Adaptation Strategy to Climate Change in Taiwan

Council for Economic Planning and Development

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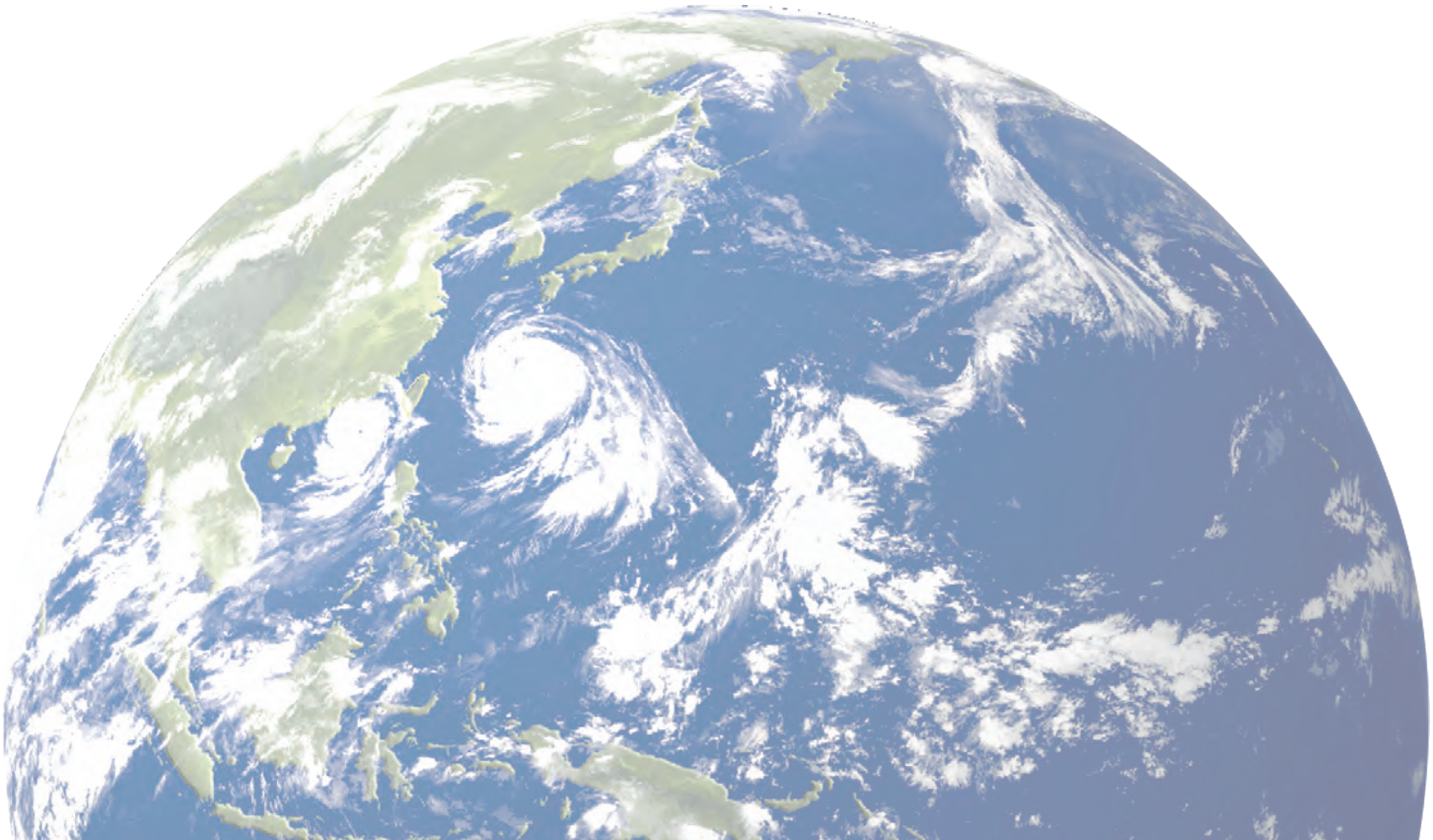

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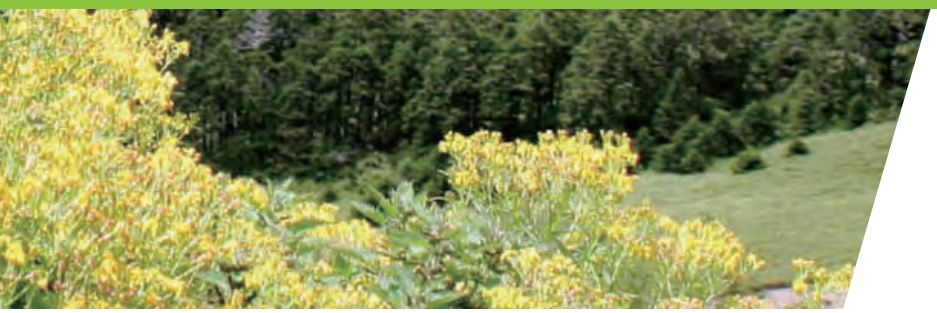
1 Preface

As the global economy grows on the back of our consumption of natural resources, most notably on fossil fuels and forest, the disruption of the planet's carbon cycle has given rise to worldwide phenomena known as global warming and climate change.

The impact of climate change has been well-documented over the past decade, during which Taiwan's drastic increase in rainfall has led to a direct loss of property and human lives. Over the years, climate change has left indelible marks on our world – ecologically, financially, socially, politically and culturally, our lives have been irreversibly altered. This trend of volatile weather, also known as global warming, is a unique topic by its own definition, and thus the special characteristic of global warming should be taken into consideration while governing issues related to it. First of all, climate is a global and intergenerational public good. The greenhouse gases (GHGs) accumulated globally will affect every corner of the world not just now, but also in the unpredictable future, and their influence on any individual will not lessen even when more people are affected. Moreover, it is our generation's duty to ensure that this commons, which we share with countless future generations, will remain part of our legacy in preserving life on this planet.

Another notable property of climate change is its sheer scale – overtaking all manmade boundaries, this fundamental shift in the global weather system is occurring in every place in the world, and is now considered to be a common threat to human security in every field. No longer can governments rely upon traditional problem-solving methods when dealing with issues related to climate change; instead of dividing the task among different agencies and experts, we need to look into cross-referencing knowledge from diverse fields and think beyond the ordinary framework between central and local governments in order to overcome this new challenge. Uncertainty, especially in regard to time and space, is another intrinsic trait of climate change. Studies by the United Nations and other international agencies all predict varying scenarios of extreme impact. However, one fact remains clear – efforts to mitigate the impact of climate change need to be made as soon as possible, as any delays will result in compounded costs and damages.

For the above reasons, measures devised to ease the effects of climate change not only need to be implemented as swiftly as possible, but also need to be formulated to minimize risks even though we are still uncertain about the effects of climate change. As part of the government's efforts to strengthen the island's adaptive capacity, to lower its social vulnerability and to establish integrated operating systems, the Executive Yuan has drawn up the National Climate Change Adaptation Policy Framework which serves as the foundation for implementing a comprehensive strategy in the face of global climate change.



1.1 Climate Change

The Intergovernmental Panel on Climate Change (IPCC), a scientific research body established by the United Nations, released four reports in 1990, 1995, 2001 and 2007 citing evidence on the rise of climate change due to human activity. The IPCC pointed out that, capitulated by industrialization, global weather has grown more unstable starting from the 1950s. This imbalance has triggered many rapid, non-linear, and unpredictable effects, especially in the fields of physics, chemistry and biology. Global warming, for example, is one of the best-known effects of atmospheric change.

Due to the rapid elevation in concentration of greenhouse gases, which include water (H2O), ozone (O3), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4); compounds like chlorofluorocarbons (CFCs), halo alkanes (HFCs) and hydro-chlorofluorocarbons (HCFCs), per fluorinated compounds (PFCs) and sulfur hexafluoride (SF6), global temperatures have soared, causing various kinds of climate change and unleashing critical damage upon our surroundings, infrastructures and economies. During the 20th century alone, carbon dioxide levels in the world's atmosphere have increased by 30 percent, translating into an increase of 0.7°C in the Earth's surface temperature. While the usage of fossil fuels is one of the leading contributors of greenhouse gases on a global scale, urbanization and the change in land use are also to blame for exacerbating the effects of climate change.

The effects of climate change on our planet are unmistakable, and include the accumulated emissions of GHGs, the changing composition of the atmosphere, the rising temperature on the Earth's surface, and the changing global climate pattern. Climate change has disrupted the planet's water cycle, increasing the frequency of precipitation and evaporation while leaving little opportunity for snowfall. Rising global temperatures have increased the chance for heat waves to occur, causing more regions to face the problem of drought. Last, but not least, the increasing occurrence of tropical cyclones and rising sea levels may also cause tremendous natural disasters.

1.2 Mitigation and Adaptation

As the effects of climate change have become more apparent by the day, the modern challenges we are facing now include adapting to the impact caused by climate change, and reestablishing the natural balance of the environment to ensure national security and maintain sustainable development. From the start of its discovery, the greenhouse effect has been the target of various mitigation proposals developed by the United Nations, governments around the world as well as non-governmental organizations. Movements that have proved to be successful in mitigating the effects of climate change include the promotion of energy-conserving habits, the improvement of energy-efficient technologies, the development of fresh and renewable energy sources, the improvement of CO2-reducing methods, etc. Global warming and climate change, however, can no longer be reversed by simply cutting down on greenhouse gas emissions; therefore, ensuring humanity's survival and seeking for continual development under extreme weather circumstances

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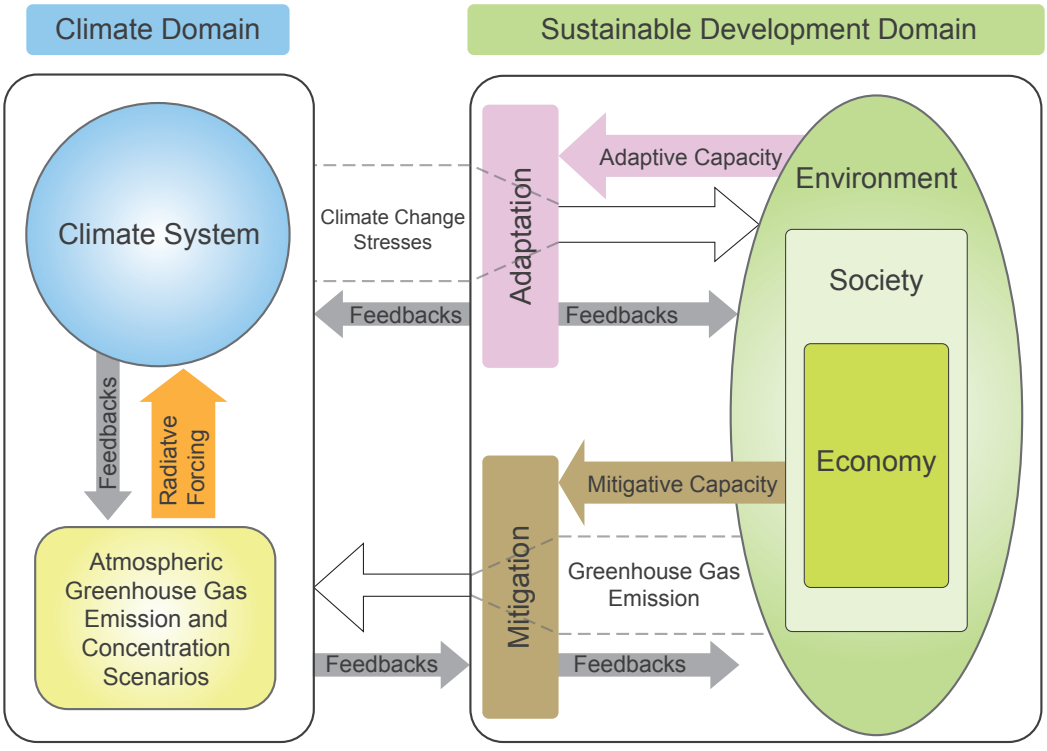
has become a top governmental priority. In short, the development of adaptation and mitigation strategies that focus on adjusting social and economic systems has become a nation's forte against the threats of climate change.

1.2.1 Mitigation

Mitigation refers to the disruption of greenhouse gas levels through human intervention for the purpose of mitigating the rate and scale of climate change. This method is concerned with either reducing the emissions or increasing the storage capacity of GHGs. The United Nations has held several large-scale meetings in the hope of garnering international support and cooperation on carbon-reduction schemes, thus mitigating the impact of climate change. 154 nations signed the United Nations Framework Convention on Climate Change (UNFCCC) at the 1992 Earth



Sources: Adapted from Munasinghe and Swatt, 2005. Primer on Climate Change and Sustainable Development: Facts, Policy Analysis and Applications. Cambridge University Press: Cambridge.

Summit in Rio de Janeiro, Brazil. In 1997, the UNFCCC was updated with the Kyoto Protocol, a legally binding protocol adopted in Kyoto that required all signatories to commit to lowering their greenhouse gas emissions within a set schedule. Due to conflicts among the participants, however, the full force of the Kyoto Protocol was delayed until February 2005. The 2009 Earth Summit held in Denmark did not reach a consensus regarding the new mitigating objective after the Kyoto Protocol expires in 2012. The summit merely resulted in the legally non-binding Copenhagen Accord, which outlined the need to prevent global temperatures from increasing by more than 2°C. Participants had agreed to continue combating climate change, to provide immediate and long-term financial aid to fellow nations that are most at risk due to their high vulnerability, and to attempt to transform the accord into a legally binding document within two years. Although subsequent attempts to legalize the accord failed, in the 2010 United Nations Climate Change Conference held in Mexico, nations came to a consensus formally known as the Cancun Agreements, in which an Adaptation Committee was established to reinforce actions in adaptation; a policy of Nationally Appropriate Mitigation Actions (NAMAs) was agreed upon to allow participants to choose their environmental priorities; and all countries were allowed to formulate their own carbon-reduction commitment. These measures resulted in a bottom-up global carbon-reduction trend. A Green Climate Fund, a Technology Mechanism and a Climate Technology Centre and Network were also established to aid the transfer of funds and technology from developed nations to developing nations, assisting these countries to enhance their mitigative and adaptive capacities.

Regardless of these developments, in considering the process of consensus building and promoting a mitigation strategy, the reality is that even though the practical emission-reducing goals are set, the accords are ratified, and countries are starting to work together in mitigating GHG emissions, the effects of climate change cannot be completely negated.

As a dutiful citizen of the global community, the Republic of China has pledged to play its part in mitigating the effects of greenhouse gases. In response to climate change and current international circumstances in energy and the environment, during its 3095th session in 2008, the Executive Yuan ratified the Sustainable Energy Policy, declaring the nation's targets of returning to 2005 carbon emission levels by 2020 (a 45% business-as-usual reduction), and returning to 2000 carbon emission levels by 2025.

In order to meet the nation's carbon-reduction targets, the Executive Yuan also founded the Energy Saving and Carbon Reduction Promotion Commission in 2009 to draft the National Master Action Plan on Energy Saving and Carbon Reduction. This action plan, which is divided into 10 topics and 35 subgroups, includes various aspects such as updating the nation's environmental laws and policies, developing a low carbon energy system and carbon-reducing community, financing eco-friendly industries, constructing greener transportation networks, building greener landscapes and green buildings, investing in carbon-reducing technology, promoting carbon-reducing infrastructure, reinforcing the concept of carbon-reduction into public and school education, and persuading the public to adopt greener lifestyles,

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etc. The goal is to lead the low carbon development through government policy and create an energy-conserving and carbon-reducing society. It is hoped that Taiwan can reach its goal of carbon reduction and transform itself into a low carbon island in both social and economic respects.

1.2.2 Adaptation

Adaptation refers to modifying natural or manmade systems in an attempt to respond to the impact of climate change, to alleviate the effects of climate change, and to develop favorable opportunities. The purpose of adaptation is to minimize a manmade or natural system's vulnerability and negative impacts under extreme climate change and global warming, and maximize the benefit under climate change. Whereas mitigation focuses on curtailing the cause of climate change through active intervention, adaptation attempts to reduce the impact of climate change. Both strategies will affect each other.

To better assist governments in setting up and implementing frameworks to adapt to the effects of climate change, the United Nations Development Program (UNDP) has drafted an Adaptation Policy Framework (APF) as a reference for designing and implementing vulnerability-reducing action plans. By following APF guidelines, nations can not only minimize the potential negative impacts, but can also profit from the expected changes brought about by climate change.

Vulnerability

Vulnerability, as defined by the Intergovernmental Panel on Climate Change (IPCC), is “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.” The main components that affect vulnerability are: the system's exposure to climate change, its changing trait, intensity, frequency, sensitivity, and adaptive capacity.

1.3 The Nation's Adaptation Policy Framework

Due to its geographical location and geological properties, the island of Taiwan regularly encounters natural disasters such as earthquakes, typhoons, mudslides and flash floods, all of which will be exacerbated by climate change. In recognition of this growing threat, the Executive Yuan has been rapidly expanding the function of its National Council for Sustainable Development (NCSD) since 2009. This includes the creation of the NCSD's working group, the Energy Conservation, Carbon Reduction and Climate Change Working Group, which now serves as a platform for promoting mitigation and adaptation policies. The Working Group is jointly led by the Environmental Protection Agency (EPA) and the Council for Economic Planning and

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Development (CEPD).

For the purpose of enhancing our nation's adaptive capacity, minimizing the society's vulnerability, integrating regional resources to establish a centralized network, and setting up an implementation basis for policy structure and plan promotion, CEPD entrusted Vice President Liu Chao-Han from Academia Sinica to form a multidisciplinary consultation team, and CEPD further established a Task Force for Formulating and Promoting the Climate Change Adaptation Policy Framework and Action Plan on January 29, 2010. This Task Force is composed of high-level officials of related agencies, experts, scholars, representatives of non-governmental organizations (NGO) and industries. This Task Force will keep on monitoring and coordinating the progress of the Adaptation Policy Framework and Action Plan.

After taking into consideration Taiwan's unique environmental characteristics and experience, CEPD has defined eight sectors under the Task Force. More than one of the ministries and councils work together cooperatively in order to implement each sector's adaptation policies. A specific ministry or council is assigned to be the lead agency of each sector as listed below. Each ministry and council may establish its own working group when needed.

Disasters : National Science Council (NSC)

Infrastructure: Ministry of Transportation and Communications (MOTC)

Water Resources: Ministry of Economic Affairs (MOEA)

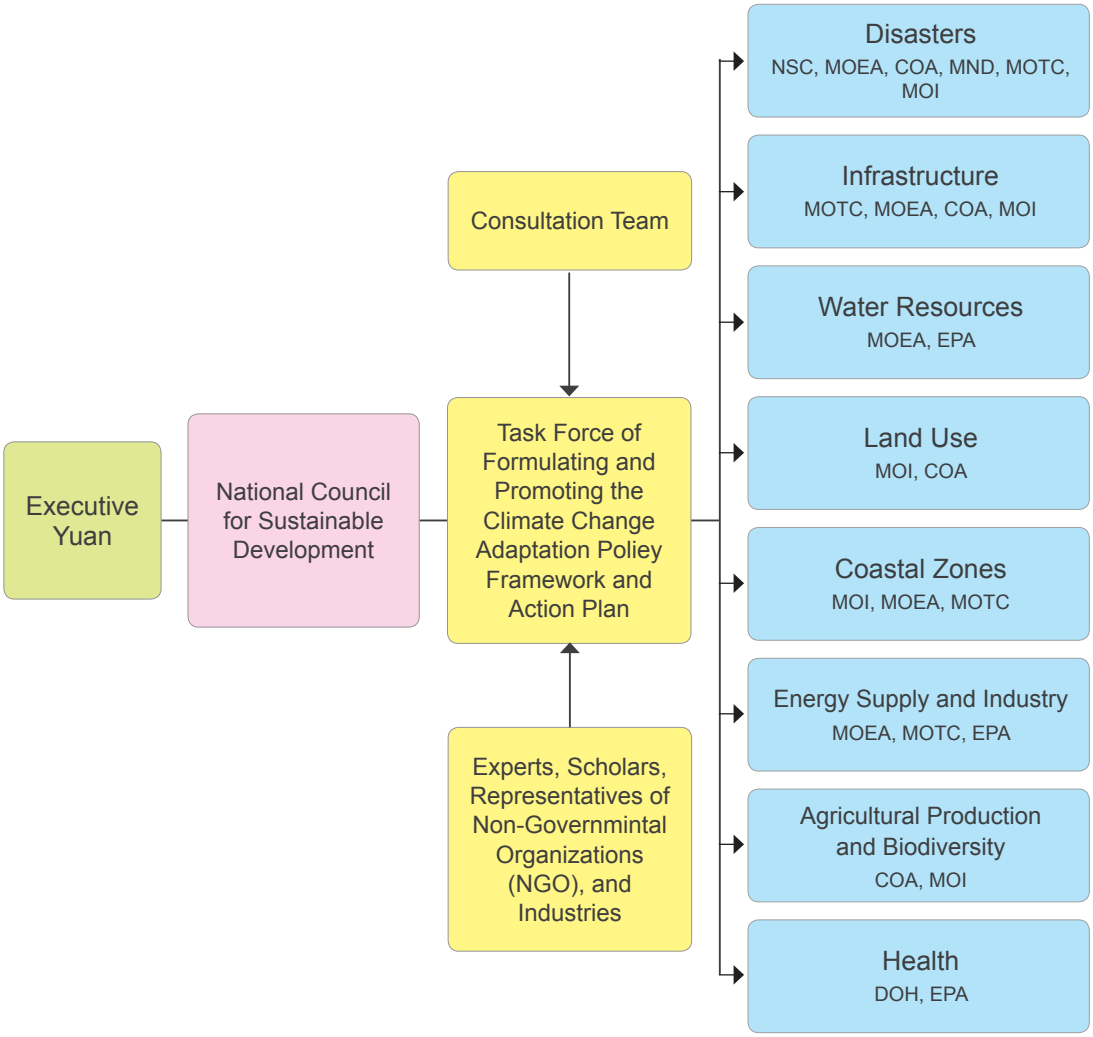
Land Use: Ministry of the Interior (MOI)

Coastal Zones: Ministry of the Interior (MOI)

Energy Supply and Industry: Ministry of Economic Affairs (MOEA)

Agricultural Production and Biodiversity: Council of Agriculture (COA)

Health: Department of Health (DOH)



The Organization of the National Adaptation Policy Framework

Note: The Agencies and their Abbreviations are listed below:

National Science Council (NSC)

Ministry of Economic Affairs (MOEA)

Coast Guard Administration (CGA)

Ministry of National Defense (MND)

Ministry of Transportation and Communications (MOTC)

Ministry of the Interior (MOI)

Council of Agriculture (COA)

Environmental Protection Administration (EPA)

Department of Health (DOH)

2 The Future Scenarios of Climate Change in TAIWAN

The Intergovernmental Panel on Climate Change (IPCC) under the United Nations has over the years released a series of reports documenting the effects of climate change as well as future climate projections based on current data. Many Taiwan-based research agencies have also been analyzing the climate change in the past and projecting future climate scenarios. The National Science Council (NSC) published “The Science Report of Taiwan Climate Change 2011” in 2011. This comprehensive report, which includes all the latest scientific advances and technological developments on climate change research in Taiwan, is used by this policy framework as the reference for projecting Taiwan's future climate change scenario. The following is a quick overview of the report, including past climate change and future climate projections in Taiwan.

2.1 Climate Change in Taiwan

2.1.1 Temperatures

The warming trend in Taiwan is significant. The rise in temperature averaged for the last thirty, fifty and one hundred years all reflects this fact. According to the statistics derived from observations in Taipei, Taichung, Tainan, Hengchun, Taitung, and Hualien, meteorological stations with records longer than a century, the annual mean temperature in the flatland of Taiwan has increased by 1.4 °C between 1911 and 2009. This is equivalent to an increase of 0.14°C per decade, which is higher than the global mean warming rate of 0.07 °C per decade. Over the past thirty years (1980-2009), the warming rate has risen to 0.29°C per decade, which is almost double the rate calculated over the century. That the warming rate has accelerated in recent years

Temperature change in Taiwan over the past century

The statistics derived from the observations of 25 Central Weather Bureau meteorological stations (situated in the flatlands, mountains, metropolitan areas, and outlying islands) show that the annual mean temperature has increased by 0.8 °C over the past century (1909-2008) in Taiwan. In the metropolitan areas, the mean temperature increase over the past century has been 1.4 °C, the same as that quoted from the NSC's “The Science Report of Taiwan Climate Change 2011”, which took measurements from the six flatland meteorological stations of Taipei, Taichung, Tainan, Hengchun, Taitung and Hualien. Over the past century, the mean temperature increase has been 0.6°C in mountainous areas, 0.9 °C in western Taiwan, and 1.3 °C in eastern Taiwan, which is slightly higher than the global mean temperature increase (0.7°C). The sea surface temperatures of the nearby basins of Taiwan have also experienced average increases of 0.9 to 1.1 °C over the past century.

is consistent with the conclusion drawn by IPCC's fourth assessment report (AR4). In addition, warming in the stations along the eastern coast has taken place much more rapidly than in those along the western coast.

In terms of seasonal characteristics, warming has been most prominent in autumn over the past century in Taiwan. However, it has been winter that warmed the fastest over the last thirty years. The number of days with high temperature has shown an increasing trend for the past one hundred years. Among the six meteorological stations referred to above, Taipei has exhibited the fastest increasing trend, which has been 1.4 days per decade for the past one hundred years, two days per decade for the past fifty years, and four days per decade for the past thirty years, respectively. On the other hand, the occurrence of extreme cold events has decreased significantly. Cold surge events decreased prominently after 1985, which never occurred before 1985.

2.1.2 Rainfall

Statistics on Taiwan's annual rainfall have not exhibited a significant trend over the past century. Further examination by averaging the data over decades, however, shows that precipitation did present dry and wet variations over decadal timescales. One of the most noticeable facts is that the annual total rain days averaged over Taiwan has decreased significantly. The rain days have exhibited a decreasing trend of -4 days per decade over the past one hundred years, and the decreasing rate has accelerated to -6 days per decade over the past thirty years. This indicates that the trend of decreasing rain days has recently become more discernible. The years from 2002 to 2004, when the latest drought occurred, were the three years with the minimum numbers of rain days over the past one hundred years. In terms of seasonal characteristics, rain days in all four seasons exhibit decreasing trends, among which the summer rain day shows the fastest decreasing rate. Furthermore, days of torrential rain (defined as daily rainfall $\geqq$ 200mm) have exhibited a significant increasing trend over the past fifty years and past thirty years, as well as the number of typhoons with extremely intense rainfall for the past decade. The light rain days (daily rainfall <1.0 mm), which benefit irrigation and the nation's water resources, have decreased substantially, with a decreasing trend of -2 days per decade in the past one hundred years and -4 days per decade in the past thirty years. This reflects the extreme decline in light rain days.

For more information on the changes in Taiwan's average temperatures and precipitation, please see Appendix I.

2.1.3 Rising Sea Level

From 1993 to 2003, the sea level in nearby basins of Taiwan rose by the rate of 5.7 mm yr-1, which was twice the rising rate over the past fifty years and was slightly higher than the 5.3 mm yr-1 rate derived from satellite observation. This rate is substantially higher than the global average rate of 3.1 mm yr-1. In addition to the effect of mean sea level rise resulting from global warming, the accelerated rising rate of sea level near Taiwan may be partly attributed to regional causes, including the falling sea level in the eastern Pacific Ocean, the steadily

The Future Scenarios of Climate Change in TAIWAN

rising sea level in the western Pacific Ocean, the effects of climate variations such as ENSO (El Niño-Southern Oscillation), and the changes in sea level of nearby basins (such as the South China Sea).

2.2 Future Climate Change Predictions

Using the IPCC-developed scenario of A1B, which is considered by the international science community as the most likely future outcome, the NSC has come up with a list of climate change projections upon the island of Taiwan by using spatial downscaling.

In terms of Taiwan's near-surface temperatures, the majority of climate models project that, relative to the end of the 20th century, the temperature increases at the end of the 21st century will range between 2°C and 3°C, which are slightly lower than the averaged global temperature rises. In terms of regional and seasonal changes, northern Taiwan will likely warm faster than southern Taiwan, and spring will be least affected by climate change.

In terms of precipitation, the global trend of greater disparities between wet and dry seasons will continue in the 21st century. The mean winter precipitation in northern, central, southern, and eastern Taiwan is projected to decrease in the future, with about half of the model projections lying between -3% and -22%. In southern Taiwan,

Photo provided by Tourism Bureau, R.O.C.

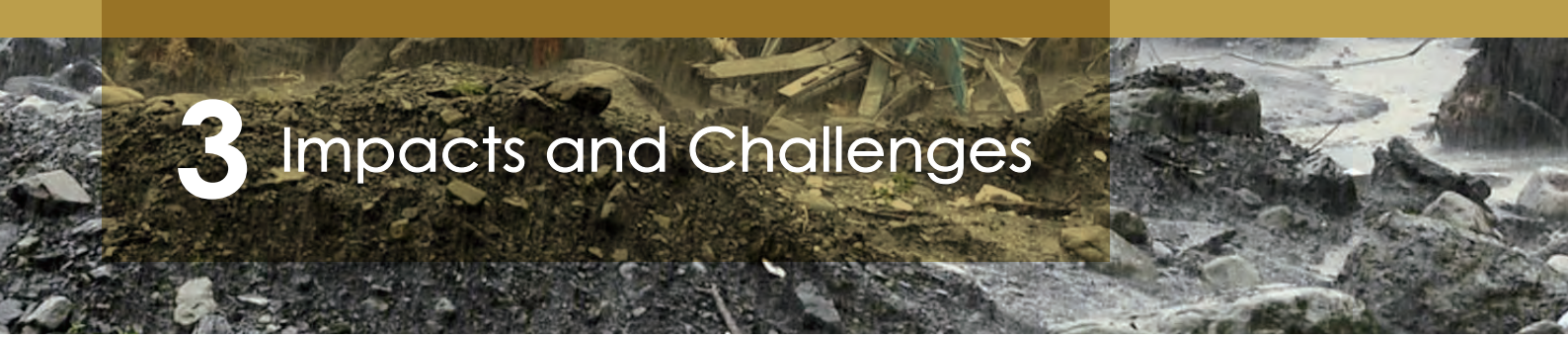
change in the mean precipitation in spring is similar to that in winter. In summer, except in northern Taiwan, over three-quarters of the models project an increase in seasonal mean precipitation, and about half of the models project the change to range between +2% and +26%. This projected scenario of increasing precipitation during rainy seasons and decreasing precipitation during dry seasons will pose a great challenge to the management of the island's water resources.

In terms of variations in typhoons, historical data show that both the frequency and the intensity of the western North Pacific typhoons and typhoons that have afflicted Taiwan are largely influenced by inter-decadal variability. The linear trend, the direct effect of global warming, is not significant. Nevertheless, most climate models project that, under global warming, the number of typhoons may decrease but the remaining typhoons' intensity and associated extreme rainfall will likely increase.

The IPCC Special Report on Future Emissions Scenarios

The IPCC released in 2000 its Special Report on Emissions Scenarios (SRES), a summary for international policy-makers outlining potential outcomes based on global and regional variables such as society, the economy, technology and the environment. The six families of SRES scenarios are given the codenames of A1T, A1FI, A1B, A2, B1 and B2: the number “1” stands for more global integration; and “2” stands for more regional independency; “A” stands for a market-oriented economy whereas “B” stands for an eco-conscious economy.

The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B).



3 Impacts and Challenges

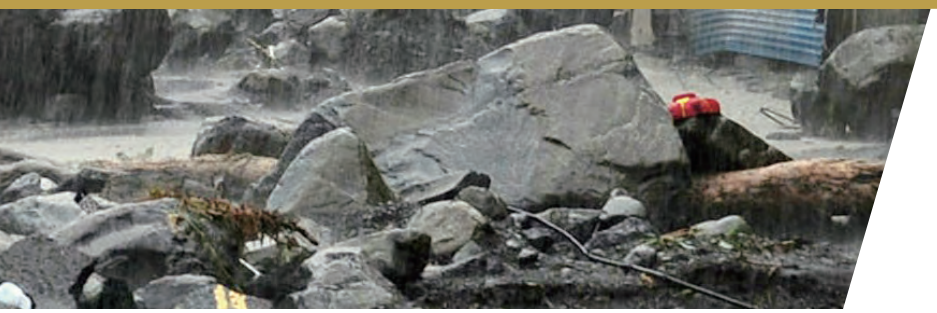
Although the island of Formosa is known for its natural beauty, its geographical location and geological properties mean that the island's climate change vulnerability and disaster risk are far higher than for other regions. The most serious impact climate change brings will be turning regular scale disasters, such as floods, mudslides and droughts, into destructive catastrophes. If we do not take any action and try to recover in the shortest time from the damage the catastrophe has caused, it will turn into compound disasters and swiftly destroy the island's ecosystem and its civilization. Therefore, we must carefully inspect the coming impacts and challenges.

3.1 Overall Impacts and Challenges

The major effects of climate change are: rising global temperatures, change in precipitation patterns, increasing frequency of extreme weather phenomena, and rising sea levels. Consequently, climate change can possibly result in droughts, heat waves, torrential rain, storm surges, mudslides, typhoons, shifts of ecological systems, changes in land-use and land cover, land subsidence, seawater encroachments, and deterioration in water and air quality.

3.1.1 Increasing Temperature and Changes in Precipitation Patterns

The increase in temperatures and the resulting change in precipitation patterns present great challenges to the island's water supply. Climate change will increase rainfall during the wet seasons, yet prolong the dry spells. This will cause subsequent changes in river flow and groundwater levels, reducing the supply capacity of reservoirs, and thus decreasing the nation's stable supply of clean water. The ecological impacts include changes in ecosystems, loss of biodiversity, the destruction of natural habitats and the extinction of indigenous species. The agricultural sector may also sustain heavy losses, since agricultural production is very sensitive towards temperature and water supply. The climate change in turn may threaten the nation's food security and increase the nation's reliance on imported goods while other countries' agriculture may also face the impact of climate change. From the perspective of public health and sanitation, higher temperatures increase the likelihood of epidemics and facilitate the transmission of infectious diseases, especially under the situation of unstable water supply. This situation may raise the possibility of infectious diseases breaking out, increasing the burden for public health and the medical system. The increase in temperatures and rainfall may also cause tremendous loss in sectors like the economy or energy supply. The change in precipitation will be the reason for floods or drought, and the increase in temperatures may contribute to higher usage of air conditioning, resulting in higher operating costs for all businesses and industries. Last but not least, volatile weather events may impact the nation's energy production by damaging equipment and facilities in areas with high disaster sensitivities and destabilizing energy distribution channels.



3.1.2 Natural Disasters Becoming More Frequent and Destructive

Climate change exacerbates the frequency and magnitude of natural disasters. On the one hand, stronger typhoons and heavier rainfall may damage the island's slopes more frequently; on the other hand, decreasing medium and small rain raise the possibility of drought. Due to location factors, the land of Taiwan often faces being struck by a typhoon or rainstorm. Furthermore, because of Taiwan's geographical and geological characteristics, disasters like rockfalls, mudslides, and landslides are not rare events in mountainous areas; as for low-lying regions, flooding is the most common problem. Another issue is the inappropriate development. This issue has resulted in an over use of land resources, causing problems in permeability and water storage capacity, and exacerbating the damage when disasters strike. Disasters of greater frequency and magnitude may also damage the nation's public infrastructure and networks for fossil fuel, electricity, natural gas, water, and the transportation system, resulting in slower recovery and greater losses in lives and goods.

3.1.3. Rising Sea Levels

Global warming and melting ice caps have led to a steady increase in sea levels, which in turn trigger the inundation of coastal areas, the erosion of seashores and loss of shorelines. Rising sea levels will increase the threat of saltwater intrusion and storm surge, forcing seaside residents to relocate and lose their livelihoods with harbors and industrial parks facing similar predicaments. Since the existence of saltwater intrusion and other related disasters are closely related to seaside land use, it is necessary to regulate the pattern for coastal and low-lying region land use. Such regions include major harbors, industrial parks, and communities. Impacts such as increasing temperature, saltwater intrusion, and water shortage will largely restrict the development of urban and rural areas; hence better planning and management of land use will become one of the challenges the government needs to address.

In summary, the government should establish Taiwan's adaptation strategies in response to the challenge caused by climate change and to decrease the possibility for extreme disasters. The most important method is to try to minimize the threat posed by disasters. It is also important to recover from the damage as soon as possible since the chances of a compound catastrophe would increase if the damage were to remain. Last, but not least, we should always be well-prepared in order to face unpredictable challenges.

Although the specific impact that climate change may cause in Taiwan requires more scientific evidence, based on Taiwan's geographical location and social properties, in what follows are some possibilities to which increasing temperature and

Impacts and Challenges

changing rainfall may give rise in different sectors: typhoons and storms of larger magnitude, frequent incidents of floods and flood-related disasters, the corrosion of public infrastructure, disruption of the nation's water supplies, increasing vulnerability of the land, erosion of national territory caused by rising sea levels, risks in the nation's energy supply and industrial management, unstable food security, loss of biodiversity and higher risks of epidemics and infectious diseases.

3.2 Impacts and Challenges: Sector by Sector

Disasters	· The incrcascd intcnsity of rainfall will lcad to higher risk of flood and causing tremendous compound soil and water disasters. · As the number and strength of typhoons increases, they will pose great impact on the contingency and recovery capacities of disaster prevention system.
Infrastructure	· Due to the influence of torrential rain and rising water level, critical infrastructrue (e.g. bridges, roads, devices, and water plant, etc.)will suffer from various level of damage based on their position.
Water Resources	· Changes in rainfall patterns and hydrological characteristics will expand the discharge gap between wet and dry season, and increase the risk of compound disaster occurrence. · Changes in temperature and rainfall will affect irrigational, municipal, And industrial water demands, creating extra difficulties for water resources management. · Increasing extuemes of river flow will adversely affect the quality of rivers.
Land Use	· Extreme climate will increase the sensitivity and vulnerability of the environment, showing the importance of land resource use safety.
Coastal Zones	· Rising sea level will damage the coastal protection structures,natural attractions, and resources. The erosion of coastal areas may also lead to loss of national territory.
Energy Supply and Industry	· Energy demand has altered, current energy production may not be able to meet the future peak demand. · The supply and industries' energy cost may be impacted. · Business enterprises may be adversely affected by the damage of infrastructure resulting from climate change, and suffer from investment loss and increasing equipment cost.
Agricultural Production and Biodiversity	· Rising temperatures and lack of rain will interrupt the growing cycle of crops, causing uncertainty in agricultural production and quality, and endangering food safety. The fishing industry's productivity will also be negatively impacted. · Changes in the environment will affect the original habitats in ecosystem and lead to a drastic loss in biodiversity.
Health	· Rising temperature will increase the risk for infectious diseases to spread out and will raise the mortality caused by respiratory and cardiovascular diseases, thus increasing the burden of maintaining public health and the health care system.

Impacts and Challenges: Sector by Sector

Impacts and Challenges

3.2.1 Disasters

1. Floods

(1) Higher extreme rainfall intensity will increase the risk of flooding and impact disaster emergency response and the capacity of the systems to recover.

Higher extreme rainfall intensity will be the critical challenge for the current drainage system, levees and river embankments. Torrential rain which exceeds the capacity of the drainage system or protection standard of levee will increase the risk of flooding. Flood-prone areas will not only face even more inundation, but will also experience the increasing vulnerability that will hamper recovery and reconstruction efforts. This will result in a higher probability of follow-up disasters breaking out, and will have a great impact on the disaster emergency response and capacity of the systems to recover.

(2) Rising sea levels will result in draining difficulties in low-lying regions.

The IPCC estimates that sea levels may rise by as much as one meter by the end of this century; whereas Taiwan's western shoreline is mostly protected by seawalls that will prevent large-scale coastal erosion and flooding, higher sea levels which are caused by torrential rain may contribute to more flooding of low-lying lands because of the difficulties in draining.

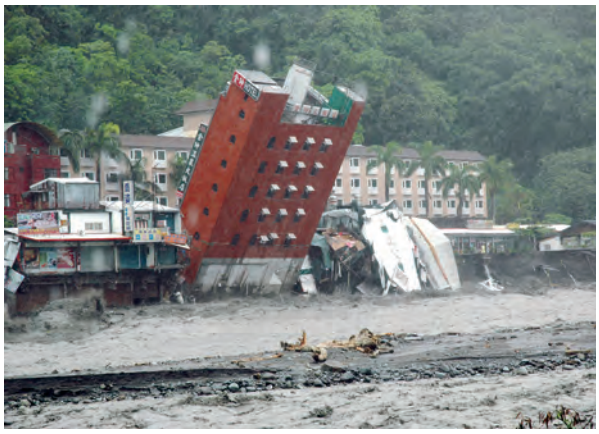
(3) Increasing occurrence of storm surge will cause higher possibility and duration of inundation, and aggravate coastal erosion.

Inundations, driven by stronger typhoon winds and rain, have coincided with high tides in recent years. The combination of high tides and flash floods raise the difficulty of waters being naturally drained by estuaries, and both oceanic and fresh water actually ends up being washed back onto coastal lands and into river mouths. Extensive damage is caused by this type of inundation, as it takes a long time for the water to recede, adding to the difficulty of restoring the area.

2. Slope Land Disasters

(1) Increasing rainfall intensity will lead to serious compound disasters.

Slope land disasters are usually linked to strong rainfall. Thus the effects of climate change will only add to the vulnerability of the nation's environment, escalate the occurrence of landslides and mudslides, and aggravate other derived rainfall-triggered compound disasters.



(2) The rising frequency of typhoons will increase the risk of cascading disasters and the difficulties of recovery.

Recurring damages inflicted by typhoons not only destabilize slope lands, but also pose a threat to the recovery process, such as the provision of

temporary shelter for the victims, the reconstruction of damaged mountain roads and bridges, and the increasing occurrence of landslides. These issues all raise the risk of cascading disasters. The subsequent sedimentation of dams, rivers and lakes are all viewed as part of the disaster from the original slope land disasters.

(3) Large-scale landslides will be the focus of slope land disaster prevention.

In 2009, Typhoon Morakot hit the village of Hsiaolin in Kaohsiung's Chiahsien Township, causing a catastrophic landslide that has never been seen before. The village was swallowed in a 250-hectare-wide collapse, and the deepest end of the debris pile measured 84 meters. The cause of the calamity stemmed from the large quantities of rain that Typhoon Morakot dispersed; landslide damage across the island was estimated to amount up to 20 million cubic meters. In short, the Hsiaolin tragedy can be viewed as a precursor to further large-scale slope land disasters that will be triggered by climate change.

3. Drought

(1) The changing precipitation pattern in dry and wet periods has increased the difficulties for water resource allocation and management.

Whereas the intensity of rainfall has increased in Taiwan, the number of rainy days has actually decreased. Due to this imbalanced precipitation pattern, rainfall that exceeds the island's water storage capacity during the wet season will increase the risks and difficulties encountered in flood prevention and endanger all residents. On the other hand, little to no rainfall during dry spells results in empty dams with low water storage. The expanding precipitation gap will become an important issue in the nation's water resource management policy.

(2) Siltation affects the operation of reservoirs.

Increased intensity of rainfall in Taiwan will also trigger more complex natural disasters, most notably the lethal combination of flood waters, driftwood and loosened soil and rocks. These high sediment loads are dispersed by heavy rainfall, only to contribute to the rapid sedimentation of the island's reservoirs, decreasing their storage capacities, and influencing the reservoirs' normal operations.

(3) Industrial and agricultural sectors lead to rapid growth in water demand, increasing the risk of drought.

Water resources are generally divided into irrigational, industrial and municipal usage. Most of Taiwan's water resources are devoted to agricultural purposes, yet global warming increases the evaporation of irrigational water supplies, meaning that more water is needed per square meter than before. Similarly, industrial and municipal demand for water grows with the increase in both global temperature and human population. The growing water demand of industrial development and high energy-consuming industries has resulted in difficulties for water resource management and increases the risk of drought.

3.2.2 Infrastructure

1. Impact on Energy Supply Facilities

(1) Safety concerns for each energy supply facilities' location

Global warming will change the weatherability of oil-refining machinery, power generators and other structures used in the energy industry. Extreme weather will also challenge the safety issue for energy supply facilities; hence the sites of such facilities need to be outfitted to meet the challenges of climate change.

2. Impact on Water Supply System

(1) Reservoirs and Dikes

Prolonged exposure to flood waters and high temperatures has visibly damaged the exterior of concrete structures like reservoirs and dikes, twisting their walls and leaving critical equipment exposed. This may induce catastrophic flooding if the reservoirs/dikes collapse. If not properly reinforced and cleaned of layers of accumulated sediment, water infrastructure will soon lose its ability to supply water.

(2) Water Purification Plants

Rainfall collected during the rainstorm period contains extremely high levels of pollutants, and purifying the polluted water could cause the productivity of water purification plants to drop, or even come to a standstill.

(3) Water Distribution Networks and Packaged Running Water Systems

River-crossing pipelines may be damaged by flood smashing or river bed scouring, thus affecting the water supply. Water distribution networks may also face increased water consumption due to rising temperatures, which would lead to an unstable water supply at the end of the pipelines or even hinder the supply. Packaged water distribution networks

are not permanently-built facilities; this makes it easy for them to be crushed by typhoons or floods. Besides, alternative supply systems are usually not available; hence damage to the distribution network could leave these regions without a clean source of water for lengthy periods of time.

(4) Hydraulic Facilities

Hydraulic facilities are also affected by greater flood waters, higher sea levels, larger loads of sediment and driftwood, stronger flood scouring and wave impact. Facilities including river embankments, coastal levees, pumping stations and floodgates all face the same predicament of stronger impact and scouring. If these facilities are damaged or submerged, the breakdown may lead to or aggravate flooding.

3. Impact on Transportation Systems

(1) Harbors

Combined with higher sea levels, erratic typhoon-driven tidal waves pose great danger to the safety of harbor structures. These waves also deposit great amounts of sediment inside harbor waters, which may affect the operation of harbors and shut down shipping routes.

(2) Railroads

Strong wind and rainfall could be the reason why railway networks break down. For example, tracks running through low-lying lands are hampered by frequent flooding. Railway networks along mountainous areas face the dual threat of mudslides and landslides, while train track foundations built above river valleys are in danger of being damaged by river erosion.

(3) Highways and Bridges

Mountain roads, which are often constructed along riverbanks and valleys, are usually exposed to threats from landslides under the influence of rainstorms. River scouring could also damage the roadbed, causing the breakdown of highways. Floods and mudslides that occur upstream are likely to weaken the foundations of bridged highways, and the entire structure may collapse due to the follow-up earthquake. As for the downstream areas, piers and the decks of bridges can also be easily destroyed or buried by mudslides or flooding.

(4) Airports

Heavy rainfall may overwhelm drainage systems and flood airport runways, thereby delaying scheduled flights. Moreover, airport facilities, such as runways or control towers, will also be affected by more severe and frequent rainfall.

4. Impact on Communication Networks

(1) Decreasing Quality of Communication

Heavy rain severely fetters the electromagnetic waves used in telecommunications systems, causing rain fade or interference which will affect the quality of communication. Flooding and mudslides may also scour the foundation of base stations, damaging stations and transmission wire, causing the breakdown of communications systems, or leading to nationwide communication blackouts.

(2) Increasing Capital Cost of Communications Equipment

Operating costs have increased substantially in recent years as floods damage low-lying generators and higher temperatures shorten the product lifespan of equipment and machinery.

3.2.3 Water Resources

1. Impact on the Hydrological Cycle

Research results indicate that, in the near future, Taiwan's water cycle may have stronger rainfall intensity, surface runoff and evapotranspiration. Despite the increased rainfall, however, global warming intensifies surface runoff and subsequent evapotranspiration, meaning that groundwater recharge will occur at a decreasing rate.

2. Impact on River Discharge

As a consequence of climate change, river discharge will mostly take place at an increasing rate during the wet season (summer), and will exhibit a decreasing rate during the dry seasons (winter, spring).

3. Impact on Water Supply System

The difference in rainfall between wet and dry seasons will affect reservoirs' capabilities of water supply storage and flood-reduction, thereby jeopardizing Taiwan's entire water supply system. Silted reservoirs with lower storage levels and increasing water demand will also lead to the risk of water-supply shortage.

4. Increasing Risk of Compound Disasters

Difficulties in water supply will increase if hydraulic structures are damaged by major flooding. Since extreme weather events like typhoons may occur more frequently than before, risks that compound disasters create will also increase. Compound disasters, which consist of flood waters, driftwood, and loose rocks and sediment, will be a possible reason for water shortage.

5. Impact on Irrigation Patterns

Irrigation demands will fluctuate with the changes in temperature and rainfall. For example, rice paddies require more irrigation at the start of the rice growing period, but the irrigation demand decreases when the later parts of the rice growing period are reached; however, the planting of the year's first rice crops coincides with the dry season. Since the water flowing through streams in the dry season may decrease in the future, the challenges posed by water allocation will be an urgent issue.

6. Water Pollution

During periods of low precipitation, rivers and streams become more contaminated by pollutants due to their sluggish water flow. This makes the rivers unable to dilute and purify themselves and thus weaken the rivers' self-purification capacity. On the other hand, during the wet season, although rivers have better self-purification capacity, rainstorms will still cause hill erosion, landslides, and riverbank erosion. This phenomenon has resulted in the high turbidity and concentration of

particulates in rivers, therefore affecting the river ecosystem and worsening the water supply system.

3.2.4 Land Use

1. Impact on Land Use Patterns

(1) Flood and droughts

Changes in precipitation patterns will adversely affect the seasonal and regional distribution of water resources. In the downstream areas with their intense urban populations and economic activities, water demand has exhibited an increasing rate, giving rise to higher risks of regional water shortages, and imbalanced water distribution could be the most serious restriction for urban development. On the other hand, the excessive withdrawal of ground water due to insufficient water resources may lead to problems such as groundwater-related subsidence and saltwater intrusion. These are all challenges for land use.

(2) Rising temperature

From the perspective of land use, flatlands and highly populated regions are more at risk from temperature increases when compared with mountainous or less developed regions; the spatial development patterns of land use should be readjusted, and there should be cooperation with other sectors such as energy industries, infrastructure, public health, green infrastructure, and building management in response to global warming.

(3) Rising sea levels

The majority of Taiwan's urban environment and economic activities are situated along the western coastal plains. Given the issue of rising sea levels, these low-lying settlements should regulate and reconsider the pattern of land use activities, and establish an overall warning system in order to cope with the challenges posed by life and property loss that rising sea levels and storm surges bring about.

(4) Urban areas

Urban areas with high population densities will be more significantly impacted by climate change; the type of disasters will also be more diversified. For example, buildings, roads, infrastructure and other facilities will increase the amount of impervious surfaces and result in significant amount of runoff from extreme rainfall events and causing failure to existing drainage systems' sewage networks and endangering public health. Prolonged exposure to precipitation can also result in the failure of electrical facilities, affecting the normal operation of cities. Moreover, due to the urban heat island effect, the

temperature difference between urban areas and the surrounding rural areas can reach up to 10°C. In addition, cities also face a severe air-pollution problem. Therefore, how to deal with the increasing surface runoff caused by extreme weather, or how to increase capacity building using land use and building management are the major challenges that cities must face to cope with climate change.

2. The Challenges of Land Use Planning and Management

(1) Land regulation of urban planned areas and non-urban planned areas

Taiwan's current policy on national territory segregates land for either urban-planned or non-urban planned usage. Related systems include the Strategic Plan for National Spatial Development, regional planning, urban planning, and non-urban land regulations. These systems all require immediate revision. Up to eighty percent of Taiwan's population is currently settled in the so-called urban planned areas, meaning that urban planning and management should actively adapt to extreme weather events. On the other hand, the lack of long-term vision and management of non-urban planned areas has contributed to over-exploitation and misusage. This will aggravate the impact towards the environment and ecosystem service, and endanger the people and economic activities in non-urban planned areas.

(2) Risk Sharing

The mitigation and adaptation strategies for different issues may have a substitutive or complementary relationship with each other, and the resolution of this conflict will be land use planning or spatial planning. Here, examples could be issues like carbon emission regulation, the allocation of disaster prevention resources, or development opportunities, etc. If we combine an adaptation strategy with land use planning, we may need to stop development in areas which are about to be over-developed. Furthermore, for some areas, providing more green-infrastructure will be necessary due to their spatial characteristics. These spatial differences also create a new risk-sharing relationship between stakeholders, and also form a new challenge in terms of the level of implementation of land use planning.

3.2.5 Coastal Zones

1. Rising Sea Levels

Rising sea levels contribute directly to coastal erosion, coastline receding, loss of marine habitats, and coastal environmental change. The slopes of Taiwan's western coasts range from 1/50 to 1/100. This means that a 1 centimeter sea level increase will cause the coastline to recede by between 50 centimeters and 1 meter, respectively. In areas such as estuaries, lagoons, wetlands, sand dunes, and shoals, due to their gentle slopes, the influence of rising sea levels will be even greater than in other places. The rising sea level will also contribute to rising river levels. That in turn will cause a malfunction of the drainage system in low-lying regions and will even cause flooding. Furthermore, rising sea levels will expand tidal prisms in estuarial areas, increasing the chances of sea water reaching river banks. Rising sea levels will also seep into

groundwater basins and increase the content of saline in groundwater.

2. Typhoon-induced Storm Surge

According to research estimations, the physical characteristics of wave, tide, and storm surge may change as a result of rising sea levels, and this will pose a great challenge for groundwater in terms of height and cost. A storm surge would increase the frequency of saltwater intrusion, causing difficulties for flood discharge and rising flood levels. Typhoon-triggered tidal waves and floods can easily overwhelm coastal areas, create erosion, and increase soil salinity. The stronger the typhoon is, the greater the impact that the storm surge will have. This phenomenon will bring erosion and environmental jeopardy to coastal areas.

3. Torrential Rain

Changes in precipitation patterns will be exacerbated in both wet and dry seasons. That means extreme precipitations, either too much or too little. During the wet season, rivers face sudden increases in water flow due to torrential rains. For residents in low-lying areas, draining problems and floods could be witnessed more often. During the dry season, however, riverbeds will be dried out and exposed and, compounded by agricultural cultivation in some regions, both will contribute to the phenomenon of fugitive dust from October to April.

Photo provided by Photo provided by Li Chen Guang

4. Oceanic Warming

Marine ecosystems, such as coral reefs, have proved to be effective in protecting the ocean environment from tsunamis and tidal waves. Global warming, which threatens the survival of up to thirty percent of marine living organisms, contributes to the heating of ocean waters, and increases the concentration of carbon dioxide. Warmer ocean water and a higher concentration of carbon dioxide will also change the saturation of oceanic calcium carbonate, heighten the coral reef's calcification rate, retard the formation of coral reefs, and even cause the collapse of reefs. As an indicator of the environmental chain, the alarming rate of coral reef wipeouts poses a great threat to marine biodiversity.

5. Inappropriate Man-made Coastal Land

Taiwan's coastal areas, which are already damaged by the over-pumping of groundwater aquifers, are at further risk from industrial development. Land reclamation, industrial parks, harbors, aqua-farms, seawalls, and tetrapods are scattered along the coastline. It is estimated that more than fifty percent of Taiwan's coast is built with man-made constructions and seven western coast cities have covered ninety percent of their coast with artificial constructions. The percentage of coastal construction is still increasing, which brings serious damage to the coastal environment and ecology. The artificial constructions may seem to be protecting the coastline at present, but in the long run they may destroy the coastal habitat of various species, interfere with the capacity for habitats to develop inland under the impact of a rising sea level, and decrease the adaptive capacity of Taiwan's coast.

3.2.6 Energy Supply and Industry

1. The indu strial loss caused by floods and drought due to Volatile Precipitation Patterns

Climate Change may increase the occurrence of drought and flooding. The lack of rainfall will lead to substantial financial losses for both manufacturers and water companies – production processes have to be altered, orders have to be pushed back, the delivery date has to be delayed, there are more expenses for purchasing water, and the costs will increase due to intensive working hours, etc. On the other hand, flooding is likely to overwhelm factories, submerging all the equipment, raw materials and products in stock; this would result in extra expenses for recovery, rehabilitation, and renewal.

2. The Urban Heat Island Effect and the Resulting Increase in Air Conditioning Installation and Operating Costs, and Energy Conservation Investments

For manufacturing industries, the air conditioning system is the second-highest energy consuming system that is only surpassed by the motor system. Statistics on non-manufacturing sectors such as airport terminals, hospitals, research centers, hotels, corporate buildings, government agencies, large retail centers, department stores, exhibition halls, schools and telecom operations also reflect the substantial costs of running air conditioning. Over forty percent of power consumed by the above entities is used for air conditioning.

3. Safety threats for electricity, oil and gas supply facilities in geological disaster-sensitive areas and flood plains

Records from Taiwan Power Company (Taipower) reveal that of its top ten major grid damage accidents in recent years, four incidents were related to the destruction of high-voltage transmission towers by strong winds, one incident was triggered by mudslides and another was caused by a tornado which blew an object that touched the high-voltage transmission lines.

4. Influence on Energy Supply and Demand Balance

Climate change affects domestic power production in several ways: on the supply side, higher temperatures adversely affect electricity generation and operation, yet the warmer sea water loses its effectiveness in cooling coastal power plants and affects the generating efficiency. On the demand side, prolonged periods of hot weather will escalate air conditioning usage, resulting in substantial increases in power consumption.

3.2.7 Agricultural Production and Biodiversity

1. Impact on Agricultural Output

(1) Agriculture

Higher temperature will interfere with the vegetative period of horticultural crops and threaten the quality and quantity of production. As higher temperature bolsters the growth of weeds and pests, it may also combine with heat waves and destroy the quality of rice and other crops' harvests. As for precipitation, uneven rain distribution or low precipitation due to climate change will lead to difficulties in water resources distribution and a shortage of agricultural water supply. Furthermore, high rainfall intensity may disturb the development of plants and damage the yield and quality of crops. Farmable territory will also disappear rapidly due to rising sea levels, land subsidence, soil salination, and the change in farmland usage. Overall, climate change will not only cause production loss to the farming sector, but will also lead to an increase in government subsidies and product prices, resulting in heavier government burdens and market inefficiencies.

(2) Forestry

The impact of climate change on woodlands and the forestry sector will result in the altered

distribution of forest vegetation zones; threatening the survival of species in different forest physiognomy, damaging man-made forests, and decreasing forests' carbon sequestration and ecosystem function.

(3) Fishery

The rising temperature of ocean waters will affect the fishing industry in numerous ways: the species and amount of fish will alter, current fish farms will relocate or vanish, deviant migration patterns will result in lower commercial harvests, and the costs of management will increase. The increase in ocean temperature will also pose significant risks to the aquaculture industry's productivity and quantity as the warmer water will change the quality of water and incubate more waterborne diseases.

(4) Livestock

Higher temperature may cause heat stress, affecting livestock's ability to grow, produce, and breed. The heat also contributes to a more disease-favorable environment, increasing the risk of infection, lowering the quality and quantity of livestock feed and decreasing the genetic diversity of livestock. Furthermore, rising temperature may lower the quality and quantity of forage crops and cause a shortage of water for animal farming, resulting in higher cost and risk for the livestock industry.

2. Impact on Biodiversity

(1) Ecosystems

A. Forest Ecosystem

Climate change may cause the coniferous forests at mid and high elevations to move upward, thus further reducing their total area. Among them, the warm-temperate montane rainforests will be affected the most and will only be distributed in the upper limit of its present range, while the cold-temperate and sub-alpine coniferous forests will be sporadically distributed in mountains of extremely high elevation. Increasing extreme rainstorms and landslides may raise the frequency and scale of forest loss and erosion.

B. Rivers and Freshwater Wetlands Ecosystem

Increasing frequency and power volatile weather, which may cause great fluctuations in the quantity and quality of water flow, will not only increase the disturbance in rivers, but will also impact their physical and chemical structure, disturbing the biological composition, and affecting the ecological function of Taiwan's river ecosystem. In addition, waterways with too many manmade constructions will decrease the river's capacity to defend the scouring of rain storm and aggravate the river ecosystem disturbance. The erosion of manmade structures also contributes to river sedimentation, causing greater destruction to the ecosystem.

C. Coastlines and Saltwater Wetlands Ecosystem

Rising sea levels and increasing frequency and intensity of typhoon and torrential rain will directly lead to the erosion of coastlines, the loss of wetlands, and shoreline recession. The higher frequency of flooding will cause salt water to infiltrate rivers and freshwater aquifers, resulting in the disappearance of coastal habitats and their functions, causing the decline of local species, and harming the fishing industry due to the decrease in marine resources. Human populations along the coastline will face further challenges in their living environment and economic activities. Windbreak forests will lose their functions of shielding inland regions from wind and salt, providing natural habitats for wild plants and animals, and preserving rural landscapes and farmlands. Climate change, coupled with the continual destruction of coastal resources by mankind, will seriously threaten the coastline and saltwater wetland ecosystem.

D. Marine Ecosystem

Increasing water temperature, sea water acidification and rainfall variation may affect the physical and chemical properties of the marine ecosystem, such as salinity, dissolved oxygen level, direction and intensity of upwelling current and thermohaline circulation, as well as the distribution of nutrients. These may all adversely impact the growth and survival of marine species, change the migration and production patterns of marine life, reduce their productivity, and influence the structure of the marine food web and the sustainable use of marine resources, including the location of fishing grounds.

(2) Species and Genes

The species and populations most vulnerable to climate change include those distributed at the margin of existing habitats, e.g., high-elevation areas, polar regions, or coastal wetlands, those with limited range of distribution, or those with special ecological requirements and weak dispersal ability. Migratory species are particularly vulnerable

because any change in their breeding habitat, overwinter refuge, or their migratory routes could have a devastating impact on their reproduction and survival. In addition, the interaction or interdependency between species may arouse a chain reaction of extinction involving more species and the loss of their genetic diversity.

(3) Protected areas

Heat, drought, flooding, typhoons, and wildfires, all of which are reinforced by climate change, will aggravate pest infestations and invasion by alien species, posing a challenge to protected area management. Furthermore, the risk of being isolated increases when the lands surrounding protected areas are utilized for various kinds of development. The distribution of protected species or ecosystems may change and expand beyond the current boundaries of protected areas; however, due to the isolation, the said species/ecosystem may be unable to disperse or move to another appropriate protected area. Thus protected areas may lose their ecological function in preserving the original biodiversity.

(4) Invasive Species and Pest Control

Whereas many species will be negatively impacted by climate change and face the crisis of extinction, there are also some highly adaptive species, including pests and pathogens, that will benefit from climate change and thrive, proliferate, invade new habitats, replace native species and negatively impact local biodiversity. Take, for example, the invasive Terpios Hoshinota, an alien type of coral-killing sponge that has dominated Taiwan's Green Island in recent years.

3.2.8 Health

1. Temperature

(1) Rising Temperatures

The rising temperature will aggravate the spread of insect-borne diseases such as Dengue Fever, Scrub Typhus, Japanese encephalitis, etc. High temperature may also extend the spreading period or area of these diseases. Infectious diseases originating in South East Asia, such as Malaria and Chikungunya, may also be introduced to Taiwan and become localized within the island.

(2) Heat Waves and Cold Waves

The impact of low temperature is relatively high when compared to that of high temperature. Furthermore, under the situation of extreme temperatures, cardiovascular disease is a more possible cause of death than respiratory disease.

2. Rainfall

Extreme rainfall patterns will result in more droughts and floods. Insufficient supplies of clean water and higher chances of making contact with dirty water will increase the risk of diseases breaking out. Such diseases include skin infections, water-related chronic poisoning, Hepatitis A, Shigellosis, Leptospirosis, and Melioidosis (also known as Whitmore's Disease), etc.

4 Prospects and Objectives

Regardless of whether the increase in global temperatures can be limited to less than two degrees Celsius, the detrimental effects of climate change will not dissipate immediately, meaning that climate change will persistently put our world at risk. According to the analysis of weather-related impacts and challenges presented in Chapter three, the prospects, principles and objectives of the Climate Change Adaptation Policy are formulated as follows.

4.1 Prospects and Principles

4.1.1 Prospects:

Building a sustainable Taiwan that is able to adapt to any risk resulting from climate change.

4.1.2 Principles

1. Making policies and mechanisms integrative and mutually supporting.
2. Placing equal emphasis on prevention, safety and efficiency.
3. Forward-thinking and no-regret policy.
4. Balancing emphasis on adaptation and mitigation.
5. Adaptation strategies should be based on the island's ecosystem.
6. Keeping all citizens accountable and getting everyone to participate and cooperate.
7. Considering the needs of minority groups and genders.
8. Enhancing the general public's self-cultivation and capacity for climate change adaptation.
9. Cooperating internationally.

4.2 Policy Objectives

4.2.1 Policy Objectives

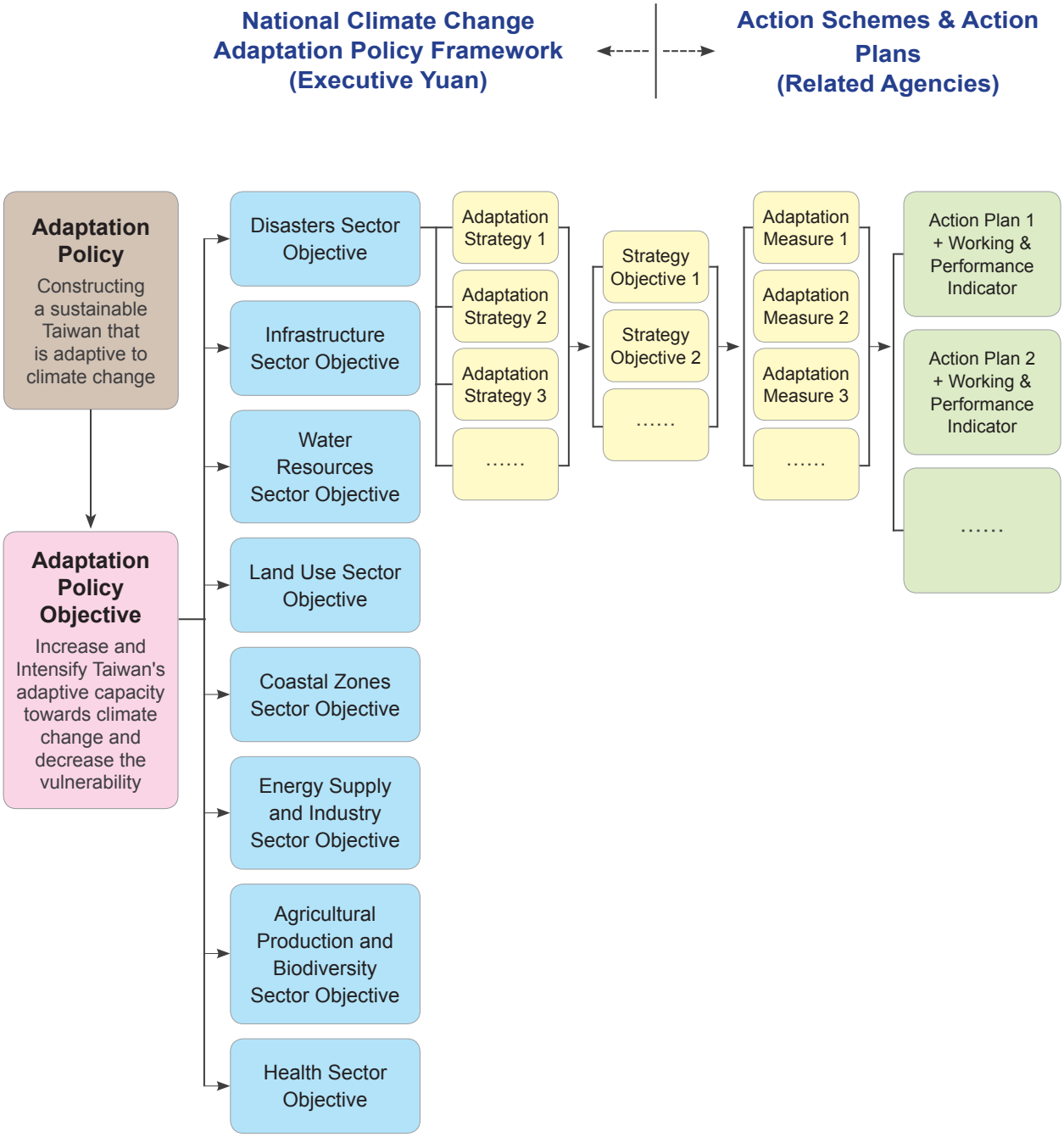
In order to improve and reinforce Taiwan's adaptive capacity for coping with climate change and to reduce Taiwan's vulnerability, the objectives include:

1. Establishing a legal framework and government organizations corresponding to climate change;
2. Drafting national policies and decision-making mechanisms that consider climatic issues;
3. Establishing a climate-related effective early warning, impact-evaluating and decision-making supporting system, and reinforcing the national and local disaster prevention and management systems;
4. Selecting no-regret policies and measures that deal with adaptation and mitigation issues simultaneously;
5. Enhancing the research and development of climate-change adaptation technology, and cultivating related specialists;
6. Raising public awareness on climate change issues; educating the general public knowledge about climate change;
7. Setting up a climate-adaptation decision-making and acting system that integrates the

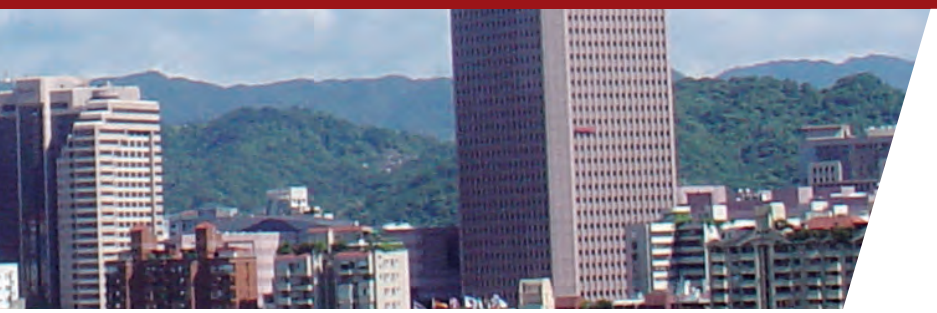
private and public sectors;

8. Devising economic incentive programs for encouraging private and public sectors to practice the climate change adaptation policy voluntarily.

5 Adaptation Strategies



Implementation



5.1 Structure

Since each area has its own level of vulnerability and each area may suffer different degrees of impact from climate change, the evaluation of the influence of climate change and the formulation of adaptation strategies should stress the differences between areas (which can be divided into flatland, coast, mountain, or northern, central, southern, and eastern areas) and cities, in order to present the special characteristics of adaptation work so as to set up the scheme according to a certain area's properties.

In order to supervise the implementation, prospects and objectives of each sector's adaptation strategies in a more effective way, a complete planning and objective system has been built. First, through careful discussions between the project teams and working groups, each sector should set up its overall objective (in a quantifiable manner), and survey each final result to see if the objectives are achieved. While reaching the stage of follow-up strategy planning, each plan has to set up its own working and performance indicator, in order to evaluate and review each plan's implementation results and performance. Here the working indicator includes some specific and representative items that each Ministry and Council should achieve, such as the amount of jobs finished, output value, the square measure, and mileage, etc. As for the performance indicator, which means the level of improvement and benefits resulting from climate change, this has to include items such as reducing the frequency of drastic weather changes, decreasing loss of life and property, cutting down time and expenditure, lowering the level of vulnerability, and enhancing the adaptive capacity, etc.

5.2 Overall Adaptation Strategies

Adaptation strategies are formulated based on two fundamental concepts: risk-avoidance and risk-reduction. The prior concept involves avoiding high-risk regions whereas the latter involves reinforcing a region's capacity to withstand the effects of climate change. Adaptation strategies for each sector are all formulated based on these two concepts.

Overall adaptation strategies are cross-territory and are the top priorities regarding all sectors, which include:

5.2.1 Implementation in territorial planning and management

Territorial planning on all levels, including national land planning, regional planning, urban planning, and non-urban land regulations, should take into consideration the mitigation and adaptation of climate change. We should first evaluate the possible impact of climate change, then improve the direction of development, adopt proper countermeasures, and continue to implement the strategies on follow-up territorial management.

5.2.2 Enhancing disaster prevention and avoidance capacities in environmental, social and economic systems.

The nation's environmental, societal and economic capacities are all closely intertwined. In order to decrease Taiwan's climate change vulnerability, all three systems' prevention and avoidance capacities need to be reinforced in order to face the challenge of climate change and high-

Adaptation Strategies

risk disasters.

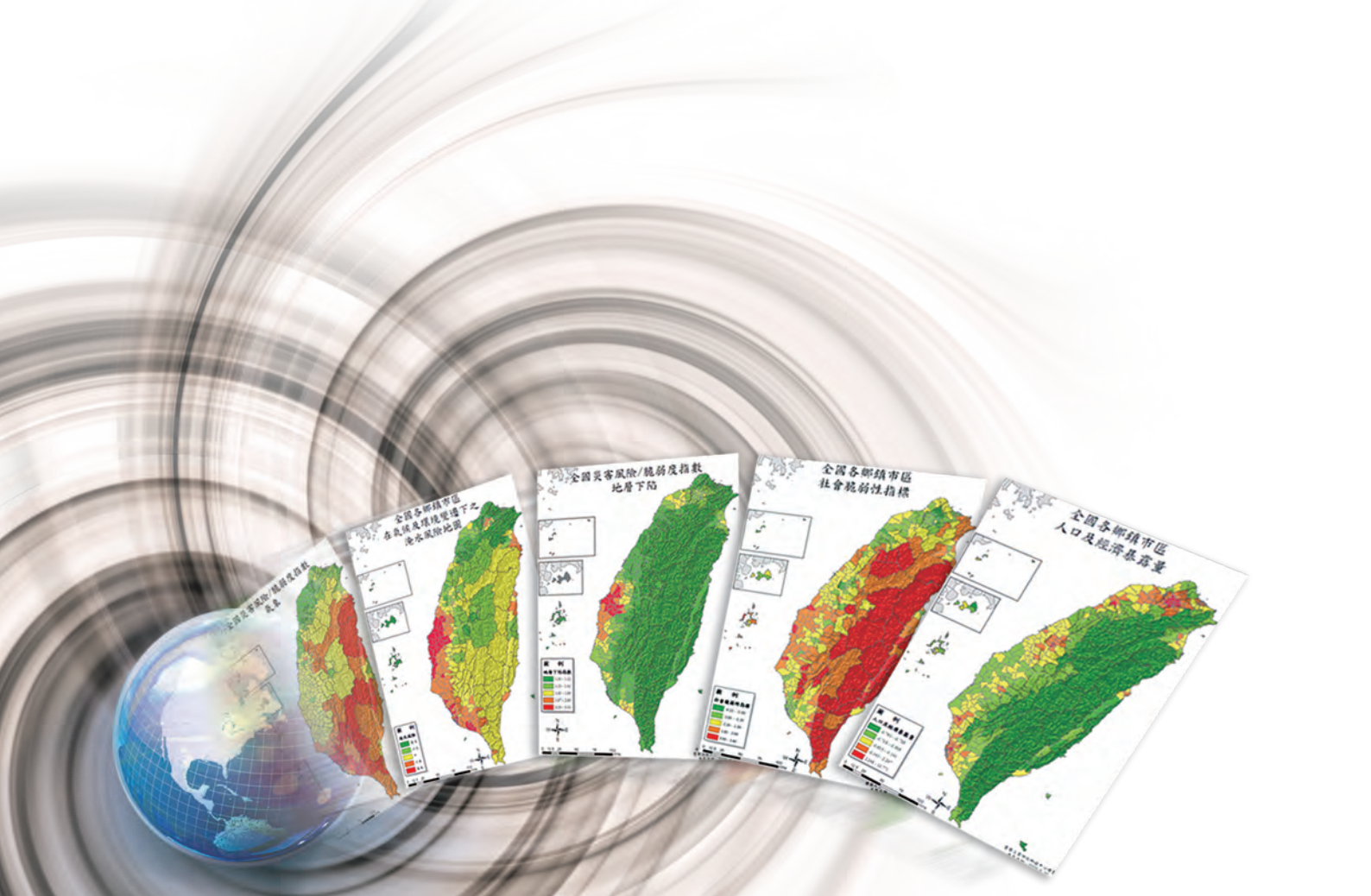
The nation's environmental, societal and economic capacities are all closely intertwined. In order to decrease Taiwan's climate change vulnerability, all three systems' prevention and avoidance capacities need to be reinforced in order to face the challenge of climate change and high-risk disasters.

5.2.3 Carrying out comprehensive river-basin governance.

Carrying out comprehensive preservation of the nation's important water basin will include preservation of the reservoir watershed, flood prevention, re-forestation, coastal support, and land use, etc.

5.2.4 Prioritizing high-risk regions for climate change.

High-risk regions are defined by their frequent exposure to flood-related compound disasters. These regions, because of their vulnerabilities and difficulties in recovery, need to be quickly identified and reinforced before more life and property losses



are incurred.

5.2.5 Enhancing prevention and protection capacities for adaptation in Urban Areas.

Up to eighty percent of Taiwan's population is settled in urban areas; this high density is coupled with a lack of proper urban planning in response to climate change, making municipal districts exceptionally vulnerable to damage from climate change. Therefore, enhancing prevention and protection capacities for adaptation in urban areas is the top priority.

5.3 Adaptation Strategies: Sector by Sector

5.3.1 Disasters

1. Objective

To implement the disaster risk evaluation and comprehensive adaptation policies as a means of reducing the disaster risk caused by climate change. To strengthen the overall adaptive capacities for disaster prevention and avoidance.

2. Adaptation Strategies

(1) Surveying and evaluating climate change disaster risk, and identifying the high disaster risk areas

A. Promoting integrative interdisciplinary research on the disaster impact of climate change.

B. Estimating the vulnerability and scales of compound or extreme disasters.

C. Identifying and demarcating potential danger areas, and evaluating areas with high risk or vulnerability due to the impact of climate change.

(2) Enhancing the integration of environmental monitoring and disaster warning systems. Creating a platform for information exchange, thus enhancing the capacities in response to the impacts of climate change

A. Strengthening the national land monitoring system and integrating the current monitoring systems.

B. Promoting the integration of disaster warning technology and improving disaster simulation and early warning systems as references for precaution, warning, and land management strategies.

(3) Reviewing and evaluating the vulnerabilities and prevention capacities of current critical public construction facilities, and reinforcing disaster prevention and protection plans.

A. Examining and evaluating the disaster vulnerability and prevention capacities of critical public constructions and infrastructure.

B. Reinforcing monitoring and disaster prevention and protection plans for public construction with high disaster vulnerabilities.

(4) Major construction and development plans should pay more attention to the impact of climate change.

A. Major construction and development plans should be carried out with vulnerability assessment and disaster prevention and protection.

B. Major construction and development plans should adhere to National Land Planning requirements.

(5) Carrying out comprehensive river basin management and reducing the overall risk of climate change.

A. Researching the evaluation methods and processes of comprehensive river basin management and disaster vulnerability. Examining and evaluating the capacity of river basin protection, the standards of evaluation, the area designated as having high potential risk, and the adaptive capacity of the said area.

B. Integrating the conservation and recovery of each river basin's water, land, forests and other natural resources, carrying out the concept of “returning the land to the ocean/river”, and making the comprehensive river basin management demonstration plan a priority.

C. Accruing data on mountain collapses, sediment, mudslides and coastal erosion and promoting sedimentary management and recycling.

D. Establishing the river basin management system. In the short term, the government should create a coordinating mechanism and integrate the river basin management; in the long term, a department should be set up to take full charge of the river basin management system.

(6) Strengthening capacities for responding to the impact of extreme climatic events, opening the risk information of impacted and endangered areas, and carrying out disaster reduction education, early warning, and drills for those areas.

A. Establishing adaptation strategies for extreme disasters and risk diversification, organizing an overall disaster prevention and protection policy/ system, and strengthening local communities' adaptive capacity towards extreme weather events.

B. Laying more emphasis on climate change and disaster-prevention education, keeping a high accessibility for disaster-related information, and encouraging citizens' participation and risk-communication.

C. Developing research about how the insurance system can strengthen disaster prevention and rescue.

D. Establishing a standard for mudslides and the dam lake's warning indicator, the areas that would be affected, and proper timing for issuing warnings. Expanding and reinforcing the mudslide early warming and river-status information system in order to decrease the risk of disasters.

E. Upgrading the disaster-preventing resources in the aspects of software and hardware, strengthening the professional ability of the emergency operating centers of different levels, standardizing evacuation procedures,

and achieving the goals of self-rescue and evacuation.

5.3.2 Infrastructure

1. Objective

To raise the adaptive capacity of infrastructure under the threat of climate change. Ensure that its functions can be maintained and the impacts on society reduced.

2. Adaptation Strategies

(1) Revising and implementing current legislation to bolster adaptive capacity for infrastructure

A. Reexamining and improving the design and safety standards of existing or newly-built facilities. Using the most destructive past natural disasters as a standard threshold.

B. Allowing for less stringent safety standards at existing, unexpired constructions.

C. Reexamining the location and design of public facilities in flood-prone areas, evaluating the feasibility of construction in flood-prone areas, and recommending new regulations for construction in these areas.

(2) Establishing a mechanism for estimating the risk of infrastructure safety and models for analyzing the impact on life loss.

Establishing the capacity to analyze the reliability and risk of infrastructure. Creating indicators and considering them as quantified references for decision-making. Conducting rolling reviews of the suitability of each indicator, and using scientific theories and models to simulate various extreme weather events' instantaneous and eventual effects on infrastructure, together with an emphasis on evaluating the loss of human life.

(3) Formulating development and restoration principles for different grades of infrastructure.

A. Each infrastructure should be coherent with the national policy of land conservation and restoration. For construction that is damaged due to natural disasters, the recovery should be divided into three levels: level one for complete recovery, level two for partial recovery and level three for salvage.

B. Appraising the governing strategies, construction methods, materials, and structural arrangements of areas with recurring disasters.

C. Reexamining the location and design of bridges and drainage facilities of roads, taking extreme weather events, upstream and downstream hydrology, geological changes, and ecological preservation into consideration.

(4) Increasing the infrastructure's adaptive capacity and implementing the periodic repair and maintenance of public infrastructure by:

A. For infrastructure that may be inadequate for disaster resistance, it is important to carry out a proper evaluation and repairs in order to increase the impact-resisting capacity.

B. Establishing a mechanism for tracking the

construction, monitoring, disaster prevention, maintenance, and reinforcement of public buildings and utilities.

(5) Enhancing the integration of governmental coordinating mechanisms and resources from industry and academia in order to respond to the impact of climate change:

A. Formalizing an infrastructure safety management program.

B. Centralizing a command center to oversee regional operations.

C. Dividing regions by their respective river basins. The newly-designated regions will then be jointly monitored by transportation, soil and water conservation, forestry and water resources agencies, thereby achieving the joint governance of mountains, rivers, roads, and bridges.

(6) Increasing the staff's quality and skills in infrastructure operation and maintenance.

A. If the existing construction methods are unable to overcome the damage, in order to minimize the loss caused by disasters, the strategy in responding will be to implement flexible disaster-prevention measures, such as planning evacuation routes and the establishment of drilling and refugee centers.

B. Developing a system for training and certifying personnel to diagnose the infrastructure's degree of damage imposed by extreme weather events.

(7) Building an infrastructure operation and management database, and enhancing monitoring procedures.

A. Creating a database for possible destruction to vital infrastructure, and a platform for cross-sector information sharing. The information gained will help predict the intensity and scope of various disasters, and aid in disaster prevention as well as disaster relief. The information in this platform should be updated in a timely manner.

B. Collecting data on infrastructure's resilience towards disaster under different weather conditions, and developing a network monitoring system.

(8) Developing new climate change adaptation technology for infrastructure.

A. Focusing on technology that can help infrastructure withstand the effects of natural disasters such as floods, droughts, strong winds and earthquakes.

B. Investing manpower and resources in international technology exchanges and transfers in return for foreign expertise and feedback and compiling domestic technology between various governmental sectors.

5.3.3 Water Resources

1. Objective

To ensure the sustainability of the nation's water resources and maintain a balance between the supply of and demand for water

2. Adaptation Strategies

(1) Taking sustainability as the highest guiding principle for the nation's water resources management, and also focusing on protecting the aqua environment by:

A. Overseeing all developmental or construction projects. While analyzing the costs and benefits and evaluating the influence on the environment, it is important to also consider climate change and the nation's water resources to prevent the current aqua environment from being upset.

B. Systematically planning and managing the governance of river basins. The planning and management should be based on each river basin's special characteristics, while taking the aqua environment pollution control, sustainability of freshwater resources, and protection of biodiversity and ecosystems into consideration.

(2) Reviewing water resources management from the supply side and reinforcing the efficient usage of water resources

A. Revitalizing current water storage capacities. Repairing and maintaining related facilities when needed, mostly to prevent unnecessary loss of water through leakage or during transportation.

B. Implementing the reservoir watershed land use management, proper use of water resource operating funds to promote reservoir watershed conservation. Converting farmland into woodlands to prevent agricultural pollutants like fertilizers and pesticides from contaminating reservoir waters.

C. Reinforcing cross-regional conjunction use of surface and ground water. Rewarding the development, promotion, and application of alternative water resources such as rainwater or reclaimed water.

D. Strengthening the contingency measures for unusual water shortages.

E. Implementing water rights administration.

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(3) Establishing a database of the regional total quantity of water supply system and reviewing water resource total quantity control policies from the demand side in order to reinforce the efficiency of water resources.

A. Adjusting the water price to a reasonable level, changing water use patterns, establishing a reasonable, fair, and flexible transformation mechanism for water utilization, promoting water conservation efforts, reexamining the current architecture laws, strengthening the regulation of public buildings and facilities, and

promoting the installation of water-conserving devices in public properties.

B. Encouraging the development of low water-consumption industries. Products that require high water-consumption during production can potentially be imported from water-abundant nations.

C. Adjusting the agricultural system by considering the environmental sustainability and farmland productivity. If the two conditions are sustained, we can then promote precise irrigation and improve irrigation methods, which would improve rainwater resource efficiency and reduce the demand for irrigation.

(4) Promoting water sustainability in line with the United Nations' water footprint concept by:

A. Requiring products to be printed with water consumption labels for the consumers' reference to reduce the consumption of products with high water usage.

B. Encouraging corporations to establish water-conserving processes of production in order to decrease the water consumption.

C. Creating financial incentives for conserving and recycling water resources.

D. Calculating water accounts through systematic analysis using the concept of material flow and water balance. Examining the reasonableness of the monitoring data of river basins from different government departments and gaining a full insight into critical environmental information such as that on the atmosphere, quality and quantity of water. Analyzing the water footprint and water resources utilization in an appropriate manner.

5.3.4 Land Use

1. Objective

To incorporate climate change adaptation strategies into relevant laws, regulations, and procedures at all levels of spatial planning.

2. Adaptation Strategies

(1) Incorporating the concept of an Environmentally Sensitive Area into the delineation and management of national conservation areas.

A. Using scenarios and geographic characteristics of disasters in mountainous regions such as mudslides, subsidence, and landslides in recent years to identify Taiwan's environmentally sensitive areas.

B. Due to the characteristics of resources and the urgent need for national land protection, we should actively manage environmentally sensitive areas, review and revise related laws and projects, delineate areas for conservation, prohibit new developments and facilities, preserve and restore national land, protect natural landscapes and forests, conserve soil and water resources, preserve biodiversity, and mitigate the loss caused by the disasters due to extreme weather events.

C. Reviewing and revising regulations on the development and management of national

preserved areas. Increasing the penalties levied on unlawful or environmentally questionable usage of the nation's lands.

(2) Legislating and revising national spatial plans in response to climate change by:

A. Adjusting the urban development pattern, and reviewing the statutory land use plan and related planning process to include climate change in the planning content.

B. Expediting legislation on the national spatial plan, coastal areas and wetlands.

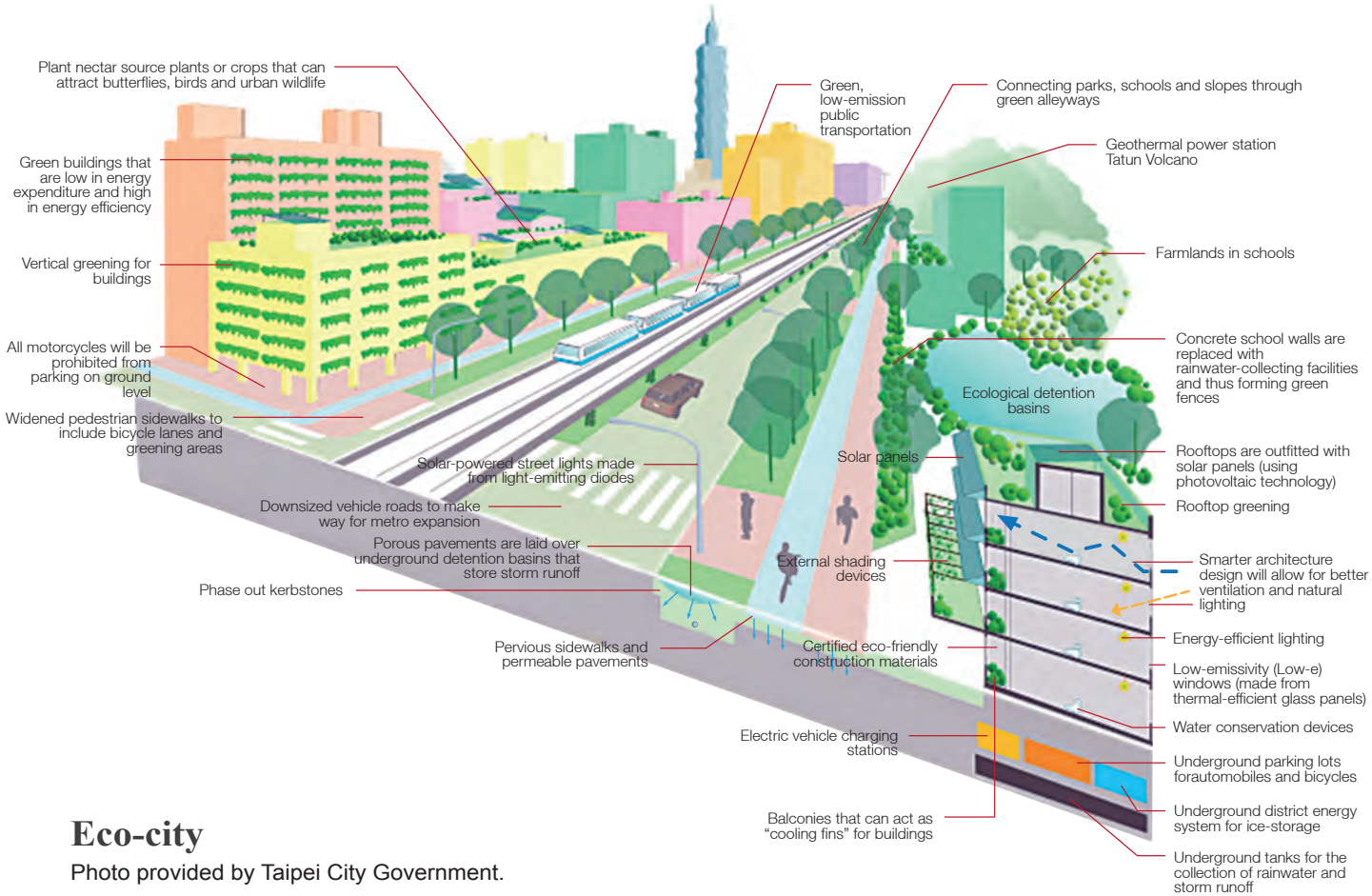
C. Revising urban planning laws, current land use and building regulation for metropolitan areas to promote the development of green infrastructure.

(3) Establishing mechanisms of land use and management for adapting climate change.

A. Establishing a land use performance control system for conservation areas.

B. Establishing programs for rescuing victims of climate change disasters and providing a nonprofit land compensation system in mitigating the effects of climate change.

C. Developing indicators for local growth management. Using the indicators as a reference for reviewing local development,



Eco-city

Photo provided by Taipei City Government.

resource utilization, and ecosystem preservation.

D. Developing mechanisms such as an environmental trust, payments for ecological services (PES), and a land development benefits balancing fund.

(4) Regularly monitoring changes in land use and land cover, and renewing geographic information system (GIS) databases

A. Utilizing satellite imagery, aerial photography and GIS to periodically track land use, cover change, disaster sensitive areas, and low-lying coastlands.

B. Establishing, maintaining, upgrading, and compiling the existing database platform of all associated agencies.

(5) Increasing the cities' managing efficiency and adaptive capacity in flood control

A. Adjusting urban development patterns based on environmental carrying capacity. Evaluating development projects to mitigate the adverse effect on the environment, such as decreasing urban runoff, improving permeability, establishing metropolitan blue and green belts and detention basins, and increasing the permeable areas.

B. A runoff management system should be included in the review of urban and regional planning. The developer should be responsible for the increase in runoff caused by the development.

C. Comprehensively review urban and regional planning, and actively implement the use of parks, schools, fallow and public lands to establish detention facilities in these areas. Properly apply the principles of reusing facilities as guidance for future development.

D. Reviewing the relevant laws and regulations regarding public facilities, strengthening the water interception and conservation capacities of public facilities; amending and increasing the regulations for rainwater storage capacity, permeability, and the use of permeable material for roads, buildings and facilities to enhance regional water conservation.

E. Reinforcing flood control systems by integrating flood prevention measures in city and peri-urban areas. Ensuring an acceptable match of flood-prevention standards between the city and suburbs.

(6) Reviewing the weaknesses and deficiencies of climate change adaptation in current spatial planning.

A. Planning land use from the perspective of entire river basins, raising the carrying capacity of river basin ecosystems, and minimizing the impact of climate change.

B. Adequate adjustment of the existing residential population, industry and land-use patterns to reduce the vulnerability to climate change and respond to the challenges of resource shortages caused by extreme weather.

C. Protecting prime farmland from non-agricultural purposes.

D. Constructing green infrastructure, strengthening

infrastructure through spatial planning, and adjusting the building structure and materials in order for rural and urban areas to adapt to climate change.

5.3.5 Coastal Zones

1. Objective

The objective of the adaption plan for Taiwan's coastal zones is to minimize environmental problems due to inappropriate plans and human developments, to mitigate coastal hazards, and to make the coastal environment sustainable.

2. Adaptation Strategies

(1) Strengthening the mission to prevent coastal erosion, safeguard national

A. Monitoring the effects of ocean and coastal change upon coastal areas and applying proper techniques to protect marine and coastal ecosystems.

B. Cleaning the river mouth areas from fugitive dust.

C. Replanting appropriate trees and shrubbery along the coastline to prevent erosion.

D. Reviewing and estimating the necessity of manmade structures on coastal zones and gradually recovering the coast to its natural state.

(2) Protecting and restoring marine wildlife habitats and wetlands that could be impacted by climate change.

A. Setting goals to protect and restore existing coastal and wetland species by restoration programs. Designating new conservation areas to protect wetlands and to restore

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damaged areas.

B. Formulating a remedy system to reduce the possible impact caused by oceanic and coastal exploitation.

C. Designing conservation plans for wetlands to restore damaged wetlands, and establishing artificial wetlands by encouraging civic groups to participate in coastal protection.

(3) Implementing transformation programs in land subsidence areas.

A. Establishing a control system for land use and applying policies of subsidies and assistance to limit the practices of aqua-farming and prevent further land subsidence.

B. Introducing new economic practices that combine multiple objectives (e.g., water control, industrial and land development) into regions of subsidence.

C. Acquiring and revitalizing subsided land that is suitable for agriculture to develop proper land use and appropriate farming systems.

(4) In response to the possible impact of climate change, the government should respect the local coastal culture and oceanic lifestyle for better practices to preserve and manage the coastal ecosystem and landscape.

A. Conducting risk analysis on both rural and urban coastal settlements, including the idea of limited development zones and buffer zones, as well as promoting disaster prevention strategies to the coastal residents.

B. Coastal settlements should maintain a database that contains cultural and historical value of settlement assets. Surveying, investigating, and evaluating underwater and coastal cultural assets. Repairing and preserving the assets as necessary.

(5) Establishing a database that contains coastal and ocean-related information by systematic observations, surveys, assessments, and evaluations; updating the database periodically.

(6) When coastal zones are being developed, the possible repercussions of extreme weather and rising sea levels should be considered. Environmental impacts for the area should be assessed before coastal developments. Standards and regulations should be set up before the approval of coastal developments.

5.3.6 Energy Supply and Industry

1. Objective

To develop a system of energy supply and related industry that will and can respond to the impacts of climate change.

2. Adaptation Strategies

For issues regarding energy conservation and the search for new and renewable energy, the Executive Yuan has already formulated a policy, the “National Master Action Plan on Energy Conservation and GHGs Emission Reduction.” In this sector, we will focus on energy supply and industrial adaptation strategies.

(1) Building an environment that reduces climate risk and strengthens adaptive capacities.

A. Improving the market mechanism is an effective way to strengthen the adaptive capacity of the energy and economic systems. Market failures that need to be adequately addressed include incomplete information, monopolies, environmental and climate change externalities, and price controls. In the short run, the market distortion can be corrected, and the efficiency of resource production, usage, and allocation can be raised. In the long run, the industrial structure can be reformed in a new direction to meet the needs of climate change.

B. Revising the laws and institutional arrangements to allow suppliers of energy and industries to adapt to the environment of climate change.

C. To help industries adapt to global warming, the government should revise laws related to the fields of land appropriation, taxes, finance and insurance, labor, environmental safety, the use of natural resources, building construction, cross-strait and international trade.

D. The government should participate in international conferences related to climate change adaptation, and form joint projects with other countries in order to allow industries to protect themselves from climate change and make them more competitive globally.

(2) Providing support for industries in response to the impacts of climate change.

A. The government should train and subsidize

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industries for more research on climate change adaptation, equipment replacement, and investment in building necessary facilities.

B. Increasing the industries' need in investing the installation of climate-proof facilities and infrastructure.

(3) Exploiting opportunities for new products and services brought about by the impact of climate change.

A. Mastering the opportunities and positive challenges posed by global warming to various industries.

B. Mastering new government regulations and measures and the industries' new opportunities and markets induced by climate change.

(4) Increasing research and development for climate change adaptation in the energy and industry sectors.

A. Reinforcing and advocating training and technology development and deployment; assisting domestic industries in equipping critical skills for climate change adaptation.

B. Strengthening the industries' adaptive capacity to climate change to reduce the damage caused by climate change impacts.

(5) Conducting an overall inspection of the energy suppliers and industries' production and transport facilities, and appropriateness of their locations, materials, and equipment in response to the impact of climate change.

A. Evaluating the impacts of climate change on energy and industries, their vulnerabilities, and resilience.

B. Evaluating the appropriateness of locations of energy suppliers and industries towards the impact of climate change. Increasing the reliability of related service functions, thereby decreasing the risk of damage caused by disasters.

5.3.7 Agricultural Production and Biodiversity

1. Objective

To develop an agricultural production system that will be sustainable-intensive, sufficiently resistant, and resilient to the effects of climate change, and to preserve the nation's biodiversity

2. Adaptation Strategies on Agricultural Production

(1) Constructing a food security system according to the level of risk

A. Modifying the production, maintenance, and managing pattern of the farming, livestock and fishery sectors in order to adapt to climate change. Improving the utilization and planning of resources in a reasonable manner; safeguarding food safety and the aforementioned sectors' comparative advantages.

B. Revising the nation's policies on fallow lands, reclassified farmland, and farming practices in preparation for crop choice and reactivating farmland after disasters.

C. Achieving the objective of preserving natural resources in a sustainable manner. Reinforcing the ecosystem service function in agricultural production. Reinforcing the effectiveness of farmland resources utilization, and ensuring that prime farmlands are planted with adaptive crops and that the nourishment of the ecological environment is also balanced.

(2) Increasing the capacity for stress resistance of the nation's agriculture by integrating technologies.

A. Introducing crops that are resilient to pests, droughts, floods and saline soil.

B. Breeding livestock that can sustain the stresses and developing the techniques in aquatic product breeding and aquaculture.

C. Adjusting the schedule for crop rotation and leaving land fallow. Developing ecologically-friendly cultivation, which has the advantage of saving both water and energy resources. Promoting precision agriculture, and tapping into the field of biotechnology.

(3) Establishing a multi-goal and sustainable adaptation model for forestry operation, and promoting forestation by:

A. Meticulously planning the delimitation of forest areas and improving the forest physiognomy. Identifying and zoning forest disaster-prone zones, environmentally sensitive areas, and their affecting scope. Effectively prohibiting over deforestation and illegal logging.

B. Promoting community forestry, and encouraging the general public to participate in conservation efforts. Letting the general public and the government share the responsibility for as well as the achievements resulting from preserving natural resources.

C. Reforestation is needed mostly in sloped areas, and on land that has recovered from pollution or has a low possibility of resuming cultivation. Subsided land and government-designated reforestation areas should also be targets for planting more trees.

(4) Establishing an agricultural meteorological monitoring system for changes in domestic and overseas economic markets.

A. Gathering information and databases on agricultural weather cycles and fish migration patterns, and setting up a monitoring/warning system.

B. Gathering information and databases about agricultural product prices in both domestic and foreign markets, and constructing a forecasting system with integration to climate fluctuation.

3. Adaptation Strategies on Biodiversity

(1) Enhancing the connection and management of blue belt and green belt networks in reserved areas.

A. Protecting and connecting existing preserved areas, and identifying potential biodiversity hotspots. Establishing coast, wetland, and freshwater conservation regions (blue belt) and patching up woodlands and grasslands (green belt). This will help alleviate the impact

of climate change and increase the level of biodiversity.

B. Based on the concept of resource sharing and resource co-management, the government should cooperate with indigenous people to protect their sacred lands, mountainous areas, forests, and other natural resources. It should enlist the help from indigenous tribes in forestation, management, and patrol the said areas.

(2) Decelerating the rate of biodiversity loss caused by human disturbance.

A. Managing human disturbance to lessen the ecosystem's pressure caused by manmade pollution, development, overexploitation, wildfires, pests and pathogens, etc.

B. Establishing a national system for the management of invasive alien species. Examining existing laws, organization, work divisions, and implementation to find gaps in the proper execution of the system and ways to improve it. Identifying the priority invasive alien species to be effectively managed.

C. Restoring degraded ecosystems and their ecological functions according to sound ecological principles.

(3) Enhancing the preservation and reasonable utilization of genetic diversity.

A. Establishing a germplasm conservation system to preserve the germplasm of crops, livestock, of harvested species of trees, fish, wildlife and other vulnerable species.

B. Identifying the strains of crops, livestock, of harvested species of trees and fish that are capable of adapting to climate change.

(4) Strengthening biodiversity monitoring, data collection, analysis and application, and assessment of the vulnerability and the risk of biodiversity by:

A. Systematically evaluating and validating the vulnerability level and risk of biodiversity. Identifying the contributions that biodiversity can make to stabilizing the global climate, alleviating ecological disasters, providing ecosystem service, and supporting people's livelihoods.

B. Developing a mechanism for evaluating biodiversity at all levels to raise its resilience to climate change.

C. Establishing a biodiversity monitoring system, database and information center that periodically collects observation data. Using this data to review the results and revise biodiversity strategies and action plans.

D. Developing a warning system against events that will possibly harm biodiversity, ensuring that people will be prepared for such an event.

5.3.8 Health

1. Objective

To modify the compiling system for environmental and health information, and improve the citizens' health condition. Specifically, to reduce the population's average disability-adjusted life years in relation to climate change by five percent every five years.

Disability-adjusted life years (DALYs)

DALY stands for a disability-adjusted life year, a measure of the number of years a person loses due to poor health, disability or early demise. One DALY stands for the loss of one healthy year of life; it can be calculated by combining one's years of life lost (YLL) with one's years lived with disability (YLD). The DALY method is now embraced by the international community as a way of assessing the impact of climate change upon a population's health.

2. Adaptation Strategies

(1) Enforcing the laws and regulations on public health by:

A. Enforcing existing laws and regulations. Enacting new laws and regulations concerning the behavior of any corporation, community, civic group and individual to protect the health of nationals.

B. Improving the implementation of laws and regulations related to environmental protection, disease-prevention and public health in order to safeguard the general public's life and health.

(2) Improving the productivity and work division of environmental and public health agencies by:

A. Revising the structure for the existing work division in order to increase the effectiveness of healthcare and disease prevention programs.

B. Connecting emergency procedures with the national health system to ensure the seamless integration of health preserving, monitoring and reporting, disease prevention, and post-disaster recovery.

(3) Every government department should arrange drills for natural disasters and the prevention of epidemics.

A. Making prevention, mitigation, contingency and recovery of all stages of emergency medical care and the follow-up medical care and medical needs assessment mechanism more sophisticated, and incorporating various types of drills to enhance overall disaster and epidemic prevention capacity.

B. Strengthening disaster and epidemic contingency in each designated department. The designated departments include local public health offices, local hospitals, designated emergency hospitals, and military bases with medical training.

C. Regularly updating and reviewing the content of disaster and epidemic prevention drills.

(4) Improving the general public's knowledge of climate change and post-disaster epidemic preventative measures.

A. The health education department should develop and update materials for climate change education and post-disaster epidemic preventative measures and sanitation, and strengthen the transmission of related

knowledge and skills to the public through various media channels.

(5) Conducting an ongoing assessment of the impact and adaptation of health issues.

A. Keeping track of the impact assessment of climate change on public health and evaluating climate change risks according to updated information on a regular basis. Based on risk assessment, compiling and constructing health care systems and adaptation strategies to ensure the efficient use of resources and to actively respond to the emerging demand.

B. Establishing an evaluation and management system for climate change and health adaptation strategies. Continuously monitoring and assessing the feasibility and actual performance of related strategies or action plans. It is also acceptable to draw comparisons with health policies around the world, and modify the strategies or action plans if needed.

C. Conducting multi-year integrated research in the fields of climate change, the impact on health issues, and adaptation strategies. Continuing to develop the available hardware and software resources for adaptation.

(6) Expanding the compilation of databases with disease-related assessments.

A. The Department of Health, Executive Yuan should provide a platform for the compilation of health information between its subordinate branches. This sharing of information allows for a complete evaluation of the impact and adaptation of health issues.

B. Compiling the time-series databases of health, climate, environmental oversight, insect-borne diseases, socio-economic indicators, and geographical information. These databases allow the future policy analysis and formulation to be based on complete and long-term data.

(7) Strengthening the monitoring system's formation and maintenance.

A. Building a real-time, continuous disease notification and monitoring system, in order to effectively control diseases.

B. Improving rapid screening technology for animal-borne diseases and health monitoring at the border in order to prevent outbreaks of new contagious diseases.

6 Implementation

6.1 Implementation Mechanism and Action Plan

Under the structure of the Climate Change Adaptation Strategies Framework, each agency should carry out the formulation, implementation, and control of adaptation action plans, in order to execute the policy framework precisely. Under this purpose, the Council for Economic Planning and Development (CEPD) established a standard operating procedure (SOP) for agencies in executing climate change adaptation action plans in August 2010 as assistance for all agencies to do the work under common concepts of adaptation.

6.1.1 Implementation Mechanism

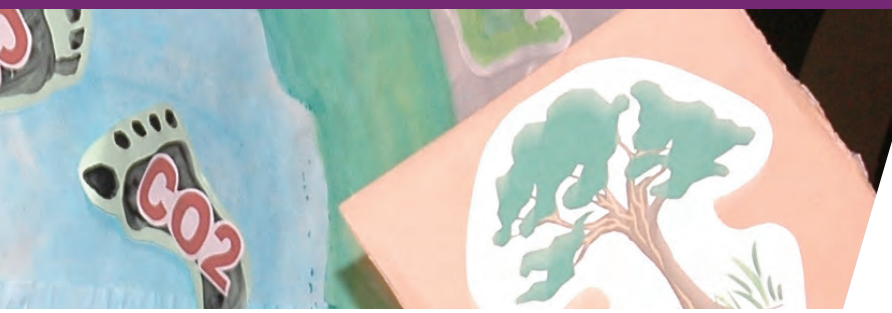
1. Legislating Structural Climate Change Laws

(1) The legislative piece should include the structure of laws, government agencies, decision-making processes, and fiscal plans in the face of climate change.

(2) The legislative piece should establish the foundation of the nation's mitigation and adaptation strategies, and state the principles, goals and policy instruments for managing climate change.

2. Government Agencies

(1) The restructuring of governmental agencies should strengthen the main agencies concerned with climate change policies. This includes the National Development Council,



which will be responsible for policy planning and coordination, and the Ministry of the Environment and Natural Resources, which will be responsible for implementing policies on climate change. These two agencies and other related agencies' functions should be properly adjusted.

(2) In the long run, a feasibility study should be conducted on whether an independent climate change commission should be elected to oversee all operations on climate change. The commission's duties will include autonomous formulation of climate change policies, the supervision and evaluation of the results of the government's policy implementation, and the objective research/analysis on the climate change policies of all associated agencies besides encouraging public participation.

6.1.2 Action Plans

1. Stages of Planning

(1) Analyzing and mapping out the impact and vulnerability of each adaptation sector by:

A. Identifying the vulnerabilities of all sectors associated with climate change (including the analysis of regional differences).

B. Evaluating the overall risk of climate change in Taiwan, including the adaptation strategies evaluation of social costs and benefits.

C. Analyzing the issues faced by all sectors associated with climate change.

(2) Examining and confirming each sector's overall goal and adaptation strategies by:

A. Reviewing the current existing policies of all associated agencies.

B. Modifying and unifying the overall objectives and adaptation strategies of all associated sectors according to the policy framework.

(3) Establishing the measures of Taiwan's adaptation strategies by:

A. Setting concrete and tangible strategic objectives (in quantitative terms if possible).

B. Preparing executable adaptation measures as a basis for formulating action plans.

(4) Regulating adaptation action plans and setting up work and performance indicators by:

A. Drafting an action plan for adaptation.

B. Mapping out a sustainable financial mechanism.

C. Setting up work and performance indicators for evaluating the achievement of action plans.

(5) Integrating and unifying action plans for each adaptation sector by:

A. Evaluating the work division of each adaptation sector and sorting the action plans from these sectors.

B. Assigning work based on the cabinet's priority system.

C. Unifying the action plans into one adaptation strategy.

2. Stages of Implementation, Evaluation, and Feedback

(1) Supervising and implementing each adaptation sector's action plans by:

A. Letting each sector implement the adaptation action plan through work division.

B. Regularly inspecting the implementation of each sector.

C. Amending the schedule and specifications of action plans if needed.

(2) Evaluating and reviewing each adaptation sector's action plans by:

A. Reviewing and evaluating the outcome and performance of each sector's adaptation action plan implementation on a yearly basis.

B. Periodically evaluating the risk and vulnerability of climate change in Taiwan. Revising the adaptation strategies framework and action plans through a rolling review.

C. Implementing the next stage of the action plans.

3. Content

According to the results compiled by the previous process, the overall adaptation strategies should be divided into different sectors, and each sector should establish its own adaptation action plan regarding the sector's characteristics. The content of the plan should include vulnerability and impact assessment, followed by adaptation strategies, objectives, mechanisms, action plans, and indicators. A sustainable financial mechanism should also be included within the content. The CEPD will then collect and review the agencies' reports and compile a final version that will be used as the framework plan of the nation's climate change adaptation action plan.

6.2 Cooperative Measures

The effects of climate change are universal; in order to prepare the nation for the upcoming climate change challenges, besides implementing the adaptation strategies, the government must also foster more collaborative measures amongst its branches to facilitate research, general public education, and citizen participation.

6.2.1 Research and Development

1. Establishing a Compiling Platform for National Climate Change Adaptation Research.

(1) Coordinating national-level scientific research concerning climate change adaptation.

(2) Facilitating cooperation among research centers and identifying gaps in climate change-related knowledge;

(3) Supporting the transfer of research achievements and other developments related to climate change adaptation.

(4) Establishing a system to proofread, compare and fact-check the official data on climate change and the impact compiled by different agencies.

(5) Conducting exchange networks with international authorities on the topic of climate change.

2. Directions for Adaptation Research and Development

(1) The objectives for constructing climate simulation and analyzing capacity are:

A. Obtaining the latest simulation results from the international authorities on climate change, thus increasing our research ability and simulation equipment in the field of climate modeling.

B. Developing a high-resolution regional climate model based on Taiwan's environment to enhance the nation's capacity in simulating and forecasting the impact of climate change upon the island and the world.

C. Continuing to develop time and spatial statistical downscaling, and utilizing dynamical downscaling to estimate Taiwan's climate scenarios.

D. Developing time and spatial downscaling tools and analytical methods based on different sectors' needs for climate risk and vulnerability assessment.

(2) Reinforcing the environmental surveillance technology and information system.

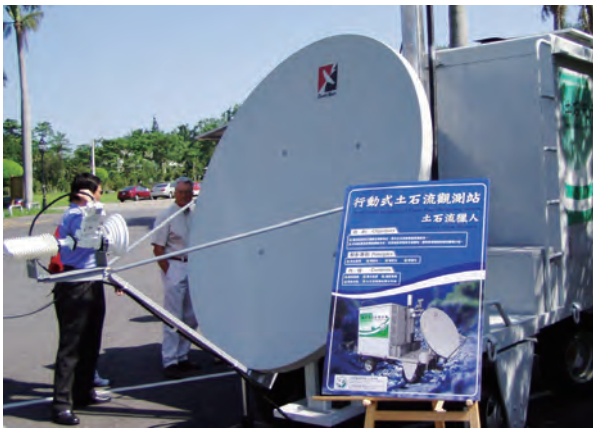
A. Establishing a database to host historical climate data. Taking climate change into consideration, and strengthening current monitoring systems by reducing uncertainty levels within the surveillance data.

B. Establishing key surveillance techniques and indicators in response to climate change.

C. Analyzing the spatial and time issue for the required surveillance data in cross-sector analysis and application. Developing the issue-responding mechanism.

D. Establishing a climate monitoring system on an effective platform for integration, analysis and application purposes, as so to provide a decision-making information service based on the user's needs.

E. Establishing and applying national sustainable development indicators and surveillance data in order to predict the trend of critical issues in climate change.



(3) Vulnerability and adaptive capacity assessments and analysis.

A. Predicting the effects of climate change upon Taiwan's natural disasters, water resources, food safety, public sanitation, ecology and wildlife, society and the economy, etc. Evaluating the risk, impact, influence of vulnerability, and adaptive capacity of the aforementioned aspects, and reinforcing the capacity of cross-sector research and cooperation.

B. Studying the critical issue of climate change under different spatial scales and developing

specific and tangible adaptation measures and technology.

C. Establishing the analytical method for climate change's risk and uncertainty, and further developing the skill of risk management and adaptive capacity in sectors such as natural disasters, water resources, food safety, public sanitation, ecology and wildlife, society and the economy, etc.

(4) Evaluating the costs and benefits of climate change adaptation policies.

A. Establishing the method for cost and benefit evaluation of climate change adaptation policies.

B. Periodically estimating the social costs and benefits of climate change adaptation policies.

(5) Climate change governance.

A. Studying the mechanism of governance under the scientific uncertainty in order to increase the adaptation decision-making capacities of the nation's government, society and industries in facing climate change.

B. Building and fostering partnerships among citizens, experts, scholars, industry heads and government officials in participating in a climate change decision-making mechanism. Furthermore, studies about how to increase the decision-making participation mechanism can be carried out.

C. Evaluating the influence of biodiversity hotspots by taking climate change into consideration. Reviewing the designation of ecological preserved areas according to the evaluation, and flexibly adjusting on-going policies.

D. Formulating the nation's policies in rural area planning, agricultural development, and farmland. The formulation of the aforementioned policies has to take national food safety, water resource supply, and climate change into consideration.

6.2.2 Educating the Public

1. Formulating and Implementing the Climate Change Adaptation EFA (Education for All) Plan

(1) Formulating and implementing the Climate Change Adaptation EFA (Education for All) Plan. Because of its integrating mechanism, the plan will be conducted through the channels of the Ministry of Education, public schools and other educational establishments. The plan will also increase the level of public participation, and the interaction between the citizens, decision makers, stakeholders, and researchers.

(2) The education structure locates climate change as a superordinate concept and mitigation and adaptation as a subordinate concept. The goal of this structure is to give a solid concept of climate change adaptation in which it combines the theory, the practice, and the global trend.

2. Increasing the crisis consciousness towards climate change, contingency ability, and related adaptation knowledge

(1) The education about climate change should

be structured with other topics in order to have a better understanding of the relationship between them. The topics may include energy conservation, carbon emissions, adaptation, resources, and disaster prevention.

(2) The topic of climate change will be incorporated into environmental education courses such as a resources class or disaster prevention class.

(3) Enhancing the fundamental research about climate change education and clarifying the content and strategy of education.

3. Promoting scientific and environmental education and increasing the adaptive capacity for the general public.

Enhancing the basic natural and social science education and training that relates to climate change with an emphasis on attitude and action. In order to increase the nation's basic adaptation capacity, we can enrich the general public's climate change-related knowledge through scientific and environmental education.

4. Cultivating and Recruiting Climate Change Experts with extensive yet specialized knowledge by:

(1) Setting up study abroad programs for local scholars to travel overseas.

(2) Recruiting foreign scholars to share their expertise and experiences.

(3) Expanding academic research on the environment, natural resources, energy and disaster prevention; training more professionals in the field of climate change; increasing international contact and interaction; and importing foreign technology and skills.

5. Promoting popular science education and increasing the nation's cultivation of climate change

(1) Constructing cultivation of climate change and adaptation.

(2) In order to familiarize the general public with topics about climate change and adaptation, the government should cooperate with communities and hold activities such as popular science lectures, exhibitions, and competitions on the topic of climate change adaptation. The methods for familiarization can also include producing educational video clips, publishing popular science books, and creating academic materials on related topics.

(3) Establishing E-learning courses about climate change adaptation and strengthening the construction and management of databases.

(4) Promoting cross-sector risk communication research and education with the topic of climate change adaptation in order to strengthen the professional degree of press media.

6. Establishing Platforms for Providing Climate Change Adaptation Information

Climate change information platforms will provide services such as academic information integration, public campaigns and information exchanging.

6.2.3 Public Participation and Community Involvement

1. Integrating and Proposing Adaptive Decision-Making and Actions between the Government, Private Groups, and the General Public

Since adaptation requires integration across various sectors, government agencies should properly integrate resources from industries and academia. Both public and private sectors are invited to contribute to the nation's overall response towards climate change.

2. Promoting Local Climate Change Adaptation

The promotion of local adaptation should be done in a gradual manner from central to local government. The local government should establish demonstration projects and standard operating procedures (SOPs) for local adaptation in order to deepen the influence of climate change adaptation. The established projects and SOPs can also be the reference for other local governments in promoting adaptation policies.

3. Establishing incentive programs to encourage the whole country in actively carrying out climate change adaptation

Governmental agencies should create incentive programs in order to encourage the public and private departments and the general public in actively carrying out adaptation policies or joining the related activities. The said activities can be competitions or interactive exhibitions on climate change.

4. Combining and Utilizing the Resources from Civil Society Groups and Communities

Local civic groups have been increasingly active in recent years, with many non-governmental organizations utilizing online platforms such as e-newsletters, blogs and Facebook to advocate environmentally friendly practices. These groups also provide information such as international trends of development in carbon emission and analysis for national policies, and have thus become an important channel for information distribution. Governmental agencies should seek to cooperate with these civic groups to raise public awareness on climate change adaptation. Possible cooperating options may include co-publishing and exhibitions with topics about climate change, or setting up a propaganda circuiting car program.

5. Promoting Adaptation Education Training Activities and Public Participation

From central to local government, various activities should be held in order to increase public participation. By holding these activities, the government can not only understand the citizens' needs, but may also create an island-wide consensus about adaptation, plus train the citizens in acquiring participation skills. The government should familiarize the general public with opinion sharing and participating in decision-making, and thus can increase the nation's cultivation, achieving efficient communication and problem-solving.

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7 Conclusions and Outlooks

Climate change is a worldwide and ongoing event that all countries around the world will confront and suffer different levels of damage as a result. However, the damage caused by climate change cannot be completely mitigated. For example, in the case of a typhoon, it is only expected that the damage can be minimized because a typhoon cannot be controlled or rerouted. Therefore, in the face of climate change, the correct courses of adaptive actions should be 1) to reinforce adaptive capacities before a natural disaster strikes, and 2) to recover from a disaster as soon as possible.

Due to the geographic and geological characteristics of Taiwan, the whole island will always be at risk from earthquakes, typhoons and other natural disasters. Extreme weather and rainfall may enhance the frequency and scope of disasters, implying that regions with high potential for hazards are found everywhere in Taiwan. As a result, setting up adaptive policies responding to climate change is very important. Therefore, the Executive Yuan has proposed a scheme referred to as the “National Climate Change Adaptation Policy Framework” in order to actively respond to the challenges and seek to transform climate change from a threat to an opportunity.

The “National Climate Change Adaptation Policy Framework” will serve as the main reference for each department's future adaptation work. The content of the Framework combines the research, planning results, and conception performed by the teams of consultants and agency representatives. Scholars, experts, and talents from various fields have joined the formulation process, and the Framework has been discussed in symposia in different regions with opinions collected from all over the country. The Framework has organized the contemporary research result of Taiwan's future climate change trend, and has been accompanied by a clear description of the relationship between mitigation and adaptation. Eight adaptation sectors have been identified in the Framework, followed by the impact and challenge that climate change has caused in each sector, and a complete adaptation strategy. Furthermore, the Framework also formulates the response measures such as research, development, education, and public participation in order to coordinate and integrate each sector's adaptation strategies.

The government departments and agencies will further implement the plan, execution and control of adaptation action plans in order to fulfill the objective of this framework and present a legacy of sustainability that is adaptive to climate change. In the future, each sector's working groups and agency's adaptation groups should always be prepared in order to respond to the new challenges from Taiwan's capricious environment. Even if a new type of disaster (accident) does happen, it is important to transform the accident into useful experiences. For new types of climate disasters, each group should formulate the effective response action in a rolling feedback manner, and gradually include feedback in the future adaptation strategies.

It is noteworthy that the actions of adaptation and mitigation are inextricably linked. Although this framework endorses mainly adaptation strategies, the Council of Economic Development also recognizes the importance of mitigation methods. As part of the global community, Taiwan

will continue to pursue its emission targets in the reduction of carbon dioxide and other greenhouse gases, such as the execution of the “National Master Action Plan on Energy Conservation and GHGs Emission Reduction” and the promotion of resources conservation, the development of green technology, and its related technology and application. Hence, it is hoped that Taiwan will progress toward the prospect of a green economy and low-carbon society in the future.

The Framework has been formulated under the recognition that the problem caused by climate change has become a global issue which has crossed all boundaries. The consequences of such a grave issue should be well-understood by the general public, and all individuals should play their part in saving the environment. Only if every citizen is participating into the work of mitigation and adaptation can we avoid the impending crisis that climate change may arouse.

Appendix
Extract from the report of climate change science

The National Science Council (NSC) released "The Science Report of Taiwan Climate Change 2011", the first official report on the effects of climate change on Taiwan in November 2011. This report analyzes the history and trend of climate change, covering changes in temperature, precipitation patterns, and sea levels in Taiwan.

Figure 1 represents the time series and trends of the annual average temperature in Taiwan. Specifically, Figure 1(a) shows the annual average temperature in Taiwan from 1911 to 2009, averaged from six meteorological stations, i.e., Taipei, Taichung, Tainan, Hengchun, Hualien, and Taitung. The black line sketches the eleven-year moving average and the results of linear regressions are shown for the last one hundred (yellow), fifty (green), and thirty (purple) years. In addition, solid lines indicate that linear time trends have passed the 95% confidence level and the dotted lines have not. The slopes of each regression are marked in the upper left-hand corner, and the average temperature of the base period, which extends from 1980 to 1999, is listed in the lower right-hand corner. Moreover, in Figure 1(b), from left to right, the bars present the magnitudes of the change over the past one hundred, fifty, and thirty years, respectively. It is noted that solid bars mean that the linear trends have passed the 95% confidence level, and the hollow bars have not.

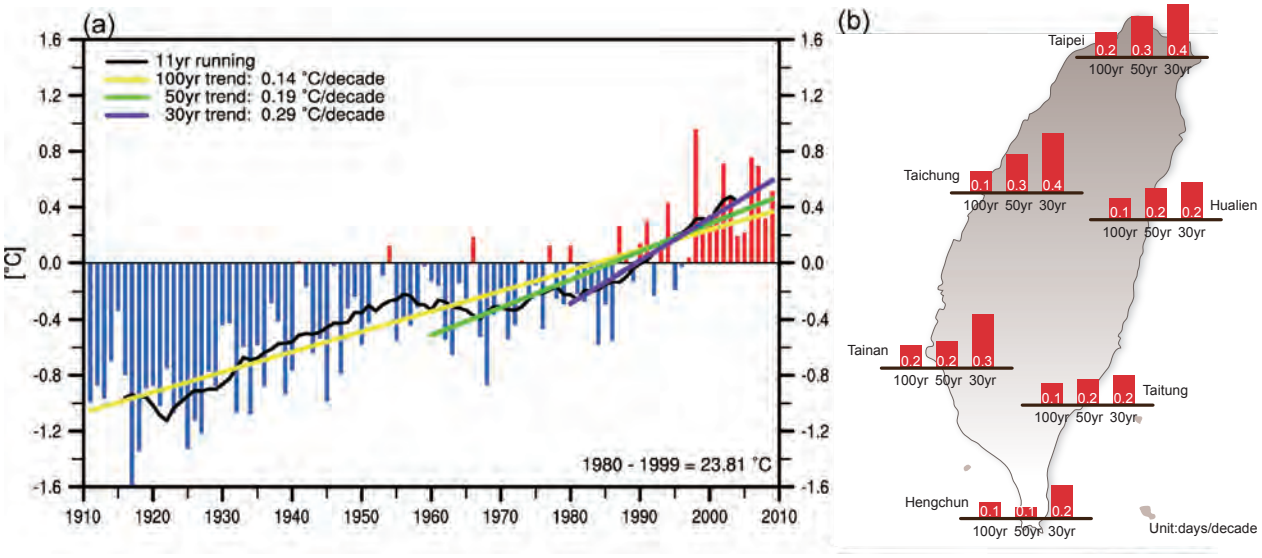

Figure 1: Time series and trends of the annual mean temperature in Taiwan. (The Science Report of Taiwan Climate Change 2011)

Figure 2 depicts the time series and trends of the annual total number of rainy days (daily rainfall ≧ 0.1 mm) in Taiwan. It is worth noting that, in Figure 2(a), the black line sketches the eleven-year moving average and linear regression lines are shown for the last one hundred (yellow), fifty (green), and thirty (purple) years. Moreover, solid lines indicate that linear trend terms have passed the 95% confidence level, and the dotted lines that they have not. The slopes of each regression are marked in the upper left-hand corner, and the average number of rainy days of the base period (i.e., from 1980 to 1999) is listed in the lower right-hand corner. In Figure 2(b), from left to right, the bars present the magnitudes of the change over the past one hundred, fifty, and thirty years, respectively. Solid bars mean that the linear trends have passed the 95% confidence level, and the hollow bars that they have not.

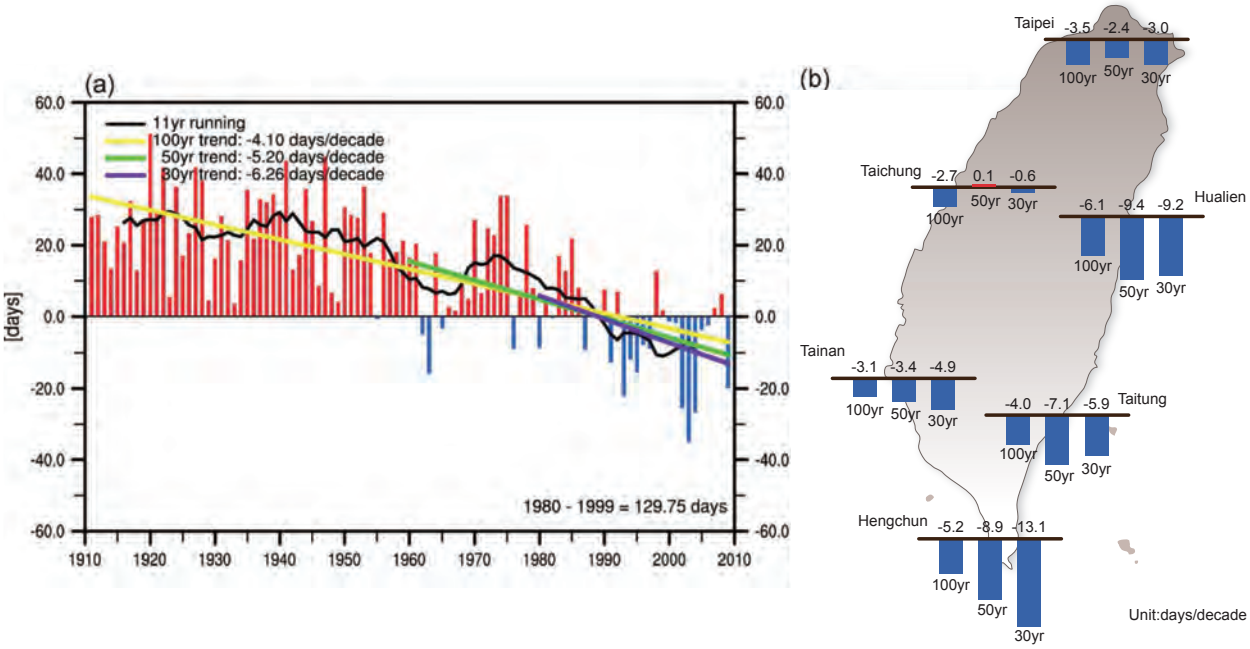

Figure 2: The annual total number of rainy days (daily rainfall ≧ 0.1mm) in Taiwan. (The Science Report of Taiwan Climate Change 2011)

Based on the A1B scenario analysis, Table 1 lists the projected climate changes, including temperature and precipitation (2080-2099 average minus 1980-1999 average), in four regions of Taiwan (i.e., north, central, southern, and eastern Taiwan). Notice that the '10', '25', '50', '75', and '90' reveal the corresponding percentiles in each season and region. With respect to the change in precipitation levels, rows in which at least 3/4 of the cells show the same sign are colored blue for increasing and orange for decreasing precipitation.

Appendix
Extract from the report of climate change science

Table 1: The regional averages of projected climate change effects in four regions of Taiwan under the SRES scenario of A1B

		Change in Ground Temperatures (%)							Change in Precipitation Levels (%)						
Regions	Seasons	Minimum	10	25	50	75	90	Maximum	Minimum	10	25	50	75	90	Maximum
Northern Taiwan	Winter (DJF)	1.9	1.9	2.1	2.7	3.1	3.4	3.8	-44	-29	-20	-13	-3	7	33
	Spring (MAM)	1.7	1.8	2.2	2.6	2.9	3.4	3.9	-31	-24	-14	-8	6	17	36
	Summer (JJA)	1.7	1.8	2.2	2.7	3.0	3.3	4.0	-15	-12	-1	14	19	46	64
	Autumn (SON)	1.6	1.8	2.2	2.6	3.1	3.3	3.8	-33	-25	-10	8	21	28	34
Central Taiwan	Winter (DJF)	1.8	1.9	2.0	2.6	3.0	3.3	3.7	-49	-33	-22	-15	-4	6	22
	Winter (DJF)	1.6	1.8	2.1	2.6	2.9	3.3	3.8	-36	-25	-16	-10	3	17	41
	Spring (MAM)	1.8	1.8	2.2	2.7	3.0	3.2	4.0	-15	13	2	-14	26	64	69
	Summer (JJA)	1.6	1.8	2.2	2.6	3.0	3.3	3.7	-34	-23	-7	11	25	31	45
Southern Taiwan	Autumn (SON)	1.7	1.7	2.0	2.5	2.9	3.2	3.4	-47	-34	-22	-13	-5	5	8
	Winter (DJF)	1.5	1.8	2.0	2.5	2.8	3.0	3.6	-41	-26	-21	-14	-5	22	34
	Spring (MAM)	1.7	1.7	2.2	2.5	2.9	3.2	4	-20	-19	7	16	26	69	76
	Summer (JJA)	1.5	1.7	2.1	2.6	2.9	3.1	3.6	-28	21	-8	13	25	36	55
Eastern Taiwan	Winter (DJF)	1.8	1.8	2.0	2.6	3.0	3.3	3.7	-44	-31	-20	-12	-3	5	17
	Spring (MAM)	1.5	1.8	2.1	2.5	2.8	3.3	3.8	-37	-25	-18	-11	1	20	36
	Summer (JJA)	1.7	1.7	2.2	2.6	2.9	3.2	4.0	-17	-15	3	15	26	57	64
	Autumn (SON)	1.6	1.8	2.1	2.6	3.0	3.2	3.7	-30	-23	-10	10	23	33	43

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