Hungarian University of Agriculture and Life Sciences

LOCAL ECONOMIC DEVELOPMENT POLICIES TO ADAPT CLIMATE CHANGE HAZARDS IN EGYPT

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KEY TERM DEFINITIONS

Adaptation is anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage they can cause or taking advantage of opportunities that may arise. It has been shown that well planned, early adaptation action saves money and lives later.

Adaptive Capacity is the ability or capacity of a system to successfully respond to climate variability and change.

Climate Change Risk a risk facing business and governmental entities resulting from climate change and affecting natural and human systems; in dealing with this loss exposure focuses on reducing the vulnerability associated with climate risk by incorporating climate-sensitive decision-making in the risk management process. The risk manager takes climate-related decisions or actions that make sense in overall business strategy terms, whether or not a specific climate threat actually materializes in the future.

Exposure is biophysical impacts of climate change that can vary in magnitude, frequency and duration.

Mitigation is consisting of actions to limit global warming and its related effects, which generally involves reductions in human emissions of greenhouse gases (GHGs).

Resilience can be generally defined as the capacity for a socio-ecological system to: (1) absorb stresses and maintain function in the face of external stresses imposed upon it by climate change, and (2) adapt, reorganize, and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future climate change impacts.

Sensitivity is the degree to which climate variability or change is negatively or positively affecting a system.

Vulnerability refers to the degree to which people or the things they value are susceptible to, or are unable to cope with, the adverse impacts of climate change. There are three dimensions of vulnerability to climate change: exposure, sensitivity, and adaptive capacity.

LIST OF ACRONYMS

BCI	Business Competitiveness Indicator
CAPAS	City Adaptation Programmes of Action
DELTA	The Dynamic Ecological-Land Tenure Analysis
ECR	Egyptian Competitiveness Report
ECCAI	Egyptian Climate Change Adaptation Index
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GHGs	Greenhouse Gases
GOPP	General Organization of Physical Planning
IBRD	International Bank for Reconstruction and Development
ICMA	International Capital Market Association
LAPAs	Local Adaptation Programmes for Action
LDCs	Least Development Countries
LED	Local Economic Development
LPC	Local Popular Council
MENA	Middle East and Northern Africa
MoLD	Ministry of Local Development
MoPIC	Ministry of Planning and International Co-operation
NAPAs	National Adaptation Programmes of Action
NCPSLU	National Centre for Planning State Lands Usage
PRA	Participatory Rural Appraisal
RDA	Regional Development Agencies
RDPs	Regional Development Policies
SCPUD	Supreme Council for Planning and Urban Development
SDGs	Sustainable Development Goals
SIDS	Small Island Developing States
TDE	The throughfall displacement experiment
UN	United Nation
UNFCCC	UN Framework Convention on Climate Change

1. INTRODUCTION

1.1. Background of the study

Climate change as an additional stress is threatening habitats, ecosystems and land globally. The effects of climate change are projected to have adverse effects on developing countries and Egypt in not an exception. Additional to the current global situations concerning the impacts of long-term climate variability and extreme weather events, continued heatwaves and increasing sea level rise are dominating across Egypt. The Paris Agreement (2015) (UNITED NATIONS, 2015) delineates the importance of greenhouse gases (GHGs) emissions mitigation and adaptation measures, which should be officially implemented by 2020. Egypt is among the pioneer countries that ratified the accord in its preliminary stages. This was a significant milestone in committing towards combating climate change across the country. Despite, Africa being rated the least among the continents contributing to the atmospheric pollution, it continues to be responsible for the least global emissions (estimated at 4%). Although they contributed to anthropogenic emission slightly, Egypt and the rest of the continent are highly vulnerable to the impacts of long-term climate variability and extreme weather events. Increased water shortages, changing rainfall patterns, sea level rise, desertification and frequent heatwaves are some of the challenges associated with climate change presently being experienced across Egypt putting the countries development path at risk.

Developing countries are the most vulnerable to climate change impacts because they have fewer resources to adapt socially, technologically and financially. Climate change is anticipated to have far reaching effects on the sustainable development path of these countries, including their ability to attain the United Nations Sustainable Development Goals (SDGs) by 2030 (UNITED NATIONS, 2016). Many developing countries' governments have given adaptation action a high, even urgent, priority. Consequently, those countries need international assistance to support adaptation in the context of national planning for sustainable development, more capacity-building and transfer of technology and funds. Systematic planning and capacity-building are also needed to reduce the risk of disasters and raise the resilience of communities to increasing extreme events such as droughts, floods and tropical cyclones. Funding for adaptation in developing countries must be sufficient and sustained. Least Developed Countries (LDCs) and Small Island Developing States (SIDS) need special consideration due to their extreme vulnerability.

Likewise, developing countries have very different individual circumstances and the specific impacts of climate change on a country depending on the climate, it experiences as well as its geographical, social, cultural, economic, and political situations. As a result, countries require diverse adaptation measures depending on individual circumstances. However, there are

crosscutting issues which apply across countries and regions. The same sectors are affected by climate change, albeit to differing degrees. These main sectors include agriculture, water resources, human health, terrestrial ecosystems and biodiversity and coastal zones.

Likely to trigger species migration and lead to habitat reduction. Up to 50% of Africa's total biodiversity is at risk due to reduced habitat and other human-induced pressures (MOHAMMED, 2020). Therefore, it is important to research initiating some policy notes; recommendations investigate proper environment policies to mitigate the degree of hazard in different regions of natural hazards.

Regional Development Policies (RDPs) target all regions (urban, rural and undeveloped areas) and cities in order to support job creation, business competitiveness, economic growth, sustainable development, and improve citizens' quality of life. This can be seen as a general effort to reduce regional disparities by supporting (employment and wealth-generating) economic activities in the regions. Previously, regional development policies tended to try to achieve these objectives by means of large-scale infrastructural development through increased inward investment. Awareness of the need for a new approach is driven by the observation that past policies have failed to reduce regional disparities significantly and have not been able to help individual lagging regions to catch up, despite the allocation of significant public funding. The result is under-used economic potential and weakened social cohesion. Also, it is reflected in the country competitive dynamic regions aiming to achieve their economic, social and environmental objectives. RDPs complement national macroeconomic and structural policies. In this context, the regional outputs aim at helping countries get regions and cities "right" through the adaptation of policies to the specificities of where people live and work thus improving their well-being.

Local economic development (LED) offers local government, the private and not-for-profit sectors, and local communities the opportunity to work together to improve the local economy. It focuses on enhancing competitiveness, increasing sustainable growth and ensuring that growth is inclusive. LED encompasses a range of disciplines including physical planning, economics and marketing. It also incorporates many local government and private sector functions including environmental planning, business development, infrastructure provision, real estate development and finance (IBRD, 2016).

1.2. Statement of the Problem

Considering the vulnerability of climate change hazards and its massive contribution to the socio-economic development of many nations including Egypt. The research tries to provide some applicable proactive policies which can deal with one of the most difficult problems in the future by developing countries in general and for Egypt in practice. The problem concerns the threats

that climate change might have to developing countries' development potentials and natural resources. The research aims to utilize the **spatial map for LED policies and projects for providing adaptation, monitor and control the risk level for climate change hazards in Egypt**.

1.3. Relevance of the topic

- Climate change continues to compound stress to already threatened habitats, ecosystems and land uses in all over the world.
- The current global situations concerning the impacts of long-term climate variability and extreme weather events.
- Many of the investments to achieve SDGs will take place at the sub national level and be led by local authorities.
- LED offers local government, the private and not-profit sectors, and local communities the opportunity to work together to improve the local economy.

2. OBJECTIVES OF THE RESEARCH

2.1. Research objectives

The main objective of this dissertation aims at **inventing a LED policies and projects for providing an adaptation framework and allocating them spatially,** this has the ability to monitor and deals with the climate change on the regional level.

Sub-objectives:

- Defining the relation between the LED policies and the climate change hazards.
- Studying the applicability of the LED policies on the climate change hazard and regional development.
- Studying international case studies dealing with climate change adaptation.
- Testing the efficiency of the policies within the limitation of the Egyptian context.

2.2. Research hypotheses

Hypotheses 1: The application of LED is more likely to be the most appropriate approach to adapt climate change.

Hypotheses 2: Applying LED is not the only proper answer to climate change but also to improve solving the social-economic problem and sustainable development.

Hypotheses 3: There is likelihood that Egypt has no LED policies currently applicable to combat climate change hazards.

Hypotheses 4: There is a higher likelihood that Egyptian institutional/ governmental systems have not been ready for handling the complexity of climate change hazards.

2.3. Research Questions

Based on the above-mentioned, the main research question is:

Why the local economic development is the best approach to achieve the development across regions while adapting climate change hazards?

Sub-questions:

- What are the kinds and types of climate change hazards experienced Egypt?
- What are the local economic development policies that provide the regional competitiveness?
- How to develop the LED process to achieve a real development in the regions?
- How conceived policies can deal with the regional and territorial development planning of the Egyptian contexts?

2.4. Structure of the dissertation

To achieve the above-mentioned objective, this research is divided into:

Part I: Introduction

This part defines the importance of the topic, problems to solve.

Part II: Objectives to achieve

This part defines and explains the research problem, questions, hypothesis, and their search methodology to investigate and test the hypothesis, the research data, and the research techniques.

Part III: Literature Review

This section elaborates on the necessary background of the research, which helps to develop the theoretical background of the research, based on an intensive literature review of the local economic development and the climate change hazards in Developing Countries. It is organised in five Chapters as follows:

Chapter 3.1: This chapter explores and defines the kinds and types of climate change hazardous in global context. In addition to the theories and scenarios plus the sustainable development aspects.

Chapter 3.2: This chapter explores and defines the kinds and types of climate change hazardous in Egypt.

Chapter 3.3: This chapter defines the Local Economic Development at all levels from the supranational level till municipality level. In addition to the policies and strategies with introductory and preliminary theoretical reviews aims to study and define the relation between the local economic development and the climate change hazards.

Part IV: Material and Methods

This part offers an intensive discussion on the materials and methods that were used to collect and analyse data on the effects of climatic hazards on LED. The discussion covers the research design of the study area, methods employed to collect data and analyse the data for this research. It discussed the data collection technique, instrument design, data analysis and limitations of the study.

Part V: Findings, Discussion (Analytical and Practical Applications)

This part covers the research analytical and practical studies, comprising several fields-studies and correlation of analytical studies that aims to examine the research problem based on the research argument and theory, and focus on covering and discussing the research findings.

Chapter 5.1: This chapter is discussing different cases studies for tackling and adapting the climate change hazards from diverse perspectives connected to the physical situation (urban areas, rural communities, land use and land cover changes).

Chapter 5.2: This chapter examine the Egyptian Climate Change Adaption Index (ECCAI) on the governorate level, according to vulnerability and readiness scores.

Chapter 5.3: This chapter illustrate the Egyptian strategic planning framework with the recommended edits to adopt the climate change.

Chapter 5.4: This chapter is related to testing the hypnotises.

Part VI: Conclusion and Recommendations

Chapter 6: This chapter presents the conclusion and recommendations.

Part VII: New scientific findings

Part VIII: Summary.

Part IX: References and Bibliography.

3. THEORETICAL FUNDAMENTALS

3.1. Global climate change hazards

3.1.1. Theory

Much more evidence has accumulated over past years to indicate that changes in many physical and biological systems are linked to climate change and global warming. There are four sets of evidence which, taken together, support this conclusion:

1. The Working Group I Fourth Assessment concluded that most of the observed increase in the globally averaged temperature since the mid-20th century is very likely due to the observed increase in GHGs emissions concentrations. (IPCC, 2007) and The IPCC is currently preparing its Sixth Assessment Report (AR6) Working Group II contribution on impacts, adaptation and vulnerability are expected to be available by October 2021 (IGNACIUK & CHIT TUN, 2019).
2. Of the more than 29,000 observational data series,7 from 75 studies, that show significant change in many physical and biological systems, more than 89% are consistent with the direction of change expected as a response to warming (Figure 2) (IPCC, 2007).
3. The global studies in this Assessment strongly found that the spatial agreement between regions of significant warming across the globe and the locations of significant observed changes in many systems consistent with warming is very unlikely to be due solely to natural variability of temperatures or natural variability of the systems (Figure 2).
4. Finally, there have been several modelling studies (simple models: energy balance models, intermediate complexity models, and general circulation models) that have linked responses in some physical and biological systems to climate change and global warming by comparing observed responses in these systems with modelled responses in which the natural forces (solar activity and volcanoes) and anthropogenic forces (greenhouse gases and aerosols) are explicitly separated. Models with combined natural and climate change forces simulate observed responses significantly better than models with natural forcing only (OLESEN, et al., 2017).

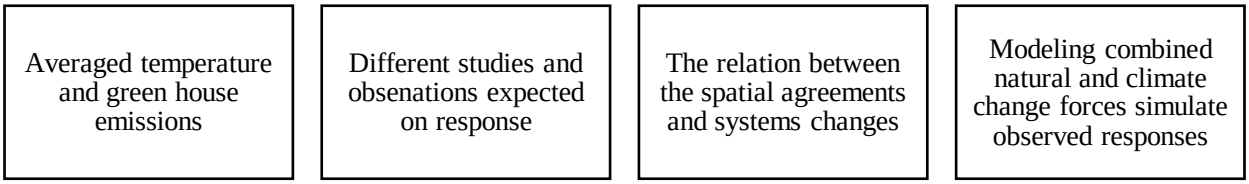


Figure 1: Climate change main evidence

Source: The author's edition based on (IPCC) 2007

Limitations and gaps prevent more complete attribution of the causes of observed system responses to anthropogenic warming. **First**, the available analyses are limited in the number of

systems and locations considered. **Second**, natural temperature variability is larger at the regional than at the global scale, thus affecting identification of changes due to external forcing. **Finally**, at the regional scale other factors (such as land-use change, pollution, and invasive species) are rapidly changing.

Nevertheless, the consistency between observed and modelled changes in several studies and the spatial agreement between significant regional warming and consistent impacts at the global scale is sufficient to conclude with high confidence that anthropogenic warming over the last three decades has had a discernible influence on many physical and biological systems.

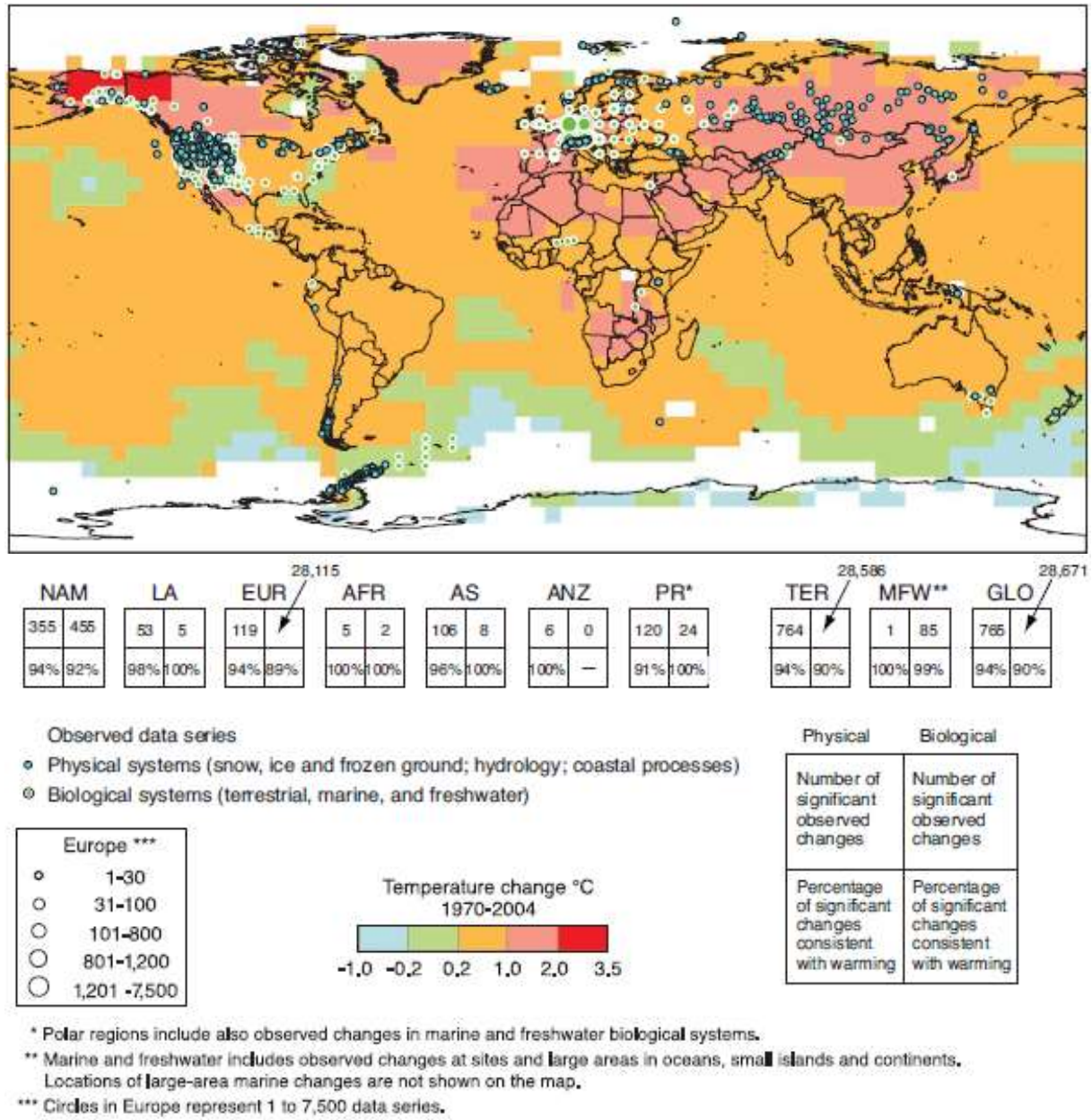


Figure 2: Climate change observation data

Source: (IPCC, 2007)

Other effects of regional climate changes on natural and human environments are emerging, although many are difficult to recognize due to adaptation and non-climatic drivers.

Effects of temperature increases have been documented in the following (medium confidence):

- Effects on **agricultural and forestry management** at Northern Hemisphere higher latitudes, such as earlier spring planting of crops, and alterations in disturbance regimes of forests due to fires and pests.
- Some aspects of **human health**, such as heat-related mortality in Europe, infectious disease vectors in some areas, and allergenic pollen in Northern Hemisphere high and midlatitudes.
- Some **human activities** in the Arctic (e.g., hunting and travel over snow and ice) and in lower-elevation alpine areas (such as mountain sports).

Recent climate changes and climate variations are beginning to have effects on many other natural and human systems. However, based on the published literature, the impacts have not yet become established trends. Examples include:

- **Settlements in mountain regions** are at enhanced risk of glacier lake outburst floods caused by melting glaciers. Governmental institutions in some places have begun to respond by building dams and drainage works.
- **In the Sahelian region of Africa**, warmer and drier conditions have led to a reduced length of growing season with detrimental effects on crops. In southern Africa, longer dry seasons and more uncertain rainfall are prompting adaptation measures.
- **Sea-level rise and human development** are together contributing to losses of coastal wetlands and mangroves and increasing damage from coastal flooding in many areas.

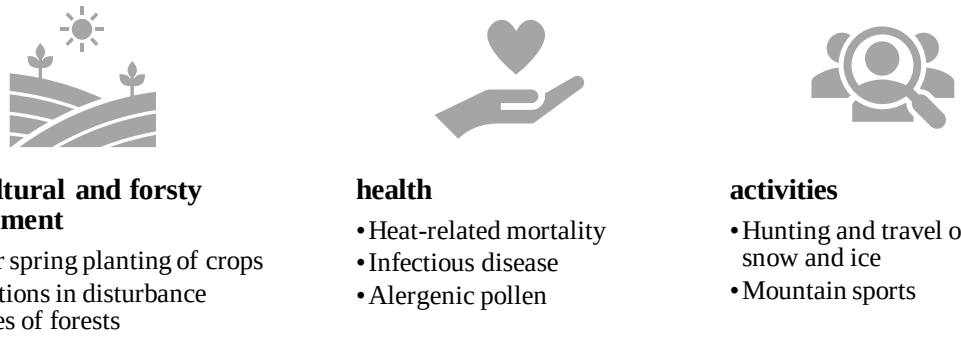


Figure 3: Climate effects on natural and human system (medium confidence) on sectors

Source: The author's edition

3.1.1.1. Different parameters and the major sectors

Below are key findings regarding projected impacts, as well on vulnerability and adaptation, in each system, sector and region for the range of (unmitigated) climate changes projected by the IPCC over this century[1] judged to be relevant for people and the environment[2]. The impacts frequently reflect projected changes in precipitation and other climate variables in addition to temperature, sea level and concentrations of atmospheric carbon dioxide. The magnitude and timing of impacts will vary with the amount and timing of climate change and, in some cases, the capacity to adapt. These issues are discussed further in later sections of the summary.

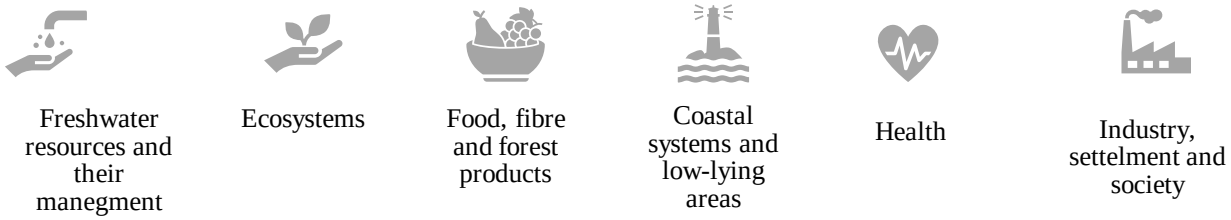


Figure 4: Major sectors

Source: The author's edition

a. Freshwater resources and their management

By mid-century, annual average river runoff and water availability are projected to increase by 10-40% at high latitudes and in some wet tropical areas and decrease by 10-30% over some dry regions at mid-latitudes and in the dry tropics, some of which are presently water-stressed areas. In some places and in particular seasons, changes differ from these annual figures.

- Drought-affected areas will likely increase in extent. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk.
- In the course of the century, water supplies stored in glaciers and snow cover are projected to decline, reducing water availability in regions supplied by meltwater from major mountain ranges, where more than one-sixth of the world population currently lives.
- Adaptation procedures and risk management practices for the water sector are being developed in some countries and regions that have recognized predicted hydrologic changes with uncertainties.

[1] Temperature changes are expressed as the difference from the period 1980-1999. To express the change relative to the period 1850-1899, add 0.5°C.

[2] Criteria of choice: magnitude and timing of impact, confidence in the assessment, representative coverage of the system, sector and region.

b. Ecosystems

The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification), and other global change drivers (e.g., land use change, pollution, over-exploitation of resources).

- Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change.
- Approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C. For increases in global average temperature exceeding 1.5-2.5°C and in concomitant atmospheric carbon dioxide concentrations, there are projected to be major changes in ecosystem structure and function, species' ecological interactions, and species' geographical ranges, with predominantly negative consequences for biodiversity, and ecosystem goods and services e.g., water and food supply.
- The progressive acidification of oceans due to increasing atmospheric carbon dioxide is expected to have negative impacts on marine shell-forming organisms (corals) and their dependent species.

c. Food, fibre and forest products

Crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1-3°C depending on the crop, and then decrease beyond that in some regions.

- At lower latitudes, particularly in dry and tropical seasonal areas, crop productivity is expected to decline, even if local temperatures rise slightly (1-2°C), increasing the risk of hunger.
- Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease.
- Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes.
- Adaptations such as altered cultivars and planting times allow low- and mid- to high-latitude cereal yields to be maintained at or above baseline yields for modest warming.
- Globally, commercial timber productivity rises modestly with climate change in the short- to medium-term, with large regional variability around the global trend.
- Regional changes in the distribution and production of particular fish species are expected due to continued warming, with adverse effects projected for aquaculture and fisheries.

d. Coastal systems and low-lying areas

Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise. The effect will be exacerbated by increasing human-induced pressures on coastal areas.

- Corals are vulnerable to thermal stress and have low adaptive capacity. Increases in sea surface temperature of about 1-3°C are projected to result in more frequent coral bleaching events and widespread mortality unless there is thermal adaptation or acclimatisation by corals.
- Coastal wetlands, including salt marshes and mangroves, are expected to be adversely affected by rising sea levels, particularly when constrained on their land side or deprived of sediments.
- Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. Those densely populated and low-lying areas where adaptive capacity is relatively low, and which already face other challenges such as tropical storms or local coastal subsidence, are especially at risk. The numbers affected will be largest in the mega-deltas of Asia and Africa while small islands are especially vulnerable.
- Adaptation for coasts will be more challenging in developing countries than in developed countries, due to constraints on adaptive capacity.

e. Industry, settlement, and society

Costs and benefits of climate change for industry, settlement and society will vary widely by location and scale. In the aggregate, however, net effects will tend to be more negative the larger the change in climate.

- The most vulnerable industries, settlements and societies, those are in coastal and river flood plains, those whose economies are closely linked with climate-sensitive resources, and those in areas prone to extreme weather events, especially where rapid urbanization is occurring.
- Poor communities can be highly vulnerable especially those concentrated in high-risk areas. They tend to have more limited adaptive capacities and are more dependent on climate-sensitive resources such as local water and food supplies.
- Where extreme weather events become more intense and/or more frequent, the economic and social costs of those events will increase, with these increases being substantially experienced in the areas most directly affected. Climate change impacts spread from directly impacted areas and sectors to other areas and sectors through extensive and complex linkages.

f. Health

Projected climate change-related exposures are likely to affect the health status of millions of people, particularly those with low adaptive capacity, through:

- Increases in malnutrition and consequent disorders, with implications for child growth and development.
- Increased deaths, disease and injury due to heatwaves, floods, storms, fires and droughts.
- The increased burden of diarrhoea disease.
- The increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change.
- The altered spatial distribution of some infectious disease vectors.

Climate change is expected to have some mixed effects, such as a decrease or increase in the range and transmission potential of malaria in Africa.

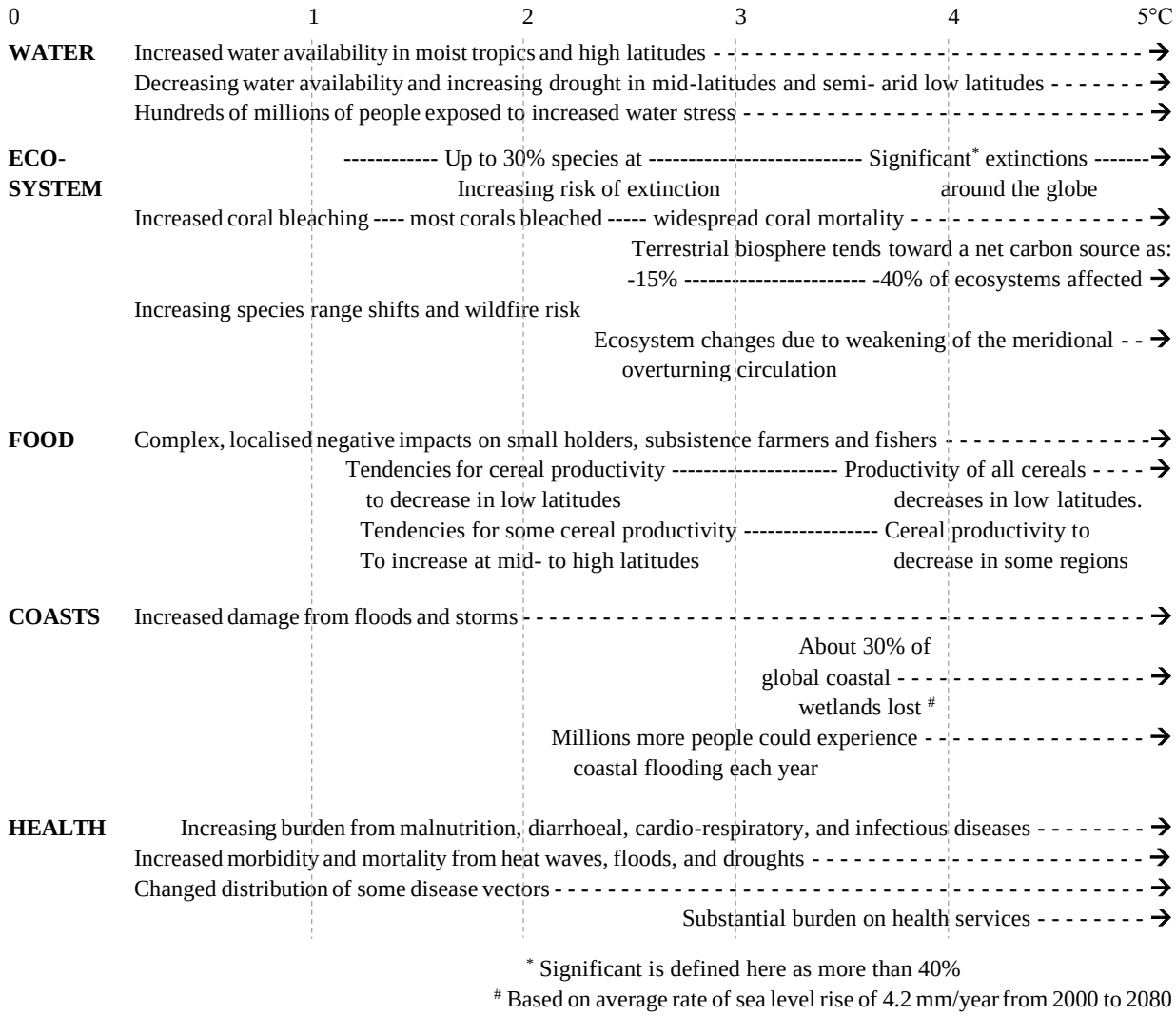
Studies in temperate areas have shown that climate change is projected to bring some benefits, such as fewer deaths from cold exposure. Overall, it is expected that these benefits will be outweighed by the negative health effects of rising temperatures worldwide, especially in developing countries.

The balance of positive and negative health impacts will vary from one location to another and will alter over time as temperatures continue to rise. Critically important will be factors that directly shape the health of populations such as education, health care, public health initiatives and infrastructure and economic development (IPCC, 2007).

3.1.2. Scenarios, Key impacts as a function of increasing global average temperature change.

Impacts will vary by extent of adaptation, rate of temperature change, and socio-economic pathways. Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century. The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of the text indicates the approximate onset of a given impact. Quantitative entries for water stress and flooding represent the additional impacts of climate change relative to the conditions projected across the range of Special Report on Emissions Scenarios (SRES) scenarios A1FI, A2, B1 and B2. Adaptation to climate change is not included in these estimations. All entries are from published studies recorded in the chapters of the Assessment with high level of confidence.

Table 1: Global mean annual temperature changes relative 1980-1999



Source: (IPCC, 2007)

The Purpose of Climate Scenarios is a plausible representation of future climate that has been constructed for explicit use in investigating the potential impacts of anthropogenic climate change. Climate scenarios often make use of climate projections (descriptions of the modelled response of the climate system to scenarios of greenhouse gas and aerosol concentrations), by manipulating model outputs and combining them with observed climate data.

Examples of possible impacts of climate change due to changes in extreme weather and climate events, based on projections to the mid- to late 21st century. These do not take into account any changes or developments in adaptive capacity. Examples of all entries are to be found in chapters in the full Assessment. The first two columns of the table (shaded light grey) are taken directly from the Working Group I Fourth Assessment. The likelihood estimates in Column 2 relate to the phenomena listed in Column 1.

Table 2: Major projected impacts by sector

Phenomenon and direction of trend	Likelihood of future trends based on projections for 21st century using SRES scenarios	Examples of major projected impacts by sector			
		Agriculture, forestry, and ecosystems	Water resources	Human health	Industry, settlement, and society
Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	Virtually certain [3]	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water resources relying on snow melt; effects on some water supplies	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells/ heat waves. Frequency increases over most land areas	Very likely	Reduced yields in warmer regions due to heat stress; increased danger of wildfire	Increased water demand; water quality problems, e.g., algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially isolated	Reduction in quality of life for people in warm areas without appropriate housing; impacts on the elderly, very young and poor
Heavy precipitation events. Frequency increases over most areas	Very likely	Damage to crops; soil erosion, inability to cultivate land due to waterlogging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries and infectious, respiratory and skin diseases	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures; loss of property
Area affected by drought increases	Likely	Land degradation; lower yields/ crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water and food borne diseases	Water shortages for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Intense tropical cyclone activity increases	Likely	Damage to crops; windthrow (uprooting)of trees; damage to coral reefs	Power outages causing disruption of public water supply	Increased risk of deaths, injuries, water and food borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; withdrawal of risk coverage in vulnerable areas by private insurers, potential for population migration, loss of property
Increased incidence of extreme high sea level (excludes tsunamis)[4]	Likely[5]	Solarisation of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risk of deaths and injuries by drawing in floods; migration-related health effects	Coasts of coastal protection versus coasts of land-use relocation; potential for movement of populations and infrastructure; also see tropical cyclones above

Source: (IPCC, 2007)

On the new IPCC assesses methods used to develop climate scenarios. Impact assessments have a very wide range of scenario requirements, ranging from global mean estimates of temperature and

[3] Warming of the most extreme days and nights each year.
[4] Extreme high sea level depends on average sea level and on regional weather systems. It is defined as the highest 1%of hourly values of observed sea level at a station for a given reference period.
[5] In all scenarios, the projected global average sea level at 2100 is higher than in the reference period. The effect of changes in regional weather systems on sea level extremes has not been assessed.

sea level, through continental-scale descriptions of changes in mean monthly climate, to point or catchment-level detail about future changes in daily or even sub daily climate.
The science of climate scenario development acts as an important bridge from the climate science of WGI to the science of impact, adaptation and vulnerability assessment, considered by WGII. It also has a close dependence on emissions scenarios, which are discussed by WGIII.

3.1.1.2. Climate change responses

- Some adaptation is occurring now, to observed and projected future climate change, but on a limited basis.
- Adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions.
- A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to future climate change. There are barriers, limits and costs, but these are not fully understood.
- Vulnerability to climate change can be exacerbated by the presence of other stresses.
- Future vulnerability depends not only on climate change but also on development pathway.
- Sustainable development[6] can reduce vulnerability to climate change, and climate change could impede nations' abilities to achieve sustainable development pathways.
- Many impacts can be avoided, reduced or delayed by mitigation.
- A portfolio of adaptation measures can reduce the risks associated with climate change.

3.1.3. Possible Measures on the African Impacts and Vulnerabilities to Climate Change

Climate change is dramatically affecting weather patterns in many areas. Evidence indicates that it has increased globally since 1970[7]. Countries that had previously been unaffected by cyclonic events, such as Grenada, have suffered catastrophic damage as the geographic range of hurricane activity has expanded. For the SIDS as a group, there has been a noticeable increase in the number of reported natural disasters over the past several decades.
One issue requiring urgent attention in the small island developing states is the impact of global warming on existing freshwater sources. In many coral atoll countries, freshwater is available from groundwater lenses that are dependent on rainfall and are extremely fragile. More frequent or longer-lasting droughts can reduce the availability of water. Similarly, with stronger and more

[6] The Brundtland Commission definition of sustainable development is used in this Assessment: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The same definition was used by the IPCC Working Group II Third Assessment and Third Assessment Synthesis Report.
[7] Category 4 and 5 storms

frequent storms occurring, the lenses can become contaminated with seawater, compromising water quality.

Africa is extremely vulnerable to the impact of climate change. Projected changes in precipitation will exacerbate an already stressed situation; extreme poverty and other major development challenges seriously limit the continent's adaptive capacity. Global warming in this region will primarily affect water resources, agriculture and food security, natural resource management and biodiversity, and human health. Many parts of Africa are already experiencing a major deficit in food production, and if soil moisture declines, as predicted, the situation will worsen. Food-insecure countries are more likely to be adversely affected by climate change.

Table 3: African Impacts and Vulnerabilities to Climate Change

Impacts	Sectoral vulnerabilities	Adaptive Capacity
Temperature – Higher warming (x1.5) throughout the continent and in all seasons compared with global average. – Drier subtropical regions may become warmer than the moister tropics. **Precipitation** – Decrease in annual rainfall in much of Mediterranean Africa and the Northern Sahara, with a greater likelihood of decreasing rainfall as the Mediterranean coast is approached. – Decrease in rainfall in Southern Africa in much of the winter rainfall region and western margins. – Increase in annual mean rainfall in East Africa. – Increase in rainfall in the dry Sahel may be counteracted through evaporation. **Extreme Events** – Increase in frequency and intensity of extreme events, including droughts and floods, as well as events occurring in new areas.	**Water** – Increasing water stress for many countries. – 75–220 million people faced more severe water shortages by 2100. **Agriculture and food security** – Agricultural production severely compromised due to loss of land, shorter growing seasons, more uncertainty about what and when to plant. – Worsening of food insecurity and increase in the number of people at risk from hunger. – Yields from rain-fed crops are threatening in some countries. Net revenues from crops could fall by 90% by 2100. – Already compromised fish stocks depleted further by rising water temperatures. **Health** – Alteration of spatial and temporal transmission of disease vectors, including malaria, dengue fever, cholera, etc. **Terrestrial Ecosystems** – Drying and desertification in many areas particularly the Sahel and Southern Africa. – Deforestation and forest fires. – Degradation of grasslands. – 25–40% of animal species in national parks in sub-Saharan Africa expected to become endangered. **Coastal Zones** – Threat of inundation along coasts in Eastern Africa and coastal deltas, such as the Nile delta and in many major cities due to sea level rise, coastal erosion and extreme events. – Degradation of marine ecosystems including coral reefs off the East African coast. – Cost of adaptation to sea level rise could amount to at least 5–10% GDP.	Africa has a low adaptive capacity to both climate variability and climate change exacerbated by existing developmental challenges including: – Low GDP per capital – Widespread, endemic poverty weak institutions – Low levels of education – Low levels of primary health care – Little consideration of women and gender balance in policy planning – Limited access to capital, including markets, infrastructure and technology – Ecosystem's degradation – Complex disasters conflicts

Source: (IPCC, 2007)

3.1.4. Methods and policies

Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases (very high confidence). A global assessment of data since 1970 has shown it is likely that anthropogenic warming has had a discernible influence on many physical and biological systems.

The IPCC Working Group II Third Assessment found evidence that recent regional climate changes, particularly temperature increases, have already affected physical and biological systems. The Fourth Assessment has analysed studies since the Third Assessment showing changes in physical, biological and human systems, mainly from 1970 to 2005, in relation to climate drivers, and has found stronger quantitative evidence. The major focus is on global and regional surface temperature increases.

Evaluation of evidence on observed changes related to climate change is made difficult because the observed responses of systems and sectors are influenced by many other factors. Non climatic drivers can influence systems and sectors directly and/or indirectly through their effects on climate variables such as reflected solar radiation and evaporation. Socioeconomic processes, including land-use change (e.g., agriculture to urban area), land-cover modification (e.g., ecosystem degradation), technological change, pollution, and invasive species constitute some of the important non-climate drivers.

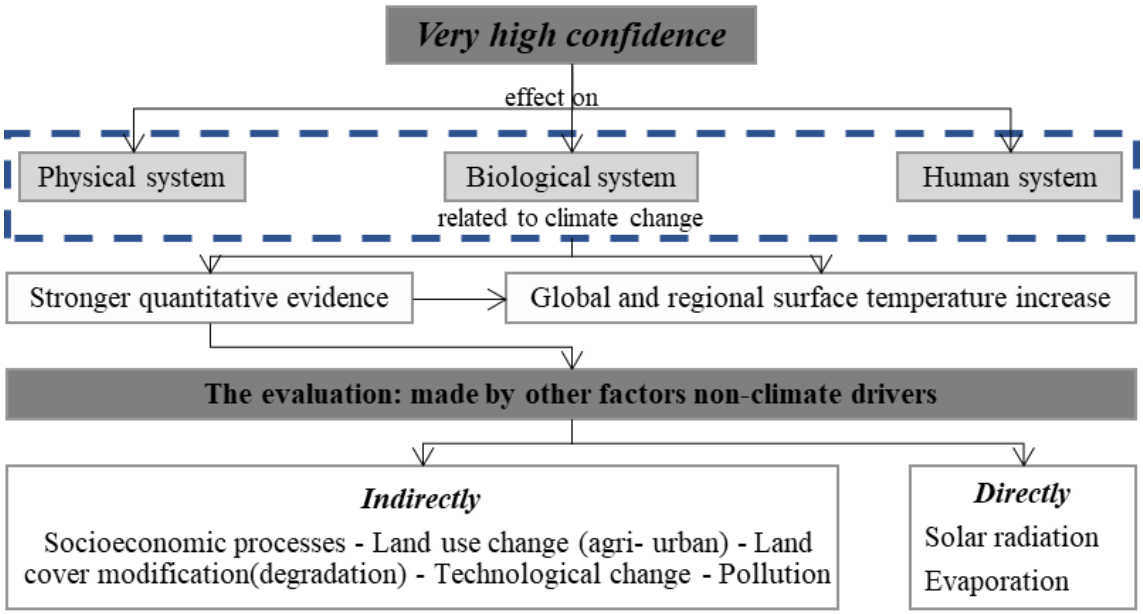


Figure 5: Evaluation of evidence on observed changes related to climate change.

Source: The author's edition

Much more evidence has accumulated over the past decades to indicate that the effects described above are linked to the anthropogenic component of warming. There are three sets of evidence which, taken together, support this conclusion.

1. There have been several studies that have linked responses in some physical and biological systems to the anthropogenic component of warming by comparing observed trends with modelled trends in which the natural and anthropogenic forces are explicitly separated.
2. Observed changes in many physical and biological systems are consistent with a warming world. The majority (>89% of the >29,000 data sets) of changes in these systems have been in the direction expected as a response to warming.
3. A global synthesis of studies strongly demonstrates that the spatial agreement between regions of significant regional warming across the globe and the locations of significant observed changes in many systems consistent with warming is very unlikely to be due solely to natural variability of temperatures or natural variability of the systems.

For physical systems: (i) climate change is affecting natural and human systems in regions of snow, ice and frozen ground, and (ii) there is now evidence of effects on hydrology and water resources, coastal zones and oceans.

- The main evidence from regions of snow, ice and frozen ground is found in ground instability in permafrost regions, and rock avalanches; decrease in travel days of vehicles over frozen roads in the Arctic; increase and enlargement of glacial lakes, and destabilisation of moraines damming these lakes, with increased risk of outburst floods; changes in Arctic and Antarctic Peninsula ecosystems, including sea-ice biomes and predators high on the food chain; and limitations on mountain sports in lower-elevation alpine areas (high confidence).
- These changes parallel the abundant evidence that Arctic sea ice, freshwater ice, ice shelves, the Greenland ice sheet, alpine and Antarctic Peninsula glaciers and ice caps, snow cover and permafrost are undergoing enhanced melting in response to global warming (very high confidence).
- Recent evidence in hydrology and water resources shows that spring peak discharge is occurring earlier in rivers affected by snow melt, and there is evidence for enhanced glacial melt in the tropical Andes and in the Alps. Lakes and rivers around the world are warming, with effects on thermal structure and water quality (high confidence).
- Sea-level rise and human development are together contributing to losses of coastal wetlands and mangroves and increasing damage from coastal flooding in many areas (medium confidence).

There is more evidence, from a wider range of species and communities in terrestrial ecosystems than reported in the Third Assessment, that recent warming is already strongly affecting natural biological systems. There is substantial new evidence relating changes in marine

and freshwater systems to warming. The evidence suggests that both terrestrial and marine biological systems are now being strongly influenced by observed recent warming.

- The overwhelming majority of studies of regional climate effects on terrestrial species reveal consistent responses to warming trends, including poleward and elevational range shifts of flora and fauna. Responses of terrestrial species to warming across the Northern Hemisphere are well documented by changes in the timing of growth stages (i.e., phenological changes), especially the earlier onset of spring events, migration, and lengthening of the growing season. Based on satellite observations since the early 1980s, there have been trends in many regions towards earlier 'greening' of vegetation in the spring and increased net primary production linked to longer growing seasons. Changes in abundance of certain species, including limited evidence of a few local disappearances, and changes in community composition over the last few decades have been attributed to climate change (very high confidence).
- Many observed changes in phenology and distribution of marine and freshwater species have been associated with rising water temperatures, as well as other climate-driven changes in ice cover, salinity, oxygen levels and circulation. There have been poleward shifts in ranges and changes in algal, plankton and fish abundance in high-latitude oceans. For example, plankton has moved pole wards by 10° latitude (about 1,000 km) over a period of four decades in the North Atlantic. There have also been documented increases in algal and zooplankton abundance in high-latitude and high-altitude lakes, and earlier fish migration and range changes in rivers. While there is increasing evidence for climate change impacts on coral reefs, differentiating the impacts of climate-related stresses from other stresses (e.g., over-fishing and pollution) is difficult. The uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic, with an average decrease in pH of 0.1 units. However, the effects of observed ocean acidification on the marine biosphere are yet undocumented. Warming of lakes and rivers is affecting abundance and productivity, community composition, phenology and the distribution and migration of freshwater species (high confidence).

Effects of regional increases in temperature on some managed and human systems are emerging, although these are more difficult to recognize than those in natural systems, due to adaptation and non-climatic drivers.

- Effects have been detected in agricultural and forestry systems. Changes in several aspects of the human health system have been related to recent warming. Adaptation to recent warming is beginning to be systematically documented (medium confidence).

- In comparison with other factors, recent warming has been of limited consequence in the agriculture and forestry sectors. A significant advance in phenology, however, has been observed for agriculture and forestry in large parts of the Northern Hemisphere, with limited responses in crop management such as earlier spring planting in northern higher latitudes. The lengthening of the growing season has contributed to an observed increase in forest productivity in many regions, while warmer and drier conditions are partly responsible for reduced forest productivity and increased forest fires in North America and the Mediterranean Basin. Both agriculture and forestry have shown vulnerability to recent trends in heatwaves, droughts and floods (medium confidence).
- While there have been few studies of observed health effects related to recent warming, an increase in high temperature extremes has been associated with excess mortality in Europe, which has prompted adaptation measures. There is emerging evidence of changes in the distribution of some human disease vectors in parts of Europe and Africa. Earlier onset and increases in the seasonal production of allergenic pollen have occurred in mid- and high latitudes in the Northern Hemisphere (medium confidence) (EEA , 2017).
- Changes in socio-economic activities and modes of human response to climate change, including warming, are just beginning to be systematically documented. In regions of snow, ice and frozen ground, responses by indigenous groups relate to changes in the migration patterns, health, and range of animals and plants on which they depend for their livelihood and cultural identity. Responses vary by community and are dictated by particular histories, perceptions of change and range, and the viability of options available to groups (medium confidence).

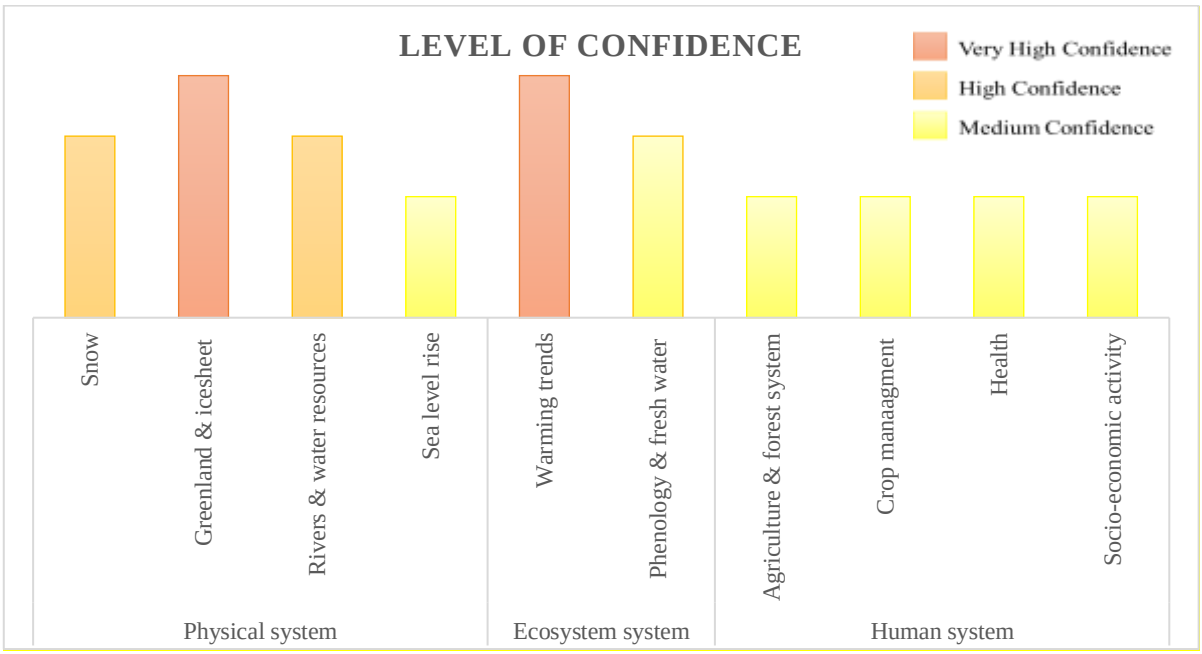


Figure 6: Climate change affecting level of confidence.

Source: The author's edition

3.1.5. Sustainable Development aspect for adapting and mitigating concepts.

When climate change is acknowledged as a key issue within the wider sustainable development context, it becomes imperative that incentives be provided for sustained economic growth along pathways that not only enhance capabilities and options among people and societies but also facilitate a major, or even total, shift away from carbon fuel use as well as the strengthening of adaptive capacities in developing countries.

Addressing climate change requires effective and sustained collaboration between industrialized and developing countries. Currently, about half of the world's carbon emissions comes from industrialized countries, where 20% of the global population is responsible for about 80% of overall economic output. The remaining half comes from developing countries, which account for the vast majority (80%) of the global population but generate only one fifth of GDP. Emissions of CO_2 far exceeds the earth's absorptive capacity, which is estimated at about 5 billion metric tons of carbon dioxide equivalent (CO_2 e) per year. Annual global fossil fuel emissions of CO_2 alone are now over 27 billion metric tons. Over the next century, the emissions of all countries have to be reduced by 80 to 95%, depending on the group as well as the target selected, if global warming is to be contained at 2˚ C. Neither developed nor developing countries can resolve this crisis by themselves; the emissions of both groups must be radically curtailed.

Given the requirements outlined above, the most constructive response would be to set up a global infrastructure investment programme that sent the appropriate market signals to the private sector and levelled the playing field for alternative energy technologies so that targets could be achieved, and adaptation facilitated.

Mitigation costs are expected to total around 1-2% of global economic output (estimated at US$ 80 trillion in 2018). Actual outlays will depend on a number of factors, including reduction targets and time frames. It should be emphasized that climate change will continue under most of the scenarios considered, though more slowly than would otherwise be the case; consequently, adaptation measures are also required.

3.1.1.3. The need for Mitigation in achieving sustainable development.

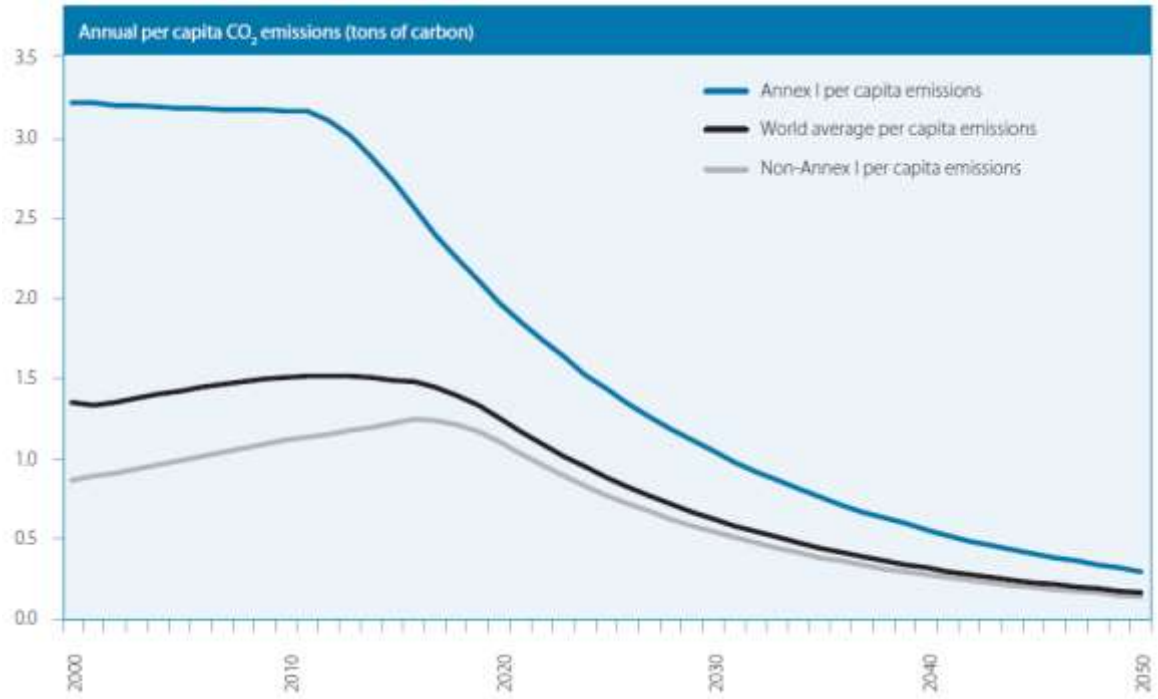
Achieving the aims reflected in the international sustainable development agenda, including the SDGs, will be impossible unless carbon emissions are drastically reduced. Key factors to consider in a sustainable development approach to mitigation include (1) equitable emission targets, (2) energy transition, (3) the impact of consumption patterns in other countries, (4) forestry and land use, (5) mitigation regimes, and (6) investment approaches to mitigation.

a. Equitable emission targets

The concentration of GHGs in the atmosphere is currently 379 parts per million (ppm) CO_2 e, compared with 280 ppm before the Industrial Revolution. Factored into CO_2 e calculations are estimated levels of CO_2 and other GHGs, with the latter accounting for about 23% of the climate change potential.

It is not enough to slow down or even halt the increase in emissions; GHG concentrations must be reduced to a fraction of what they are today in both developed and developing countries. This represents an unprecedented challenge—one that will require drastic changes in the way the world operates.

The Bali Action Plan recognizes "that deep cuts in global emissions will be required to achieve the ultimate objective" of the United Nations Framework Convention on Climate Change and emphasizes the urgency of the situation. However, no specific targets or time frames for reducing emissions beyond 2012 have yet been established.



[8]

Figure 7: Per capita emissions from fossil fuel combustion, 2000-2050

Source: (BAER, et al., 2008)

Global emission reduction targets will need to be regionally differentiated. Existing proposals that, for example, call for a 50% reduction in 1990 emissions by the year 2050 may require developed countries to shoulder 70% of the burden, which implies total emission cuts of 30% for developing

[8] Note: Among industrialized countries and economies in transition (Annex I Parties to the United Nations Framework Convention on Climate Change), the figure for 2050 indicates as 90% decline in 1990 emission levels.

countries. However, because the population in developing countries is expected to double during the period 1990-2050, such cuts would amount to per capita reductions in developing countries close to those suggested for developed countries. Clearly, this does not reflect the principle of differentiated responsibilities. Larger reductions, which are necessary to ensure that emissions are stabilized at a level that will prevent the global temperature from rising by more than 2˚ C, would leave developing countries with very little room to manoeuvre in terms of increasing their consumption of energy from traditional sources (see figure 7). In any case, significant cuts in developing countries would pose a major challenge given the need to reconcile mitigation efforts with the necessary growth in energy consumption.

b. Energy transition

The energy sector is enormously important within the present context, as it is responsible for over three quarters of total GHG emissions but is also inextricably linked to economic activity and the fulfilment of human needs.

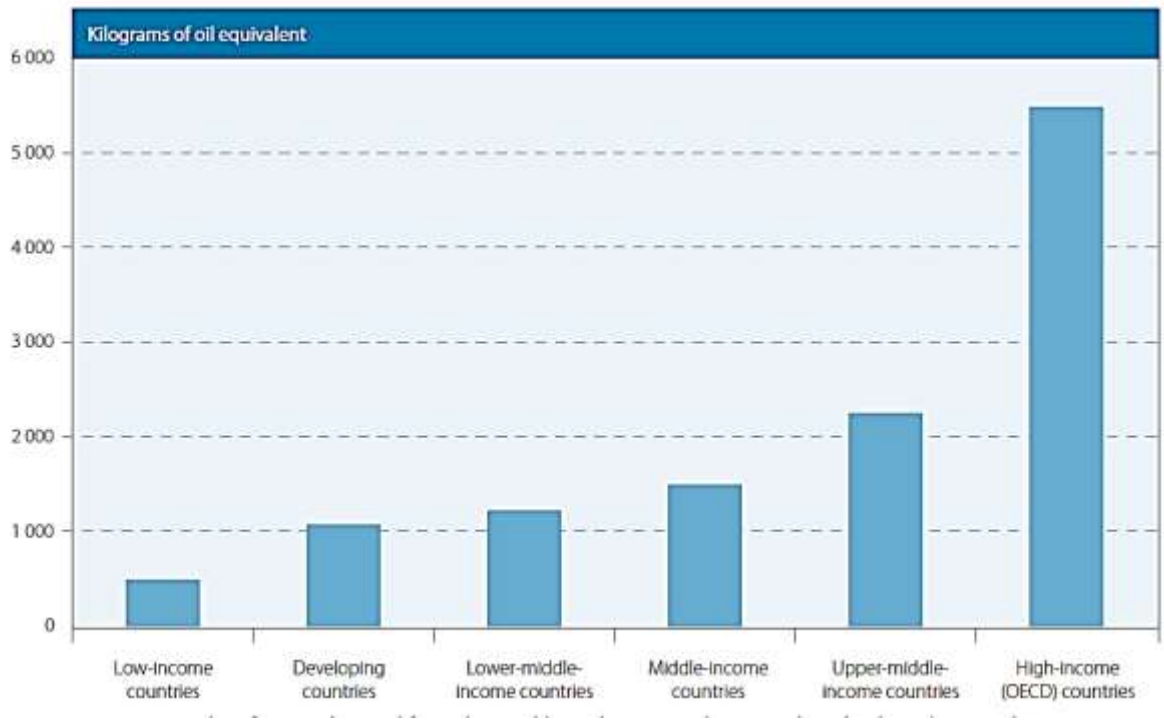


Figure 8: Energy use per capita, 2005.

Source: (BAER, et al., 2008)

Access to energy is distributed very unevenly both within and between countries. As mentioned previously, per capita energy consumption in developing countries averages less than a fifth of that in industrialized countries (see figure 8). A key element of the sustainable development agenda is the enhancement of energy availability in the longer run.

Per capita energy consumption in the developing world is expected to increase fourfold to sixfold over the next century. In its Reference Scenario, the International Energy Agency (IEA) projects that the world's primary energy needs will rise by 55% between 2005 and 2030, growing at an average rate of 1.8% a year. It is predicted that around US$ 22 trillion will have to be invested in the supply infrastructure to meet global energy demand by the end of this period. This can be compared with gross world product of about US$ 48 trillion in 2006 and official development assistance totalling US$ 104 billion in 2007. The Agency maintains that "mobilizing all this investment will be challenging".

c. Consumption and emission targets

In determining equitable reduction targets to achieve sustainable development, one important question relates to the attribution of liability for production-related environmental pressures (including climate change).

Consumption follows production in its various stages, but production and consumption take place in different locations. Using a product life-cycle approach, the environmental repercussions of producing various goods (such as GHG emissions) will need to be incorporated in the calculations of environmental pressures related to the consumption of these goods. Such assessments will have a bearing on the calculation of equitable targets.

In a globalizing world with rapidly expanding trade flows, it is likely that the economic structure of countries will continue to change and evolve. Developed countries will become increasingly service-oriented, shifting away from high-emission industries such as iron, steel, aluminium, chemical, glass, and paper production. "Outsourcing" the production of fossil-fuel-intense, high-emission goods to developing countries has been occurring for some time. However, once developed countries enact provisions that require these industries to pay a price for their carbon emissions, disputes could arise between producers in developed countries and those in developing countries, with the former claiming that the latter have an unfair advantage in not having to pay for their emissions.

d. Forestry and land use

Land use and deforestation are responsible for roughly a quarter of global greenhouse gas emissions. The inclusion of emissions resulting from land use conversion makes for a very different ranking of countries according to their overall emissions. Land use conversion to allow the production of other crops or the introduction of larger-scale production systems (such as plantations) can result in increased employment and income. However, this often involves trade-offs in terms of the rights and socio-economic prospects of local communities that made their living from the

previous land use patterns. One issue with particular relevance to sustainable development is the large-scale shift in land use towards the production of biomass for fuel generation, as evidence suggests that there may be significant trade-offs related to food security and food prices. Issues such as these highlight the importance of using an integrated approach to address challenges linked to climate change.

e. Mitigation regime: combining different options.

The three main, though not mutually exclusive, policy approaches to dealing with mitigation in general and with environmental "negative impacts" in particular include creating a quasi-market to define emission rights (such as the CAP and- trade system); applying taxes and incentives to internalize the external costs of emissions and the benefits of cleaner alternatives; and dealing directly with the causes of the "negative impacts" through regulation. All these options imply some level of public regulation. The first two rely on the self-correcting capacity of the market (following a redefinition of property rights or the cost conditions under which they operate), while the third involves more formal regulatory procedures as even corrected markets may not generate acceptable solutions (or do so within an acceptable time frame). A number of other options that may be more effective in the developing country context appear to have been disregarded in policy discussions. Foremost among these are research and development funding, the regulation of fuel portfolios as well as emission levels, economic incentives, technological support, and education. It is essential, given the urgency of the situation, that the complementarity of these alternatives be recognized and that a multiplicity of approaches be incorporated into mitigation regimes.
The investment approach to mitigation: Development paths differ in terms of their impact on the climate, just as diverse climate policies affect development trajectories in different ways. If sustainable development is to be achieved, countries will no longer have the option of following a traditional fossil-fuel-dependent development path.

Effecting the energy transition described earlier requires an innovation and investment-oriented approach to mitigation, complemented by institutional capacity-building; the successful model of institutional support for the green revolution in South Asia could guide efforts to enhance the mitigation capacity of developing countries in particular. There are strong win-win possibilities for both developed and developing countries in terms of increased energy efficiency; for the latter group, however, care must be taken to factor in the rapid growth in the energy sector as consumption requirements continue to rise.

3.1.1.4. The need for Adaptation in achieving sustainable development.

a. Poverty and adaptation

Vulnerability to climate change is closely linked to poverty through the following: climate-related risks to securing and sustaining well-being; poverty- related constraints on adaptive capacity; and poverty-related determinants of exposure. These factors need to be addressed if poverty reduction and adaptation efforts are to reinforce one another. Successful adaptation requires a more equitable distribution of economic growth, access to resources, greater equity between genders and social groups, and increased participation in local decision-making (especially by the poor).

b. Local engagement and adaptive capacity

Awareness of local vulnerabilities to climate change is emerging, as are coping strategies. However, there is a need to engage with local residents and grass-roots groups to enhance awareness and identify the most effective strategies. Local adaptive capacities- influenced at the individual and community levels by resource availability and by access to social and economic networks, entitlements, institutional support, education and technology- are unevenly distributed within and between societies and need to be strengthened.

c. Policy integration and coherence at the national level

Because adaptation is seen primarily as an environmental issue, there is a tendency to compartmentalize climate change policies and place them under the direct purview of environmental or natural resource protection ministries. As a result, most Government officials in other ministries do not consider addressing climate change a development issue. This constitutes one of the main institutional barriers to mainstreaming adaptation in development policies. Adaptation must be integrated not only into development policy in general but also into policy areas such as poverty reduction, rural development, disaster risk management, water resources, health, and infrastructure investment. Similarly, sustainable development policies aimed at improved governance and natural resource management are vital to climate change adaptation.

3.1.6. The most important international agreements on climate change

Montreal Protocol, 1987. Though not intended to tackle climate change, the Montreal Protocol was a historic environmental accord that became a model for future diplomacy on the issue. Every country in the world eventually ratified the treaty, which required them to stop producing substances that damage the ozone layer, such as chlorofluorocarbons (CFCs). The protocol has

succeeded in eliminating nearly 99% of these ozone-depleting substances. In 2016, parties agreed via the Kigali Amendment to also reduce their production of hydrofluorocarbons (HFCs), powerful greenhouse gases that contribute to climate change.

UN Framework Convention on Climate Change (UNFCCC), 1992. Ratified by 197 countries, including the United States, the landmark accord was the first global treaty to explicitly address climate change. It established an annual forum, known as the Conference of the Parties (COP) for international discussions aimed at stabilizing the concentration of greenhouse gases in the atmosphere. These meetings produced the Kyoto Protocol and the Paris Agreement.

Kyoto Protocol, 2005. The Kyoto Protocol, adopted in 1997 and entered into force in 2005, was the first legally binding climate treaty. It required developed countries to reduce emissions by an average of 5% below 1990 levels and established a system to monitor countries' progress. But the treaty did not compel developing countries, including major carbon emitters China and India, to take action. The United States signed the agreement in 1998 but never ratified it and later withdrew its signature.

Paris Agreement, 2015. The most significant global climate agreement to date, the Paris Agreement requires all countries to set emissions-reduction pledges. Governments set targets, known as nationally determined contributions, with the goals of preventing the global average temperature from rising 2°C above preindustrial levels and pursuing efforts to keep it below 1.5°C. It also aims to reach global net-zero emissions, where the amount of greenhouse gases emitted equals, the amount removed from the atmosphere, in the second half of the century. (This is also known as being climate neutral or carbon neutral.)

Every five years, countries are supposed to assess their progress toward implementing the agreement through a process known as the global stocktake; the first is planned for 2023. Countries set their own targets, and there are no enforcement mechanisms to ensure they meet them.

3.2. Climate change hazards in Egypt

In Africa, 2020, between 75 million and 250 million people were projected to be exposed to increased water stress due to climate change. If coupled with increased demand, this will adversely affect livelihoods and exacerbate water-related problems.

Agricultural production, including access to food, in many African countries and regions is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2025.

Local food supplies are projected to be negatively affected by decreasing fisheries resources in large lakes due to rising water temperatures, which may be exacerbated by continued overfishing. Towards the end of the 21st century, projected sea-level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5-10% of GDP. Mangroves and coral reefs are projected to be further degraded, with additional consequences for fisheries and tourism.

New studies confirm that developing countries are the most impacted by climate change and the least able to afford its consequences. Egypt is one of the most vulnerable countries to climate variability and change because of multiple stresses and low adaptive capacity. Some adaptation to current climate variability is taking place; however, this may be insufficient for future changes in climate. Egypt is the second developing country suffering from the climate change after Malaysia, especially by the sea- level rise. Approximately, 10% of Egypt population under threat in case of 1m rise. And it also effects on 12.5% of the Agri-land.

3.2.1. Reflections on development and resources in Egypt

Lots more evidence has piled up over the past ten years to show that changes in many physical and biological systems relate to global warming. Then, needing an action for mitigating the climate change impacts through regional development policies target all regions (urban, rural and undeveloped areas) and cities in order to support job creation, business competitiveness, economic growth, sustainable development, and improve citizens' quality of life. And to make it easy to be implemented, so it has to be integrated with the administration levels to achieve the final aim for those objectives (ADGER, et al., 2005).

Understanding of the demand for a raw approach is pushed by the observation that past policies have broken to reduce regional disparities significantly and have not been able to help individual lagging regions to capture up, despite the allocation of significant public financing. The result is

under-used economic potential and weakened social cohesion. Also, it is reflected in the country competitive dynamic regions aiming to achieve their economic, social and environmental objectives. Regional development policies complement national macroeconomic and structural policies. In this context, the regional outputs aim at helping countries get regions and cities "right" through the adaptation of policies to the specificities of where people live and work and so improve citizens' well-being (EVERSOLE & MARTIN, 2005).

Egypt's administration system is composed of two levels, the central and local levels. The central level consists of ministries, central agencies, and public enterprises. The local level consists of governors, which in turn are classified into two types of hierarchies, those with a complex structure and those with a simple structure. The simple structure governors are composed of three levels: governors, city and district levels. The structure governors consist of four levels: governorate, Markaz, city/village and district levels. The local administration system is currently governed and ruled by law 43 issued in 1979, which was based on the previous 1971 constitution (AHMED, 2016).

The main components of the local administration system in Egypt; according to law 43/1979 and its amendments, Egypt is divided into (27) major units called governorates. These governors are classified into either fully urban governors of simple structure, or mixed urban and rural governors of complex structure. The simple structure governors consist of three levels: governorate, city, and district.

Confronting the impact of climate change requires local, regional and international cooperation. This is a tremendous and sophisticated challenge which humanity is faced with, for the current and future generations. The government of Egypt undertakes its activities based upon the principle of common responsibilities at the domestic level. In collaboration with the international community, the government implements the key objectives, while considering the social and economic indicators, as well as the social dimension. The government adopts its national policies and measures, since these are vital for the protection of existing investments, and simultaneously secures growth and sustainable development (AAREF, 2015).

3.3.1.1. The National Strategy aims at achieving the following goals.

a. Increasing the flexibility of the Egyptian community in dealing with the risks and disasters caused by climate change and its impact on different sectors.

These sectors include the coastal zones, water resources and irrigation, agriculture, health; urban areas, housing & roads; and tourism. This goal can be achieved by carrying out an in-depth analysis of the current situation in different sectors of the community. These are the facilities that are available and required to raise the degree of preparedness of confrontation and flexible interaction with developments.

b. Enhancing the capacity to absorb and contain climate-related risks and disasters.

This is attained through the development of specialized sectorial programs and action plans to meet the needs of the community at large, and to adapt to the new conditions through various means, ranging from basic fundamentals to the use of state-of-the-art technologies. In this manner, systems are set up for adaptation to potential climate changes, namely temperature increase and water scarcity, and the adverse expectations on the increase and decrease of precipitation and sea level rise.

c. Reduction of climate change- related disasters

This is feasible through accurate scientific calculations; field and theoretical observation of the different sectors of the community; appropriate support of the existing projects; selection of the most convenient and appropriate locations and designs for new projects; and strengthening the infrastructure in a manner that would help reduce the disasters related to climate change. (AZAB, 2009).

Approximately 94% of the total population occupies about 7 percent of the total landmass in Egypt occupying about 1 million m^2. Egypt's population in 2019 was approximately 100 million and had increased by 2.3% per year over last 10 years (EEAA, 2010) Egypt is a developing country with a growing population and a growing economy. Egypt's population is projected to reach 119 million by 2030.

3.3.1.2. Governmental actors involved in administration levels in Egypt.

The key administrator and legislative entities involved in territorial governance at the different levels according to the 1971 constitution and the different art objects of legislation (most prominently planning law no. 70/1973, Local administration law no. 43/1979 and the Building Law no 119/2008), Fig. 9.

a. National level

The Key National-level institutions in Egypt are involved in territorial governance and planning for regional economic development. There are four main entities within central government that are directly involved in territorial governance at the national level, these entities are: The Ministry of Planning and International Co-operation (MoPIC); the General Organization of Physical Planning (GOPP); the National Centre for Planning State Lands Usage (NCPSLU); and the Supreme Council for Planning and Urban Development (SCPUD), headed by the Prime Minister. (AHMED, 2016)

Figure 9: Key governmental entities involved in planning at the different levels.

Source: The author's edition based on (AHMED, 2016)

b. Economic regions and regional institutions

Economic regions were not mentioned in the Egyptian constitution, however, according to the article no. 161 of the constitution, administrative units could be created if there is a need. Economic regions were created by presidential decree in 1977. In 1979, the local administrative law was issued with a chapter dedicated to the economic regions and the regional planning authorities. All the same, these changes did not provide economic regions with any actual power as they are without real planning powers and budgetary authority and do not bear the strong executive machinery that connects to the deconcentrated offices of central ministries (AHMED, 2016).

There are currently seven economic regions each with a capital: 1) Cairo Region: Cairo is the capital; 2) Alexandria Region: Alexandria is the capital; 3) Delta Region: Tanta is the capital; 4) Suez Canal Region: Ismailia is the capital; 5) Northern Upper Egypt Region: Menia is the capital; 6) Asyout Region: Asyout is the capital; 7) Southern Upper Egypt Region: Aswan is the capital.

[9] * SCPUD Supreme Council for Planning and Urban Development, * GOPP General Organization of Physical Planning, * MoLD Ministry of Local Development, * MoPIC Ministry of Planning and International Co-operation, * NCPSLU National Centre for Planning State Lands Usage, * LPC Local Popular Council

c. Local administrative units

The Local Popular Council (LPC), according to the constitution, is part of the executive authority and is formed for each administrative unit (Governorate, Markaz, city, hay, and village local administration), by direct election. The constitutional amendments of 2008 explicitly mentioned decentralization and empowerment of administrative units and stipulated that a gradual transfer of competences from the central level to the local popular council should be granted. The local administration law stipulates in article 27 that the governor is the *"representative of the President in the governorate, and shall take charge of supervising the execution of the State General Policy, and s/he has a complete authority over all services utilities and production within the scope of the governorate."* (AHMED, 2016)

3.3.1.3. The administrative challenges for the environmental issues in Egypt

Since the mid-1980s, Egypt has introduced different components and measures in its economic reform and structural adjustment programmes to reduce the budget deficit, sustain economic growth and improve the standard of living. From the beginning of the 21st century until the 25 January revolution, a rapid acceleration in growth took place, making Egypt one of the Middle East's fastest-growing economies and resulting in the creation of record numbers of jobs. Also, investor confidence remained relatively high. (AZAB, 2009)

The expansion in economic activities was mainly in the fields of energy, construction, and telecommunications as well as labour-intensive sectors such as agriculture and manufacturing. In 2005, the Egyptian Competitiveness Report (ECR) records notable improvements in Egypt's competitiveness rankings, reflecting the impact of these significant economic reforms. This was reflected in an impressive leap of Egypt's ranking in the third pillar of the Global Competitiveness Index, "macro-economy index", from 81st to 50th place. Having said that, Egypt did not perform as well on Michael Porter's Business Competitiveness Indicator (BCI), which focuses on the "micro foundations of competitiveness" which include the quality of the business environment operations and the sophistication of company strategy. The results indicate that major work must be done at the macroeconomic level to improve the business environment if growth is to be sustainable (MAHMOUD, 2012).

3.3.1.4. The main challenges facing environmental issues in Egypt are:

a. Confusion in the Legal Framework Governing Planning for Regional Economic Development.

The legal basis for planning in Egypt stems from two key laws: the planning law no. 70/1973 which regulates the process of developing the national socioeconomic plan; and the Building Law

no. 119/2008 which regulates the process of undertaking the strategic planning process at different levels (national, regional, governorate, cities and village levels).

Both laws offer two parallel, conflicting and contradicting approaches to planning. While the methodology adopted in the Building law is more in line with decentralization, both plans are managed centrally (AHMED, 2016).

This has led to confusion about: Who is leading the planning process (MoPIC[10], GOPP[11], or line ministries-but it is clear it not local government); Who is responsible for integrating between different sectors (MoPIC or GOPP –Not local government); At which level this integration should occur (at the national level as in the Planning Law or at each and every level as in Building Law) (AHMED, 2016).

The presidential decree contradicts with the roles given to the GOPP in the building law with respect to planning outside the settlements Zamam.

i. Planning Law, No 70/1973

The national socioeconomic plan:

- Aims at raising the standard of living, melting differences between classes through the increase of the national income, expansion of the services scope till reaching a sufficient and just community.
- Should ensure the comprehension and integrity of the plan which guarantees for it the use of all national physical, natural and human resources.
- Should ensure the economic, administrative and geographical distribution of projects in a way that guarantees the establishment of economic regions beside the local administrative units.
- Done centrally with safeguarding the widest participation by the local ruling units, the economic units and the public in the preparation of the plan and its execution.
- Is a long-term general national plan which gets divided into time phases of medium terms, and these, in turn, are divided into annual detailed plans (MAHMOUD, 2012).

ii. Strategic Planning According to the building Law, No 119/2008

The Strategic Plan (AHMED, 2016):

- It is the plan which defines the future vision for urban development.
- It could be on the national, regional, governorate, city, or village's level.
- It exhibits the objective, policies, economic and social development plans, and the urban environment necessary for sustainable development.

[10] MoPIC Ministry of Planning and International Co-operation
[11] GOPP General Organization of Physical Planning

- It defines future requirements for urban expansion, use of diverse lands, programs, priorities, execution mechanisms, and financial resources for each planning level.

iii. The National Centre for Planning State Land Uses (Presidential decree No 153/2001)

- Counting and reformatting the state lands outside the reins and the preparation of the general planning for their development within the framework of the general policy of the country.
- The preparation of the maps of the uses of the state lands outside the reins in all the purposes in coordination with the Ministry of Defence.
- Giving each ministry the maps of the lands specified for the uses of its activities, known that it will have complete and free authority in the specialization and the supervision of the uses of these lands and how to develop them.
- The restriction and handling of the annual programs of the development and the uses of the lands of each ministry and budgeting the revenues and expenditures of these developments.
- The coordination between the ministries concerning the land pricing rules and the system of their sale and the collection of their value and organizing their protection.
- Assuring that the Treasury of the state gets the net income from the land development that was allocated to each ministry (AAREF, 2015).
- Preparing special studies for the state lands outside the reins that have not been previously allocated and coordinating with the different state authorities to plan the ideal use of these lands.
- The coordination with the Ministry of Defence regarding the different uses of the lands outside the ruins of what does not contradict the affairs of defending the country.
- Keeping all the data related to the state lands outside the reins and what has been allocated for them to each ministry and the annual uses of these lands and what remains of them without being used.
- Expressing the opinion in the disagreements that arise between the ministries and the public authorities and the local administration units or between these authorities and the individuals about specifying the authority responsible for managing and using the disputed lands outside the reins.
- Preparing detailed maps for planning the state lands that are outside the reins, according to the general map of planning.
- Expressing the opinion in the ministries' and the different state authorities' requests for the modification of the lands that have been previously allocated or the lands that have been added to them.

- Preparing the studies and the technical and environmental research necessary for the state land uses outside the reins in coordination with the ministries and the concerned authorities in the country (WIESEL & MODELL, 2014).

b. Weak Institutional Relationship Between Public Research Institutions and Universities and Regional and Local Actors Engaged in Economic Development.

According to the Local Administration Law, the governor shall act to support cooperation between the governorate institutions and universities and research institutes which are located within the governorate area, to serve the environment and promote the local society. However, the governor role in practice is very limited in the coordination of research endeavours and economic development at the local level since such research efforts are predominately either executed at or planned by the central level. (AHMED, 2016)

3.3.1.5. The main environmental challenges in the administration levels

As highlighted in the challenges presented above, Egypt, predominantly follows the hierarchical and top-down approach to territorial governance. The lead organization for managing territories is the central government (in planning for regional development, regional policy setting, land administration, implementation of development projects, and financing). In this situation, ministries and central agencies mandated with economic development follow an administrative DE-concentration model whereby they create deconcentrated offices at the regional level, which do not coordinate with each other and are not accountable to the regional institutions or local administrative units (AHMED, 2016).

Clarify the planning approach that will be adopted at the regional level: The different institutional actors, including the Regional Development Agencies (RDAs)[12], will have different roles in the planning process. The reforms' ultimate goal is to enable the RDA to lead the planning for economic and urban development, in accordance with the state general policies and a framework for regional planning drafted by the central government highlighting key regional polices and guidelines. This envisioned reform will not be achieved instantly but will require a gradual shift of planning competences from national level institutions to the RDAs (EVERSOLE & MARTIN, 2005).

[12] The RDA model means that there is a specific set of regional institutions established that are still under the oversight of the central government, but which possesses a set of competences and resources that allow it to develop policies appropriate to its territory.

3.3.1.6. The staged approach towards reforming territorial governance.

Lessons learned from international experience suggest that the best way to approach territorial governance is to introduce the reform based on a long-term vision combined with gradual and incremental actions. Enabling the RDA is not an easy fix and would require continuous efforts on the ground to enhance the organizational capacity at the regional level. Likewise, in this new setting, new roles will be assigned to the government at the central level, which will require time and tailor-made capacity building interventions (DENHARDT & DENHARDT, 2009).

a. A national policy framework for regional development

By the MoPIC, GOPP, and NCPSLU to specify the Egyptian government's vision for sustainable development and how this would impact on economic, environmental, and social planning policies. The framework will provide parameters within which regions can produce their own Regional Strategic Spatial Plan for Economic Development. These strategic plans specify the vision for the economic development of each region. They spell out the major economic development interventions that will be carried out at the regional level. The plans will cover a long-term period (20-30 years) but with a detailed 5-year plan which is linked to the budget. During the first phase, the planning process will be facilitated by the central level, however, with strong engagement of the RDA and regional partners (WIESEL & MODELL, 2014).
The strategic planning department at the RDA will work closely with MoPIC, GOPP, NCPSLU, and the National Planning Institute to draft the strategic plans. In addition, the department will be drafting a midterm and annual investment plans based on the regional strategic plans as well as the state general policies and the policy framework for regional development prepared by the central government.

b. Ensure Stakeholder engagement with the RDA through different mechanisms.

The regional law should highlight different mechanisms that enable the engagement of the different stakeholders within the region with the RDA and its board. Among these mechanisms could be a regular stakeholder consultation process; reinforcing the engagement of different actors during the environmental and social impact assessment; engagement during the planning process; consultation process on the progress of key performance indicators; among others. For the stakeholders' engagement to be meaningful, access to information should be granted, including information about proposed regional plans and strategies, regional competitiveness reports, regional budget and the report of the Central Agency for Accounting (EVERSOLE & MARTIN, 2005).

3.3.1.7. Sectoral impacts of climate change

Climate change - with its many dimensions (social, environmental, economic and political) - is expected to lead to multiple impacts at various scales and levels. The impacts on natural ecosystems will be reflected on all socioeconomic levels, affecting livelihoods and human well-being. The prevailing climatic conditions in the Arab region have highly significant impacts on the different components of the ecosystems. Major impacts could be attributed to the inherent fragility of the dominating arid ecosystems of the region. These arid ecosystems are generally characterized by inferior physiochemical properties, the weak resilience of soil resources and relatively limited availability of surface/ground-water resources (BURTON, et al., 2002).

a. Water resources

Nine out of fourteen countries in the MENA region already have an average per capita water availability below the water scarcity threshold. A warming climate is expected to place additional stresses on water resources in the MENA countries, whether or not future rainfall is significantly altered (HUME, et al., 2015). Per capita renewable water resources in the region, which in 1950 were 4,000m³ per year, are currently 1,100m³ per year. Trends of reduced surface water availability reduced groundwater reserves, and increased occurrence of drought and flood events have been observed in several countries (e.g., in Morocco over the last 30 years). Projections indicate that per capita renewable water resources will drop by half, reaching 550m³ per person per year in 2050 (IBRD, 2006). Countries expected to experience decreased precipitation include Egypt, Jordan, Lebanon and the Occupied Palestinian Territory (IPCC, 2007).
Rising temperatures and changes in runoff patterns will influence the flow of rivers upon which countries in the region depend.

b. Agriculture and food security

Agricultural production and food security are closely linked to the availability of water. Climate change is expected to affect food security through its impact on agriculture and food production systems. At the global level, aggregate agricultural output potential will be less affected by climate change, with significant variations between regions. According to the (IPCC, 2007), by the 2080s, agricultural potential could increase by 8% in developed countries, primarily as a result of longer growing seasons, while in the developing world, it could fall by 9%, with sub-Saharan Africa and Latin America projected to experience the greatest losses (MUELLER & RYNNE, 2009). Most Arab countries are considered among the world's most water scarce, and in many places demands for water have already exceeded supply. Higher temperatures and less rainfall will reduce the flow

of rivers and streams, slow the rate at which aquifers recharge, and make the entire region more arid. These changes will have a series of effects, particularly on agriculture, energy and food security.

The main climate change risks in the North African and Middle East region will largely be linked to long-term desiccation and drought associated with climatic variability. Water stress is of huge importance and decreases in water availability may have severe impacts on food security. Some projections indicate that under moderate increases in temperature, water flow will be largely impacted. This is true for the Euphrates and Jordan Rivers, which could shrink by 30% and 80%, respectively, by the end of the century (ADGER, et al., 2005).

c. Sea level rise, coastal inundation and erosion

The extremely low elevation of arable cropland in the Nile Delta in Egypt makes sea level rise a clear threat for the country, as most of the 50km wide land strip along the river is less than 2m above sea-level and is protected from flooding by only a 1 to 10km wide coastal sand belt. Erosion of this protective sand belt, which is essential for the protection of the lagoons and the low-lying reclaimed lands, could be a serious problem. The impacts would be very serious, as one-third of Egypt's fish catch is made in lagoons. Erosion could also affect the water quality and productivity of agricultural lands.

Infrastructure, roads, and recreational tourism, beach facilities would be endangered, and essential groundwater would be contaminated with salt. Based on the UN-Habitat's State of the World's Cities 2008/09, by 2070 coastal cities that could be severely affected by rising sea levels include Alexandria (Egypt) (IPCC, 2007).

3.3. Local Economic Development

3.3.1. Definitions

Local economic development (LED) offers local government, the private and not-for-profit sectors, and local communities the opportunity to work together to improve the local economy. It focuses on enhancing competitiveness, increasing sustainable growth and ensuring that growth is inclusive. LED encompasses a range of disciplines including physical planning, economics and marketing. It also incorporates many local government and private sector functions including environmental planning, business development, infrastructure provision, real estate development and finance. (IBRD, 2016)

The purpose of LED is to build up the economic capacity of a local area to improve its economic future and the quality of life for all. It is a process by which public, business and nongovernmental sector partners work collectively to create better conditions for economic growth and employment generation (IBRD, 2016).

3.3.2. Development Levels

3.3.2.1. International

Globalization increases both opportunities and competition for local investment. It offers opportunities for local businesses to develop new markets but also presents challenges from international competitors entering local markets. Multi-site, multi-national manufacturing, banking and service corporations compete globally to find cost efficient sites in which to locate (SWINBURN, et al., 2006).

Technologically advanced growth industries require highly specialized skills and a supporting technology infrastructure, but increasingly all industrial and service sectors need highly specialized and specific skills and business environments. Local conditions determine the relative advantage of an area and its ability to attract and retain investment. Even small towns and their surrounding rural regions can develop local economic opportunities at a national or international level by building on their local economic strengths.

3.3.2.2. National

At the national level, macro-economic, fiscal and monetary reforms have directly impacted the economy at the local level. National regulatory and legal frameworks such as tax reform, telecommunications deregulation and environmental standards directly influence the local business climate, either enhancing or reducing the potential for local economic development. In

many countries, national government functions continue to be decentralized thereby increasing the responsibility of municipal governments to retain and attract private industry (SWINBURN, et al., 2006).

3.3.2.3. Regional

Communities within and between regions often compete to attract external and local investment. Opportunities exist for communities across regions to collaborate with each other to help their economies grow, for example, by supporting infrastructure or environmental improvements that demonstrate a broad regional impact. An association of local municipalities or regional governments can serve to facilitate these types of LED effort by acting as an intermediary between national and municipal governments (SWINBURN, et al., 2006).

3.3.2.4. Metropolitan and Municipal

Businesses, both large and small, often choose to locate in urban areas because of agglomeration economies (i.e., the benefits derived from sharing markets, infrastructure, labour pools and information with other firms). The economic advantage of urban areas depends significantly on the quality of urban governance and management, and on the policies affecting the availability, or lack, of electricity, transport, telecommunications, sanitation and developable urban land. Factors affecting labour productivity in the local economy include the availability and quality of housing, health[13] and education services, skills, security, training opportunities and public transport. These 'hard' and 'soft' infrastructure factors are major determinants of a community's relative advantage. The quality and provision of 'hard' and 'soft' infrastructure forms the cornerstone of a successful local economy.

Metropolitan areas can offer increasing opportunities through economies of scale and effort because of the size of the physical and human capital available, as well as the size of its services and internal market. Uncoordinated and desperate institutional frameworks and planning bodies in metropolitan areas can serve to undermine area-wide economic growth. Metropolitan-wide LED agencies, consortia and networks can be created to address these constraints. These innovative institutional frameworks, which represent the interests of different municipalities and partner agencies in the same metropolitan area, can bring benefits to the key actors of each municipality (public departments, business and civil society organizations). These frameworks can serve to unite the efforts of different localities and increase LED results, and can strengthen representation

[13] LED infrastructure comprises two main components, 'hard' physical infrastructure incorporating roads, rail, water, sewerage and drainage systems, and energy and telecommunications networks; and 'soft' infrastructure of social, cultural and community facilities and capacity that enhance the quality of life and encourage industry and business development.

in higher levels of decision-making. This type of cooperation has worked well for cities that belong to common market agreements or that have common sector interests (i.e., Euro cities, Indonesian City Network, South African Cities Network) (SWINBURN, et al., 2006).

The most important and effective local economic development activity that a municipality can undertake is to improve the regulatory processes and procedures to which businesses are subjected by the municipality itself. A survey of most municipalities would reveal a number of complexes, poorly managed, expensive and unnecessary business registration systems. By reducing these, a municipality can quickly improve its local investment climate.

3.3.3. Stakeholders; Organizing the effort and related Stakeholders.

It is important to have substantive stakeholder input and involvement if we are to properly design and develop a local economic development strategy and then begin implementing it effectively. Such an active and open process of stakeholder engagement is a central theme in defining the enabling environment. To this end stakeholder engagement needs to be broad and deep; equal and equitable; and, organized early (VNG, 2015).

Table 4: LED typical stakeholders

Public/Government	Private (business)	Civil Society
▪ Elected officials. ▪ Local government, including all operational departments. ▪ District/ regional and national government departments and agencies, especially those charged with specific responsibility for economic development planning and implementation. ▪ Other government authorities and agencies, such as regulatory bodies. ▪ Universities, collages and institutions of research and higher learning.	▪ Large corporations and enterprises. ▪ Small, medium and micro-scale enterprises including individual entrepreneurs. ▪ Industrial, commercial and residential land/ real estate developers. ▪ Banks, credit unions and other financial institutions. ▪ Business development and support agencies, councils and intermediaries, including but not limited to business centres and development authorities, sector specific agencies and authorities (e.g., tourism, high-tech, clusters/ associations). ▪ Chambers of commerce and other business associations.	▪ Neighbourhood and community service organizations. ▪ Local schools and clubs. ▪ Organizations and associations representing special community interests such as youth, minorities, the disabled and other disadvantaged or marginalized citizens. ▪ Organizations or associations focused on specific LED issues (e.g., environmental sustainability, gender equality, etc.) ▪ Trade unions and other professional associations.

Source: (UCLG, 2016)

The involvement and collaborative efforts of the public (government and governmental agencies), business (private sector) and non-government or non-profit (civil society) sectors in the community are essential to the process: each group of stakeholders brings its unique skills and resources to the process and, significantly, each has a role to play in representing the best interests

of all. Establishing working relationships and structures that fully engage these stakeholders in the process will also build trust and lead to beneficial long-term, formal public/private/non-governmental partnerships to further facilitate and build the effort (UCLG, 2016).

LED programs have been initiated in many countries of Sub-Sahara Africa. Most of them are supported by a multitude of non-governmental organisations (NGOs) and national or multinational development organisations. GIZ for example supports LED in Egypt, South Africa, Namibia, Zambia, Ethiopia, Nigeria, Ghana, etc.

3.3.4. Elements and Characteristics of Local Economic Development

LED strategies contain the following fundamental elements broadly: (Feasibility, Resource Availability, Capacity, Holistic Transparency, Cultural Influences) (UCLG, 2016) (TÓTH, 2005).

3.3.4.1. Feasibility

The grounds for the formulation of LED strategies are to be based on the need for specified change and the ability of municipalities to exercise their authority to create and implement development plans in relation to municipal environments. National governments are to be instrumental in facilitating need analyses and guiding the frames for strategy formulation (TÓTH, 2005).

Strengths, Weaknesses, Opportunities and Threats' (SWOT) analyses of the physical and economic environment and associated conditions must precede strategy formulation or redesign of respective strategies area requisition to promote increased economic growth levels in cities and the transformation of municipalities to the satisfaction of communities via optimal use of limited resources. SWOT analyses will assure policy formulators of corrective action that is required in the light of weaknesses and threats and will simultaneously enable municipal officials to build on the strengths and opportunities for strategies that are presented in a specified municipal jurisdiction (UCLG, 2016).

3.3.4.2. Resource Availability

LED strategies are to consider the municipal budgets as determined and allocated by national bodies and the strategy per municipality must be formulated in an integrative manner. Formulation of LED strategies must be developed on the grounds of available funds that will drive the programs and projects attached to each of the municipal strategies.

For a LED strategy to have a long-term impact, the strategy should be clearly defined during formulation and should be extensively funded during the initial stages until the strategy has the potential to become self-sustaining (TÓTH, 2005).

The LED strategy for a municipality should furthermore be envisioned in its entirety, which includes a fully-fledged plan, including detailed programs and projects that are concerned with the implementation and evaluation of each program. This finer detail in a development strategy will allow the commitment of a greater number of resources in comparison to the former and current detachment of LED programs to an overall strategic plan (UCLG, 2016).

3.3.4.3. Capacity

Records of core competencies of officials in a municipality are essential in the content of the municipality's LED strategy. Strategies have maintained that objective achievement and effectiveness are dependent on the capacity of municipalities to carry out daily tasks with the required specialized expertise or techniques. It is thus recommended that LED strategies be determined and formulated in relation to the capacity presented in their municipalities (TÓTH, 2005). Cities are comprised of various categories of municipalities, differing in structural abilities and capacity. This means that the development of relationships for a municipality with outsourcing; privatized practices as well as private-public partnerships will assist in building stature and building municipal expert backgrounds. It is further recommended that municipal officials undergo training to improve their expertise and to contribute to effective productivity in primary tasks. Emphasis on capacity is crucial for successful results and to satisfy the expectations of citizens by means of service delivery through strategy implementation (UCLG, 2016).

3.3.4.4. Transparency

The political system dictates the value of transparency in the formulation of LED strategies. In the present context, municipalities are obligated to and guided in maintaining openness in processes and transparent activity in the light of the concerns of the democratic citizens. Therefore, formulators of the LED strategies must acknowledge that the citizens should remain the foundation of municipal practice throughout the formulation process. Citizens as founding bodies of LED strategy formulation are crucial, in that the citizens are the central evaluators of the end products produced by municipalities during LED planning and strategy formulation (UCLG, 2016).

3.3.4.5. Cultural Influences

Prior to the formulation of an LED strategy, it would be more effective to consider the social environments that the strategy is expected to affect (i.e., the communities). The communities concerned are comprised of diverse cultures. Cultural clashes can also influence strategic objective achievement and can delay strategies in the latter periods of implementation; if not fully acknowledged and resolved before the formulation process (TÓTH, 2005).Prior to the formulation

of an LED strategy, it would be more effective to consider the social environments that the strategy is expected to affect (i.e., the communities). The communities concerned are comprised of diverse cultures. Cultural clashes can also influence strategic objective achievement and can delay strategies in the latter periods of implementation; if not fully acknowledged and resolved before the formulation process (UCLG, 2016).

3.3.5. LED Various Approaches

- Public -private partnership approach: to assess/seize economic comparative advantage.
- Small business approach: for innovation, private investment and job-creation
- Regional approach: leveraging the resources of surrounding areas.
- Sector-cluster approach: supporting the most promising sectors by bringing together business, educational institutions, NGOs and government (IBRD, 2016).

A typical LED project is led by a certain number of basic elements:

Private/public partnership: cooperation between, and the coordination of different development activities deter actors from ineffective go-it-alone approaches while supporting the legitimacy and sustainability of the development process. LED is a means to achieve the effective mobilization of local resources by encouraging investments with the highest rate of socio-economic return. The partnership between private, public and non-profit actors becomes crucial for a sustainable development process allowing the convergence in investment programming between the different local actors.

Good practice tells us that LED should always be guided by a strategy. According to the World Bank, a LED strategic planning process has five stages:

Stage 1: Organize the Effort

Stage 2: Conduct a Local Economic Assessment

Stage 3: Develop the LED Strategy

Stage 4: Implement the LED Strategy

Stage 5: Review the LED Strategy

The strategy will define areas of economic opportunity and obstacles to overcome information that will guide the direction of the LED initiative and potential interventions.

3.3.6. LED Policies

Local Economic Development recommended policies and strategies:

According to the EU Directorate General of Communication (2009), climate change was rated by Europeans as the second most serious problem the world is facing today. 47% of the 26,719

interviewees felt that climate change was a severe problem and was even more serious than for example international terrorism, the spread of infectious diseases, armed conflicts, an increasing world population or the proliferation of nuclear weapons. A survey (All in all 13,518 people in the US, Japan, France, Russia, Mexico, Turkey, Iran, China, Egypt, Indonesia, India, Vietnam, Senegal, Bangladesh and Kenya were interviewed) by IBRD- 2009 showed that about 59% of the interviewees considered climate change or global warming to be a "serious problem" whereas 27% saw it as a "somewhat serious problem". Only 9% felt that it was not very serious and 3% thought that it was no problem at all. In the US only 31% of the interviewees and in Japan only 38% believed that climate change posed a serious problem compared to 85% in Bangladesh and to 90% in Mexico.

LED Enabling Policies: Local economic development is arguably affected by all local government activities.

However, local economic development policy is usually defined more narrowly as special activities, undertaken by public or private groups, to promote economic development. The activities labelled "economic development programs" fall into two categories:

1. Providing customized assistance targeted at individual businesses that are thought to provide greater economic development benefits.
2. Strategic initiatives in which more general tax, spending, and regulatory policies of government are changed to promote local economic development.

Even without these government efforts, local economic development will often occur. However, local economic development programs are argued to increase the quantity or quality of local economic development.

Local economic development is increasingly regarded as a major local government responsibility. Many believed that "bringing about economic development" is a major responsibility of local governments. The "first priority goal" for local economic development is "increasing jobs located in the city", increasing the local tax base, and diversifying the local economy.

According to the ICMA[14] survey of local governments, the most common barriers to local economic development include limited availability of land, lack of skilled labour, high land costs, lack of capital and funding, citizen opposition, a limited number of major employers, and traffic congestion. Local government economic development strategies focus on manufacturing industries, retail or service industries, technology and telecommunications, tourism, and warehousing and distribution industries. Among the most common economic development

[14] International Capital Market Association

programs supported by local governments are tax incentives, either citywide or in designated; job training programs customized to the needs of individual firms or industries; community development loan funds for businesses; community development corporations; and microenterprise programs.

3.3.7. Strategic plans

The five-stage strategic planning process:

A local economic development strategic planning process typically has five stages. Although these are highlighted below as separate stages, in reality, LED strategic planning is a flexible process, and one stage often continues in parallel with another according to local needs. If problems are encountered during a particular stage, it may not be as a result of work in that stage but the appropriateness of a previous stage. Previous and subsequent stages may need to be refined or reworked to resolve problems. The strategy is a living document that should be changed as circumstances dictate.

The five-stage sequence of the local economic development strategic planning process:

Stage 1: Organizing the Effort: To successfully organize a local economic development strategy, institutional arrangements and stakeholder involvement should be agreed at an early stage of the planning process. An LED team should be established in City Hall or within a partner organization and this team should initially manage the strategic planning process.

Successful local economic development requires the collaborative effort of public (governmental), private (business) and non-governmental (NGOs, trade unions, social, civic, religious) sectors. The strategic planning process begins by identifying the people, public institutions, businesses, industries, civic organizations, professional organizations, think-tanks, training institutions and other groups that comprise and/or impact the local economy.

The skills, experiences and resources that stakeholder groups bring to the effort will each contribute to the overall strategic planning process. Establishing solid working relationships and organizational structures to support the strategy planning process will lead to beneficial long-term, public, private and non-governmental partnerships. These working relationships can range from relatively informal working groups to semi-formal, loosely aligned networks, to the establishment of a regional development agency or a constituted public-private partnership. Maintaining and sustaining such partnerships is often the critical and challenging factor determining the effectiveness of LED efforts.

Stage 2: Local Economy Assessment: Knowing the characteristics of the local economy is critical if stakeholders are to identify and agree a realistic, practical and achievable LED strategy. To elicit key data on the local economy, an effective local economy assessment will start with a

preliminary review of the existing economic relationships and activities within an area and will make use of available quantitative and qualitative information that highlights existing structures and trends in business development, manufacturing, employment, skills, and other data that will help to identify the strategic direction of the local economy. The assessment need not necessarily be limited by an administrative jurisdiction or boundary such as a municipal boundary. An area might consist of a metropolitan region, a travel-to-work area, a town, city or its urban or rural hinterland. The information collected may highlight the need for specific projects and programs that will expand and diversify the local economic base.

The first step in a local economy assessment is to determine what information is pertinent, required and available, and to identify the vague, missing or non-existent data that it will be necessary to obtain for the local economy assessment. After obtaining this data, it will be necessary to collate and analyse the data so as to provide a profile of the local economy. Several tools including SWOT analysis, benchmarking and regional economic indicators may be used to identify key information on the local economy. Effective LED strategy planning will include a review and analysis of the contribution of local economic development programs and projects that are already happening in the area.

Table 5: SWOT Analysis: Examples of Local Economy Assessment Issue

Strengths **Local assets**	Competitive wage rates, skilled workforce, educational and research institutions, strong transportation network, safe locality, productive existing firms, proximity to raw materials or other natural resources.
Weaknesses **Obstacles to growth**	Worsening poverty, complex local regulatory procedures, inadequate infrastructure, limited access to credit, health issues affecting the workforce (e.g., HIV/AIDS), high crime rates.
Opportunities **Favourable exogenous (external) conditions**	Technological change, new international trade arrangements, macroeconomic/political developments, expanding markets, the development of a regional airport, emerging skilled workforce.
Threats Unfavourable exogenous (external) trends	Demographic changes, downsizing of global business or loss of markets resulting in local plant closure, unstable exchange rates inhibiting local investment, loss of educated population to other areas - outward migration.

Source: (SWINBURN, et al., 2006)

LED assessment will be used to:

- Identify public, private and non-governmental resources.
- Collect and analyse existing or critical new quantitative and qualitative information; and,
- Establish data management systems for future use in monitoring and evaluation.

Also important is comparative information on the resources and activities of neighbouring communities or other local, regional, national or international competitors. The assessment should

consider the potential for a wide range of local economic development opportunities across all the major sectors, including the formal, informal and community sectors.

The level and depth of data to be collected will be determined by availability, budget and nature of the local economy. In many developing countries, information about the economy is only available at the national level. Collecting detailed information about the local economy can be an expensive process that municipalities with limited funds have difficulty in undertaking. In this situation, it is necessary to consider various methods and approaches to understanding the local economy. Such approaches may include meetings with businesses and community groups, interviews and simple surveys.

Stage 3: Strategy Making: As in comprehensive city strategic planning, the intent is to achieve an integrated approach to local economic development strategic planning. In devising strategy, practitioners in municipal government and principal stakeholder groups will need to balance local economic development with environmental and social needs. A typical LED strategy has several components.

Table 6: The 5 Steps of LED Elements

Vision	Goals	Objectives	Programs	Projects & Action Plans
Describes the stakeholders' consensus on the preferred economic future of the community.	Based on the overall vision and specify desired outcomes of the economic planning process.	Establish the performance standards and target activities for development of each goal. They are time bound and measurable.	Set out approaches to achieving realistic economic development goals. They are time bound and measurable.	Implement specific program components. They must be prioritized, and costs must be established. They are time bound and measurable.

Source: (UCLG, 2016)

LED strategic objectives:

Overall, the LED should aim to the following points. The five most important objectives (**in bold**) are more or less the same for all stakeholder groups which means that they need to be more addressed in the developing plans and actions (TOTH & TOPA, 2014).

- Crime prevention/ reduction of drug and alcohol abuse
- **Strengthen adaptive capacity of locality to climate change impact.**
- Reduce natural resource degradation / protect environment.
- **Better cooperation between civic, public, private sector / improve social cohesion.**
- Improve access to affordable energy/reduce cost of energy.
- Improve productivity of land.
- Improve access to clean water.
- Reduce dependencies on imports (e.g., electricity, oil)

- **Improve situation of underdeveloped areas / informal sector.**
- Improve access to resources for the poor/empower disadvantage people.
- Increase tax revenue/income.
- Achieve shared vision for development / increase transparency.
- **Diversify economic activities.**
- Reduce aftermath of apartheid.
- Reduce greenhouse gas emissions.
- Employment and income generation (quality and number of jobs)
- Development of new skills / transfer of new technology
- Improve efficient use of resources.
- Provide housing to people.
- Empowerment of women / more free time for women
- Improve access to finance/ improve financial literacy.
- Retain and support existing businesses.
- Improve access to health services / reduce HIV/AIDS.
- Achieve cleaner environment (e.g., less litter, better waste handling)
- **Attract new businesses to the locality.**

Stage 4: Strategy Implementation: An LED strategy is an overall plan that has short, medium or long-term aims and actions and sets out what is going to be achieved. It will establish an agenda to promote and develop a local community's economic, physical, social and environmental strengths and will address both challenges and opportunities.

Implementation Plan: Every LED strategy should have an implementation plan that in turn is supported by individual project action plans. The implementation plan sets out the budgetary and human resource requirements, and institutional and procedural implications of implementing the LED strategy. As a single document that contains all of the LED programs and projects within a strategy, it serves as an integrated programming document to maintain clarity of strategy direction and ensures that programs and projects do not inappropriately compete for resources and support. With a timeframe of between one and three years, a good implementation plan will result in a more efficient and effective use of existing budgets and can be used to attract funding from external sources such as national government, bilateral and multilateral donor agencies, and the private sector.

Action Plans: LED action plans provide specific details on project components including a hierarchy of tasks, responsible parties, a realistic delivery timetable, human resource and financial

needs, sources of funding, expected impacts, results, performance measures and systems for evaluating progress for each project.

Projects that can be implemented in the short term and that result in "early wins" play an important role in building momentum and stakeholder confidence. Other projects will have a medium to long-term timeframe. In each case, projects should be "championed" by individuals or a group of stakeholders according to interests, resources, commitment and expertise.

Developing a good monitoring and evaluation system for an integrated LED strategy is important and allows for analysis and review. It enables the LED team to correctly quantify outcomes, justify expenditures, determine necessary enhancements and adjustments, and develop good practices. Indicators can be identified to measure both process and impact.

Stage 5: Strategy Review: Although an LED strategy is usually written for a three to eight-year period, the strategy should be reviewed annually to allow for adjustment in response to changing local conditions. A more comprehensive revision usually takes place every three years. The implementation of the LED strategy should, however, be subject to a rigorous annual assessment. This review should consider the resources available for the delivery of the strategy and include established and agreed monitoring and evaluation indicators of the local economy. The review should include, where possible, inputs, outputs, outcomes and impacts, and also the implementation process and the level and extent of stakeholder participation. Alongside the strategy review, systems should be in place to monitor the progress of each project. These systems will allow decision makers to adjust the strategy in response to changing local conditions. As programs or projects are completed or deemed to be inappropriate, new ones can be identified.

3.3.8. Good Practice for Strategy Success

Good practice in local economic development requires tailored approaches to local conditions, and the following are excellent guiding principles:

- An integrated approach that includes social, environmental and physical, as well as economic issues.
- A carefully developed strategy built by all relevant partners and based on a shared vision.
- Reference to the informal economy: the informal economy needs to be carefully taken into account. In some localities, it can represent a significant part of the local economy, be strongly inter-linked with formal activities and provide the economic basis for the majority of the poor.
- A range of projects: short, medium and long-term, to catalyse partnerships and build stake-holder confidence.
- Influential and effective local leaders that bring commitment, credibility and an ability to unite stakeholders.

- Capacity building of management and ‘on the ground’ teams are essential to project implementation.
- The LED strategy should be owned by the municipal government with a demonstrated strong political will to implement it.
- Political, financial and technical support from other levels of government that adds value.
- Projects and action plans should be undertaken only where a responsible manager or champion has been identified who is committed to successful implementation.

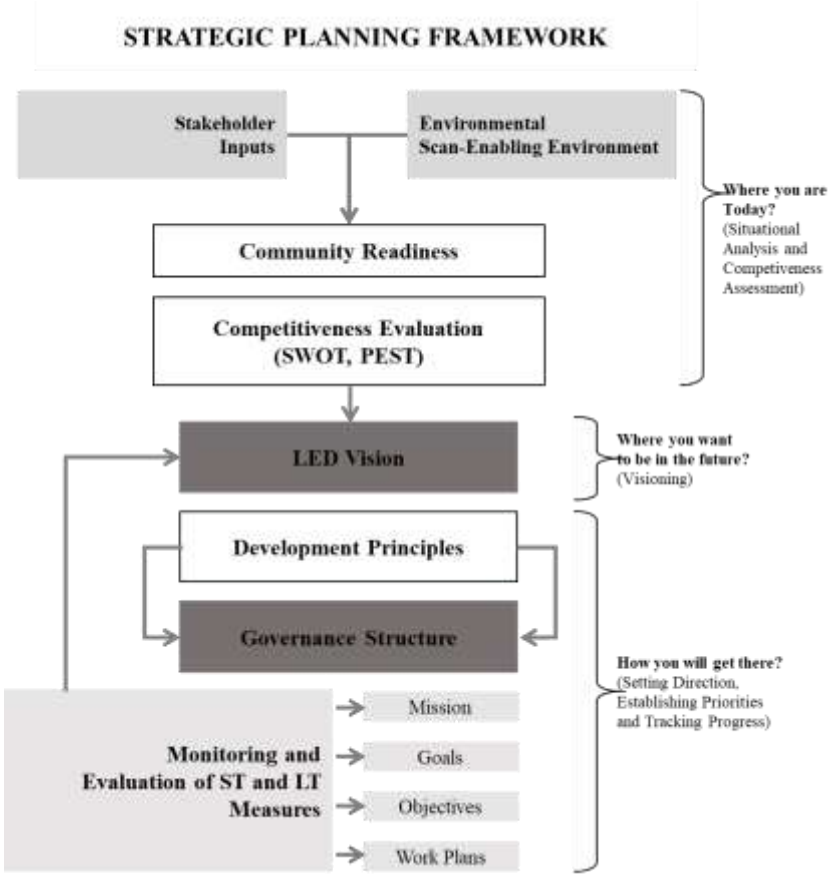


Figure 10: Strategic planning framework

Source: The author’s own edition based on LED principles and Practices, (FCM, 2014)

3.3.9. The process of territorial planning

To establish coherence between the previous mentioned, the LED strategic planning with spatial planning, we integrate the territorial planning approach aimed at achieving a more convenient model for actions implementation of actions (TÓTH, 2005) (JÓNA & TÓTH, 2012). The hybrid model is outlined in the following table.

Table 7: Territorial planning process

Description	Applicable methods	
	Group methods	Methods based on
Step 1: To map the requirements of the players in territorial development		
▪ The requirements of inhabitants and visitors ▪ The requirements of settlement and municipality associations ▪ The requirements of entrepreneurs and their associations ▪ The requirements of civil organizations	▪ Interviewing, brain storming, collective notebook (CNB) procedure, logical frame	▪ Macro models: societal accounting matrix.
Step 2: The evolution of environment		
a. The evaluation of global environment, the drawing up of tendencies		
▪ The spatial determination of regional development, its spatial effects ▪ The major tendencies of world economy, the possible effects of changes ▪ The international development directions of the dominant economic sectors in the area	▪ regional map of losses, SWOT analysis. ▪ Mathematical statistical methods: (regression analysis, factor analysis, main component analysis, cluster analysis.) ▪ Optimization methods: (Fuzzy logic) Presentation on maps and spatial informatics methods	▪ Indicators: (indicators based on the comparison of extreme values, deviation-type indicators, public road indicator, complex transportation network indicator (TRANS), pointing methods) ▪ On macro models: (regional models, ECO-line model, Socio-line model, LINE model) ▪ On macro models: (input-output approach, societal accounting matrix.)
b. The evaluation of national economic environment, drawing up tendencies		
▪ National economic and sectoral tendencies ▪ Public administrational and institution-development tendencies	▪ Logical frame, regional map of losses, SWOT analysis. ▪ Mathematical statistical methods: (regression analysis, factor analysis, main component analysis, cluster analysis.)	▪ On macro models: (ECO-line model, Socio-line model, LINE model, input-output approach, societal accounting matrix.) ▪ Presentation on maps and spatial informatics methods
c. The evaluation of the instruments and the institutional system of territorial development		
▪ The evaluation of territorial development sources ▪ The evaluation of the institutional system of territorial development ▪ The evaluation of efficiency of territorial development	▪ Interviewing, SWOT analysis, logical frame, regional map of losses. ▪ Mathematical statistical methods: regression analysis, main component analysis, cluster analysis.	▪ Presentation on maps and spatial informatics methods ▪ On macro models: LINE model, societal accounting matrix.
d. The evaluation of development concepts of the area		
e.g., the areal directions and results of National Spatial Development Concept	▪ Interviewing, regional map of losses.	▪ Indicators based on the comparison of extreme values, deviation-type indicators, public road indicator, complex transportation network indicator (TRANS), Hoover index, pointing methods. ▪ Presentation on maps and spatial informatics methods ▪ On macro models: LINE model.
Step 3: The evaluation of the endowments of the area		
▪ Societal environment, human resources (societal organizations, cultural features, values, territorial	▪ Regional map of losses. ▪ Optimization methods: Fuzzy logic, Linear programming.	▪ Indicators based on the comparison of extreme values, deviation-type indicators, public road

Description	Applicable methods	
	Group methods	Methods based on
identity – demographical structure and forecast, employment conditions, human capacity, institutional network) ▪ Economic base (major economic sectors and their development directions, the internal and external connections of the economy, the condition of infrastructure, the evaluation of locational factors, the innovation potential of the area, the economic competitiveness) ▪ Environment (natural endowments, environment, the quality of nature, the influential factors on its formation) ▪ Infrastructure, the institutional conditions of the area (the population's health, social, educational, cultural, leisure, sport, commercial, service and public administrational institutions, housing) ▪ The network of settlements, the evaluation of cohesion relationships	▪ Mathematical statistical methods: regression analysis, main component analysis, cluster analysis.	indicator, complex transportation network indicator (TRANS), Hoover index, pointing methods. ▪ Presentation on maps and spatial informatics methods ▪ Macro models: societal accounting matrix.
Step 4: The dynamic evaluation of the area's conditions and needs		
▪ SWOT analysis of external environmental conditions ▪ SWOT analysis of the area's conditions ▪ The reconciliation of the requirements and possibilities of the players of territorial development	▪ SWOT analysis, logical frame. ▪ Mathematical statistical methods: regression analysis, factor analysis, main component analysis, cluster analysis.	▪ Presentation on maps and spatial informatics methods ▪ Macro models: LINE model, societal accounting matrix.
Step 5: Setting the strategical aims		
▪ The main aims and directions of the actual territorial development concept ▪ The hierarchy of aims, pyramid of aims, connection between the subaims, the planned schedule of their implementation	▪ Brain storming, collective notebook (CNB) procedure, Rohr Bach's 635 method, METAPLAN method, logical frame, regional map of losses, SWOT analysis.	▪ Optimization methods: Fuzzy logic, Linear programming.
Step 6: The elaboration of a possible model and scenario of the development		
	▪ Brain storming, collective notebook (CNB) procedure, Rohr Bach's 635 method, METAPLAN method, logical frame, SWOT analysis.	▪ On macro models: LINE model, societal accounting matrix.
Step 7: Impact study		
▪ Proposal for the measuring of the development impacts, possible environmental, economic changes and societal reactions	▪ SWOT analysis, regional map of losses. ▪ Mathematical statistical methods: cluster analysis.	▪ Presentation on maps and spatial informatics methods ▪ Methods based on macro models:(ECO-line model, Socio-line

Description	Applicable methods	
	Group methods	Methods based on
		model, LINE model, input-output approach, societal accounting matrix.)
Step 8: Suggestions for a system of instruments and institutions suit the objectives		
▪ Financial resources ▪ Non-financial instruments ▪ The organizational frame and human resources of strategic implementation	▪ Collective notebook (CNB) procedure, Rohr Bach's 635 method, METAPLAN method, logical frame.	▪ Optimization methods: Fuzzy logic, Linear programming.
Step 9: Implementation		
▪ The realization of the strategy, the dividing of programs, projecting	▪ METAPLAN method, logical frame.	
Step 10: Monitoring		
▪ The elaboration of the plan to monitor the development process in favour of the realization of objectives. ▪ Making the necessary corrections because of occurred effects not expected	▪ Interviewing, logical frame	▪ On indicators: (public road indicator, complex transportation network indicator (TRANS), Hoover index.) ▪ On macro models: ECO-line model, Socio-line model, LINE model, input-output approach, societal accounting matrix.

Source: (JÓNA & TÓTH, 2012)

3.3.10. LED Projects

The following program options are typical core choices, and their selection will be dependent on local circumstances (IBRD, 2016).

a. **Improving the Local Business Investment Climate:** This is an essential component of every strategy. Measures to improve the local climate for businesses include improving processes and procedures for business registration, taxation, etc., within City Hall. These efforts should also complement and ensure consistency with reforms or measures that may be taken at the national/state level to improve the investment climate.

b. **Investment in Hard Strategic Infrastructure:** Improving the built environment for businesses including transport infrastructure (roads, rail, air and sea) and utilities (industrial and potable water, waste disposal, gas and electricity, and telecommunication systems).

c. **Investment in Sites and Premises for Business:** Enabling the provision and availability of land and sites, premises and units for productive economic and business development (sites and premises, and managed workspace and business units).

d. **Investment in Soft Infrastructure:** Improving the commercial environment for businesses through, for example, regulatory reform, skills training and business-focused education, research

and development, "one-stop shop" advisory services, business networking, guidance to accessing capital and finance sources.

e. **Encouraging Local Business Growth:** Enabling the provision of advice, technical support and resources to enable existing local business to grow with the goal of retaining and strengthening existing local business.

f. **Encouraging New Enterprise:** Enabling the provision of advice, technical support, information and resources to support individuals set up new business.

g. **Promoting Inward Investment:** Attracting business to a community from elsewhere in the country or from other countries. This option needs careful weighing of the costs and benefits. It can be risky and at most should only form a targeted part of a broader LED strategy.

h. **Sector (and business cluster) Development:** Focuses on facilitating linkages and interdependence amongst firms (including suppliers and buyers), supporting services (including training institutions and banks) in a network of production (and sale) of products and services. Local governments can collaborate locally and regionally to become facilitators of industry networking and catalysts/brokers to bring the actors together.

i. **Area Targeting/Regeneration Strategies:** Addressing specific area-based problems such as regenerating a run-downtown centre, a declining commercial zone or neighbourhood. Fostering promising growth opportunities where market potential is already demonstrated by emerging private investment (e.g., along area transport corridors).

j. **Integrating Low-Income or Hard-to-Employ Workers:** Programs to mainstream the poor and disadvantaged populations into the economy. Ensuring that new growth industry extends employment opportunities to low-income workers (including those in the "informal sector") and that such workers have access to, and can take advantage of, opportunities for advancement.

4. MATERIAL AND METHODS

This chapter offers an intensive discussion on the materials and methods that were used to collect and analyse data on the effects of climatic hazards on LED. The discussion covers the research design of the study area, methods employed to collect data and analyse the data for this research. It discussed the data collection technique, instrument design, data analysis and limitations of the research.

4.1. Research Philosophy

In social science, two key philosophies are known, namely: the positivist and interpretivist values (BABBIE, 2013). The positivists claim that reality exists in the world, and this can be observed, measured and described from objective view stand without deducing from the circumstantial evidence and reasoning with the phenomenon under study. However, interpretivists also believe that reality is subjective in the mind of the person, and it is interpreted differently by different people (SARANTAKOS, 2005). This research was situated on the positivist approach of social research. Also, the research used both qualitative and quantitative research approaches. Qualitative research is the "nonnumerical examination and interpretation of observations to discover underlying meanings and patterns of relationships" (BABBIE, 2013). In this case, the research observed the LED projects mitigating the climate change hazards. However, quantitative research is the numerical representation and manipulation of observations to describe the phenomena that those observations reveal. Since the quantitative method can give precise and concise answers to problem statements using numerical values or percentages, it has become more advantageous and common to use in social science research like this thesis.

4.2. Research Design

Descriptive design was employed in this work. This type of design does not allow the key variables to be manipulated, but it describes and interprets what exists in the field of study. According to (CRESWELL, 2009)"descriptive research design is concerned with conditions or interrelationships that exist, opinions that are held, processes that are going on, effects that are evident and trends that are developing''.

(LENCUCHA, et al., 2010)defines research design as an organized process through which the problem at hand or under study is solved by careful planning, organization, collection and analysing of the available data into synthesised useful information. The research employed a descriptive research design. Descriptive research design is useful in the descriptive process for the phenomenon under observation (MAXFIELD & BABBIE, 2018).

(LENCUCHA, et al., 2010) further adds that elaborative research design provides a description of situations in their natural phenomenon. Descriptive research design was considered suitable in this research since it will help in analysing the effects of hazards from the global and regional scale using secondary data sources.

4.3. Methods description

The research has applied the **deductive approach** to define the local economic development policies to adapt the climate change hazards. Induction is defined as the process of observing phenomena and collecting data about them to arrive at general principles and holistic relationships, and the inductive approach moves from the part to the whole or from the specific to the general, where he begins to identify the particles and generalizes to the whole and the induction is divided into two parts (complete induction and incomplete induction).

Table 8: Research Questions and methodologies Matrix

Hypotheses	Research Questions	Research methodologies	Research Tools	Chapter
Why the local economic development is the best approach to achieve the development in the regions, adapting climate change hazards?				
There is a higher likelihood that Egyptian institutional/ governor systems have not been ready for handling the complexity of climate change hazards.	What are the kinds and types of climate change hazards in Egypt?	Deductive	Theory& Operationalization	3.1 3.2
There is likelihood that Egypt has no LED policies currently applicable to combat climate change hazards.	What are the local economic development policies that provide the competitiveness?	Deductive	Theory& Observation	3.3
The application of LED is more likely to be the most appropriate approach to adapt climate change.	How to develop the LED process to achieve a real development in the regions?	Comparing case studies	Operationalization	5.1
Applying LED is not the only proper answer to climate change but also to improve solving the social-economic problem and sustainable development.	How conceived policies can deal with the current development and planning limitations of the Egyptian contexts?	Analytical	Observation	5.2 5.3

Source: The author's edition

Accordingly, the historical inductive approach is used to present developmental concepts and policies, and it is also used to extrapolate project objectives and applications for different sectoral

levels. The deductive approach to derive development policies to adapt to climate change, to deduce the policies pursued through global experiences.

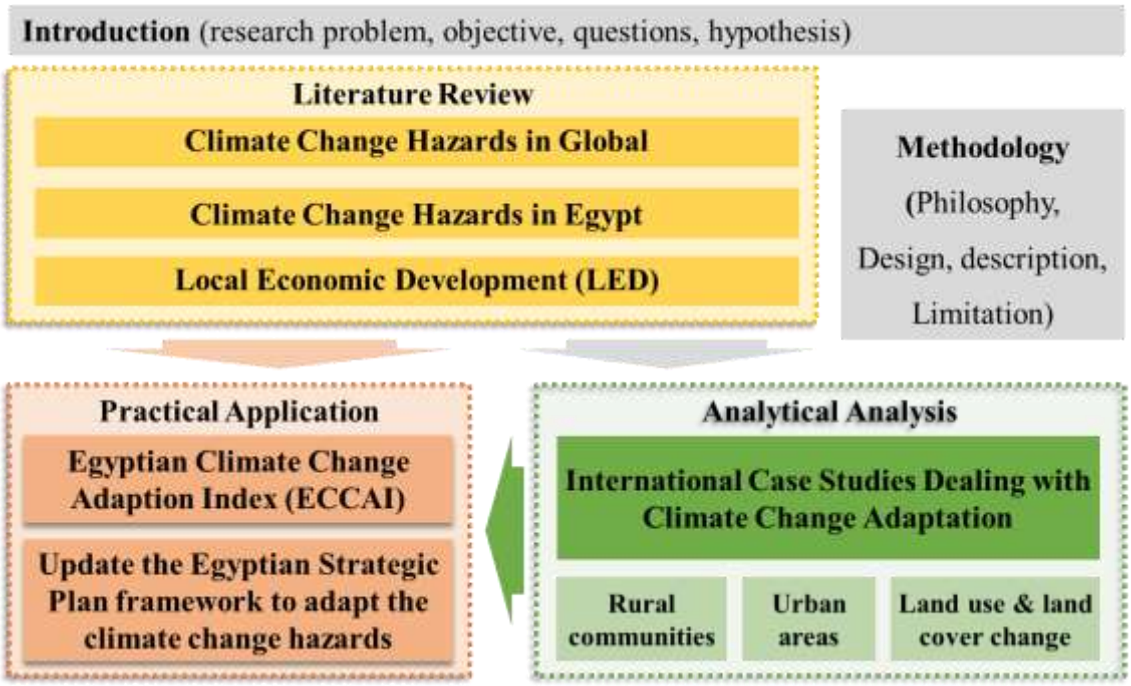


Figure 11 Research Methodology chart
Source: Author's edition

4.3.1. Climate change hazards in Egypt

In the course of elaboration of the present study the research methodology's applied was the interpretation and understanding in a comprehensive way for what are the adaptation policies for climate change hazards in Egyptian regions according to the administrative laws. The novelty of our examinations also derives from the fact that as far as I know it, there has not been any research on this issue to determine the mitigation policies on the Egyptian regions from the legality perspective. The main method was qualitative research study through documents and reports reviews such as the administration laws and environmental reports of Egypt. On the aim of developing and acceptance of adapting inquiry as understanding deepens and situations change; analysing existing data -inductive analysis- involve in the details to discover important patterns, themes, and interrelationships to investigate the effective policies through theoretical perspective. At first, I had an overview on the climate change hazards in Egypt. Next, I determined the major environmental issues in Egyptian administration levels. Finally, discussed about certain policies to adapt and mitigate climate change within Egyptian regions.

4.3.2. Local Development Economic

Here' the state of the research methodology, which is aiming to find the policies that important for developing the communities. Climate change is not only a global or national challenge, but its

consequences will have severe impacts on the socio-economic development of sub-national geographic and administrative structures, such as regions and towns. That means that climate change will also have ramifications on LED initiatives. In this chapter it is investigated if LED stakeholders perceive climate change to be a threat to the socio-economic development of their territories.

4.3.3. Climate change case studies

There are three main categories for the case studies related to the urban/physical status. Therefore, the settlement scale are two main domains which are the rural communities and the urban areas, and for the larger scale and different connections land use change would be the related response.
With the use of analytical tools in the applied part, and the following table shows the research methods and tools used.

4.4. Limitation of the research

Due to the Pandemic Situation, the research design was altered, and the researcher opted for secondary data sources as it was impossible for field data collection as it was originally planned. The secondary data sources used for the descriptive analysis were collected from the IPCC and other secondary literature. Sources of the secondary data were used instead of proposed methodology which aimed to apply the Delphi Method.
The deviation from the original plan of using the Delphi Method resulted in change of the research outcome where the results are presented in the form of good practices and the Egyptian framework for the territorial mitigation and adaptation to the climate change hazards.

5. DISCUSSION AND RESULTS

This chapter presents an elaborate discussion on case studies where adaptation good practices have been successfully taken place at different levels of governance and in different sectors of the economy.

5.1. Case studies

There are three main categories for the case studies related to the urban/physical status. Therefore, the settlement scale are two main domains which are the rural communities and the urban areas, and for the larger scale and different connections land use change would be the related response.

5.1.1. Case study, Climate Change in Rural communities in greater Mekong subregion – A framework for Assessing vulnerability and adaptations (May 2014)

The main focus highly dependent upon natural resources, face particular obstacles in responding to climate change that increase their vulnerabilities to its impacts. (Asian Development Bank, 2014)

The following is a summary of key messages:

Figure 12 Greater Mekong subregion Map

Source (Asian Development Bank, 2014)

1. Climate change planning requires a shift from a "predict-then act" approach to a "no regret" approach. It requires an understanding of vulnerabilities and investments in resilience that would be justified in a broad range of climate scenarios or even in the absence of climate change. It is independent of detailed climate forecasts.
2. The vulnerability of communities to climate change must be considered within a wider socio-economic context. Because climate change can change over decades, socio-economic change can have a larger impact on communities in a much shorter period of time, potentially reversing

a vulnerable environment. It is essential for climate change vulnerability assessments to analyse socioeconomic dynamics.

3. To guide community development planning, the Climate Change Vulnerability assessment framework should be as practical as possible. The framework should be accessible to diverse users and applicable to local conditions. This requires a balance between the use of scientific information (such as climate projections, crop model outputs, etc.) define context and a simple step-by-step approach that allows non-technical to apply the framework in a community context. A structure that does not include scientific information is less reliable, and too technical can be less user-friendly and replicable, particularly for community applications.
4. Participatory approaches are critical to the assessment of climate change vulnerability at the community level. Participatory tools help fill information gaps and inform community concerns about climate and non-climate issues. Community participation in the assessment process offers a collaborative visualization of future scenarios and a selection of contextual adaptation options. It will also give rise to increased interest in implementing adaptation strategies.
5. Ecosystem-based and community-based approaches required to develop a climate change adaptation strategy for natural resource dependent communities. Vulnerability assessments should consider the potential impacts of climate and non-climate risks not only in the agricultural sector itself, but also on the broader ecosystems that support agricultural production and other aspects of community life. The role of ecosystems and associated services in the livelihoods of rural communities must be analysed.
6. The adaptation strategy should be mainstreamed into local development plans. The update ensures that development plans do not increase vulnerability and are in a position to meet their objectives and achieve milestones in the current and future climate. Points of entry for discounting should be determined when developing adaptation strategies.

5.1.1.1. The principal outcomes of the study

1) A framework and methodology for participatory assessment of climate vulnerability and adaptation of rural communities within the greater Mekong subregion (GMS).
2) The vulnerability and socio-economic profiles of selected communities at study sites,
3) Assessments of climate change risks in selected communities.
4) Determining accommodation options for selected communities.

The purpose of the report is to stimulate discussion between practitioners and researchers in order to enhance the evaluation framework as a tool to support climate change adaptation planning in the GMS. The report begins with an overview of agriculture, rural communities and climate change

in the GMS. It then presents the study sites followed by a discussion of the assessment framework, including a step-by-step description of how it was applied. Findings from the evaluation are then presented before the report concludes with key recommendations and next steps. (Asian Development Bank, 2014)

5.1.1.2. Key Concepts

The two key concepts employed in this Case Study are "vulnerability and adaptation."
According to the IPCC, climate change vulnerability refers to "the degree to which a system is susceptible or unable to cope with the adverse effects of climate change, including climate variability and extreme events." Vulnerability can also be seen as the underlying vulnerability to harmful shocks, disruptions or stresses, rather than the likelihood or expected manifestation of those shocks themselves. In simple terms, vulnerability can be viewed as the likelihood of harm. (E.g., a coastal community is most vulnerable to sea level rise and cyclones than a community far from the coast. Likewise, a community that depends on agriculture is more vulnerable to droughts and floods than a community with greater access to non-agricultural income opportunities.)
Vulnerability of an individual, a community or a system to climate change is determined by three components: Exposure; Sensitivity; and Adaptive Capacity.
The IPCC defines adaptation as "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects." In essence, climate change adaptation is about reducing vulnerability to future climate risks.
Vulnerability can be decreased by diminishing presentation to future impacts and risks, reducing sensitivity to future impacts and risks, and increasing adaptive capacity to deal with future impacts and risks. Adaptation measures may be infrastructure-based (such as building a sea wall) and ecosystem-based (such as mangrove restoration to relieve storm surges). These measures can be complemented by actions focusing on information sharing, capacity building and policy improvement (such as changes in land zoning laws), sometimes referred to as "soft" adaptation.
As climate change adjustment in this think about is concentrate on individuals, vulnerability needs to be considered in socioeconomic terms. "Socioeconomic vulnerability" is an aggregate measure of human welfare that integrates environmental, social, economic and political exposure to a range of harmful perturbations, including climate change. In other words, an individual, a community, or a system can be vulnerable to climate change due to socioeconomic factors, including geographical location, demographic profile, economic conditions, and livelihood strategies.
Based on these concepts of vulnerability and adaptation, the study aimed to assess how rural communities may be vulnerable to climate threats, both now and under future conditions. Non-climate changes—such as infrastructure developments, changes in land use planning, fluctuating

commodity prices, changing demographics—could affect both the exposure and adaptive capacity of the communities and the agroecosystems that support them. Since the climate changes relatively slowly over decades, socioeconomic changes may have a larger impact in a much shorter timeframe, potentially changing the vulnerability context completely. This is often likely to be the case within the fast-changing GMS; in this manner, it is pivotal to address financial elements as a fundamental portion of a climate alter vulnerability Evaluation. (Asian Development Bank, 2014)

5.1.1.3. Assessment Approach

In its Fourth Assessment Report (AR4), the IPCC identified five approaches to climate change impact adaptation and vulnerability (CCIAV) assessments:

1) impact assessment.
2) vulnerability assessment.
3) adaptation assessment.
4) integrated assessment.
5) risk management-based assessment.

This is considering building on these approaches, defining a coordinate assessment framework suitable for community level application. Particularly, the integrated framework combined the risk management and vulnerability approaches. The combination was both necessary and practical for understanding threats to rural communities, which result both from climate variability and change and from non-climate risks. The integrated approach is a simplified way to understand the current risk and vulnerability of the communities and use climate projections as information to determine risk and vulnerability. The study determined the current context by considering socioeconomic conditions and key climate threats that have already affected the communities.

In this way, the longer-term context of the think about destinations was created as a premise for assessing future vulnerability. Long-standing time setting was based on the desire of results of progressing and predictable advancement plans and socioeconomic changes, as well as a changing future climate. Based on the understanding of vulnerability in a conceivable future setting, adaptation was then formulated as a strategy which could be mainstreamed into local development plans. An emphasis on mainstreaming ensures that development plans will not increase vulnerability, while achieving the development goals and targets under the current and future climate, based on currently available knowledge.

The study team applied the integrated approach through a participatory process. Vulnerability of the communities and livelihood groups was assessed using Participatory Rural Appraisal (PRA) tools including hazard mapping, livelihood calendar development, household surveys, and group

discussions. The PRA-based approach made a difference recognize the communities' current adapting methodologies and their appropriateness to future climate alter scenarios. Subjective data collected from the think about communities were complemented with climate projection information in order to get it each community's current and future chance profile and create hazard administration techniques. Drawing on this data, community agents and government authorities worked together in a workshop setting to recognize potential adjustment mediations for each of the consider sites.

5.1.1.4. Assessment Steps for integrated approach

The study has applied the integrated approach through the following steps:

Step 1: Assessing the current socioeconomic context.

The study has examined the current context of the communities, focusing on the agricultural system and different livelihood groups. To determine the context, the study team collected data on the communities' basic socioeconomic conditions, agricultural production, and livelihood strategies. Methods of data collection included the review of secondary data sources (such as online community databases), household surveys, and interviews with key informants (such as commune/village leaders and members, government officials, and patriarchs) to fill data gaps.

Step 2: Assessing current risk and vulnerability.

The study has determined the communities' current vulnerability to climate risk and other significant shocks by assessing the vulnerability (exposure, sensitivity, and adaptive capacity) of agricultural systems and livelihood groups within the communities. For this step, the study team gathered data on key climate and non-climate risks and how these risks have affected the communities. The team also assessed how past and current coping mechanisms were and are able to respond to the risks, and how they could inform future adaptation options. Methods and tools employed at this step included participatory group work to develop seasonal livelihood calendars, conduct hazard mapping, determine historical timelines of key events, and elicit indigenous knowledge for risk management. The study team used the outcomes of these discussions to develop vulnerability and adaptation screening matrices.

Step 3: Formulating a plausible future.

The study has formulated a plausible future context for the communities by assessing the potential consequences of foreseeable changes in socioeconomic conditions, based on an analysis of development plans and changes in key climate risks. The team chose a future climate scenario from downscaled climate projections, developed by SEA START RC, to form the basis of the climate risk assessment. The chosen scenario represented a future with "big change" in the climate pattern as it would better stimulate visualization and discussion. Under the big-change scenario, the team

developed temperature and rainfall-based climate indicators to assess the potential impacts of climate change on agriculture and different livelihood groups in the studied communities.

Step 4: Assessing future risk and vulnerability.

The study has assessed changes in the vulnerability profile of the agricultural system and livelihood groups, which may be altered by socioeconomic changes and by climate change. While Step 3 looked at how the future context might change, here the focus was on understanding how the communities' vulnerability profile might change in the new climate and socioeconomic context. Specifically, the team assessed community vulnerability to increased risks associated with more severe and frequent floods and droughts. The assessment was conducted for four farming systems in Lao PDR, for three farming systems in Vietnam, and for a range of different crops (under the same farming system) in Thailand. The study has also sought to understand how socioeconomic changes may affect the vulnerability profile of the communities under a future climate pattern. The team considered socioeconomic changes such as new infrastructure developments, changes in conservation policy and land use plans, government agricultural policy, and new economic opportunities in the location.

Step 5: Formulating an adaptation strategy.

The study has identified an adaptation strategy that could help communities minimize future vulnerability. For this step, the study team held multi-stakeholder workshops with community representatives and government officials from the study areas. Workshop participants reviewed results of the vulnerability assessments, verified key findings, and discussed future livelihood options as part of a local risk management strategy.

Step 6: Identifying options to operationalize the adaptation strategy.

The study has led an examination of options to operationalize the adaptation strategy. They evaluated these options for benefit, feasibility, and suitability, and identified the enabling and critical success factors. To do this, participants in the workshop were divided into two subgroups: The Policy and Planning Subgroup and the Community Subgroup. The Policy and Planning Subgroup focused on adaptation options that need government intervention (e.g., subsidies, incentives to change land and water management practices). The Community Subgroup considered adaptation options that can be implemented by households and communities (e.g., new crop varieties, improvement to land and water management systems, rice bank, community fishponds, village development funds). The Policy and Planning Subgroup developed a "policy matrix" for government consideration, while the Community Subgroup looked at adaptation options for each livelihood group. (Asian Development Bank, 2014)

5.1.1.5. Case's Recommendations

The following eight recommendations suggest ways in which the study approach and methodology can be improved. (Asian Development Bank, 2014)

- **Strengthen socioeconomic analyses:** As socioeconomic changes significantly influence local livelihoods along with climate change, development scenarios used for climate vulnerability assessments must be informed by comprehensive socioeconomic analyses. These analyses need to project socioeconomic changes that will affect human communities and natural ecosystems over near, medium, and long terms. future studies could use multiple socioeconomic scenarios to better address uncertainty with long term time scales. Effective socioeconomic analyses require improved baseline data as well as the combination of quantitative and qualitative research techniques.
- **Apply multiple climate scenarios:** just one climate scenario that represented a "big change" in the climate pattern. Future studies would be strengthened by applying multiple climate scenarios to inform the discussion on alternative futures and to test the robustness of adaptation strategies. In addition, improvements are needed to enable regional climate projections to be more confidently applied to local scales.
- **Integrate community-based adaptation (CBA) and ecosystem-based adaptation (EBA) approaches**: considered agroecosystems within the immediate study sites and did not analyse potential climate impacts on broader forest ecosystems that also support community livelihoods. As a result, adaptation measures to protect biodiversity and ecological services that support local livelihoods were not directly considered. Future assessments need to better understand the role of forest ecosystems in supporting agriculture livelihoods to promote more effective resilience strategies. This could be achieved by integrating CBA and EBA in the assessment.
- **Improve participatory approaches**: Community members appeared to have great difficulty in visualizing "what things might be like" in the medium and long terms. Therefore, many of the adaptation options proposed during the consultation workshops focused on short term measures to current climate risks. Future studies could improve the participatory approach to identify adaptation options. Communities would benefit from new techniques and approaches to help them better visualize future scenarios and understand the longer-term implications of adaptation options.
- **Integrate site specific crop model simulations where possible**: Future studies will need to better examine the potential impact of climate change on agriculture productivity. However, the need for site specific data to parameterize the crop models made it impractical to undertake crop modelling at all sites. If possible, future assessments should secure adequate resources to collect more site-specific data necessary for crop model simulations.

- **Integrate an economic analysis**: The study did not analyse and compare costs and benefits of different adaptation options. Before investments are made, adaptation options should be subjected to an economic analysis to understand costs and benefits of adaptation as well as the cost-effectiveness of different options.
- **Analyse the broader policy and planning environment**: large scale changes in the broader policy and planning environment also influence risks and adaptation options for communities. Understanding this context will help identify constraints and opportunities for community adaptation more effectively. Future studies should examine the policy and planning environment nationally and provincially, as well as locally.
- **Upscale to regional studies**: As only a small sample of communities was included in the study, its specific findings cannot be generalized to the broader GMS. To move to a regional level, future studies will need to include more landscapes and many more communities. Such studies will need to target a representative set of communities carefully stratified based on biological, geographical, and climatic factors; current and future climate risks; development pressures; and livelihood, population and demographic features.

5.1.2. Case study, Climate Change in Urban areas- Adaptation and the possibilities and constraints in low- and middle-income nations

As cities have become early responders to climate change challenges and opportunities due to large growing population, and extensive infrastructure system. (SATTERTHWAITE, et al., 2007) Hundreds of millions of urban dwellers in low- and middle-income nations are at risk from the direct and indirect impacts of climate change. Without effective, locally driven adaptation, there will be very serious consequences for them and for national economies. However, there are limits to the damage or devastation that adaptation can prevent and very serious deficiencies in the institutional capacities for urban adaptation in most low- and middle-income nations. This makes it more urgent that global agreements are reached to achieve the needed cuts in greenhouse gas emissions.

But there are very substantial synergies between successful adaptation to climate change and successful local development. Indeed, reductions in poverty, including improvements in housing and living conditions and in provision for infrastructure and services, are central to adaptation. Successful, well-governed cities greatly reduce climate-related risks for low-income populations; unsuccessful, badly governed cities do not and may greatly increase such risks.

Urban vulnerabilities: The scale of the devastation to urban populations and economies caused by extreme weather events in recent years highlights their vulnerabilities. Worldwide, there has been a rapid growth in the number of people killed or seriously impacted by storms and floods and also in the amount of economic damage caused; a large and growing proportion of these impacts are in urban areas in low and middle-income nations. Climate change is likely to have been a factor in much of this, but even if it was not, it is proof of the vulnerability of urban populations to floods and storms whose frequency and intensity climate change is likely to increase in most places. Climate change will also bring other less dramatic stresses such as heat waves and, for many urban areas, reductions in freshwater availability, also sea-level rise for all coastal cities. Without major changes in the ways that governments and international agencies work in urban areas, the scale of these impacts will increase.

5.1.2.1. The direct and indirect impacts of climate change

The vulnerability of urban populations in low- and middle-income nations focuses on direct and indirect impacts of climate change. This is for three reasons. (SATTERTHWAITE, et al., 2007)

a. The scale of the population at risk: An expansive and developing extent of those most at hazard from climate change lives in urban regions. More than a third of the world's add up to populace lives in urban ranges in low and middle-income countries. These countries presently have

most of the world's urban populace and most of the biggest cities. Their urban facilities will house most of the development within the world's populace over another few decades and how typically arranged for and overseen has exceptionally expansive suggestions for the degree to which adjustment limits the costs of climate change. Since 1950, there has been a sevenfold increment within the urban populaces of low- and middle-income countries and a much-increased concentration of individuals and financial exercises in low-lying coastal zones or other ranges at chance from flooding and extraordinary climate occasions.

In fact, Africa, long considered a rustic landmass, has two-fifths of its populace in urban zones – and a bigger urban populace than Northern America. Moreover, the past decades, has brought an awfully expansive increment within the number of urban tenants living in destitution, missing arrangement for the fundamental foundation and administrations that ought to ensure them from natural wellbeing risks and fiascos – and which ought to shape the premise for assurance from most impacts related to climate alter. Around one billion urban tenants live in poor-quality, packed lodging in "slums" or casual settlements, and a tall extent of these settlements are on destinations at chance from flooding or avalanches.

b. The economic costs without adaptation: Effective national economies depend on well-functioning and strong urban centres. Critical activity is required presently both to address urban centres' current vulnerabilities to extraordinary climate and to construct into extending urban centres security from likely future changes. Most buildings and framework have long lives; what is built presently has to be able to manage with the climate change-induced dangers over the following few decades. Ninety-nine % of families and businesses in low-income countries don't have catastrophe protections.

c. The vulnerability of urban populations to climate change: As well small consideration has been given to the helplessness of urban populaces to climate alter – and particularly to the defencelessness of their low-income populaces. The require for more consideration to this does not infer that provincial populations' vulnerabilities ought to be given less consideration; undoubtedly, a tall extent of the individuals whose lives and vocations are most at chance from climate alter are rustic tenants. But the developing writing on adjustment gives distant more consideration to farming and to country vocations than to urban economies and jobs. It is additionally improper to consider rustic and urban zones independently, given the reliance of urban centres on country biological administrations, the significance for numerous urban economies of rustic request for products and administrations, and the dependence of much of the provincial populaces on urban centres for get to markets, merchandise and administrations.

5.1.2.2. The local nature of successful adaptation

Adaptation to climate change requires local knowledge, local competence and local capacity within local governments. It needs households and community organizations with the knowledge and capacity to act. It also requires a willingness among local governments to work with lower-income groups.

For most prosperous and well-governed cities, adaptation to the likely risks from climate change for the next few decades does not appear problematic. This centres on adapting buildings and infrastructure to these increased risks; working with population groups and settlements most at risk to find solutions that serve them; and good disaster preparedness. But you cannot adapt infrastructure that is not there.

Hundreds of millions of urban tenants have no all-weather streets, no channelled water supplies, no channels and no power supplies; they live in poor-quality homes on wrongfully possessed or sub-divided arrive, which represses any speculation in more strong buildings and regularly avoids framework and benefit arrangement. A tall extent are inhabitants, with exceptionally restricted capacities to pay for lodging – and their proprietors have no motivation to contribute in better-quality buildings. Most low-income urban tenants confront genuine imperatives in any plausibility of moving to less perilous locales, since of their got to be near to income-earning openings and since of the need of elective, well-located, more secure sites.

Around the world, numerous of the urban centres that have to be adjust most to dodge genuine (and possibly disastrous) impacts have expansive insufficiencies in all of these preconditions for fruitful adjustment – and for tending to the advancement insufficiencies that support their need of adjustment capacity. Most of the hazard to urban populaces is related with the inadequacy of nearby governments to guarantee arrangement for framework and for fiasco hazard decrease and catastrophe readiness – or their refusal to work with the tenants of "illegal settlements", indeed when a third or more of the populace (and workforce) live in these.

This makes large sections of the urban population very vulnerable to any increases in the frequency or intensity of storms, floods or heat waves, and to increased risk of disease, constraints on water supplies or rises in food prices – which in wealthier, better-governed cities are usually easily adapted to. You cannot fund a pro-poor adaptation strategy if the city government refuses to work with the poor, or sees their homes, neighbourhoods and enterprises as "the problem". It is difficult to conceive of how to achieve the needed adaptation in the many nations that have weak, ineffective and unaccountable local governments; some also suffer from civil conflicts and have no economic or political stability. Building the needed competence, capacity and accountability within local governments in high-income nations was a slow, difficult, highly contested process that did

not have to deal with climate change and that was much helped by prosperity and economic stability.

The vulnerability of low-income urban dwellers to climate change is often ascribed to their poverty but it is far more the result of failures or limitations in local government. These in turn are linked to the failure of national governments and international agencies to support urban policies and governance systems that ensure needed infrastructure is in place, along with preparedness for extreme weather and, where needed, sea-level rise. Most international agencies have chosen to avoid investing in urban initiatives.

Building local capacity: Most national governments and international agencies have had little success in supporting successful local development in urban centres. They need to learn how to be far more effective in this and in supporting good local governance if they are to succeed in building adaptive capacity. Within international development assistance agencies, there may be a growing recognition of the importance of supporting "good governance", but this rarely focuses on the importance of good local governance. Even if it does, the institutional structures of most international agencies limit their capacity to support this. Meanwhile, the international agencies that are leading the discussions on how to support adaptation to climate change do not understand the political and institutional constraints on successful local adaptation. There is also a tendency to assume that as long as new funding sources for adaptation are identified, adaptation can take place.

Adaptation needs the attention of all sectors: There are clear and obvious linkages between adaptation to climate change and most other areas of development and environmental management.

Housing and infrastructure policies and housing finance systems that support better-quality housing and provision for water and sanitation (which has to include provision for drainage) is one key part of adaptation; achieving this will also require more competent, accountable urban governments. Addressing health issues means not only better health care available to all (which should include emergency response capacity for extreme weather events) but also reducing environmental health risks. This should also reduce many of the increased health risks that climate change is likely to bring. Adaptation also has to focus on what is needed to reduce the vulnerabilities of particular groups to particular aspects of climate change – for instance, the particular vulnerabilities of infants and children and their careers and of older age groups. This too needs more competent and accountable urban governments. For any growing urban centre, a large part of urban planning should focus on providing lower-income groups with safer, legal alternatives to informal settlements by increasing the supply and reducing the cost of land for housing and supporting infrastructure on suitable sites. This too is at the core of city adaptation to changing risk patterns related to climate change. So too is the kind of land use management that protects and enhances

natural buffers and defences for cities and their surrounds. Getting the needed collaboration and "joined-up-thinking" between so many different departments within national and local governments will be difficult.

Clearly, careful attention is needed in each nation and city to the contributions that private enterprises and investments can make to adaptation. This obviously includes more attention to adapting their own premises. It also includes the many enterprises that can offer goods and services that help individuals, households and governments adapt. Extending appropriate financial services to lower-income groups can help them save and invest in safer homes and better livelihoods, all of which generally increases adaptive capacity. Insurance can also protect households and enterprises – and if appropriately structured, encourage risk reduction. But care is needed not to overstate the potential. Climate change will increase risks and most of those who face the most serious risks have very limited incomes. If local governments do not act to reduce risks, insurance premiums will be unaffordable – or no insurance will be on offer. Most of the financial safety nets that work for low-income groups are ones they set up and manage themselves. The potential of private sector investments and public–private partnerships to address urban development issues has long been overestimated; there is a danger that it will also be overstated for funding adaptation. An analysis of private investment flows into urban areas in low- and middle-income nations shows their potential to help fund some forms of infrastructure improvement and adaptation – but not the infrastructure most in need of improvement and adaptation, and not in most of the nations and cities where adaptation is most urgently needed.

Local precedents show possibilities and constraints. There are innovative urban policies and practices underway, which show that adaptation is possible and can be built into development plans. These include examples of community-based initiatives led by organizations formed by the urban poor that greatly reduce their vulnerability to storms and floods – at very low unit cost. There are also good examples of local governments working in partnership with their low-income populations to improve housing conditions and infrastructure provision, or to develop new good-quality settlements. These include many partnerships between local governments and federations formed by slum and shack dwellers. There are also more post-disaster responses that recognize the competence and capacity of those displaced to rebuild their lives, including their homes and livelihoods if the organizations that respond to the disaster allow them to do so.

But these are the exceptions. Few government bodies or international agencies recognize the competence and capacity within the populations they identify as "most at risk". What is needed is consideration of how local development + adaptation innovations, comparable to those noted above, can be encouraged and supported in many more places. This is not replication, because

each urban centre needs adaptation that responds to particular local conditions and capacities and that overcomes particular local constraints.

There are nations where the competence and accountability of city and municipal governments have increased considerably, providing the needed adaptive capacity – but most are in middle-income nations. And even here, it is difficult to get much attention to climate change adaptation from city governments and most national ministries and agencies within their urban policies and investments. Most have more pressing issues, including large backlogs in provision for infrastructure and services, and many urban dwellers living in poor-quality housing. They are also under pressure to improve education, health care and security – and seek ways to expand employment and attract new investment. Even competent and accountable national and local (city and municipal) governments will not engage with adaptation to climate change unless it is seen as supporting and enhancing the achievement of development goals.

There is also the important shift underway in many agencies that focus on disasters away from disaster response to disaster preparedness and disaster risk reduction. This has great relevance for adaptation to climate change but, as yet this has not influenced many city and national policies.

Global issues: Those discussing adaptation must remember the profound unfairness that exists globally between those who cause climate change and those who are most at risk from its effects. With regard to people, it is the high-consumption lifestyles of the wealthy (and the production systems that meet their consumption demands) that drive climate change, but it is mostly low-income groups in low- and middle-income nations, with negligible contributions to climate change, that are most at risk from its impacts.

With regard to nations, the very survival of some small-island and some low-income nations (or their main cities) is in doubt, as much of their land area is at risk from sea-level rise, even though they have contributed very little to the global warming that drives it. With regard to cities, most larger companies and corporations can easily adjust to the new patterns of risk induced by climate change, and they move their offices and production facilities away from cities at risk. But cities cannot move. And all cities have within them the homes, cultural and financial assets and livelihoods of their inhabitants, much of which cannot be moved.

5.1.2.3. Tackling policies

What will happen to international relations as increasing numbers of people lose their homes, assets, livelihoods and cultural heritages to climate change-related impacts – especially when the main causes of this are strongly associated with the lifestyles of high-income groups in high-income nations, and the reason for their loss is the failure of high-income nations to cut back their emissions?

What needs to be done? The key issue is how to build, in tens of thousands of urban centres, resilience to the many impacts of climate change that:

- supports and works with the reduction of risks to other environmental hazards, including disasters (there are strong complementarities between reducing risk from climate change, non-climate change-related disasters and most other environmental hazards).
- is strongly pro-poor (most of those most at risk from climate change and from other environmental hazards have low incomes, which limits their autonomous adaptive capacity).
- builds on the knowledge acquired over the last 20 years on reducing risks from disasters in urban areas (there have been important advances here).
- is based on and builds a strong local knowledge base of climate variabilities and of the likely local impacts from climate change scenarios.
- encourages and supports actions that reduce risks (and vulnerabilities) now, while recognizing the importance of measures taken now to begin the needed long-term changes – urbanization processes have a momentum and drivers that are difficult to change, but at present these are mostly increasing risks from climate change and so can be considered mal-adaptation.
- recognizes that the core of the above is building the competence, capacity and accountability of city and sub-city levels of government and is changing their relationship with those living in informal settlements and working in the informal economy – and the importance within this of supporting civil society groups, especially representative organizations of the urban poor (this is also to avoid the danger of "adaptation" providing opportunities for powerful groups to evict low-income residents from land they want to develop);
- recognizes that government policies must encourage and support the contributions to adaptation of individuals, households, community organizations and enterprises.
- recognizes the key complementary roles required by higher levels of government and international agencies to support this (and that this requires major changes in policy for most international agencies that have long ignored urban issues and major changes in how adaptation is funded).
- builds resilience and adaptation capacity in rural areas – given the dependence of urban centres on rural production and ecological services and the importance for many urban economies and enterprises of rural demand for (producer and consumer) goods and services; and also
- builds into the above a mitigation framework (if successful cities in low- and middle-income nations develop without this, global greenhouse gas emissions cannot be reduced).

Two final points. First, it is inappropriate to conceive of "the problem" as mainly one of a lack of funding.

Certainly, new funding sources are required to address backlogs in infrastructure and services and to build adaptive capacity. But, for most urban centres, the problem is as much a lack of local government competence and capacity. The need to adapt is being forced onto nations and cities that lack the political and economic basis for adaptation, even if new funding is provided. Within discussions on climate change adaptation, there is too much focus on trying to calculate the funding needed for adaptation without recognizing the political and institutional constraints on adaptive capacity and without discussing the institutional mechanisms to get the needed funding for adaptation to those who can use it well – including community-based or grassroots-led initiatives.

Second, NAPAs (National Adaptation Programmes of Action) need to be built from city focused CAPAs (City Adaptation Programmes of Action) and locally focused LAPAs (Local Adaptation Programmes for Action). Risks and vulnerabilities in all aspects of climate change are shaped by local contexts and much influenced by what local governments do or do not do. In the end, almost all adaptation is local and, to be effective, needs strong local knowledge and strong local adaptive capacity. Certainly, for urban areas, there need to be CAPAs and, very often, smaller-scale LAPAs – especially for the settlements or areas most at risk. These, in turn, can also promote learning and innovation on how public policies and investments can work best with community-based adaptation. They also provide the practical experience on which NAPAs can be much improved.

…those systems are often connected to rural locations at great distance from urban centre.

5.1.3. Case study, Climate Change in Land Use and Land Cover Change

The research is needed to supply critical information for such assessments and models. The emphasis is on global and regional landscapes, for these are the spatial scales at which land-use and climate-change interactions occur. The most productive research areas for enhancing our understanding of global ecological changes are identified. (DALE, 1997)

5.1.3.1. Effects on communities and ecosystems

Land-use change is related to climate change as both a causal factor and a major way in which the effects of climate change are expressed. As a causal factor, land use influences the flux of mass and energy, and as land-cover patterns change, these fluxes are altered. Projected climate alterations will produce changes in land-cover patterns at a variety of temporal and spatial scales, although human uses of the land are expected to override many effects. A review of the literature dealing with the relationship between land-use change and climate change clearly shows that:
(1) Land-use change has had much greater effects on ecological variables than has climate change.
(2) The vast majority of land-use changes have little to do with climate change or even climate
(3) Humans will change land use, and especially land management, to adjust to climate change and these adaptations will have some ecological effects.
Therefore, an understanding of the non-climatic causes of land-use change (e.g., socioeconomics and politics) are necessary to manage ecological functions effectively on regional and global scales.
During the coming years, global ecological changes are expected to have major impacts on ecological, social, economic, and political aspects of human society. The ecological impacts include changes to biodiversity, productivity, migration, and sustainability. Climate and land-use changes are two major global ecological changes predicted for the future.
Heretofore, causes and consequences of human-induced climate change and land-use activities have largely been examined independently. However, climate change and land use affect each other. Land-use activity contributes to climate change, and changes in land-cover patterns are one way in which the effects of climate change are expressed (Fig. 13).
Land use refers to the management regime humans impose on a site (e.g., plantations or agroforestry), where-as land cover is a descriptor of the status of the vegetation at a site (e.g., forest or crop). Land-use effects on climate change include both implications of land- use change on atmospheric flux of CO_2 and its subsequent impact on climate and the alteration of climate-change impacts through land management. Effects of climate change on land use refers to both how land use might be altered by climate change and what land management strategies would mitigate the

negative effects of climate change. Many resources are being expended to study causes and effects of climate change.

However, there is concern that the results of these studies may not be relevant to decision makers because the research does not deal with major factors influencing climate change impacts. The Sustainable Biosphere Initiative of the Ecological Society of America therefore commissioned this paper in order to evaluate the importance of land use in considering climate change impacts.

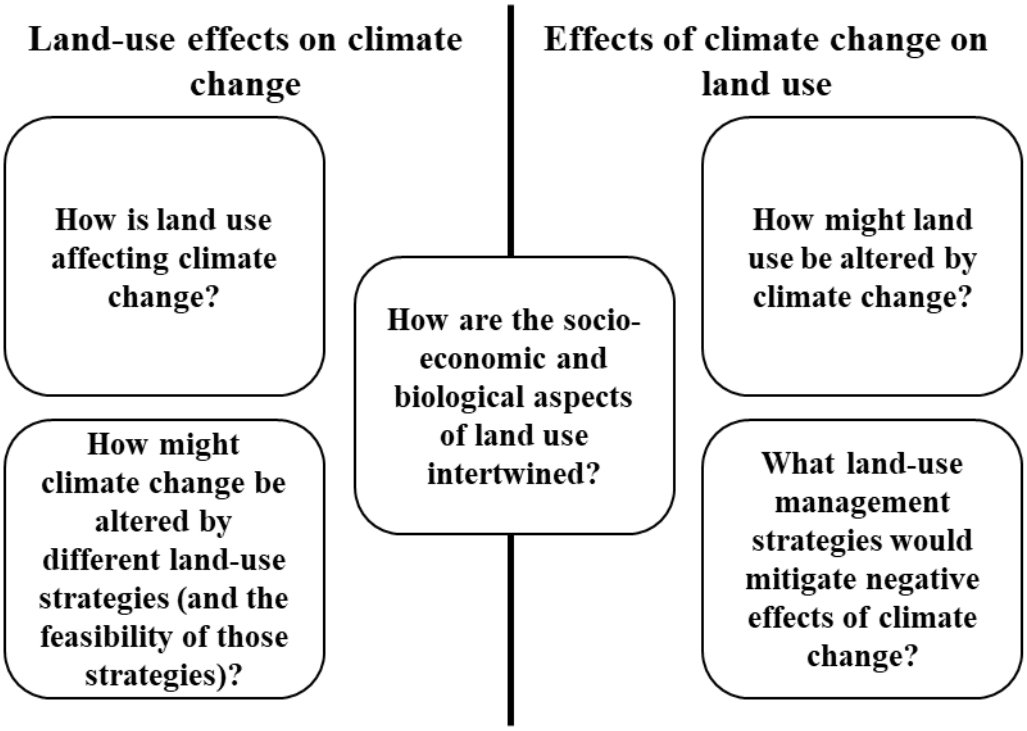


Figure 13: Relationship between land use change and climate change

Source: The author's edition based on (DALE, 1997)

5.1.3.2. Land-use contributions to climate change

Human activities influence climate change by altering the distribution of ecosystems and their associated fluxes of energy (e.g., latent and sensible heat and radiative exchanges and mass (e.g., water vapor, trace gases, and particulates). Here, the focus on how land-use change can affect those fluxes.

At the landscape scale, changes in land-cover patterns can directly impact energy and mass fluxes. For example, when large areas of forests are cleared, reduced transpiration results in less cloud formation, less rainfall, and increased drying. Simulations of the deforestation of Amazonia indicate that evapotranspiration and forests would be replaced by either desert or pasture (Dickinson 1991). Although the model results are variable, they do indicate the sensitivity of regional climate to the type and density of vegetation.

Both field studies and model simulations suggest that spatially alternating bands of transpiring vegetation with dry soil on a scale of tens of kilometres can influence atmospheric circulation and cloud formation. Because land-surface characteristics influence surface temperatures and latent heat flux, the contrasting characteristics of adjacent land-cover types can induce convection that enhances clouds and precipitation.

Increased albedo and its subsequent effects on climate also result from changes in land-surface characteristics. Changes in land cover can alter the reflectance of the earth's surface and induce local warming or cooling; generally, as albedo increases, surface temperatures decline. Desertification can occur when overgrazing of savanna vegetation alters surface albedo and surface water budget and thus changes the regional circulation and precipitation patterns. Overgrazing can also increase the amount of suspended dust that, in turn, causes radiative cooling and a decline in precipitation.

Increased atmospheric concentration of GHGs that result in global climate change is discussed at length below because (1) a wealth of data is available and (2) it illustrates how changes in particular land-cover categories can dominate the impact.

It summarizes the industrial and biotic sources of the primary greenhouse gases: carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons.

At the global scale, human activities influence the greenhouse effect by releasing greenhouse gases into the atmosphere and by changing the-patterns of carbon storage through land-use activities. The discussion focuses on effects of greenhouse-gas emissions due to land use rather than those due to industrial activities.

i. Carbon dioxide

The anthropogenic release of CO_2 has increased greatly since the industrial age began and fossil fuels began being intensively used as an energy source. Currently, 61% of the anthropogenic greenhouse forcing can be attributed to CO_2 increases.

During 1850 to 1980, fossil fuels accounted for the release of 150-190 picogram (Pg) of carbon (PgC), and land-use change accounted for the release of 90-120 PgC with land-use changes making the greater contribution prior to about 1910. The estimated world's total forested area in 1700 was 6042*106 ha. And for 1987-1990 was 4165*106 ha.

By comparing it leads to believe that >30% of the world's forests have been cleared since 1700 (not including areas that were cleared and grew back to forests). This large-scale de-forestation has resulted largely from agriculture expansion. World Resources Institute (1992) estimates that 1478*106 ha were in cropland and 3323*106 ha were in permanent pasture by 1989. These areas

constitute 11% and 25% of the world's land area, respectively, and represent increases of 2.2% and 0.1% since 1979. During that time, the area in forest decreased by 1.8% to 4095*106 ha.

Deforestation and the associated agricultural expansion are particularly important because clearing induces carbon losses from the soil and vegetation, and forests contain 90% of the carbon stored in global vegetation (calculated from the estimated biomass in forests compared to that in all vegetation using data in (WHITTAKER & LIKENS, 1973).

Carbon releases from terrestrial ecosystems that result from land-use change are difficult to quantify accurately because of uncertainties in (1) the rates of land clearing and abandonment, (2) the estimates of the carbon stored in the vegetation and soils of managed and unmanaged ecosystems, and (3) the fate of carbon subsequent to land-use changes. It is clear that the location of major land clearing and abandonment has changed with time and that the form and magnitude of the carbon released from terrestrial ecosystems have also varied.

Before 1930, the primary biotic contributions of CO_2 were from the clearing of the temperate forests in the northern hemisphere and from the losses of soil carbon because of agriculture. Some of these temperate areas are now reforested, and today's 112*106 ha of forest plantations worldwide constitute a carbon sink as the growing trees rapidly accumulate carbon. Currently, the most important changes in CO_2 storage are caused by tropical deforestation; 15.4*106 ha are being cleared each year. Although large regions of the tropics are set aside for protection from forest harvesting, the degree to which forests are protected depends on political pressures within a government, population pressures within a country, the availability of other resources to sustain the lives and livelihoods of that population, economic pressures from within and without the country, the political stability of governments, the number and ability of law enforcement agents to uphold the laws, and the respect the citizens have for the laws. These factors are unpredictable in most developing countries.

Natural wetlands can also process and transfer significant amounts of CO_2 and other greenhouse gases. The reduction of natural wetlands, largely caused by drainage for agriculture, has resulted in a reduction of a biotic source of CO_2. A computer model indicated that by 1990 28-38% of the temperate- zone carbon source had been eliminated by agricultural drainage.

Retrospectively estimating land clearing and wetland conversion has been complicated by the historic use of a large number of land-cover classification systems.

The classification system has been found changes to be the major difficulty in compiling their 100 years history of land-use changes in south and southeast Asia. A proposed vegetation classification logic for remote-sensing data and recent computer advances with geographic information systems (GIS) make estimation of potential vegetation repeatable and quantifiable. Remote-sensing imagery makes it possible to measure land-cover patterns since 1972 (when LANDSAT was first

established), and current remote sensing can detect and distinguish a diversity of land-cover types. But knowing the current and historic land cover is not enough. The amount of carbon stored in the terrestrial system also affects carbon releases, and the amount and form of carbon stored in vegetation and soils varies by vegetation type, prevailing temperature and precipitation conditions, prior disturbances, the state of recovery, and current management.

The Terrestrial Carbon Model provides a basis for ascertaining the kind and status of data needed to estimate the amount of and changes in vegetal and soil carbon. That model assumes that carbon in vegetation and soils declines with disturbances and recovers a portion of its initial value if the disturbance ceases and does not recur.

Both the remote-sensing-imagery and the Terrestrial Carbon Model approaches suffer from the same Achilles heel. They both rely on the determination of a single value to represent a vegetation type within a region. However, the basic parameters may vary from vegetation type to vegetation type more than is currently documented.

It is possible is gain an understanding of the sort of data needed to estimate carbon flux by reviewing the parameters used in the Terrestrial Carbon Model. Carbon in the vegetation has been estimated in two ways, both of which assume that carbon constitutes about half of vegetation biomass. (BROWN & LUGO, 1992) point out that ecologists typically measure biomass in pristine forests, whereas foresters typically obtain biomass estimates from large statistical samples of forests that include a variety of stand histories. Thus, the ecologists' measures of biomass are generally higher than the foresters', and the foresters' estimates characterize average conditions of existing forests more accurately.

In computer models of regional land-use change, carbon flux is modelled in a simplified manner. Carbon in "recovered" ecosystems is generally modelled as a portion of the biomass in the original system. In some cases, it is simply represented as 90% of the original value. However, recovered ecosystems may actually contain <90% of the original carbon, depending on how "recovery" is defined. In such models, carbon in crops and pastures is almost uniformly given a value of 5×106 g/ha. However, carbon content varies depending on the species planted, soils, use of fertilizers or irrigation, and prevailing climate. Even so, given economic constraints, agricultural lands are probably more similar (have less variance in biomass) than forests. In addition, the models usually assume that the time required for an abandoned system to recover is a constant regardless of vegetation type. However, based on a study of plant succession in the Eastern Amazon, Uhl et al. (1988) suggest that the time for vegetation to recover to initial biomass levels may vary from 100 to 500 years, depending on the intensity of the land use (particularly soil compaction by cattle).

In incorporating the effects of soil into assessments of vegetative cover, the spatial heterogeneity of soil properties complicates obtaining representative measures of soil conditions and maps of soil taxonomy.

Yet as Schlesinger (1991) has pointed out, soil carbon and its changes, difficult as they may be to measure, may be key factors in accurately determining carbon flux. To estimate carbon flux, a major research need is information on soil characteristics (e.g., water-holding capacity, soil depth, texture, pH, redox potential, and hydrologic regime) and the roles played by the vegetation, detritus, and other biota.

Once the carbon content of abandoned systems is determined, the rate of change in carbon storage must be established. It depends on the carbon initially in the vegetation and soils, the time to "recovery," and the carbon content of soils and vegetation of a system considered to be recovered. These factors are a function of the nature of the surface of the soil, soil depth, the carbon and nutritive content of the soil, prevailing weather conditions, slope of the soil surface, suitability for revegetation, the presence of sources of seed for regeneration of the forest, and many more conditions.

ii.Methane

Methane is a chemically active trace gas produced by anaerobic processes. Since the industrial age began, methane has grown to comprise 17% of the anthropogenic greenhouse forcing. Methane is a very powerful greenhouse gas with a radiative effectiveness that is about 9 times that of CO_2. Wetlands are the largest natural source and contribute 22% of the total release of CH_4 to the atmosphere. Any activity that disturbs the soils of these wetlands (e.g., drainage for agriculture or forestry use) can affect anaerobic processes. Rice paddies are another major source of methane, with the amount being released depending on agricultural practices (fertilization, mulching, water management, plant density, and rotations), soil characteristics, and season. The 41% increase in wetland rice production since 1951 has increased methane releases from this source. Emissions from natural wetlands and rice paddies are particularly sensitive to temperature and soil-moisture changes and may be affected by future climate changes. For example, modelling studies suggest that northern high-latitude wetlands are a potential source of methane under warmer and wetter conditions than presently occur.

Biomass burning also releases methane, and thus the increase in rates of forest cutting (much of which is subsequently burned) correlates with the increase in methane release. Emissions of methane from ruminants depend on the density of animals as well as the type of food consumed. Increases in populations of cows and sheep have occurred as elephant and bison herds have decreased, which make it difficult to calculate the changes in methane emissions. It is unclear how

much termites contribute to the methane flux because of uncertainties in the global termite population and the consumption of biomass by termites. If the termite population declines, methane from that source will correspondingly decrease. The anaerobic activity of landfills is another major source of methane to the atmosphere that increases with the growth in human population.

iii. Nitrous oxide

Nitrous oxide is produced from a diversity of biological sources in soils and water. Nitrous oxides comprise 4% of the anthropogenic greenhouse forcing over the past five centuries, but their contribution has increased with the spread of human activity. Nitrous oxide is 190 times more effective radiatively than CO_2. The major background source of nitrous oxide (prior to human activities) was tropical forest soils. Oceanic release of N20 occurs through both nitrification in near surface waters and denitrification in oxygen-deficient deep waters.

Within the biotic sphere, human activities and particularly agriculture have had a major influence on the flux of nitrous oxides. The release of nitrous oxides to the atmosphere has increased with human activities as a result of tropical land clearing and replacement by agriculture, biomass burning, and degassing of irrigation water. Emission of nitrous oxide has been increased by the use of fertilizers and by the expansion of the area in nitrogen-fixing leguminous plants in agriculture. However, our understanding of the global budget for nonindustrial and non-transport-related nitrous oxide is not complete because of uncertainties in the fluxes and a paucity of information on some of the processes.

5.1.3.3. Ecological effects of climate change

Climate change affects terrestrial ecological systems at a variety of temporal and spatial scales. To predict effects of climate change, the expected precipitation and temperature patterns for particular regions and times need to be known. However, there is a high degree of variability in projections of temperature and precipitation from general circulation models (GCMs) for any area. Therefore, it is not currently possible to provide a prediction of expected changes for biomes or landscapes. However, the ecological processes that would likely be susceptible to climate change are readily identified. Currently there is no direct evidence of any effects of human-induced climate change on ecosystems. Therefore, analysis of anticipated effects relies on models or historical and paleo ecological evidence.

Global responses to climate change involve alterations in energy, carbon, or water fluxes of vegetation, which, in turn, depend on the spatial distribution of the different vegetation types. The Holdridge life-zone classification has been used to ex amine potential global shifts in major ecosystems with climate change. The Holdridge classification scheme relates the distribution of major

ecosystem complexes to mean annual bio-temperature, mean annual precipitation, and the ratio of potential evapotranspiration to precipitation. Smith et al. (1992) compare potential impacts on vegetation distribution of the climate changes projected by four GCMs. All four climate-change scenarios suggest a decrease in the area of tundra and desert and an increase in grassland area. The model projections also show forest areas increasing toward the poles, an increase in the extent of tropical forests into areas now occupied by subtropical or warm temperate forests, and a shift of the boreal forest zone into areas now occupied by tundra. All scenarios suggest an increase in terrestrial carbon storage ranging from 8.5*1012 kg to 180.5*1012 kg. Using the Holdridge classification[15] approach to estimate effects of climate change on vegetation assumes that vegetation complexes move as a fixed unit in time and space, that vegetation distribution is solely correlated to climate (e.g., soils are not considered), and that equilibrium solutions exist.

This view is a great simplification of the real situation: at the biome level, species respond to climate change through migration, extinction, or adaptation to new disturbance regimes. The potential for plants to evolve in response to climate change depends on genetic variation. The response to climate change has generally been via migration rather than evolution, and the potential for extinction is enhanced by (1) barriers to migration and (2) low genetic diversity. Disturbance intensity, frequency, and duration are likely to change with climate.

A number of examples of such environmental disturbances caused by climate change can be given. With a doubling of CO_2, the frequency of Caribbean hurricanes may double Wendland 1977, and the destructive potential of hurricanes may increase by 40-60%. Natural fire frequency, duration, and intensity are closely tied to storm occurrences and therefore to precipitation regimes. Insect outbreaks are a function of the prevailing moisture and temperature conditions, insects' physiological responses to extremes, and plant stress. In addition to direct mortality, these disturbances are important, for it is through disturbances that species replacement occurs more rapidly (Franklin et al. 1992). Climate change may have little direct effect on existing mature forests whose trees live hundreds of years; however, the ability of long-lived trees to reproduce and grow under new climate regimes may be best observed in areas that have been disturbed.

Landscape responses to climate changes may take years to centuries to express themselves and may occur in terms of nutrient cycling, water use, production, succession, competition, and response to changes in disturbance regimes. Climate change affects nutrient cycling by changing litter decomposition rates, plant nutrient uptake, and/or internal cycling. Species shifts associated with climate change may also change patterns of nutrient cycling.

[15] The Holdridge life zones system is a global bioclimatic scheme for the classification of land areas. It was first published by Leslie Holdridge in 1947 and updated in 1967. It is a relatively simple system based on few empirical data, giving objective mapping criteria.

Vegetation's water use is a complex interaction of water-use efficiency, soil characteristics, and climate. Therefore, it is difficult to predict a general response of how water use will be affected by climate change. Productivity will likely decrease' in some places and increase in others, depending on the spatial distribution of temperature and precipitation changes. Succession patterns and competitive interactions are likely to be altered with climate change, but it is difficult to make specific predictions because of the complex nature of these interactions. Pastor and Post (1988) show that the landscape response to climatic warming depends on the spatial pattern of soils and the nutrient-cycling properties of the vegetation.

As at the biome level, disturbance frequency and intensity will modify the responses of vegetation to climate change. Wetlands are particularly susceptible to changes in disturbance regimes. Sea-level rise would alter the distribution and condition of wetlands by altering the area they currently cover and changing the species they support. In the short term (5-20 years), extreme weather events (such as storms, floods, droughts, and fires) may disrupt vegetation growth. These effects may be particularly severe in wetlands previously disturbed by human activities.

Directly affects: Climate-change effects on agriculture are probably the best known. Direct climate effects include changes in crop yield and spatial shifts of agricultural potential. Decreasing rainfall can lead to the need for irrigation. Changing temperature or rainfall patterns can change which crops are most suitable for an area; however, land managers can frequently identify replacement varieties or crops that perform equally well under new climate conditions.

Indirect effects include altered farm profitability, regional productivity costs, regional and national food production, and the number of people at risk of hunger. For instance, climate-change-induced alterations in agricultural productivity in one region can affect productivity in another region (e.g., loss of productivity in the Northern Hemisphere may lead to greater demand from the Southern Hemisphere). Also, climate-induced changes in disturbance regimes can indirectly affect land-use practices (e.g., the frequency of fire, wind, or insect outbreaks may affect the potential for forest harvesting).

The predicted rise in sea level from global warming will have major impacts on coastal zones and estuaries. As some areas are lost and replaced by higher-elevation sites, humans will build new commercial and industrial facilities. Currently, the human population is concentrated in coastal zones. For example, 53% of the United States population lives in counties within 80 km of the coast. Therefore, modifications of coastal zones will have significant impacts on social and economic systems.

5.1.3.4. Causes of land-use change.

The major drivers of land-use changes are human population, affluence, technology, political economics, political structure, attitudes, and values. The importance of these factors varies with the situation and the spatial scale of analysis. Human population growth can be considered an ultimate cause for most land-use changes; however, local demographics as well as consumption per capita and its variability can modify the effects of population.

Economic incentives set by government policies are a key cause of deforestation. Quantifying the effects of land-use change from a long-term economic perspective that includes environmental feedbacks is useful, for it emphasizes the opportunity for government policy on sustainability to modify negative effects of deforestation.

Climate changes affect the major drivers of land-use change can be answered by postulating many scenarios of the effects of local or regional temperature and precipitation changes on land-use practices. Existing policies, economics, and attitudes may no longer be applicable in a changing world; new technologies may be developed to deal with the problems; and people's attitudes and values may change. It is not useful here to go through some of those scenarios, for only a small set could be thoroughly discussed. Rather, it is important to note that climate change can affect these land-use drivers and that the directions of the impacts must be considered to understand the effects of climate change.

Typical land-cover changes include forest harvesting, agricultural expansion, slash-and-burn agriculture, urbanization, and flooding (e.g., for rice cultivation).

A number of common themes relate the drivers to particular land-cover patterns. For example, local population increase leads to urbanization and a decline in the natural land-cover types of the region. Elucidating these themes would help us understand better the causes of specific land-use patterns. Turner et al. (1993) emphasize that theories relating human causes of land-use change to changes in land cover are not fully developed. Correlations among these phenomena at the global level do not always hold for local or regional scales. For example, global or regional population growth may not always be the prime cause of agriculture expansion.

Therefore, case studies of the relation between human drivers and land-cover changes for specific regions are useful. However, determining the primary causes of land-use changes is difficult. For example, Rondônia, Brazil, is a region that has undergone rapid deforestation since 1968 because of colonization projects along a road system that was paved in 1984, largely accomplished through funding from the World Bank. Between 1970 and 1988, 37500 km_2 (18% of the area in Rondônia) were cleared as a direct result of the road and colonization projects. It is difficult to discern the

ultimate causes of the colonization in Rondônia. There are proposed reasons: social, political, and economic.

- The social reason for the colonization program was to relieve the pressures of population growth along the coastal zones of Brazil. However, 73% of the colonists' families moved from farm regions of south and southwest Brazil.
- The political reason for settling Rondônia was to encourage Brazilians to settle in the frontier community that was once a part of Peru.
- The economic reason was that the president of Brazil offered colonization of Rondônia as a solution to the famine resulting from a recent drought. Individual farmers have specific reasons for migrating to Rondônia, but many of them moved because of the opportunity to work on their own land. Thus, Rondônia was colonized and deforested for a variety of reasons.

Modification of land-cover types should also be considered in development of land-use theories. Typical land-cover modifications include irrigation, fertilization, introduction of exotic species, forest degradation, and landscape fragmentation. Forest degradation occurs when the forest type is retained yet structural features of the forest are changed. For example, removal of limbs and small trees for firewood reduces the forest biomass. Species introduction (e.g., the introduction of the European boar into the southern Appalachians) may reduce the diversity of the natural land-cover type. And fragmentation occurs when a land-cover type is segmented by roads, transmission lines, or a managed land cover (e.g., agriculture).

5.1.3.5. Ecological effects of land-use change

Ecological effects of land-use conversion include changes in biodiversity, habitat availability, soil erosion and degradation, productivity, extractable resources, and water quality. These changes largely occur as a direct result of changes in the land-cover pattern. Over a period of decades, these well-documented effects of land-use change exceed the effects anticipated from human-induced climate change.

Biodiversity reductions occur when a natural land cover is replaced by a new cover type that does not support some of the former species. On a local scale, diversity is lost when a forest is replaced by agriculture. The reduction in diversity can also be indirect through habitat modification. Currently, tropical deforestation is one of the major threats to biodiversity because of habitat alteration and loss.

Habitats are changed by almost all land-use modifications. Fragmentation can reduce species diversity through changes in natural processes (e.g., disruption of seed dispersal) or the addition of new processes (e.g., competition with exotic species). Landscape fragmentation can cause declines in habitat and reduce or eliminate some animal or plant species. For example, as the preferred

habitat for a species becomes less connected, the species may not have sufficient breeding habitat to survive. Such effects largely depend upon the habitat size requirements for the species and the ability of the species to move across areas outside its preferred habitat. In addition, increases in the amount of edge habitat may compromise some species. E.g., populations of neotropical migrant birds are being reduced by increases in cowbirds that parasitize nests of other bird species more frequently along forest edges, which are close to abundant food resources of agricultural areas and grasslands. Predation can also increase along habitat edges.

Land-use activities can also increase the area of some habitats, such as in Northern Wisconsin where logging has increased the area and connectedness of early successional forests. The larger area of successional forest has resulted in the abundance of species associated with those forests (such as white-tailed deer and grouse) and a decline in species sensitive to patchiness or roads.

Soil-quantity and soil-quality changes occur when land-management practices cause erosion or export soil nutrients as agricultural or forest products. Currently, topsoil is being lost from the agricultural lands in the world at the rate of 25*1012 kg [25*109 metric tons]/year. The concept of sustainability is important to introduce in conjunction with soil quality, for frequently land-management practices are considered to be sustainable without considering the long-term implications on soil-quality degradation.

The natural and the managed productivity system can be altered by land-management practices.

Use of fertilizers and irrigation are known to increase productivity. On the other hand, export of products from the land can reduce natural productivity.

Loss of extractable resources (e.g., fruit, rubber) is another consequence of land-use changes. For example, indigenous people generally manage the use of natural extractable resources in a responsible manner when their populations are stable. However, developed countries promote landscape uses that typically do not take advantage of extractable resources.

Thus, many species having potential for food, fibre, or pharmaceutical drugs are being eliminated.

Water resources are compromised by increased demand, reduced capacity of the land to filter water, and increased pollution. These pressures are particularly apparent in arid regions, such as the southwestern United States. In their review of global change effects on freshwater ecosystems, freshwaters have been found that its tightly linked to climate and land use. In particular, watershed modifications and use and modifications of aquatic resources by human's stress freshwater ecosystems and must be considered in concert with climate-change effects.

Certain land-use activities can modify the effects of climate change on ecological systems at the biome and landscape levels through their effects on energy fluxes. These land-use activities include land management and conservation at the biome scale and fire suppression, flood control, forest management, and soil management at the landscape scale.

At the biological scale, impacts of a particular climate change may be exacerbated by human activities. For instance, forest cutting, road development, and urban expansion create land-cover patterns that may impede the natural processes of seed dispersal and plant establishment that might otherwise compensate for changes occurring in the forest. On the other hand, some human activities may mitigate effects of climate change on forests. E.g., some tree species may not be able to migrate to the regions where climate change produces appropriate habitats, but seedlings of those species could be intentionally planted.

At the landscape scale, agricultural management using fertilizers, crop rotation, irrigation, selection, or genetic engineering may reduce changes in crop yields or productivity that might otherwise occur with climate change. Predicting how agriculture systems respond to climate change requires information on how and when climate will change, information that is not now available nor is likely to be available soon. However, some possible adaptations are known:

- Changes in length of the growing season can be countered with the use of cultivars that require either longer or shorter growing seasons.
- Photoperiod limitations can be overcome by traditional plant-breeding procedures.
- Greater warming or desiccation can be dealt with by using drought- and heat-resistant strains of crop species.
- Moisture-conserving tillage methods can be adopted.
- Dryland agriculture may no longer be economic in some areas, and demand for irrigation water may decrease; however, demand for irrigation may increase elsewhere (although greater demand for water may limit the potential for irrigation).
- Improvements in irrigation efficiency can compensate some-what for increased water demands.

In agriculture, capital investments are relatively small (compared to those for forestry) and can be modified in a short time period with changing environmental conditions.

5.1.3.6. Methods for studying interactions between land-use and climate changes.

Historical and ecological evidence shows that the effects on forests of climate change have been significant. Because species' responses to climate change have been complex, it is difficult to predict patterns of responses. E.g., with climate warming, intact forest ecosystems have not moved northward as a unit; instead, species have responded individually. Different combinations of tree species occur today than in the past. Also, the order of species entry into an ecosystem has been unique or has occurred with time lags. Thus, understanding the functional response of species and ecosystems to climate change is required.

Although historical and ecological studies of effects of climate change on forests provide much information about responses in the past, their results cannot be directly applied to future conditions for two reasons: (1) the current size, age, and species composition of temperate forests are unique and have been strongly affected by human activities; (2) global temperatures are predicted to increase at an unprecedented rate.

i. Field and greenhouse studies

These studies of the interactions of climate change and land-use change are hampered by the logistical difficulties of implementing changes at the scale of entire ecosystems. Elucidating effects of one of these changes is difficult to do with sufficient size and replication of plots.

Therefore, studies focus on some aspects of predicted climate change or land-use change. E.g., the effects of soil degradation or reduced precipitation can be experimentally documented.

The challenge of field and greenhouse studies of changes at the scale and complexity of a forest is to design studies that deal with specific interactions or that provide information that can be extrapolated to larger scales. An example of the type and scale of experiment required to investigate impacts of climate change is the throughfall displacement experiment (TDE) being performed in an upland forest of the Walker Branch Watershed in East Tennessee. The TDE is a stand-level manipulation experiment that provides the appropriate environment for mechanistic studies of ecosystem response to changing climatic conditions.

Approximately 25% of the throughfall on the "dry" plot is being collected in polyethylene troughs and transported by gravity though pipes to the "wet" plot.

The experimental system is able to produce statistically significant differences in soil water content for years having both extremely dry and extremely wet conditions.

Biological and chemical characteristics of two treatment plots and a control plot (each covering 0.6 ha) are being monitored for 5 years. These characteristics include forest growth and the physiological responses of major tree and understory species, leaf-area index, herbivore activity, litterfall, understory competition, litter composition, soil organic matter and microbial populations, nutrient availability, soil and soil solution chemistry, and biogeochemical cycling processes.

ii. Models

Understanding how current land cover will respond to transient patterns of global temperature, precipitation, solar radiation, etc. requires reliance on computer models that can deal with some of the complexities of the vegetation and climate systems. Because human activities are an important determinant of many land-cover types, the influence of humans must be included in some of the modelling studies. Human use of the land is largely influenced by available resources and social

and economic conditions, so socioeconomic models must be paired with ecological models to understand the complex responses of modern ecosystems.

This discussion of models that relate land-use change and climate change builds upon recent reviews of land-use models and models used to understand ecological impacts of climate. The challenge here is to consider how modelling approaches can be used to examine land-use and climate-change interactions. Of the 14 categories of climate-change models that DALE and RAUSCHER (1994) reviewed, they found that only three types considered land-use change.

1. Global models.

Global models of vegetation change have been used to project vegetation patterns under changing climate. Climate-change scenarios have been provided for these models in three ways. One approach uses mesoscale climate models to predict regional climate processes, such as the location of the arctic frontal zone, which is a good predictor of the boundaries of the boreal forest biome. A second approach is to scale up a community demographic model by using functional plant groups instead of species, because the number of species that would need to be simulated on a global scale is overwhelming. Functional plant types are groups of species that germinate and grow under similar sets of environmental conditions (e.g., dry-deciduous sclerophyll). The third approach correlates projected empirical models of climate and vegetation in a spatial context by using the Holdridge life-zone classification system.

Global models can be used to examine the relative influence of land-use change, biomass estimates, and the fate of carbon after land management on terrestrial carbon flux (including CO2 fertilization and carbon sequestration). In such models, the problem of modelling interactions between climate change and land use is one of scale. Because of the large area involved, global models must rely on pixel sizes of about 1 km or larger; however, land management frequently occurs on a much smaller spatial scale. At such scales, it is difficult to model interactions among land-use drivers, topography, transportation networks, and climate change.

2. Regional models.

The region or landscape is the scale at which land-use changes frequently occur and at which estimates of climate change can be made. Currently, regional climate-change models' predictions do not agree on projected temperatures or precipitation for any area. However, regional models can be used to examine scenarios of land management and climate change to determine sensitive variables and features of the region. Regional vegetation and land-use models focus explicitly on how changes in the regional pattern of vegetation affect the carbon budget or other properties, a process in which the cause of land-use change plays a key role. As a result, these models may have

complex socioeconomic components. All of these models are spatially explicit in the sense that they refer to actual land patterns, although some patterns may be hypothetical.

Regional-vegetation and land-use models are exemplified and illustrated the approach which have developed spatially explicit simulations of land-use changes in central Rondônia, Brazil. The Dynamic Ecological-Land Tenure Analysis (DELTA) model operates at the individual-farm level (using digitized maps of farms that average 101 ha in size). The model simulates changes in the impacts and spatial arrangement of farm practices and carbon release over 40 years. The typical land-use scenario simulates farmers clearing an increasing amount of forest up to year 3 and stopping most of the clearing by year 7, at which time about half of the lot is cleared. This model's projections under this scenario compared to activities of farmers in central Rondônia.

Global climate-change effects on the central Amazon may result from economic pressures rather than temperature or precipitation alterations. The DELTA model is used to explore the implications of increased demand for agricultural productivity that may result from reduced productivity in the temperate zones with climate warming. This simulation can be done in a variety of ways in the model: decreasing the likelihood that farmers leave the farms, increasing the value of production, and increasing the importance of the link to the market via primary and secondary roads. In all cases, the model outputs were similar to the typical case discussed in the previous paragraph and by year is resulted in >80% deforestation. The reason for this similarity is probably that without technology changes, the farmers cannot clear land at a faster rate and cannot increase their productivity.

Thus, the model suggests that the increase in demand of agricultural products from the tropics would have to be accompanied by technological advances for there to be an impact on the carbon released and rate of fragmentation of areas that are already subjected to farming. New areas may still come under pressure to clear forests for agriculture expansion. The exercise shows that the model needs to consider technology development as a driver to fully explore this case. Such modelling experiments illustrate the limitation of existing models and the direction for new developments.

3. Landscape-transition models.

Landscape-transition models use a cellular-automata approach to explore effects of changes in the location, size, shape, and composition of vegetation boundaries. The cellular-automata approach tracks interactions within and between each location in the spatial model.

Landscape-transition models that can incorporate land-use and climate changes are exemplified and developed a cellular-automata model that explores the spatial distribution of two competing species (a generalist and a specialist) with a severe perturbation in the abundance of the species,

such as might be caused by a severe drought. The simulation was run for 100 generations, with and without a land-use modification (e.g., forest harvesting) that causes habitat destruction in either a blocked or fragmented fashion. Simulated land-use changes altered the habitat types by preventing the specialists from being able to germinate. Survival of the specialists was greatest with no harvesting and no drought. With larger areas of the forest being harvested, survival and abundance of the specialist species declined.

In summary, global, regional, and landscape models can address issues relevant to the interaction between land use and climate change. However, the models have typically been used only to consider one type of change. The interaction between climate and land-use changes is clearly amenable to modelling studies.

5.1.4. Case studies' Comparison

In the following table there is the case studies simple comparison highlighting the main points in each one.

Table 9: Case studies comparison

Rural communities	Urban areas	Land Use and Land Cover Change
Greater Mekong subregion (May 2014)	Adaptation possibilities and constraints in low- and middle-income nations	emphasis on global and regional landscapes, spatial scales at land-use and climate-change interactions
key messages: • "predict-then act" approach to a "no regret" approach. • Wider socio-economic context understanding for the community [16] • To guide community development planning. The framework should be accessible to diverse users and applicable to local conditions. (climate projections, crop model outputs, etc.). • Participatory approaches help fill information gaps and inform community concerns about climate and non-climate issues. Community participation offers a collaborative scenarios visualization and a selection of contextual adaptation options with increased interest in implementing adaptation strategies. • Ecosystem-based and community-based approaches required to	• There are limits to the damage or devastation that adaptation can prevent and very serious deficiencies in the institutional capacities for urban adaptation in most low/ middle-income nations. This makes it more urgent that global agreements are reached to achieve the needed cuts in greenhouse gas emissions. **Urban vulnerabilities**: Urban populations and economies devastation caused by extreme weather events in recent years highlights their vulnerabilities. Worldwide, there has been a rapid growth in killed people or serious impact on storms and floods and in the amount of economic damage caused; a large and growing proportion in urban areas in low/ middle-income nations. Climate change is likely to have been a factor in much	**Effects on communities and ecosystems** 1) Land-use change has had much greater effects on ecological variables than has climate change. 2) The vast majority of land-use changes have little to do with climate change or even climate 3) Humans will change land use, and especially land management, to adjust to climate change and these adaptations will have some ecological effects. **Land-use contributions to climate change** Human activities influence climate change by altering the ecosystems' distribution and associated energy' fluxes. At the landscape scale: changes in land-cover patterns can impact energy and mass fluxes.

[16] Because climate change can change over decades, socio-economic change can have a larger impact on communities in a much shorter period of time, potentially reversing a vulnerable environment.

Rural communities	Urban areas	Land Use and Land Cover Change
develop a climate change adaptation strategy for natural resource dependent communities. • The adaptation strategy should be mainstreamed into local development plans.	of this, but even if it was not, it is proof of the vulnerability of urban populations to floods and storms whose frequency and intensity climate change is likely to increase in most places. Climate change will also bring other less dramatic stresses such as heat waves and, for many urban areas, reductions in freshwater availability, also sea-level rise for all coastal cities.	Increased atmospheric concentration of GHGs because (1) a wealth of data is available and (2) it illustrates how changes in particular land-cover categories can dominate the impact. At the global scale, Human activities influence the GHGs into the atmosphere and by changing the patterns of carbon storage through land-use activities (focused on land use than industrial activities) (Carbon dioxide, Methane, Nitrous oxide).
Key Concepts: vulnerability and adaptation, **Exposure, Sensitivity, and Adaptive Capacity** Adaptation measures may be infrastructure-based (such as building a sea wall) and ecosystem-based (such as mangrove restoration to relieve storm surges). "Socioeconomic vulnerability" is an aggregate measure of human welfare that integrates environmental, social, economic and political exposure to a range of harmful perturbations, including climate change.	**The direct and indirect impacts of climate change** 1) The scale of the population at risk: 2) The economic costs without adaptation 3) The vulnerability of urban populations to climate change	**Ecological effects of climate change** Global responses: (Vegetation distribution, the biome level and species, plant stress, direct mortality) Landscape responses: (Vegetation's water use, wetlands and Sea-level rise, human activities) **Direct effects:** • Agriculture • Decreasing rainfall • Temperature or rainfall **Indirect effects** • Profitability • Regional productivity costs • Regional and national food production • The number of people at risk of hunger
Assessment Approach Climate Change Impact Adaptation and Vulnerability (CCIAV) assessments: 1) impact assessment. 2) vulnerability assessment. 3) adaptation assessment. 4) integrated assessment. 5) risk management-based assessment. the integrated framework combined the risk management and vulnerability approaches. The integrated approach is a simplified way to understand the current risk and vulnerability of the communities and use climate projections to determine risk and vulnerability.	**The local nature of successful adaptation** Building the needed competence, capacity and accountability within local governments in high-income nations was a slow, difficult, highly contested process that did not have to deal with climate change and that was much helped by prosperity and economic stability. The vulnerability of low-income urban dwellers to climate change is often ascribed to their poverty but it is far more the result of failures or limitations in local government. **Building local capacity** "good governance" **Adaptation needs the attention of all sectors:**	**Causes of land-use change.** The major drivers of land-use changes are human population, affluence, technology, political economics, political structure, attitudes, and values. • Economic incentives set by government policies are a key cause of deforestation. • Climate changes affect the major drivers of land-use change can be answered by postulating many scenarios of the effects of local or regional temperature and precipitation changes on land-use practices. **There are proposed reasons:** • The social reason for the colonization program was to relieve the

Rural communities	Urban areas	Land Use and Land Cover Change
PRA-based approach made a difference recognize the communities' current adapting methodologies and their appropriateness to future climate alter scenarios.	• Housing and infrastructure policies • Local illustrates possibilities and constraints. • important shift underway in many agencies **Global issues** • environmental hazards, including disasters. • strongly pro-poor	population growth along the coastal zones of Brazil. • The political reason for settling Rondônia was to encourage Brazilians to settle in the border community that was once a part of Peru. • The economic reason resulting from a recent drought. Individual farmers have specific reasons for migrating to Rondônia, but many of them moved because of the opportunity to work on their own land.
Assessment Steps for integrated approach Step 1: Assessing the current socioeconomic context. Step 2: Assessing current risk and vulnerability. Step 3: Formulating a plausible future. Step 4: Assessing future risk and vulnerability. Step 5: Formulating an adaptation strategy. Step 6: Identifying options to operationalize the adaptation strategy. **Case's Recommendations** • Strengthen socioeconomic analyses. • Apply multiple climate scenarios. • Integrate community-based adaptation (CBA) and ecosystem-based adaptation (EBA) approaches. • Improve participatory approaches. • Integrate site specific crop model simulations where possible. • Integrate an economic analysis. • Analyse the broader policy and planning environment. • Upscale to regional studies.	**Tackling policies** • supports and works with the reduction of risks to other environmental hazards. • builds on the knowledge acquired over the last 20 years on reducing risks from disasters in urban areas. • is based on and builds a strong local knowledge base of climate variabilities and of the likely local impacts from climate change scenarios. • encourages and supports actions that reduce risks (and vulnerabilities) now to begin the needed long-term changes; urbanization processes have difficult drivers to change. • recognizes that the core is building the competence, capacity and accountability of city and sub-city levels of government, changing the relationship with those living in informal settlements and informal economy. • recognizes government policies must encourage and support the contributions to adaptation of individuals, community organizations and enterprises. • recognizes the key complementary roles required by higher levels of government and international agencies to support this requires major changes in policy for most international agencies that have long ignored urban issues and major changes in how adaptation is funded. • builds into the above a mitigation framework (if successful cities in	**Ecological effects of land-use change** • Biodiversity reductions • Habitats • Land-use activities • Soil-quantity and soil-quality changes • The natural and the managed productivity system • Loss of extractable resources • Water resources • Certain land-use activities At the biological scale At the landscape scale 1) Changes in length of the growing season can be countered with the use of cultivars that require either longer or shorter growing seasons. 2) Photoperiod limitations can be overcome by traditional plant-breeding procedures. 3) Greater warming or desiccation can be dealt with by using drought- and heat-resistant strains of crop species. 4) Moisture-conserving tillage methods can be adopted. 5) Dryland agriculture may no longer be economic in some areas, and demand for irrigation water may decrease; however, demand for irrigation may increase elsewhere. 6) Improvements in irrigation efficiency can compensate some-what for increased water demands.

Rural communities	Urban areas	Land Use and Land Cover Change
	low- and middle-income nations develop without this, global greenhouse gas emissions cannot be reduced). • builds resilience and adaptation capacity in rural areas given the dependence of urban centres on rural production and ecological services and the importance for many urban economies and enterprises of rural demand for goods and services	
		Methods for studying interactions between land-use and climate changes. future conditions for two reasons: (1) the current size, age, and species composition of temperate forests are unique and have been strongly affected by human activities; (2) global temperatures are predicted to increase at an unprecedented rate. a) Field and greenhouse studies b) Models ▪ Global models. ▪ Regional models. ▪ Landscape-transition models.

Source: The author's edition based on chapter 5.1

5.2. Egyptian Climate Change Adaptation Index (ECCAI)

5.2.1. Composite index Development

NDUE and GODA (2021) Defines Composites or indices an outcome of an elaborate sequential long process with steps that need to be followed keenly. They outline that indices or composite development, is guided by principles that are governed by a stepwise approach. In adherence to the outline guidelines, this study adopted the framework by the Organization for Economic Development, the European Joint Research Centre, The Notre Dame Institute and Other scientists who have tried to come up with such indices in various economic sectors. This led to the development of the Egyptian Climate change Adaptation Index (ECCAI)

The methodological process was based on the conceptual framework as presented in table 10 below. Post conceptual building, empirical application of statistical steps such as data selection, aggregation, normalization, and visualization characterised data manipulation. The conceptual framework was developed as a tool for indicator development and determinants development post the literature review. A similar approach was applied by (ACOSTA et al., 2020, NDUE and GODA 2021) in the formulation of indicators for natural capital and Climate change adaptation in the European Agricultural sector respectively. The desirability of the chosen indicators was determined by the reviewed literature and the Egyptian general strategic plan for the Governorates. The Joint Research Centre of the European Union credited the methodology and argued that the subjectivity of indicators formulation is one of its strengths when supported with well-documented evidence (OECD, 2008).

Data for all the indicators were gathered from the Egyptian general strategic plan for the Governorates. Although questions may arise on the constancy and the robustness of the data, (ACOSTA et al., 2020; PEYRIERE & ACOSTA, 2019) proposes further engagement of stakeholders in the process to evaluate their key interests which can play a significant role in weighting the indices. Stakeholder engagement was not part of this study necessitating further research to validate the indices and updating of the subjective indicators. To ensure coherence and completeness of data from the indicators, simple imputation by omitting uncomplete data was selected over the extrapolation and mean imputation due to their limitations of implausible assumption (ZHU et al., 2012). They outlined the challenges of mean imputation on how it reduces variance thus changing the correlation between indicators.

5.2.2. Selecting the indicators:

The data selected that quantifies the ECCAI indicators have the following features to ensure transparency, reliability and consistency:

- Available for a high proportion for most of the governorates.
- Time-series so that changes and trends in governorate vulnerability and readiness can be tracked. Indicators with data from 2006 to the present are preferred.
- Freely accessible to the public.
- Collected and maintained by reliable and authoritative organizations that carry out quality checks on their data.
- Are transparent and conceptually clear.

Table 10 Vulnerability indicators

Sectors	Indicators			
Food	Total area of cultivated land (Thousand feddans)	No. of livestock farms (FARM)	Rural Population (population)	
	Total cropped area (Thousand feddans)		Agricultural land percentage of the total area (%)	
Water	Production of potable water (Thousand m3/ Day)		Per capita water production (Litter. day/ Person)	
Health	slum population (thousand person)		Capacity of sanitation (Thousand m3/ Day)	
Ecosystem services	No. of natural protectorates (Protectorate)	Ecological footprint (gha)	No. of air monitoring stations (Station)	No. garbage recycling factories (Factory)
Human habitat	No. of civil airports (Airport)	Length of paved roads (Thousand km)	Urban concentration (%)	Unemployment rate (%)
Infrastructure	Population living under 5m above sea level (thousand population)		Total amount of electricity used (million million kWh annually)	

Source: Autor based on the data availability on Egyptian governorate level

Table 11 Readiness indicators

Sectors	Indicators		
Economic Readiness	Governorates Performance Index in Empowering Small and Medium Enterprises		
Governance Readiness	Political participation in the vote on elections (%)	governorates abilities to attract domestic capital.	infrastructure and services availabilities for investment attraction for small and medium enterprises
Social Readiness	Human Development Index (HDI)	Illiteracy ratio (10 years +) (%)	

Source: Autor based on the data availability on Egyptian governorate level

5.2.3. Score Calculations and Index formulation

When working with multidimensional indicators with different units and dimensions, its essential to subject the data to the normalization process (POLLESCH & DALE, 2016). Normalisation in composite index development helps in indicator transformation into the uniform scale and unitless numbers that aids in comparison(OECD, 2008). The min-max normalization method(rescaling method) as outlined by (MAZZIOTTA & PARETO, 2013) was applied to align indicators with both positive and negative relationships to the index thus reducing the effect of extreme values on

the index. Rescaling was chosen for its simplicity in application and the ability to eliminate extreme values therefore removing outliers partially. Xi normalised

The min-max transformation method rescales the different indicators (Xi) into an identical range (0-1) based on the minimum (Xmin) and maximum (Xmax) as presented in Equation 1 below.

Step 1. Select and collect data from the sources (called "raw" data), or compute indicators from underlying data. Some data errors (i.e. tabulation errors coming from the source) are identified and corrected at this stage. If some form of transformation is needed it happens also at this stage.

Step 2. At times some years of data could be missing for one or more governorates; sometimes, all years of data are missing for a governorate.

Step 3. This step can be carried out after of before Step 2 above. Select baseline minimum and maximum values for the raw data. These encompass all or most of the observed range of values across governorate.

Step 4. Whenever applicable, set proper reference data points for measures. The reference points stand for the status of perfection, i.e. the best performance that represents either zero vulnerability or full readiness. In some cases, reference points were the baseline minimum or maximum identified in Step 3. For certain measures, based on the adaptation or development practices, reference points were set by common sense. If data sources have reference points by default for a measure, these are adopted. (See reference points section below).

Step 5. Recaling "raw" data to "score", ranging from 0 to 1, to facilitate the comparison among countries and the comparison to the reference points. Scaling follows the formula below:

$$\textit{"score"} = \left|\textit{"direction"} - \frac{\textit{"raw" data} - \textit{reference point}}{\textit{baseline maximum} - \textit{baseline minimum}}\right|$$

Equation 1

The parameter of "direction" has two values, 0 when calculating score of vulnerability indicator; 1 when calculating score of readiness indicators, so that a higher vulnerability score means higher vulnerability ("worse") and a higher readiness score means higher readiness ("better").

Step 6. Compute the score for each sector by taking the arithmetic mean of its 6 constituent indicators (all scaled 0-1, weighted equally). Then calculate the overall vulnerability score by taking the arithmetic mean of the 6 sector scores.

Step 7. Follow the same process as Step 6 to calculate the overall readiness score.

Step 8. Compute the ECCAI score by subtracting the vulnerability score from the readiness score for each governorate, and scale the scores to give a value 0 to 100, using the formula below:

*ECCAI = (readiness score – Vulnerability score +1) *50*

Equation 2

5.2.4. The ECCAI matrix

ECCAI can be represented as a scatter plot of readiness against vulnerability. The Matrix provides a visual tool for quickly comparing countries and tracking their progress through time. The plot is divided into four quadrants, delineated by the median score of vulnerability across all the countries and overall years, and median score of readiness calculated the same way. Approximately half the countries fall to the left of the readiness median and half to the right. Similarly, half fall above the vulnerability median and half below.

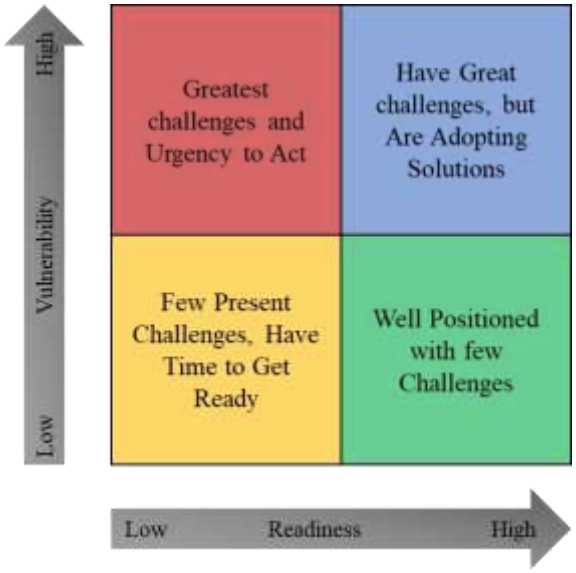


Figure 14 Readiness Matrix

Source: Author's edition based on (CHEN et al.,2015)

Red (Upper Left) Quadrant: Governorates with a high level of vulnerability to climate change but a low level of readiness. These governorates have both a great need for investment to improve readiness and a great urgency for adaptation action.

Yellow (Lower Left) Quadrant: Governorates with a low level of readiness but also a low level of vulnerability to climate change. Though their vulnerability may be relatively low, their adaptation may lag due to lower readiness.

Blue (Upper Right) Quadrant: Governorates with a high level of vulnerability to climate change and a high level of readiness. In these countries, the need for adaptation is large, but they are ready to respond. The private sector may be more likely participate in adaptation here than in governorates with lower readiness.

Green (Lower Right) Quadrant: Governorates with low level of vulnerability to climate change and a high level of readiness. These countries still need to adapt (none of them have a perfect vulnerability score) but may be well positioned to do so.

ECCAI scales measures using the "proximity-to-reference point" approach, which scores the level of vulnerability and readiness by the distance to the ideal status, (i.e. least vulnerable is 0 and most ready is 1). 0 for vulnerability or 1 for readiness is considered "full score," and measure scores can be used to assess distance from a desired state. Reference points in ECCAI as follow as reference points for individual measures are provided in Table 12 below.

Table 12 Reference points for individual indicators

Sector	Indictor	Reference point	Baseline Min	Baseline Max
Food	Total area of cultivated land (thousand feddans)	20.12	1.3	1929.67
	No. Of livestock farms (farm)	228	1	2408
	Rural population (population)	0	0	5422698
	Total cropped area (thousand feddans)	21.24	1.53	2171.12
	Agricultural land percentage of the total area (%)	0.7%	0.0%	25.3%
Water	Production of potable water (thousand m3/ day)	5748.7	26.6	5748.7
	Per capita water production (litter. Day/ person)	1659.449	1511.378	28171.84
Health	Slum population (thousand person)	311.7708	0	311.7708
	Capacity of sanitation (thousand m3/ day)	3461	9	3461
Ecosystem services	No. Of natural protectorates (protectorate)	2	0	5
	Ecological footprint (gha)	1.36	0.16	6.98
	No. Of air monitoring stations (station)	31	0	31
	No. Of garbage recycling factories (factory)	7	1	7
Human habitat	No. Of civil airports (airport)	1	0	4
	Length of paved roads (thousand km)	29.92	0.99	29.92
	Urban concentration (%)	24.0%	0.1%	24.0%
	Unemployment rate (%)	14.62%	2.17%	29.5%
Infrastructure	Population living under 5m above sea level (thousand population)	0	0	6171.613
	Total amount of electricity used (million million kwh annually)	23993.7	679	23993.7
Economic Readiness	Governorates Performance Index in Empowering Small and Medium Enterprises	6.02	0.00	6.02
Governance Readiness	Political participation in the vote on elections (%)	34.8%	0.00%	38.70%
	governorates abilities to attract domestic capital	0.27	0.00	0.66
	infrastructure and services availabilities for investment attraction for small and medium enterprises	0.26	0.00	0.33
Social Readiness	Human Development Index (HDI)	0.743	0.699	0.794
	Illiteracy ratio (10 years +) (%)	15.2%	4.3%	28.8%

Source: Autor based on the data availability on Egyptian governorate level

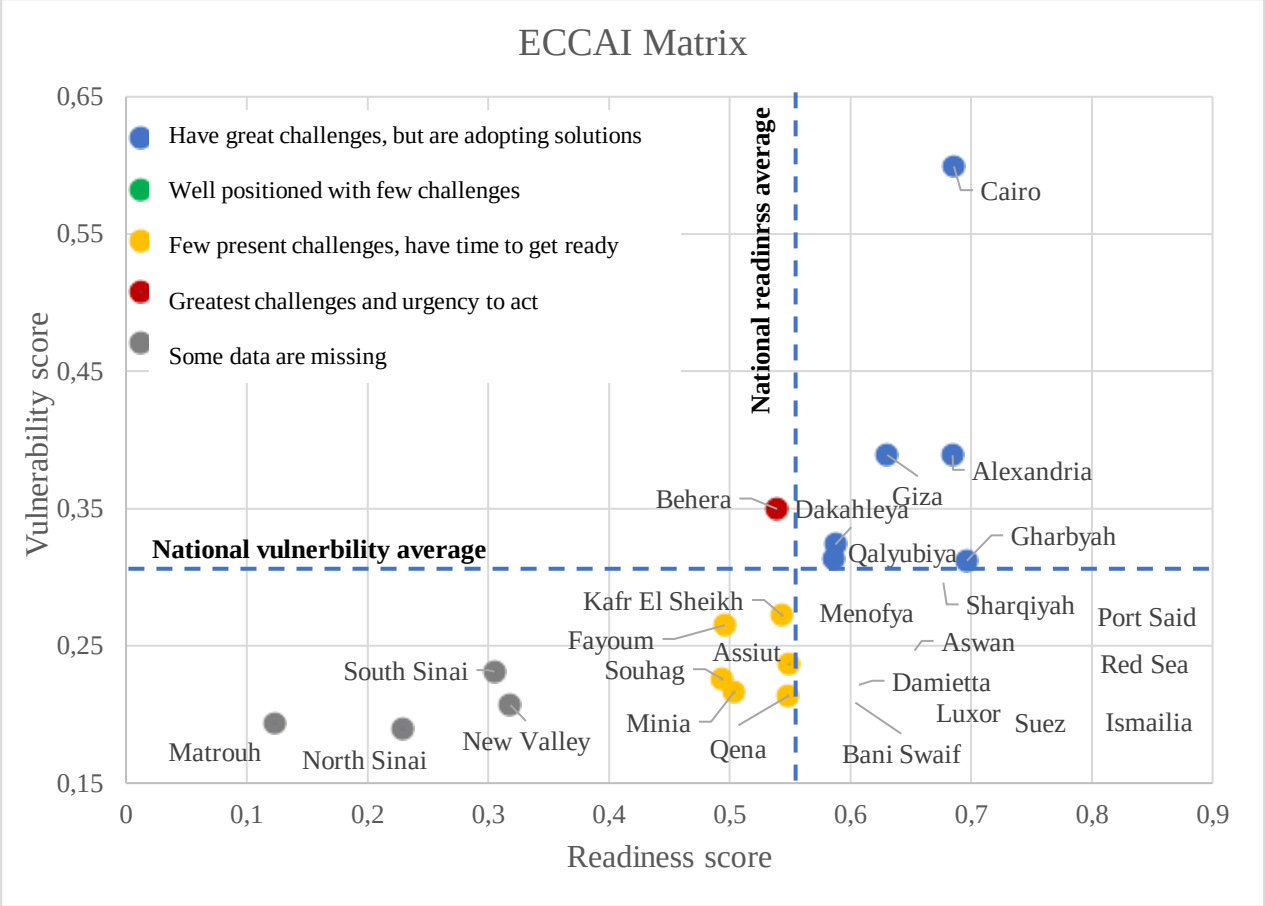


Figure 15 Egyptian governorates distribution in ECCAI matrix

Source: Author's edition

Red (Upper Left) Quadrant (Greatest challenges and urgency to act): Behara.

Yellow (Lower Left) Quadrant (Few present challenges, have time to get ready): Kafr EL Sheikh, Assiut, Fayoum, Minia, and Qena.

Blue (Upper Right) Quadrant (Have great challenges, but are adopting solutions): Cairo, Giza, Alexanderia, Qalyubiya, and Gharbyah

Green (Lower Right) Quadrant (Well positioned with few challenges): Menofya, Sharqiyah, Aswan, Port Said, Damietta, Red Sea, Ismailia, Suez, Bani Swaif, and Luxor.

Grey Some data are missing, For the governorates North Sinai, South Sinai, Matroh, New Valley Their values were not fully presented especially for the readiness indicators.

Table 13 Egyptian Adaptation governorate score

Governorate	Readiness Score	Vulnerability Score	ECCAI Score
Cairo	0.685742	0.60	54.31797
Giza	0.630527	0.39	62.07217
Port Said	0.799493	0.26	77.12181
Alexandria	0.684703	0.39	64.78865
Dakahleya	0.587548	0.32	63.18535
Sharqiyah	0.677012	0.30	69.04715
Ismailia	0.801468	0.20	80.20725
Suez	0.721137	0.18	76.98485
Bani Swaif	0.604125	0.21	69.77372
Gharbyah	0.69654	0.31	69.22405
Menofya	0.656271	0.29	68.12712
Fayoum	0.495963	0.27	61.54466
North Sinai	0.229646	0.19	52.01286
Behera	0.539144	0.35	59.46999
Minia	0.503853	0.22	64.36936
Qalyubiya	0.58585	0.31	63.63347
Red Sea	0.791984	0.22	78.35161
Damietta	0.607001	0.22	69.27207
Souhag	0.493661	0.23	63.38769
Kafr El Sheikh	0.543529	0.27	63.56661
Aswan	0.653126	0.25	70.32845
Assiut	0.548857	0.24	65.60708
Luxor	0.656155	0.20	72.63309
New Valley	0.318367	0.21	55.57524
South Sinai	0.305263	0.23	53.70302
Qena	0.548574	0.21	66.75162
Matrouh	0.123308	0.19	46.49666

Source: Author, based on the data availability on Egyptian governorate level (equation 1, 2)

5.3. Egyptian Framework recommendations

This part of the research is based on what was previously reached through the previous parts and the chapters it contained, and analyses at all stages of the research, through methodologies and the intellectual framework derived from the analysis of past experiences as pioneering global experiences that achieved tangible successes that were positively reflected on the state of development at regional levels. What has been previously studied, as well as what is related to it with national development trends and the extent of the role that local regional units play in activating these trends and aspirations at the national levels to curb climate changes, the conceptual framework drawn up is dropped through a number of areas: (The study steps follow, methods and measures and clarify the idea of difference, and the output of the stage)

5.3.1. The current Egyptian framework

Presentation of the conceptual framework applied in the Egyptian case based on the reference guide for preparing the general strategic plan for the governorates prepared by the General Organization for Physical Planning (GOPP), 2011; appears as follows:

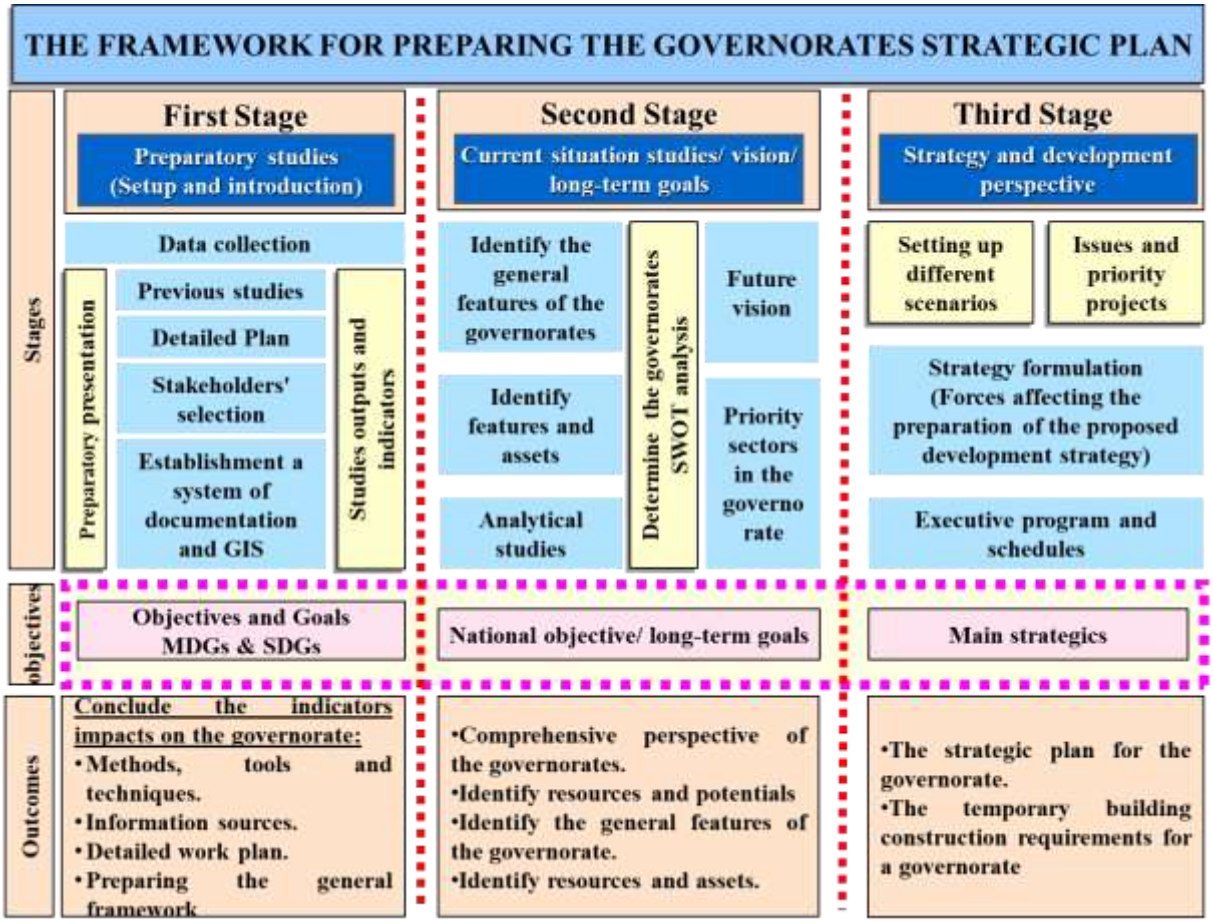


Figure 16: The Current Egyptian framework

Source: The author's edition based on GOPP 2011

5.3.2. General methodology for preparing the strategic plan for the Egyptian governorates.

The study steps are followed by the methodology of preparing the strategic plan for the provinces as shown in the following figure.

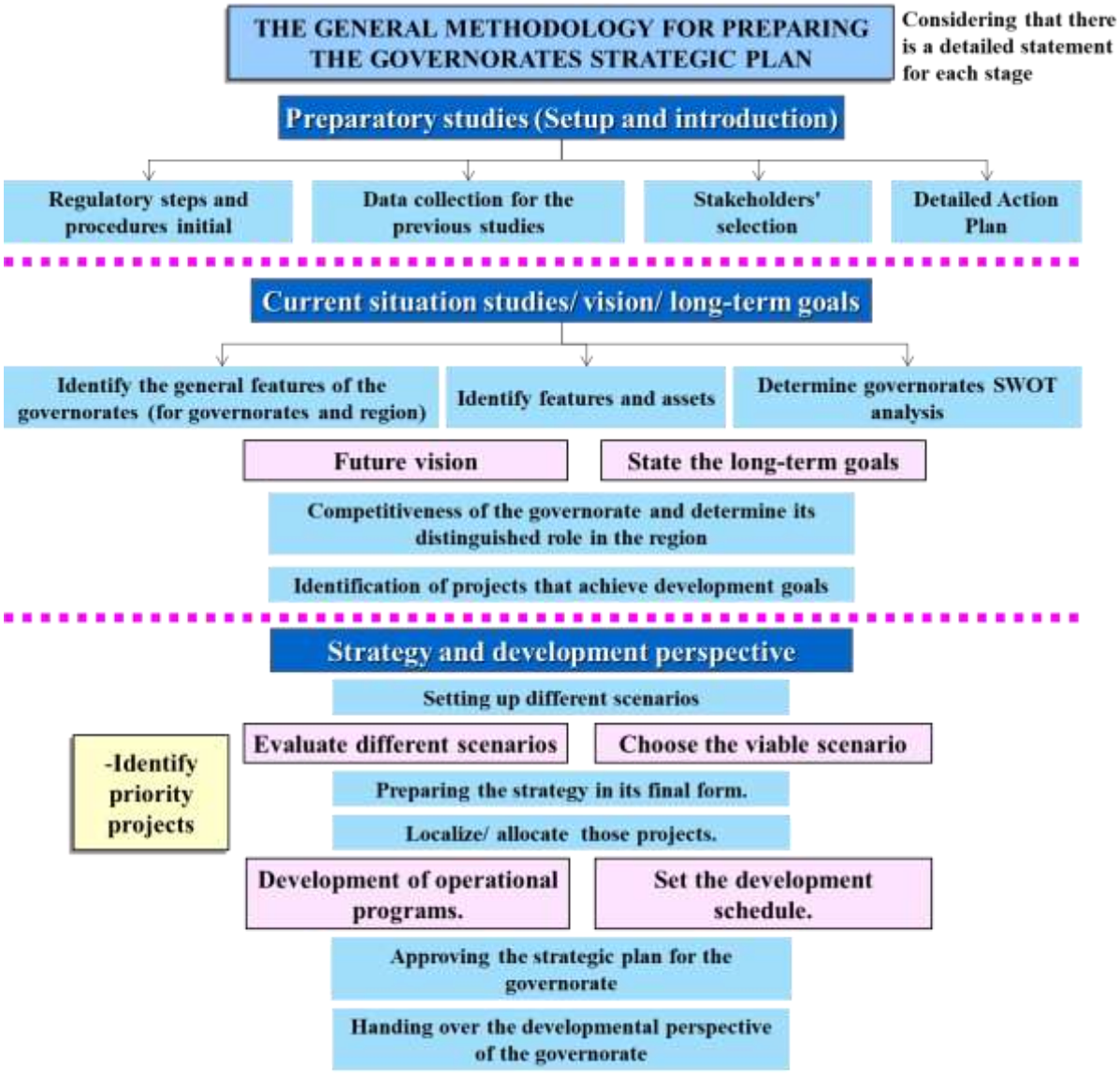


Figure 17: General methodology for preparing the strategic plan for the Egyptian governorates.
Source: The author's edition based on GOPP 2011

From the above, we find that there is a difference in the proposed intellectual framework for preparing the strategic plan for the provinces, and the intellectual framework previously discussed through global experiences, for example, we find that the "vision formulation" process is better for it to come at an advanced stage, relying on the national vision to provide the best translation of the national goals at the provincial level.

5.3.2.1. First Stage, Preparatory studies

The following is the detailed methodology for the first stage, and as mentioned earlier, emphasis must be placed on the vision set for the region (the governorate), and emphasis must be placed on formulating and translating the goals that achieve that vision, with an emphasis on the process of community participation among the relevant parties.

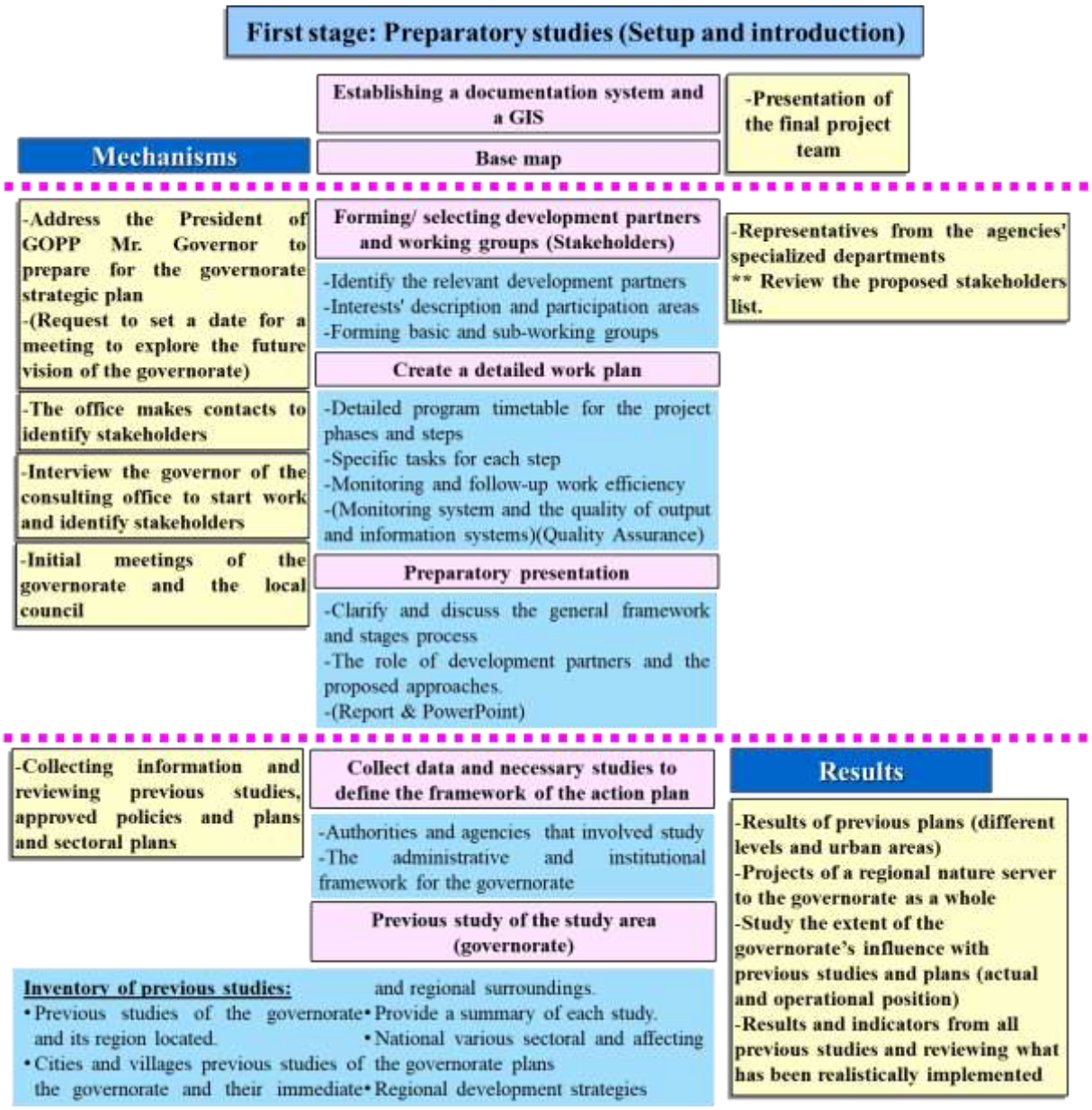


Figure 18: First stage, Preparatory studies

Source: The author's edition based on GOPP 2011

5.3.2.2. Second Stage, Current situation, vision and long-term goals

It is for preparing the strategic plan is the main stage, where studies of the current situation and formulation of the vision and sectoral goals, in order to reach the foundations of the formulation of the strategic plan but based on the proposed scenario after the national vision has been

emphasized, appropriate indicators and methods must be used for each region (governorate) separately, based on the region's characteristics. one of the most important steps within the stage is to identify the resources and assets that contribute directly to the formation of priority use areas or specialized areas.

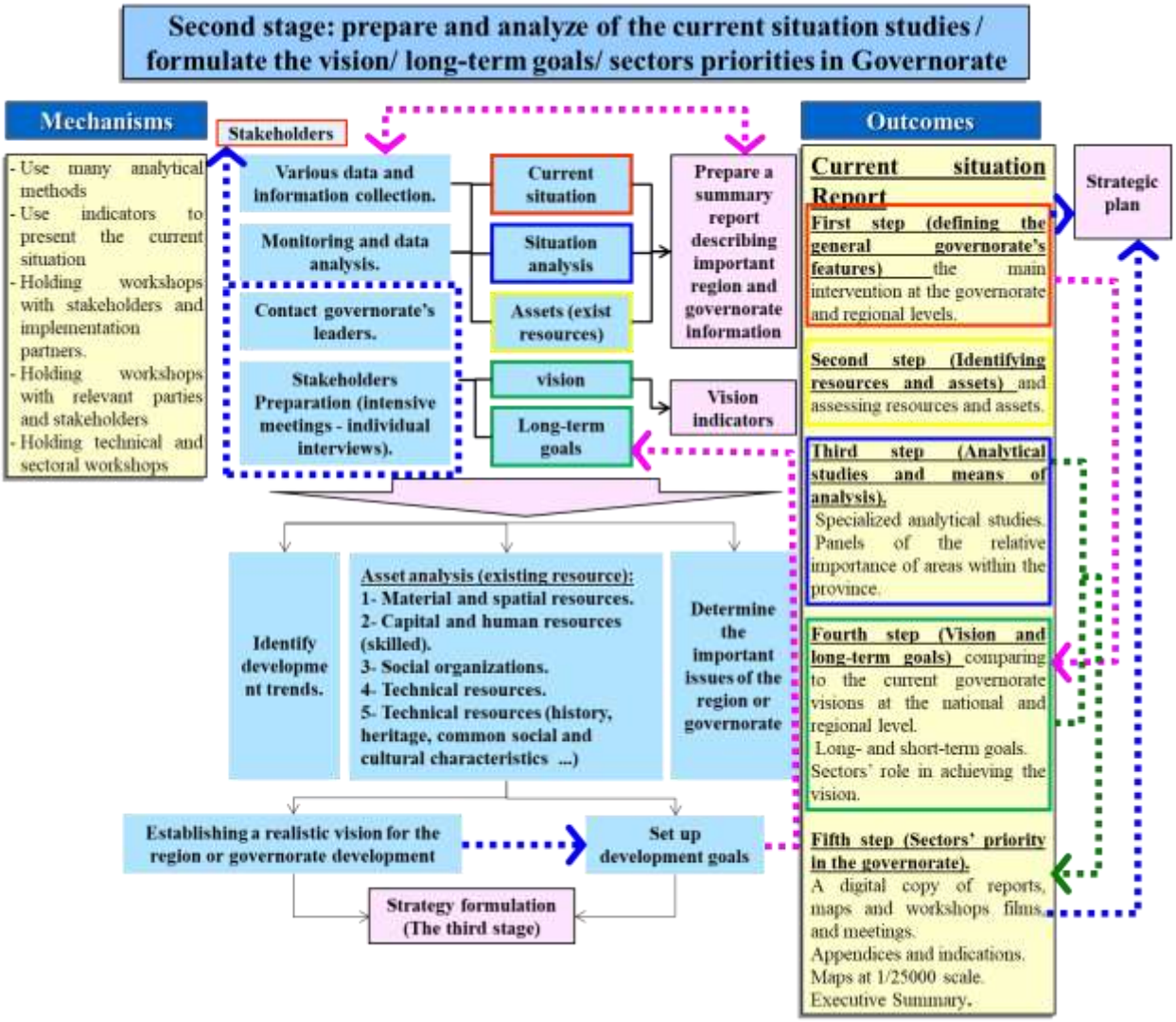


Figure 19: Second stage, Current situation, vision and long-term goals

Source: The author's edition based on GOPP 2011

a. First Step, Defining governorate general features.

One of the most important steps in preparing the strategic plan is to concern with defining the governorate's features completely internally and externally to formulate and define sectoral capabilities for a comprehensive description of the main features of the governorate, in addition to analysing and classifying issues.

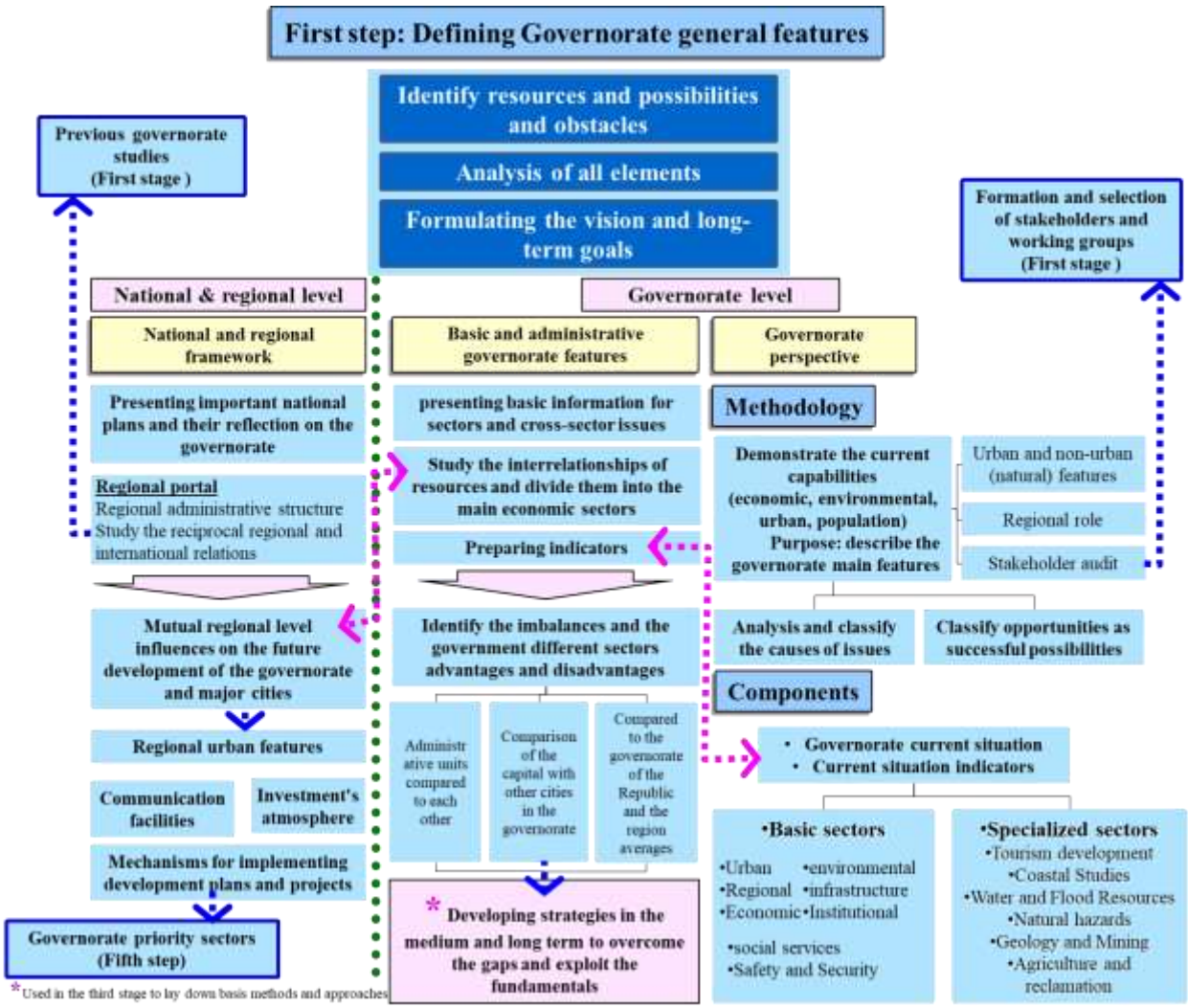


Figure 20: First Step, Defining governorate general features.

Source: The author's edition based on GOPP 2011

b. Second Step, Identifying the assets and resources.

This step is the articulated step as it depends on the previous steps as inputs and has a clear and direct reflection on the next steps, to analyse the natural and non-natural resources of the governorate, however, it needs to be rearranged, and it is progressed within the methodology to be integrated with the vision proposed at the national level, to be supported by the resources and components of the governorate when formulating the goals achieved.

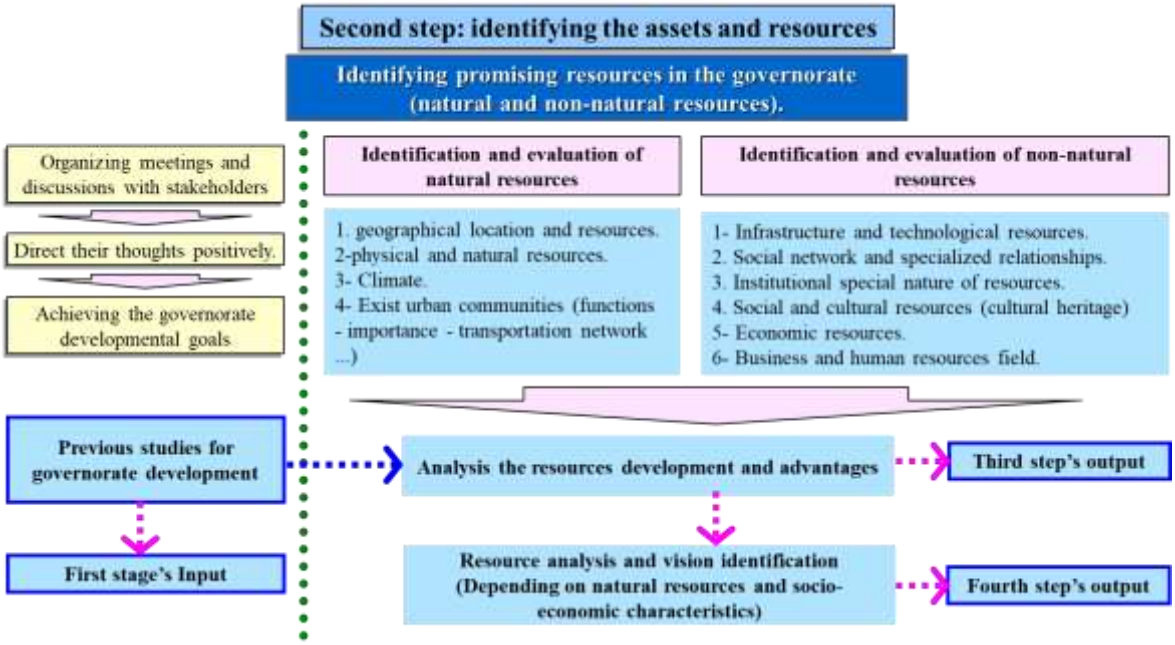


Figure 21: Second Step, Identifying the assets and resources.
Source: The author's edition based on GOPP 2011

c. Third Step, Governorate Analytical studies

As for this step, it needs a lot of development by adding appropriate methods and measures that are reflected in the outputs looking for. Where the Ecological footprint scale and its relationship with the Human Development Index should be added mainly to support the sustainable development process and to determine where the region is located on the environmental and development ruler to find the best entrances for planning land uses and to identify priority areas for uses or special economic zones.

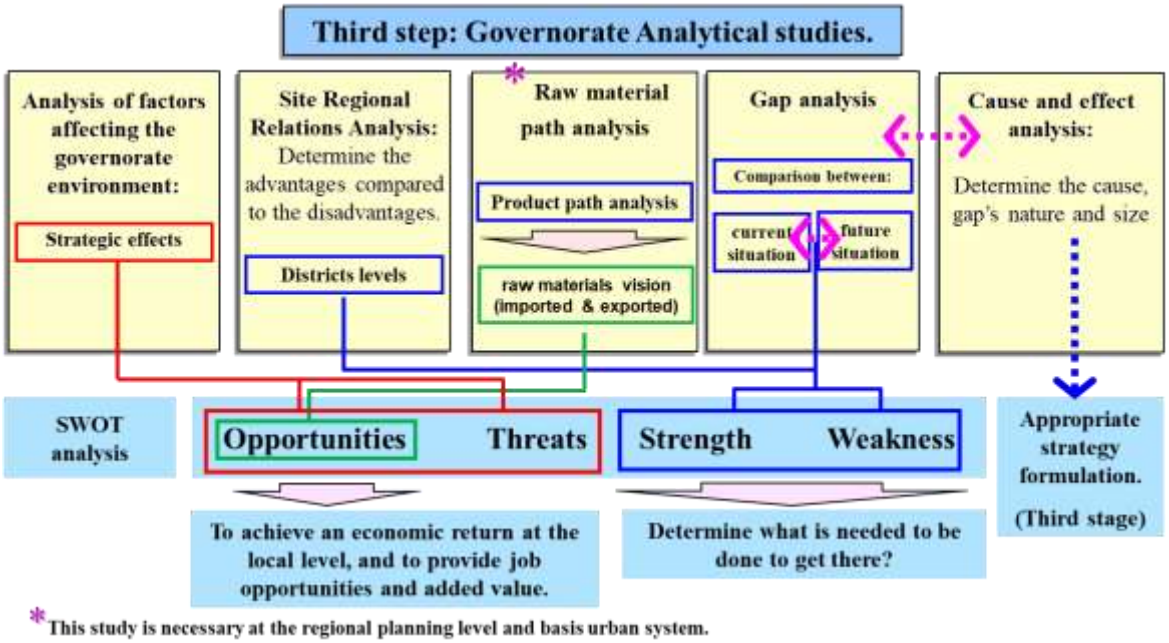


Figure 22: Third Step, Governorate Analytical studies
Source: The author's edition based on GOPP 2011

d. Forth Step, Vision and long-term goals

The methods of regional impact assessment should be added to the entire methodology within the context of the methodology to measure the suitability of the proposals to achieve the desired development for the province.

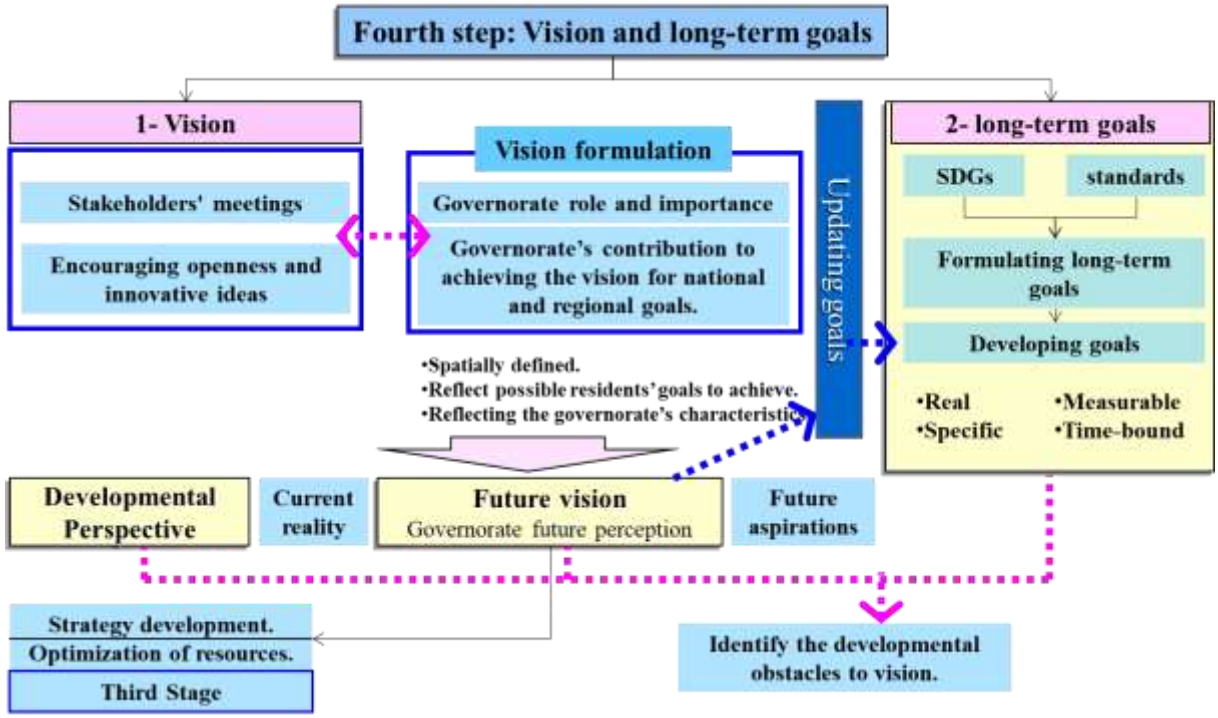


Figure 23: Forth Step, Vision and long-term goals

Source: The author's edition based on GOPP 2011

e. Fifth Step, Governorate's priority sectors

This step is developed to be the identification of priority areas for private or economic uses and not only service or economic projects.

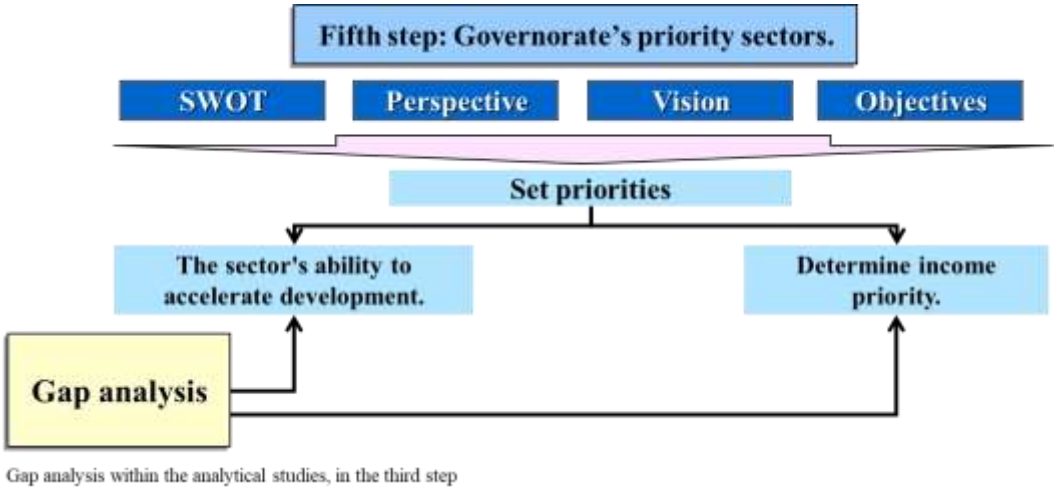


Figure 24: Fifth Step, Governorate's priority sectors

Source: The author's edition based on GOPP 2011

5.3.2.3. Third Stage, Strategy formulation

This stage requires a reformulation, especially of the outputs, to reach the planned land uses, and not just formulating a strategy to suit the planning level under study.

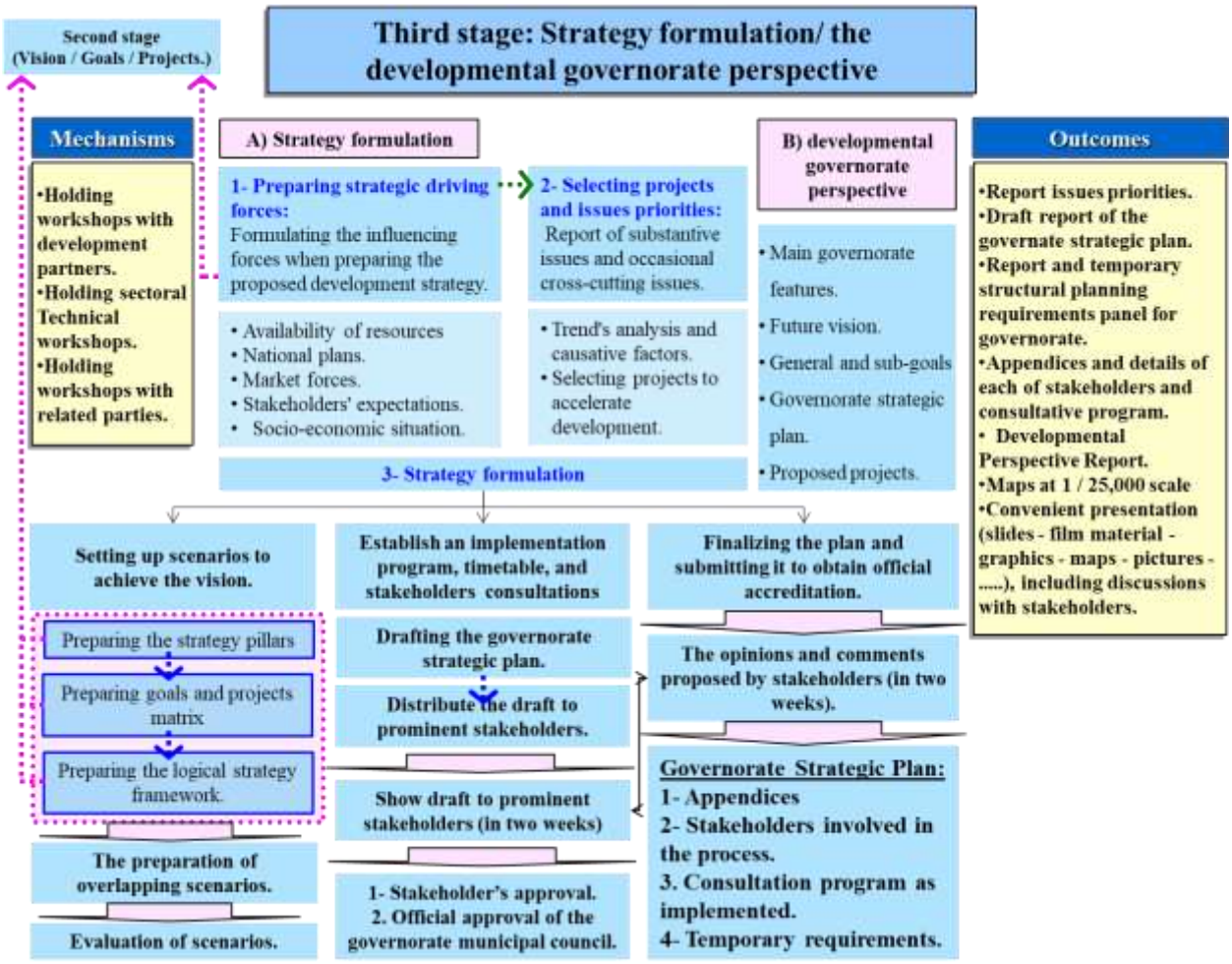


Figure 25: Third Stage, Strategy formulation

Source: The author's edition based on GOPP 2011

5.3.3. Proposed general methodology -modified- for strategic plan for the Egyptian governorates.

According to what was previously listed, the amendments requested to be added can be summarized as follows.

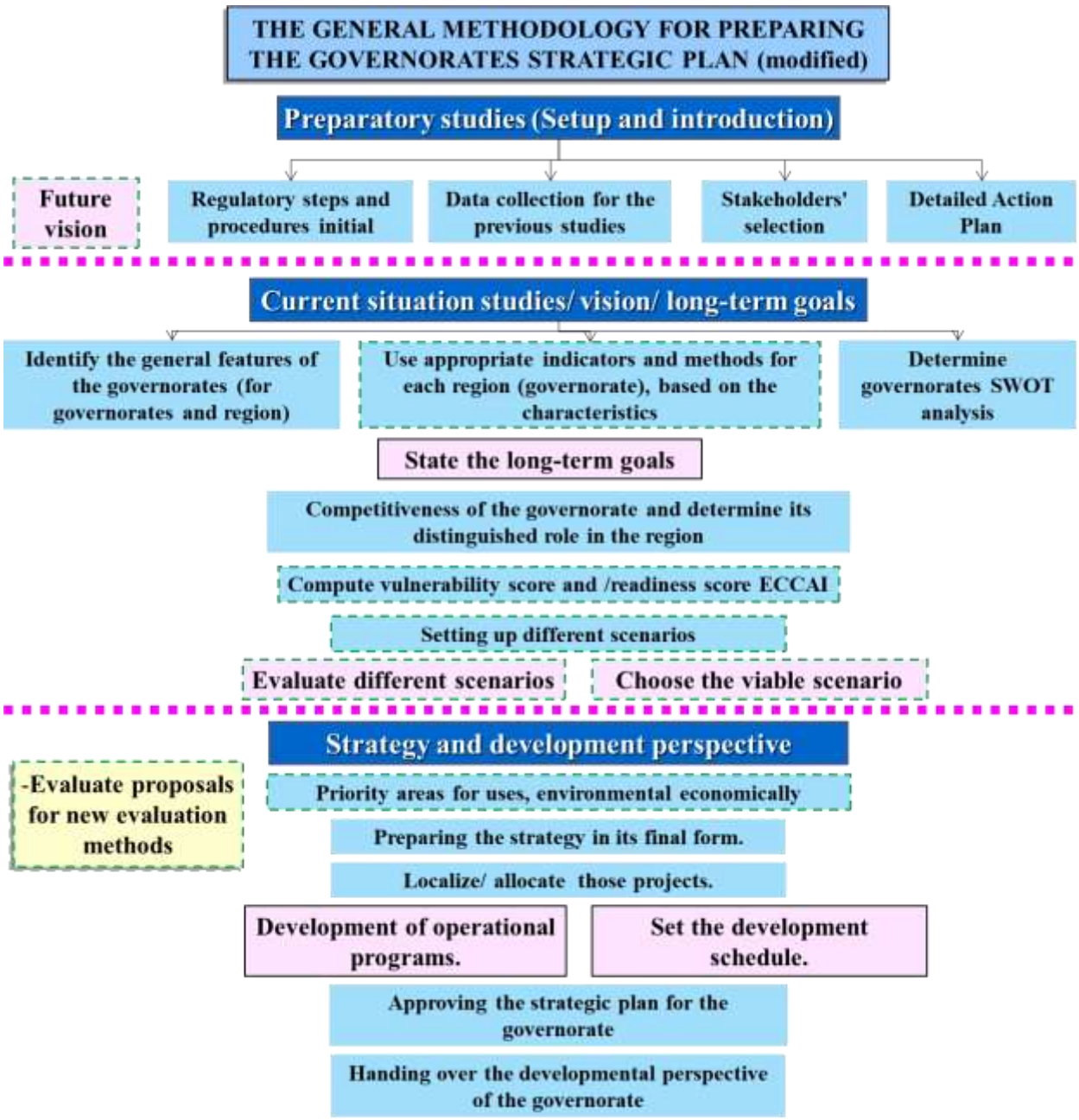


Figure 26 Modified general methodology for preparing the strategic plan for the Egyptian governorates.

Source: The author's edition

5.4. Testing of Hypotheses

Verification of testing of the hypotheses

Four proposed hypotheses were tested in the course of the work, and this section presents the confirmation of the hypotheses. 1) There is a higher likelihood that Egyptian institutional/ governmental systems have not been ready for handling the complexity of climate change hazards; 2) There is likelihood that Egypt has no LED policies currently applicable to combat climate change hazards; 3) The application of LED is more likely to be the most appropriate approach to adapt climate change; 4) Applying LED is not the only proper answer to climate change but also to improve solving the social-economic problem and sustainable development.

Table 14: Hypotheses testing relatives to research questions and methodologies.

Hypotheses	Research Questions	Research methodologies	Research Tools	Chapter	Testing of Hypotheses
Why the local economic development is the best approach to achieve the development in the regions, adapting climate change hazards?					
There is a higher likelihood that Egyptian institutional/ governor systems have not been ready for handling the complexity of climate change hazards.	What are the kinds and types of climate change hazards in Egypt?	Deductive	Theory& Operationalization	2.1 2.2	Partly Approved
There is likelihood that Egypt has no LED policies currently applicable to combat climate change hazards.	What are the local economic development policies that provide the competitiveness?	Deductive	Theory& Observation	2.3	Approved
The application of LED is more likely to be the most appropriate approach to adapt climate change.	How to develop the LED process to achieve a real development in the regions?	Comparing case studies	Operationalization	5.1	Approved
Applying LED is not the only proper answer to climate change but also to improve solving the social-economic problem and sustainable development.	How conceived policies can deal with the current development and planning limitations of the Egyptian contexts?	Analytical	Observation	5.2 5.3	Partly Approved

Source: The author's edition

6. CONCLUSIONS AND RECOMMENDATIONS

Part five is the final part of the study, and it highlighted the summary, conclusions and recommendations of the work. It presented the summary and findings based on the objectives of the research. It further stated the policy interventions to adapt the climate change hazards in Egypt.

The purpose of the study was to invent a LED policies and projects for providing an adaptation and allocating them spatially, this has the ability to monitor and deals with the climate change on the regional level in Egypt. Specifically, the study aimed at:

- Defining the relation between the LED policies and the climate change hazards.
- Studying the applicability of the LED policies on the climate change hazard and regional development.
- Studying international case studies dealing with climate change adaptation.
- Testing the efficiency of the policies within the limitation of the Egyptian context.

6.1. Climate change hazards

Main concept/ policies of adaptation, mitigation is related to the issues in the region mainly the social issues fit more the adaptation concept, but the physical and environmental impact need mitigation approach to make a real effect to achieve the sustainable development. As shown in the following Tab. 15.

6.2. Climate change Hazards in Egypt

Climate change impacts through regional development policies target all regions and cities to support job creation, business competitiveness, economic growth, sustainable development, and improve citizens' quality of life. The government adopts its national policies and measures, since these are vital for the protection of existing investments, and simultaneously secures growth and sustainable development.

6.2.1. Aims of National Strategy

1. Increasing the flexibility of the Egyptian community in dealing with the risks and disasters.
2. Enhancing the capacity to engage and contain climate-related risks and disasters for adapting temperature increase and water scarcity, and the precipitation and sea level rise.
3. Reduction of climate change- related disasters; field and theoretical observing the different sectors of the community, appropriate support of the existing projects, locations and designs for new projects.

Table 15: Climate change adaptation /mitigation polices related to the main issues.

	Adaptation	Mitigation
Socio-economic	**Poverty and adaptation** • more equitable distribution of economic growth, access to resources, greater equity between genders and social groups, and increased participation in local decision-making (especially by the poor) **Local engagement and adaptive capacity** resource availability and by access to social and economic networks, entitlements, institutional support, education and technology- are unevenly distributed	**Investment approaches to mitigation** countries will no longer have the option of following a traditional fossil-fuel-dependent development path. strong win-win possibilities for both developed and developing countries in terms of increased energy efficiency
Legal	**Policy integration and coherence at the national level** integrated not only into development policy in general but also into policy areas such as poverty reduction, rural development, disaster risk management, water resources, health, and infrastructure investment	**Mitigation regimes** the regulation of fuel portfolios as well as emission levels, economic incentives, technological support, and education
Environmental		**Equitable emission targets** • Implies total emission cuts of 30% for developing countries. • Population changes would amount to per capita reductions in developing countries close to those suggested for developed countries. • Larger reductions, which are necessary to ensure that emissions are stabilized at a level that will prevent the global temperature from rising by more than 2˚ C, would leave developing countries with very little room to manoeuvre in terms of increasing their consumption of energy from traditional sources. **Energy transition** • it is responsible for over three quarters of total GHG emissions but is also inextricably linked to economic activity and the fulfilment of human needs. • The Agency maintains that "mobilizing all this investment will be challenging". **Consumption and emission targets** • Using a product life-cycle approach, the environmental repercussions of producing various goods (such as GHG emissions) will need to be incorporated in the calculations of environmental pressures related to the consumption of these goods. Such assessments will have a bearing on the calculation of equitable targets. • Developed countries will become increasingly service-oriented, shifting away from high-emission industries such as iron, steel, aluminium, chemical, glass, and paper production. "Outsourcing" the production of fossil-fuel-intense, high-emission goods to developing countries has been occurring for some time.
Physical		**Forestry and land use** • large-scale shift in land use towards the production of biomass for fuel generation, as evidence suggests that there may be significant trade-offs related to food security and food prices. • Issues such as these highlight the importance of using an integrated approach to address challenges linked to climate change.

Source: The author's edition based on chapter 3.1

6.2.2. Egyptian environmental issues challenges

1. Confusion in the Legal Framework Governing Planning for Regional Economic Development; The legal basis for planning in Egypt stems from two key laws: 1. Planning Law No 70 for the year 1973: The national socioeconomic plan; 2. Strategic Planning According to the building Law No 119 for the Year 2008: The Strategic Plan; 3. The National Centre for Planning State Land Uses (Presidential decree number 153 for the year 2001): Counting and reforming the state lands and preparing the general planning.
2. Weak Institutional Relationship Between Public Research Institutions and Universities and Regional and Local Actors Engaged in Economic Development; According to the Local Administration Law, the governor shall act to support cooperation between the governorate institutions and universities and research institutes which are located within the governorate area, to serve the environment and promote the local society. However, the governor role in practice is very limited in the economic development at the local level that efforts are predominately either executed at or planned by the central level.

For the environmental issues, Clarify the planning approach that will be adopted at the regional level: The different institutional actors, will have different roles in the planning process. The reforms' goal to lead the planning for economic and urban development, in accordance with the state general policies and a framework for regional planning drafted by the central government.

Sectoral impacts of climate change: Climate change - with its many dimensions (social, environmental, economic and political) - is expected to lead to multiple impacts at various scales and levels. The impacts on natural ecosystems will be reflected on all socioeconomic levels, affecting livelihoods and human well-being. The prevailing climatic conditions in the Arab region have highly significant impacts on the different components of the ecosystems. Major impacts could be attributed to the inherent fragility of the dominating arid ecosystems of the region. These arid ecosystems are generally characterized by inferior physiochemical properties, the weak resilience of soil resources and relatively limited availability of surface/ground-water resources.

According to administration levels and their relation to adopt the climate change hazards, the following Table .16 illustrate how could adaptation policies work by the regions.

Table 16: Adaptation policies for climate change hazards along economic regions

Region	Climate Change Adaptation Policies		
	Water resources	**Agriculture and food security**	**Sea level rise, coastal inundation and erosion**
1) Cairo	– Water recycle usage for garden irrigations		
2) Alexandria	– Water recycle usage for garden irrigations		– Rocky barriers, sea walls, wave barriers – Beach maintenance
3) Delta	– New irrigation techniques – Water recycle usage	– Use different water resources. – Develop the crop cycles. – Use the new agriculture techniques	– Rocky barriers, sea walls, wave barriers
4) Suez Canal	– Water recycle usage for garden irrigations		– Rocky barriers, sea walls, wave barriers
5) Northern Upper Egypt	– New irrigation techniques – Water recycle usage	– Use different water resources. – Develop the crop cycles. – Use the new agriculture techniques	– Create bumpers in the highlands
6) Asyout	– New irrigation techniques – Water recycle usage	– Use different water resources. – Develop the crop cycles. – Use the new agriculture techniques	
7) Southern Upper Egypt	– New irrigation techniques – Water recycle usage	– Use different water resources. – Develop the crop cycles. – Use the new agriculture techniques	– Create bumpers in the highlands

Source: The author's edition based on chapter 3.2

6.3. Local Economic Development

As mentioned, LED stakeholders should believe that climate change activities have a potential for economic development. Therefore, the stakeholders should support mitigation and adaptation initiatives contribute to local economic development. As they uphold the potential of mitigation and adaptation initiatives. Additional qualitative data should be obtained through stakeholder interviews. To summarize:

- Mitigation and adaptation initiatives were both perceived as a potential for economic development by all stakeholders.
- Stakeholders of the same stakeholder group did not differ between the perceived potential for mitigation and adaptation.
- LED consultants perceived the potential for adaptation higher than other stakeholder groups.
- Stakeholders within the energy sector did not distinguish between mitigation and adaptation.
- LED consultants did not care about distinguishing mitigation from adaptation initiatives as long as they contribute to the objectives of LED.
- Mitigation and adaptation were considered to have an impact on job creation, skills development, and inventiveness.
- Most stakeholders rated the potential based on a gut feeling rather than on knowledge.

- Stakeholders could identify the economic development potential for mitigation more easily than for adaptation.
- LED consultants and stakeholders with a background in the energy sector provided more qualified answers.
- Stakeholders believed that fire management, replacing flaming light bulbs with energy efficient lighting systems and solar power usage have the highest potential for economic development.
- The generally high ratings suggested that stakeholders overrated the economic potential and did not differentiate much between initiatives.
- The rating was based on the stakeholders' level of knowledge, their priorities, and especially their personal motives and experiences.

6.4. Case studies

There are three main categories for the case studies related to the urban/physical status. Therefore, the settlement scale are two main domains which are the rural communities and the urban areas, and for the larger scale and different connections land use change.

6.4.1. Rural communities

The main focus highly dependent upon natural resources, face particular obstacles in responding to climate change that increase their vulnerabilities to its impacts. Therefore, Climate change planning requires a shift from a "predict-then act" approach to a "no regret" approach. It requires an understanding of vulnerabilities and investments in resilience. The vulnerability of communities to climate change must be considered within a wider socio-economic context. Because climate change can change over decades, socio-economic change can have a larger impact on communities in a much shorter period of time, potentially reversing a vulnerable environment. It is essential for climate change vulnerability assessments to analyse socioeconomic dynamics.

6.4.2. Urban Areas

Two main points related to the climate change adaptation into the urban areas are: 1) Within discussions on climate change adaptation, there is too much focus on trying to calculate the funding needed for adaptation without recognizing the political and institutional constraints on adaptive capacity and without discussing the institutional mechanisms to get the needed funding for adaptation to those who can use it well – including community-based or grassroots-led initiatives. 2) Almost all adaptation is local and, to be effective, needs strong local knowledge and strong local adaptive capacity. Certainly, for urban areas, there need to be CAPAs and, very often, smaller-scale LAPAs – especially for the settlements or areas most at risk. These, in turn, can also promote

learning and innovation on how public policies and investments can work best with community-based adaptation. They also provide the practical experience on which NAPAs can be much improved.**…those systems are often connected to rural locations at great distance from urban centre.**

6.4.3. Land use and land cover change

There are two aspects to considering impacts of land use: effects of land use on climate change and the effects of human-induced climate change on land use. The direct ecological effects of the land-use and climate change are dominated by the land-use change effects, at least over the period of a few decades. Because climate-change effects are largely determined by land-cover patterns, land-use practices set the stage on which climate alterations can act. Determining the effects of climate change on land use involves resolving direct biophysical effects as well as management responses to climate impacts. Climate change might constrain or mandate particular land- management strategies; however, these options will be different for each case.

6.5. Egyptian Climate Change Adaption Index (ECCAI)

According to the previous calculations and the scattered diagram for the Egyptian governorates are distributed as follow: Red (Upper Left) Quadrant (Greatest challenges and urgency to act): Behara; Yellow (Lower Left) Quadrant (Few present challenges, have time to get ready): Kafr EL Sheikh, Assiut, Fayoum, Minia, and Qena; Blue (Upper Right) Quadrant (Have great challenges, but are adopting solutions): Cairo, Giza, Alexanderia, Qalyubiya, and Gharbyah; Green (Lower Right) Quadrant (Well positioned with few challenges): Menofya, Sharqiyah, Aswan, Port Said, Damietta, Red Sea, Ismailia, Suez, Bani Swaif, and Luxor; and Grey Some data are missing, For the governorates North Sinai, South Sinai, Matroh, New Valley Their values were not fully presented especially for the readiness indicators.

6.6. Egyptian Framework recommendations

Hybrid the ECCAI into the strategic plan framework to enhance the vision and built-up reliable scenarios dealing with the stakeholders to activate Local Economic Development principles.

7. NEW SCIENTIFIC FINDINGS AND THEIR UTILIZATION

The study finds that there are advanced developments in climate hazards modelling where scholars are performing extremely well in expressing new skills in finding sustainable solutions. On the other hand, policy makers are at advanced stages with coming up with the best policies for mitigating and adapting these hazards. Albeit of these developments, a wide gap exists between the two groups. Reducing the nature of the gap between policy makers and researchers or scientists is a plausible pathway towards sustainable climate change hazards adaptation. Therefore, this study recommends the adoption of transdisciplinary approach towards climate change hazards adaptation through adoption of measures that transcends beyond the respective disciplines and specializations to ensure a hybrid-model for solving the hazards is arrived at and designed.

7.1. New Scientific Achievements/Observations

7.1.1. Developing the climate change policies implementations for adaptation

- Proposed future directions in exploring the interactions between land-use change and climate change.

  1) Transdisciplinary studies of land-use and climate-change effects are necessary. For example, economic, political, and social changes must consider ecological responses, and vice versa. Also, biologists need to work with climatologists to develop climate models at spatial scales that are useful in assessing the state of the biotic system. Scientists need to be aware that many problems are not solvable based on a single-discipline approach.

  2) Spatially explicit models at local and regional scales are necessary to relate land-use changes to climate change. Many management questions are at the landscape or regional scale, and land management tends to occur at these scales. If these models have biologically relevant and socioeconomically meaningful interfaces and outputs, then these models can meet many of the management needs.

- Proposed new climatical and ecological inputs into the developmental process, the strategic plan framework updates.
- Developed the adaption index to classify the Egyptian governorates based on ECCAI. As shown in the following figure

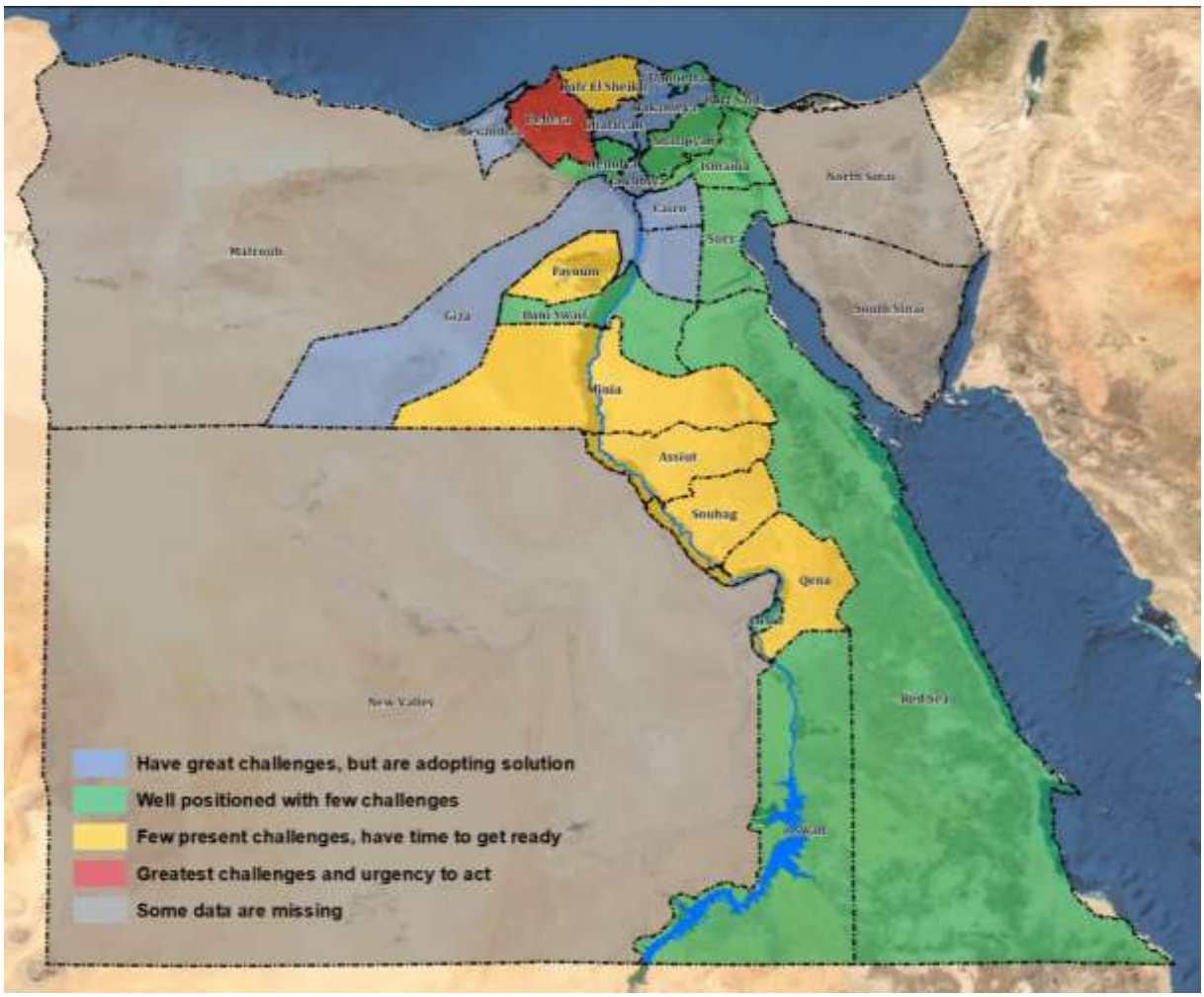


Figure 27 Egyptian adaption index visualisation on the governorate level
Source: Author's edition made by GIS 10.7

7.1.2. Developing the tasks of the executive institutions Sector

- Establishment of strong and joint cross-sectoral taskforces for developing and editing the plans methodology for implementing the new economic projects and their allocation based on the climate change adaptation policies.
- Information needs to be collected on how climate change (as compared to other confounding factors, e.g., land-cover change) will affect.
  - The spatial distribution of natural vegetation (particularly rare species or those at the edges of their ranges), human population, land-use practices, and land-cover types.
  - The distribution of natural and human-induced species movements (including movements of humans).
  - The distribution and frequency of disturbances (e.g., hurricanes, tornadoes, fires, and insects) and the responses of organisms to disturbance.
  - Changes in patterns of economic growth and the resulting need for land-use change (e.g., for agricultural expansion).

- There is a need for developing a framework embracing for open sharing if the collected climate data for the different stakeholders and experts and the public. This will increase the reliability, accessibility and availability of the information.
- Establishing a multiagency governorate teams for monitoring, reading and validation of the climate change adaptation in line with the general development agenda remains imperative for the whole Egypt in pursuit for achieving SDGs.

7.1.3. Developing the higher education

- Develop some courses and curriculums for the ecological planning, hazards management, and economic approaches to adapt climate change hazards.
- Focus on the local communities and stakeholders power techniques, Scientists need to assist policy makers, stakeholders, and the public by:
  - Providing information linking climate change and land use.
  - Defining what climate change would mean (in an ecological, social, health, political, and economic sense); and
  - Relating people's lifestyles and energy choices to environmental consequences (e.g., demonstrating the effects of automobile and other energy use on climate change, pointing out the repercussions of local and regional land-use activities on the global environment, and identifying the per capita impact of human population and consumption).

7.2. Policy Implications and Recommendations

- To achieve the Paris Agreement together with the SDGs, countries must accelerate their level of commitment whether at the National, regional, or local level. This is achievable through establish of government mechanisms those shall oversee a coherent development and climate change hazards control framework in place. A framework that is defined by sustainability at its core. To develop such a framework, interdisciplinary research is not enough especially in those issues that interferes with different stakeholders' interests. Therefore, in coming up with sustainable policy directions and guidelines territorial development, adopting a transdisciplinary approach would be a potential solution for future developers.

7.3. Future Research areas (Fundamental research)

- Relation between causes of land-use and actual land-cover changes-How can the causes and effects of these relations be clarified?
- Paleoecology-How have species and ecosystems responded to climate changes in the past? Note that predicted changes are different from past climate alterations.

- Agriculture- What are best land-use practices on tropical and temperate soils? Can use of native species offset climate-change effects on agriculture? Can use of species from warmer environments offset effects of temperature increases?
- Testing the stakeholders and the expertise knowledge in the applicable adaption policies in different settlements status.

8. SUMMARY

Climate change as an additional stress is threatening habitats, ecosystems and land globally. The effects of climate change are projected to have adverse effects on developing countries and Egypt in not an exception. Additional to the current global situations concerning the impacts of long-term climate variability and extreme weather events, continued heatwaves and increasing sea level rise are dominating across Egypt. The Paris Agreement (2015) delineates the importance of GHGs emissions mitigation and adaptation measures, which should be officially implemented by 2020. Egypt is among the pioneer countries that ratified the accord in its preliminary stages. This was a significant milestone in committing towards combating climate change across the country. Despite, Africa being rated the least among the continents contributing to the atmospheric pollution, it continues to be responsible for the least global emissions (estimated at 4%). Although they contributed to anthropogenic emission slightly, Egypt and the rest of the continent are highly vulnerable to the impacts of long-term climate variability and extreme weather events. Increased water shortages, changing rainfall patterns, sea level rise, desertification and frequent heatwaves are some of the challenges associated with climate change presently being experienced across Egypt putting the countries development path at risk.

Considering the vulnerability of climate change hazards and its massive contribution to the socio-economic development of many nations including Egypt. The research tries to provide some applicable proactive policies which can deal with one of the most difficult problems in the future by developing countries in general and for Egypt in practice. The problem concerns the threats that climate change might have to developing countries' development potentials and natural resources. The purpose of the study was to invent a LED policies and projects for providing an adaptation and allocating them spatially, this has the ability to monitor and deals with the climate change on the regional level in Egypt. Specifically, the study aimed at: Defining the relation between the LED policies and the climate change hazards; Studying the applicability of the LED policies on the climate change hazard and regional development; Studying international case studies dealing with climate change adaptation; and testing the efficiency of the policies within the limitation of the Egyptian context. The research has state four hypotheses: 1) The application of LED is more likely to be the most appropriate approach to adapt climate change; 2) Applying LED is not the only proper answer to climate change but also to improve solving the social-economic problem and sustainable development; 3) There is likelihood that Egypt has no LED policies currently applicable to combat climate change hazards; and 4) There is a higher likelihood that Egyptian institutional/ governmental systems have not been ready for handling the complexity of climate change hazards.

According on that, the main adaptation and mitigation policies are related to the issues in the region mainly the social issues fit more the adaptation concept, but the physical and environmental impact need mitigation approach to make a real effect to achieve the sustainable development. However, Climate change impacts through regional development policies in Egypt target all regions and cities to achieve general development goals and objectives. The government adopts its national policies and measures, since these are vital for the protection of existing investments, and simultaneously secures growth and sustainable development. The National Strategy aims at achieving the following goals: 1) Increasing the flexibility of the Egyptian community in dealing with the risks and disasters; 2) Enhancing the capacity to engage and contain climate-related risks and disasters for adapting temperature increase and water scarcity, and the precipitation and sea level rise; and 3)Reduction of climate change-related disasters; field and theoretical observing the different sectors of the community, appropriate support of the existing projects, locations and designs for new projects.

For the environmental issues in Egypt, Clarify the planning approach that will be adopted at the regional level: The different institutional actors, will have different roles in the planning process. The reforms' goal to lead the planning for economic and urban development, in accordance with the state general policies and a framework for regional planning drafted by the central government. Climate change - with its many dimensions (social, environmental, economic and political) - is expected to lead to multiple impacts at various scales and levels. The impacts on natural ecosystems will be reflected on all socioeconomic levels, affecting livelihoods and human well-being. Major impacts could be attributed to the inherent fragility of the dominating arid ecosystems of the region. These arid ecosystems are generally characterized by inferior physiochemical properties, the weak resilience of soil resources and relatively limited availability of surface/ ground-water resources.

LED stakeholders should believe that climate change activities have a potential for economic development. Thus, the stakeholders should support adaptation initiatives contribute to local economic development. Additional qualitative data should be obtained through stakeholder interviews as: adaptation initiatives were both perceived as a potential for economic development by all stakeholders; that the energy sector did not distinguish between mitigation and adaptation; Most of them rated the potential based on a gut feeling rather than on knowledge; they could identify the economic development potential for mitigation more easily than for adaptation; Stakeholders believed that fire management, replacing flaming light bulbs with energy efficient lighting systems and solar power usage have the highest potential for economic development; LED consultants perceived the potential for adaptation higher than other stakeholder groups; both of them with a background in the energy sector provided more qualified answers; The generally high

ratings suggested that stakeholders overrated the economic potential and did not differentiate much between initiatives; and that rating was based on the stakeholders' level of knowledge, their priorities, and especially their personal motives and experiences.

There are three main categories for the case studies related to the urban/physical status. Therefore, the settlement scale are two main domains which are the rural communities and the urban areas, and for the macro scale and different connections land use change would be the related response. Rural communities are mainly focus highly dependent upon natural resources, face particular obstacles in responding to climate change that increase their vulnerabilities to its impacts. And for the urban areas that inappropriate to conceive of "the problem" as mainly one of a lack of funding. And those systems are often connected to rural locations at great distance from urban centre.

Land-use changes are having major ecological repercussions at a variety of biological scales. Being able to project effects of particular land-management strategies requires an understanding of the socioeconomic and biological aspects of land-use decisions. Such research will involve interdisciplinary efforts and will provide a better understanding of potential impacts of global change. The study finds that there are advanced developments in climate hazards modelling where scholar is performing extremely well in expressing new skills in finding sustainable solutions. Therefore, this study recommends the adoption of transdisciplinary approach towards climate change hazards adaptation through adoption of measures that transcends beyond the respective disciplines and specializations to ensure a hybrid-model for solving the hazards is arrived at and designed. And the study has examined the adaption index by calculating the ECCAI on Egyptian governorate level, and combine the results to update the strategic plan framework.

Proposed future directions in exploring the interactions between land-use change and climate change. 1) Transdisciplinary studies of land-use and climate-change effects are necessary to develop climate models at spatial scales. 2) Spatially explicit models at local and regional scales are necessary to relate land-use changes to climate change. Many management questions are at the landscape or regional scale, and land management tends to occur at these scales.

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