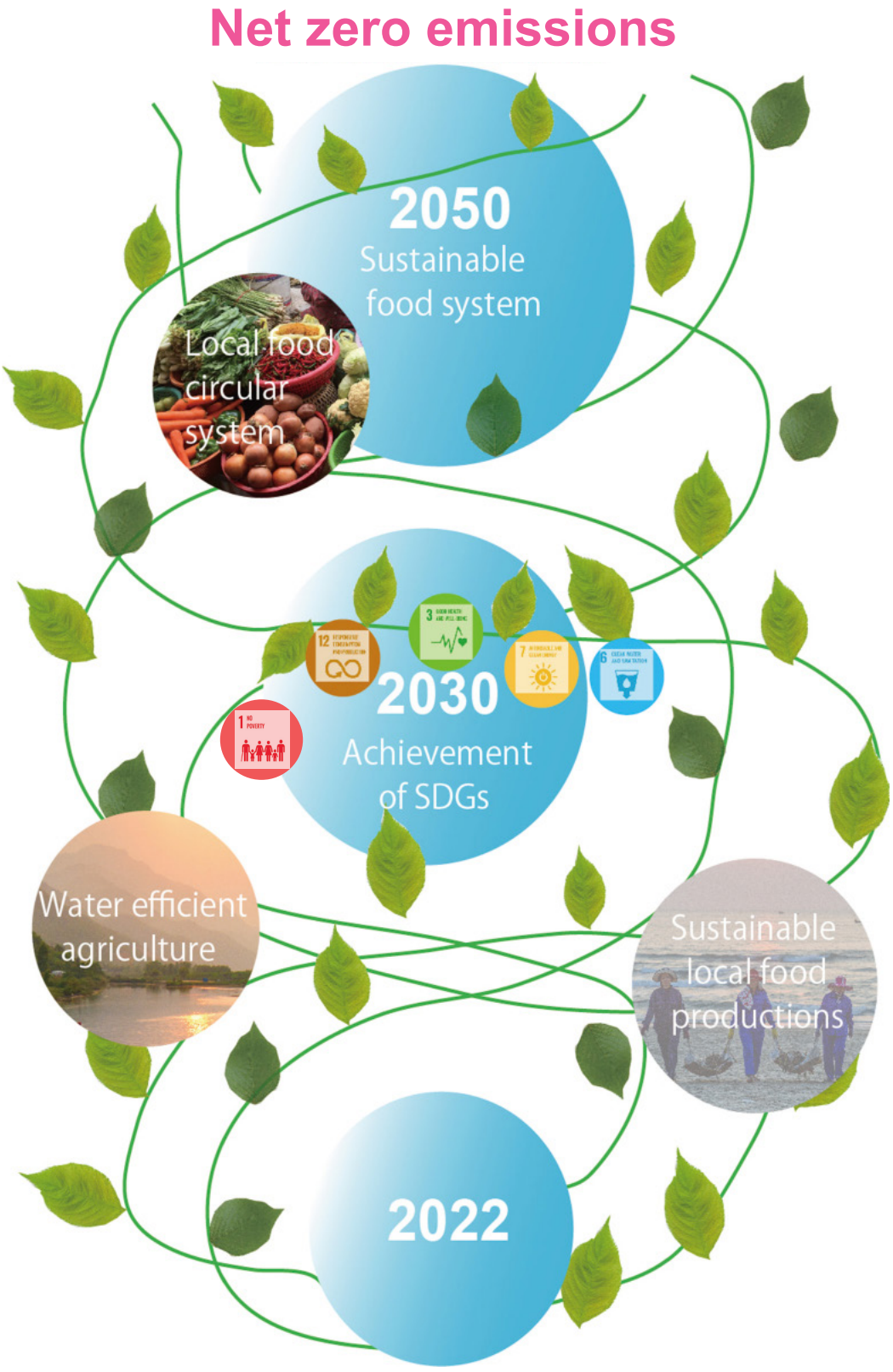
3.4 Food and Agriculture

Principles of Climate Action for Food and Agriculture

The food sector (food production, processing and distribution) is responsible for over one-quarter of the world's greenhouse gas emissions. These emissions are mostly emitted as a result of livestock rearing and crop production (58%). Food processing, packaging and transport also emit 15% of food-related GHG emissions globally. Hence, mitigation measures within the food production and processing sectors can play an important role in reducing Da Nang City's emissions. In parallel, the food sector can play an important role in achieving urban economic prosperity and human wellbeing.

For instance, urban gardens can provide urban dwellers with fresh and affordable food, and at the same time, they can participate in maintaining the gardens, thereby improving their physical and mental health. Urban gardens can provide employment, and play a role as a tourist attraction, thus providing revenue for the city. In environmental terms, urban and periurban gardens can provide habitat for local biodiversity (Blair, Giesecke and Sherman, 1991; Reuther and Dewar, 2006; Cianga and Popescu, 2013; Soga et al., 2017; Schram-Bijkerk et al., 2018).

Pathway to Achieve Sustainable Food & Agriculture



3.4.1 Mitigation Measures

Vietnam's greenhouse gas emissions in the agricultural (and land use) sector are due to several main factors: firstly, emissions associated with rice production (rice is the most emitting cereal as rice soils are often submerged, which creates the right conditions for bacteria to emit methane). Secondly, enteric fermentation (digestive processes of livestock) and manure management contribute to 26% of the sector's emissions, and can be attributed to livestock rearing. Finally, the use of synthetic fertilizer (instead of relying on composting or other natural fertilization techniques, such as crop rotation) contributes to 9% of the sector's GHG emissions.

GHG emissions from the food sector have not been calculated for Da Nang City. However, it is known that the city's food and forestry production reached 34,569 tons in 2016, mainly from fishing. The crop that is mostly grown is rice, although other crops are also grown (maize, sweet potatoes, vegetables and beans). Cows, buffaloes, pigs and poultry are also reared in and around the city. In total, agricultural land represents 117km2 (9% of Da Nang total land use) (sources: GHG inventory report, Da Nang City).
Rice is grown on 5,434 hectares. Based on FAOSTAT yield and emissions intensity data for rice production in Vietnam, we can estimate that rice production in Da Nang emits 28,851 tons of CO_2 per year.
Based on this information, this action plan proposes the following mitigation measures for the agricultural sector:

Action 1: Conduct a study on rice production system, to potentially switch to a more water-efficient and less GHG-emitting system

Research has shown that alternate wetting and drying (rather than continuously wetting rice fields) can reduce rice GHG emissions up to 63% (Win et al., 2020). A study should be undertaken of Da Nang's rice production systems to check whether it can be altered to reduce associated GHG emissions.

Action 2: Encourage the substitution of synthetic fertilizers by organic fertilizers

Organic waste (food waste and human waste) emits GHGs when they are decomposing on a landfill. Instead, processing this waste so that it can be used as fertilizer in agriculture provides a way to close the nutrient cycle and reduce dependency on synthetic fertilizers. Previous research in Da Nang has shown that producing organic biomass liquid fertilizer locally is economically viable and would reduce the use of synthetic fertilizers (Kohlbacher, 2015; Hong, Takahashi and Yabe, 2017). This should be pursued in Da Nang. Other alternatives are providing training and incentives for community groups to produce their own compost and use it in local agricultural projects, or producing compost in government-funded infrastructures (Kohlbacher, 2015).

Action 3: Consume less meat

As meat production (and particularly red meat) plays an important role in global GHG emissions, a reduction of 50% in the consumption of red meat globally is necessary to achieve sustainable food systems (Willett et al., 2019). Vietnam's meat intake is average (38 grams / person / day of animal protein as part of the country's food supply (FAOSTAT, 2021), compared to a global average of 37 (and ranging from 6 grams in Ethiopia to 105 in Iceland). However, as meat consumption is consistently increasing across the world (Henchion et al., 2014), raising consumer awareness and providing affordable alternatives in the form of vegetarian protein will play an important role in reducing GHG emissions associated with food (Willett et al., 2019).

3.4.2 Adaptation Measures

Action 1: Increase resilience and food security

Food security may be affected by spikes in energy prices (energy affects both the cost of synthetic fertilizers, on which Da Nang's agriculture is currently dependent, and the cost of food transport). Encouraging an increase in local food production of different food types and at different scales (from household and community gardening to commercial farms) will play a key role in ensuring food security for Da Nang. Encouraging community gardening can play a role in enhancing local residents' physical and mental health and provide them with a livelihood and access to affordable healthy food. Besides, these gardens can play a role in making the city more attractive for tourists.

Action 2: Mitigate urban heat island effect

Climate change has already had an impact on urban temperatures. Modern cities in particular have much concrete and asphalt which absorbs heat during the day and emits this heat overnight. Urban green space can mitigate such urban heat effects by utilizing green shade and discharging water vapor. Increasing green rooftops and flower beds in the city will prevent a drastic rise in urban temperatures and help to avoid the impacts on human health caused by urban heat.

Action 3: Enable risk reduction

Urban agriculture can install updated innovative technologies to alleviate the risk of seasonal disasters such as flooding. For instance, indoor agriculture, waste water recycling, and satellite observation systems can help to minimize the impacts caused by local disasters. Adequate knowledge and capacity development for adapting these new facilities and technologies also have to be provided by local authorities.

3.4.3 Synergies with Other Actions and Resilience of Sustainable Food System

Green roofs & facades can mitigate heat and produce local food

Green roofs and facades are an adaptation measure for the building sector, as they can reduce the need for cooling buildings. These green roofs and facades can easily be used to produced fresh herbs and vegetables, thus contributing to local food sovereignty.

Local food systems can decrease road congestion

Local food production can reduce the need for food importations and thus reduce associated road travel and freight. This is congruent with the “avoid strategy” in the transport section which entails reducing the total number of trips to reduce congestion.

Food waste can be used for green energy production

Food waste that results from urban food growing activities (for instance, compost and green waste) can be used to produce green energy at a local scale and thus reduce dependence on external gas and fossil fuels.

Local food systems can contribute to public health

Finally, urban food production can promote the consumption of fresh, healthy food by urban residents, which can decrease health problems related to diet, such as obesity or diabetes, which have been shown to worsen the consequences of COVID.

3.5 Water System

Principles of Climate Action for Water System



Comprehensive management of Da Nang's diverse water resources is crucial in supporting the growing, economically-vibrant city. A high-quality, consistent, and affordable water supply is important not just for daily life, but also for business, commerce, and tourism. This will require the maintenance and construction of water infrastructure as well as the protection of natural landscapes.

Da Nang is located within the transboundary Vu-Gia - Thu Bon River Basin (Ribbe et al.). Surface water flows in the highlands are detained by 10 hydroelectric plants, which supply 7% of Da Nang's total energy demand (Ostojik et. al). Electricity production is affected by seasonal changes in precipitation. The operation of the hydropower plants significantly alters patterns of flow in the region, exacerbating drought in the dry season and flash floods in the wet season (Nhien, 2014).

Water released from hydropower plants flows into the larger Han River and through central Da Nang. Municipal water supply is provided by the Da Nang Water Supply Company (Dawaco), which is mainly reliant on surface water from Cau Do River in the south of the city (UNESCAP). Urban municipal water provision has increased from 52% in 2007 to 93% in 2017.The extraction of groundwater is rapidly expanding and largely unregulated, leading to further saltwater intrusion and aquifer depletion (Long and Dat, 2020). A network of pumps transports river water to irrigate lower basin agriculture. In total, there are three treatment plants, 106 reservoirs, 560 dams, 208 pumping stations and four canal systems in the area (Van Don, 2021).

Climate change is shifting the way water moves in Da Nang and altering the city's risk profile. Precipitation and drought are becoming more extreme in the wet and dry seasons. Sea level rise along with riverine flooding mean that more than 60% of Da Nang is under moderate-to-very high flood vulnerability levels (Thi An et. al). Additionally, water demand is projected to increase by 7.5% per year, putting a strain on existing supply iand its nfrastructure.

Building a water-friendly Da Nang will require a comprehensive water management study that assesses hazard, vulnerability, and risk across scales and sectors. Clean water and flood management are central to protecting residents and supporting economic activity. Building a climate-friendly and livable Da Nang will require collaboration between a broad range of city, community and private stakeholders, reflecting the diverse roles of water in urban life.

Key Targets:

1. Currently, 93% of the urban population is supplied with clean water and 83.5% of urban domestic wastewater is collected; by 2030, ensure a clean water supply for 100% of residents and collect/treat 90% of wastewater up to prescribed standards and regulations (UNESCAP, 2023)

2. Put 100% of industrial parks and export processing zones into operation with a centralized wastewater treatment plant, meeting environmental standards by 2030

3. Cut CO_2 emissions level in the water management sector (500kton CO_2 in 2021) to 80% below 2017 levels by 2050

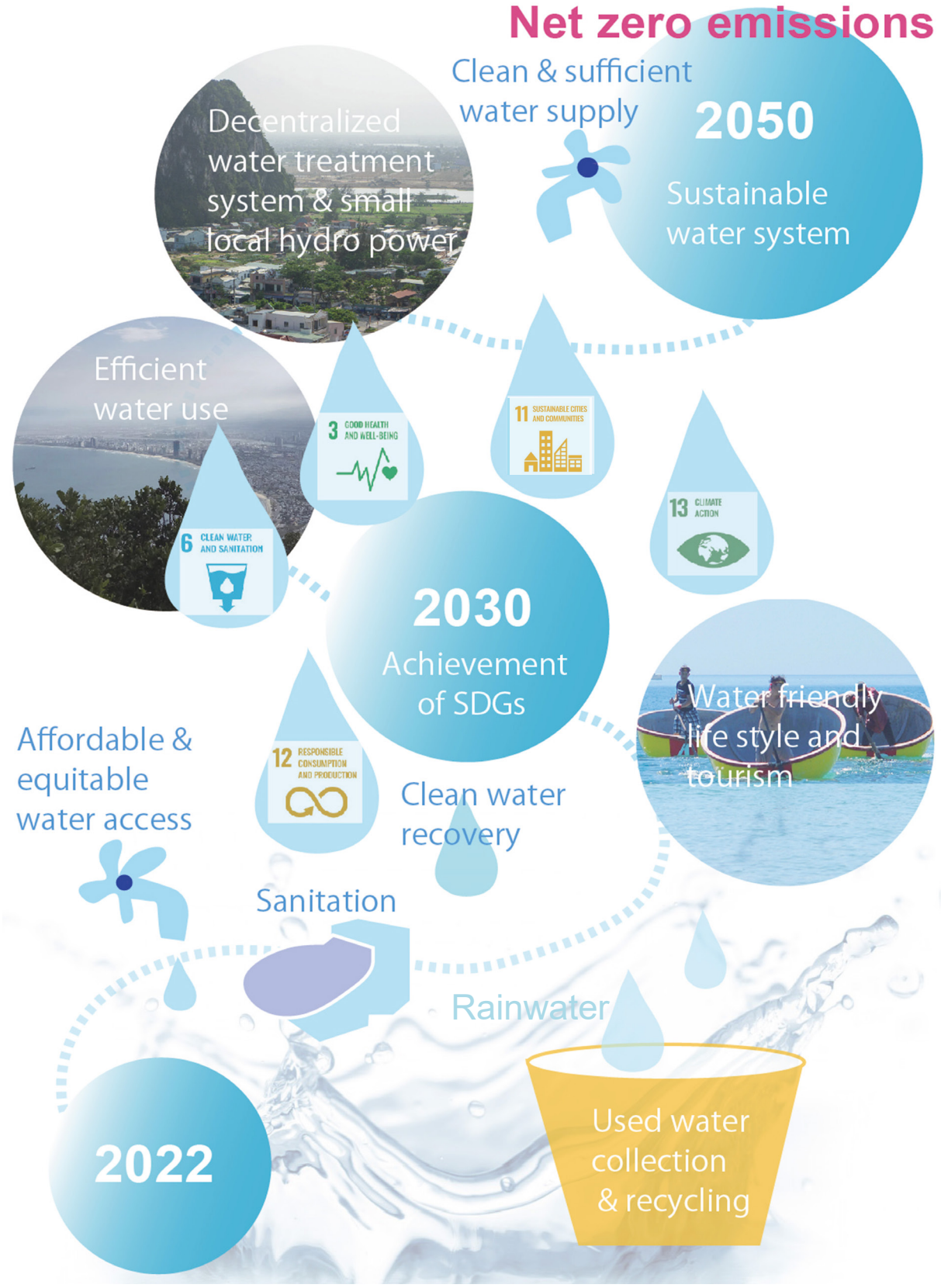
4. Protect aquatic ecosystems and resources

5. Mitigate coastal erosion and saline intrusion (for water source, coastal industry, tourism and agriculture)

6. Ensure affordable and equitable water access for Da Nang residents

7. Promote effective regulation and governance of wastewater release and the implementation of decentralized systems

Pathway to Achieve Sustainable Water



3.5.1 Mitigation Measures

Action 1: Reduce water use in water-intensive industries

Vietnam's industrialization significantly alters patterns of water use. The proportion of surface water used for industry in Vietnam is projected to increase by 190% in the next decade. Da Nang has six concentrated industrial parks. The 2021 city master plan includes further industrial clusters covering 83 hectares, as well as a tech innovation center. Industrial parks utilize surface water from municipal treatment plants. Reducing water use in industry alleviates the burden on these plants, reducing energy consumption as well as overall water use. This also reduces the risk of pollutant release into waterways. However, with less industrial water use, wastewater discharged from industry may also have higher pollutant concentrations, thereby necessitating effective discharge regulation. Many industrial establishments are under direct government control, as such, addressing water use in industry will require municipal and private sector coordination.

Action 2: Prevent industrial and sewage pollution

By reducing water pollution by industry and sewage, the energy needed to purify water to usable standards is significantly reduced. This approach requires investments into wastewater treatment infrastructure and the effective regulation of polluting industries. Da Nang's wastewater treatment facilities are aging and overburdened– the wastewater collection rate is just 60% and the treatment rate just 42% (Nhien, 2019). This results in the release of polluted water, posing a threat to public health, and negatively impacting the tourism industry. Additionally, only 16% of Da Nang's residences are connected to the municipal wastewater treatment system; most have their own septic systems located beneath the floor. These tanks are difficult to access and often allow wastewater to infiltrate directly into the ground, contaminating groundwater (Mohr, 2014). The promotion of effective decentralized wastewater treatment systems, the regulation of polluting industries, and the connection of more households to expanded municipal wastewater treatment systems may reduce pollution.

Action 3: Amend treatment standards by considering external flows

During the rainy season, high flow conditions in waterways dilute water released from treatment plants, reducing contaminant levels to much lower than regulatory standards. In these conditions, treatment plants may release less intensively treated water, as the surrounding environment will reduce contaminant levels to below acceptable limits. By reducing wastewater treatment standards during high surface water flow conditions, the energy used for wastewater treatment may be significantly reduced. However, this approach must involve a robust water quality monitoring program to ensure that pollutants in Da Nang's waterways remain below acceptable limits across a range of flow rates.

Action 4: Expand energy-efficient water and wastewater treatment plants

Emissions from the transportation and treatment of water and wastewater can be mitigated through energy-efficient infrastructure, the use of renewable energy, and the reduction of methane emissions from wastewater treatment. Newly constructed transport and treatment systems must utilize energy-efficient technologies. Additionally, improved stormwater management can also reduce the volume of water entering treatment systems, reducing energy consumption. Green infrastructure and nature-based solutions can detain stormwater, encouraging groundwater recharge, natural filtration, and providing green spaces for a more livable city. The use of renewable energy for water wastewater treatment may include the installation of solar panels at treatment sites or the use of hydropower. Additionally, with the expansion of water wastewater storage capacity, water the treatment can function as an energy demand response mechanism. Wastewater is treated during periods of high renewable energy production and stored during low production. Finally, the anaerobic portion of the wastewater treatment process produces significant quantities of methane, a greenhouse gas that is 25 times more potent than carbon dioxide. Preventing the release of methane from treatment plants through reuse as fuel or burning is a powerful mitigation strategy.

Action 5: Encourage the use of household water-saving devices

Water-saving devices like low-flow shower heads and toilets have significant potential to reduce household water use. Their use may be encouraged through subsidies as well as through policy mandating their inclusion in new construction projects. Smart meters are often cited as a demand-side method of reducing water use, but the large-scale production of these electronic components is water and carbon intensive. Passive devices like flow modifiers may be a more effective approach.

3.5.2 Adaptation Measures

Action 1: Develop more sustainable agriculture

The promotion of sustainable agriculture necessitates coordinated urban planning, technological innovation, and workforce development. Urban agriculture provides livelihoods for local farmers, supports an affordable food supply, and eliminates the emissions involved in transport. Especially in the south of the peninsula, Da Nang has a number of productive agricultural plots (Mohr, 2014). However, urbanization reduces the area of land available for cultivation in Da Nang by 10-15% on average per year (Hoang, 2022). Construction also changes runoff and nutrient flows, affecting the productivity of remaining land (Tran et al, 2017). Runoff from fields may bring nutrients and pesticides into local waterways, causing algal bloom and contamination. Pesticides in waterways increase the energy needed for surface water treatment. Urban planning policy to protect arable land and ensure adequate irrigation is necessary to ensure productive urban agriculture. Additionally, encouraging low-tech (e.g. cover crops) agricultural practices may significantly reduce water use during cultivation. The city of Da Nang has selected high-tech agriculture as one of the five spheres for socioeconomic development (VNA, 2020). The successful implementation of these technologies requires workforce development as well as foreign investment.

Action 2: Improve rainwater collection/greywater reuse

Rainwater collection and greywater reuse can reduce the burden on municipal water treatment. On the household scale, rainwater and greywater can be collected and used for irrigation, flushing toilets, and more. Da Nang city encourages large resorts, which use large amounts of water for landscaping and swimming pools, to reuse their greywater rather than drawing from groundwater sources (Hiep, 2022). Initiatives like these may be promoted on a broader scale or mandated for new construction projects. However, it should be noted that rainwater is how groundwater is recharged and the salt line is kept further downstream. Careful planning and monitoring is needed for rainwater collection policy to ensure that saltwater intrusion is not exacerbated. On an urban scale, rainwater can be collected using green infrastructure. These projects reduce the urban heat island, support local ecosystems, protect groundwater resources, and create urban green space.

Action 3: Implement affordable point-of-use treatment and cultural shift away from bottled water

Point-of-use treatment is when individual households utilize secondary filtration devices to bring water up to drinkable standards. The widespread use of these devices can reduce dependence on bottled water, reducing plastic use. Household filters are also a form of crisis infrastructure in the case of pollution or disaster. The widespread implementation of point of use treatment requires affordable, accessible filtration technology. A cultural shift away from bottled water, achieved through outreach, would support its implementation.

Action 4: Protect and develop natural infrastructure

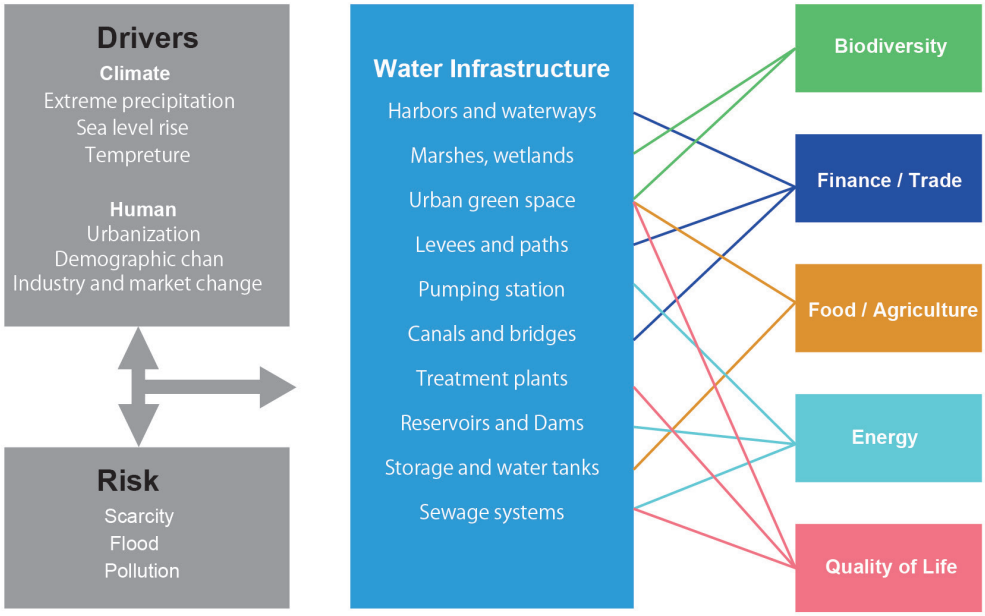
Natural infrastructure like forests and coastal wetlands play vital roles in protecting Da Nang's water resources. The preservation of these landscapes has co-benefits including biodiversity preservation, the reduction of the urban heat island, and the creation of a more livable city. Forests protect groundwater, promote a more consistent flow during the dry season, and mitigate flooding in the wet season.The protection of coastal wetland reduces coastal erosion and saltwater intrusion while protecting marine ecosystems. Wetlands reduce wave intensity and provide a sheltered space for marine life. Plant species like mangroves filter water, reducing salinity within the estuary. The protection of these landscapes and the construction of nature-based coastal infrastructure is important given more frequent coastal storms and sea level rise. Urban green spaces like vegetated river catchments, cool surfaces, and bioswales also protect water quality and improve quality of life.

Action 5: Implement an integrated watershed management plan

A comprehensive water management plan for Da Nang requires coordinated action between public and private actors across many scales. Advance warning systems, improved monitoring, and intersectoral communication can support integrated watershed governance. Monitoring flows allows for water use planning and risk reduction. Data enables smart decision-making regarding discharge rates from hydropower and treatment plants. City-level collection of SDG-related data is also helpful in guiding stewardship actions or investment from corporations. Coordination between hydropower plants, regulatory agencies, and industry can prevent saltwater intrusion caused by hydropower plant water storage and flooding from reservoir release. Industry can also time production for times of peak hydropower energy availability, which may be enacted by an energy pricing system. In 2017, Da Nang and Quang Nam provinces agreed to establish an experimental collaborative River Basin Organization (RBO), with a mandate for data collection, modeling and information sharing (MacClune et. al, 2019). Collaborations like this can enable effective tradeoff analysis and engage vulnerable community members.

3.5.3 Synergies with Other Actions and Water Systems

Water is an inherently intersectional issue. Connections between different kinds of water infrastructure and biodiversity, finance/trade, food/agriculture, energy, and quality of life are shown in the Synergy figure below. For example, reservoirs and dams connect to energy through hydroelectric power generation. However, the climate risks that affect water infrastructure also affect these other sectors by extension, as shown on the right hand side of the figure .



Electricity section synergy

A detailed study is recommended to explore the effects of climate change on demand for water and energy in Da Nang, as well as the interactions between the two sectors.

Hydropower release timing

- Hydropower can help sustain high energy demand peaks, as production is less volatile than solar or wind
- Hydropower potential is dependent on decadal climate variability and climate change's impact on precipitation upstream of the dam
- Dam releases should take into consideration ecosystem requirements, e.g., maintaining base level flow and fresh-saline water interface line
- The storage of water in hydropower reservoirs can exacerbate saltwater intrusion, and release during high flow conditions can exacerbate flooding

Energy involved in water infrastructure for both treatment and pumping

- Water can be treated and stored during times of excess energy availability
- This functions as a demand response mechanism for volatile renewable sources of energy

3.6 Waste Management

Principles of Climate Action for Waste Management & Smart Consumption

In Da Nang, the amount of municipal solid waste (MSW) generated has been rapidly increasing, from 274,149 tons in 2016 to 390,336 tons in 2019 (in 2020, due to the COVID-19 pandemic, the collected MSW amount decreased slightly to 373,292 tons). MSW is collected and treated at Khanh Son landfill site, and is composed mainly of organic material (68.47%), followed by plastic (11.36%), sand (6.75%), paper (5.07%) and other waste. The Da Nang People's Committee formulated the "Master Plan Towards 2030, Vision to 2050", which set out an objective to collect 100% of household solid waste by 2030. Out of this, 80 – 90% would be separated for recycling, reuse, energy recovery, and material recovery by composting.

Promotion of Leadership, Policy, and Capacity Building

Promotion of leadership, policy and capacity building is a vital principle to successfully implement a sustainable climate action strategy. It is crucial that capacity building strategies recognize all stakeholders involved in waste management, including the informal sector.

Promotion of Waste Reduction and Resource Efficiency

The objective of the promotion of waste reduction and resource efficiency as a principle is to decrease the total amount of waste produced. Approaches to encourage waste reduction and optimize resource usage may involve enacting regulations and schemes to prevent over-consumption, extending the life of goods and materials, advocating sustainable production techniques, and boosting the use of eco-friendly waste management technologies such as composting.

Promotion of Recycling

This principle relies on identifying recycling potentials of recyclable materials: plastic, glass, paper and metal. Recycling has great benefits to achieve the zero-waste target. Recycling is the fundamental component to formulate the regional circular economy.

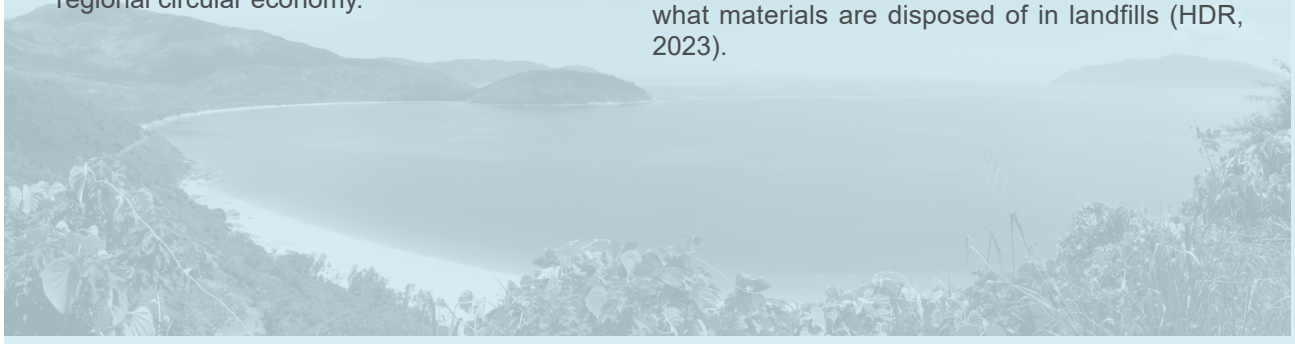
It is important to establish a collective community and industry-wide approach to achieve the advantages of exchanging recycled materials and substituting them to avoid raw material use. Improving recycling collection systems has great social and environmentalcan benefits.

Promotion of Organic Waste Management

The largest component of waste in Da Nang is organic material, thus it should be addressed as a key climate action. Low-carbon waste management technologies such as composting and anaerobic digestion can be key infrastructural opportunities to ensure successful climate mitigation and adaptation strategies. (HDR, 2023) Such technologies can potentially minimize the ecological impact of the waste management sector by diverting organic waste from landfills and generating organic materials for agriculture, as well as producing biogas for the energy sector.

Promotion of Landfill Gas Recovery

Sanitary landfills are one of the most crucial parts of waste management infrastructure as they ensure the protection of public health. Captured landfill gases are not emitted directly into the atmosphere. Instead, they are used to produce energy beneficial to the community.Waste characterisation studies continue to be significant to understand where materials could ultimately be diverted to strengthen the regional circularity, and what materials are disposed of in landfills (HDR, 2023).



Pathway to Achieve Sustainable Waste Management

3.6.1 Sustainable Waste Management System

Action 1: Implement material recycling (plastic, paper, metal)

Community waste management strategies involve engaging individuals and communities in waste reduction, separation and management activities. By doing so, environmental awareness is promoted, waste is reduced, and overall health is improved. Recycling campaigns and composting programs are just a few examples of community waste management strategies. These initiatives aim to encourage community participation in waste management and ultimately contribute to a more sustainable waste management system. Informal waste sector is crucial in waste management. Recognizing and integrating this sector into the formal waste management system can be an effective way to improve recycling rates. This can be achieved by providing training and resources to informal waste workers, developing formal partnerships with them, and recognizing their contributions.

Action 2: Recover energy from waste incineration

Excluding all types of recycling, about 70% of solid waste is combustible. That includes paper, cardboard, biodegradable waste, textiles, plastics and more. Incineration is first and foremost a way of eliminating a sizable amount of MSW. Some 90% of its initial volume goes up in smoke. This represents a healthier solution than landfills, which release huge amounts of GHGs. Two types of energy are produced in an incineration plant: heat and power. Each type has its own production process and level of energy efficiency. Heat production involves simply heating water through waste combustion. This process is energy efficient, with 70 to 80% of the combustion heat recovered after incineration. The heat produced then has to be used somewhere near the incineration plant. In the power production, the heat exchanger has to contain steam at the highest possible pressure. This steam is sent to a turbine that drives an electric generator. The power produced can be supplied to the grid all year round. The energy efficiency of this process is about 20 to 25%.

Action 3: Recover landfill gas

This method relies on capturing methane gas from existing landfills to help generate electricity and simultaneously reduce GHG emissions. The methane gas serves as an energy source to power turbines, and, in turn, the turbines generate electricity for the grid. As biodegradable waste, wood poles and other untreated wood material produce methane during the degradation process.

Action 4: Introduce composting

Composting can significantly reduce the amount of organic waste generated and contribute to the development of low-carbon strategies. Composting involves the conversion of organic waste into nutrient-rich fertilizers through natural processes. This technology can be used to reduce the amount of organic waste sent to landfills and mitigate GHG emissions by preventing organic waste from being sent to landfills where it would have decomposed anaerobically emitting methane in the process.

3.6.2 Responsible Production & Consumption

Action 1: Promote 3Rs (Reduce, Reuse, and Recycle)

It is vital to integrate the 3Rs and resource efficiency in the overall policy, planning and development, by encouraging local governments, the private sector, industry and business groups (including small and medium-sized enterprises (SMEs)), and civil society, to contribute to sustainable waste management, and achieve a low-carbon and resource-efficient society. Waste separation at source has been promoted since 2007 and has spread to many communities. According to Plan 6404/KH-UBND, the Danang People's Committee implemented waste separation at source and 3R promotion in Thuan Phuoc and Thach Thang wards, and in Hai Chau district between 2017 – 2018. The campaign improved citizens' awareness on the 3Rs, changed their behavior and reduced the amount of waste. These activities have been gradually deployed in other areas in the city.

Action 2: Introduce Extended Producer Responsibility

Extended Producer Responsibility (EPR) is an environmental protection strategy aiming to decrease the total environmental impact of a product, by making the manufacturer responsible for the entire life-cycle of the product, especially for the take-back, recycling and final disposal. EPR is mainly applied in the field of waste management, and from 2005 to 2020, the EPR model in Vietnam was based on a voluntary mechanism, which made the implementation of regulations less effective. However, following the global trend of developing a circular economy, it has become necessary to apply a mandatory EPR model to achieve the SDGs. To shift from the voluntary EPR model to a mandatory one, the Law on Environmental Protection laid down some principles and measures for application. Article 54 of the 2020 Law on Environmental Protection (the 2020 Law) requires producers and importers of recyclable products and packages to recycle such products and packages according to the prescribed recycling rate and specifications. To make it clearer, the Decree detailing the 2020 Law states that mandatory recycling rate is the minimum ratio of volume of products and packages subject to recycling according to prescribed recycling specifications to the total volume of products and packages produced and marketed and imported in the year of EPR implementation. Regarding recycling specifications, the Decree sets the minimum recovery rate of 40% for materials.

Action 3: Reduce food waste and increase resource exchange programs within the community

According to the Da Nang Department of Natural Resources (DONRE), the percentage of biodegradable organics in municipal solid waste at the Khanh Son landfill has been steadily increasing over the past decade, from 56.85% in 2009 to 66.71–74.65% for the period 2010–2014, of which 80–90% was food waste. Food waste in landfills causes several health and environmental concerns, such as transmission of diseases and GHG emissions. In Da Nang, food waste is collected and transported by pig farmers to be used as feed. However, there is a strong need to take both consumer-oriented waste prevention and waste management measures, such as waste segregation at source and introduction of effective food waste recycling techniques, to ensure that food waste can be safely and sustainably used as a "valuable resource" rather than "wasted." In some restaurants, particularly buffet restaurants, a penalty fee could be applied to customers based on their leftover food amount. On the other hand, some restaurants exhibit the portion of model meals for customers to select the proper amount of food. These are good practices in reducing food waste in Da Nang.

Action 4: Identify all opportunities of converting waste into energy

Da Nang can take several actions to convert waste into energy and make its waste management system sustainable. The city can invest in waste-to-energy technologies such as anaerobic digestion, gasification and incineration to convert the organic portion of waste into biogas or electricity. By investing in waste-to-energy technologies, Da Nang can not only reduce the amount of waste going to landfills but also generate renewable energy to power its own infrastructure or feed into the grid. This can help the city become less reliant on fossil fuels and reduce its GHG emissions, contributing to its climate action goals.

Action 5: Create the conditions for making a more inclusive waste management sector that considers all relevant stakeholders, including the informal sector

To create a more inclusive waste management sector that considers all relevant stakeholders, including the informal sector, the city can take several actions. This includes formalizing the informal waste management sector through training, equipment and resources, establishing partnerships with community groups to involve marginalized communities in waste management decision-making, and investing in public awareness campaigns to reduce stigma and discrimination against waste pickers and recyclers. Creating a collaborative and participatory approach involving all relevant stakeholders can help develop a more equitable and sustainable waste management system.

3.6.3 Synergies with Other Actions and Sustainable Waste Management and Smart Consumption

Effective circularity and valuable use of food waste (link to food system and agriculture)

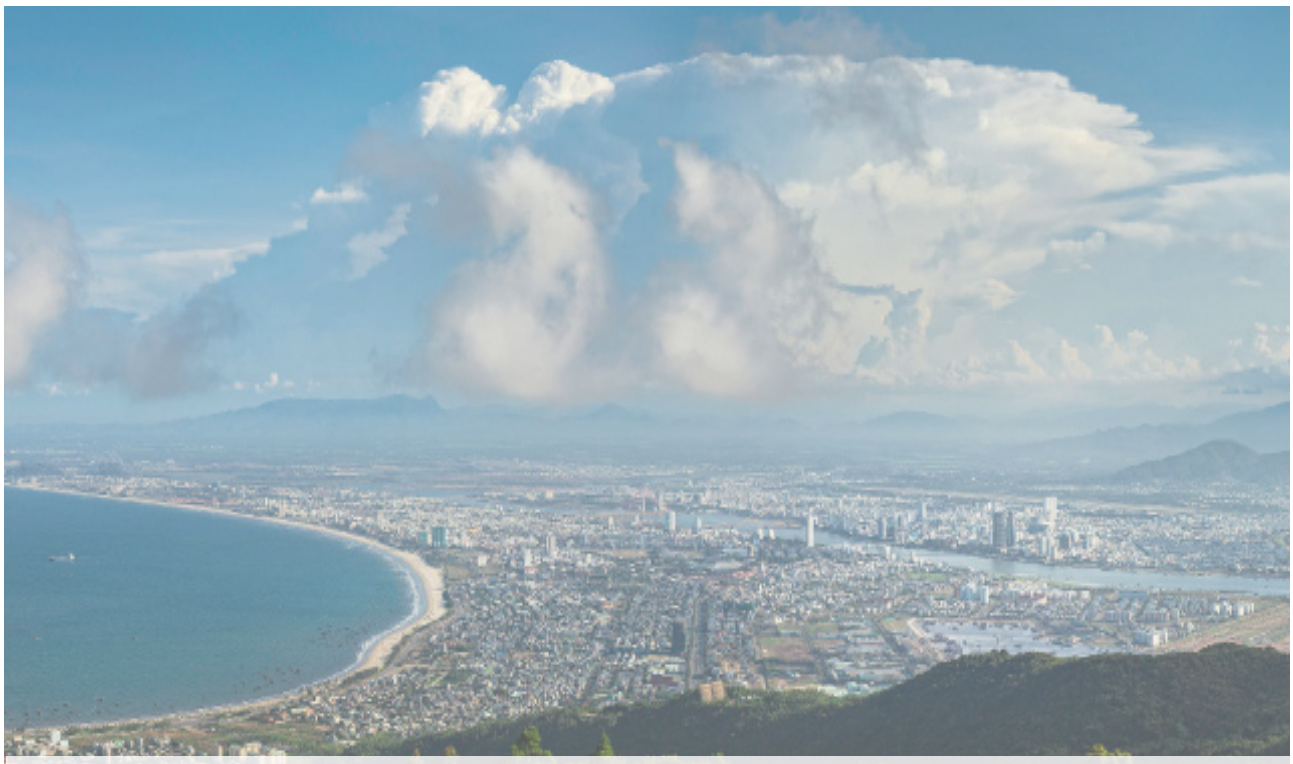
Food waste is gradually increasing in Da Nang. While this waste is used by the livestock industry for feeding animals, there is still a large amount of wasted food remaining which causes health problems for people. An effective food recycling technique can be adapted to Da Nang's situation to increase the use of food waste as a valuable resource such as agriculture fertiliser, as well as managing consumer choices of appropriate portion for their food amount.

Waste-to-energy technology deployment (link to energy section)

Waste is a valuable source for producing renewable energy. Currently, Da Nang city has very limited production of on-site renewable energy sources, and the deployment of a variety of on-site renewable energy sources is an key strategy for achieving the net zero target. The waste sector has great potential to make use of heat and power generation from its incineration plants, which can also off-set GHG emissions.

Reduce inequality and accelerate the local oriented circular economy system

An effective waste management system, recycling system (3Rs), increased community knowledge, and local sharing economy can bring a major social transformation to avoid the mass production of inefficient economic systems and mass consumer mentalities. However, these fundamental transformations require mature community networks and communications. Furthermore, sustainable neighborhood planning has to be organized effectively. Public spaces, green infrastructure, safe community parks, transport networks, energy systems & local markets are good examples of ways to make use of such local community networks, and should be considered to be basic part of the social infrastructure of local circular economy systems.



3.7 Integrated Urban Planning

Integration of sustainable living, biodiversity, and smart solutions for urban planning

Da Nang is aiming to become an economic, cultural, and sustainability center in Vietnam and Southeast Asia. The city hopes to accelerate innovation, green tourism, sustainable finance, advanced technology, and renewable energy deployment to achieve the net zero target by 2050. Integrated urban planning is needed to achieve ambitious goals and comprehensive sustainable city targets. These include generating a local green circular economy; planning for sustainable buildings, transportation and energy use; and enhancing local climate change resilience, healthy living, and social equity. All key action areas (Buildings, Transport, Energy, Agriculture & Food, Water, and Waste Management) have to be effectively integrated into the local development master plan to produce a sustainable Da Nang City. Nature conservation is also an additional key element in the city which should be integrated into local infrastructure plans, ecological tourism, as well as green investment plans.

1. Sustainable urban planning and lifestyles

1.1 Healthy living, neighborhood planning

Da Nang City is currently moving towards a compact urban fabric concept combining limited urban expansion with increasing population density. Buildings are planned for mixed use with a variety of functions, thereby creating lively and diverse urban services in urban neighborhoods, thus reducing mobility needs. All basic infrastructure is well connected to households, public buildings and industries. In Da Nang, more than 97% of households own a motorbike. Short distance trips can be made by walking and cycling, which also reduces motorcycle use, energy consumption and air pollution. These well-organized, clean and healthy neighborhoods can increase the well-being of their residents. Organic local (and urban) agriculture also contributes to air quality improvement and increases healthy living standards.

1.2 Energy transitions

Energy transition within the city is also an important element. Currently almost 100% of electricity comes from outside the city. To align with zero emission target and address energy security concerns, the city should increase energy production within the city using distributed generation principles. Rooftop PV has great potential for Da Nang as most of the land is covered by high, medium and small buildings. Producing energy from waste also has high potential to address Da Nang's energy needs. The energy production supply system can be transformed effectively as one of the circular economy concepts.

1.3 Responsible lifestyles and consumption (access to local market and basic services)

Transforming the lifestyles of local residents is one of the most important elements to achieve the carbon neutral and sustainable city target. Currently, huge steps are needed to improve the efficient access and use of basic services. Recently, food has increasingly become more centralized and large supermarkets have been developed within the city, while small farmers and local shops suffer from such rapid modernization. However, realizing local circular supply and responsible consumption loops, local production should be enhanced and connected to those platforms that are easily accessed by all types of local residents. Local markets have recently been highlighted in many advanced global cities. Da Nang has several of these local food markets which can be protected and revitalized.

1.4 Climate resilience (Disaster risk reduction)

Da Nang City is under threat from significant climate change impacts such as sea level rise, flooding and increasing urban temperature. Resilient planning specifically for coastal areas is needed. Water sensitive urban design has been adopted in several cities in Vietnam, which effectively integrates water cycle management into the built environment. This integrative planning has a variety of co-benefits: mitigating climate risks; creating platforms for social activities; increasing carbon sequestration; controlling soil erosion and sedimentation; increasing land value and people's well-being; and water conservation. One of the techniques refers to the multi-edge treatment of water front area. Water edge is the interaction between people, water and aquatic wildlife.

2. Biodiversity

Da Nang has established two principles for the ecological city concept:

1. Preservation of biodiversity
Urban biodiversity must be ensured by protecting natural habitat corridors and existing biodiversity, and providing easy access to nature for people. Urban biodiversity contributes to the vitality of urban landscapes as well as encouraging cultural diversity.

2. Design in harmony with the principles of nature
There must be a balance between inputs (resources, energy, and food) and outputs (waste, industrial products, and services). Creating a positive ecological circulation requires fundamental transformation, including material flows, resource closed cycles such as energy, and human lifestyles.

In addition to the two basic principles outlined above, other key elements that support regional biodiversity could also be addressed.

• Conservation of forests, green spaces and local agriculture
Forests in Da Nang City consist mostly of tropical, low-mountain, high-sloop rainforests, which have a high level of species diversity. By 2020, Da Nang completed three types of planning forests with a total area of 59,989.5 ha. However, insufficient quality of basic infrastructure, illegal logging, and illegal forest products have a negative impact the quality of the environment and biodiversity (Da Nang city, 2022)
Climate change has also resulted in storms, forest fires, and prolonged heat. In order to protect the biodiversity of Da Nang city, socioeconomic development should be evaluated based on its impacts on ecosystems and biodiversity loss. The transformation of current production models in agriculture, forestry, and fisheries should also be promoted.

3. Ecosystem Services

Greening the urban fabric can increase biodiversity, cool temperature, create shade, increase water absorption, trap dust, mitigate flood risks, and provide space for leisure and relaxation. Protecting and planting trees can also increase the tree canopy for citizens and visitors. These ecosystem services should be easily accessible everywhere by all. For public spaces and public roads, using permeable materials and increasing vegetation will help restore the permeability of the soil to capture groundwater. Such ecological surface materials can mitigate heat effects, pollution, and noise.

4. Da Nang's smart solutions

4.1 Smart infrastructures

Da Nang city has developed its smart city concept consisting of six pillars: 1) Smart management; 2) Smart economy; 3) Smart environment; 4) Smart living; 5) Smart citizens; and 6) Smart transportation. Smart cities are closely linked with urban infrastructure systems using advanced ICT. An intelligent operating centre is the core that links all smart system networks in a city. Buildings and transportation form the core system for basic urban infrastructures. Similarly, smart water management, smart hygiene and food security systems can also be connected. The local health system and education system are also part of the Smart living component and also encompass disaster risk prevention system. Smart citizens and Smart management are the part of city governance using advanced ICT systems which encourage more equal participation by all citizens on the the political and variety of city platforms.

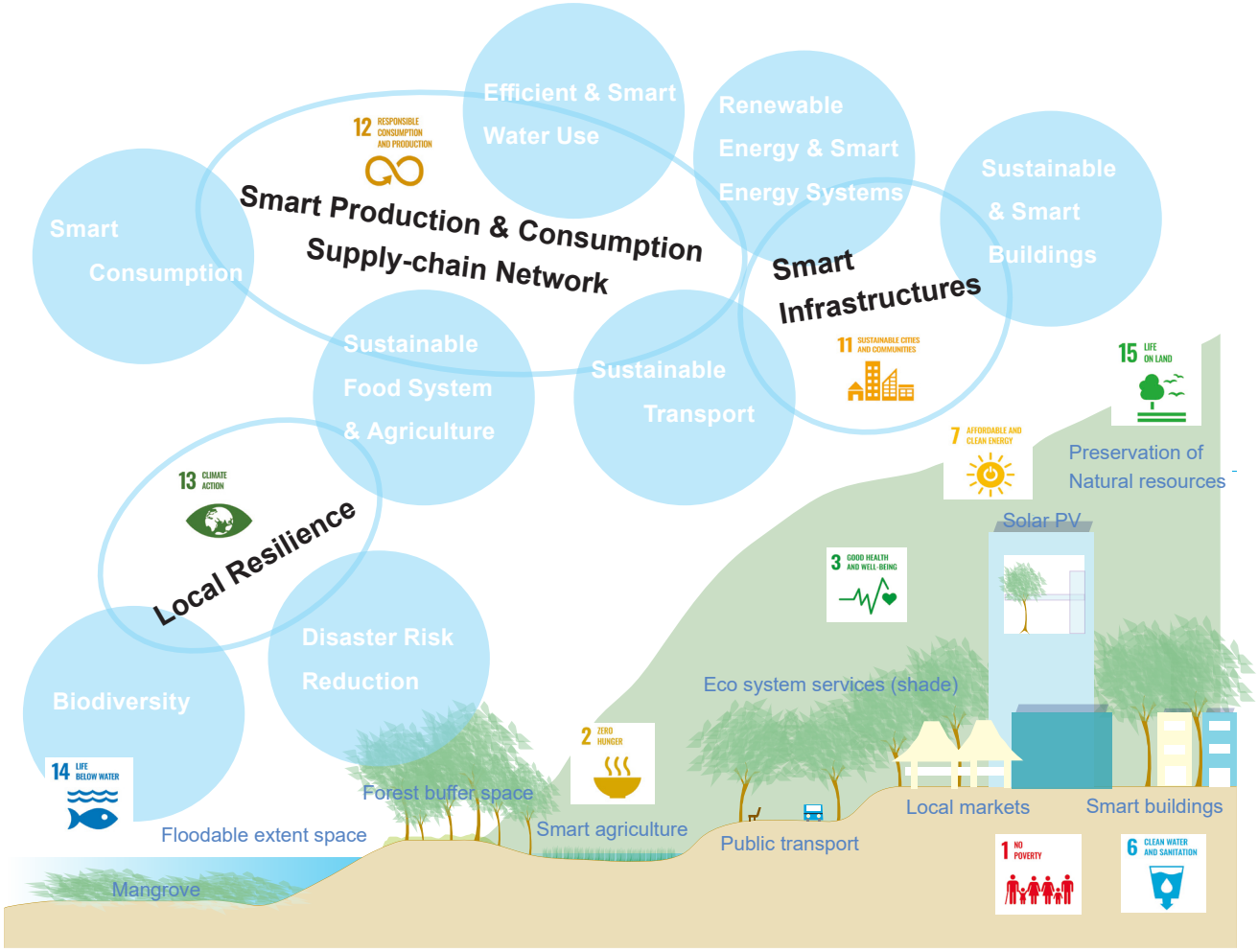
4.2 Smart agriculture and supply chain systems

In its sustainable growth strategy, Da Nang has planned a high-tech green agriculture which includes organic agriculture, offshore seafood associated with fisheries logistics, and forest protection. This is also the direction of modern, value-added, efficient, ecological products, and ensures food security. Applying advanced science and technology to create high quality economic values and sufficient market demand is a key target. This strategy aims to attract businesses to invest more in local agriculture and R&D to enable new advanced technology in that field.

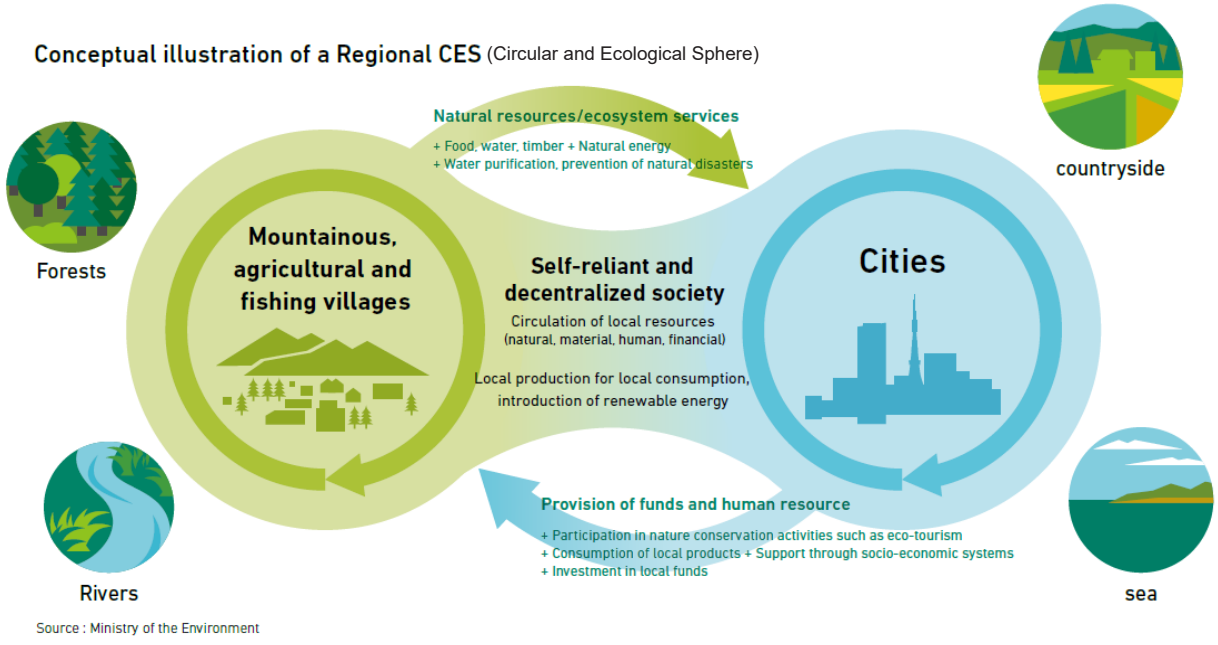
4.3 Cyber security and resilience

As global society has gradually been moving to mass digitization and the automation of various human activities, cyber security has to be maintained and secured. However, ensuring security requires more advanced technologies, and there needs to be more investment on R&D in this field. Moreover, increasing climate risks have caused a number of unpredicted natural disasters. This can be more precisely forecast using smart disaster risk prevention systems, which can effectively provide advanced warning to citizens to reduce related accidents.

Da Nang Green Growth & Smart Strategies



Regional Circular and Ecological Sphere Concept (Source: Ministry of the Environment Japan)



3.8 SDG Interactions

Climate change issues go far beyond the environmental dimension to enter the broader context of development and its sustainability. At the city level, climate challenges are strongly intertwined with other socioeconomic dynamics, such as poverty and inequality, public health, housing conditions, waste management, etc. Through the implementation of both mitigation and adaptation actions Da Nang is aiming to achieve multiple Sustainable Development Goals (SDGs).

To explore the connection between the climate actions in this plan and the SDGs, we rely on the existing literature in order to make sure that the linkages are supported by scientific evidence. We first group both the mitigation and adaptation actions prosed in broader categories and then assess their linkages with each global goal, as defined by the 2030 Agenda for Sustainable Development. We assume that all actions contribute, by definition, to achieve SDG11 on sustainable cities and SDG13 on climate change. Results of our analysis are reported in Table 3.8.1.

		Goal 1 - Poverty	Goal 2 - Hunger	Goal 3 - Health	Goal 4 - Educat	Goal 5 - Gender	Goal 6 - Water	Goal 7 - Energy	Goal 8 - Growth	Goal 9 - Infrastruct.	Goal 10 - Inequalities	Goal 11 - Cities	Goal 12 - Sustainability	Goal 13 - Climate	Goal 14 - Life Water	Goal 15 - Land	Goal 16 - Peace	Goal 17 - Partnership	Total
Agri &Food	Irrigation efficiency (M1)																		8
	Substitution of synthetic fertilizers (M2)																		6
	Dietary changes (M3)																		6
	Local/urban agriculture (A1)																		10
Transport	Sustainable transport (M1-5, A3)																		8
	Nature based-solutions and flood buffer zones (A1-2																		9
Buildings	Energy efficiency (M1-2-4; A1)																		14
	Building standards (M3)																		8
	Renewable energy (M5)																		16
	Waste reduction and recycling (M6)																		9
	Stormwater projects, water harvest/treat/reuse (A2																		11
	Reduce heat island effect (A3)																		7
	Information and education (A4)																		7
Total		7	7	11	5	3	8	8	6	8	4	13	8	13	6	5	5	2	119
By Sector	Agri &Food	1	4	3	1	0	4	1	1	1	0	4	2	4	1	2	1	0	30
	Transport	1	0	2	2	1	0	1	1	2	1	2	0	2	0	1	1	0	17
	Buildings	5	3	6	2	2	4	6	4	5	3	7	6	7	5	2	3	2	72
	Adaptation	5	3	6	3	2	3	5	3	4	3	7	5	7	3	3	3	1	66
	Mitigation	3	5	7	3	2	5	5	4	6	3	8	4	8	4	3	3	2	75

Table 3.8.1 Synergies between Da Nang climate change actions and the Sustainable Development Goals
(Author's analysis based on Davide et al. 2019)

Among the climate change actions proposed in this plan, those related to the building sector have the potential to unlock a higher number of sustainable development synergies. Deployment of renewable energy, improvement of energy efficiency and more effective water management through stormwater projects provide key opportunities for Da Nang to make progress in becoming a sustainable city, as wll as contributing to the national climate change strategy and at the same time reaching other important socio-economic objectives for its citizens.

Overall, major synergies of the actions proposed in this plan are related to health, energy, growth, food security (beyond SDG11- sustainable cities and SDG13- climate change).
In particular, implementing renewable energy and energy efficiency measures can unlock potential co-benefits for the Da Nang community in terms of improved access to sustainable and clean energy sources (SDG7), better and healthier living environment (SDG3) as well as increased economic opportunities.
Energy efficiency measures in the residential sector can reduce households' energy expenditure and thus contribute to reducing exposure and alleviate poverty (SDG1). In the commercial, public and business sectors, a more efficient use of energy and resources (waste) can free up economic resources that would otherwise be invested in other productive activities. The development of renewable energy expertise may also be beneficial in terms of job creation and enterprise development (SDG8). Sustainable agriculture practices offer large potential synergies in the food (SDG2) and health sectors (SDG3), by contributing to increase sustainable food production and reduce the carbon footprint and pollution of the agricultural sector. Sustainable public transport options play a crucial role in broadening access to basic services, especially for women (SDG5), improving infrastructure services and resilience (SDG9) as well as reducing air pollution exposure and road fatalities (SDG3).

Also adaptation measures offer the opportunity for Da Nang to build a resilient and prosperous future. Green infrastructure, such as nature-based solutions and buffer zones, aimed at providing heat-proof and flood-resilient urban pathways, are in line with the targets of improving the city's community health (SDG3), developing reliable, sustainable and resilient infrastructure (SDG9) as well as reducing exposure and vulnerability to climate-related extreme events of the poorer citizens (SDG1). Similarly, green building improvement and technologies to control thermal comfort, including green/PV roofs and facades, can further support the achievement of these objectives. Support to local and urban agriculture is compatible with food security objectives (SDG2) as well as with an increased awareness about the benefits of a sustainable and healthier diet.

All these measures are also important to protect the natural environment and at the same time to make the city more attractive, economically stronger, and more livable.
A comprehensive assessment of the synergies connected to climate change actions must consider that cities have been on the front line in coping with the COVID-19 pandemic and its impacts. Recent studies (Nethery et al., 2021) found that air quality matters in COVID-19 related mortality. By reducing both outdoor and indoor harmful pollutants, actions aimed at increasing the use of low-carbon transport modes, improving housing conditions, and deploying clean energy sources can help to build a healthier urban community. Also, an efficient urban transport system may help reach people in need. Larger green spaces and protected areas can improve the coexistence and health of animals whereas sustainable agricultural practices, including those avoiding intensive animal farming, can prevent transmissions between animals and spillover into human populations. Overall, the transformations induced by both mitigation and adaptation measures would allow Da Nang to prevent future challenges, better react to external health issues and, at the same time, alleviate pressure on the health care systems.

Some of the measures outlined in the plan may also pose potential challenges for Da Nang. The development of the urban area, through improved transport services and infrastructure, could attract more people from the rural areas toward the city and therefore put pressure on key resources such as water, affect the management of surrounding forests and arable lands, or impose some extra costs on society in the short term. In the building sector, modernization and innovation technologies to improve energy efficiency or deploy renewable energy sources sometimes may not be in line with the objective of preserving cultural heritage and promote tourism. However, as Table 3.8.1 shows, the number of synergies from climate action are well above the trade-offs, and to know in advance about potential challenges would allow the city administrators to prevent them and to put in place the necessary countermeasures in order to unlock long-term benefits.

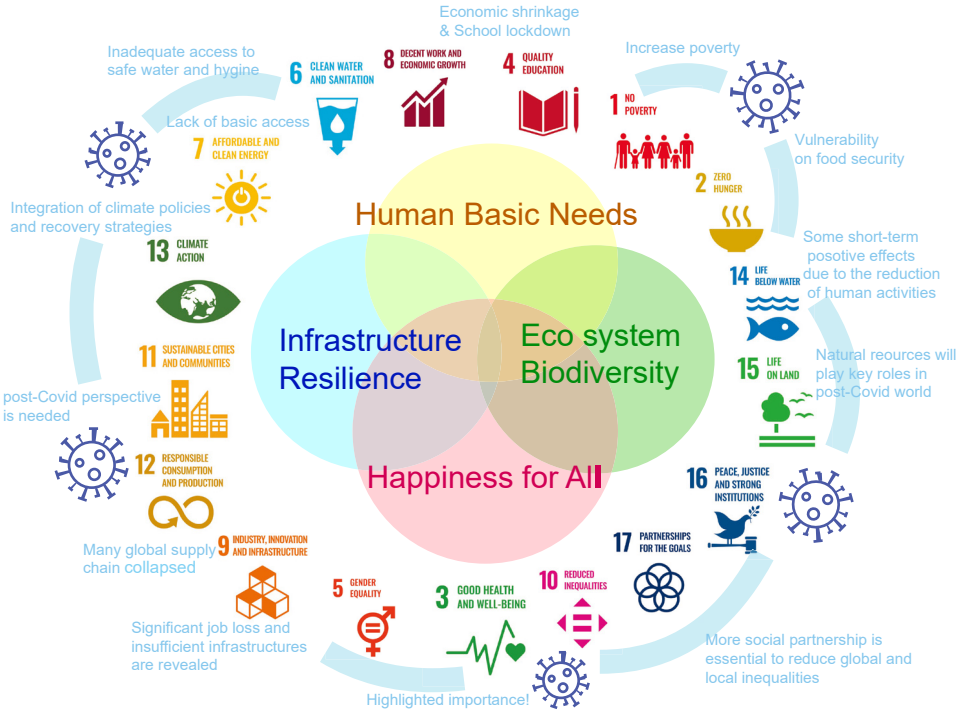


Figure 3.8.1 COVID-19 socio-economic impacts on SDGs (Developed by M.Kamei)

4. Moving Forward and Implementation

Da Nang City encourages its citizens to mobilize themselves. Therefore, it is essential to have an effective governance system involving all residents as well as a finance system which can realize sustainable transformation for society.

Governance system mobilizing citizens:

This climate action plan provides the first step to develop citizen's involvement and multi stakeholder discussions. The city needs to further develop an effective platform to share updated information and experiences. Digital tools can help to strengthen such a platform and coordinate a variety of collaborations. This platform should also include all stakeholders; policymakers, experts, businesses, scientists, and school children. A global platform like C40, can inform the latest global agenda on urban sustainable development issues and share updated knowledge and experiences. Climate change is not only a national and local issue, rather, global cooperation and partnership needs to be strengthened alongside local actions. Vietnam's government has already announced its Nationally Determined Contribution to realize the Paris Agreement target (Vietnam NDC, 2022). Da Nang is expected to be a national leader in making practical actions and realizing local targets. Da Nang's green growth strategy is consistent with the global and national agenda, and the city needs to promote its sustainable visions together with newly developing sectoral climate actions. To develop transparency for citizens and promote climate actions, the city needs to further develop an effective monitoring system in all related sectors, specifically building management, energy supply & demand management, and industry energy use. Policy evaluation also recognizes annual progress and identifies the gap in these targets. The planning, implementation, monitoring and evaluation processes should be coordinated under a climate action plan. Institutional arrangements, on the other hand, are also important to enable collaborations among necessary agencies within local and national contexts, and extend them to global networks.

Innovative finance system to support sustainable transitions:

The development of a practical finance system to support climate action is essential. The city should develop incentives for industry to promote green investment and invite global green businesses to the city. Da Nang should initiate public investments for renovation of public buildings and develop a green transport system as well as deployment of renewable energy. These public actions constitute good practices and can act as a showcase to the citizens so that they can take their own actions. The city and local banks may set priority investment areas and criteria for establishing green loan systems. EU taxonomy, for instance, has identified a list of environmentally-sustainable economic activities. These systems can motivate local businesses and steer investments in the right direction to achieve targets for carbon neutrality.

Further achievement of SDGs for Da Nang City:

Climate action comes under SDG13. However, Da Nang City needs to work on achieving other targets to realize its comprehensive sustainable vision. Therefore, this sectoral climate action plan contains various sectoral actions which are interlinked with multiple SDG targets. Over the next 10 years, energy systems, food security, and water supply should achieve a level of sufficiency for all citizens with an increase in the city's own supply chains. This is still a very challenging agenda, however, and an increase in local resource management and circular economic systems can ensure the security of human basic needs and local resilience. Da Nang City has been impacted by the COVID-19 pandemic in the same way as other global cities, and so the development of a community resilience framework is recognized to be a significant priority for maintaining a basic quality of living standards and human health.

Reference List

Asian Development Bank (ADB) (2009) Water: Vital for Vietnam's Future. 2009. https://www.adb.org/sites/default/files/publication/29806/water-vital-vietnam-future.pdf.

Cianga, N. and Popescu, A. C. (2013) Green Spaces and Urban Tourism Development in Craiova Municipality in Romania, European Journal of Geography, 4(2), pp. 34–45.

Chisholm, A., 2013. A blueprint for carbon emissions reductions in the UK water industry. London: CIWEM.

Da Nang City (2020) Da Nang Environment City Plan (ECP)

Da Nang City (2021) BUILDING DA NANG - AN ENVIRONMENTAL CITY' PERIOD 2021 - 2030, Da Nang.

Da Nang City (2021) Action Plan on response to climate change of Da Nang city

Da Nang City (2022) Environmental Status Report: Period 2016-2020.

Da Nang City, Viet Nam. n.d. UNESCAP. (2023) https://www.unescap.org/sites/default/d8files/2020-08/DaNangCity_0.pdf.

Davide, Marinella, Enrica De Cian, and Alexis Bernigaud. 2019. "Building a Framework to Understand the Energy Needs of Adaptation" Sustainability 11, no. 15: 4085. https://doi.org/10.3390/su11154085

EREA & DEA (2019) Vietnam Energy Outlook Report 2019

HDR (2023) 20 North American Climate Action Plans Reveal Hundreds of Waste Opportunities. accessed June 2023

Henchion, M. et al. (2014) 'Meat consumption: Trends and quality matters', Meat Science. Elsevier Ltd, 98(3), pp. 561–568. doi: 10.1016/j.meatsci.2014.06.007.

Hoang, Van (2022) Review of Da Nang Promotes Sustainable Agricultural Development. Edited by Nguyen Duc Nam. Da Nang Today. Viet Nam's Ministry of Information and Communications. November 4, 2022. https://baodanang.vn/english/business/202211/da-nang-promotes-sustainable-agricultural-development-3929113/.

Hong, B., Takahashi, Y. and Yabe, M. (2017) 'Determinants of Marketability for Organic Biomass Liquid Fertilizer from Human Waste in Da Nang City, Vietnam', Journal of Environmental Protection, 08(11), pp. 1354–1371. doi: 10.4236/jep.2017.811083.

Hiep, Hoang (2022) Review of Da Nang Eyes Measures to Promote Water Reuse. Da Nang Today. April 8, 2022. https://baodanang.vn/english/business/202204/da-nang-eyes-measures-to-promote-water-reuse-3909778/.

Huu Nghi, Tran (2016) Review of Hydropower Plant Development in Viet Nam's Central Zone and Central Highlands: A Trade-Off. Tropenbos International. December 12, 2016.

Kainuma, M., Pandy, R., Kamei, M., Nishioka, S., Ishikawa, T (2017) Climate actions and interactions with SDGs and S. Kimura (eds.), Energy Outlook and Energy Saving Potential in East Asia 2020, Jakarta: ERIA, pp.281-299.

Kieu, Thi Kinh, Karen Grattan, Bailey Goldman, Tran Thi Thuy Ha, Tran Thi Thu Thi, Amanda Pomeroy–Stevens, and Damodar Bachani (2022) Bringing Sectors Together in Da Nang, Vietnam: Participatory Systems Mapping. Journal of Urban Health 99 (4): 760–69. https://doi.org/10.1007/s11524-022-00650-6.

Kohlbacher, B. (2015) Urban agriculture in Da Nang and the utilization of by- products from waste water and solid waste processing for urban agriculture.

Long, P. N., & Dat, H. T. (2020). Application of GIS-Base GALDIT for vulnerability assessment to saltwater intrusion of Holocene coastal aquifer: a case of Quang Nam - Da Nang city, Vietnam. Vietnam Journal of Earth Sciences, 42(3), 298–310. https://doi.org/10.15625/0866-7187/42/3/15454

MacClune, Karen, Stephen Tyler, and Tho Nguyen. 2019. Review of TRANS-BOUNDARY RIVER BASIN MANAGEMENT in CENTRAL VIETNAM. Institute for Social and Environmental Transition - International. https://www.preventionweb.net/publication/da-nang-and-quang-nam-vietnam-trans-boundary-river-basin-management-central-vietnam.

Ministry of Construction of Viet Nam (2018) Guidelines for application of national technical regulations on energy efficient construction works QCVN 09:2017/BXD. Hanoi: Ministry of Construction.

Ministry of Industry and Trade of Viet Nam (2021) Renewable energy has accounted for 11.8% of the total electricity output of the whole system(https://moit.gov.vn/tin-tuc/phat-trien-nang-luong/nang-luong-tai-tao-chiem-11-8-tong-san-luong-dien-san-xuat-toan-he-thong-trong-thang-9.html

Mohr, Ing Marius, ed. (2014) Review of Concept for Wastewater Treatment on Son Tra Peninsula (Da Nang, Vietnam). Frauenhofer IGB. Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH . https://www.unescap.org/sites/default/files/Report_Concept%20for%20wastewater%20treatment,%20Danang.pdf.

Nhien, Thien. (2014) Review of Hydropower Plants Deplete Da Nang Tap-Water Sources. VietnamNet. September 18, 2014. https://vietnamnet.vn/en/hydropower-plants-deplete-da-nang-tap-water-sources-E111972.html.

Nhien, Thien. (2019) Review of Waste and Wastewater Problems in Da Nang, the "Livable City." VietnamNet. October 30, 2019. https://vietnamnet.vn/en/waste-and-wastewater-problems-in-da-nang-the-livable-city-583176.html.

Nguyen, A. T. & Reiter, S., 2014. A climate analysis tool for passive heating and cooling strategies in hot humid climate based on Typical Meteorological Year data sets. Energy and Buildings, Volume 68, pp. 756-763.

Nguyen, M.B. (2021) Viet Nam Country Report, in Han, P. OECD (2021) Assessment of a social discount rate and financial hurdle rates for energy system modelling in Viet Nam. https://doi.org/10.1787/a4f9aff3-en

Ostojic, Dejan R., Ranjan K. Bose, Holly Krambeck, Jeanette Lim, and Yabei Zhang (2013) Chapter 8: Da Nang. Energizing Green Cities in Southeast Asia. https://doi.org/10.1596/978-0-8213-9837-1.

Otani, T., Toyosada, K. and Shimizu, Y., (2015) CO2 reduction potential of water saving in Vietnam. Water, 7(5), pp.2516-2526.

Parsons et al. (2013)Policy brief on carbon sensitive urban water futures. Trust, January

Prime Minister Approves Adjustments to Da Nang City Master Plan (2021) Nhan Dan Online. March 16 2021 https://en.nhandan.vn/prime-minister-approves-adjustments-to-da-nang-city-master-plan-post95862.html.

Reuther, S. and Dewar, N. (2006) Competition for the use of public open space in low-income urban areas: The economic potential of urban gardening in Khayelitsha, Cape Town, Development Southern Africa, 23(1), pp. 97–122. doi: 10.1080/03768350600556273.

Ribbe, Lars, Viet Trinh, Firoz Abm, Anh Nguyen, Uyen Nguyen, and Alexandra Nauditt. (2017) Integrated River Basin Management in the Vu Gia Thu Bon Basin, 153–70. https://doi.org/10.1007/978-981-10-2624-9_10.

Schram-Bijkerk, D. et al. (2018) Indicators to support healthy urban gardening in urban management, Science of the Total Environment. Elsevier B.V., 621, pp. 863–871. doi: 10.1016/j.scitotenv.2017.11.160.

Soga, M. et al. (2017) Health benefits of urban allotment gardening: Improved physical and psychological well-being and social integration, International Journal of Environmental Research and Public Health, 14(1). doi: 10.3390/ijerph14010071.

The Blair, D., Giesecke, C. C. and Sherman, S. (1991) A dietary, social and economic evaluation of the Philadelphia urban gardening project, Journal of Nutrition Education. Society for Nutrition Education and Behavior, 23(4), pp. 161–167. doi: 10.1016/S0022-3182(12)81191-5.

The Socialist Republic Of Vietnam (2020) Updated NATIONALLY DETERMINED CONTRIBUTION (NDC), Hanoi.

Thi An, Tran, Saizen Izuru, Tsutsumida Narumasa, Venkatesh Raghavan, Le Ngoc Hanh, Nguyen Van An, Nguyen Vinh Long, Ngo Thi Thuy, and Truong Phuoc Minh (2022) Flood Vulnerability Assessment at the Local Scale Using Remote Sensing and GIS Techniques: A Case Study in Da Nang City, Vietnam. Journal of Water and Climate Change, August. https://doi.org/10.2166/wcc.2022.029.

Tran, Phong, Stephen Tyler, Than Huynh, Ha Nguyen, and Tran Viet Dung. (2017) Review of Experience of Urban Development and Climate Change Adaptation in Da Nang City. PreventionWeb: Institute for Social and Environmental Transition - International Asian Cities Climate Change Resilience Network. https://www.preventionweb.net/publication/experience-urban-development-and-climate-change-adaptation-da-nang-city.

UN Habitat (2021) Green Growth City Development Strategy for Da Nang

Van Don, Than (2021) Review of RESEARCH for REASONABLE DISTRIBUTION of SURFACE WATER RESOURCES for vu Gia - Thu Bon River Base. Ministry of Resources and Environment, Institute of Science, Hydrology, and Climate Change.

VNA. (2020) Review of Da Nang Develops High-Tech Agriculture. Vietnam+. October 12, 2020. https://en.vietnamplus.vn/da-nang-develops-hightech-agriculture/188420.vnp.

Vietnam Stastical Publishing House (2020) Completed Results of the 2019 Vietnam Population and Housing Census

Water Users/Stakeholders - BASIN INFO – Web Based River Basin Information System." n.d. Www.basin-Info.net. (2023) http://www.basin-info.net/river-basins/vu-gia-thu-bon-information-centre-vietnam/water-users-stakeholders.

Willett, W. et al. (2019) Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems, The Lancet, 393(10170), pp. 447–492. doi: 10.1016/S0140-6736(18)31788-4.

Win, E. P. et al. (2020) Greenhouse gas emissions, grain yield and water productivity: a paddy rice field case study based in Myanmar, Greenhouse Gases: Science and Technology, 10(5), pp. 884–897. doi: 10.1002/ghg.2011.

World Bank (2013) Energizing Green Cities in Southeast Asia. https://doi.org/10.1596/978-0-8213-9837-1

Working Team

Coordinating lead authors:

Miho Kamei (IGES)

Anh-Tuan Nguyen (The University of Da Nang)

Section contributions (Working team):

1. Miho Kamei (IGES) & all members
2. Nguyen Dang Mau (IMHEN), Dam Viet Bac (IMHEN), Miho Kamei (IGES)

3.1 Buildings : Anh-Tuan Nguyen (The University of Da Nang), Miho Kamei (IGES), Pamela Fennell (UCL)

3.2 Transport : Miho Kamei (IGES), Peter Jones (UCL)

3.3 Energy System : Miho Kamei (IGES)

3.4 Food & Agriculture: Louise Guibrunet (UNAM), Miho Kamei (IGES)

3.5 Water System: Lili Boenigk (Columbia University), Laureline M. Josset (Columbia University), Nguyen Dang Mau (IMHEN), Dam Viet Bac (IMHEN), Anh-Tuan Nguyen (The University of Da Nang)

3.6 Waste Management: Le Hoang Son (The University of Da Nang), Alejandro Rivero (CDMX), Miho Kamei (IGES)

3.7 Integrated Urban Planning: Miho Kamei (IGES), Perrine Hamel (NTU), Kathryn Davies (Tufts University), Louise Guibrunet (UNAM), Dam Viet Bac (IMHEN), Thi-Ha-Thanh Mac (The University of Da Nang), Anh-Tuan Nguyen (The University of Da Nang)

3.8 SDGs Interactions: Marinella Davide (CMCC), Miho Kamei (IGES)

4. Moving Forward & Implementations:Miho Kamei (IGES) & all members

Acknowledgements

The author team gratefully acknowledges the support and collaboration of Da Nang City, specifically the Department of Nature Resource and Environment (DONRE), in developing the initial idea and recommendations for Da Nang City sectoral climate actions. This publication has been supported by the Ministry of the Environment, Japan (MOEJ) under the "city-to-city collaboration project between Yokohama City and Da Nang City", and IGES Strategic Research Fund. Da Nang City, DONRE, kindly organized and chaired the stakeholder discussion workshop in January 2022, and the experts workshop was hosted by The University of Da Nang in January 2023. This publication has been developed and revised through in-depth communications with city-related departments. The key information and images (under the copyright of Da Nang City) have been provided by DONRE. The author team intends to continue collaboration and aims to develop a further technical report based on this first framework and sectoral climate action report. The author team would also like to acknowledge Yokohama City for its continuous collaboration under the MOEJ project, the advisory boards, Prof. Peter Jones, Prof. Ryozo Ooka, and Dr. Pamela Fennell for their support as advisors throughout the project. Our thanks also go to Dr. Shuzo Nishioka, Dr. Mikiko Kainuma, Prof. Keisuke Hanaki, Prof. Kazuo Matsushita, Dr. Xin Zhou, Dr. Mark Elder, and Dr. Joana Portugal Pereira for their valuable review comments to improve the report, and finally to Ms. Emma Fushimi for her English editing.