Chapter–4

Theoretical Orientation

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Theoretical orientation is used in research articles for providing a detail background idea about the research article. A researcher's theoretical orientation will inform readers about the branch or theory the paper uses as its foundation. This allows the reviewers for an improved ability to evaluate the research within the framework of theoretical construct.

Social Change

Social change refers to an alteration in the social order of a society. Social change may include changes in nature, social institutions, social behaviours, or social relations. It involves the complex interaction of environment, technology, culture, personality, political, economic, and religious.

Social change may refer to the notion of social progress or sociocultural evolution, the philosophical idea that society moves forward by dialectical or evolutionary means. It may refer to a paradigmatic change in the socio-economic structure, for instance a shift away from feudalism and towards capitalism. Accordingly it may also refer to social revolution, such as the Socialist revolution presented in Marxism, or to other social movements, such as Women's suffrage or the Civil rights movement. Social change may be driven by cultural, religious, economic, scientific or technological forces. Change comes from two sources. One source is random or unique factors such as climate, weather, or the presence of specific groups of people. Another source is systematic factors. For example, successful development has the same general requirements, such as a stable and flexible government, enough free and available resources, and a diverse social organization of society. So, on the whole, social change is usually a combination of systematic factors along with some random or unique factors.

There are many theories of social change. Generally, a theory of change should include elements such as structural aspects of change (like population shifts), processes and mechanisms of social change, and directions of change.

Causal Factors

Factors causing social change include: environment, cultural innovation, population, technology, and human action— individual, collective.

Environmental change

- Physical environment causes social change through influences of changes in environment.
- Quick change because of environmental disasters: hurricanes, tornadoes, fires, earthquakes.
- Slow change because of pollution, garbage disposal needs, greenhouse effect.

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- The degree of natural disasters between different countries and regions also lead the different social changes between the countries. The shift from collecting, hunting and fishing to agriculture may have happened because, in some areas, the human population grew too large to be sustained by existing resources.

Cultural innovation

- Discovery—new perception of something that exists.
- Invention—combination or new use of knowledge to produce something that did not exist before.
- Diffusion—spread of cultural elements from one society to another.

Population

- Increases or decreases in population create social change affecting all institutions.

Technology

- The practical applications of scientific or other knowledge creates social change
- Theory of technological determinism is that a society's use of technology determines culture, social structure and history
- Technological culture lag is the delay between a change in material culture and the adjustment of nonmaterial culture to that change, I.e. computer use.
- Diffusion leads to cultural homogenization.

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Human action

- Individual—"great man" theory of history.
- Collective action—collective behaviour and social movements. Includes invasions, occupations by foreign powers, wars, subversions, colonization

Theories of social change:
Cyclical theory

Civilizations go through cycles of growth and decay. Each civilization learns from its predecessors. Paul Kennedy: The Rise and Fall of Great Powers.: History demonstrates that "all of the major shifts in world's military-power balances have followed alterations in the productive balances."

Socio-cultural evolution

- Societies shaped by the forces of social evolution.
- Social Darwinism: survival of the fittest or how everyone should aspire to Western civilization and development.

Functionalist theory

- Society consists of interdependent parts each of which helps to maintain the stability of the entire social system which has a tendency to seek equilibrium and balance.
- Imbalances mean system has to adjust to new equilibrium.
- Social change is means to get from one state of social stability to another: traditional societies move from traditional values/kin ties to industrialization with weakened kin ties and individualism.

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Conflict theory

- Conflict is normal not abnormal. Social change is constant and inevitable.
- Marx: change is exploited social classes overthrowing those exploiting them. Modern theorists focus on multi-power analysis

Development theory

- Seeks to explain economic and cultural development of societies and differences in development between “developed” and “developing” countries.
- Modernization theory—developing societies must become like developed societies focus on culture.

World systems theory

- Focus on development of political economy, history, and globalization.
- World system is network of unequal economic and political relationships between “cores” developed countries and “periphery” developing countries.
- Due to export dependence, debt trap, multinationals

Revolution

- Systems of exploitation inevitably lead to some form of revolution—non-violent or violent.
- Conditions leading to revolution include: widespread grievance, rising expectations, blockage of change, loss of legitimacy of gov’t, military breakdown or politicization, class coalitions like People Power.

Ecosystem

An ecosystem is a community of living organisms (plants, animals and microbes) in conjunction with the non-living components of their environment (things like air, water and mineral soil), interacting as a system. These components are regarded as linked together through nutrient cycles and energy flows. As ecosystems are defined by the network of interactions among organisms, and between organisms and their environment, they can come in any size but usually encompass specific, limited spaces (although it is sometimes said that the entire planet is an ecosystem).

Energy, water, nitrogen and soil minerals are other essential abiotic components of an ecosystem. The energy that flows through ecosystems is obtained primarily from the sun. It generally enters the system through photosynthesis, a process that also captures carbon from the atmosphere. By feeding on plants and on one another, animals play an important role in the movement of matter and energy through the system. They also influence the quantity of plant and microbial biomass present. By breaking down dead organic matter, decomposers release carbon back to the atmosphere and facilitate nutrient cycling by converting nutrients stored in dead biomass back to a form that can be readily used by plants and other microbes.

Ecosystems are controlled both by external and internal factors. External factors such as climate, the parent material which forms the soil and topography, control the overall structure an ecosystem and the way things work within it, but are not themselves influenced by the ecosystem. Other external factors include time and potential biota. Ecosystems are dynamic

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entities—invariably, they are subject to periodic disturbances and are in the process of recovering from some past disturbance. Ecosystems in similar environments that are located in different parts of the world can end up doing things very differently simply because they have different pools of species present. The introduction of non-native species can cause substantial shifts in ecosystem function. Internal factors not only control ecosystem processes but are also controlled by them and are often subject to feedback loops. While the resource inputs are generally controlled by external processes like climate and parent material, the availability of these resources within the ecosystem is controlled by internal factors like decomposition, root competition or shading. Other internal factors include disturbance, succession and the types of species present. Although humans exist and operate within ecosystems, their cumulative effects are large enough to influence external factors like climate.

Biodiversity affects ecosystem function, as do the processes of disturbance and succession. Ecosystems provide a variety of goods and services upon which people depend; the principles of ecosystem management suggest that rather than managing individual species, natural resources should be managed at the level of the ecosystem itself. Classifying ecosystems into ecologically homogeneous units is an important step towards effective ecosystem management, but there is no single, agreed-upon way to do this.

Ecosystem dynamics

Ecosystems are dynamic entities—invariably, they are subject to periodic disturbances and are in the process of recovering from some past disturbance. When an ecosystem is subject to some sort of perturbation, it responds by moving away from its initial state. The tendency of a system to remain close to its equilibrium state, despite that disturbance, is termed its resistance. On the other hand, the speed with which it returns to its initial state after disturbance is called its resilience.

From one year to another, ecosystems experience variation in their biotic and abiotic environments. A drought, an especially cold winter and a pest outbreak all constitute short-term variability in environmental conditions. Animal populations vary from year to year, building up during resource-rich periods and crashing as they overshoot their food supply. These changes play out in changes in NPP, decomposition rates, and other ecosystem processes. Longer-term changes also shape ecosystem processes—the forests of eastern North America still show legacies of cultivation which ceased 200 years ago, while methane production in eastern Siberian lakes is controlled by organic matter which accumulated during the Pleistocene.

Disturbance also plays an important role in ecological processes. F. Stuart Chapin and co-authors define disturbance as "a relatively discrete event in time and space that alters the structure of populations, communities and ecosystems and causes changes in resources availability or the physical environment". This can range from tree falls and insect outbreaks to hurricanes and wildfires to volcanic eruptions and can cause large changes in plant, animal and microbe populations, as well soil organic matter content. Disturbance is followed by succession, a "directional change in ecosystem structure and functioning resulting from biotically driven changes in resources supply."

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The frequency and severity of disturbance determines the way it impacts ecosystem function. Major disturbance like a volcanic eruption or glacial advance and retreat leave behind soils that lack plants, animals or organic matter. Ecosystems that experience disturbances that sever undergo primary succession. Less severe disturbance like forest fires, hurricanes or cultivation result in secondary succession. More severe disturbance and more frequent disturbance result in longer recovery times. Ecosystems recover more quickly from less severe disturbance events.

The theoretical ecologist Robert Ulanowicz has used information theory tools to describe the structure of ecosystems, emphasizing mutual information (correlations) in studied systems. Drawing on this methodology and prior observations of complex ecosystems, Ulanowicz depicts approaches to determining the stress levels on ecosystems and predicting system reactions to defined types of alteration in their settings (such as increased or reduced energy flow, and eutrophication).

Ecosystem ecology

Ecosystem ecology studies "the flow of energy and materials through organisms and the physical environment". It seeks to understand the processes which govern the stocks of material and energy in ecosystems, and the flow of matter and energy through them.

Aquatic ecosystem

An aquatic-ecosystem is an ecosystem in a body of water. Communities of organisms that are dependent on each other and on their environment live in aquatic ecosystems. The two main types of aquatic ecosystems are marine ecosystems and freshwater ecosystems.

Types

Marine- Marine ecosystems cover approximately 71% of the Earth's surface and contain approximately 97% of the planet's water. They generate 32% of the world's net primary production. They are distinguished from freshwater ecosystems by the presence of dissolved compounds, especially salts, in the water. Approximately 85% of the dissolved materials in seawater are sodium and chlorine. Seawater has an average salinity of 35 parts per thousand (ppt) of water. Actual salinity varies among different marine ecosystems. Fishes caught in marine ecosystems, are the biggest source of commercial foods obtained from wild populations.

Environmental problems concerning marine ecosystems include unsustainable exploitation of marine resources (for example overfishing of certain species), marine pollution, climate change, and building on coastal areas.

Freshwater

Freshwater ecosystems cover 0.80% of the Earth's surface and inhabit 0.009% of its total water. They generate nearly 3% of its net primary production. Freshwater ecosystems contain 41% of the world's known fish species.

There are three basic types of freshwater ecosystems:

- **Lentic**: slow-moving water, including pools, ponds, and lakes.
- **Lotic:** rapidly-moving water, for example streams and rivers.

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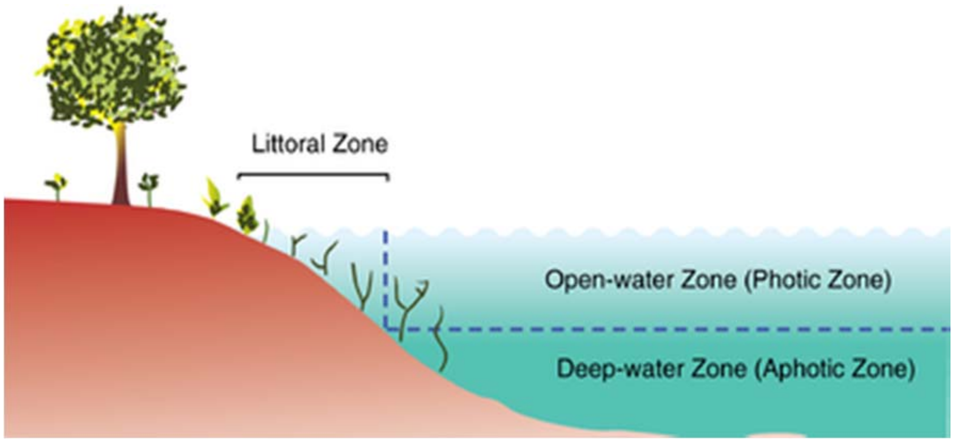
- **Wetlands:** areas where the soil is saturated or inundated for at least part of the time.

Lentic



The three primary zones of a lake.

Lake ecosystems can be divided into zones. One common system divides lakes into three zones (see figure). The first, the littoral zone, is the shallow zone near the shore. This is where rooted wetland plants occur. The offshore is divided into two further zones, an open water zone and a deep water zone. In the open water zone (or photic zone) sunlight supports photosynthetic algae, and the species that feed upon them. In the deep water zone, sunlight is not available and the food web is based on detritus entering from the littoral and photic zones.. The off shore areas may be called the pelagic zone, and the aphotic zone may be called the profundal zone. The production of the lake as a whole is the result of production from plants growing in the littoral zone, combined with production from plankton growing in the open water.

Lotic

The major zones in river ecosystems are determined by the river bed's gradient or by the velocity of the current. Faster moving turbulent water typically contains greater concentrations of dissolved oxygen, which supports greater biodiversity than the slow moving water of pools. Environmental threats to rivers include loss of water, dams, chemical pollution and introduced species. A dam produces negative effects that continue down the watershed. The most important negative effects are the reduction of spring flooding, which damages wetlands, and the retention of sediment, which leads to loss of deltaic wetlands.

Wetlands

Wetlands are dominated by vascular plants that have adapted to saturated soil. There are four main types of wetlands: swamp, marsh, fen and bog. Wetlands are the most productive natural ecosystems in the world because of the proximity of water and soil. Hence they support large numbers of plant and animal species. Due to their productivity, wetlands are often converted into dry land with dykes and drains and used for agricultural purposes. The construction of dykes, and dams, has negative consequences for individual wetlands and entire watersheds. Their closeness to lakes and rivers means that they are often developed for human settlement. Once settlements are constructed and protected by dykes, the settlements then become vulnerable to land subsidence and ever increasing risk of flooding. The Louisiana coast around New Orleans is a well-known example; the Danube Delta in Europe is another.

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Ecology

Ecology is the scientific study of the relationships that living organisms have with each other and with their natural environment.

Behavioural ecology

All organisms are motile to some extent. Even plants express complex behaviour, including memory and communication. Behavioural ecology is the study of an organism's behaviour in its environment and its ecological and evolutionary implications. Ethology is the study of observable movement or behaviour in animals. This could include investigations of motile sperm of plants, mobile phytoplankton, zooplankton swimming toward the female egg, the cultivation of fungi by weevils, the mating dance of a salamander, or social gatherings of amoeba.

Adaptation is the central unifying concept in behavioural ecology. Behaviours can be recorded as traits and inherited in much the same way that eye and hair colour can. Behaviours can evolve by means of natural selection as adaptive traits conferring functional utilities that increases reproductive fitness.

Social ecology

Social ecological behaviours are notable in the social insects, slime moulds, social spiders, human society, and naked mole rats where eu-socialism has evolved. Social behaviours include reciprocally beneficial behaviours among kin and nest mates and evolve from kin and group selection. Kin selection explains altruism through genetic relationships, whereby an

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altruistic behaviour leading to death is rewarded by the survival of genetic copies distributed among surviving relatives.

Human ecology

Ecology is as much a biological science as it is a human science. Human ecology is an interdisciplinary investigation into the ecology of our species. "Human ecology may be defined: (1) from a bio-ecological standpoint as the study of man as the ecological dominant in plant and animal communities and systems; (2) from a bio-ecological standpoint as simply another animal affecting and being affected by his physical environment; and (3) as a human being, somehow different from animal life in general, interacting with physical and modified environments in a distinctive and creative way.

The ecological complexities, human beings are facing through the technological transformation of the planetary biome has brought on the Anthropocene. The unique set of circumstances has generated the need for a new unifying science called coupled human and natural systems that builds upon, but moves beyond the field of human ecology. Ecosystems tie into human societies through the critical and, all-encompassing life-supporting functions they sustain. Ecosystems produce, regulate, maintain, and supply services of critical necessity and beneficial to human health (cognitive and physiological), economies, and they even provide an information or reference function as a living library giving opportunities for science and cognitive development in children engaged in the complexity of the natural world. Ecosystems relate importantly to human ecology as they are the ultimate base foundation of global economics as every commodity and the capacity for exchange ultimately stems from the ecosystems on Earth.

Relation to the environment

The environment of ecosystems includes both physical parameters and biotic attributes. It is dynamically interlinked, and contains resources for organisms at any time throughout their life cycle. Like "ecology," the term "environment" has different conceptual meanings and overlaps with the concept of "nature." Environment "...includes the physical world, the social world of human relations and the built world of human creation." The physical environment is external to the level of biological organization under investigation, including abiotic factors such as temperature, radiation, light, chemistry, climate and geology. The biotic environment includes genes, cells, organisms, members of the same species (conspecifics) and other species that share a habitat.

There is an interpenetration of cause and effect between the environment and life. The laws of thermodynamics, for example, apply to ecology by means of its physical state. With an understanding of metabolic and thermodynamic principles, a complete accounting of energy and material flow can be traced through an ecosystem. In this way, the environmental and ecological relations are studied through reference to conceptually manageable and isolated material parts. After the effective environmental components are understood through reference to their causes, however, they conceptually link back together as an integrated whole, or *holocoenotic* system as it was once called. This is known as the dialectical approach to ecology. The dialectical approach examines the parts, but integrates the organism and the environment into a dynamic whole. Change in one ecological or environmental factor can concurrently affect the dynamic state of an entire ecosystem.

Disturbance and resilience

Ecosystems are regularly confronted with natural environmental variations and disturbances over time and geographic space. A disturbance is any process that removes biomass from a community, such as a fire, flood, drought, or predation. Disturbances occur over vastly different ranges in terms of magnitudes as well as distances and time periods, and are both the cause and product of natural fluctuations in death rates, species assemblages, and biomass densities within an ecological community. These disturbances create places of renewal where new directions emerge out of the patchwork of natural experimentation and opportunity.

Ecological resilience is a cornerstone theory in ecosystem management. Biodiversity fuels the resilience of ecosystems acting as a kind of regenerative insurance.

Global Warming

Extra carbon dioxide [CO_2] in the atmosphere enhances a natural process known as the greenhouse effect. Greenhouse gases, such as carbon dioxide, absorb heat and release it slowly. Without this process, Earth would be too cold for life to survive. Over the past 200 years mankind has increased the proportion of greenhouse gases in the Earth's atmosphere, primarily by burning fossil fuels. The higher levels of greenhouse gases are causing our planet to warm - Global warming.

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Every year temperature is rising due to these greenhouse gases by about 0.2 degree centigrade indicating that the temperature will rise by nearly 5 degrees within a few years. The sea level along much of the US coast is already rising at a rate of 2.5 to 3.0 mm per year or about 10-12 inches per century, (Jena&Mishra,2011).Agriculture represented 13.5% of global GHG emissions and forestry (mainly through deforestation) 17.4% of emissions (IPCC,2004). Agricultural emissions represented 47% of global Methane (CH_4) emissions that are mainly due to ruminants' enteric fermentation and anaerobic degradation of crop residues in paddy fields; and 58% of global Nitrous Oxide (N_2O) emissions mainly due to the production and the use of nitrogenous fertilisers for crop production.

A studies carried out by Sinha and Swaminathan (1991) and Aggarwal and Kalra (1994), show that on a 2°C increase in mean air temperature, rice yields could decrease by about 0.75 ton/hectare in the high yield areas and by about 0.06 ton/hectare in the low yield coastal. A temperature rise by 0.5oC in winter temperature is projected to reduce rain fed wheat yield by 0.45 tonnes per hectare in India (Lal et al., 1998).

Key facts

- Climate change affects the social and environmental determinants of health–clean air, safe drinking water, sufficient food and secure shelter.
- Global warming that has occurred since the 1970s caused over 140 000 excess deaths annually by the year 2004.
- The direct damage costs to health (i.e. excluding costs in health-determining sectors such as agriculture and water and sanitation), is estimated to be between US$ 2-4 billion/year by 2030.

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- Many of the major killers such as diarrhoeal diseases, malnutrition, malaria and dengue are highly climate-sensitive and are expected to worsen as the climate changes.
- Areas with weak health infrastructure–mostly in developing countries–will be the least able to cope without assistance to prepare and respond.
- Reducing emissions of greenhouse gases through better transport, food and energy-use choices can result in improved health.

GREENHOUSE GAS	HUMAN SOURCES
Carbon dioxide	Burning fossil fuels (industry, transport, domestic use) and deforestation
Methane	Cows
Ozone	Industry
Nitrous oxide	Fertilizers
Chlorofluorocarbons	Refrigeration systems

- Global temperatures have risen by over 0.7^{o}C in the last 100 years and eleven of the last twelve years (1995-2006) are the warmest on record.
- By 2050, higher temperatures and more variable weather are predicted.
- Global mean surface temperatures are projected to be 1.4°C to 3°C higher by 2050, relative to 1961 to 1990.
- Changes in rainfall patterns will vary regionally. Rainfall is forecast to increase in the tropics and higher latitudes, and decrease in the semi-arid to arid mid-latitudes, as well as in the interior of large continents.
- Droughts and floods are expected to become more severe and frequent. More intense rainfall is expected with longer dry periods between extremely wet seasons. The intensity of tropical cyclones is expected to increase.

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- In developing countries agricultural production capacity is projected to decline by 9 to 21 per cent by 2080, due to a reduction in the area and potential productivity of crop land as weather patterns change.
- India and South Asia may see agricultural production decline by as much as 25 per cent by 2050, compared to a baseline without climate change.

Principles for Global Warming Legislation

1. Reduce emissions to levels guided by science to avoid dangerous global warming.
2. Set short and long term emissions targets that are certain and enforceable, with periodic review of the climate science and adjustments to targets and policies as necessary to meet emissions reduction targets.
3. Ensure that state and local entities continue pioneering efforts to address global warming.
4. Establish a transparent and accountable market-based system that efficiently reduces carbon emissions.
5. Use revenues from the carbon market to:
    - Keep consumers whole as our nation transitions to clean energy;
    - Invest in clean energy technologies and energy efficiency measures;
    - Assist states, localities and tribes in addressing and adapting to global warming impacts;
    - Assist workers, businesses and communities, including manufacturing states, in the transition to a clean energy economy;

- Support efforts to conserve wildlife and natural systems threatened by global warming; and
- -Work with the international community, including faith leaders, to provide support to developing nations in responding and adapting to global warming. In addition to other benefits, these actions will help avoid the threats to international stability and national security posed by global warming.

6. Ensure a level global playing field, by providing incentives for emission reductions and effective deterrents so that countries contribute their fair share to the international effort to combat global warming.

Climate Change

Climate change refers to changes in either the average state of the climate (e.g. with regards to temperature, places may, on average, become hotter or colder) or in its variability (e.g. change in rainfall seasons), persisting for an extended period (typically decades or longer).

Throughout its history, Earth's climate has varied, reflecting the complex interactions and dependencies of the solar, oceanic, terrestrial, atmospheric, and living components that make up planet Earth's systems. For at least the last million years, our world has experienced cycles of warming and cooling that take approximately 100,000 years to complete. Over the course of each cycle, global average temperatures have fallen and then risen again by about 9°F (5°C), each time taking Earth into an ice age and then warming it again. This cycle is believed associated with regular changes in Earth's orbit that alter the intensity of solar energy the planet receives. Earth's climate has also been influenced on very long timescales by changes in ocean

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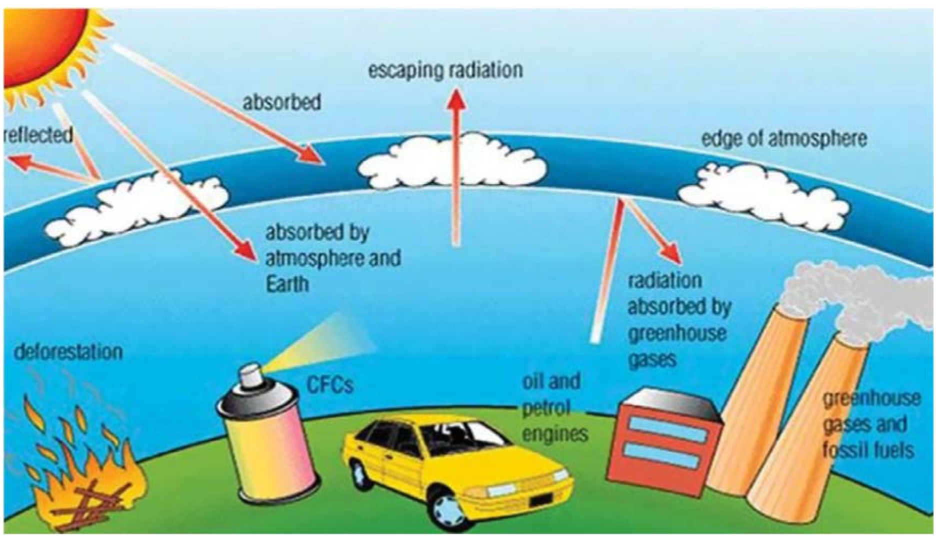
circulation that result from plate tectonic movements. Earth’s climate has changed abruptly at times, sometimes as a result of slower natural processes such as shifts in ocean circulation, sometimes due to sudden events such as massive volcanic eruptions. Species and ecosystems have either adapted to these past climate variations or perished.

While global climate has been relatively stable over the last 10,000 years—the span of human civilization—regional variations in climate pattern shave influenced human history in profound ways, playing an integral role in whether societies thrived or failed. It had “very high confidence that the global average net effect of human activities since 1750 has been one of warming” (IPCC, 2007). The IPCC attributes humanity’s global warming influence primarily to the increase in three key heat-trapping gases in the atmosphere: carbon dioxide, methane, and nitrous oxide.

Climate change results from an increase in the Earth’s temperature caused by a build- up of carbon dioxide and other greenhouse gases in the atmosphere due to human activity. Climate change means a change in climate that persists over a sustained period of time. The World Meteorological Organization defines this time period as 30 years. Examples of climate change include increases in global surface temperature (global warming), changes in rainfall patterns, and changes in the frequency of extreme weather events. Changes in climate may be due to natural causes, e.g., changes in the sun's output, or due to human activities, e.g., changing the composition of the atmosphere. Any human-induced changes in climate will occur against the "background" of natural climatic variations. Also, the term "anthropogenic forcing" refers to the influence exerted on a habitat or chemical environment by humans, as opposed to a natural process.

Social-ecological systems, or systems where ecosystems and humans are inextricably linked, are facing unpredictable pressures and shocks due to global change and unsustainable human use of resources (Chapin et al., 2010). These shocks may be internal to the system, such as overuse of a particular natural resource, or external, such as possible impacts of climate change. It is difficult to predict the effects of these shocks on social-ecological systems, given that there are often thresholds and non-linearity in the system's response to disturbance (Liu et al, 2007; Burkett et al, 2005). This inability to predict and respond to future shocks is problematic since it may result in the irreparable loss of ecosystem functions and services, and a subsequent collapse of dependent human livelihoods.

HUMAN CARBON FOOTPRINT



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Projected warming in context

Scientists have used various "proxy" data to assess past changes in Earth's climate (pale climate). Sources of proxy data include historical records (such as farmers' logs), tree rings, corals, fossil pollen, ice cores, and ocean and lake sediments. Analysis of these data suggest that recent warming is unusual in the past 400 years, possibly longer. By the end of the 21st century, temperatures may increase to a level not experienced since the mid-Pliocene, around 3 million years ago. At that time, models suggest that mean global temperatures were about 2–3 °C warmer than pre-industrial temperatures. Even a 2 °C rise above the pre-industrial level would be outside the range of temperatures experienced by human civilization.

Predicted effects of climate change on agriculture over the next 50 years

Climatic element	Expected changes by 2050's	Confidence in prediction	Effects on agriculture
CO_2	Increase from 360 ppm to 450 - 600 ppm (2005 levels now at 379 ppm)	Very high	Good for crops: increased photosynthesis; reduced water use
Sea level rise	Rise by 10 -15 cm Increased in south and offset in north by natural subsistence/rebound	Very high	Loss of land, coastal erosion, flooding, salinization of groundwater

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Temperature	Rise by 1-2^{o}C. Winters warming more than summers. Increased frequency of heat waves	High	Faster, shorter, earlier growing seasons, range moving north and to higher altitudes, heat stress risk, increased evapotranspiration
Precipitation	Seasonal changes by ± 10%	Low	Impacts on drought risk' soil workability, water logging irrigation supply, transpiration
Storminess	Increased wind speeds, especially in north. More intense rainfall events.	Very low	Lodging, soil erosion, reduced infiltration of rainfall
Variability	Increases across most climatic variables. Predictions uncertain	Very low	Changing risk of damaging events (heat waves, frost, droughts floods) which effect crops and timing of farm operations
Source: Climate change and Agriculture, MAFF (2000)			

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Predicted inundation of biogeographic zones of India by marine intrusion as a result of 1m and 6m sea-level rise.

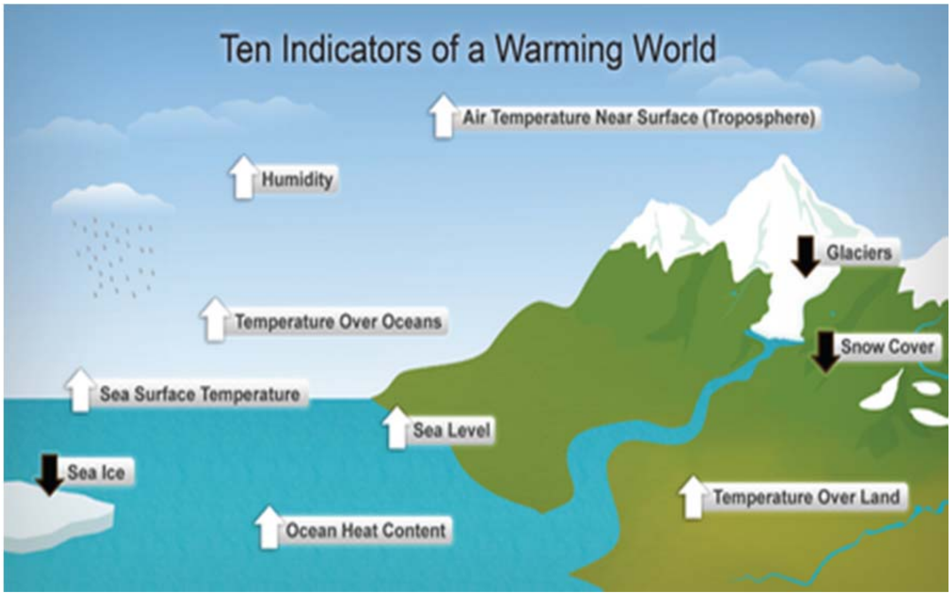
Biogeographic Zone*	Total area	Area inundated			
		1m sea-level rise		6m sea-level rise	
	km^2	km^2	%	km^2	%
Coasts	103,747	12,631	12.2	58,282	56.2
Desert	197,480	32	0	191	0.1
Western Ghats	132,141	73	0.1	419	0.3
Islands	7,058	1237	17.5	1605	22.7
TOTAL	440,426	13,973	3.2	60,497	13.7

***Source: Rodgers & Panwar (1988), Rodgers et al. (2000), Islam & Rahmani 2004**

Physical impacts

Human activities have contributed to a number of the observed changes in climate. This contribution has principally been through the burning of fossil fuels, which has led to an increase in the concentration of GHGs in the atmosphere. Another human influence on the climate are sulfur dioxide emissions, which are a precursor to the formation of sulfate aerosols in the atmosphere.

The world's surface air temperature increased an average of 0.6° Celsius (1.1°F) during the last century according to the Intergovernmental Panel on Climate Change (IPCC). This may not sound like very much of a temperature change, but it is. And the warmer temperature is causing noticeable changes to our planet. Below are some effects of climate change that we see happening.



- **Sea level is rising**. During the 20th century, sea level rose about 15 cm (6 inches) due to melting glacier ice and expansion of warmer seawater. Models predict that sea level may rise as much as 59 cm (23 inches) during the 21st Century, threatening coastal communities, wetlands, and coral reefs.
- **Arctic sea ice is melting**. The summer thickness of sea ice is about half of what it was in 1950. Melting ice may lead to changes in ocean circulation. Melting ice speeds up warming of the Arctic because water absorbs more heat than ice.
- **Glaciers and permafrost are melting.** Over the past 100 years, mountain glaciers in all areas of the world have decreased in size and so has the amount of permafrost in the Arctic. Greenland's ice sheet is melting faster too.

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- **Sea-surface temperatures are warming**. Warmer waters in the shallow oceans have contributed to the death of about a quarter of the world's coral reefs in the last few decades. Many of the coral animals died after weakened by coral bleaching, a process tied directly to warmed waters.
- **The temperatures of large lakes are warming**. The temperatures of large lakes world-wide have risen dramatically. Temperature rises have increased algal blooms in lakes, favour invasive species, increase stratification in lakes and lower lake levels.
- **Heavier rainfall cause flooding in many regions.** Warmer temperatures have led to more intense rainfall events in some areas. This can cause flooding.
- **Extreme drought is increasing**. Higher temperatures cause a higher rate of evaporation and more drought in some areas of the world. Areas that are currently prone to drought are expected to become even drier over the next century.
- **Crops are withering**. Increased temperatures and extreme drought are causing a decline in crop productivity around the world. Decreased crop productivity can mean food shortages which have many social implications.
- **Ecosystems are changing**. As temperatures warm, species may either migrate to a cooler, more suitable habitat or die. Species that are particularly vulnerable include endangered species, coral reefs, and polar animals. Warming has also caused changes in the timing of spring events and the length of the growing season.

- **Hurricanes have changed in frequency and strength.** There is evidence that the number of intense hurricanes has increased in the Atlantic since 1970. This may also be true for tropical cyclones in other parts of the world. Scientists continue to study whether climate is the cause.
- **More frequent heat waves.** It is likely that heat waves have become more common in more areas of the world.
- **Warmer temperatures affect human health.** There has been an increase in heat-related deaths, some changes in the ranges of animals that carry disease like mosquitoes, and an increase in the length of the pollen season.
- **Seawater is becoming more acidic.** Carbon dioxide dissolving into the ocean, is making seawater more acidic. There could be impacts on coral reefs and other marine life.

According to computer models, more global warming is in our future. If we continue to emit as many, or more, greenhouse gases, this will cause much more warming during the 21st century than we saw in the 20th century. During the 21st century, various computer models predict that Earth's average temperature will rise between 1.8 and 4.0° Celsius (3.2° and 7.2° F).

How climate affects agriculture

Climate change can affect agriculture in a variety of ways. Beyond a certain range of temperatures, warming tends to reduce yields because crops speed through their development, producing less grain in the process. And higher

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temperatures also interfere with the ability of plants to get and use moisture. Evaporation from the soil accelerates when temperatures rise and plants increase transpiration—that is, lose more moisture from their leaves. The combined effect is called “evapotranspiration.” Because global warming is likely to increase rainfall, the net impact of higher temperatures on water availability is a race between higher evapotranspiration and higher precipitation. Typically, that race is won by higher evapotranspiration. But a key culprit in climate change—carbon emissions— can also help agriculture by enhancing photosynthesis in many important, so-called C3, crops (such as wheat, rice, and soybeans). The science, however, is far from certain on the benefits of carbon fertilization. But we do know that this phenomenon does not much help C4 crops (such as sugarcane and maize), which account for about one-fourth of all crops by value.It has been projected that under the scenario of a 2.5 °C to 4.9 °C temperature rise in India, rice yields will drop by 32 %-40 % and wheat yields by 41 %-52 % (OECD, 2002).

Higher temperatures, more variable precipitation, and changes in the frequency and severity of extreme climate events will have significant consequences for food production and food security. However, the frequency of heat stress, drought, and flooding are also expected to increase, even though they cannot be modelled satisfactorily with current climate models. They will undoubtedly have adverse effects on crops and agricultural productivity over and above the effects due to changes in mean variables alone. The impacts of climate change on agriculture are likely to be regionally distinct and highly heterogeneous spatially, requiring sophisticated understanding of causes and effects and careful design and dissemination of appropriate responses.

These changes will challenge the livelihoods of farmers, fishers, and forest-dependent people who are already vulnerable and food insecure. More than 75 % of south Asia's people depend on rain-fed agriculture, livestock and forests for subsistence (sapkota, 2010).Agricultural activity is highly sensitive to climate change, as it depends on biodiversity and environmental conditions. Adapting to these changes, while continuing to feed a world of 9 billion people, requires the formation of a global partnership in science, technology development, and dissemination of results to millions of smallholder farmers, bringing together research workers and resource managers from many fields. To take an international approach to climate change, new partnerships must be forged, linking the agricultural research and climate science communities.

Agriculture and climate change are linked in important ways, and this brief focuses on three: (1) climate change will have large effects on agriculture, but precisely where and how much are uncertain, (2) agriculture can help mitigate climate change, and (3) poor farmers will need help adapting to climate change.

Challenges to crop agriculture

The current climate change scenarios demand adaptation to temperature increases, changing amounts of available water, climatic instability and increased frequency of extreme weather events, and rises in sea level and saline intrusion in the coastal zones. Thus future crop farming and food systems will have to be better adapted to a range of abiotic stresses (such as

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heat or salinity) and biotic stresses (such as pests) to cope with the consequences of a progressively changing climate.

Crop germplasm improvement, natural resource management, and inclusion of enhanced agro-biodiversity have a proven track record of decreasing susceptibility to individual stresses. Breeding and marker-assisted selection are important mechanisms for introducing improved characteristics and achieving yield improvements for most crops. Defining future targeted farming systems and their environments could allow breeding and management programs to be matched with geo-referenced data on crop germplasm collections. This would allow the identification of crops and cultivars best suited to predicted conditions, based on the agro-ecological parameters of their places of origin. Improved water-management approaches, with conservation agriculture, are likely to be central to adaptation strategies in both irrigated and dry land agriculture. Work on feed plants (for livestock and aquaculture) should be incorporated into this research approach. However, technical innovations will not be sufficient on their own. Strengthening the adaptive capacities of farmers and other land users requires a variety of strategies ranging from diversification of production systems to improved institutional settings. It is crucial to add value to current investment in agronomic crop management and germplasm improvements by integrating new results and best practices from these fields into adaptation options proposed in the policy domain. (CGIAR, 2009)

Challenges to livestock agriculture

Livestock are a critical component of agriculture, particularly for the income and nutrition of the poor in developing countries. Ruminant livestock themselves have important impacts on climate, through the emission of methane and through the land-use change that may be brought about by livestock keepers. Nevertheless, meeting anticipated demand for meat and milk and other necessary livestock products in the coming decades will require attention to the supply of livestock feeds. Climate change sharpens the edge of the production dilemma among human food, animal feed, and (potentially) energy on a finite amount of land. Critically, altered climate regimes will alter the ranges of insect pests and vectors; a major risk of climate change is that it will change or extend the range of current diseases or, through unknown effects, create the conditions for the spread of new diseases to the livestock population. Human health would also be threatened by an increase in zoonotic diseases. Heat wave can reduce a milk yield by 10-30% in first lactation and 5-20% in second and third lactation periods in cattle and buffaloes it also effect the growth, puberty and maturity of crossbreed of cows and buffaloes (CRIDA, 2012).Since the impacts of climate change on livestock disease may be extremely complex, integrated approaches must go well beyond climate and risk mapping and will require epidemiological reconnaissance, new diagnostic reagents, adapted or new livestock genotypes, and new veterinary and public health management services.

Challenges to forests and forestry

Major recent for a on forestry have concluded that integrated approaches to adaptive forest management are a central component of the global response to climate change. Within global approaches, there is the opportunity to both reduce forest destruction and potentially to sequester carbon (atmospheric CO2) as a climate change mitigation measure. Test cases for the payment for environmental services approach are being tried in the forestry sector (for example, Reduced Emissions from Deforestation (REDD) payment schemes). There should be continuous scientific, economic, and social evaluation of Payments for Environmental Services (PES) schemes so that their true value to the environment and to the lives of the poor are put on an evidence-based footing.

Challenges to fisheries

Fisheries are key natural resources ensuring food security for large numbers of people. Successful fisheries depend upon coherent marine and freshwater ecosystems, which are at risk of disruption by climate change. As temperatures change, fisheries are likely to gradually be displaced or migratory patterns may become erratic, affecting fish supplies for both human consumption and aquaculture and livestock feeds. There could be long-term effects on coral reefs (which are very susceptible to small changes in temperature). The rise in coastal sea levels could disrupt livelihoods and cause salt water intrusion into agricultural land. Like livestock industries, aquaculture competes for feed resources (from aquatic or terrestrial sources). A broad set of tasks, linking research assessment and

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monitoring of fisheries to the design of adaptive measures and appropriate policies, must be addressed to sustain poor communities through the expected changes. Aquaculture will require that particular attention be given to the breeding of robust genotypes and the design of sustainable feed resource policies. New collaborative arrangements will need to be implemented, with each organization playing its part according to its comparative advantage.

Challenges to Health

Human beings are exposed to climate change through changing weather patterns (temperature, precipitation, sea-level rise and more frequent extreme events) and indirectly through changes in water, air and food quality and changes in ecosystems, agriculture, industry and settlements and the economy (Confalonieri *et al.*, 2007). According to an assessment of the scientific literature by Confalonieri *et al.* (2007), the effects of climate change to date have been small, but are projected to progressively increase in all countries and regions.

A study by the World Health Organization (WHO, 2009) estimated the effect of climate change on human health. Not all of the effects of climate change were included in their estimates, for example, the effects of more frequent and extreme storms were excluded. Climate change was estimated to have been responsible for 3% of diarrhoea, 3% of malaria, and 3.8% of fever deaths worldwide in 2004. Total attributable mortality was about 0.2% of deaths in 2004; of these, 85% were child deaths.

SOUTH ASIA

Regional climate changes

South Asia as a region is experiencing very rapid growth. It is also highly vulnerable to climate change (Cruz et al, 2007). This vulnerability is driven by the region's geographic diversity, high population and density and extreme poverty (World Bank, 2009). For these reasons, it is very important to understand the regional impacts of climate change

The South Asia region is geographically highly diverse, including the Himalayas for northern India, Bhutan and Nepal, the fertile delta of Bangladesh in eastern India and the Indian Ocean islands of the Maldives and Sri Lanka. This diversity leads to wide variety of expected climate impacts, including glacial melting, forest fires, rising sea levels, mountain and coastal erosion and salt water intrusion.

Weather and climate patterns are also expected to change. The region is already experiencing disruptions to the monsoon season and more frequent and intense storms. Given that the region is home to 600 million of the world's poorest people, most of who depend on climate-sensitive sectors such as agriculture, forestry and traditional fishing, the combined impacts of climate change and natural disasters has important consequences for the region.

PROJECTED CHANGES IN CLIMATE IN SOUTH ASIA

FACTOR	EXPECTED CHANGE
Temperature	-Mean annual temperature increase of 3.3°C for South Asia (Christensen et al, 2007) • Range of warming estimates under different emission scenarios extends from 2.7°C to 4.7°C • High-lying regions of the Himalayas can expect greater warming (mean increase of 3.8°C with a range of 2.6°C to 6.1°C projected for Tibet)
Rainfall	- Greater uncertainty exists for estimates of rainfall changes as a result of climate change - Some evidence for a slight increase in precipitation for the Indian subcontinent by the end of this century (Christensen et al, 2007) - Some indications that rainfall will become more variable • Increase in inter-annual rainfall variability means an increase in the number of very dry and very wet years (Baettig et al, 2007) • Changes in the distribution of rainfall within a year will be characterized by an increase in the number of *heavy* rainfall days, but a decrease in overall number of days receiving rain. - Some evidence for a change in seasonality. -Projected increases in extreme rainfall will be characterized by increases in the frequency and intensity of heavy rainfall events.
Monsoons	-The Indian monsoon is expected to intensify with climate change. -The timing of the monsoons may become more variable under climate change.
Extreme Events	-Increase in hot extremes, as well as heat waves expected More extreme rainfall events - increase in both frequency and intensity.
Sea-level Rise (SLR)	-Increase in mean sea-level of 0.18 to 0.59 m projected by 2100, relative to 2000 (Christensen et al, 2007).

INDIA

India’s climate is dominated by monsoons, which together account for more than 80% of the total annual rainfall. The main monsoon season - the summer “southwest” monsoon - extends over a four month period between June and September, brining warm moist air over India from the southwest. The “retreating” or “northeast” monsoon (between October and December), is generally associated with drier conditions as air descends off the Tibetan highlands, but picks up moisture as it passes over the Bay of Bengal, and is associated with rainfall predominantly over the eastern portions of the Indo-Gang etic (Pad ham, 2009). Given their predominance and massive amount of rainfall involved, Indian agriculture is highly dependent on the timing and strength of the monsoons. However, the distribution and timing of monsoon precipitation can be highly variable. For example, under extreme cases, up to 60% of annual rainfall can occur within a period of several days, resulting in severe flooding, high crop and livestock loss, and reduced groundwater recharge (Mall et all., 2006)

Droughts tend to have a more severe impact than floods, and are common over the western portions of the Indo-Gangetic Plain. The eastern part of the region is highly flood-prone as seasonal flooding associated with glacial melting and the monsoon flood the Ganges River system. Some of the climate change impacts forecasted by the IPCC and already seen in India include more extreme rainfall events in India, Bangladesh and Nepal, more floods in the flood plains and droughts associated with El Niño in north India becoming more common.

Climate change impacts in India

Impacts of climate change most likely to affect India between now and 2100 (Netcom report, 2004):

- Decreased snow cover will affect snow-fed and glacial systems such as the Ganges and Brahmaputra. 70 % of the summer flow of the Ganges comes from melt water.
- Erratic monsoons will affect India's rain fed agriculture, peninsular rivers, water and power supply,
- Wheat production will drop by 4-5 mt, even with a rise in temperature of only 1 ºc.
- Rising sea levels will cause displacement along one of the most densely 7500 k.m. populated coastlines in the world, also threatening freshwater sources and mangrove ecosystems.
- Floods will increase in frequency and intensity.
- Over 50 % of India's forests are likely to experience shift in forest types, adversely impacting associated biodiversity, regional climate dynamics and livelihoods based on forest products.
    - By 2020, monsoon sorghum production was predicted to decrease by 14 % in CZ and SWZ and by 2 % in SCZ, whereas winter sorghum production was estimated to decrease by up to 7 % by 2020. (Srivastava et al. 2010)

Is Odisha being affected by climate change?

The state’s fluctuating weather conditions suggest that it is reeling under climatic chaos. For more than a decade now, it has experienced contrasting extreme weather conditions: from heat waves to cyclones, from droughts to floods. In the last four years, calamities have claimed more than 30,000 lives. They have not only become more frequent, but have hit areas that were never considered vulnerable. As a result, Odisha's economy has been ripped apart. Floods have become an annual affair with the monsoon of 2001 leading to the worst ever flood recorded in Odisha in the past century, as 25 of the 30 districts were inundated affecting one-third of the state's 30 million residents. Areas with no history of floods such as districts in western Odisha were submerged.

Odisha is facing many problems due to changes in weather patterns in the recent past. The annual mean temperature in the state increased by 10C in the 40 years from 1950 to 1990 and continued to rise by 0.10C during the past 14 years (Orissa University of Agriculture and Technology).

40% of rice and grain is grown in the flood prone coastal areas. As a result of erosion, salinization and inundation the farmlands are less fertile. There has already been a 7, 7% reduction of farmland in 13 years. The economy will lose rs. 360 crore per meter of rising in sea level, losing an area of 170.000 ha??

Mid-summer rain and floods in 23 districts of Odisha in 1995, the deaths of 2,042 people due to a heat-wave in Odisha in the summer of 1998, two devastating cyclones (including the Super Cyclone) in Odisha during 1999 leaded to two million tons of rice crop was lost and 17,000 square kilometre of agricultural land was devastated. Official estimates put the loss at Rs.10, 000 core.Drought in 2001 caused an economic loss of about Rs 643 crore due to crop damage and affected 11 million people. Massive floods in 23 districts of Odisha in 2003, 14 depressions along with floods in 27 districts of Odisha in 2006, the largest ever floods in Balasore and floods in 19 districts of Odisha (Mahanadi basin) in 2008 along with occurrence of drought and cyclones at frequent intervals. One trend all these clearly reveal is the growing climatic uncertainties and extremities across Odisha. There are also many more which can be listed to open our eyes to realize the extent of climatic changes in Odisha. Summer temperatures are now crossing the 40^0C mark in coastal areas in the State. The Odisha coast has come under severe erosion threats as sea water increasingly engulfs land areas in Kendra Para and Puri districts. The monsoon itself has become unpredictable. However, one thing that is certain about the changing nature of the monsoon is that rainfall is decreasing but the intensity of rains is on the increase. Many areas are experiencing flash floods for the first time.

Recently, the cyclonic storm, Phailinhit 99 blocks, 1,895 gram panchayats, 14,514 villages, 39 urban local bodies and 123 wards across the state and of the total cultivable area of 3.6 million hectares, 0.5 million has been affected. The crop loss has been estimated at Rs 2,300 crore.

Change in climate following the super cyclone possibly caused the state's mango and mahua trees to flower unusually early. Mango trees in Odisha generally begin to flower in November while mahua trees flower from February. But in 2000, mango trees began bearing flowers in September and the mahua trees started flowering in December.

Such events have hit agriculture — the state's backbone, the most. Due to calamities, an average 900,000 ha of agricultural lands lose crop every year

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in the state. In the last 50 years, the food production has decreased by 40 per cent.

Why Climate Change is a Serious Issue for Odisha?

With a 480 km coast line that is prone to climate-mediated cyclones and coastal erosion and water resources dependent on monsoons, Odisha is relatively more vulnerable to climate change. Water-consuming rice is its main crop and therefore its agriculture is vulnerable to the vagaries of climate-induced weather changes. Though 38 percent of the state's geographical area is recorded as forests, much of these forests are degraded. Vector-borne diseases, particularly malaria, are fairly rampant and climate change may make the prevalence of the disease even more widespread.

Indeed, climate change has the potential to derail the current growth strategy and deepen poverty in Odisha. Continuing climate variation is predicted to alter the sectorial growth, including the ability of the poor to engage in farm and nonfarm sector activities. The direct impacts of extreme climate-induced events could include loss of life, livelihoods, assets and infrastructure. All of these could affect the state's economic growth and nullify the effectiveness of macroeconomic policies and pro poor initiatives.

What could be the other impacts of climate change on a coastal state like Odisha?

With sea level rise, many coastal systems will experience increased levels of inundation and storm flooding, accelerated coastal erosion, seawater intrusion into fresh groundwater and encroachment of tidal waters into river systems. Big cities situated on coasts, flood plains and river deltas, supporting a large number of people and industries can expect increased

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flood damage causing loss of structures and property. Disappearing shorelines also mean some loss of social amenities.

Coastal erosion will increase substantially, endangering natural protective features such as mangroves and barrier islands, and exacerbating flood risk. Consequently, many coastal communities dependent on these and fisheries will suffer. Deltas and low lying coastal areas will be inundated by sea level rise. Increased rainfall during the monsoons will increase the frequency of floods. Areas already prone to floods will suffer more. Both religious and resort-based coastal tourism will suffer. It is important to note that all this implies displacement of large numbers of people leading to rapid urbanization, straining resources and putting more pressure on civic amenities.

Agriculturally fertile coastal regions with paddy fields are vulnerable to inundation and salinization. Orissa normally produces around five million tons of rice each year. The rice crop on the coast contributes about 40 per cent to the total rice grown in the state.

With rising temperatures, pest population will significantly increase because generally warmer and moist conditions are highly conducive to them. Higher temperatures also speed up the life cycle of both the mosquito and the disease organisms they harbor and make adult mosquitoes bite more often. The state accounts for 15-22 per cent of malaria cases in the country and 40-50 per cent malaria related deaths. At 20°C, mosquitoes take 26 days to breed. This period reduces to 13 days when the temperature rises to 25°C, which is also the average temperature of Orissa now.

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A possible increase in cyclone intensity of 10-20 per cent against a rise in sea surface temperature of 2 to 4°C is very likely to happen. Climate change has already intensified the Asian monsoon and increased river flows. Experts say, Odisha should brace itself for more severe flooding in years to come because of deforestation, faulty flood control planning and global climate changes.

Disasters have a long-term impact, as people are forced to spend more of their earnings on basics like home and agriculture. The already stressed ecosystem is made even more fragile with each disaster. And the poor living on the margins of subsistence are forced into greater penury. With each disaster their capacity to rebuild is reduced.

What Is the Coastal Zone

The coastal zone, where land meets ocean, is one of the most dynamic natural systems. Here, the three main components of our planet—the hydrosphere, the lithosphere, and the atmosphere—meet and interact, forming interconnected systems. Coastlines are formed by morphological changes governed by climatic and geological processes. They constitute a transition zone where land and freshwater meet saline water, and across which the effects of land on the ocean, and vice versa, are transferred and modified. Coastal zones are a crucial battleground in the current fight against climate change. This paper follows the definitions of coastal zones adopted in two key publications. For the Millennium Ecosystem Assessment (2005), "the inland extent of coastal ecosystems is defined as the line where land-based influences dominate up to a maximum of 100 kilometres from the coastline or 50-meter elevation (whichever is closer to the sea), and with the outward extent as the 50-meter depth contour. Marine ecosystems begin at the low water mark and encompass the high seas and deep water habitats.” For the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), “coastal systems are considered as the interacting low-lying areas and shallow coastal waters, including their human components. This includes adjoining coastal lowlands, which have often developed through sedimentation during the Holocene (past 10,000 years), but excludes the continental shelf and ocean margins [and inland seas].”6 Coastal systems also form part of the larger marine ecosystems that include coasts and open ocean areas. Coasts are of great ecological and socioeconomic importance. They sustain economies and provide livelihoods through fisheries, ports, tourism, and other industries. They also provide ecosystem services such as regulating atmospheric composition, cycling of nutrient and water, and waste removal. These areas have been centres of human settlement since perhaps the dawn of civilization, and have cultural and aesthetic value as well. Coastal ecosystems are among the most productive because they are enriched by land-based nutrients and nutrients that well up into the coastal waters from deeper levels of the ocean. Coastlines are also among the most populated regions. Nearly half the world’s major cities are located within 50 kilometres of a coast, and coastal population densities are 2.6 times greater than those of inland areas.

Length of coastline of India including the coastlines of Andaman and Nicobar Islands in the Bay of Bengal and Lakshadweep Islands in the Arabian Sea is 7517 km. Length of Coastline of Indian mainland is 6100 km. Coastline of Indian mainland is surrounded by Arabian Sea in the west, Bay of Bengal in the east, and Indian Ocean in the south. The long coast line of India is dotted with several major ports such as Kandla, Mumbai, Navasheva, Mangalore, Cochin, Chennai, Tuticorin, Vishakhapatnam, and Paradip.

Changing Coastal Zone Ecology

Coastal ecosystems are repositories of biological diversity and provide a wide range of goods and services. The major habitats of the coastal zone are coral reefs; sea grass beds/meadows; coastal or barrier islands; rocky coasts; cliffs; intertidal rocky, mud, or salt flats; rock pools; sandy, pebble, or rocky beaches; dune systems; saline, brackish, and freshwater lagoons; estuaries and coastal river floodplains; salt marshes; and mangrove forests—all of which have been highly modified over millennia by human activities. The Indian Ocean region is particularly rich in marine biodiversity. For example, the diversity of a number of marine taxa, including corals, fishes, lobsters, and snails, peaks in the so-called East Indies Triangle (Indonesia, Malaysia, New Guinea, and the Philippines) and (though declining in the central Indian Ocean) shows another lower peak in East Africa and Madagascar.

Adaptation

- **Adaptation** as a process, through which communities gain access to resources, information and the ability to shape their lives and livelihoods as the environment changes around them.

- **Adaptive capacity** is defined as “the ability of a system [human or natural] to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences” (IPCC, 2001).
- Adaptive capacity of individuals, households and communities is shaped by their access to and control over natural, human, social, physical and financial resources (Care 2010).

Climate Change Adaptation

- An adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC WG II, 2007).
- Climate Change Adaptation, which includes initiatives and measures to reduce the vulnerability of human and natural systems facing actual and/or expected effects of climate change.
- Particularly focused on small-holder producers who are considered to be the most vulnerable to climate change.
- Adaptation needs to be understood as a process, through which communities gain access to resources, information and the ability to shape their lives and livelihoods as the environment changes around them.
- The technologies are relevant primarily to the crop, livestock, and forestry sectors particularly focused on small-holder producers who are considered to be the most vulnerable to climate change.

Key Criteria for Prioritisation of Adaptation Technologies

When it comes to prioritising technologies for climate change adaptation, the following criteria should be discussed and evaluated by the range of actors within the CBA framework.

- **Environmental**. The extent to which the technology conserves and strengthens biological diversity and promotes environmental sustainability. This is an important criterion because biological diversity increases resilience of the ecosystem and therefore of the community (where technologies are selected to work in harmony with natural biodiversity). The technology should also promote sustainable local resource use, for example, the hardware technology can be manufactured and serviced locally where possible.
- **Awareness and Information**. The extent to which the technology enables and facilitates (i) access to information about climate change and the uncertainty of future conditions, (ii) integration of information from seasonal and weather forecasting and early warning systems into decision-making processes, and (iii) strengthening information systems in general (and with local knowledge more specifically).
- **Productivity**. The extent to which the technology (i) supports natural life cycles (nutrients of soil and water) and thus, conserves adequate biological conditions for future production; (ii) enables farmers to produce enough for self-consumption (to achieve food security), (iii) improves crop quality and productivity; (iv) improves crops quality and (v) is of easy dissemination and replication.

- **Economic**. The extent to which the technology: (i) strengthens existing productive systems. For example, growing maize starch in rural household plots provides a product for human consumption and food for cattle. Livestock activities can generate manure for organic fertiliser. (ii) Increases the amount of information about variations of prices of inputs and final products in the different months of the year. This protects and enables farmers to produce a surplus that can be sold on local markets to generate additional income. (iii) Reduces transaction costs of productive and commercial activities, for example, transportation costs, credit and rural insurance costs, costs incurred due to theft, among others.(iv) Does not generate influence, power and natural resource management inequities, which could be the source of social conflicts that obstruct the development of productive activities.
- **Cultural**. The extent to which the technology (i) respects cultural diversity, (ii) allows for an intercultural dialogue and the incorporation of ancient and local knowledge, and (iii) is understandable and easily applied by farmers in their current context.
- **Political**. The extent to which the technology is integrated coherently into regional and national policies and can be scaled-up for wider implementation.
- **Institutional**. Strong institutions can sustain development and are vital for implementing adaptation measures. Adaptation technologies should therefore be evaluated and prioritised based on the extent to which they strengthen formal and informal institutions, such as government ministries, civil society organisations and community-based

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organisations by building capacity for planning and execution of adaptation strategies. Technologies should also support civil society to form social networks and participate in decision-making processes.

Examples of Resources Affecting Adaptive Capacity

Human	Knowledge of climate risks, conservation agriculture skills, good health to enable labour
Social	Women's savings and loans groups, farmer-based organizations, traditional welfare and social support institutions
Physical	Irrigation infrastructure, seed and grain storage facilities
Natural	Reliable water resources, productive land, vegetation and trees
Financial	Micro-insurance, diversified income sources

Community-Based Adaptation

- Climate change is global, but impacts are regional and local
    - Impacts will affect different communities differently based on their specific circumstances. So, solutions must be locally specific
    - CBA is community-driven
    - CBA is the grass-roots component of climate change adaptation
- CBA aims to enable communities to understand and integrate the concept of climate risk into their livelihood activities in order to cope with and respond to immediate climate variability and long-term climate change.
- The impacts of climate change vary from place to place, so the adaptation needs are location specific.

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- CBA encourages local communities to identify and prioritise their adaptation needs and to seek funding from the local authority.

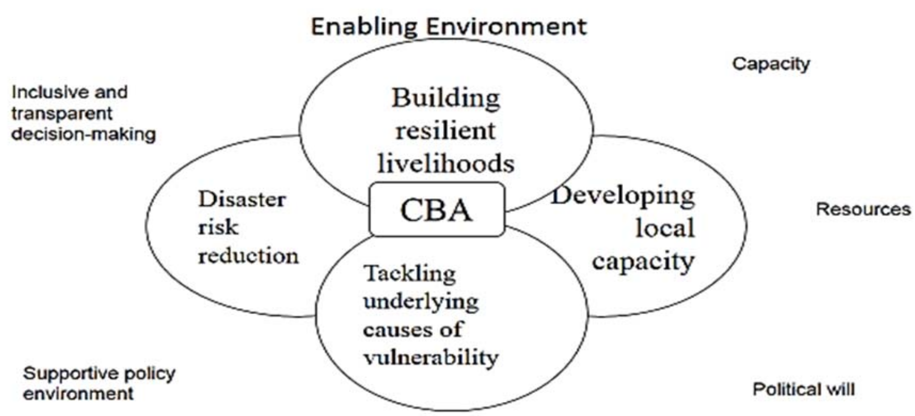
Community based adaptation as an effective tool

- Enable communities to understand and integrate the concept of climate risk into their livelihood activities in order to cope with and respond to immediate climate variability and long-term climate change.
- Encourages local communities to identify and prioritise their adaptation needs and to seek funding from the local authority.
- To link local evidence to national strategies and global policy with local institutions

Four elements for successful adaptation

1. Social mobilization
2. Skill development
3. Appropriate technology
4. Awareness

Community knowledge is fundamental for developing adaptation strategies



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Four emerging areas of critical learning

1. **Climate change communication–**including combining local knowledge with scientific knowledge
2. **Community ownership–**developing successful adaptation strategies and increasing ongoing adaptive capacities
3. **Integrating gender equality and women's empowerment–**promoting gender-equitable adaptation strategies with participation of both women and men
4. **Linking local evidence to national strategies and global policy–** creating a space for exchange and learning between different adaptation actors

Role of extension in CBA

- Extension services are an essential element for transferring climate change-related innovations to rural areas.
- Extension and education must be strengthened in order to enhance farmers' capability to respond to climate change issues.
- Extension, in its capacity as a national boundary organization, can serve as an intermediary between climate science and technology and the needs of end users or stakeholders.
- They also facilitate an exchange of experience among farmers and serve as a direct link between farmers and the government (speranza et al. 2009).
- Facilitate capacity building of local people.

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- Help in increasing the climate literacy of stakeholders in agriculture, forestry, and water resources and within local communities through science-based information and decision support tools that are disseminated through meetings, written publications and digital (internet) services.
- Extension has often reinvented or repurposed its existing capacity to meet the needs of its constituents by focusing on adaptive management, testing the principles of being a “learning organization,” and investing heavily in internal capacity building.
- Conflict management
- Helps direct research priorities
- Extension fills a unique niche in the landscape of resources, providing scientific information that is highly personalized, tailored to location, audience, and need.
- Extension excels at forming partnerships
- Extension must identify new public and private funding sources
- Extension and its additional partners can help bridge the enormous gap and countless challenges posed to constituents by climactic and market uncertainties
- Promotes climate literacy.

National Action Plan on Climate Change

India released its National Action Plan on Climate Change (NAPCC) on 30th June 2008 to outline its strategy to meet the challenge of Climate Change. The National Action Plan advocates a strategy that promotes, firstly, the adaptation to Climate Change and secondly, further enhancement of the ecological sustainability of India's development path.

1. Approach to Climate Change

The National Action Plan recognises that climate change is a global challenge and, that it should be successfully overcome through a globally collaborative and cooperative effort based on the principle of equity. The Action Plan expresses India's willingness to play its role as a responsible member of the international community and to make its contribution. However, it emphasises that, this requires not only sustainable production processes, but also sustainable life styles across the globe.

In this effort, every citizen of the planet should have an equal share of the planetary atmospheric space. The Action Plan suggests that the long-term convergence of per capita GHG emissions is the only equitable basis for a global agreement to tackle climate change. The Action Plan assures the international community that India's per capita GHC emissions would not exceed the per capita GHG emissions of developed countries, despite India's developmental imperatives.

2. Domestic Action

India's National Action Plan stresses that maintaining a high growth rate is essential for increasing living standards of the vast majority of people of India and reducing their vulnerability to impacts of climate change. Accordingly, the Action Plan identifies measures that promote the objectives of sustainable development of India while also yielding co-benefit for addressing climate change. Eight National Missions which form the core of the National Action Plan represent multipronged, long term and integrate strategies for achieving key goals in the context of climate change. The focus is on promoting understanding of Climate Change, adaptation and mitigation, energy efficiency and natural resource conservation. While, several of these programmes are already a part of the current actions, the Action Plan seeks to enhance them in scope, and effectiveness and implement them in an accelerated manner through time bound plans.

3. Solar Mission

This mission aims at promoting the development and use of solar energy for power generation and other uses, as well as to render solar energy competitive with fossil based energy options in urban areas, industry, and commercial establishments. Its goal is to generate at least 10,000 megawatts of solar power and to create a solar research canter, among other things.

4. Mission for Enhanced Energy Efficiency

This mission seeks to yield savings of 10,000 megawatts through the implementation of certain initiatives, such as energy incentives (including differential taxation on energy efficient appliances); setting up fi nuancing platforms for public-private partnerships to reduce energy consumption through demand side management programs; and establishing a system for large energy-intensive industries and facilities to trade energy-savings certificates so that they can meet government-mandated reductions in energy consumption, as per the Energy Conservation Act.

5. Mission on Sustainable Habitat

This mission seeks to promote energy efficiency in urban planning through measures such as putting more emphasis on urban waste management and

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recycling, strengthening the enforcement of automotive fuel economy standards, using pricing measures to encourage the purchase of fuel-efficient vehicles, and providing incentives for people to make greater use of public transportation.

6. Water Mission

This mission aims to increase water use efficiency by 20 percent through pricing and regulatory measures, including the recycling of wastewater, increases in irrigation efficiency, and incentives to promote water-neutral or water-positive technologies and groundwater recharge.

7. Mission for Sustaining the Himalayan Ecosystem

This mission seeks to promote the conservation of biodiversity, forest cover, and other ecological values in the Himalayan region to help stop the retreat of glaciers, as they constitute a major source of India's water supply.

8. Mission for a "Green India"

The mission plans to expand forest cover in India by 10 percent through afforestation of 6 million hectares of degraded forest lands.

9. Mission for Sustainable Agriculture

The mission will foster adaptation in the agricultural sector by supporting the development of climate-resilient crops and the expansion of weather insurance mechanisms, among other measures.

10. Mission on Strategic Knowledge for Climate Change

This mission will promote "a better understanding of climate science, impacts and challenges." It calls for the establishment of a new Climate Science Research Fund, improved climate modelling, and increased international collaboration. It will also foster private sector initiatives aimed at developing adaptation and mitigation technologies through venture capital funds.

11. Other Initiatives

Apart from the eight National Missions, the National Action Plan also envisages other initiatives aimed at enhancing mitigation and adaptation. These include research &development in the area of ultra-super critical boilers in coal-based thermal plants; integrated gasification combined cycle technology to make coal based power generation efficient; setting up more combined cycle natural gas plants; promotion of nuclear energy through adoption of fast breeder and thorium-based thermal reactor technology in nuclear power generation; adoption of high-voltage AC and high-voltage DC transmission to reduce technical losses during transmission and distribution; small and large scale hydro power; promotion of renewable energy technologies such as bio-mass combustion and gasification-based power generation; enhancements in the regulatory/tariff regimes to help mainstream renewable-based sources in the national power system; and renewable energy technologies for transportation and industrial fuels. In addition, the Action Plan envisages effective disaster management strategies that include mainstreaming disaster risk reduction into infrastructure project design, strengthening communication networks and disaster management facilities at all levels; protection of coastal areas, provision of enhanced public health care services, and assessment of increased burden of disease due to climate change. The Action Plan also highlights the role of Central Government, State Governments and local Bodies in putting in place

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appropriate delivery mechanisms and building adequate capacity and knowledge in the relevant institutions for effective adaptation and mitigation actions. Institutional Mechanism the National Missions are to be institutionalized by the respective Ministries and will be organized through inter-sectorial groups. Appropriate mechanisms including public private partnership and civil society actions, will be devised, as suited, for effective delivery of each individual Mission's objectives. Comprehensive Mission documents detailing objectives, strategies, plan of action, timelines and monitoring and evaluation criteria of all eight Missions and Other Initiatives are to be developed by December 2008 and submitted to the Prime Minister's Council on Climate Change. The work is to be coordinated by the Ministry of Environment & Forests.

"When I was growing up, we used to receive lots of rain here in Malud, during Monsoon, it used to rain continuously for several days in a week," said Jalandhara Jena (82), a farmer. He said the rainfall pattern then, was mostly regular and predictable. Farmers knew exactly when to sow which of their crops. "But things have changed. It is now difficult to plan and we are not sure when to plant anymore. Timing of sowing is a crucial issue and we cannot rely on previous experiences anymore as growing seasons seem to shift," he said.