Final Report of the Project on Establishment of Strategies Responding to Climate Change on Island and Coastal Biosphere Reserves

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Chapter 1
Research Questions and Objectives

The first stage of 'The Impacts of Climate Change on Island and Coastal Biosphere Reserves' research was conducted for a year from March 2014 to February 2015. This is the second research stage on island and coastal biosphere reserves to establish strategies responding to climate change.

Various strategies against climate change including mitigation and adaptation are established and implemented at a global, national and local level. However, even though international protected areas (IPAs) including biosphere reserve (BR) are more vulnerable to climate change, the establishment and implementation of IPA-specific or BR-specific strategies against climate change are quite rare. In accordance with such ~~a~~ circumstance, international organizations have emphasized the importance and necessity to establish and implement IPA-specific or BR-specific strategies. The evidences include the following.

The Seville Strategy on BRs that were developed in 1995 may be the most significant initiative that officially recognized the importance and necessity of developing a special strategy for the conservation and sustainable use of BRs. In 2010, IUCN-WCPA et al (2010) have emphasized protected areas helping people cope with climate change. In the "Madrid Action Plan of 2008", the key result of the 3rd World Congress of Biosphere Reserves, accelerating climate change has been referred to as the first of three major challenges for the MAB Programme to effectively respond to in the period until 2013 (for detailed activities related to climate change in UNESCO BRs, see GCUNESCO, 2011: 12-20). Following this, in June 2011, UNESCO adopted the Dresden Declaration at the 40th anniversary conference of UNESCO's MAB Programme titled 'For Life, for the Future: Biosphere Reserves and Climate Change', focusing on political commitment and decisive action worldwide at policy level in the member states, practical level in the biosphere reserves, and UNESCO level.

From a macro perspective, it might also be maintained that the Convention on Biological Diversity (CBD), WWF's Manual for Building Resistance and Resilience to Climate Change in Natural Systems (WWF, 2003), the Aichi Biodiversity Targets 'Living in Harmony with Nature' in 2010, and EU Biodiversity Strategy for 2020 are the special categories applicable to the conservation of BRs in relation to climate change.

In such context of international activities, some strategy researches were conducted for conservation of domestic or international protected areas such as national park, biodiversity site, and World Natural Heritage site, etc. They cover a specific sector, such as biodiversity in protected areas or multi sectors (eg. Wein et al, 1990; Hannah et al, 2002; Scott et al, 2002; Scott et al, 2005; Welch, 2005; Baron et al, 2009; Heo et al, 2010; World Bank, 2014).

However, even though IPAs including biosphere reserve are more vulnerable to climate change, the research on the BR-specific or IPA-specific strategy responding to climate change are quite rare. There are only a few researches that focus on the conservation of biodiversity in relation to climate change in a specific BR site (eg. Yang and Ming, 2003; Scott et al, 2005; Heller and Zavalet, 2009; Lemieux et al, 2011).

In these contexts, this research aims to establish the strategies responding to climate change on island and coastal BRs. The significance and necessity to conduct this research are: 1) Original ecological and geological quality should be conserved so that the original quality of BR contributes to mitigating climate change through their ecological services; 2) Due to BR's vulnerability to climate change, BR-specific strategies should be established and implemented; 3) Without implementation of BR-specific strategy, the original ecosystem of BR could not be conserved, and sustainable use could not be achieved; 4) At a local level, the establishment of a BR-based strategy will enhance awareness and capacity building as well as benefiting from pre-existing engagements and motivations from local stakeholders towards the implementation of effective adaptation measures.

Chapter 2
Research Contents and Methodology

In order to achieve the objectives, this research covered the following themes.

(1) Chapter 3: Reviewing the Existing Mitigation and Adaptation Measures against Climate Change: A wide range of mitigation and adaptation measures have been developed and implemented at a national, local, and global level. However, mitigation measures are characterized by not applying to a specific target sector, but by contributing to the entire earth from the reduction of greenhouse gas emission. Inversely, adaptation measures are characterized by applying to a specific target sector. Thus, mitigation measure can be applicable to all countries, regions, and specific target sectors, but adaptation measures differ by target sectors due to the ecological, geological, and socio-economic differences. In this sense, it may be maintained that mitigation measures are in a generalization level, while adaptation measures are in empirical uniqueness by target sector.

In this context, this research reviewed the existing mitigation and adaptation measures at a general level, with a purpose to draw significant measures applicable to the establishment of island and coastal BR-specific mitigation and adaptation strategies.

(2) Chapter 4: Reviewing Protection Strategies of Protected Areas: Some countries or regions and academic scholars have published the protection measures of protected areas such as domestic national parks, ecological protection zones, and international protected areas, etc. (eg. Yang and Ming, 2003; Scott et al, 2005; Heller and Zavalet, 2009; Lemieux et al, 2011).

These protection measures will provide a more direct and useful guide to the research's objectives than the information that were concluded from existing mitigation and adaptation measures against climate change. This research summarized the review as below.

o General questions on protected areas in terms of climate change strategy.

o Main climate change strategies for protected areas in terms of networking, adaptation and mitigation measures, etc.

o Protected areas at an international level with a special reference to Biosphere Reserve, World Heritage site and Ramsar site, etc. in relation with protection strategies.

(3) Chapters 5, 6 and 7: Establishment of Strategy against Climate Change on Island and Coastal Biosphere Reserve: This theme is the main core of this research. The research was based on the following methodologies.

Firstly, the strategy for island and coastal biosphere reserves (hereafter ICBR) should be established on the basis of real impacts of climate change. The first stage of this research focused on the findings of climate change impacts on ICBRs at a desk research level (Jeong et al, 2015). Basically, the strategy was established on the findings of the basis of climate change impacts from the five ICBR sites in the first stage of research, but this research attempted to establish more comprehensive strategies which are applicable to other BRs in general.

Secondly, the findings of climate change impact on ICBRs from the first stage of research enable us to categorize the impact sectors into, at least, ecological vulnerability, social vulnerability, and economic vulnerability. In accordance with this finding, this research established strategies against climate change by the three sectors of vulnerability being defined as the system's capacity or resilience to absorb and recover from hazardous event.

Thirdly, the three vulnerability sectors were composed of the following research themes, respectively.

o Strategy against Ecological Vulnerability: Ecological vulnerability is an ecological burden of risk arising from the unsustainability of BR. The target of strategy included ecosystem, biodiversity, communities of flora and fauna, and species (threatened/invasive ones), etc.

o Strategy against Social Vulnerability: Social vulnerability is a social burden of risk arising from the unsustainability of BR. Compared to ecological and economic vulnerability, the sectors of social vulnerability that can be included research are too many. The examples include soil erosion, coastal erosion, beach erosion, and natural disaster, etc. Therefore, this research approached the establishment of strategy on social vulnerability not from individual sector, but how to access the establishment of strategy on social vulnerability to climate change.

o Strategy against Economic Vulnerability: Economic vulnerability is an economic burden of risk arising from the unsustainability of BR. The target of strategy included agriculture, tourism and fishery industry etc.

Fourthly, the research was based on the following integrated policy paradigm in the establishment of strategy against climate change on the above three sectors of vulnerability.

o Even though human-induced greenhouse gas emission as the core cause of climate change is locally sourced, its impact is global.

o Human-induced greenhouse gas began to be emitted from the emergence of social system of industrial society which is characterized as industrialization, urbanization, consumerism and globalization, all of which began to emerge from the 18^{th} century. In this sense, the social system of industrial society is the source of environmental problems including climate change, and the determinant of the state of environmental problems.

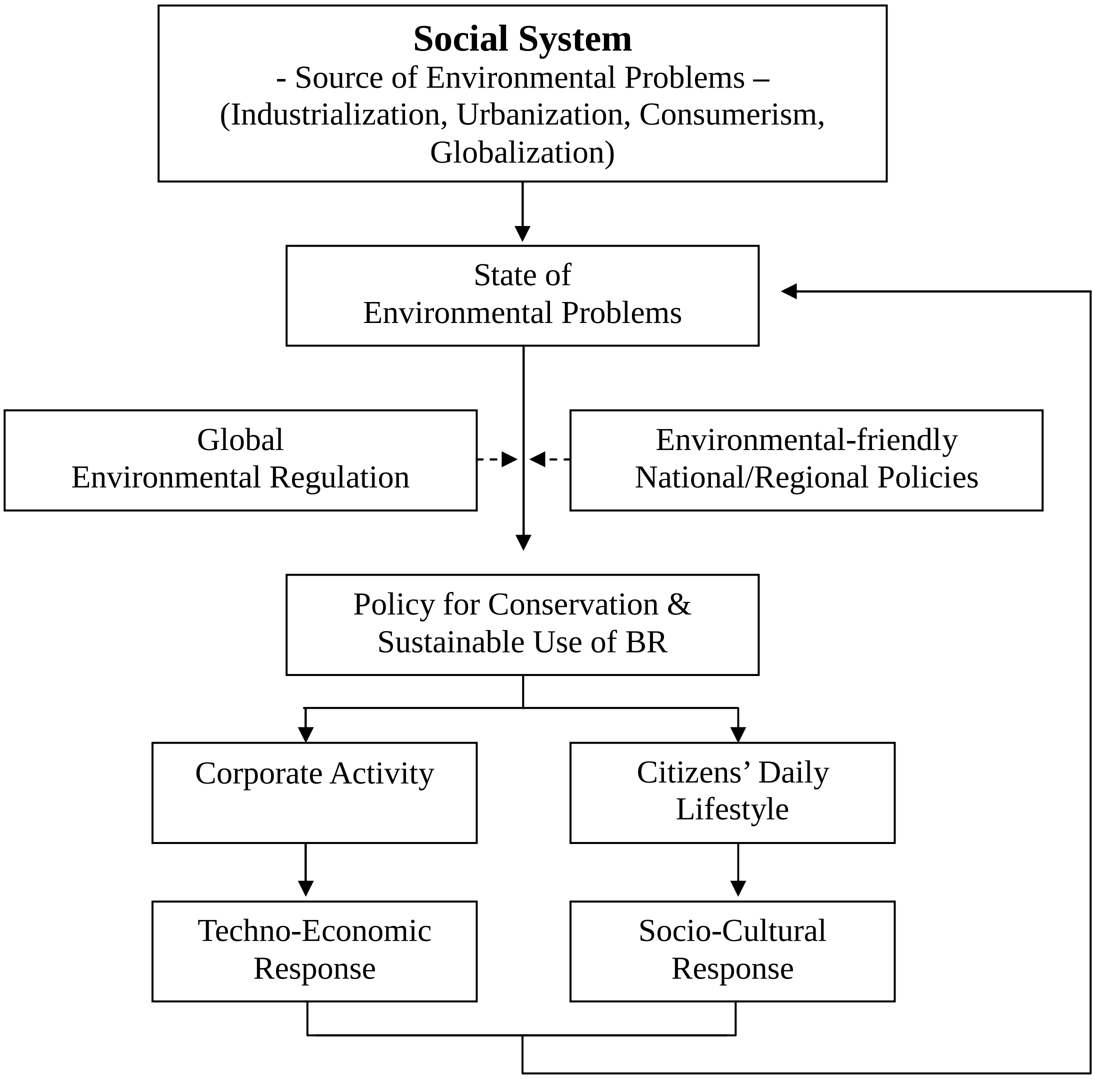
o International organizations such as United Nations have proposed the guideline of environmental regulation at global level. In accordance with this, local and state government have developed and launched environmental-friendly national and regional policies.

o The policy for conservation and sustainable use of BR is being launched independently and/or as a part of environmental-friendly national and regional policies, focusing on corporate activity and citizens’ daily lifestyle which are the major sources of pollutions including human-induced greenhouse gas.

o Corporate activity is the target of techno-economic response to environmental problems, while citizens’ daily lifestyle is the target of socio-cultural response.

o Both techno-economic and socio-cultural response is applied to the state of environmental problems as a feedback mechanism.

o The above- mentioned policy paradigm of environmental problems including climate change is diagramed as <Figure 1> (Jeong, 2015b).



<Figure 1> Integrated Paradigm for Establishing the Strategy against Climate Change on Island and Coastal BRs

Fifthly, the strategies were established, focusing on adaptation. This is because mitigation is a measure for applying to the entire regional, national and global level rather than BR alone. However, this research also examined mitigation as the strategy on ICBRs, including energy, waste management, forest management, key ecosystems protection as carbon sink, etc. As identified in the first stage of research (Jeong et al, 2015), various mitigation and some adaptation measures are already implemented in the five ICBR sites.

However, the adaptation and mitigation measures can be applied not only to the five ICBR sites alone, but to the entire island and coastal region where the five ICBRs are located. In such context, the establishment of ICBR-specific mitigation and adaptation measures are based on the adaptation capacity of ICBR sites being defined as ‘the potential or capacity of a system to adjust via changes in its characteristics so as to cope better with existing climate variability, or with changes in variability and mean climate conditions’ (UNDP, 2004).

Chapter 3
Reviewing the Existing Mitigation and Adaptation Measures against Climate Change

1. Conceptual Implications of Strategy, Policy and Measure

There are some terminologies in relation to the response to climate change. Examples include climate change strategy, climate change policy and climate change measure. Before reviewing the existing mitigation/adaptation measures of climate change, we need to understand the differences in concepts among strategy, policy and measure.

A reality consists of many components implying internal attributes, and the concept of a reality is defined as a synthetic connotation implying the internal attributes consisting of the reality. In this context, climate change strategy, policy and measure are all the conceptual terminologies that are applied to the response to climate change, but they have different conceptual implications. The differences are explained below (Jeong, 2004, 316-325).

Strategy: Strategy is a method or plan chosen to bring a desired future such as achievement of a goal or solution to a problem. In this sense, strategy is about means being mobilized to attain ends, but not with their specifications. The specification of ends is a matter of stating those future conditions and circumstances toward which effort to be devoted until such time of those ends are obtained.

Strategy is concerned with how we will achieve our goals, not with what those goals are or ought to be, or how they are established. If strategy has any meaning at all, it is only in relation to some goal or end in view.

Such strategy has a four-part structure. First are the ends to be obtained. Second are the policies for obtaining the ends, the ways in which resources will be deployed. Third are tactics, the ways in which deployed resources are actually used or employed. Fourth and last are the resources themselves, the means at our disposal.

Over time, the employment of resources yield actual results and these, in light of intended results, shape the deployment of the resources' future. Thus, "realized" strategy emerges from action and decision patterns. And thus, that strategy is an adaptive, evolving view of what is required to obtain the ends in view.

Policy and Measure: Policy is defined as an action plan projecting the practice of value being set up as a goal in strategy. In this sense, policy is a sub-concept of strategy. A variety of policies can be set up for implementing a strategy.

Policy includes at least three components. They are an intention to change a target to a direction, a goal to change the target to the direction, and the means necessary for achieving the goal. For example, the target of climate change policy is climate change. The goal for climate change policy is to maintain the original state of climate. If the climate is changing, a goal is set up to recover the changing climate to its original state. Means is the instrument being mobilized to achieve the goal such as how to reduce greenhouse gas emission or how to adapt to the changing climate change. As a variety of policies can be set up for implementing a strategy, a variety of means can be mobilized to achieve a policy goal.

Measure is defined as a way of achieving a goal set up or a method for dealing with a situation. Thus, explained above, measure is equivalent to the means of policy being defined as the instrument being mobilized to achieve the goal set up.

The Relation among Strategy, Policy and Measure: As reviewed above, strategy, policy and measure are independent concepts, but their conceptual implications are rather interrelated as below. Strategy is a genetic concept, while policy is a specific concept. The former is a concept including sub-concepts, while the latter is a concept being included in a genetic concept. For example, animal is a genetic concept and human beings and dogs are specific concepts. Meanwhile, measure is a specific concept of policy like how man and woman are specific concepts when human beings is a genetic concept.

Applying such a hierarchically conceptual position of the three to climate change, climate change strategy is the guiding instrument of climate change policy, both in the medium and long-term, to face the impacts of climate change and to transition towards a competitive, sustainable low-carbon emission economy. Climate change policy is an instrument being mobilized to achieve climate change strategy. Meanwhile, measure is a means being mobilized to achieve the goal of climate change policy.

In this sense, for the case of climate change, mitigation/adaptation is neither strategy nor policy, but a measure being mobilized as a means for achieving the goal climate change policy as a conceptual component of climate change strategy.

However, in a narrow sense, the terminology, strategy, is used in relation to mitigation and adaptation. Strategy of mitigation and adaptation measure is an example. In this case, to achieve their goals, the terminology, strategy implies what options to select among the available options of mitigation and adaptation. Thus, the terminology, strategy being used in relation to mitigation and adaptation measure does not imply the strategy as the genetic concept, but implies planning that is defined as the process of thinking and organizing the activities required to achieve a desired goal that is being set up in the options of mitigation and adaptation measure.

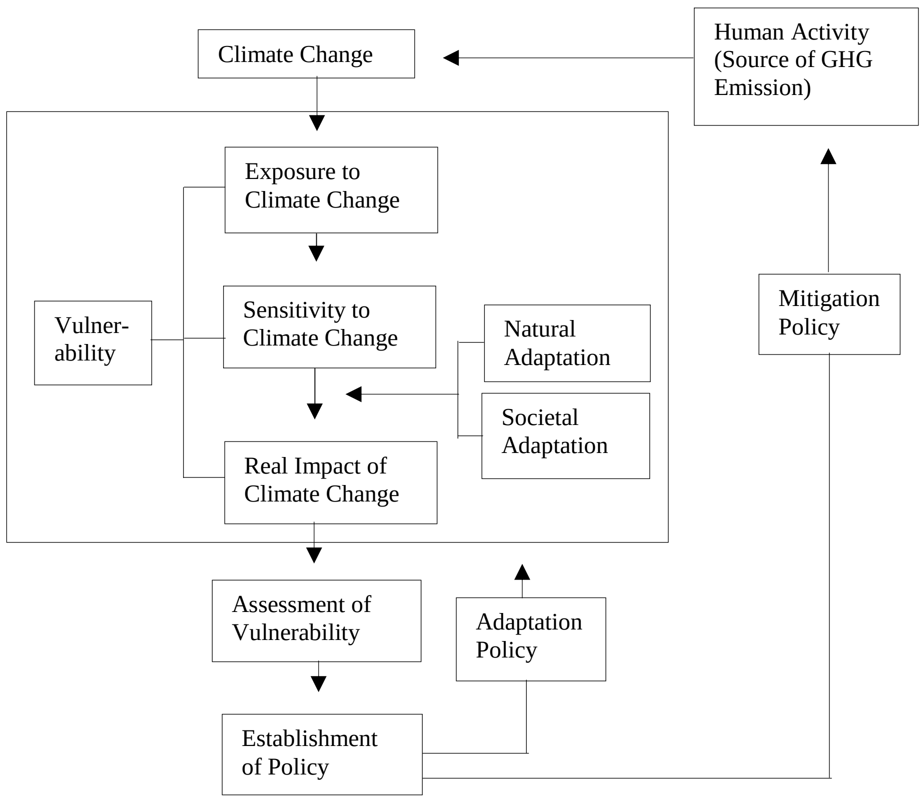
2. Conceptual Position of Mitigation and Adaptation Measure as a Means of Climate Change Policy

Global warming is the cause of climate change. There are two groups of scholars arguing the cause of global warming. One is those arguing the natural factors (eg. Sylvestre, 2000: 273-275; Flannery, 2005: 78; Ruddiman, 2007: Chapters 3-4; Choi, 2008: 325-329). The other is those arguing the emission of greenhouse gases induced by human activity in the process to improve material affluence and convenience in everyday life (eg. Kraus et al, 1992: 4, 28; Miller, 2002: 452-453; IPCC, 2007).

United Nations Framework Convention on Climate Change (UNFCC) argues that the current state of climate change is caused by both natural and human-induced greenhouse gas emission, but 20% are from natural factors and 80% are from the emission of greenhouse gas by human activities (Jeong, 2009).

The six global warming substances have a different impact on climate change. Some scholars (eg. Kraus et al, 1992: 4, 28; Miller, 2002: 452-453) argue that the impact of CO_2 on climate change occupies 66% at minimum and 99% at maximum. However, UNFCC argues the impact of CO_2 on climate change occupies 80% among all of the six global warming substances (Jeong, 2009). This is the reason why we emphasize reducing CO_2 emission when we mention about climate change.

As recognized, there are two measures responding to climate change. One is mitigation measure and the other one is adaptation measure. The conceptual positions of the two measures are diagramed as <Figure 2> in relation to the impact of climate change on nature and human society from the emission of human-induced greenhouse gas (Jeong et al, 2015: 5).



<Figure 2> Conceptual Position of Mitigation and Adaptation Measure as the Climate Change Strategy

As shown in <Figure 2>, human induced greenhouse gas is emitted from Human Activity. In this sense, Human Activity is the major source of climate change. Human beings and nature are exposed to the changed and/or changing climate caused by

Human Activity. This is Exposure to Climate Change. However, when the same climate change arises in different regions and countries, its real impact on human beings and nature are different. This is because an intervening factor determining the real impact of climate change exists between Exposure to Climate Change and Real Impact of Climate Change. The intervening factor may be termed Sensitivity to Climate Change which is an existing adaptation mechanism inherent in each region/country. This means that the Real Impact of Climate Change in a region/country is determined by Exposure to Climate Change through Sensitivity to Climate Change inherent in the region/country. Sensitivity to Climate Change is defined as the inherent capacity, state, or degree to respond to the changed and changing climate before any strategy being launched. Each region/country is in different state in terms of Exposure to Climate Change, Sensitivity to Climate Change, and Real Impact of Climate Change. Such a different state is Vulnerability to Climate Change with which each region/country faces.

Each region and country should identify and analyze their state of climate change in terms of Exposure, Sensitivity, and Real Impact. This process is termed Assessment of Vulnerability to Climate Change. Based on Assessment of Vulnerability to Climate Change, each region/country establishes Climate Change Policy.

Adaptation and Mitigation Measure is established as a means for implementing climate change policy. Adaptation Measure is applied to the box of Vulnerability and aims at adapting to the changed and/or changing climate, while Mitigation Measure is applied to Human Activity as the source of greenhouse gas emission and aims at eliminating the cause of climate change or reducing greenhouse gas emissions. In other words, Adaptation Measure is for applying to Vulnerability to Climate Change directly. Meanwhile, Mitigation Measure is for applying to Human Activity as the human-induced cause of climate change.

3. Mitigation Measure

3.1: The Categories of Mitigation Measure

As shown in <Figure 2>, mitigation measure is applied to human activity as the source of human-induced greenhouse gas emission. IPCC (2014b: 125) defines mitigation as “technical change and substitution that reduce resource inputs and emissions per unit of output with respect to climate change. Mitigation means implementing policies to reduce greenhouse gas emissions and enhance sinks.” However, at a very general level, mitigation is defined as the reduction of adverse impact of climate change on nature and human society caused by human-induced greenhouse gas emission.

As explained previously in session 2 in this chapter, some argue that the impact of CO_2 on climate change occupies 66% at minimum and 99% at maximum. However, UNFCC argues the impact of CO_2 on climate change occupies 80% among all of the six global warming substances. This is the root for why the terminology, carbon is used when mitigation measure is implemented.

Therefore, even though a wide variety of mitigation options as measures are available for reducing the adverse impact of climate change caused by human-induced greenhouse gas emission, the review of the existing mitigation measures at a regional, national and global level reveals that they can be classified into four categories – ; Low Carbon measure, Carbon-Neutral measure, Carbon-Zero (or Carbon-Free) measure and Climate Neutrality (Jeong, 2015b), and their concepts and implications are as below (Jeong, 2015b).

Low-Carbon: Low-Carbon is generally used to describe forward-looking national economic development plans or strategies that encompass, focusing on low-emission and/or climate-resilient economic growth. However, Low-Carbon measure does not set up the absolute level of reduction, but sets up a goal, like below 20%, and also includes provisions to reduce vulnerability to the impact of climate change.

Carbon-Zero: Carbon-Zero is based on the conversion to run on zero carbon emitting energies, no more carbon emissions being added to the atmosphere or natural carbon balance that existed before industrialization. ‘Actual carbon-zero’ is not possible. Therefore, the best Low-Carbon measure that we can achieve is ‘virtual zero emission’ (for example, at least a 90% reduction) or ‘negative carbon emission’ (for example, artificial carbon sink by tree planting, carbon capture and storage, etc.). This implies that true carbon zero is (virtual zero carbon) + (some negative carbon).

Carbon-Neutral: Carbon-Neutral implies removing as much carbon from the atmosphere as we put in for achieving net zero carbon emission. The overall goal is to achieve a zero carbon footprint which refers to achieving net zero carbon emission by balancing a measured amount of carbon released with an equivalent amount sequestered or offset (eg. wind farm and solar park), buying enough carbon credits to make up the difference, industrial process such as production of carbon neutral fuel, and reducing and/or avoiding carbon emission, etc. The best practice for seeking Carbon-Neutral entails reducing and/or avoiding carbon emission first so that only unavoidable emissions are offset.

Climate Neutrality: Unlike Low-Carbon, Carbon-Zero and Carbon-Neutral, there is no rigorous scientific definition of Climate Neutrality. At a general level, Climate Neutrality means living in a way which produces no net greenhouse emissions. This should be achieved by reducing one’s own greenhouse gas emissions as much as possible and using carbon offsets to neutralize the remaining emissions. This implies that Climate Neutrality's net change to atmosphere is zero ton. There is no “one-size-fits-all” approach to being climate neutral. It involves different practices and priorities for different organizations through Low-Carbon, Carbon-Zero and Carbon-Neutral as a set of mitigation measures.

3.2: Sectors and Technologies of Mitigation Measure

As identified from the previous session 3.1 in this chapter, mitigation measure aims at reducing and/or avoiding greenhouse gas emission from the existing societal system which is the base of human activity and is structured in a way to maximize material/cultural affluence and convenience in life as the major cause of current human-induced climate change. This means that mitigation measure focuses on re-structuring the existing societal system.

In such context, there are a variety of societal sectors and technologies of mitigation measures as a re-structuration of the existing societal system in a way to reduce and/or avoiding greenhouse gas emission. Many scholars, international environment-related organizations and governments suggested the societal sectors and technologies of mitigation measures (eg. IPCC, 2007; AG, 2008; Lutsey and Sperling, 2008; UNEP, 2008; Adley and Pizer, 2009; KRISH, 2009; MOSKG, 2010; UNEP, 2010b; Van Tilburt et al, 2011; World Bank, 2013; IPCC, 2014a; UNESCAP et al, 2014). The important key societal sectors and technologies suggested by these scholars are summarized as <Table 1> (eg. IPCC, 2007). The societal sectors are the targets of mitigation measures, and technologies are the efficient instruments mitigation of measures mobilizing to achieve their goals. It is of course true that there are many other societal sectors and technologies of mitigation measures.

<Table 1> Selected Important Examples of Key Sectors and Technologies of Mitigation Measures

Sector	Key Mitigation Technologies and Practices	Measures to Be Environmentally Effective	Key Constraints or Opportunities
Energy Supply	Improved supply and distribution efficiency; fuel switching from coal to gas; nuclear power; renewable heat and power; combined heat and power; early applications of carbon dioxide capture and storage (CCS); tidal and wave energy, solar photovoltaics	Reduction of fossil fuel subsidies; taxes or carbon charges on fossil fuels	Resistance by vested interests may make them difficult to implement
		Feed-in tariffs for renewable energy technologies; renewable energy obligations; producer subsidies	May be appropriate to create markets for low-emissions technologies
Transport	More fuel-efficient vehicles; hybrid vehicles; cleaner diesel vehicles; biofuels; modal shifts from road transport to rail and public transport systems; non-motorized transport (cycling, walking); land-use and transport planning; second generation biofuels; higher efficiency aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries	Mandatory fuel economy; biofuel blending and CO_2 standards for road transport	Partial coverage of vehicle fleet may limit effectiveness
		Taxes on vehicle purchase, registration, use and motor fuels; road and parking pricing	Effectiveness may drop with higher incomes
		Influence mobility needs through land-use regulations and infrastructure planning; investment in attractive public transport facilities and non-motorized forms of transport	Particularly appropriate for countries that are building up their transportation systems

<Table 1> Selected Important Examples of Key Sectors and Technologies of Mitigation Measures - Continued

Sector	Key Mitigation Technologies and Practices	Measures to Be Environmentally Effective	Key Constraints or Opportunities
Buildings	Efficient lighting and day lighting; more efficient electrical appliances and heating and cooling devices; improved cook stoves, improved insulation; passive and active solar design for heating and cooling; alternative refrigeration fluids, recovery and recycling of fluorinated gases; integrated design of commercial buildings including technologies, such as intelligent meters that provide feedback and control; solar photovoltaics integrated in buildings	Appliance standards And labelling	Periodic revision of standards needed
		Building codes and certification	Attractive for new buildings. Enforcement can be difficult
		Demand-side management programmes	Need for regulations so that utilities may profit
		Public sector leadership programmes, including procurement	Government purchasing can expand demand for energy-efficient products
		Incentives for energy service companies (ESCOs)	Success factor: Access to third party financing
Industry	More efficient end-use electrical equipment; heat and power recovery; material recycling and substitution; control of non-CO_2 gas emissions; and a wide array of process-specific technologies; CCS for cement, ammonia, and iron manufacture; inert electrodes for aluminium manufacture	Provision of benchmark information; performance standards; subsidies; tax credits	May be appropriate to stimulate technology uptake. Stability of national policy important in view of international competitiveness
		Tradable permits	Predictable allocation mechanisms and stable price signals important for investments
		Voluntary agreements	Success factors include: clear targets, a baseline scenario, third-party involvement in design and review and formal provisions of monitoring, close cooperation between between government and industry

<Table 1> Selected Important Examples of Key Sectors and Technologies of Mitigation Measures - Continued

Sector	Key Mitigation Technologies and Practices	Measures to Be Environmentally Effective	Key Constraints or Opportunities
Agri-culture	Improved crop and grazing land management to increase soil carbon storage; restoration of cultivated peaty soils and degraded lands; improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions; improved nitrogen fertilizer application techniques to reduce N_2O emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency; improvements of crop yields	Financial incentives and regulations for improved land management; maintaining soil carbon content; efficient use of fertilizers and irrigation	May encourage Synergy with Sustainable Development and with reducing vulnerability to climate change, thereby overcoming barriers to implementation
Forestry/ Forests	Afforestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forestry products for bioenergy to replace fossil fuel use; tree species improvement to increase biomass productivity and carbon sequestration; improved remote sensing technologies for analysis of vegetation/soil carbon sequestration potential and mapping land-use change	Financial incentives (national and international) to increase forest area, to reduce deforestation and to maintain and manage forests; land-use regulation and enforcement	Constraints include lack of investment capital and land tenure issues
Waste Manage-ment	Landfill CH_4 recovery; waste incineration with energy recovery; composting of organic waste; controlled wastewater treatment; recycling and waste minimization; biocovers and biofilters to optimize CH_4 oxidation	Financial incentives for improved waste and wastewater management	May stimulate technology diffusion
		Renewable energy incentives or obligations	Local availability of low-cost fuel
		Waste management regulations	Most effectively applied at national level with enforcement strategies

4. Adaptation Measure

4.1: The Categories of Adaptation Measure

As shown in <Figure 2>, adaptation measure is applied to the Vulnerability box and aims at adapting to the changed and/or changing climate, leaving the Human Activity as is. This means that adaptation seeks to lower the risks posed by the consequences of climatic changes. IPCC(2014b: 125) defines as "adjustment in natural or human systems to a new or changing environment in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities."

Adaptation to climate is not a new phenomenon. Indeed, throughout human history, societies have adapted to natural climate variability by developing practices such as altering settlement and agricultural patterns and other facets of their economies and lifestyles. Human-induced climate change lends a complex new dimension to this age-old challenge.

However, adaptation to climate change is a different issue in that previous experiences are not prepared for. In relation to current issues of climate change, adaptation refers to the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences. Adaptation aims to manage climate risk to an acceptable level, taking advantage of any positive opportunities that may arise.

Like mitigation measures, adaptation measures also have a wide variety of options in terms of timing, goals and motives of their implementation. However, the review of the existing adaptation measures at a regional, national and global level reveals that they can be classified into several categories as below (Pittock and Jones, 2000; Burton et al, 2006; OECD, 2006: 18; IPCC, 2007; Chambwera and Stage, 2010; IPCC, 2012; Tompkins and Eakin, 2012; USDOE, 2014).

Anticipatory vs. Reactive Adaptation: Anticipatory Adaptation is the adaptation that takes place before climate change impacts are observed. This is also referred as proactive adaptation. Reactive Adaptation is the adaptation that takes place after climate change impacts have been observed.

Anticipatory approach aims to reduce exposure to future risks, for instance by avoiding development on flood-prone lands. Meanwhile, reactive approach aims only to alleviate impacts once they have occurred, for instance by providing emergency assistance to flood victims. When reactive response perpetuates or exacerbates exposure to climate risks, for instance by assisting reconstruction in a flood-stricken area, it might be termed 'maladaptation'.

Experience suggests that, typically, proactive adaptation requires a greater initial investment but is more effective at reducing future risk and cost. As reactive adaptation is informed by direct experience, resources can be targeted to known risks. In addressing future risks, however, uncertainties in the extent, timing, and distribution of impacts make it harder to determine the appropriate level of investment, exactly what measures are needed, and when the measures are needed.

As a general rule, adaptation measures should give priority to anticipatory actions reducing future risk, but, insofar as significant risks will remain, should provide as well for reactive approaches to help vulnerable populations recover from unavoidable impacts.

Autonomous vs. Planned Adaptation: Autonomous Adaptation is the adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. This is also referred to as spontaneous adaptation. Meanwhile, Planned Adaptation is the adaptation that is a result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

Planned Adaptation would progress from the top-down approach, through regulations, standards, and investment schemes. In this sense, Planned Adaptation is an anticipatory approach, and is particularly important for decisions that have long-term implications such as the design and citing of long-lived infrastructure.

Meanwhile, Autonomous Adaptation refers to those actions that are taken as individual institutions, enterprises, and communities independently adjust to their perceptions about climate risk. Such autonomous actions may be short-term adjustments, and are often considered as a reactive or bottom-up approach.

Planned Adaptations are the result of deliberate policy decisions on part of public agencies, based on awareness that conditions are about to change or have changed and that action is required to minimize losses or benefit from opportunities. Meanwhile, Autonomous Adaptations are widely interpreted as initiatives by private actors rather than by governments, usually triggered by market or welfare changes induced by actual or anticipated climate change. In other words, Autonomous Adaptations are those that occur “naturally” by private actors without interventions by public agencies, whereas Planned Adaptations are called “intervention strategies.

It is also proposed that Autonomous Adaptation forms the baseline which is needed for planned anticipatory adaptation so it can be evaluated. Thus, Autonomous and Planned Adaptation largely correspond with Private and Public Adaptation, respectively as are explained below.

Private vs. Public Adaptation: Private Adaptation is the adaptation that is initiated and implemented by individuals, households or private companies. Public Adaptation is the adaptation that is initiated and implemented by governments at all levels. Public adaptation is usually directed at collective needs.

Private Adaptation is usually in the actor's rational self-interest while Public Adaptation may not accrue at the location where the private action is taking place. However, in many cases Public Adaptation only materialize through the participation of numerous private resource users/managers. Public Adaptation is thus dependent on the coordination and commitment of private actors. Such an interrelation between Private and Public Adaptation is extended to a mechanism as below.

As with most environmental policy challenges today, the private provisioning of public adaptation demands complex governance, and will involve multiple actors and stakeholder groups in potentially innovative private-public partnerships. Mechanisms of governance of adaptation must be coupled with knowledge processes that identify the public adaptation need. Without this, it is difficult to assess the need for individual action, or to find ways to coordinate action at the appropriate scale. Ensuring adaptive outcomes in such circumstances will require a foundation of trust, common understanding and fairness. A combination of private-public approaches will undoubtedly be needed, in which social contracts among different populations are strengthened in public discourse, moral and ethical appeals are made to motivate individual collaboration for collective good, education and knowledge serve to situate individuals within broader systemic processes and outcomes, and specific incentives, rewards and penalties orchestrate individual action.

4.2: Sectors and Technologies of Adaptation Measure

As explained in the previous session 3.1 in this chapter, mitigation aims at reducing and/or avoiding greenhouse gas emission from the existing societal system which is the base of human activity and is structured in a way to maximize material/cultural affluence and convenience in life as the major cause of current human-induced climate change. This means that mitigation focuses on re-structuring the existing societal system. Meanwhile, adaptation aims adjusting to a new or changing environment in response to actual or expected climatic stimuli or their effects, leaving the existing societal system as is.

Another key difference between the two is that mitigation measure is established at a regional, national or global level while adaptation measure is based on region-specific application at a broad level or based on vulnerable target-specific application at a narrow level. In this sense, unlike mitigation measure, adaptation measure is in fundamental ways inherently “local”. In other words, the direct impacts of climate change are felt locally, and response measures must be tailored to local circumstances. However, for these efforts to be robust – or, in many cases, even possible – they must be guided and supported by national policies and strategies. For some cases, these, in turn, need to be facilitated through international measures.

In such context, a wide array of adaptation measures has been launched to reduce vulnerability to climate change. Many scholars, international environment-related organizations and governments suggested the societal sectors, strategy, underlying policy framework and key constraints/opportunities of adaptation measures (eg. Burton et al, 2006; UNFCCC, 2006; IPCC, 2007; UNEP, 2008; KRISH, 2009; UNEP, 2010b; Chai and Jo, 2011; Kang et al, 2011; EEA, 2012; EMCCC, 2012; ICLEI, 2012; Park and Kim, 2012; Bark-Jones et al, 2013; ADB, 2014; IPCC, 2014a; UNESCAP et al, 2014). Their suggestions correspond to Planned Adaptation measures in which most of them are based on government-led measures.

The important key societal sectors, strategy, underlying policy framework and key constraints/opportunities of adaptation measures suggested by them are summarized as <Table 2> (eg. IPCC, 2007). It is of course true that there are many other societal sectors and technologies of mitigation measures.

<Table 2> Selected Important Examples of Key Sectors, Strategy, Underlying Policy Framework and Key Constraints/Opportunities of Adaptation Measures

Sector	Strategy	Underlying Policy Framework	Key Constraints or Opportunity
Water	Expanded rainwater harvesting; water storage and conservation techniques; water re-use; desalination; water-use and irrigation efficiency	National water policies and integrated water resources management; water-related hazards management	Financial, human resources and physical barriers; integrated water resources management; synergies with other sectors
Agriculture	Adjustment of planting dates and crop variety; crop relocation; improved land management, e.g. erosion control and soil protection through tree planting	R&D policies; institutional reform; land tenure and land reform; training; capacity building; crop insurance; financial incentives, e.g. subsidies and tax credits	Technological and financial constraints; access to new varieties; markets; longer growing season in higher latitudes; revenues from 'new' products
Infrastructure/ Settlement (including Coastal Zones)	Relocation; seawalls and storm surge barriers; dune reinforcement; land acquisition and creation of marshlands/wetlands as buffer against sea level rise and flooding; protection of existing natural barriers	Standards and regulations that integrate climate change considerations into design; land-use policies; building codes; insurance	Financial and technological barriers; availability of relocation space; integrated policies and management; synergies with sustainable development goals
Human Health	Heat-health action plans; emergency medical services; improved climate-sensitive disease surveillance and control; safe water and improved sanitation	Heat-health action plans; emergency medical services; improved climate-sensitive disease surveillance and control; safe water and improved sanitation	Limits to human tolerance (vulnerable groups); knowledge limitations; financial capacity; upgraded health services; improved quality of life

<Table 2> Selected Important Examples of Key Sectors, Strategy, Underlying Policy Framework and Key Constraints/Opportunities of Adaptation Measures - Continued

Sector	Strategy	Underlying Policy Framework	Key Constraints or Opportunity
Tourism	Diversification of tourism attractions and revenues; shifting ski slopes to higher altitudes and glaciers; artificial snow-making	Integrated planning (e.g. carrying capacity; linkages with other sectors); financial incentives, e.g. subsidies and tax credits	Appeal/marketing of new attractions; financial and logistical challenges; potential adverse impact on other sectors (e.g. artificial snow-making may increase energy use); revenues from 'new' attractions; involvement of wider group of stakeholders
Transport	Relocation; design standards and planning for roads, rail and other infrastructure to cope with warming and drainage	Integrating climate change considerations into national transport policy; investment in R&D for special situations, e.g. permafrost areas	Financial and technological barriers; availability of less vulnerable routes; improved technologies and integration with key sectors (e.g. energy)
Energy	Strengthening of overhead transmission and distribution infrastructure; underground cabling for utilities; energy efficiency; use of renewable sources; reduced dependence on single sources of energy	National energy policies, regulations, and fiscal and financial incentives to encourage use of alternative sources; incorporating climate change in design standards	Access to viable alternatives; financial and technological barriers; acceptance of new technologies; stimulation of new technologies; use of local resources

5. The Differences and Relationship between Mitigation and Adaptation Measure

Differences: As shown in <Figure 2> and explained in sessions 3 and 4 in this chapter, mitigation and adaptation are conceptually and realistically different in terms of their target and goal, etc. In summary, mitigation is for making changes to slow down climate change by lowering the amount of greenhouse gas emission, while adaptation is for making changes that enhance resilience or reduce vulnerability to changes in climate. In this context, both mitigation and adaptation have evolved along different pathways. The key between mitigation and adaptation measure are drawn from sessions 3 and 4 in this chapter as shown in <Table 3>.

<Table 3> Key Difference between Mitigation and Adaptation Measure

Measure Sector	Mitigation	Adaptation
Addressing on	The cause of climate change	The impact of climate change
Area of impact decision making level	Global – national - local	Local (mainly)
Time perspective Of the effect	Decades (average temperature of the earth) – immediate (monitoring emissions)	Immediate (vulnerability to weather phenomena) – centuries (sustainable community structure)
Approaches to Combat change	Technological solutions (low emissions technologies) – reducing consumption and changing its structure – maintenance of gas sinks	'Soft' methods (changing behavior, increasing knowledge) – technological solutions (structural protection methods)
Responsible actors	Main emissions sectors (energy generation, transport) – private individuals (consumption)	Vulnerable actors in several sectors and administrative levels

However, addressing climate change challenges through only one lens (either mitigation or adaptation) can lead to trade-offs and one could undermine the other. Even if strong efforts are put on mitigation, the climate will still continue changing in future decades; hence, adaptation efforts are also greatly needed. But if the focus is only on adaptation, all negative impacts will not necessarily be reduced, so mitigation actions are also needed to limit changes in the climate system (Klein et al, 2007; Locatelli, 2011).

In addition, even if emissions are dramatically decreased in the next decade, adaptation will still be needed to deal with global changes that have already been set in motion. In this sense, even though conceptually mitigation and adaptation measures are different as shown in <Table 3>, realistically the two are in relationship and complementarities, because that adaptation will not be able to eliminate all negative impacts and mitigation is crucial to limit changes in the climate system. This implies that adaptation and mitigation measures are complementary to each other. For example, if mitigation measures are undertaken effectively, lesser will be the impacts to which we will need to adapt. Similarly, if adaptation measures (or the degree of preparedness) are strong, lesser might be the impacts associated with any given degree of climate change (IPCC, 2007; Martens et al, 2009). In this sense, it would be valuable to examine the relationship between mitigation and adaptation measures. Their relationship would be complementarities resulted in synergy effects on the response to climate change.

Relationship as Complementarities: The key relationship as complementarities are summarized as below (Goklany, 2005; IPCC, 2007; Martens et al, 2009; IPCC, 2014a).

First: Four types of inter-relationships can be distinguished. The four types are mitigation actions that have consequences for adaptation, adaptation actions that have consequences for mitigation, decisions that include trade-offs and synergies between adaptation and mitigation, and processes that have consequences for both adaptation and mitigation.

Second: Mitigation efforts can foster adaptive capacity if they eliminate market failures and distortions, as well as perverse subsidies that prevent actors from making decisions on the basis of the true social costs of the available options. The implications of adaptation can be both positive and negative for mitigation. For example, afforestation that is part of a regional adaptation strategy also makes a positive contribution to mitigation. In contrast, adaptation actions that require increased energy use from carbon-emitting sources (eg., indoor cooling) would affect mitigation efforts negatively.

Third: Synergies can increase the cost-effectiveness of adaptation and mitigation. However, synergies provide no guarantee that resources are used in the most efficient manner when seeking to reduce climate risks. Opportunities to create synergies are greater in some sectors (eg. agriculture and forestry, buildings and urban infrastructure) but are limited in others (eg. coastal systems, energy, health). The ability to create synergies is limited by the absence of a relevant knowledge base and of human, institutional and organizational capacity.

Fourth: It is not yet possible to say whether or not adaptation buys time for mitigation. Challenges to making trade-offs beyond the local scale include the different spatial, temporal and institutional scales of options and the different interests, beliefs, value systems and property rights of actors. An “optimal mix” would reconcile welfare impacts on people living in different places and at different points in time into a global aggregate measure of well-being.

Fifth: Social and economic development enhances capacity to adapt and mitigate. Response capacity is often limited by a lack of resources, poor institutions and inadequate infrastructure. People’s vulnerability to climate change can therefore be reduced not only by adaptation and mitigation, but also by development aimed at improving the living conditions and access to resources of those experiencing the impacts.

Six: Trading-off adaptation and mitigation is not a zero-sum game. Real synergies between adaptation and mitigation are few and far between. Adaptation and mitigation are both closely intertwined with development choices. Research on the links between adaptation and mitigation needs to go beyond economic and integrated assessment modeling.

Integrated Response to Climate Change: Considering the above six key relationships as complementarities, it would be argued that the integrated response of mitigation and adaptation measure to climate change produces trade-offs and synergies as below (Illman et al, 2013: 5; IPCC, 2014a: 112).

First: There are many opportunities to link mitigation, adaptation and the pursuit of other societal objectives through integrated responses. Successful implementation relies on relevant tools, suitable governance structures and enhanced capacity to respond. A growing evidence base indicates close links between adaptation and mitigation, their co-benefits and adverse side effects, and recognizes sustainable development as the overarching context for climate policy.

Second: Increasing efforts to mitigate and adapt to climate change imply an increasing complexity of interactions, encompassing connections among human health, water, energy, land use and biodiversity. Mitigation can support the achievement of other societal goals, such as those related to human health, food security, environmental quality, energy access, livelihoods and sustainable development, although there can also be negative effects. Adaptation measures also have the potential to deliver mitigation co-benefits, and vice versa, and support other societal goals, though trade-offs can also arise.

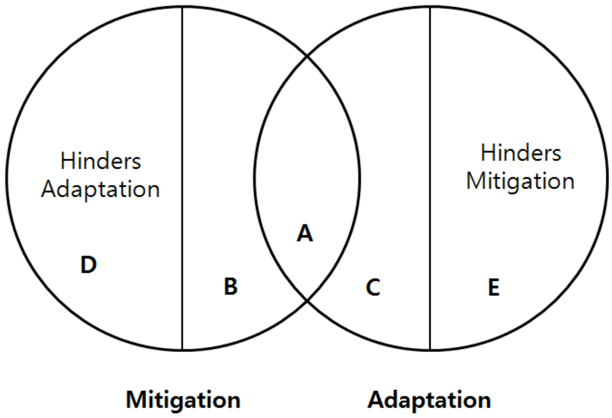
Third: Integration of adaptation and mitigation into planning and decision-making can create synergies with sustainable development. Synergies and trade-offs among mitigation and adaptation policies advancing other societal goals can be substantial, although sometimes difficult to quantify especially in welfare terms. A multi-objective approach to policy-making can help manage these synergies and trade-offs. Policies advancing multiple goals may also attract greater support.

Fourth: Effective integrated responses depend on suitable tools and governance structures, as well as adequate capacity. Managing trade-offs and synergies are challenging and require tools to help understand interactions and support decision-making at local and regional scales. Integrated responses also depend on governance that enables coordination across scales and sectors, supported by appropriate institutions.

Fifth: Great potential exists for creating synergies between mitigation and adaptation and implementing climate policy options in a more cost-effective way. Some progress has been made in this regard. This initiative aims to capture experience and evidence related to the co-benefits of adaptation and mitigation in the areas of low carbon development, water-energy-land nexus, bioenergy, blue carbon and so on. In many cases, synergies are examined in a broader sustainable development context and reference is often made to developing adaptive and mitigative or even response capacity, climate compatible development, reducing vulnerabilities, seeking co-benefits with development policy and enabling sustainable livelihoods.

Relationship in terms of the Task of Measure: As policy experts and other decision-makers attempt to address the dual challenge from both mitigation and adaptation, they must think clearly about how mitigation relates to adaptation. In the absence of solid, pervasive efforts to mitigate, adaptation would be open ended – some would say absurd. Because the challenge of mitigation will be even more enormous if decision-makers unintentionally allow their adaptation efforts to undermine it, some analysts argue that adaptation should be carried out principally in ways that avoid increasing emissions of greenhouse gases.

In such relationship, the relationship between mitigation and adaptation in terms of the task of measure can be classified into five categories (Howard, 2009). They are diagramed as <Figure 3>.



<Figure 3> Relationship between Mitigation and Adaptation as Task of Measure

<Figure 3> somewhat simplistically depicts the relationship between mitigation and adaptation. The implications of A to E are as below.

A: Activities simultaneously serve the purposes of both mitigation and adaptation. For example, urban tree planting captures carbon from the atmosphere and cools nearby dwellings during heat waves.

B: Tactics such as reducing vehicle miles traveled serve the purpose of mitigation but neither help nor hurt adaptation.

C: Adaptation tactics such as improved storm warning systems neither help nor hurt mitigation.

D: Mitigation measures undermine adaptation efforts. For example, use of biodiesel to reduce use of fossil fuel results in poorer air quality than might have existed.

E: Adaptation measures undermine mitigation. For example, installation of air conditioning to combat heat waves increases electricity use and thus raises greenhouse gas emissions at a power plant burning coal or natural gas.

Extensive adaptation measures in E would be especially problematic, and even adaptation in C would need to be avoided if it diverts resources or distracts attention from mitigation. It is important, therefore, that adaptation today be carried out largely in a way that is compatible with mitigation – and hence help reduce the need for (and the costs of) adaptation later.

Policy makers always need to beware of potential side effects. To make climate change adaptation efficient and effective in the long run, adaptation programs undertaken today should whenever possible be designed to avoid compromising mitigation. Otherwise adaptation programs will, ironically, tend to make long-run adaptation more difficult. And whenever possible, both mitigation and adaptation should be undertaken in ways that serve both purposes simultaneously.

Chapter 4
Reviewing Protection Strategy of Protected Areas

1. Protected Areas - General Questions

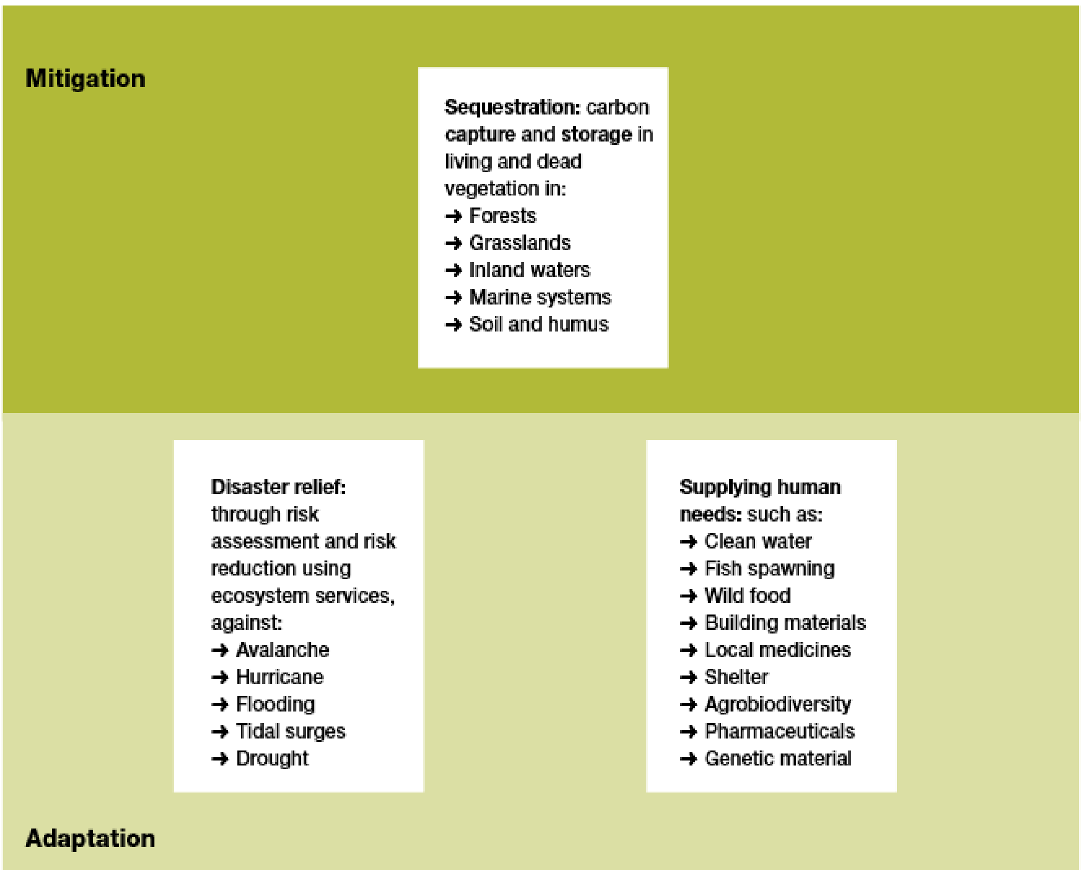
Protected Areas (PAs) have been recognized by a broad fan of institutions (eg. IUCN, WWF, UNEP, etc.) as a part of the solution of climate change. In this sense, in Dudley et al (2010) we can read that "At the IUCN Council Meeting held from 8-10 March 2008, climate change was acknowledged to be the greatest threat to biodiversity and the global system of protected areas was noted as one of the most powerful solutions". And according to UNEP and IUCN (2014), "Protected areas are essential to the conservation of species, ecosystems and the livelihoods they support, and also play a key role in adapting to and mitigating the impacts of climate change".

UNEP/IUCN's report (2014) finds that the "15.4 per cent of terrestrial and inland water areas and 3.4 per cent of the global ocean are now protected — highlighting growing global awareness of the need to safeguard the natural resources that will play a crucial role in the upcoming Sustainable Development Goals. This report shows how protected areas deliver numerous benefits for people and nature and need to be recognized as a proven and cost-effective natural method to deal with global challenges such as water provision, food security, disaster-risk reduction, and climate change mitigation and adaptation. For these reasons, protected area coverage has been used as one of the indicators to track progress towards the Millennium Development Goals.

Target 11 of the Convention on Biological Diversity's Aichi Biodiversity Targets calls for effectively and equitably managed conservation areas covering at least 17 per cent of the world's terrestrial areas and ten per cent of marine areas — especially areas of particular importance for biodiversity and ecosystem services — by 2020.

According to Dudley et al (2010) protected areas play a key role in both mitigation and adaption to climate change (<Figure 4>).

Mitigation plays a role of ‘store’ and ‘capture’. ‘Store’ is to prevent the loss of carbon that is already present in vegetation and soils. ‘Capture’ is to sequester further carbon dioxide from the atmosphere in nature ecosystem. The key roles of adaptation are ‘protect’ and ‘provide’. ‘Protect’ is to maintain ecosystem integrity, buffer local climate, reduce risks and impacts from extreme climatic events such as storms, droughts and sea-level rise. ‘Provide’ is to maintain essential ecosystem services that help people cope with changes in water supplies, fisheries, incidence of disease and agricultural productivity caused by climate change.



<Figure 4> Three Pillars of Protected Area Benefits

(Source: Dudley et al, 2010)

The following the same authors, PAs are real tools to fight against climatic change because they are a huge structure that managers have on field. Effectively, PAs mean:

o Governance and Safeguards: Defined borders, operate under legal or other effective frameworks and have experience in implementing accessible, local approaches involving people.

o Permanence: They are based around a commitment to permanence and long-term management of ecosystems and natural resources.

o Effectiveness: For example, management plans, staff and equipment, understanding of how to manage ecosystems.

o Monitoring, Verification and Reporting

2. Main Climate Change Strategies of Protected Areas

2. 1: General Principles

The IUCN and other institutions like UNEP (UNEP, 2010a; IUCN, 2015) have emphasized that strategies to mitigate and adaptation to climate change of protected areas should be carried out according to the principles of:

o The important role that ecosystem-based approaches and nature-based solutions can play in both climate change mitigation and adaptation.

o Maintains the highest possible level of environmental integrity.

o Restoration of degraded habitats and landscapes, but not just to a previous state, but to future conditions.

o Use of indigenous knowledge for planning and management of ecosystems (Community based adaptation, CBA).

o Promote connectivity protected areas.

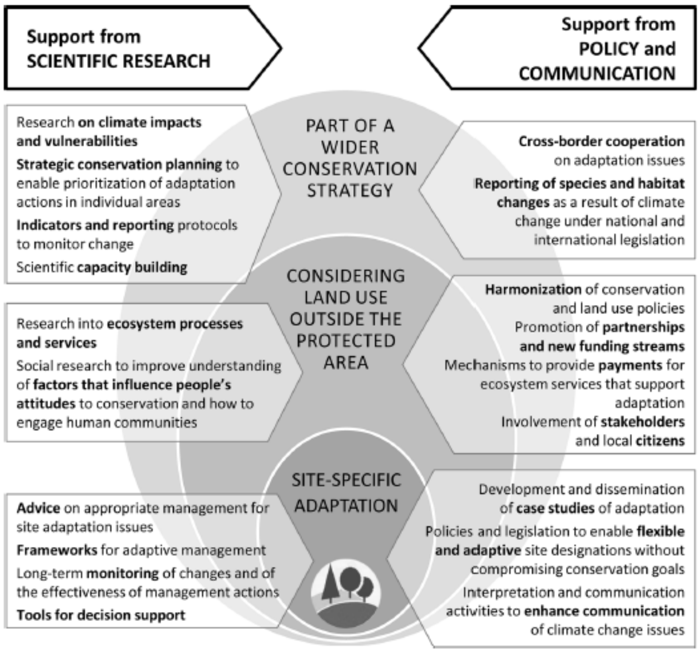
o Increase the Coverage of protected areas (Expanding the existing coverage of terrestrial, coastal and marine protected areas consistent with *Aichi Biodiversity Targets 11 and 15.*

There are numerous papers which present reviews of strategies for mitigation and adaptation to climatic change. For instance, Mawdsley et al (2009) suggested 16 strategic lines for managing biodiversity in a climate change scenario. On the other hand, Rannow et al (2014) said that there are no easy single ‘‘recipes’’ for strategies to cope with climate change which is applicable everywhere. For these authors, any strategy needs to develop actions from a local point of view to PA networks with three main levels (<Figue 5>):

o It should be designed for any specific protected area and local conditions.

o It is necessary to take a wider perspective and consider land use beyond the protected area boundaries.

o Finally, protected areas cannot be managed in isolation from each other.



<Figure 5> Protected Area Network with Three Main Levels

(Source: Dudley et al, 2010)

2. 2: Networking

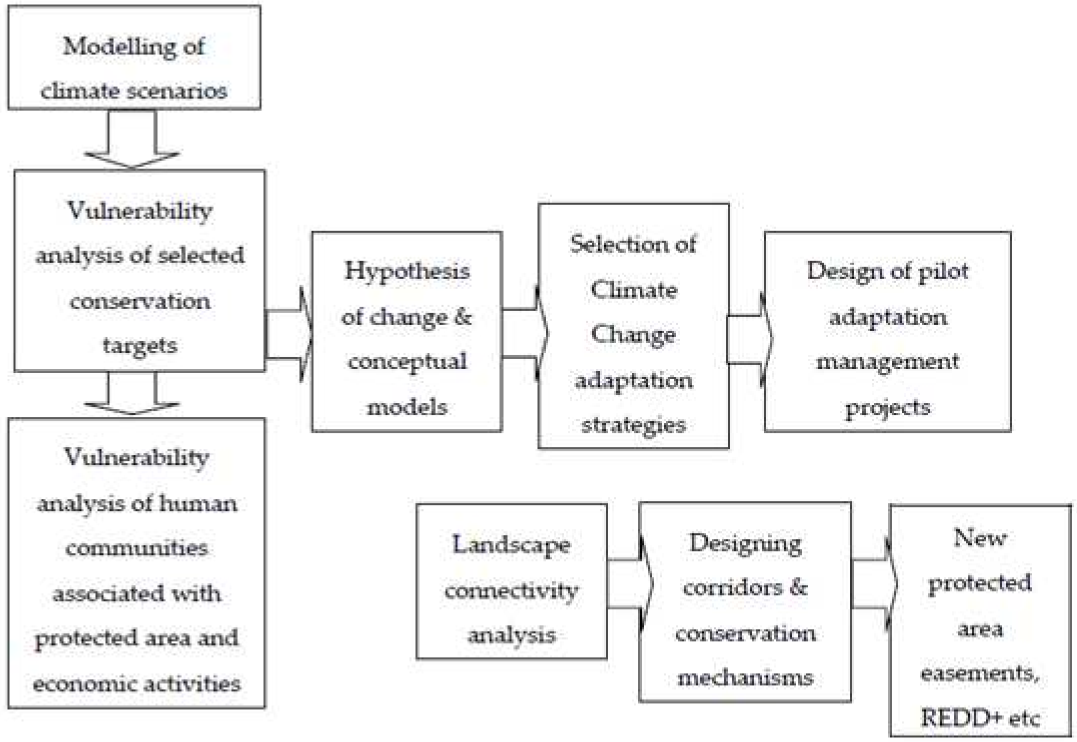
Networking is a very useful strategy for protected areas, not only for mitigation and adaptation to climate change, also for a more effective management of PAs. There are some very interesting networking experiences at a regional scale, for example, to produce common initiative and documents for the main regional and/or global conferences, such as Latin American Network for Technical cooperation on National Parks (REDPAARQUES) for the 21st Conference of the Parties (COP) of the UN Framework Convention on Climate Change in Paris. On the other hand, regional networking is very useful to create common tools to exchange information, experiences and know-how among the members. For example, the network PARCC, Protected Areas Resilient to Climate Change of West Africa (http://www.parcc-web.org/).

2. 3: Planning – Management for Change

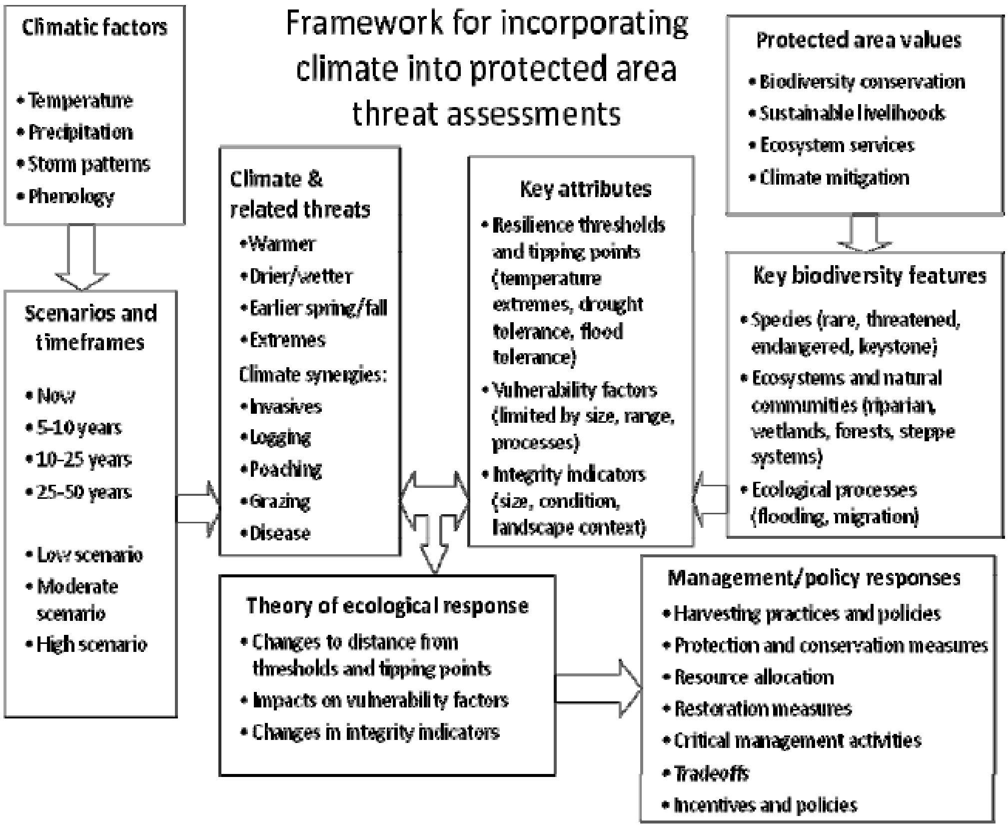
Planning is the required fundamental step for any chosen strategy for the management of protected areas. Planning is a more complex future scenario; it changes and is full of uncertainties.

Proper design of planning is essential to the success of any measures for adaptation and mitigation of climate change, ultimately for the conservation of environmental values of the protected areas. However, these conservation values must take into account that current environmental characteristics will change in the future. Therefore, in many cases, these conservation plannings must be based on the assumption of change. IUCN, in a draft document (Gross et al, 2106) about Protected Areas and Climate Change said: "Given the broad and pervasive ecological changes underway and expected as a consequence of a shifting climate, protected area managers increasingly will be challenged to actively manage for change, rather than focusing just on maintaining the persistence of existing systems".

Thus, for planning based on a scenario that will change, there should be some models of what the changing trends will be and where the vulnerabilities of our ecosystems are. March (2010) and Ervin (2010) developed these ideas in the following schemes (Fig. 3 and 4):



<Figure 6> Methodology Overview for Modelling of Climate Scenario (Source: March, 2010)



<Figure 7> Framework for Incorporating Climate into Protected Area Threat Assessment (Source: Ervin, 2010)

2. 4: Climate Vulnerability Assessment

One of more important steps for modelling of climate scenarios and to develop a strategy is Climate Vulnerability Assessment. In order to understand (Gross et al, 2016);

o Which species, systems, or other conservation targets are most vulnerable;

o Why they are vulnerable; and

o Where they are vulnerable within a given protected area.

According to the same authors, vulnerability has three main components: exposure, sensitivity and adaptive capacity.

2. 5: Some Principles for a Climate Change Strategy

Recently the IUCN (2016) has elaborated the next table to summarize the main principles for a climate change strategy for protected areas (<Table 4>).

<Table 4> General Approaches to Identify Adaption Options
(Source: Gross et al, 2016)

Principle	Description
Reduce non-climate stressors	Pollution, disturbances, disease, and other stressors reduce the ability of species and ecosystem to adapt to climate change.
Prioritise the protection of intact, connected ecosystems	Intact, functioning ecosystems are more resilient to climate change than degraded systems. Prioritising the protection of intact systems is essential for allowing species to adapt to current and future changes.
Identify and protect climate refugia	Climate refugia are local areas that experience less climate change than the broader surrounding area and are areas that in the future that are likely to experience less climate change. These areas preserve existing populations of species that are more likely to be resilient to climate change and may be a destination for future climate-sensitive migrants.
Conserve key ecological features	Focus management on enduring ecological features (the geophysical stage), structures, organisms, and areas that are the foundations of communities and ecosystem properties. Riparian corridors, freshwater supplies (springs, lakes, etc.), and critical habitat for keystone species are typically high priority.
Preserve and enhance connectivity	Connectivity operates on multiple levels. For species and communities, provide the opportunity to respond to climate changes by shifting their distributions. Facilitate the movement of water, nutrients, energy, and organism between resources and habitats. Connectivity is often considered to enhance system resiliency.
Sustain or restore ecosystem process and function to promote resilience	Climate changes will challenge our ability to preserve all current species, and the focus here is to preserve fundamental ecosystem properties like primary productivity (biomass growth), decomposition, wetland filtration of nutrients and sediments, and nutrient cycling. These processes contribute to ecological integrity even if there are changes in species composition and ecosystem structure.
Improve representation, redundancy and replication	Both within and across PAs, attempt to conserve or protect samples of key species, habitats, and ecosystems (representation) at multiple sites (redundancy and replication). This addresses a fundamental conservation principle to spread risk and bet-hedge against catastrophic losses at a specific site. Where possible, manage to assist adaptive evolutionary change by e.g. supporting populations in diverse habitats, facilitating gene flow, or actively managing genetic composition of species (e.g. via forest management).
Assist colonization	It may be appropriate, or necessary, in some situations to actively move organisms and assist in their establishment at locations where they currently or never previously existed. Some argue that this is an essential task due to human-caused habitat fragmentation and artificial barriers to species movements. Assisted colonization is highly controversial as a climate adaptation strategy, but relocations, introductions, and reintroductions have been routine practices in conservation, wildlife management, and agriculture for centuries.

2. 6: Mitigation, Strategy for the Main Biomes

The main goal of PAs for mitigation of climate change is to reduce greenhouse gas emissions from deforestation and land degradation. This means maintaining a good state of surface conservation for natural land and sea habitats. There are two main ways to obtain mitigation goals:

o Carbon stores: It means to prevent the loss of carbon that is already present in vegetations and soils.

o Carbon capture: It means to sequester further carbon dioxide from the atmosphere in natural ecosystems.

Nevertheless, if protected areas include humanized spaces (such as in many Biosphere Reserves), you should add other possible actions related to our lifestyle to reduce carbon emissions:

o Energy efficiency (including transportation)

o Increase renewable energy

o Improve waste management

IUCN, in common with other institutions, published an especial report where the main strategic line for mitigation of climatic change were summarized (Dudley et al, 2010). Below, we have selected the world's main principles for the principal biomes.

o Forests are the world’s largest terrestrial carbon stock and continue to sequester in old-growth phases.

- Increase the area of forest protected areas: both by expanding existing protected areas and creating new protected areas.
- In efficiency of management in forest protected areas: by further applications of assessment drawing on the IUCN-WCPA management effectiveness assessment framework and building management capacities.
- Restore forests in protected areas: For example, abandoned farmland in logged over areas and in areas where climate change make other land use untenable.
- Develop more efficient methodologies and criteria for identifying areas with high carbon storage and sequestration potential: and use this as an additional filter for selecting protected areas.
- Undertake management training to plan for climate change, including responded likely to fire regimes, stream flow and invasive species.

o Inland wetlands, particularly peatlands, store huge amounts of carbon and their protection are critically important. In 2014, there were reports of massive peat forests being documented in a remote part of the Republic of Congo (Congo-Brazzaville) in central Africa. Scientists estimated that the peatland covers between 100,000 and 200,000 km^2 with peat depth as much as 7m beneath the surface. Some of the areas in the Congo-Brazzaville already are a community reserve, jointly managed by the Wildlife Conservation Society, the government and the local people. This is one example where new information on carbon reserves can be used in protected area planning, with a goal to mitigate climate change (Gross et al, 2016, draft document).

- Protection of natural peat: urgent steps are needed to protect standing sources of peat in the boreal, temperate and tropical regions, including appropriate regions by the expansion of protected area networks. This will often involve some protection for entire watersheds that feed into the peat areas, as much as the areas themselves.
- Working out the best management strategies: further work is needed to find out more about carbon balance in peatlands and other inland waters; and particularly the combination of conditions that can tip a system from being a sink to source of carbon, along with the best management methods to maintain wetlands as sinks for carbon.

o Salt marshes, mangroves and seagrass beds all have important potential to sequester carbon.

- Increase protection for coastal mangrove, salt marsh and seagrass communities: through marine protected areas and integrated coastal management as an excellent way to increase the world’s natural carbon sink and develop more effective marine management regimes that integrate the ocean in the larger carbon management scheme.
- Add carbon sequestration potential to marine gap analyses and other protected area assessments: use and improve simulation models and field studies to develop tools for enhancing management plans for ecosystems

protection, rehabilitation and restoration, including optimal scenarios for carbon allocation and CO uptake.

- Increase management effectiveness of marine protected areas: retain, maintain and recover ecosystem resilience and hence marine natural carbon sinks by reducing other human induced stressors such as coastal destruction, overfishing or ocean and land-based pollution.

o Natural grasslands represent a major carbon store but loss and degradation are currently releasing large amounts of carbon, and grasslands can either be a source or sink for carbon depending on management, precipitation and CO levels.

- Expand protected areas in grassland habitats: including both strictly protected areas (IUCN categories I-IV) and protected landscapes (category V and VI) in sites where careful integration of low-level domestic grazing on grasslands can help stabilize and rebuild carbon stocks.
- Improve management: including introduction of sustainable grazing practices within protected landscapes and extractive reserves.
- Carry out further research on the status and trends in carbon sequestration in grasslands: focusing particularly on management options that can minimise losses and maximize storage and sequestration.

o Soil provides a huge carbon reservoir.

- Adopt farming methods that capture carbon as well as producing food and fibre: through legislation, incentives, preferential funding and capacity-building in the farming community, particularly focusing on organic production, low tillage and where appropriate permanent set aside.
- Promote model approaches: making farming within category V protected areas a model and test-bed for new and traditional carbon-capture techniques.
- Beach better understanding of the potential for agricultural sequestration: continuing uncertainty about the size of the potential is hampering

implementation of new management approaches; urgent work to complete and synthesize estimates is required.

2.7: Adaptation

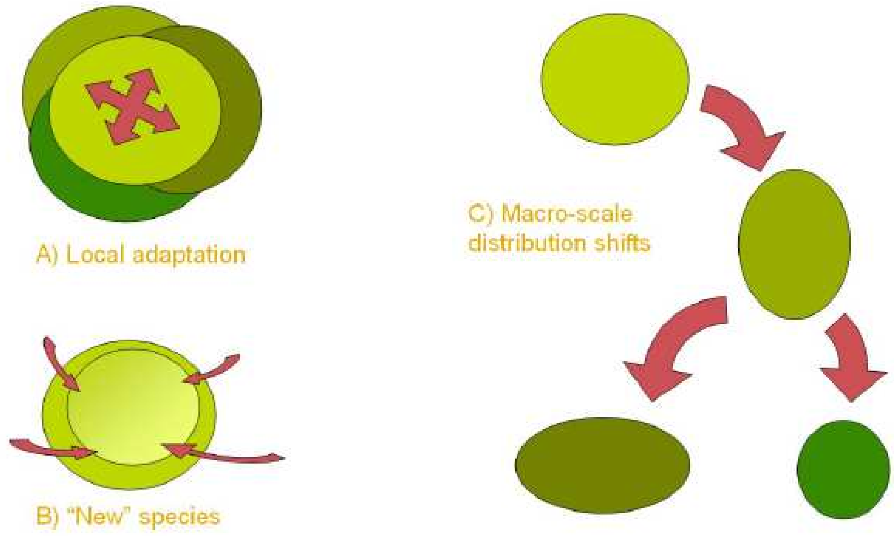
Climate change will undoubtedly have consequences in both habitats of many species and in ecosystems functionalism. As a result, there will be consequences for many services these ecosystems provide to humanity, and water supplies or protection from natural disasters. Then climate change will become a threat to:

- o Habitats
- o Species
- o Human resources
- o Human safety

Against this, planning and management of protected areas to adapt to these changes are necessary. Ecosystem-based adaptation is the best approach for planning and management of PAs, it uses biodiversity and ecosystem services in an overall adaptation strategy. It includes the sustainable management, protection and restoration of ecosystems to maintain services that help people adapt to the adverse effects of climate change (Colls, 2009).

As Dunlop (2010) wrote, many of these changes are still very hard to predict, while significant change to biodiversity is highly certain, there will be many types of change and there is much uncertainty about the specific details of future changes and losses (Dunlop, 2010). Nevertheless, according to this author, there are three overarching scenarios of change of the ecosystems (< Figure 8>):

- Local adaptation
- Macro-scale distribution shift
- Influxes of “new” species, both exotic and natives



<Figure 8> Three Mental Models Characterizing Different Ecological Outcomes as a Result of Climate Change. Note: Different Colors represent different environments, and the arrows Represent population shifts as different environments become Suitable (Source: Dunlop, 2010)

This means that protected areas must be prepared for changes in the characteristics of ecosystems and landscapes, and should be prepared for the entry of alien species and the disappearance or migration of native species. In front of this scenario it is essential to increase and improve connectivity between the AP as an essential measure for adapting to change.

2.8: Examples of Connectivity and Networking between PAs

In mountain ecosystems, the landscape approach and connectivity corridors are viable means of achieving climate change adaptation and mitigation. The International Centre for Integrated Mountain Development regional cooperative framework, which is being implemented in eight Hindu Kush Himalayan countries, is a prime example. Some 39 per cent of the region is protected, with 488 protected areas falling within the

International Union for Conservation of Nature’s categories I–VI. Regional cooperation is promoted through conservation corridors that aim to restore disturbed connectivity between existing mountain protected areas that cross political boundaries. In Europe, a number of governmental and non-governmental organizations are cooperating to develop a corridor between the Alps and the Carpathians and to foster exchange on ecological networks. The Yellowstone-to-Yukon Conservation Initiative, covering more than 3,000 km stretching north from the United States of America to Canada, is probably the most highly developed continental-scale connectivity initiative.

Some authors have proposed the concept of assisted migration, or assist colonization, to describe the actions to facilitate to threatened species to establish in new areas following the changes of climate (<Figure 8> and <Table 5>).

<Table 5> Concept of Assisted Migration (Source: Gross et al, 2016)

Assisted migration

Assisted migration is the intentional movement and establishment of species to a new location. The rate and magnitude of climate change projected for the 21st century is likely to exceed many of the thresholds to which current species assemblages have become adapted, regardless of any management interventions. In such situations, very difficult decisions will be required to decide which species can be saved. As such, ‘conservation triage’ may emerge as a critical process in the prioritization and selection of which species to assist. The allocation of scarce resources to help certain species (and not others) has considerable ethical implications.

Three different types of assisted migration can be identified (Ste-Marie et al., 2011):

- **Assisted population migration:** The movement of populations with different genetic makeups within a given species' current range. This speeds up a process in which the species is likely to have spread anyway.
- **Assisted range expansion:** The movement of a given species to areas just outside its current range, mimicking how it would naturally spread.
- **Assisted long-distance migration:** The movement of a given species to areas far outside its current range (beyond where it would naturally spread).

Assisted population migration (type 1 above) and assisted range expansion (type 2) are currently used in many parts of the world, primarily in forestry and agriculture to bring in genetic varieties to match a changed climate (Ste. Marie et al., 2011). Assisted long-distance migration (type 3) should only be considered where a species is likely to go extinct in the wild. This type of assisted migration is riskier than the other two because it involves new genetic stock that may significantly impact the ecosystem into which it is introduced. There are varying perspectives on using assisted migration as an adaption tool (see Riccardi and Simerloff, 2008; Aubin et al., 2011; Pedlar et al., 2011, 2012; Larson and Palmer, 2013; Schwartz et al. 2012; Thomas et al. 2011). The best practice is to be very careful and only use this tool after a complete assessment of the risk and rewards. This is a rapidly developing topic and managers should obtain careful advice before proceeding. The wise use of assisted migration will vary according to the goals and objectives for the protected area and the intervening landscapes and waterscapes.

2.9: Using Protected Areas to Reduce the Impacts of Natural Disasters Linked to Climate Change

Recently IUCN has published a document with the best practices for planning and managing PAs for disaster risk reduction (Dudley, 2015). Even though the document analyzes different kinds of natural disasters, the majority has a link with climate change. Below is the summarization of the best practices that were proposed by IUCN.

o Cyclones, Typhoons and Hurricanes

- **M**aintain natural barriers (forests, mangroves, coral reefs, coastal marshes, barrier islands, and sand dunes) in storm-prone areas, particularly along coasts where human communities have been established.
- By actively planting or seeding, actively restoring land barriers and/or through removal of pressures, it is necessary to restore natural barriers that have disappeared.
- Introduce Introduce protected zoning areas that incorporates DRR elements.

o Flooding

- Design protected area systems to include a range of natural floodplains and wetlands that can absorb and store flood water, include natural forests on steep slopes and next to watercourses, to provide maximum buffering potential.
- Ensure that vegetation is in good health and resilient to natural flood patterns, including through restoration policies if necessary.
- Build good working relations between DRR specialists, protected area authorities, and water authorities to ensure that everyone understands how they can contribute to flood prevention strategies. This can be achieved through development of collaborative working groups and

representation of protected areas on regional disaster planning committees.

- Include integrated water management elements and watershed approaches into protected areas. Planning to better connect protected areas with the surrounding hydrological system.

o Sea Level Rise

- Manage, restore and where necessary, relocate natural buffers like mangroves and sand dunes so that they can provide maximum coastal protection.
- Include regular studies of changes in coastal vegetations within monitoring systems to allow sufficient time to respond to any changes.
- Develop cooperation between DRR and protected area specialists to ensure that strategies for management of coastal change include protected areas as tools for both coastal protection and biodiversity conservation.
- Use the results from monitoring to raise awareness and educate the surrounding communities about sea-level rise, the potential impacts and the need for better protection.

o Drought

- Work out agreements with relevant local and nomadic communities related to access and use of resources (grazing, collection of fodder, collection of non-timber forest products) before a drought takes place and work together to ensure compliance in the event of a crisis.
- Maintain or restore ground vegetation through agreements with farmers and pastoralists, the control of off-road vehicles and where active restoration efforts are necessary.
- Pay particular attention to protection of surface and groundwater sites and to their catchments, to maximize water availability.

- Introduce use of sustainable gravity water flow schemes or water pumps to provide water to communities outside protected areas for home-based/small-scale irrigation, thus reducing pressure on protected natural ecosystems.
- Maintain bee habitats to ensure cross-pollination of crops to increase food security.

o Desertification and Dust Storms

- Locate protected areas as buffer zones around settlements or at the edge of desert areas for slowing down the rate of soil erosion and reduce levels of dust storms.
- Maintain or more likely restore vegetation through grazing control, prevention of off-road vehicles and where active restoration programs are necessary.
- Encourage sustainable grazing practices in protected landscapes and other less strictly protected areas.

o Wildfire

- Plan protected area fire management strategies on a national or regional scale, tailored to particular conditions (presence of human communities, proximity to other forests, risks of fire during high risk periods etc.).
- Maintain detailed fire prevention, management and safety strategies, particularly in protected areas that are heavily visited.
- Provide visitors with advice and instructions about preventing accidental fires.
- Coordinate between different stakeholders to address prevention and control of wildfire.

3. Protected Areas at an International Level

3. 1: Biosphere Reserves

Biosphere reserves are particularly protected areas because many BRs include humanized areas. The core BR area is usually a classical protected area, while the other two areas (buffer and transition) can have a more or less intense economic activity and human occupation. In this way, the Madrid Action Plan (2008) highlights that climatic change can be approached from a holistic perspective in biosphere reserves: “MAB and the World Network of Biosphere Reserves bring added value to addressing climate change through the integrated approach which is generally absent elsewhere. Buffer zones and transition areas of biosphere reserves may also be used to test many mitigation tactics and strategies.”

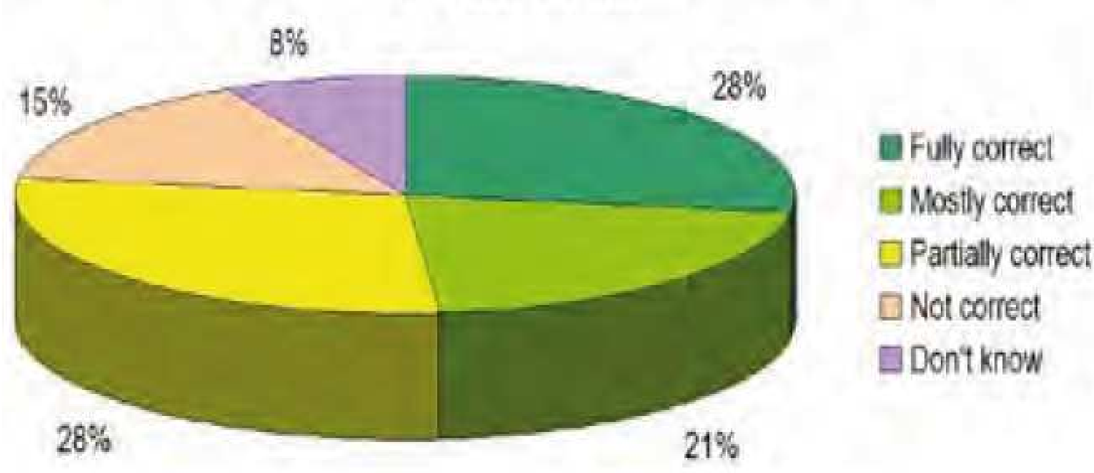
However, there is a huge variability of situations. Because of this uniqueness, adaptation and, especially, mitigation strategies have to be wider than in classical protected areas. The reason is because it must include the lifestyle of the human population living within the reserve. For example, mitigation strategies should include the use of energy and waste management. On the other hand, adaptation strategies should include both the vulnerability of ecosystem services (particularly water and natural resources supply, and protection against natural disasters), and the possibility that the BRs are places that welcome climate refugees.

In 2011 an international meeting was organized in Dresde (Germany) specifically on the topic of biosphere reserves and climate change. One of the main topics was to find good examples of best practices to deal with climatic change, and to conduct a questionnaire to know how it was addressing climate change in biosphere reserves. The main results were published in Möller (2011).

The questionnaire's main results were:

o 31% of the BRs which were answered can be considered as already intensively and diversely active in the field of climate change, with projects in many different areas of mitigation and adaptation (projects in at least 15 different areas).

o About half of all respondents said that climate change is highlighted as an important issue in their management plan (<Figure 9>).



<Figure 9> Perception on Climate Change Being Highlighted as an Important Issue in the Management Plan of Biosphere Reserve (Source: Möller, 2011).

o However, there are specific action plans or climate change strategies in only about a third of all biosphere reserves. Another third have not done anything in this regard.

Other interesting key conclusions of the questionnaire were:

o The areas where most biosphere reserves report specific projects were raising public awareness, long-term climate change monitoring, and mitigating climate change through forest management or reforestation.

o Other fields were climate change education for children, rehabilitation of high-C ecosystems, low-impact tourism, and maintaining/re-establishing biological corridors needed to facilitate climate change adaptation.

o Among mitigation projects, forestry was the most frequently used approach, followed by rehabilitation of high-C ecosystems and improved agriculture techniques.

o With the exception of low-impact tourism, the economic dimension of climate change mitigation (regional marketing, low-impact public transport) was not yet a clear focus area.

o So far, very few biosphere reserves were implementing international emissions reduction trading schemes (CDM, JI, LULUCF, REDD+, etc.) – even fewer than those that were experimenting with local transfer schemes.

o A clear focus area in many biosphere reserves were to adapt their governance system, bringing in new stakeholders, bridging several governmental levels, varying the time-frame of the management plan, etc.

o Research on climate change was also a clear strength, with long-term monitoring and local climate change predictions being the focal areas.

o Even more important was the field of education and raising public awareness, including sensitizing decision makers – combining all factors, this field of activity was even more widely used than that of climate change mitigation through land use.

This review presented a collection of 28 good practices cases that could be interesting as examples for other sites. These cases show good initiatives for the next topics:

o Mitigation

- Renewable energies and energy efficiency - Grosses Walsertal RB (Austria)
- Piloting carbon neutrality - Agua y Paz RB (Costa Rica)
- Avoiding deforestation through Participatory Forest Management - Kafa RB (Ethiopia)
- Carbon in old forests - DingHuShan RB (China)
- Setting up a local carbon credit scheme - Kruger to Canyons RB (South Africa)
- Becoming a zero-emissions region - Bliesgau RB (Germany)

- Reorganizing agriculture to improve carbon sequestration - Buena Vista RB (Cuba)
- 100 percent renewable energies - El Hierro RB (Spain)

o Adaptation

- Coastal water management - Wadden Sea of Lower Saxony RB (Germany)
- Community adaptation – Noosa RB (Australia)
- Cooperation on sea-level rise - Malindi Watamu RB (Kenya) - North Devon (UK)
- Including indigenous people in adaptation - Sierra Nevada de Santa Marta RB (Colombia)
- Adapting to increasing drought - Spreewald RB (Germany)
- Protecting mangroves through buffer zones - Delta du Saloum RB (Senegal)
- Global species migration and global change Mariposa Monarca RB (Mexico)
- Adapting to increasing floods - Trebon basin RB (Czech Republic)
- Monitoring the mountains - Sierra Nevada RB (Spain) and Katunskiy RB (Russian Federation)

o Mitigation and Adaptation

- Adapted agriculture and bog restoration - Schaalsee RB (Germany)
- Islands in climate change – Jeju RB (Republic of Korea)

o Biosphere Reserves and Networking

Networking is is a biosphere reserves' characteristic. In fact, MAB-UNESCO was created as a worldwide network of reserves, which are then structured in regional and thematic networks. This structure is very useful for sharing experiences especially in the areas of planning and management, so is to mainstream adaptation and mitigation of climate change in their management plans.

Below are a few examples.

o Dresde Declaration. In 2011, the international MAB Conference "For Life, for the Future: Biosphere Reserves and Climate Change", held in Dresden, Germany, called on MAB states to place greater emphasis on biosphere reserves in their strategies on climate change mitigation and adaptation, and to transfer approaches developed in biosphere reserves to other regions.

o International Conference of Island and Coastal Biosphere Reserves: Climate Change and Island and Coastal Ecosystems.

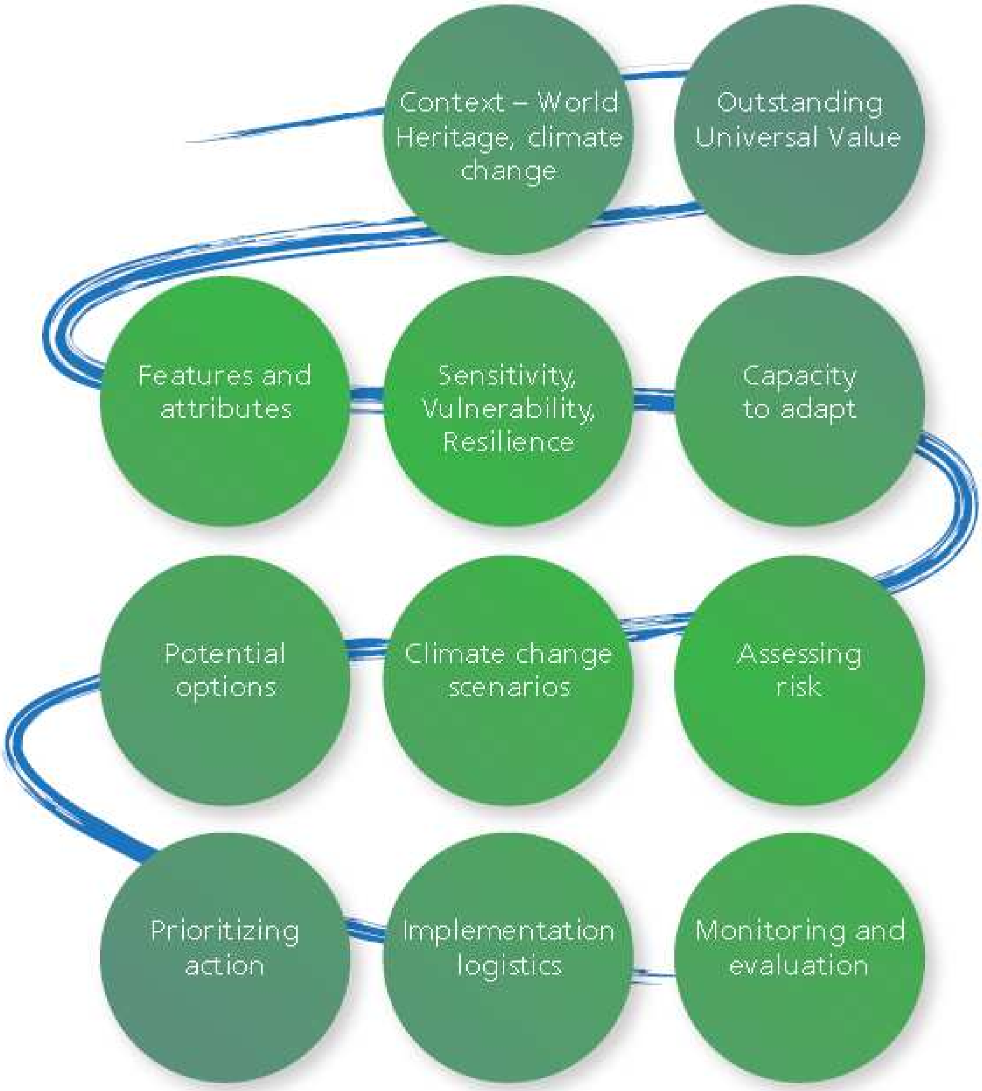
o World Network on Islands and Coastal Biosphere Reserves. In 2012, the World Network on Islands and Coastal Biosphere Reserves was founded. Presently, the network consists of 26 Islands and Coastal Biosphere Reserves around the world. It was established due to the high vulnerability of especially small islands to climate change. The office located on the island of Jeju in South Korea, focuses on climate change issues.

o BiosphereSmart. BiosphereSmart is a global observatory created to share ideas, knowledge, good practices, and experiences among Biosphere Reserves on issues related to climate change, green economies, and sustainable development. The BiosphereSmart Initiative is based on the idea to maximize the use of new informational technologies to build a covenant for a sustainable future and transition to green societies based on knowledge. This performance is based on a website where the best examples of actions developed in biosphere reserves are showed. Most of them have some linkage with mitigation or adaptation to climate change.

3. 2: World Heritage Sites

Many declared World Heritage (WH) sites include biosphere reserves or national parks, so mitigation strategies and adaptation have many things in common with these other~~s~~ protected areas. However, the WH sites differ from biosphere reserves because the emphasis is on conservation of a valuable heritage (to sustain its Outstanding Universal Value (OUV), whether naturally or culturally, rather than on models of human development. For this reason, it makes little sense to discuss strategies to mitigate climate change in WH sites, and emphasis is on adaptation strategies. The World Heritage Centre of UNESCO has been working intensively to assess the risks that exist for World Heritage, to define the best strategies for adapting to climate change and recognizing the places where they have developed successful experiences in this regard. A meeting of experts was convened in March 2006, to discuss current and future impacts of climate change on World Heritage sites. The outcome of this initiative included a ‘Report on Predicting and Managing the Effects of Climate Change on World Heritage’, as well as a ‘Strategy to Assist States Parties to Implement Appropriate Management Responses’. From this initiative a few documents were published that are essential to define the strategies for adapting to climate change in the global network of WH sites. The following are the highlights: WHC (2007a) is a selection of places that are examples of adaptation in different ecosystems and historical sites; WHC (2007b) which provides a first strategy for adaptation to climate change, and Perry and Falzon, (2014) which is a practical guide for managers.

The following lines were summarized from Perry and Falzon (2014), with the main ideas, the best ideas and best practices for adaptation to climate change in the declared WH sites. These authors propose a scheme that reflect the general approach and thinking processes that a site manager would normally follow (<Figure 10>).



<Figure 10> Main and Best Ideas and Practices for Adaptation to Climate Change in World Heritage Sites (Source: Perry and Falzon, 2014)

According to Perry and Falzon (2014), “In general, adaptation practices should conserve the geophysical stage, protect refugia, and promote connectivity within the greater landscape. Some interventions require hard engineering, such as artificial reefs, breakwaters, roads, canals, removing invasive species, re-vegetation, managing dunes, restoring wetlands, or burning. Others focus on changing human behaviour, such as education, zoning, taxation, legislation, or social programmes. Significant engagement with stakeholders in the surrounding land/seascape when such practices are being designed will increase understanding and protection of the OUV. In all cases, it is essential that monitoring is carried out regularly and accurately.

On the other hand, a list of options and best practices for adapting the WH sites are:

o Reduce existing stressors.

o Remove/control invasive species.

o Raise awareness among partner communities, visitors and colleagues.

o Build alliances with NGOs, businesses and landowners.

o Expand the effective size of the site, by introducing a buffer zone if possible, in order to allow for movement and population growth.

o Encourage, lead/participate in the design and designation of new protected areas.

o Work with national planning and development agencies to include conservation and enhancement of OUV in all policies and plans.

o Form alliances with managers of other natural World Heritage sites and protected areas.

o Carry out interventions, such as planting, clearing and fire setting in order to manage the balance of habitats, optimize colonization and reduce the risk of climate-linked calamities.

o Rarely, large engineering projects such as water or road diversions may be appropriate.

o Identify appropriate sites that can be protected and enhanced to provide migratory stopping points, or corridors to enable wildlife to move into new areas.

o Where important species are in severe danger of extinction, and where feasible, it may be necessary to relocate them to a new area, or to a controlled environment.

3. 3: Ramsar Sites

The RAMSAR Convention specifically protects those wetlands that are included in the Convention. These areas also are protected at a national level and its main objective is the conservation of biodiversity. However, as many other PAs, wetlands provide many other services to humanity. Wetlands supply resources, including fresh water, and often act as a physical protection against extreme weather events.

As wetlands, effects of climate change manifest themselves in a particular way also, and probably stronger than other types of ecosystems. RAMSAR, has produced various documents to facilitate planning and management of these PA. This institution has highlighted the vulnerability of these PAs to climate change (sea level rise, increased severe storms, droughts, etc.), and the need to carry out a proper vulnerability assessment before any plan or performance for mitigation or adaptation (Gitay, 2011; RAMSAR, 2012).

Wetlands (eg. coastal salt marshes, mangroves and seagrass beds, peatlands) have a very important role in the carbon balance, because they are important carbon stores, and at the same time their emitters of carbon. Peatlands, for example, are extremely important in this sense. Last year's publications, meeting and institutional declarations, mainly from RAMSAR, try to raise awareness among the international communities for the importance of these ecosystems (RAMSAR, 2012; Joosten, 2015). Therefore, the preservation of the integrity of these ecosystems and the restoration of those that have been degraded are very important actions to mitigate climate change.

The following paragraphs summarize the main recommendations RAMSAR has been publishing for adaptation and mitigation of climate change on wetlands, most of the information was transcribed RAMSAR (2012).

(1) The main impacts of climate change that particularly affect wetlands are stated below (RAMSAR, 2008).

o Sea Level Rise

- Major change to wetland water regimes – flooding/drying.
- Sea level rise inundates coastal wetlands - tidal and storm surge.
- Further salinisation - loss of freshwater wetlands.
- Loss/change of habitat (eg. migratory birds – intertidal and inland habitats).
- Loss of ecosystem services and livelihoods.

o Storm Surge and Large Events

- Storm surges occurring on higher mean sea levels will enable inundation and damaging waves to penetrate further inlands.

- This would increase flooding, erosion and damage to built infrastructures and natural ecosystems.
- Changes to wind speed will also affect storm surge height.
- Extreme events such as large storms are also likely to increase.

o Drought and Fire

- Droughts are projected to increase in some areas.
- A substantial increase in fire risk is likely.
- Increased wetland degradation and release of carbon gases.

(2) Vulnerability Assessment of RAMSAR Sites (Gitay, 2011; RAMSAR, 2012)

In the context of the Ramsar Convention, vulnerability assessment refers to the relationship between exposures to a particular risk event, the impact of that event on a wetland, and the ability of the wetland to cope with the impacts or the efforts needed to minimize the impacts. The concepts of coping capacity or resilience and sensitivity are included within vulnerability, and are especially important in the context of assessing changes in the ecological character of a wetland due to climate change.

By bringing information together from various methods and approaches, a general framework for wetland vulnerability assessment has been developed, with the following elements:

o Establishing present status and recent trends: description of the wetland, the present and recent pressures, and the present condition. Due to limited data for many wetlands, local knowledge is used to complement the information collected by contemporary scientific means;

o Determining the wetland's sensitivity and adaptive capacity to multiple pressures description of the pressures on the wetland and the development of plausible future changes in order to assess the sensitivity and adaptive capacity of the wetland;

o Developing responses: determining the likely impacts of these changes on the wetland and the desired outcomes for it, as well as the responses that can be developed and implemented given its sensitivity and resilience; and o Monitoring and adaptive management: determining the necessary steps to ensure the path to the desired outcomes.

(3) Adaptation in RAMSAR Sites (RAMSAR, 2012)

The IPCC considers adaptation as actual adjustments or changes in decisions that ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate. For wetlands this could include further investment in coastal infrastructure to reduce vulnerability to storm surges and sea-level rise, or changes in policies to support increased resilience to climate variability, whether differentiated by spatial scale, the sectors that affect wetlands, or the type of action to avoid or repair adverse change in wetlands, or by a combination of activities. Further, adaptation can include responses to current variability, observed medium and long-term trends in climate, and anticipatory planning in response to scenarios of long-term climate change.

Assessments of adaptation costs and benefits are required, including evaluations of the impacts, or likely impacts, of sea level or storm surges on coastal wetlands, including mangroves and lagoons that support the livelihoods of many people. It is also necessary to consider, in addition to economic costs and technology, the influence of social factors and institutional arrangements on the ability of individuals and communities to respond to changes in the climate and how these impact on wetlands.

Peatlands cover only 3% of the global land surface. Some 15% of these peatlands have been drained for agriculture, forestry and grazing, which leads to the release of carbon stored in their soils. Degrading peatlands contribute no less than 5% to total global anthropogenic emissions. These emissions can be reduced by rewetting the drained peatlands, which can involve alternative forms of utilization.

Rewetting prevents soil subsidence and eventual flooding and salt water intrusion as well as soil erosion and desertification. Rewetted peatlands store water so it helps adaptation to a changing climate.

(4) Mitigation in RAMSAR Sites (RAMSAR, 2012)

o Carbon storage in, and emissions from wetlands

- The importance of carbon storage and emissions from wetlands, in particular from tropical peatlands and coastal salt marshes, mangroves and seagrass beds, is increasingly being recognized
- Many wetlands contain large stores of carbon laid down over centuries. If these should be degraded, large amounts of carbon in the form of Greenhouse Gases (GHGs) can be released to the atmosphere and contribute to anthropogenic climate change. This is well known for peatlands, both forested and non-forested.
- Recently there has been an increased attention to the storage of carbon in coastal ecosystems, notably mangroves, tidal saltmarshes and seagrass beds, which can store large quantities of what is increasingly becoming called 'blue carbon'. There is growing evidence that the management of 'blue carbon' wetlands has the potential to transform global carbon management, contributing to avoiding further loss and degradation of these ecosystems, and providing further incentives for their restoration and sustainable use.

3. 4: Natura 2000 Network

The Natura 2000 network is the largest network of protected areas in Europe that provides protection of natural areas worthy of protection at a Eurpoean level as a group. The LIFE program is a financial instrument that facilitates the development of conservation projects in Natura 2000. One of the priorities of LIFE is climate change, with three sub-programmes - Mitigation, Adaptation and Gobernance and Information.

Chapter 5

Strategy against Climate Change on Island and Coastal Biosphere Reserve - Ecological Vulnerability

Ecological vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Habitat loss and fragmentation, overexploitation, pollution, the impact of invasive alien species and, increasingly, climate change all threaten global biodiversity. Global warming will affect all species and exacerbate the other environmental stresses already being experienced by ecosystems. Climate change may thus further accelerate both the ongoing impoverishment of global biodiversity, caused by unsustainable use of natural capital, and the degradation of land, freshwater, and marine systems.

Climate change is already impacting on ecosystems and livelihoods, but enhanced protection and management of biological resources can mitigate these impacts and contribute to solutions as nations and communities strive to adapt to climate change. Protecting forests and other natural ecosystems can provide social, economic, and environmental benefits, both directly through more sustainable management of biological resources and indirectly through protection of ecosystem services.

Although further attempts to describe, understand, and predict the effects of climate change are important, there is also considerable interest in identifying principles and approaches that could help reduce or ameliorate anticipated negative effects of climate change (Hannah et al, 2002a; Inkley et al, 2004; Da Fonseca et al, 2005; Fischlin et al, 2007). The legacy of past changes to biodiversity sets the initial conditions for the world biodiversity. The overarching goal remains to minimize the loss of biodiversity.

In such a context, this chapter attempts to establish the strategies on ecological vulnerability in terms of ecosystems, biodiversity, communities of flora and fauna, and species.

1. Ecosystems

The Millennium Ecosystem Assessment showed that over the past 50 years human activities have changed ecosystems more rapidly and extensively than at any comparable period in our history. Biodiversity loss matters because species and habitats are the building blocks on which human livelihoods depend on, the foundation for production forests, fisheries, and agricultural crops. Enhanced protection and management of biological resources will also contribute to solutions as nations and communities strive to adapt to climate change. Possible strategies that will enable ecosystems to become resilience to climate changes are the following 10 sectors.

o Maintaining Well-Functioning Ecosystems

o Protecting a Representative Array of Ecological Systems

o Removing or Minimizing Existing Stressors

o Managing Appropriate Connectivity of Species, Landscapes, Seascapes and Ecosystem Processes

o Eco-engineering for Assisting the Transformation of Some Communities under Climate Change

o Increasing the Extent of Protected Areas

o Improving Representation and replication within Protected Area Networks

- o Improving Management and Restoration of Existing Protected Areas to Facilitate Resilience
- o Managing and Restoring Ecosystem Function rather than Focusing on Specific Components (Species or Assemblages)
- o Evaluating and Enhancing Monitoring Programs for wildlife and Ecosystems

(1) Maintaining Well-Functioning Ecosystems

With decades and centuries of projected climatic change that is significant in magnitude but uncertain in detail, the single most important principle guiding the management of biodiversity is the maintenance of well-functioning ecosystems. Maintenance of a high level biodiversity is a good strategy to ensure the good functioning of ecosystems. However, this is not a simple principle to implement under a changing climate. Maintenance or enhancing the resilience of ecosystems is crucial to ensure the continuation of adequate function. However, under a changing climate, the maintenance of resilience of existing ecosystem might become counter-productive and there is the possibility of the transformation of the ecosystem. If transformation becomes more common, it will be imperative to monitor the ecosystem functionality and also their ability to deliver services on which the society depends for its survival.

(2) Protecting a Representative Array of Ecological Systems

Not only is it important to have well functioning ecosystems, but also the full diversity of these systems need to be included in areas managed for conservation. This basic principle of conservation needs renewed emphasis and reinterpretation under climate change. The principle of representativeness which represents all biodiversity in all appropriately managed systems, remains essential under climate change.

However, the purpose now is to represent as many different combinations of underlying environments and drivers, rather than specific arrays of species. While the particular assemblage of species or genes in a single location may change, aiming to encompass diversity provides the best likelihood of having conditions for all biodiversity somewhere. All environments should be represented in national, regional or global systems of protected areas or reserves. A diversity of landscape architectures in terms of the arrangement of patches and connecting habitats should be well represented. This diversity should also be maintained at a national level.

(3) Removing or Minimizing Existing Stressors

The biggest threat to biodiversity continues to be a number of existing stressors such as direct human modification of ecosystems and the introduction of exotic species. These will continue to be important, but climate change will act as an additional stressor on species and ecosystems, as well as exacerbating the effects of the many existing stressors. Thus, as a management principle, it will become even more important to minimize or remove existing stressors.

(4) Managing Appropriate Connectivity of Species, Landscapes, Seascapes, and Ecosystem Processes

With increasing pressure on species to migrate in response to a changing climate, and for ecosystems to disassemble and reassemble, there is a greater focus on achieving appropriate types of landscapes and seascapes connectivity to create more space for nature to self adapt (Mansergh and Cheal, 2007), while protecting some areas from disruption and invasion. The concept of landscape fluidity, defined as the ebb and flow of organisms within a landscape (or seascape) through time (Manning et al, 2009), provides a more appropriate dynamic underpinning to biodiversity in a rapidly changing world. Marine ecosystems may have an advantage, in that many (not all) organisms may be able to change their geographical position in response to changes in the abiotic environment around them. Terrestrial ecosystems face more severe challenges, because most terrestrial organisms are less mobile, and are subject to more direct and pervasive human modification. Freshwater organisms may face the greatest challenge, given that they may need to move between catchment.

Such an emphasis on the landscape as an integral part of biodiversity management indicate the need to move from a simplistic polarized pattern of landscape structure and use to more fluid multiple use landscapes with self adaptation of ecosystems in the landscape. Support for such adaptation must come from those who live in and on the landscape, and who must therefore be productively engaged in policy formulation and implementation. This principle implies the need to reverse the trend towards simplicity and efficiency in landscapes and to build landscapes and ecosystems with more complexity, redundancy and resilience.

(5) Eco-engineering for Assisting the Transformation of Some Communities under Climate Change

Driven somewhat by the growing interest and experience in restoring ecology, as well as the improved understanding of ecosystem structure and functioning, there will be cases where passive approach can and should be augmented by more proactive measures to conserve biodiversity. This approach invariably involves the direct and substantial modification of communities in direction consistent with the impacts of climate change. Eco-engineering has some major limitations that must be considered before it is applied as it is costly and not always successful. Eco-engineering should be focused in places where the best return on investment may be obtained. Research is needed to identify critical intervention points in various landscapes in the context of climate change. Most likely, however, based on ecological principles on how communities are structured, the preservation or reestablishment of keystone species would give the best chance for an ecological system to self organize in a way that will reduce total species loss and maintain ecosystem functioning.

(6) Increasing the Extent of Protected Areas

This strategy would increase the extent of terrestrial and aquatic habitat protected from non-climate anthropogenic threats (McNeely & Schutyser 2003; Mitchell et al, 2007). The strategy could also be used to protect refugia (areas with minimal climate impacts), movement corridors, or stepping stones for wildlife dispersal. A suite of legal tools are already available for protecting lands, waterways, and marine areas (including easements, proclamation and legislation). The global conservation community has used these tools to protect high-priority conservation areas in ecosystem types and human societies around the world (Bruner et al, 2001).

Given the resource needs of the world's growing human population, it is unlikely that society will be able to directly protect enough land to facilitate the movement of all species and communities. Furthermore, the world's existing protected-area networks have been designed to protect static (rather than dynamic) patterns of biodiversity (Lemieux & Scott 2005; Lovejoy 2005; Scott & Lemieux 2005). The performance of static networks at conserving biodiversity in the face of climate change remains largely untested (Zacharias et al, 2006), but simulation studies suggest that some of these networks will likely fail to achieve their original objectives (Hannah et al, 2005). New approaches to land conservation that acknowledge the dynamic nature of climate-change effects on ecosystems will likely be needed.

(7) Improving Representation and Replication within Protected Area Networks

Representation attempts to build a more comprehensive portfolio of protected areas (e.g., protecting examples of all major ecosystem types within a country), whereas replication attempts to conserve multiple examples of each ecosystem type (Julius & West 2007).

As noted, conservation tools are available for protecting terrestrial and aquatic areas. Both strategies may work well as part of a matrix conservation or a steppingstone approach to facilitate dispersal. Representation has already been used as a strategy for local and regional land-protection efforts (Wisconsin Natural Areas Program 2008), and tools such as land-cover maps and geospatial data on rare species distributions could facilitate the broader application of both strategies. It is unclear that representation will continue to be a relevant conservation strategy long-term because distributions of the individual components of ecosystems may shift in different ways as a result of climate change, potentially resulting in new combinations of species and even new ecosystem types (Carroll 2005; Hannah & Hansen 2005).

(8) Improving Representation and Replication within Protected Area Networks

It may be possible to offset some of the small-scale effects of climate change in protected areas through direct management activities (Mitchell et al, 2007). A number of commonly used techniques for ecological restoration (SERI 2006) may be still relevant (Julius & West 2007): riparian forest plantings could shade streams and offset localized warming; dikes and levees could protect coastal sites from sea-level rise; and prescribed fire could reduce fuel loads and potential for catastrophic wildfires (The Sheltair Group 2003; Fischlin et al, 2007).

Intensive management is usually more tractable at small, well-defined sites such as parks, nature reserves, and natural areas (Kusler & Kentula 1990; Thayer 1992; National Research Council 1994). Restoration techniques for certain communities have received considerable attention and testing (SERI 2006; Julius &West 2007). Nevertheless, direct management is expensive and may only be feasible for small sites and limited areas (Fischlin et al, 2007). Also, focusing on protected areas neglect the overall matrix in which these areas are embedded: what happens outside protected areas often influences what happens inside (da Fonseca et al, 2005).

(9) Managing and Restoring Ecosystem Function Rather Than Focusing on Specific Components (Species or Assemblages)

This strategy focuses on the maintenance of aspects of ecosystem function (such as nutrient uptake by riparian forest buffers or wetland filtration of nutrients and sediments) in conservation areas. It de-emphasizes historical condition, historic species composition, and the condition of reference sites as sources of management information. To implement this strategy, managers would first define key variables or indicators of ecosystem function, and then undertake activities designed to keep those variables within acceptable parameters (Harris et al, 2006; Fischlin et al, 2007; Mitchell et al, 2007). Ecological conditions at individual sites are likely to shift in ways that are difficult to predict and that differ from historic reference conditions (Harris et al, 2006). To date, those practicing ecological restoration have used historic data or undisturbed reference sites as a baseline for management (SERI 2006). Given the significant shifts that have and will occur in species distributions, it may be easier for managers to focus on sets of variables describing ecosystem function, rather than attempting to maintain a particular species composition or community type at a given site (Harris et al, 2006).

This strategy may be difficult to implement in practice without focusing on individual ecosystem components. Shifting the focus of management from components to functions may mean some components will become extirpated or extinct. Depending on the attributes of ecosystem function selected, it may be possible to maintain these variables within acceptable limits with a greatly reduced complement of species or even with non-native species.

(10) Evaluating and Enhancing Monitoring Programs for Wildlife and Ecosystems

Monitoring systems provide information that managers can use to adjust or modify their activities (Walters 1986; Margoluis & Salafsky 1998). Such information is particularly relevant in times of rapid global change (Adger et al, 2003; Fischlin et al, 2007). This strategy suggests evaluating the current state of the systems that collect, analyze, and interpret environmental information. Many of the systems for collecting this information are incomplete (Heinz Center 2002, 2006). Significant gaps exist within and among current environmental monitoring systems (Heinz Center 2002, 2006). Society clearly needs a better system for monitoring and reporting on ecosystem conditions.

Costs to adapt existing monitoring systems and develop new monitoring systems are likely to be high, in many cases requiring new legislation and regulations and possibly new tools and approaches to monitoring. Also required is better integration and coordination across the existing monitoring programs (Heinz Center 2006).

2. Biodiversity

Biodiversity is the foundation and mainstay of agriculture, forests, and fisheries, as well as soil conservation and water quality. Biological resources provide raw materials for livelihoods, sustenance, medicines, trade, tourism, and industry. Genetic diversity provides the basis for new breeding programs, improved crops, enhanced agricultural production, and food security. Forests, grasslands, freshwater, and marine and other natural ecosystems provide a range of services, often not recognized in national economic accounts but vital to human welfare: regulating water flows, flood control, pollination, decontamination, carbon sequestration, biodiversity conservation, and nutrient and hydrological cycling. Biodiversity conservation contributes to environmental sustainability. Biodiversity conservation is one of the three functions of UNESCO biosphere reserve.

Based on the principles and approaches to effectively conserve biodiversity, the following six strategies will cope with climate change and appear to be most relevant to the direct management of species and ecosystems which are the main components of biodiversity.

- o Applying a Risk Management Approach to Deal with Uncertainties about Climate Change

- o Minimizing Threats and Seizing Opportunities
- o Managing Invasive Alien Species
- o Developing Dynamic Landscape Conservation Plans
- o Reviewing and Modifying Existing Laws, Regulations and Policies Regarding Wildlife and Natural Resource Management
- o Education and Communication to Bring the Public along with Change

(1) Applying a Risk Management Approach to Deal with Uncertainties about Climate Change

Significant uncertainties surround critical features of climate change science such as how the hydrological cycle will change, and the consequences for these changes for water resources and water availability. Some of these issues, and the question of how much mitigation will be implemented in the coming decades, represent irreducible uncertainties. Strategies and tools for biodiversity conservation under a changing climate therefore must embrace uncertainty as an underpinning principle. A greater emphasis on risk management and adaptive management approaches are essential. The linear approach from research to outcome through policy and management needs to be replaced by an iterative, cyclical approach in which biodiversity outcomes are appraised, leading to new research and adjusted policy and management. Such an adaptive, cyclical approach needs high quality information based on monitoring and experimentation. The society needs to learn to accept some initial failures in policy and management approaches to deal with such a complex stressor as climate change. However, failures are only true failures if management and policy fail to learn from them, adapt their approaches and do better the next time (Lindenmayer and Franklin, 2002).

(2) Minimizing Threats and Seizing Opportunities

Biodiversity conservation must look towards new opportunities and more creative strategies and tools. Many of the socio-economic trends offer opportunities for new conservation approaches and tools. Other, however, could easily turn into threats. Schemes to sequester carbon in landscapes or to produce biofuels to substitute fossil fuel could easily lead to deleterious outcomes for biodiversity especially if there is a trend towards highly simplified industrial landscapes. However, with good research and astute policy developments, these potentially perverse outcomes could also be turned into opportunities. Complex, biodiversity-rich ecosystems invariably store more carbon than simple monoculture (Mackay et al, 2008). Creating much synergies among ecosystem services should become a central organizing principle for all proposals to mitigate climate change.

(3) Managing Invasive Alien Species

Invasive alien species has been found to be among the most important driver for biodiversity loss especially in island ecosystems. Many introduced species that are already considered as pests will have an advantage under climate change because they possess life history and other characteristics that give them an edge under any disturbance. Vacant niches may also be created by decline in local populations as some species become stressed by rapid climate change. This will enhance the colonization of newly introduced species or expansion of sleeper invasive species that are already present in the ecosystem in low numbers.

Even without extreme weather events, climate change will provide many opportunities for weed establishments wherever native plants are killed by heat or moisture stress. Most environment weeds are escaped garden plants originating from many different climatic zones. In addition to increasing weed problems, introduced species replacement will be most likely to occur in freshwater environments where rising temperature will most likely to suit aquarium dumped in streams, and in coastal waters where marine invasive species that arrive in ballast waters represent a large pool of immigrant species (Low, 2008).

A strategy to combat invasive species should be implemented in a changing climate change scenario. The strategy should consist of the following.

- Prevention through good biosecurity measures.
- Early detection of invasive species and their eradication.
- Management of the invasive species that have already established.

(4) Developing Dynamic Landscape Conservation Plans

As described by Hannah and Hansen (2005), dynamic landscape conservation plans include information on fixed and dynamic spatial elements, along with management guidelines for target species, genetic resources, and ecosystems within the planning areas. Fixed spatial elements include protected areas where land use is fully natural. Dynamic spatial elements include all other areas within the landscape matrix, where land use may change over time. The plan includes a desired future condition for each element, based on predicted shifts in distribution of species and other ecosystem components. It also describes any intermediate conditions that may be necessary for a species to transition between current and future conditions. The management guidelines suggest mechanisms and tools for management and provide specific recommendations to the government agencies responsible for implementation.

Unlike many traditional resource management plans, dynamic landscape conservation plans explicitly address the climate adaptation needs of wildlife and biodiversity at a landscape scale (Hannah & Hansen 2005). Such plans are likely to be compatible with other regional planning efforts (e.g., county or watershed management plans). Nevertheless, planning efforts can be resource intensive, and many natural resource management plans have been developed but not implemented. Dynamic landscape plans may recommend that certain spatial elements (areas of land or water) be converted from human uses to "natural" management to facilitate species movements (Hannah & Hansen 2005). Such recommendations are likely to prove controversial, especially in settings where the condemnation of private property or the translocation of human populations would be required.

(5) Reviewing and Modifying Existing Laws, Regulations and Policies Regarding Wildlife and Natural Resource Management

Laws and policies related to wildlife management, natural resource management, and biodiversity conservation should be reviewed to ensure that their provisions are consistent with the needs of managers dealing with the effects of climate change. Many of these laws and regulations are decades old, and most were developed before climate change became a significant concern. New legislative tools or regulations may be necessary to address specific climate-change impacts. Existing laws and regulations were designed for the conservation of "static" biodiversity (Lovejoy 2005; Lemieux & Scott 2005; Scott & Lemieux 2005). Many of these regulatory tools and approaches will need to be revisited in the light of the significant changes that are anticipated under even moderate climate-change regimes. Actually addressing the deficiencies identified through these reviews may be difficult without significant political will. There will likely be significant concern expressed from all sides about sweeping revisions to existing laws and regulations.

(6) Education and Communication to Bring the Public along with Change

The public as well as, political and institutional leaders must recognize that climate change is driving the natural world in uncharted territory in the 21st century. Furthermore, we are not starting with a clean slate; the amount of biodiversity loss later in the century will depend on a large degree on what we will do in the next decade or two to reduce the impact on current stressors. Social and political support is necessary for these new approaches to succeed. This may require the reexamination of some strongly held views on biodiversity and its conservation (Hobbs et al, 2006). Dunlop and Brown (2008) have already argued for a shift on minimizing loss rather than preserving all. Beyond this, the public must learn to value new, unique and diverse ecosystems over individual species that may no longer inhabit them. In a rapidly changing abiotic environment, preservation strategies based on equilibrium dynamic will not work. Landscapes will change; some species will be lost and others will not persist in their current locations. In general, the current emphasis on species will need to be balanced by a focus on ecosystem services, processes and diversity. Managing for resilience of existing ecosystems may work to a point, but we must also manage for transformation of ecosystems, landscapes, seascapes and perhaps even whole biomes. Such a wide ranging change in management of biodiversity will pose a challenge to existing governance arrangement and to administrative institutions. The increasing urbanization of the global population also means that the public know less and less about the significance of biodiversity in providing services to their everyday life. Engaging their interest in maintaining biodiversity is thus increasingly critical.

3. Communities of Flora and Fauna

Climate change creates new challenges for biodiversity conservation. Species ranges and ecological dynamics are already responding to recent climate shifts, and current protected areas will not continue to support all species they were designed to protect. Climate change may have already resulted in several recent species extinctions (McLaughlin et al, 2002; Pounds et al, 2006). Many species ranges have moved poleward and upward in elevation in the last century (Parmesan and Yohe, 2003; Root et al, 2003) and will almost certainly continue to do so. Local communities are disaggregrating and shifting toward more warm adapted species (Parmesan, 2005). Phenological changes in populations, such as earlier breeding or peak in biomass, are decoupling species interactions (Walther et al, 2002).

The following four would be the core strategies to assist the communities of flora and fauna to be adapted to climate change.

- o Developing Dynamic Landscape Conservation Plans
- o Dealing with Uncertainties: Ecological Resilience and Transformation
- o Bridging Ecological Knowledge Gaps and Research
- o Ensuring Wildlife and Biodiversity to Be Considered as Part of the Broader Societal Adaptation Process

(1) Developing Dynamic Landscape Conservation Plans

As described by Hannah and Hansen (2005), dynamic landscape conservation plans include information on fixed and dynamic spatial elements, along with management guidelines for target species, genetic resources, and ecosystems within the planning areas. Fixed spatial elements include protected areas where land use is fully natural. Dynamic spatial elements include all other areas within the landscape matrix, where land use may change over time. The plan includes a desired future condition for each element, based on predicted shifts in distribution of species and other ecosystem components. It also describes any intermediate conditions that may be necessary for a species to transition between current and future conditions. The management guidelines suggest mechanisms and tools for management and provide specific recommendations to the government agencies responsible for implementation.

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(2) Dealing with Uncertainties: Ecological Resilience and Transformation

It will be very important to focus on the biological and ecological qualities that give biodiversity increased resilience; that is, the capacity to experience shocks while retaining essentially the same functioning, structure, feedback and therefore identity. This can apply to an individual species or to a community or ecosystem where the resilience refers to particular trophic structures or functioning. It also applies to maintenance of evolutionary processes through preservation of genetic diversity. Preservation of genetic heterogeneity and diversity of environments is particularly important in providing avenues for resilience of biodiversity. In turn, society will be required to appropriate actions, in the face of uncertainties, that will increase the resilience of biodiversity.

It is almost certain that some transformation will occur in both climate and biodiversity. Ancillary question as to how society plans for transformation and predicts them wherever possible, and the degree to which society can assist the transformations to new states beneficial to both biodiversity and human society, also needs addressing with urgency.

(3) Bridging Ecological Knowledge Gaps and Research

There are substantial gaps in our ecological knowledge and research questions of direct relevance to the climate change challenge. Many relate to an improved understanding of how the ecological principles described earlier are expressed in real world situations under rapid environmental change. The gaps should be grouped by level in the biological hierarchy (species, community, ecosystem and paleo-ecology) relevant to current and future impacts of climate change on biodiversity. The gaps will serve to highlight the wide range of issues requiring more information.

The type of knowledge gaps and research questions will present a big challenge to the research community. The ecological principles and the analysis of observed and projected climate change impacts should provide a comprehensive framework within which a coherent and integrated research programmes to eliminate gaps can be built.

(4) Ensuring Wildlife and Biodiversity to Be Considered as Part of the Broader Societal Adaptation Process

Many of the adaptation strategies being developed in communities around the globe are focused on human health and infrastructure needs (The Heinz Center 2007). Mitchell et al (2007) recommended that the needs of wildlife and biodiversity also be considered as part of the overall societal adaptation process. Given the importance of wildlife for human recreation and enjoyment and the value of ecosystem services, such as pollination and water filtration, wildlife and ecosystems should also be addressed in climate-change adaptation plans (Mitchell et al, 2007). If global climate change leads to significant crises in human society, there may be a tendency to view the needs of wildlife and the needs of humans as conflicting, rather than complementary. In such either-or comparisons, the needs of human society could trump the needs of wildlife and biodiversity.

4. Species

With the magnitude of climate change expected in the current century, many vegetation types and individual species are expected to lose representation in protected areas (Araujo et al, 2004; Burns et al, 2003; Lemieux and Scott, 2005; Scott et al, 2002). Reserves at high latitudes and high elevations, on low-elevation islands and the coast, and those with abrupt land use boundaries are particularly vulnerable (Sala et al, 2000; Shafer, 1999). Landscapes outside of protected areas are hostile to the survival of many species due to human infrastructure and associated stressors, such as invasive species, hunting, cars, and environmental toxins.

Global climate change is already having significant effects on species and ecosystems (Gitay et al, 2002; Hannah et al, 2002a, 2002b; Schneider & Root 2002; Stenseth et al, 2002; Walther et al, 2002; Hannah & Lovejoy 2003; Parmesan & Yohe 2003; Root et al, 2003; Inkley et al, 2004; Thomas et al, 2004; Lovejoy & Hannah 2005; Parmesan 2006; Fischlin et al, 2007). Effects described to date include:

- o shifts in species distributions, often along elevational gradients;
- o changes in the timing of life-history events, or phenology for particular species;
- o decoupling of coevolved interactions, such as plant–pollinator relationships;
- o effects on demographic rates, such as survival and fecundity;
- o reductions in population size;
- o extinction or extirpation of range-restricted or isolated species and populations;
- o direct loss of habitat due to sea-level rise, increased fire frequency, pest outbreaks, altered weather patterns, glacial recession, and direct warming of habitats;
- o increased spread of wildlife diseases, parasites, and zoonoses;
- o increased populations of species that are direct competitors of focal species for conservation efforts and;
- o increased spread of invasive or non-native species, including plants, animals, and pathogens.

It seems that climate change will have the most detrimental impact at the species level. This will eventually means that species should be targeted and conserved holistically through different strategies as below.

- o Designing New Natural Areas and Restoration Sites to Maximize Resilience
- o Protecting Movement Corridors, Stepping Stones and Refugia
- o Improving the Matrix by Increasing Landscape Permeability to Species Movement

- o Focusing Conservation Resources on Species That Might Become Extinct
- o Translocating Species at Risk of Extinction
- o Establishing Captive Populations of Species That Would Otherwise Go Extinct
- o Reducing Pressures on Species from Sources Other Than Climate Change
- o Incorporating Predicted Climate Change Impacts into Species and Land-Management Plans, Programs and Activities
- o Considering Genetic Preservation in Some Cases

(1) Designing New Natural Areas and Restoration Sites to Maximize Resilience

It may be possible to design new natural areas and restoration sites to enhance the resilience of natural systems to climate-change effects (Lovejoy 2005). For example, saltmarsh restoration sites adjacent to steep shorelines would likely be inundated and lost under conditions of accelerated sea-level rise. In contrast, restored marsh communities adjacent to gently sloped shorelines may be able to regress naturally landward as sea-level rises (Yamalis & Young 2007). Similarly, the establishment of protected area networks along elevational gradients may be a viable adaptation strategy for certain taxa; such networks would provide organisms with the spatial flexibility to shift distributions along elevational gradients as climatic conditions change. Protection of such future habitat areas should be a key consideration whenever new natural areas or extensions to existing natural areas are proposed (Fischlin et al, 2007).

Ecological restoration projects often use multiple plant species, some of which may exhibit greater resilience to climate change at particular sites. Mixes of species for restoration projects could be adjusted to include species that are thought to be more resilient to anticipated changes in a particular area. Increased vigour and rate of spreading of invasive plant species has been identified as a potential problem under certain climate-change scenarios (Truscott et al, 2006; Yamalis & Young 2007), and innovative management strategies will probably be needed to address this problem. This strategy is likely to serve as an important filter criterion for future protection and restoration efforts.

Funders and project managers may question the wisdom of investing scarce conservation funds in projects that are not sustainable in the face of climate change. Nevertheless, projects that are not sustainable over long term may nonetheless have important short-term benefits, for example providing intermediate areas of habitat for climate-sensitive species until longer-term refugia are identified (Hannah & Hansen 2005).

(2) Protecting Movement Corridors, Stepping Stones and Refugia

This strategy will direct protection efforts toward areas and regions that have been deemed essential for climate induced wildlife movements (Allan et al, 2005). Such areas might include movement corridors for terrestrial species, habitat islands that could serve as stepping stones between larger reserves, stopover areas for migratory waterfowl, or refugia where climate-change impacts are predicted to be less severe (Julius & West 2007). In aquatic systems, unblocked streams and rivers serve as important movement corridors for aquatic species (Pringle 2001; Chu et al, 2005).

Tools are already available for protecting terrestrial areas and riverine corridors. It can be difficult to predict future species movements with confidence. A practical concern is the tremendous cost associated with protection of large-scale movement corridors (Fischlin et al, 2007).

(3) Improving the Matrix by Increasing Landscape Permeability to Species Movement

This strategy focuses on increasing broader landscape connectivity and permeability to species movement (da Fonseca et al, 2005), especially outside protected areas and protected-area networks. Rather than focusing on a single species or ecosystem type, this approach would use a variety of existing management techniques to enhance the ability of the broader landscape matrix to support movements by large numbers of animal and plant species in response to climatic changes. This strategy is consistent with a number of existing management approaches, such as agri-environment schemes in the United States and Europe (Donald & Evans 2006; Giliomee 2006) and dam removals, fish ladders, and other techniques to restore connectivity in freshwater aquatic systems (Pringle 2001; Chu et al, 2005; Battin et al, 2007).

A suite of conservation tools are already available for implementing this approach (including agri-environment schemes and dam removals), and large-scale implementation programs have been successfully demonstrated in the United States and Europe (Donald & Evans 2006). Modeling techniques are available to assess landscape permeability to species movement (Singleton et al, 2002) and to predict likely paths of dispersal across the landscape matrix under particular climate-change scenarios (Carroll 2005). Nevertheless, this approach does not focus on rare species or species with narrow habitat requirements, and a pure application of this approach would likely consign some of these species to extinction.

(4) Focusing Conservation Resources on Species That Might Become Extinct

This strategy would invest resources in the maintenance and continued survival of species most likely to become extinct as a result of global climate change. The IUCN (2008) has recently begun incorporating projections of future risk from climate change into its red-list rankings, an activity that is also consistent with this strategy. This is an intuitive strategy for wildlife managers, following a long tradition of conservation efforts for rare or extinction-prone species. Rare species may be especially susceptible to climate-change effects, and there may be climate thresholds above which extinction probabilities for these species increase dramatically (Hoyle & James 2005; Fischlin et al, 2007). There are numerous published reports of species declining and even extinctions correlated with climate change (Parmesan 2006). From a management perspective, climate change may provide opportunities for innovative approaches, such as the scheme described by Kilpatrick (2006) to accelerate the evolution of resistance to avian malaria in native Hawaiian birds.

Conventional management of endangered species has relied heavily on in situ conservation approaches. Such approaches will be increasingly difficult to sustain in a world where climate change is dynamically altering both ecosystem components and processes (Lovejoy 2005). Despite our best efforts, rare or endemic species will likely become extinct as a result of climate change (Koprowski et al, 2005). Traditional endangered species management can also be extraordinarily expensive (Canadian Wildlife Service & U. S. Fish and Wildlife Service 2005). Unless significant new sources of funding are developed, resources will simply not be available for comprehensive conservation actions targeting every species imperiled by climate change.

(5) Translocating Species at Risk of Extinction

This approach recommends moving animals, plants, and other organisms from sites that are becoming unsuitable due to global climate change to other sites where conditions are thought to be more favorable for their continued existence. Other names for this strategy include assisted dispersal, assisted migration, and assisted colonization (Julius &West 2007; McLachlan et al, 2007; Mitchell et al, 2007; Hoegh-Guldberg et al, 2008).

Translocation techniques have been developed and demonstrated for many plant and animal species (e.g., Schweitzer 1994; Thomas 1995; Griffith et al, 1989; Thomas 1999; Haight et al, 2000; Bothma 2002; Tenhumberg et al, 2004). Nevertheless, with any translocation attempt, there is a risk of failure and even extinction (Maxfield et al, 2003; Groombridge et al, 2004). For many species, it will be difficult to predict optimal locations for assisted dispersal. This is due to significant gaps in our knowledge regarding the biology of many rare species and challenges associated with forecasting optimal future habitats (Suarez-Seone et al, 2004; Tolimieri & Levin 2004; Carroll 2005).

(6) Establishing Captive Populations of Species That Would Otherwise Go Extinct

This approach would initiate captive maintenance programs for species that would otherwise become extinct due to climate change. Such an approach would necessarily serve as the last resort strategy for species otherwise facing extinction (Hansen et al, 2003). Seed, sperm, and egg banking represent extreme forms of this strategy (Guerrant et al, 2004).

Rearing techniques and approaches to captive husbandry and propagation have been described for many animals (Kleiman et al, 1997) and plants (Guerrant et al, 2004), and modern society has an industry (zoos, botanic gardens, and aquaria) dedicated to this approach. Nevertheless, given the resources required for captive maintenance programs (Kleiman 1989), this is unlikely to be a viable long-term strategy for any more than a few species. Under extreme climate-change scenarios, ecosystem conditions may be so altered that the reintroduction of these species will be unfeasible, essentially making these species living fossils.

(7) Reducing Pressures on Species from Sources Other Than Climate Change

This strategy seeks to reduce or remove other, non-climate stressors to give wildlife species the maximum flexibility to evolve responses to climate change (Lovejoy 2005; Robinson et al, 2005; Julian & West 2007; Mitchell et al, 2007). Species clearly experience multiple stressors, and the removal of these other stressors may allow individual species the flexibility needed to adapt to climate change. Fischlin et al (2007) and Robinson et al (2005) noted that this may be the only practical large-scale adaptation policy for marine systems. Although numerous other stressors affect species, limited resources are available to address the broad suite of stressors. Given these circumstances, there is potential for a loss of focus and much diffuse action across a broad range of stressors.

(8) Incorporating Predicted Climate Change Impacts into Species and Land-Management Plans, Programs and Activities

Climate change is not addressed in many existing natural resource plans (Hannah et al, 2002a, 2002b). This strategy recommends incorporating climate-change information into existing and future natural resource planning activities. Information about actual and potential climate-change impacts can be of considerable benefit to land and natural resource managers in refining decisions. Many existing natural resource plans already contain provisions for updates and revisions, which could provide a mechanism for incorporating information about climate-change effects and adaptation strategies into these documents. In addition, the IUCN (2008) is now including projections of future risk to species from climate change into its Red List.

The problems with this approach are mainly practical at present. There is a cost associated with revisiting and revising management plans (as well as institutional inertia and potential unwillingness to do so), and detailed predictions of potential climate-change effects are currently only available for a small subset of species and areas.

(9) Considering Genetic Preservation in Some Cases

As a last resort approach, some species may need to be preserved outside of an ecosystem context, whether it is an existing or transformed natural ecosystem or a human-engineered ecosystem. However, such last resort ex situ methods should be seen in no way as substitution for well functioning ecosystems.

Some examples of ex situ methods are:

- Cryogenic seed banks
- Refrigerated seed stores and cryogenic germplasm stores
- The potential role of zoos to conserve small number of charismatic and highly valued species

- The breeding and maintenance of nearly extinct species in isolated or quarantine areas

Chapter 6
Strategy against Climate Change on Island and Coastal Biosphere Reserve - Social Vulnerability

1. Social Vulnerability and Climate Change

Social vulnerability in relation with climate change impacts is the result of a complex combination and interaction of different factors such as the existing natural, environmental and geographical conditions of each site as well as the socio-economic structure, dynamics and capacity to cope and adapt to natural and human induced impacts.

Small Islands and Coastal areas are particularly vulnerable to climate change impacts because of their sensitivity, exposure and limited capacity to adapt to the vagaries of climate change. When considering vulnerability on islands and coastal zones, usually the natural features, such as endemism and rarity of species and habitats are the key elements considered. On Island and Coastal Biosphere Reserves this is even more emphasized as these sites usually host a high biodiversity including relevant elements (species and habitats) with highly important conservation value (rare, endemic and vulnerable). Social vulnerability is also exacerbated on island and coastal Biosphere Reserves due to the close relation and dependence of communities on the natural resources. Thus, with climate change, it is vital to understand, not only the consequences for ecosystems (biophysical vulnerability), but also if, and how, the social exposure unit will be able to respond to changing exposures and the effects on their coping capacities (social vulnerability) (Vincent, 2004).

2. How to Assess Social Vulnerability to Climate Change

Social vulnerability strongly depends on land cover patterns, landscape use and management including soil and coastal erosion, mountain deforestation and other human uses of natural resources that should be linked with the level of socio-economic development and capacity to minimize and adapt to the impacts of climate change.

Assessing social vulnerability to climate change implies three main factors: a) exposure, b) sensitivity and, c) adaptive capacity. Together, these three areas determine the level of vulnerability to climate change impacts which may be defined as follows (Wongbusarakum & Loper, 2011: 41):

o Exposure is the extent to which a community comes into contact with climate change events or specific climate impacts.

o Sensitivity is the degree to which a community is negatively affected by changes in climate.

o Adaptive capacity is the potential or capability of a community to adjust to impacts of changing climate.

Therefore, social vulnerability to climate change can be measured by combining measurements of these three components and considering different scales (individuals and/or communities).

It is relevant for the understanding of social vulnerability to climate change to know the character, magnitude and rate of climate variation to which coastal communities and marine-based industries are expected to be exposed (IPCC 2003), and this also applies to the particular case of islands and coastal zone Biosphere Reserves. Several methods can be used to compile information (qualitative and quantitative) and assess the exposure such as existing vulnerability assessments, expert opinions, models or observational data (Liverman, 2008).

Assessing social sensitivity to climate change relates with the degree of dependence that individuals or communities have on the ecosystem goods and services that are affected by climate change related impacts.

Adaptive capacity can be assessed at different levels from individuals and communities to local and national areas. Each of these levels will determine distinct factors and characteristics to be analyzed for determining the capacity to cope and adapt with the impacts of climate change.

3. Biosphere Reserves and Community Resilience through Adaptation Strategies

The MAB Strategy (2015-2025) approved during the 4th World Congress of Biosphere Reserves (Lima, Peru, March 2016), recognizes Biosphere Reserves as a global network of sites of excellence to promote learning and pilot innovative actions to adapt to and mitigate the effects of climate change and other types of global environmental change. Protected areas can play a decisive role in enhancing community resilience in relation with adaptation to climate change and, Biosphere Reserves, due to their close links and permanent interactions with communities, are well positioned to contribute to vulnerability assessments and consequent establishment of strategies for building social and ecological resilience. Marshall et al 2010, propose a four step approach for building resilience:

- o Vulnerability assessment
- o Identification of resilience-building strategies
- o Prioritizing resilience efforts
- o Implementation of resilience-building strategies

Biosphere Reserves may serve as a unit that fits, in terms of scale and capacity, with the development of local climate adaptation plans. At the same time BRs ensure adequate participatory mechanisms through existing management plans, operational structures and their permanent connection with the communities. This proximity with the communities will contribute to a strong recognition and identification by the communities with the results of the vulnerability assessments and its relation with the conservation and sustainable use of natural resources. A Biosphere Reserves combine integrated actions on conservation and sustainable development, adaptation to climate change strategies on Biosphere Reserves will always consider Community-based Adaptation and Ecosystem-based Adaptation, thus, facilitating a broader and integrated approach.

The foundations for the development of an integrated adaptation to climate change oriented towards the reduction of social vulnerability and, at the same time enhancing ecosystem conservation should consider the role of both the natural and hard infrastructures and not just the later as it happens in most cases.

Chapter 7
Strategy against Climate Change on Island and Coastal Biosphere Reserve - Economic Vulnerability

BR stands for harmonized management and conservation of biological and cultural diversity, and economic and social development based on local community efforts and sound science. The main objective of BRs listed in the MAB Programme's World Network of Biosphere Reserves is to promote solutions reconciling the conservation of biodiversity with its sustainable use. BRs are considered as "science for sustainability support sites", and they function as interdisciplinary testing sites to understand and manage changes and interactions between social and ecological systems.

Particularly, adaptation to climate change in relation to economic vulnerability should be recognised as an integral part of the development planning process and, when considering the economic evaluation of potential adaptation measures it is vital to consider and clarify the baseline from which all possibilities will be analysed including the zero alternative, corresponding to non adoption of adaptation measures.

Economic vulnerability linked to climate change includes a vast array of implications such as human resettlements, loss of access to resources (water, fisheries) or reduction in production (agriculture and livestock) and income from tourism and other economic activities, often associated with loss of jobs and social disturbance.

Coastal and Island Biosphere Reserves bring together high level of vulnerability to climate change related impacts resulting from their insular and/or coastal nature combined with the presence, and need to preserve, of outstanding and fragile biodiversity (species, habitats and landscapes) and cultural heritage that are closely related most of the times. Moreover, BRs are not necessarily administrative entities which reduce their capacity to cope with local or national adaptation strategies and available means. This brings significant constraints to the development of an adaptation strategy specifically designed for the BRs. On the other hand, the lack of adaptive measures bring significant risks to economic growth and, consequently, to human and natural wellbeing. For BRs, as sites are compromised with sustainable development, the lack of adaptation also means the risk of losing investments and successes achieved or pursued for many years. While quantification of climate change impacts on a global scale is important, on a local scale (that is the case for BRs), decision-makers must assess the total losses they are likely to face in the future in order to avert them with the most appropriate adaptation measures (ECA, 2009: 164).

Considering the above statements in relation to the establishment of strategy against climate change on island and coastal BRs, the economic vulnerability to climate change is related to sustainable use of BR. As identified from the first stage of this project on the five research BRs (Jeong et al., 2015), the economic activities of sustainable use are taking place in transition areas, and the three areas are agriculture, tourism and fishery industry.

Thus, this chapter will establish strategies of economic vulnerability to climate change on agriculture, tourism and fishery industry. The establishment of strategies will be focused on adaptation. This is because mitigation strategies on agriculture, tourism and fishery industry can’t be applied only to BR, but are applicable to island as a whole where BR is located.

As identified in the first stage of this research, there are many categories of mitigation strategy implemented on islands where the five research BR sites - Jeju Island BR, Menorca BR, Macchabee-Bel Ombre BR, Príncipe BR and St. Mary’s BR – are located (Jeong et al., 2015: 69-95). However, the existing mitigation strategies are not established on the basis of the specific sources of greenhouse gas emission by socio-economic sector. Therefore, reminding that agriculture, tourism and fishery industry in BR have their own specific sources of greenhouse gas emission in the process of their production activities, mitigation strategies will be established on the basis of their specific sources of greenhouse gas emission.

In the context of the above, this chapter will first summarize the impact of climate change on agriculture, tourism and fishery industry in the five research BR sites identified from the first stage of this research (Jeong et al., 2015) and then will establish the strategy against climate change. However, the summary of climate change impact on tourism in Macchabee-Bel Ombre BR and on fishery industry in Macchabee-Bel Ombre BR, Príncipe BR and St. Mary's BR will be excluded because they do not have tourism resorts and marine in their boundary of BR.

One more important reminder in this chapter is that the first stage of this research analyzed the impact of climate change on marine ecology in the boundary of BR, but the climate change impact on marine fishery industry were not analyzed. Therefore, the summary is regarding the climate change impact on marine ecology, but it is inevitable to establish the strategy of ocean fishery industry in general against climate change.

1. Agriculture

1.1: Impact on Agriculture

Jeju Island BR (Jeong et al., 2015: 102-103): Five agricultural products are produced in Jeju Island BR – shiitake mushroom, green tea, *Sasa palmate* (Bean) E.G.Camus, wood-cultivated ginseng and pork. There are no existing empirical research available on the change in their cultivation mode, arable land, production output, and profit which might be caused by climate change. However, climate change impacts on the entire island have been identified.

Firstly, the arable land of tangerine (Citrus unshiu S.Marcov.) and subtropical fruits have moved northward due to the rise in temperature. The sugar content of tangerine is changing. Secondly, subtropical or tropical crops such as pineapple, and mango, etc. can be cultivated in the naked land. Thirdly, agricultural products are damaged by the invasion and settlement of exotic diseases and insect pests. Fourthly, exotic plants invade new sites where there are no pathogenic fungus and insects in the mechanism of food-chain. This results in a natural selection of original plants due to the lack of their adaptation to exotic plants which are new neighborhoods. Fifthly, exotic weeds have invaded and settled down in Jeju Island. They have a high possibility to weed out the indigenous species and derive them to extinction. Sixthly, an earlier seeding period for barleys and leafy vegetables, and their production output is decreasing.

Menorca BR (Jeong et al., 2015: 108-109): Bluetongue which is a viral disease of ruminants transmitted by biting mosquitos (*Culicoides* spp.) is prevailing in Menorca BR. It represents one of the most plausible examples of climate change driving the emergence of a vector-borne disease. This is a major risk in Menorca given how important the horses are for the island's culture and festivals.

In such situation, it is likely that there are serious consequences to the island's agricultural/livestock system. The most important agricultural production in Menorca is cow milk and cheese. In fact, the current trend is the reduction of farm numbers, and the intensification of exploitation of the farms that remain operational. Climate change is likely to exacerbate this trend.

Macchabee-Bel Ombre BR (Jeong et al., 2015: 108-109): Climate change impacts on the production and quality of sugar cane and hence entails serious socio-economic responses. Low cane productivity of the lowlands has been attributed to lack of available moisture while comparatively lower temperatures and radiation are the limiting factors in the uplands. Quantitative studies reveal approximately 30% to 56% decrease in the yield. The recoverable sucrose content is lower with increase in temperature. Higher frequencies of climate extremes such as cyclone, droughts and prolonged rainfall impact on sugar production. This situation has led some planters to abandon this cultivation specifically on marginal lands where it is no more economically sustainable.

Príncipe BR (Jeong et al., 2015: 121-122): Drought, floods (caused by the rain and waters of the sea), squalls and landfalls are the most important events influencing agriculture and forest. These extreme events are responsible for losses of agricultural production and changes in crops and are becoming more frequent, increasing vulnerability of some communities, particularly in the Northeastern part of the Island. Changes in rain patterns and periods are also major concern as traditional agriculture practices and calendars will need to adapt to the vagaries of climate change.

The Southern part of Príncipe Island benefits from a dense forest cover that ensures protection against heavy rain and high temperatures, thus being less sensitive to climate change.

St. Mary's BR (Jeong et al., 2015: 124): Changes in rainfall patterns and the increased frequency of extreme events affect agriculture production directly. Although agriculture is not a relevant activity within the area of St. Mary's Biosphere Reserve, the effects of climate change on agriculture in the rest of the island might lead to a search for other sources of income, increasing and introducing new human activities in the area of the Biosphere Reserve. Potential indirect negative impacts such as erosion, habitat and landscape degradation will result from the increase in the use of the Biosphere Reserve.

With the prediction of a drier climate, rain fed agriculture will be affected with yields being below economically viable levels. This will be the case of sugarcane cultivation that certainly will require irrigation management, ensuring adequate water quantity and quality. Salinization of coastal lower aquifers will negatively affect availability of water for agriculture.

1.2: Strategy for Agriculture

Subsistence as well as commercial agriculture have a common use of soil, water and close implication with landscape management, factors directly impacted with climate change at short and long term scales. Extreme events, at a local scale, may induce loss of soil, flooding, landslides, rock falls, droughts that directly impact on livelihood and all socioeconomic related conditions while, at a global scale, may hide trends towards radically different scenarios. Adaptation strategies for agriculture should provide measures and solutions to cope with short-term events and, at the same time, ensuring that these actions will not undermine the capacity to deal with expected major changes even if under a high level of uncertainty. While basic infrastructure investments improving efficiency on water and soil use and management may be feasible without the need to change traditional ways of farming, it is advisable to introduce complementary measures such as new varieties that are more resistant to the expected temperature, soil composition, salinity and other physical and chemical conditions. These knowledge needs are extended to optimized inputs, timely information on weather, water cycle changes, monitoring and preventing pests, diseases and implies capacitation and changes on water management, soil conservation, crop storage and marketing strategies.

Depending on the specific conditions (geographical, dimension, social, economic, etc.), there are different options and ways to promote and implement adaptation to climate change in agriculture systems. Some of the most common are (Howden et al, 2017):

o Introducing new varieties/species that are better adapted to the existing and predicted conditions.

o Enhancing water collection and management through climate smart infrastructures and conservation agriculture.

o Optimizing timing and/or location of cropping activities.

o Ensuring sounding and effective pest and disease management.

o Diversifying income by integrating agriculture with other activities.

However, adaptation in agriculture may imply impacts on other sectors such as conservation due to the potential change in land use, introduction of new crops that interfere with natural landscapes, habitats and species. Also on the socioeconomic side it may bring changes on the social structure and traditional knowledge including migration. Adaptation outputs are not a linear positive process as it implies a combination of a complex combination of factors from which, long term impacts may be hidden by immediate positive results of single actions that will have different results in a long term perspective. The Biosphere Reserves' zonation scheme in which there are core zones and buffer zones, may be affected due to the implementation of adaptation measures such as relocation of agricultural activities, the introduction of new crops and associated vectors.

In addition, what we need to be reminded is that agriculture itself is a source of greenhouse gas emission. This implies that it is necessary to establish a strategy to reduce greenhouse gas (GHG) emission from agricultural activity in BR. This strategy may be termed the agricultural sector's own mitigation strategy.

Emissions from the agricultural sector are very substantial, especially when accounting not only for emissions from direct production, but also for fossil fuel emissions along the agricultural supply chain, and emissions associated with agriculture's role in driving deforestation.

Mitigation potential in the agricultural sector through a combination of emissions reduction, sequestration of carbon in agricultural systems, and major shifts in consumption patterns. These levels of mitigation would make the agricultural sector roughly GHG neutral. While a GHG neutral agricultural sector is conceptually possible given the benefits of carbon sequestration (while it is actively occurring), this scenario is highly unlikely. Broadly, mitigation from agriculture can result from three types of interventions as below (Dickie, et al. 2014: 26-33).

o Reducing the emissions intensity along the entire agricultural supply chain, including avoided land use change driven by agriculture.

o Sequestering additional carbon in agricultural systems.

o Reducing overall agricultural production (e.g., by reducing food loss and waste or demand for biofuels) or shifting away from high-carbon intensity agricultural products such as meat from ruminants.

2. Tourism

2.1: Impact on Tourism

Jeju Island BR (Jeong et al., 2015: 102-103): Tourism activities in the buffer zone are conducted mostly in public tourist resorts, such as Natural Forest Resorts, Roe Deer Eco-Park, Saryeoni Forest Trail, and Seogwipo Provincial Marine Park, etc. The majority of Jeju Island BR's economic activities are located in the transition area. There are 21 golf courses, 31 public and private facilities that are related to tourism, 26 accommodations, and 15 schools, etc. However, no data on the individual tourism sights that are located in Jeju Island BR buffer zone are available.

Menorca BR (Jeong et al., 2015: 108-110): Menorca's tourism demands will follow decrease in holiday travel during summer due to too high temperatures and heat waves in the summer, an increase of Northern European tourists spending comfortable summer climates in their own countries or region, an increase of travel during spring and autumn reducing the strong seasonality that exists today.

Moreover, Menorca is a tourist destination that is based on the sun and beaches. It is extremely likely that two elements may affect Menorca's tourism; beach erosion and water scarcity. In addition, there are many other factors that could affect tourism linked with global change, as the increase of jellyfish in the sea (see section below) or wild forest fires, which could have a big impact on tourists and they are very difficult to forecast.

Príncipe BR (Jeong et al., 2015: 122): Tourism is expected to be the major economic activity in Príncipe Island. The expected impacts of climate change in the tourism sector is related with health (accidents during extreme events), limitation of flight connections during storms and eventual damages on existing infrastructures located near the coastal areas. The increment of diseases linked with climate change will also impact tourism as the choice of a touristic destination that includes health security.

St. Mary’s BR (Jeong et al., 2015: 125): The vulnerability of tourism infrastructures to extreme events is becoming more evident with the economic and infrastructural damage, which resulted from two consecutive major hurricanes in 1998 and 1999. In the long term, the changes and destruction of coastal areas including beaches will also result in a lower quality of beaches and seafront areas, which are extremely sensitive and have a high value in terms of tourism. Other implications include structural damage to coastal infrastructure (harbors, roads) and increases in the costs of insurance.

2.2: Strategy for Tourism

For many BRs, tourism is a major contributor to the local economy. The increase of extreme events and other climate change related trends such as increase of vector-borne diseases, floods, landslides, turn some areas less attractive for tourists. Lack of health facilities, remote location and poor communication infrastructures may also exacerbate constraints on tourism development leading to reduction of investments and ultimately on loss of jobs and opportunities for local communities and companies.

Specific adaptation measures on tourisms sector must be combined with land planning in order to minimize impacts but also to ensure feasibility of tourism activities. Moving from bed-based to activity-based tourism is a good option not only as a way to create more and diversified job opportunities, to increase the offer of activities and improve tourism experience but also as it requires a global approach on how to manage natural resources, including biodiversity. Biodiversity conservation ensuring the maintenance of goods and services provided by species, habitats and ecosystems come as a main contributor to support activity-based tourism, including visits, trails, bird watching, whale and dolphin watching, or simply enjoy of natural landscape. All these activities may support sustainable, diversified and qualified jobs with economic significance at a local level. For small communities it may be one of the few available options.

Part of any adaptation strategy to explore tourism as an alternative to support community development should be supported by knowledge and information. Biodiversity and landscape inventories including the understanding of the structure and dynamics of existing ecosystems, determination of carrying capacity, enforcement of planning and management capacity are in fact important components of any adaptation strategy that brings together sectors that usually are separated. If well designed and implemented, tourism can be a driver of adaptation strategies in biosphere reserves due to the direct and indirect links that tourism promotes between different socioeconomic sectors.

Tourism is a contributor to and a victim of climate change. The terminology is the paradox of tourism. This paradox is applied to the tourism in biosphere reserve. In order to overcome the paradox, in addition to adaptation strategy, the tourism in biosphere reserve should establish mitigation strategy for reducing greenhouse gas emitted in the process of operating its own tourism resort.

Mitigation strategy of tourism in biosphere reserve can be implied by the ecotourism-based operation of all tourism resources being used. The concept of ecotourism is very broad, but its core conceptual components can be drawn as the following three (Zebich-Knos, 1991; Eum and Yang, 2010; Cho and Kim, 2014).

o All nature-based forms of tourism in which the main motivation of the tourists are the observation and appreciation of nature as well as traditional cultures prevailing in natural areas.

o It minimizes negative impacts upon the natural and socio-cultural environment.

o It supports the maintenance of natural areas which are used as ecotourism attractions.

The mitigation strategies should be established in away to meet the above three conceptual components in the process of operating. In other words, the operators of tourism resorts in biosphere reserve should develop their own strategies to minimize greenhouse gas emissions in the process of operating their tourism resorts.

There are many sectors related to the reduction of greenhouse gas emission. However, the major sectors are summarized as below (Issacs, 2000; Pearson, 2002; Oh, 2003; Choi and Lim, 2005; Brenner and Job, 2006; Uddhammar, 2006; Cifton and Benson, 2009; Kim, 2011; Cini and Passafaro, 2012; Lu and Stepechenkova, 2012; Ahn, 2013; Hakim and Nakagoshi, 2004; Park, 2015).

o Developing a manual for reducing greenhouse gas emission on the basis of calculating greenhouse gas emission by sector in the process of operating tourism resorts.

o Establishing the system of energy and resource circulation through saving resources and energy, improving the efficiency of resources and energy, introducing new and renewable energy, and reducing emission of pollutant and waste discharge, etc.

o Providing visitors with environmental education program for leading them to environmentally friendly behavior during their tour in the tourism resort.

Such an ecotourism potential would contribute not only to the survival of tourism resort itself in BR, but also to the mitigation strategy of the island or coastal area where the BR is located. In addition, ecotourism will become a potential solution for reducing greenhouse gas emission and create a clean development strategy not only for BR, but also for other tourism resorts.

3. Fishery Industry

3.1: Impact on Marine Ecology

Jeju Island BR (Jeong et al., 2015: 103-104): Sea lettuce is reproduced throughout the year and restrains the reproduction of other sea algae. Crustose coralline algae increase rapidly. Especially, crustose coralline algae is known as a major dominant species informing the decrease in the biodiversity of sea algae. The change in physical environment influences the organisms living in the marine ecosystem in terms of their reproduction, growth, and breath, etc. New fishing ground of tropical climate has been formed, while cold current fish species are disappearing.

In addition, the spreading whitening (efflorescence marine), which is caused by the change in marine ecosystem due to the increase in carbon dioxide in atmosphere and the rise of seawater temperature, is a major indicator informing a significant change in marine ecology across the coast of Jeju Island.

Menorca BR (Jeong et al., 2015: 110-112): Three salient climate change impact are the decline of Seagrass *Posidonia oceanic*, the increase of exotic invasive species in the Mediterranean sea, and the increase in jellyfish populations (*Pelagia noctiluca*.)

Seagrass *Posidonia oceanic* is particularly sensitive to human disturbances but also has been found that it’s affected by rising seawater temperature. Another finding is that the mortality rates in natural populations in the Balearic Islands increased threefold with a 3◦C increase in maximum annual seawater temperature.

Most of the species are of tropical origin. Since some years ago, it has been observed that global warming facilitates the invasion of exotic species in the marine environment. About 110 species of exotic macrophytes have been cited.

Since the late 20th century there is evidence that blooms *Pelagia noctiluca* is conditioned by climatic variables such as mild winters, low rainfall, high temperature, and high-atmospheric pressure. Most of these variables correspond to forecasted trends of the models on climate change in the region.

3.2: Strategy for Fishery Industry

The scope of causes impacting on marine BR is much wider than that that of the scope of causes on terrestrial BR in terms of the actor contributing to climate change, the boundary of source where the impact is originated, and unclear boundary of the activity of fishes between marine BR and non-marine BR.

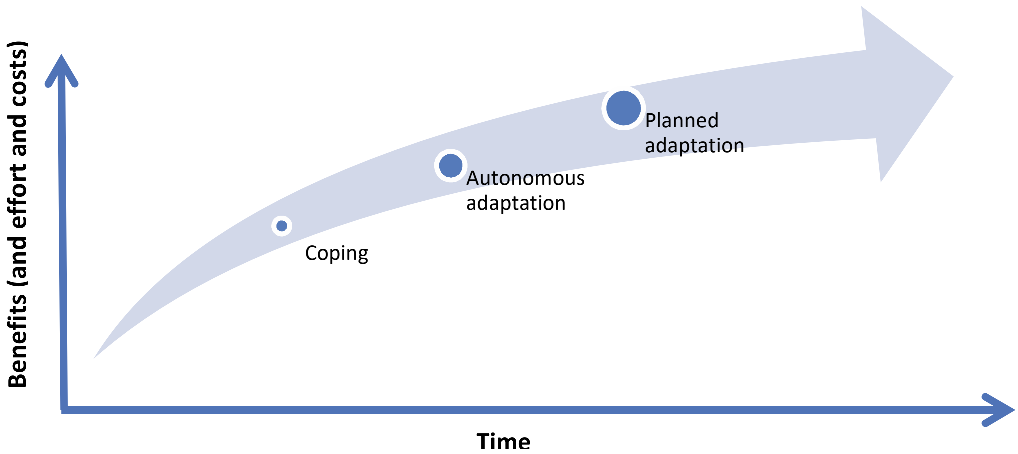
Due to these reasons, the adaptation and mitigation strategy on fishery industry in marine BR should not be on the basis of only the actors related to their marine BR, but on the basis of all the domestic and international actors related to fishery industry in the ocean. Such special situation implies that the establishment of adaptation and mitigation strategy on fishery industry should be based not on marine BR-specific, but on fishery industry covering ocean in general, and that priority should be given to adaptation when the strategy is focused on marine BR-specific one.

Therefore, this research established the strategy on fishery industry in marine BR, considering the profiles of coastal BR areas being impacted (see 3.1: Impact on Marine Ecology), focusing on adaptation, and considering the fishery industry in ocean general.

The most direct climate change impacts include further reductions of fisheries and aquaculture output resulting from increasing sea surface temperature, ocean acidification and rise in the sea level (Dey et. al., 2016). Disturbance of coastal habitats and coral reef bleaching will result in changes of fish stocks impacting many coastal communities that depend directly on artisanal fisheries and small scale aquaculture.

Adaptation from the fishery sector can be part of a well designed plan or can be the whole set of individual actions that are undertaken by individuals and communities addressing climate change related events or trends. Individual adaptation actions in fisheries may be changing the timing or locations of fishing as species arrive earlier/later or shift to new areas while planned adaptation may be research funding for finding species resistant to salinity and temperature fluctuations for aquaculture (Shelton, 2014: 34).

There are a vast diversity of measures, scales (geographic and temporal) and resources (financial, administrative, human) implied on fisheries adaptation that should be considered during the process of selecting adaptation priorities and measures and combined with cost-benefit and time-scale analysis.



<Figure 11> Time Scale and Cost-Benefits Required by Different Types of Adaptation (Graphic from Shelton, 2014)

Again, for fisheries, in small island and coastal Biosphere Reserves, it is highly improbable to ensure access to capacity and resources that would support the establishment of long term adaptation strategies. Instead, Biosphere Reserves should explore and benefit from integrated approaches promoting sectoral contribution such as the reinforcement of conservation through the core zones as these areas have already local and/or national legal status. Conservation of coastal and marine sanctuaries is very important to provide nursery and feeding areas for fish and shellfish resources. Small and smart infrastructures supporting fishing activities, capacity building and risk management are other elements that can be combined as the basis for local-based successful fisheries adaptation strategies.

However, legal and political instruments at national and international levels are also necessary to prevent contradiction and conflicts between the well addressed local actions and the external trading and management frameworks. Access to markets, technology and competition for resources are usually factors affecting artisanal and small scale fisheries that are not able to face impacts generated upstream such as those generated by overfishing by industrial fisheries that limits or interdicts local sustainable fisheries.

Knowledge, information, capacitation and monitoring are also key elements for adaptation that should be combined under integrated wide adaptation-planning frameworks and strategies that in their turn should cope with climate change models and local specific environmental and socioeconomic conditions.

Chapter 8
Summary and Conclusion

Various strategies against climate change including mitigation and adaptation are established and implemented at a global, national and local level. International organizations have emphasized the importance and necessity to establish and implement IPA-specific or BR-specific strategies. The evidences include the ‘Seville Strategy on BRs’ developed in 1995, the “Madrid Action Plan of 2008”, the ‘Dresden Declaration’ adopted by UNESCO in 2011, and ‘EU Biodiversity Strategy for 2020’, etc.

With such implications of international activities, some researches were done on the strategy for the conservation of domestic or international protected areas such as national park, biodiversity site, and World Natural Heritage sites, etc. They cover a specific sector such as biodiversity in protected areas or multi sectors. However, even though international protected area (IPA) including biosphere reserve (BR) is more vulnerable to climate change, the establishment and implementation of IPA-specific or BR-specific strategies against climate change is quite rare.

However, even though IPAs including biosphere reserve are more vulnerable to climate change, the research on the BR-specific or IPA-specific strategy responding to climate change is quite rare. There are only few researches focusing on the conservation of biodiversity in relation to climate change in a specific BR site.

In such a context, this research aimed at establishing the strategies responding to climate change on island and coastal BRs. The significance and necessity to conduct this research are: 1) Original ecological and geological quality should be conserved in that the original quality of BR contributes to mitigating climate change through their ecological services; 2) BR-specific strategy should be established and implemented in that BRs are more vulnerable to climate change; 3) Without implementation of BR-specific strategy, the original ecosystem of BR could not be conserved, and sustainable use could not be achieved; 4) The establishment of a BR-based strategy will enhance awareness and capacity building at a local level as well as benefiting from the already existing engagement and motivation from local stakeholders towards the implementation of effective adaptation measures.

In order to achieve the objectives, this research first reviewed the existing mitigation and adaptation measures at a general level, with a purpose to draw significant measures applicable to the establishment of island and coastal BR-specific mitigation and adaptation strategies, and was followed by the review of protection strategies of protected areas for drawing a more direct useful guide than the information to be drawn from the review of the existing mitigation and adaptation measures against climate change. And finally establishment of strategy against climate change on island and coastal biosphere reserves in terms of ecological, social and economic vulnerability.

The strategies were established, focusing on adaptation. This is because mitigation is a measure for applying to the entire regional, national and global level rather than BR alone. However, this research also examined mitigation as the strategy, including energy, waste management, forest management, key ecosystems protection as carbon sink, etc.

1. Summary

1.1: Reviewing the Existing Mitigation and Adaptation Measures against Climate Change

The Difference in the Concept of Strategy, Policy and Measure

There are some terminologies in relation to the response to climate change. The examples include climate change strategy, climate change policy and climate change measure. Their concepts and implications are different with a close relation when they are applied to climate change.

Strategy: Strategy is a method or plan chosen to bring a desired future such as an achievement of a goal or a solution to a problem. In this sense, strategy is about means being mobilized to attain ends, but not with their specification. Strategy is concerned with how we will achieve our aims, not with what those aims are or ought to be, or how they are established. If strategy has any meaning at all, it is only in relation to a few aims or an end in view.

Policy and Measure: Policy is defined as an action plan projecting the practice of value being set up as a goal in strategy. In this sense, policy is a sub-concept of strategy. A variety of policies can be set up for implementing a strategy. Meanwhile, measure is defined as a way of achieving a goal set up or a method for dealing with a situation. Thus, explained above, measure is equivalent to the means of policy being defined as the instrument being mobilized to achieve the goal set up.

The Relation among Strategy, Policy and Measure: As reviewed above, strategy, policy and measure are independent concepts, but their conceptual implications are rather interrelated as below. Strategy is a genetic concept, while policy is a specific concept. The former is a concept including sub-concepts, while the latter is a concept being included in a super-concept. Meanwhile, measure is a specific concept of policy. Applying such a hierarchically conceptual position of the three to climate change, climate change strategy is the guiding instrument of climate change policy, both in the medium and long-term, to face the impacts of climate change and to transition towards a competitive, sustainable low-carbon emission economy. Climate change policy is an instrument being mobilized to achieve climate change strategy. Meanwhile, measure is a means being mobilized to achieve the goal of climate change policy. In this sense, mitigation/adaptation is neither strategy nor policy, but a measure being mobilized as a means for achieving the goal of climate change policy as a component of climate change strategy.

The Position of Mitigation and Adaptation Measure as a Means of Climate Change Policy

Mitigation: Mitigation is applied to human activity as the source of greenhouse gas emission and aims at eliminating the cause of climate change or reducing greenhouse gas emission. In other words, mitigation is defined as the reduction of adverse impact of climate change on nature and human society caused by human-induced greenhouse gas emission.

Even though a wide variety of mitigation options are available, they can be classified into four categories – Low-Carbon measure, Carbon-Neutral measure, Carbon-Zero (or Carbon-Free) measure and Climate Neutrality.

Low-Carbon is generally used to describe forward-looking national economic development plans or strategies that encompass, focusing on low-emission and/or climate-resilient economic growth without setting up the absolute level of reduction. Carbon-Neutral implies removing as much carbon from the atmosphere as we put in to achieve net zero carbon emission by balancing a measured amount of carbon released with an equivalent amount sequestered or offset. Carbon-Zero is based on the conversion to run on zero carbon emitting energies, no more carbon emissions being added to the atmosphere or natural carbon balance that existed before industrialization. Actual carbon-zero is not possible. This implies that true carbon zero is (virtual zero carbon) + (some negative carbon). Climate Neutrality means living in a way which produces no net greenhouse emissions, implying net change to atmosphere zero ton. There is no “one-size-fits-all” approach to being climate neutral.

There are a variety of societal sectors and technologies of mitigation measures as a re-structuration of the existing societal system in a way to reduce and/or avoiding greenhouse gas emission. However, the important key societal sectors and technologies include energy supply, transport, building, industry, agriculture, forest, and waste management. The societal sectors are the targets of mitigation measures, and technologies are the efficient instruments mitigation of measures mobilizing to achieve their goals.

Adaptation: Adaptation is applied to vulnerability to climate change for reducing human losses from climate change and living together with changing and changed climate through the management of climate risk to an acceptable level.

Like mitigation measures, adaptation measures also have a wide variety of options in terms of timing, goals and motives of their implementation. However, the review of the existing adaptation measures at a regional, national and global level reveals that they can be classified into these categories – Anticipatory vs. Reactive Adaptation, Autonomous vs. Planned Adaptation, and Private vs. Public Adaptation.

Anticipatory Adaptation is the adaptation that takes place before climate change impacts are observed while Reactive Adaptation is the adaptation that takes place after climate change impacts have been observed. As a general rule, adaptation measures should give priority to anticipatory actions reducing future risk. Autonomous Adaptation is the adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Meanwhile, Planned Adaptation is the adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state. It is proposed that Autonomous Adaptation forms the baseline against which the need for planned anticipatory adaptation can be evaluated. Private Adaptation is the adaptation that is initiated and implemented by individuals, households or private companies. Public Adaptation is the adaptation that is initiated and implemented by governments at all levels. Public adaptation is usually directed at collective needs while Private Adaptation is usually in the actor's rational self-interest.

There are a variety of societal sectors and technologies of adaptation measures. However, the important key targets are water, agriculture, infrastructure, human health, tourism, transport, and energy, etc.

The Relationship between Mitigation and Adaptation Measure

Relationship as Complementarities: Mitigation and adaptation are conceptually and realistically different in terms of their target and goal, etc. However, they are in inter-relationship as complementarities as below.

Mitigation is an action that has consequences for adaptation. Mitigation efforts can foster adaptive capacity while the implications of adaptation can be both positive and negative for mitigation. Synergies can increase the cost-effectiveness of adaptation and mitigation. However, it is not yet possible to say whether or not adaptation buys time for mitigation. Social and economic development enhances capacity to adapt and mitigate. Trading-off adaptation and mitigation is not a zero-sum game.

Integrated Response to Climate Change: The integrated response of mitigation and adaptation measure to climate change produces trade-offs and synergies as below.

Integration of adaptation and mitigation into planning and decision-making can create synergies with sustainable development. Effective integrated responses depend on suitable tools and governance structures, as well as adequate capacity. Great potential exists for creating synergies between mitigation and adaptation and implementing climate policy options in a more cost-effective way.

Relationship in terms of the Task of Measure: The relationship between mitigation and adaptation in terms of the task of measure can be classified into four categories.

Firstly, activities simultaneously serve the purposes of both mitigation and adaptation. Secondly, tactics such as reducing vehicle miles traveled serve the purpose of mitigation but neither help nor hurt adaptation. Thirdly, adaptation tactics such as improved storm warning systems neither help nor hurt mitigation. Fourthly, mitigation measures undermine adaptation efforts. Fifthly, adaptation measures undermine mitigation.

1.2: Reviewing Protection Strategies of Protected Areas

Protected Areas (PAs) have been recognized as a part of the solution for climate change. Protected areas play a key role in both mitigation (sequestering carbon dioxide from the atmosphere and preventing the loss of carbon present in vegetation and soils), and adaption to climate change (preserving ecosystem integrity to reduce risks from extreme climatic events and maintain essential ecosystem services). On another hand, PAs are real tools to fight against climatic change because they are a large permanent and global structure that managers have on field, with governance and safeguard on the areas (with defined borders, management plans, equipment and staff experienced in implementing local approaches involving people operate under legal frameworks), which allow to increase the effectiveness of the performances, as well as monitoring, verification and reporting.

Main Climate Change Strategies for Protected Areas

The IUCN and other institutions like UNEP have emphasized that strategies to mitigate and adapt to climate change of protected areas should be carried out according to the principles of :

o The important role that ecosystem-based approaches and nature-based solutions.

o Maintains the highest possible level of environmental integrity.

o Restoration of degraded habitats and landscapes, but not just to a previous state, but for future conditions.

o Use of indigenous knowledge for planning and management of ecosystems (Community based adaptation, CBA).

o Promote connectivity of protected areas.

o Increase the Coverage of protected areas (Expanding the existing coverage of PAs consistent with Aichi Biodiversity Targets 11 and 15).

The main goal of PAs for mitigation of climate change is to maintain ecosystem capacities to store and capture carbon. This means to maintain in good state of conservation of how much surface of natural habitats (both land and sea) for reducing greenhouse gas emissions from deforestation and land degradation. If protected areas include humanized areas (such as in many Biosphere Reserves), we should add additional possible actions related to our way of life to reduce carbon emissions:

o Energy efficiency (including transportation)

o Increase renewable energy

o Improve waste management

Moreover, the approaches for adaptation performances in PAs could include:

o Reduce non-climatic stressors

o Prioritize the protection of intact and connected ecosystems

o Identify and protect climate refuges

o Conserve ecological features

o Preserve and enhance connectivity

o Sustain or restore ecosystem process

o Improve representation, redundancy and replication

o Assist colonization

On another hand, the main tools to address the fight against climate change in PAs are

Networking: It is a very useful tool for protected areas, not only for mitigation and adaptation to climate change, also for a more effectiveness management of PAs.

Planning, but manage for change: Proper design of planning is essential for the success for adaptation and mitigation of climate change, but it must take into account that environmental characteristics in the future will be different from the current. Therefore, planning must be based on the assumption of change.

Climate Vulnerability Assessment**,** taking into account the three main components: exposure, sensitivity and adaptive capacity. According to these components, it is necessary to know which species and ecosystems are most vulnerable and why and where they are vulnerable.

Given that the diversity of ecosystems is enormous, these general principles should be concretized in specific actions for each of the major biomes: Forest areas, wetlands and peatlands, salt marshes, mangroves and seagrass beds, natural meadows, etc.

In the same way, best practices should be applied for planning and managing the PAs for disaster risk reductions: typhoons and hurricanes, flooding, sea level rise, drought, desertification and dust storms, wildfires, etc.

Protected Areas International Level

(1) Biosphere Reserves

Biosphere reserves are very particular protected areas because many of them include humanized areas. Because of this uniqueness, adaptation and~~,~~ especially, mitigation strategies have to be wider than in classical protected areas, because it must include lifestyle of the human population living inside the reserve~~,~~. For example, they should include the use of energy and waste management. On another hand, adaptation strategies should include both the vulnerability of ecosystem services (particularly water and natural resources supply, and protection against natural disasters), and the possibility that the RBs are places that welcome climate refugees.

(2) World Heritage Sites

Many declared WH sites include biosphere reserves or national parks, so mitigation strategies and adaptation have many things in common with these others protected areas. However, the WH sites differ from biosphere reserves because the emphasis is on conservation of a valuable heritage rather than on models of human development. For this reason, in WH sites the emphasis is on adaptation strategies.

(3) Ramsar Sites

The RAMSAR Convention specifically protects those wetlands included in the Convention. These areas also are protected at a national level and its main objective is the conservation of biodiversity. However, as many other PAs, wetlands provide many other services to humanity. Wetlands supply many resources, including fresh water, and often act as a physical protection against extreme weather events. RAMSAR has highlighted the vulnerability of these APs to climate change (sea level rise, increased severe storms, droughts, etc.), and the need to carry out a proper vulnerability assessment before to any plan or performance for mitigation or adaptation.

1.3: Strategy on Ecological Vulnerability

Habitat loss and fragmentation, overexploitation, pollution, the impact of invasive alien species and, increasingly, climate change all threaten global biodiversity. Global warming will affect all species and exacerbate the other environmental stresses already being experienced by ecosystems. Protecting forests and other natural ecosystems can provide social, economic, and environmental benefits.

The legacy of past changes to biodiversity sets the initial conditions for the world biodiversity. The overarching goal remains to minimize the loss of biodiversity through strategies addressed to ecosystems, its biodiversity, communities of fauna and flora and finally at the species level.

Strategy on Ecosystems

Possible strategies that will enable ecosystems to become resilient to climate changes are as follows:

- o Maintain well-functioning ecosystems
- o Protect a representative array of ecological systems

o Remove or minimize existing stressors

o Manage appropriate connectivity of species, landscapes, seascapes and ecosystem processes

o Eco-engineering may be needed to assist the transformation of some communities under climate change

o Increase the extent of Protected Areas

o Improve representation and replication within Protected-Area Networks

o Improve management and restoration of existing Protected Areas to facilitate resilience

o Manage and restore ecosystem functions rather than focusing on specific components (species or assemblages)

o Evaluate and enhance monitoring programs for wildlife and ecosystems

Strategy on Biodiversity

Based on the principles and approaches to effectively conserve biodiversity, the following strategies will cope with climate change and appear to be most relevant to the direct management of species and ecosystems which are the main components of biodiversity.

o Apply a risk management approach to deal with uncertainties about climate change

o Minimize threats and seize opportunities

o Manage invasive alien species

o Develop dynamic landscape conservation plans

o Review and modify existing laws, regulations, and policies regarding wildlife and natural resource management

o Education and communication to bring the public along with change

Strategy on Communities of Fauna and Flora

Strategies to assist communities to adapt to climate change are ‘Develop dynamic landscape conservation plans, Deal with uncertainties: ecological resilience and transformation, Bridge ecological knowledge gaps and research, Ensure wildlife and biodiversity needs are considered as part of the broader societal adaptation process’.

Strategy on Species

It seems that climate change will have the most detrimental impact at the species level. This will eventually mean that species should be targeted and conserved holistically through different strategies.

o Design new natural areas and restoration sites to maximize resilience
o Protect movement corridors, stepping stones, and refugia
o Improve the matrix by increasing landscape permeability to species movement
o Focus conservation resources on species that might become extinct
o Translocate species at risk of extinction
o Establish captive populations of species that would otherwise go extinct
o Reduce pressures on species from sources other than climate change
o Incorporate predicted climate-change impacts into species and land-management plans, programs and activities
o Genetic preservation must be considered in some cases

1.4: Strategy on Social Vulnerability

Social Vulnerability and Climate Change

Social vulnerability in relation with climate change impacts is the result of a complex combination and interaction of different factors such as the existing natural, environmental and geographical conditions of each site as well as the socio-economic structure, dynamics and capacity to cope and adapt to natural and human induced impacts. Small Islands and Coastal areas are particularly vulnerable to climate change impacts.

How to Access Social Vulnerability to Climate Change

Assessing social vulnerability to climate change implies three main factors: a) exposure, b) sensitivity and, c) adaptive capacity. Together, these three areas determine the level of vulnerability to climate change impacts. Therefore, social vulnerability to climate change can be measured by combining measurements of these three components and considering different scales (individuals and/or communities).

Several methods can be used to compile information (qualitative and quantitative) and assess the exposure such as existing vulnerability assessments, expert opinions, models or observational data.

Assessing social sensitivity to climate change relates with the degree of dependence that individuals or communities have on the ecosystem goods and services that are affected by climate change related impacts.

Biosphere Reserves and Community Resilience through Adaptation Strategies

There are four step approaches for building resilience. They are vulnerability assessment, identification of resilience-building strategies, prioritizing resilience efforts, and implementation of resilience-building strategies. In relation to these steps, Biosphere Reserves need always consider Community-based Adaptation and Ecosystem-based Adaptation, thus, facilitating a broader and integrated approach.

The foundations for the development of an integrated adaptation to climate change oriented towards the reduction of social vulnerability and, at the same time enhancing ecosystem conservation should consider the role of both the natural and hard infrastructures and not just the later as it happens in most cases.

1.5: Strategy on Economic Strategy

Agriculture

Agriculture adaptation strategies should provide measures and solutions to cope with short-term events and, at the same time, ensure that these actions will not undermine the capacity to deal with expected major changes despite under a high level of uncertainty. While basic infrastructure investments improving efficiency on water and soil use and management may be feasible without the need to change traditional ways of farming, it is advisable to introduce complementary measures such as new varieties that are more resistant to the expected temperature, soil composition, salinity and other physical and chemical conditions.

Depending on the specific conditions (geographical, dimension, social, economic, etc.), there are different options and ways to promote and implement adaptation to climate change in agriculture systems. Some of the most common are introducing new varieties/species better adapted to the existing and predicted conditions, enhancing water collection and management through climate smart infrastructures and conservation agriculture, optimizing timing and/or location of cropping activities, ensuring sounding and effective pest and disease management, diversifying income by integrating agriculture with other activities. However, adaptation outputs are not a linear positive process as it implies a combination of a complex combination of factors from which, long term impacts may be hidden by immediate positive results of single actions that will have different results in a long term perspective.

Agriculture itself is a source of greenhouse gas emission. This implies that it is necessary to establish a strategy to reduce greenhouse gas emission from agricultural activities in BR. Broadly, mitigation from agriculture can result from three types of interventions. The types of interventions consist of reducing the emissions intensity along the entire agricultural supply chain, including avoided land use change driven by agriculture, sequestering additional carbon in agricultural systems, and reducing overall agricultural production (e.g., by reducing food loss and waste or demand for biofuels) or shifting away from high-carbon intensity agricultural products such as meat from ruminants.

Tourism

Specific adaptation measures on tourism sector must be combined with land planning in order to minimize impacts but also to ensure feasibility of tourism activities. Moving from bed-based to activity-based tourism is a good option not only as a way to create more and diversified job opportunities, to increase the offer of activities and to improve tourism experience but also as it requires a global approach on how to manage natural resources, including biodiversity. Part of any adaptation strategy to explore tourism as an alternative to support community development should be supported by knowledge and information. If well designed and implemented, tourism can be a driver of adaptation strategies in biosphere reserves due to the direct and indirect links that tourism promotes between different socioeconomic sectors.

On the other hand, tourism is a contributor to and a victim of climate change. This is termed as the paradox of tourism. In order to overcome the paradox, tourism in biosphere reserve should establish mitigation strategies for reducing greenhouse gas emitted in the process of operating own tourism resort. The mitigation strategy can be implied by the ecotourism-based operation for all tourism resources being used. In other words, biosphere reserve tourism resort operators should develop their own strategies to minimize greenhouse gas emissions in the process of operating their tourism resorts, and adopting the following strategies.

- o Developing a manual to reduce greenhouse gas emission on the basis of calculating greenhouse gas emission by sectors in the process of operating tourism resort.
- o Establishing the system of energy and resource circulation through saving resources and energy, improving the efficiency of resources and energy, introducing new and renewable energy, and reducing emission of pollutant and waste discharge, etc.

o Providing visitors with environmental education program for leading them to environmentally friendly behaviors during their tour in the tourism resort.

Fishery Industry

The scope of causes impacting on marine BR is much wider than that of the scope of causes on terrestrial BR in terms of the actor contributing to climate change, the source boundary where the impact is originated, and the unclear boundary of the activity of fishes between marine BR and non-marine BR. Such special situations imply that the establishment of adaptation and mitigation strategy on fishery industry should be based not on marine BR-specific, but on general marine fishery industry, and priority should be given to adaptation when the strategy is focused on marine BR-specific one.

Adaptation from the fishery sector can be part of a well designed plan or can be the whole set of individual actions that are undertaken by individuals and communities addressing climate change related events or trends. Individual adaptation actions may be changing the timing or locations of fishing as species arrive earlier/later or shift to new areas.

There are a vast diversity of measures, scales (geographic and temporal) and resources (financial, administrative, human) implied on fisheries adaptation that should be considered during the process of selecting adaptation priorities and measures and combined with cost-benefit and time-scale analysis.

However, for fisheries, in small island and coastal Biosphere Reserves, it is highly improbable to ensure access to capacity and resources that would support the establishment of long term adaptation strategies. Instead, Biosphere Reserves should explore and benefit from integrated approaches promoting sectoral contribution such as the reinforcement of conservation through the core zones as these areas have already local and/or national legal status.

However, legal and political instruments at national and international level are also necessary to prevent contradiction and conflicts between the well addressed local actions and the external trading and management frameworks. Knowledge, information, capacitation and monitoring are also key elements for adaptation that should be combined under integrated wide adaptation-planning frameworks and strategies that in their turn should cope with climate change models and local specific environmental and socioeconomic conditions.

2. Conclusion

According to the geographical boundary of impact, environmental problems are classified into two categories – local and global. The former is defined as the impacts of environmental problems are around the region where pollution is emitted, while the latter is defined as regardless of region where pollutions are emitted, the environmental impact is global. The former includes soil pollution and water pollution, etc. The latter are climate change, acid rain, and ozone depletion, etc.

Global environmental problems are more serious than local issues in terms of its impact on nature and human society, and it is known that climate change impacts are most serious on nature and human society. This is the reason why climate change is placed as priority for environmental problems as if it is the representative of environmental problems. Another scientifically found fact is that internationally protected areas are more sensitive to climate change than other terrestrial and marine areas.

Considering the above scientific facts, how to respond to climate change is the most important strategy for conserving biosphere reserve as an internationally protected area and its sustainable use.

A wide range of climate change adaptation and mitigation have been established at a global, national and/or local level. However, they should be specific by target of strategy establishment. This principle should be applied more strictly to BRs despite BRs have some common profiles of nature and socio-economy, each BR has more unique profiles than common ones.

As this attempted research is to establish strategies responding to climate change on island and coastal biosphere reserves as a common unit in terms of nature and socio-economy, adaptation should be more of a BR-specific strategy than mitigation. This is because mitigation strategy being established by region where BR is located can become a BR, but adaptation strategy should be based on sectors in BR itself. Therefore, the following are the most efficient, effective and desirable approaches to the development of concrete measures to be launched for implementing climate change mitigation and adaptation strategies on BR which were proposed in this report.

Mitigation Measure: As mentioned above, the mitigation strategy being established for an entire region by national and/or local government is applied to BR. And as this research proposed in Chapter 7, mitigation strategy on BR alone should focus on the reduction of greenhouse gas emission from the operation of socio-economic activity in BR. The development of concrete measures for realizing the mitigation strategy requires, at least, three phases as below (IPCC, 1996; Han et al., 2011: 102-103; DECC, 2012; Jeong et al., 2016).

1st Phase (Preparing greenhouse gas inventory by sector of socio-economic activity): This enables to estimate not only total quantity of greenhouse gas emission, but also the quantity by sector.

2nd Phase (Setting up the goal of reduction): A large amount of finance is required for reducing greenhouse gas emission. How much reduction depends on the availability of its own finance. Based on the availability of finance, the total goal of reduction should be set up, and then the total goal of reduction should be allocated by sector of greenhouse gas emission identified from greenhouse gas inventory in the 1st Phase.

3rd Phase (Establishing reduction method): There are a lot of applicable methods of reducing greenhouse gas emission. The examples are reduction of energy use, the improvement of energy efficiency, carbon capture and carbon sequestration, etc. However, efficient and/or effective method is different by sector for reduction. Therefore, different reduction methods should be selected by sector.

Adaptation Measure: Adaptation should be a more BR-specific strategy than mitigation. As explained in Chapter 3, it is desirable to establish adaptation strategy by sector in BR. The sectors to be adapted to climate change in BR would be different in terms of their vulnerability and the state of being impacted from climate change. This implies that whether to launch anticipatory, reactive, autonomous, planned, private and/or public adaptation should be based on the vulnerability and the state of impact of each sector. Based on the selection of adaptation strategy of each sector, the most efficient, effective, and low-cost measures should be launched.

An additional important factor to consider in the process of following the above phases is how to improve adaptation capacity. The reason for this is that mitigation strategy being launched by national and/or local government at a regional level is more fundamental for BRs than the reduction of greenhouse gas emitted by the socio-economic activity in BRs, but the effectiveness and success of adaptation depends more on BR-specific strategy than the strategy being launched by national and/or local government at a regional level. This is the ground for improving adaptation capacity so that all BRs would have the full ability to achieve the planned adaptations successfully.

The concept of adaptation capacity, kinds of adaptation capacity, and the strategy to improve adaptation capacity are as below (Jeong et al, 2016). These would be applicable not only on island and coastal BRs, but also to BRs all over the world.

The Concept of Adaptation Capacity: Adaptation capacity can be defined as the ability to plan, facilitate, and implement measures to adapt to climate change. Factors that determine adaptation capacity may include level of economic wealth and well-being, availability of appropriate technology, extent of information and skills, provision of sufficient infrastructure, effectiveness of institutions, political stability, cultural cohesiveness and social equity.

Such an adaptation capacity has the potential or capacity for a system to adjust, via changes in its characteristics or behavior, so it can cope better with existing climate variability, or with changes in variability and mean climate conditions.

Kinds of Adaptation Capacity: There are two kinds of adaptation capacity. They are genetic and specific capacity. The former is applied to the capacity for a wide range of responses to many different risks, while the latter is applied to the capacity for adaptation solely or primarily to climate change and variability.

In more detail, genetic capacity refers to availability of finance and technology, governance, effectiveness, equity, and social cohesion, etc. Specific capacity refers to budget allocation for adaptation by sector, availability of meteorologists/climate scientists/forecasters., availability of human resources such as environmentalist/climate economist/policy analyst, adaptation technology by sector, and climate education and awareness, etc.

The genetic and specific capacity require both scientific and management capacity. The former is for understanding of, at least, earth sciences and social and management science. Meanwhile the latter is for adaptation policy and measures.

Strategy to Improve Adaptation Capacity: This refers to the choice of adaptation measures. There are two available choices. One is theoretical range of choice, and the other is practical range of choice. The former is all the different methods for adapting that have been used, plus any new methods that can be created. Meanwhile, the latter are choices which are not blocked by constraints.

There are some important factors to be considered in the process of selecting the choices. In other words, the following factors should be considered in the selection of choices to be launched as measures of adaptation. They are what blocks specific choices, cost, technical capacity, spatial linkages, social/ cultural/ legal acceptability, political considerations, and vested interests, etc.

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