CHAPTER ONE

1. UNDERSTANDING ENVIRONMENTAL HAZARDS AND DISASTERS

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1.Understanding Environmental Hazards and Disasters

1.1. Hazard and related Concepts

1.1.1. Hazard

- The academic community has not reached a consensus on the concepts of ***hazard***, ***disaster***, and ***disaster risk***.
- Under the *Sendai Framework for Disaster Risk Reduction* 2015–2030, the *United Nations* proposed a terminology that has been widely adopted by researchers and practitioners as:

  *"**Hazard** is **a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation**" (UNDRR, 2017).*

- Hazards includes ***biological***, ***environmental***, ***geological***, ***hydrometeorological*** and ***technological*** processes and phenomena (UNISDR, 2015).

- Hazards can be **single**, **sequential,** or **combined** in their ***origin*** and ***effects***.

- Each hazard is characterized by its ***location***, ***intensity,*** and ***probability***.

- Typical examples of ***hazards*** can be the ***absence of rainfall*** (leading to ***drought***) or ***excess of rainfall*** (leading to ***flooding***).

- ***Chemical manufacturing plants*** near ***settlements*** can also be a source of hazards; similarly, ***inappropriate agricultural practices*** will, in the ***long run***, lead to possible disasters such as ***loss of crops and famine.***
- Hazards can either be a ***creation of humans*** or the ***environment***.
- Although the ***former*** can ***more easily be planned*** for than the ***latter***, in ***both cases the management of the impact*** of the hazard will remain the ***same***.

1.1.2. Vulnerability

- Vulnerability is a ***set of conditions and processes resulting from physical, social, economic, and environmental factors***, which ***increase the susceptibility of a community to the impact of hazards*** (UNISDR, 2002:24).
- It can comprise of physical, socio-economic, environmental, and/or political ***factors that adversely affect the ability of communities to respond to events.*** (Jegillos, 1999)

➢ According to Blaikie *et al*. (1994), vulnerability can be defined as ***the characteristics of a person*** or ***group in terms*** of ***their capacity to anticipate***, ***cope with***, ***resist,*** and ***recover*** from the ***impact of a hazard.***

- Vulnerability can also be expressed as ***the degree of loss*** (*for example, expressed as a percentage from 0 to 100*) ***resulting from a potentially damaging phenomenon*** or ***hazard***.
- It is therefore the ***extent to which a community will degrade*** when ***subjected to a specified set of hazardous conditions***.
- Vulnerabilities can be ***physical***, ***social***, or ***attitudinal*** and can be ***primary*** or ***secondary*** in ***nature***.
- If there are ***positive factors***, that increase the ability of people and the society they live in, to cope effectively with hazards, that ***increase their resilience***, or that otherwise ***reduce their susceptibility***, they are considered as ***capacities*** **(capabilities** and **coping mechanisms)**.

- Vulnerability has some ***distinct underlying causes***.
- The *magnitude of each disaster*, measured in ***deaths***, ***damage***, or ***costs*** (for a given developing country) increases with the ***increased marginalization*** of the population.
- This can be caused by a ***high birth rate***, ***problems of land tenure and economic opportunity***, and the ***misallocation of resources to meet the basic human needs of an expanding population***.
- As the ***population increases***, the best land in ***both rural and urban areas is taken up,*** and those seeking land for farming or housing are forced to accept ***inadequate land***.
- This offers ***less productivity*** and a smaller measure of physical or economic safety, thus rendering the ***community vulnerable***.

1.1.3. Disaster

- Probably one of the most debated terms in ***disaster reduction*** remains the *basic definition of a* ***disaster***.
- Many scholars (e.g. Quarantelli, 1998b; Quarantelli & Perry, 2005) have expressed diverse views on ***what exactly constitutes a disaster.***
- Some scholars link the existence of a disaster to a ***specific amount of losses sustained*** (e.g. ***number of people killed and injured***), others judge an event to be a disaster if a certain predefined threshold is breached (e.g. a trigger to a certain contingency measure is reached), some others judge disasters on their ***geographical extent*** and ***significance with regard to "normal" conditions***, while some express a disaster in terms of ***its monetary value in losses.***

- However, since the *International Decade of Natural Disaster Reduction* (IDNDR) the various scientific understandings of disaster have culminated in a globally accepted definition.
- The UNISDR (2009) defines a disaster as: "***A serious disruption of the functioning of a community or a society involving widespread human, material, or environmental losses and impacts which exceeds the ability of the affected community to cope using only its own resources.***"

UN International Strategy for Disaster Reduction (UNISDR)

Some aspects of this definition need to be highlighted.

- **Firstly** the emphasis of the definition is on "***a serious disruption***".
- One can therefore expect a disaster event to be ***something that significantly changes*** the "***normal***".
- It is an event that the majority of the affected community will perceive as removing them from the "***normal***".

- **Second** and **most important** is the distinction that the definition places on abnormal events and an event that we can classify as being a disaster.
- If the event "***exceeds the ability***" of the a***ffected community to handle the consequences by making use of all their resources,*** then the event can be classified as "a disaster".
- **Lastly**, note should be taken of the concept "***community***".

- Various disciplines define "***community***" quite differently.
- A community is a collection of ***people sharing common interests and values***.
- Despite being culturally diverse, mobile, or unstable, members of a community communicate with or on behalf of each other in order to achieve a mutually beneficial outcome – they are bound together by a common goal, their sense of belonging, and a sense of place.

- One should therefore appreciate the fact that in order for a government to adequately manage disasters, the definition of "***community***" must be very clear.
- To this end it has become common practice for governments to use their ***administrative units*** to define the affected "***community***".
- Thus, if an event exceeds the coping ability of a village, local municipality, district, state/province, or even the nation, then a sp***ecific type of disaster*** can be ***declared*** (i.e. local, state/provincial, or national).

- The UNISDR goes on to indicate:

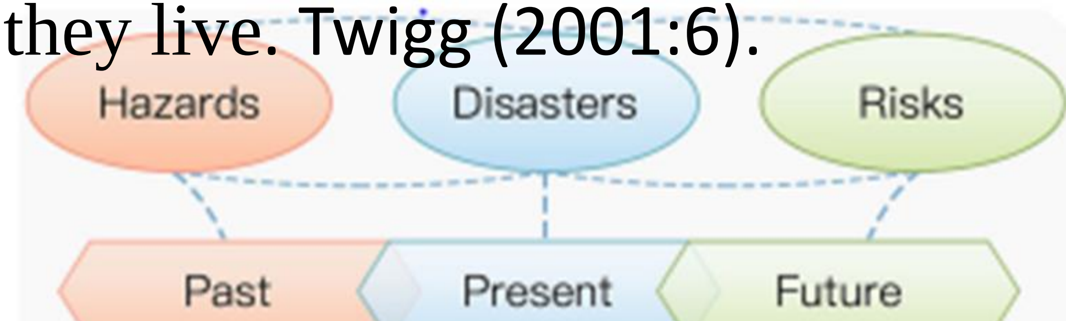
"Disasters are often described as a result of the combination of the ***exposure to a hazard***; the ***conditions of vulnerability*** that are present; and ***insufficient capacity*** or ***measures*** to ***reduce*** or ***cope*** with the potential negative consequences.

- Disaster impacts may include ***loss of life***, ***injury***, ***disease*** and other ***negative effects*** on human ***physical***, ***mental*** and ***social*** *well-being*, *together with* ***damage to property***, ***destruction of assets***, ***loss of services***, ***social and economic disruption*** *and* ***environmental degradation***."

- **Disaster** is “a ***serious disruption*** of the *functioning of a community or a society at any scale due to hazardous events interacting with **conditions of exposure, vulnerability and capacity**, leading to one or more of the following*: ***human***, ***material***, ***economic*** and ***environmental losses*** and ***impacts***” (UNDRR, 2017).

Difference between a hazard and a disaster

- Strictly speaking there are ***no*** such things as ***natural disasters***, but there are ***natural hazards***.
- A disaster is the result of a hazard's impact on society. So the effects of a disaster are determined by the ***extent of a community's vulnerability to the hazard*** (conversely, its ***ability***, or ***capacity*** to ***cope with*** it).
- This ***vulnerability*** is ***not natural***, but the ***result of an entire range of constantly changing*** physical, ***social***, ***economic***, ***cultural***, ***political,*** and even ***psychological*** factors that shape people's lives and create the environments in which they live. Twigg (2001:6).



1.1.4. Risk and disaster risk

- Risk has various connotations within different disciplines.
- In general ***risk*** is defined as "***the combination of the probability of an event and its negative consequences***" (UNISDR, 2009).
- According to the UNDP, risk is the ***probability of harmful consequences***: *casualties*, *damaged property*, *lost livelihoods*, *disrupted economic activity*, and *damage* to the *environment* resulting from interactions between natural or human-induced hazards and vulnerable conditions.

- **Risk** is usually associated with ***the degree to which humans cannot cope*** (lack of capacity) with a ***particular situation*** (e.g. natural hazard).
- The term ***risk*** is thus multidisciplinary and is used in a variety of contexts.
- As of the UNDRR **(**2017), ***disaster risk*** is the ***potential loss of life***, ***injury***, or ***destroyed*** or ***damaged assets*** that ***could occur to a system***, society or a community in a specific period of time, determined ***probabilistically as a function of hazard, exposure, vulnerability and capacity.***

- The term ***disaster risk, therefore,*** refers to the potential (not actual and realised) ***disaster losses***, in lives, health status, livelihoods, assets and services, which could occur in a particular community or society over some specified future time period.
- Disaster risk is the product of the ***possible damage*** caused by a ***hazard*** due to the ***vulnerability*** within a community.

- It should be noted that the effect of a hazard (of a particular magnitude) would affect communities differently (Von Kotze, 1999:35).
- This is true because of the level of the coping mechanisms within that particular community.
- ***Poorer communities*** are therefore ***more at risk*** than communities that do have the ***capacity to cope.***

- Risks exist or are created within social systems.
- The social context in which risk occurs is an important consideration.
- It should also be noted that people, therefore, do not share the same perceptions of risk and their underlying causes due to their social circumstances.
- To determine ***disaster risk*** ***three aspects*** need to be present:
  - a ***hazard***,
  - ***vulnerability*** to the hazard and
  - some form of ***coping capacity***.
- These terms will now enjoy greater attention.

1.1.5. Interaction of Hazards, Vulnerability and Disaster Risk

- In the previous section you were able to develop an understanding of core concepts which included the terms ***hazard***, ***vulnerability,*** and ***disaster risk***.
- In this section we will examine how the interaction between ***hazards*** and ***vulnerability*** translates into ***disaster risk***.

- In the process, we will identify the ***political***, ***economic, physical***, ***social***, and ***ecological*** factors that interact to ***increase the susceptibility of individuals, households,*** and ***communities*** to the impact of hazards.
- The identification of these factors provides the basis for the ***prioritization of initiatives*** that will ***contribute to*** ***reduce vulnerability*** and thus eliminating and/or ***reducing*** ***disaster risk***.

- The initiatives so prioritized should then be integrated by the various spheres of government into sustainable development and disaster risk reduction planning.
- ***Disaster risk reduction*** is ***only valuable*** once the ***concerned body understands the contexts*** in ***which people live***, the ***changing environment in which they find themselves***, ***the impact of this environment on their ability to sustain their livelihoods*** and ***the presence of a number of natural forces*** (natural hazards).

- ***Hazards in themselves do not constitute disasters***.
- The ***magnitude of a disaster*** is usually described in terms of the ***adverse effects*** which a hazard imposes on lives, property, infrastructure; environmental damage, and the costs attached to post-disaster recovery and rehabilitation.
- In other words there is a direct link between the capacity of those affected to withstand, cope and recover from the adverse effects of a hazard using only their own resources, and what constitutes disaster risk.
- Put simply *disaster risk* is the ***product of the combination of three elements*** – ***vulnerability***, ***coping capacity*** and ***hazard*** (UNISDR 2002:41).

The following notation illustrates this interaction:

$$\text{Disaster risk (R)} = \frac{\text{Vulnerability (V) x Hazard (H)}}{\text{Capacity (C)}}$$

OR

Disaster risk = function of H and V/C

- It is common cause that in countries where the majority of the ***population*** have been ***marginalized*** the adverse ***effects of hazards*** are of far ***greater magnitude***.

- The interaction of ***political, physical, social, economic***, and ***environmental*** conditions which are linked to the ***marginalized state of those communities*** translates into ***extremely unsafe*** and ***fragile conditions*** thus rendering them ***most vulnerable*** to the ***impact of hazards***.

(UNISDR 2002:47)

- For example in South Africa, the apartheid ideology of the previous government (which resulted in the majority of the population being forced to live in **severe poverty** in extremely unsafe conditions *without access to basic services*) has left a legacy of individuals, households, and communities highly susceptible to the impact of hazards.
- Vulnerability is the key element in the link between hazards and what constitutes disaster risk.

1.2. Hazard and Risk Management related Concepts

1.2.1. Prevention

- **Prevention** refers to ***activities to provide outright/absolute avoidance of the adverse impact of hazards*** and related ***environmental***, ***technological,*** and ***biological disasters***.
- Depending on social and technical feasibility and cost/benefit considerations, investing in preventive measures is justified and acceptable in areas frequently affected by disasters.
- In the context of ***public awareness and education***, prevention refers to ***changing attitudes*** and ***behavior towards*** a "***culture of prevention***".

1.2.2. Preparedness

- **Preparedness** refers to ***specific measures*** taken ***before disasters strike***, usually to forecast or warn against them, take precautions when they threaten, and arrange for the appropriate response (such as ***organizing evacuation/departure*** and ***stockpiling food supplies***).
- Preparedness falls within the broader field of mitigation.

1.2.3. Mitigation

- ***Mitigation*** refers to ***structural*** and ***non-structural*** measures undertaken ***to limit the adverse impact*** of natural hazards, environmental degradation, and technological hazards.
- It can be also defined as ***any action taken to minimize the extent of a disaster or potential disaster***.
- Mitigation can take place ***before***, ***during,*** or ***after*** a ***disaster***, but the term is ***most often*** used to refer to ***actions against potential disasters***.
- Mitigation measures are both physical or ***structural*** (such as ***flood defenses*** or ***strengthening buildings***) and ***non-structural*** (such as ***training in disaster management, regulating land use, and public education***).

1.2.4. Disaster Risk Reduction (Disaster Reduction)

- This refers to the ***systematic development*** and ***application*** of ***policies***, ***strategies,*** and ***practices*** to ***minimize vulnerabilities*** and ***disaster risks*** throughout a society, to ***avoid*** (prevention) or to ***limit*** (mitigation and preparedness) the ***adverse impact of hazards***, within the broad context of ***sustainable development.***

- The ***disaster risk reduction framework***, as described in the 2002 ISDR review document, is composed of:

- ***Risk awareness*** and ***assessment*** including hazard analysis and vulnerability/capacity analysis;
- ***Knowledge development*** including education, training, research and information;
- ***Public commitment*** and ***institutional frameworks***, including organizational, policy, legislation and community action;
- ***Application*** of ***measures*** including environmental management, land-use and urban planning, protection of critical facilities, application of science and technology, partnership and networking, and financial instruments; and
- ***Early warning systems*** including forecasting, dissemination of warnings, preparedness measures and reaction capacities.

1.2.5. Disaster Management

- This term is often used in a general sense, covering the ***implementation*** of **preparedness**, **mitigation**, **emergency response,** and **relief** and **recovery** measures.

1.2.6. Disaster risk management

- It refers to the ***systematic management*** of ***administrative decisions***, ***organization***, ***operational skills,*** and ***responsibilities*** to ***apply policies, strategies***, and ***practices*** for ***disaster risk reduction.***
- It can be also defined as a process through which ***disaster risk reduction activities*** are ***practically applied***.

- It is an ***integrated approach*** to ***multisectoral*** and ***multidisciplinary planning***, that aims at ***lessening the impacts of natural hazards*** and ***related environmental*** and ***technological threats***.
- It is therefore a ***proactive approach*** that focuses on ***preparedness***, ***mitigation***, ***prediction***/***early warning actions*** that could r***educe future impacts*** & ***lessen*** the need for government intervention in the future.

1.2.7. Coping Capacity

- ***Coping capacity*** for disaster risk reduction refers to the ***ability of people***, ***organizations*** and ***systems***, using ***available skills*** and ***resources***, to ***face*** and ***manage adverse conditions*** such as hazards, emergencies or disasters.
- ***Coping capacities*** contribute to the ***reduction of disaster risks*** (UNISDR, 2009).
- The focus here should therefore ***not only*** be on the ***individual*** or the ***community*** but also on the ***capacity of the supporting mechanisms*** to the ***individual*** and the ***community*** at large.

- For example, one specific community might consist of a number of ***new immigrants*** but this new community might enjoy the support of the local municipality.
- In themselves, the new community might not have cohesion yet, but their capacity lies in the ***support they have.***
- Similarly, an ***impoverished community*** might ***not*** be the focus of development, but ***inherent*** in their in***ternal social and economic structures*** they ***might possess significant coping capacity*** and ***resilience***.
- Coping capacity is therefore just as much about ***what a community internally possesses***, as the ***external structures*** on which they depend.

1.2.8. Resilience

- In the natural environment, **resilience** means that an area or ***ecosystem under threat*** is ***restored*** to ***its original pristine state.***
- In the construction and engineering industry, resilience would be the ***ability of metal*** or a ***structure*** to ***return*** to an ***original state*** – being able to withstand shock, weight or pressure.

- However, human systems cannot be untouched by life events – they do not necessarily return to an original or former state and the challenge is to continuously develop, improve and refine existing structures, systems and environments in order to progress.
- Returning to an original or previous state, therefore, corresponds with the ***tendency of certain communities*** to return to ***vulnerable locations*** and ***rebuild their houses***, **without** ***improving conditions*** and ***increasing chances to progress***.
- ***Resilience***, however, ***implicitly requires improvement.***

- For example, with ethnic based conflicts, the population from Wellega and some other parts of Oromia region displaced in many thousands. Apart from displacements, thousands are died. If we are talking about resilience of these communities, we refer the displaced people, not those who were killed or not the loss of life.
- For resilience, before returning the displaced people to their original place of residence, there should be a sustained improvement of the social environment at large including its root and immediate causes. That is why it is said ***Resilience***, however, ***implicitly requires improvement.***
- If we are helping the people in their encamp where they settled after displacement, that is a coping strategy.

- The UNISDR defines **resilience** as "***the ability of a system, community or society exposed to hazards*** *to* ***resist, absorb, accommodate*** *to and* ***recover from*** *the* ***effects of a hazard in a timely*** and ***efficient manner***, *including through the* ***preservation*** *and* ***restoration*** *of its* ***essential basic structures*** *and* ***functions***"

(UNISDR, 2009)

- This definition, therefore, considers the presence of a ***hazard*** and ***not a disaster***.
- Thus, ***once a disaster actually occurs***, it would be ***incorrect*** to ***refer to resilience*** but rather ***to coping capacity.***

- ***Resilience*** and the ***building of resilience*** should therefore be seen as an ***integral part*** of ***disaster risk reduction activities.***
- Resilience, therefore, means the ability to "***spring back from***" a shock.
- The resilience of a community in respect of potential hazard events is determined by the degree to which the community has the necessary resources and is capable of organizing itself both prior to and during times of need.

(UNISDR, 2009).

1.3. Hazard Assessment

- **Hazard assessment** refers to the ***identification***, ***studies,*** and ***monitoring*** of ***any hazard*** to ***determine*** its ***potentiality***, ***origin***, ***characteristics,*** and ***behavior***.
- The process of ***collecting information related to the nature and characteristics of hazards*** is called ***hazard assessment***.

➢ It is therefore the interaction of the characteristics of a hazard in terms of the ***type of hazard***, ***its projected intensity, space or physical location of onset***, and ***its duration.***

1.3.1. Hazard Assessment Approaches

- The process of ***hazard*** assessment depends on the following ***types*** and ***sources of information***:

A. **Available scientific information**, including ***geologic***, ***geomorphic***, and ***soil maps***; ***climate*** and ***hydrological data***; and ***topographic maps***, ***aerial photographs***, and ***satellite imagery***.

B. **Historical information**, both ***written reports*** and ***oral accounts*** from ***long-term residents***.

- These may include myths and legends.

- For the assessment of most disasters, one cannot expect complete data required to carry out a comprehensive assessment.
- Depending on the situation, ***various assessment approaches*** are used with obvious variations in the ***degree of accuracy***.
- There are ***four*** types of disaster assessment approaches:
  - ***quantitative***,
  - ***qualitative***,
  - ***deterministic*** and
  - ***probabilistic***.

1. Quantitative approach

- Here ***mathematical functions are used to denote relationships between variables considered to quantify the hazard***.
- ***Numerical data*** can be fed in to assess the impact of the hazard event. An example is the ***probable flood*** that a particular ***rainfall*** could cause within a ***watershed area***.
- Flood dimensions such as ***depth of flood*** and ***area of inundation*** would *depend on the volume of water* that flows into the stream.
- Surface run-off, soil permeability, vegetation cover etc. would determine this.

- The empirical data collected from historical records as well as *theoretical data* from basic principles of physics are used to derive the relationship between variables.
- The ***mathematical expression*** so derived could be used to ***forecast future events***.
- However, ***quantitative assessment*** may not be possible for all hazard events.

2. Qualitative approach

- This method uses ranking such as ‘**high**’, ‘**moderate**’ and ‘**low**‘ to ***assess a hazard event***.
- Where there is a ***lack of sufficient data for quantitative evaluation***, or where ***certain variables cannot be expressed numerically***, this *qualitative ranking may be appropriate to take hazard mitigation decisions*.

3. Deterministic approach

- A **past event is selected** and ***its associated characteristics*** and ***the consequences are described***.
- ***Past impact data*** *can be combined with* ***current conditions*** and *possible exposure levels* and impact could be determined.
- This would be adequate to ***visualize the recurrence*** of an event for community awareness ***but leaves room for inaccuracies.***

4. Probabilistic approach

- After *identifying the hazards* that *affect communities* and assessment of the impacts from those hazards, a ***probability analysis*** is undertaken.
- It provides an estimate of the ***probability of each hazard affecting an area or region***.
- Probability for each hazard may be categorized as '***high***', '***moderate***' or '***low***'.
- ***Probability of occurrence*** can be calculated through research on past events.

1.3.2. Hazard Assessment Methodology

- ***Hazards trigger disasters*** when they occur in a ***vulnerable environment*** otherwise the ***hazard phenomenon remains a threat.***
- The ***objective of hazard assessment*** is to ***identify the probability of occurrence of a specific hazard in a specific future time period***, as well as its ***intensity*** and ***area of impact***.
- For example, the assessment of ***flood hazards*** is extremely important in the ***design of engineering facilities*** and in ***zoning for land use***.

- Construction of buildings and residences is often restricted in high flood hazard areas.
- Flood assessments should be developed for the design of sewerage treatment facilities, as well as for sites having ***industrial materials*** of a toxic or ***dangerous nature***.
- **Certain hazards** have ***well-established*** techniques available for their assessment.
- This is the case for ***floods, earthquakes***, and ***volcanic*** hazards.

- Many of the ***analytical techniques*** useful for hazard assessments can be accomplished using ***standard computers*** and widely available ***software packages***.
- Even ***without sophisticated assessment tools***, it is possible for ***local communities*** to ***collect hazard information.***
- While hazard mapping has been improved by the wider use of geographic information systems (GIS), the inclusion of social, economic and environmental variables into GIS models remains a ***major challenge***.

- The need to assign quantifiable values to the variables analyzed in the ***spatial models*** used by ***GIS*** is not always possible for social and economic dimensions of vulnerability.
- Moreover, the diverse scales at which different dimensions of socio-economic vulnerability operate make spatial representation very difficult.
- In addition, the ***quality*** and ***detail of the data*** required for ***GIS analyses*** are, in many cases, nonexistent, especially in LDCs.
- On the other hand, well-conceived ***low-tech*** approaches can be a very good alternative to GIS-based techniques.

- The use of GIS for vulnerability/capacity analysis is still at an ***embryonic*** stage in comparison with its wider use in hazard mapping.
- Several research initiatives are aiming to solve these current ***methodological*** constraints, especially those dealing with quantifying social aspects of vulnerability.

1.3.3. Components of Hazard Assessment

- Hazard assessment is a matter of identifying, profiling, ranking or measuring and mapping hazards.

Hazard identification: A good starting point is to simply list all the potential hazards, natural or human-made, that are likely to occur in an area within a given time frame.

This can be accomplished at the community or even household level using a variety of PRA techniques:

- semi-structured interviews
- group hazard identification technique
- transect walks with key informants
- community mapping of topography, houses, land use, etc
- historical profiling
- seasonal calendars.

Hazard profiling and ranking (describing and measuring):

Once we have a complete list of potential hazards in a locality, each hazard can be described and measured according to certain characteristics, such as:

- causes
- direct impact (at this stage the immediate impact on the environment rather than the longer - term impact on people's lives)
- intensity
- Frequency
- seasonality
- location
- history and trends
- predictability and controllability.

Hazard mapping: The flood hazard can then be mapped with high, medium, and low hazard locations within the community assigned different shading to show their comparative threat.

- **Hazard mapping** is most useful when conducted at ***local level***.
- It can be, and where possible should be, complemented by technical studies but if these contradict local knowledge priority should be given to the latter.
- Ideally you ***should use a map*** *but* if maps are not available you can use a ***drawing of the locality instead of a map.***

Survey methods and RAP/PRA techniques to assess hazards: There are also non-GIS methods (ground-level hazard assessment tools) that can be used to identify main hazards for a given community.

The methods include, among others:

- ***trend***/historical ***analysis*** of hazards
- desk/***literature review*** of the occurrence, frequency and magnitude of various hazards in a country/community

- studies on various ***communities*** about their ***perception*** and ***experience*** about hazards using PRA, RRA or PPA
- community ***historical profile***, historical visualization, seasonal calendar, hazard/risk mapping, transect walk, ranking and scoring matrix, and problem tree analysis are also additional tools that can be used at the lower/community level

Summary of potential methods/tools to assess hazards

Drought: ***GIS*** *applications and* ***satellite image*** *analysis, remote sensing, historical trend analysis and mapping of drought-prone areas, and identification of areas at risk (chronically moisture-stressed areas).*

Flood: ***GIS*** *applications and* ***satellite image*** *analysis,* ***remote sensing****, historical trend analysis and mapping of flood-prone areas, and identification of areas at risk.*

Conflict: *Community historical profile, historical visualization, seasonal calendar, hazard/risk mapping, transect walk, ranking and scoring matrix, problem trees, conflict timeline, problem/solution analysis.*

HIV/AIDS: *Knowledge attitude practice (KAP) surveys, demographic and health surveys (DHS), PRA techniques, community historical profile, historical visualization.*

Malaria: *KAP surveys, DHS, PRA techniques, community historical profile, historical visualization, seasonal calendar, hazard/risk mapping, transect walk, ranking and scoring matrix, problem trees.*

1.4. Vulnerability Assessment

- Vulnerability Assessment is the ***process of estimating the susceptibility*** of '***elements at risk***' to various hazards and analyzing the ***causes behind*** their ***vulnerability***.
- The assessment takes into account the physical, geographical, economic, social, political and psychological factors, ***which make some people more vulnerable to the dangers*** of a given hazard while others are relatively protected.

- The concept of vulnerability has emerged across various disciplines, ranging from engineering to psychology, and its definition varies accordingly.

- In the ***developing community***, vulnerability has become an important concept used to guide the design, evaluation, and targeting of programs.

- Hoddinott and Quisumbing (2003) pose five questions that a ***vulnerability assessment*** should ultimately answer:

1) ***What*** is the ***extent of vulnerability***?
2) ***Who*** is ***vulnerable***?
3) ***What*** are the ***sources*** of ***vulnerability***?
4) ***How*** do ***households respond*** to ***shocks***?
5) ***What gaps*** exist between ***risks*** and ***risk management mechanisms***?

- Selecting vulnerability assessment methods will depend on the ***purpose*** and ***focus*** of the ***vulnerability assessment***.
- This will also affect the level of analysis required.
- Population level measures, used to ***segment a population*** into different ***categories of vulnerability,*** are useful for policy, planning, and project design.
- When used with ***participative methods***, they can also be useful for ***community mobilization***.
- For project targeting, household level methods will be required.

1.4.1. Participatory Vulnerability Analysis (PVA) and Participatory Vulnerability & Capacity Analysis (PVCA)

- ***Participatory Vulnerability Analysis*** (PVA) and ***Participatory Vulnerability & Capacity Analysis*** (PVCA) are based on ***PRA*** methods specialized to assess vulnerability.
- In addition to the sustainable livelihoods literature, they are both influenced by the disaster management literature and were originally developed for the intended use in natural disaster contexts, although both also assess other types of shocks.

- PVA is a ***rights-based approach*** developed by Action Aid in 2000 with a focus on action planning.

(Chiwaka & Yates, 2004)

- Like other participatory methods, it ***mobilizes community information*** about vulnerability and facilitates the process of ***making plans to address*** it.
- It distinguishes itself as a "***multi-level, multi-stakeholder approach***," whereby long-term action planning flows up from the community level all the way to international level policy.

- PVCA is a similar, ***action-oriented approach*** to ***vulnerability assessment***, developed by ***Christian Aid***.
- The additional letter in its acronym signals a greater focus on ***understanding the capacity of a target population***, also called ***coping or resilience.***

1.4.2. Participatory Wealth/Well-being Ranking (PWR)

- Community ranking exercises are considered a *best practice for individual-level targeting*.
- Generally, PWR involves the facilitation of a ***discussion with community members*** to come up with a definition of the topic of analysis.

  (Simanowitz & Nkuna, 1998)
- Though the exercise was originally used for ***wealth ranking***, conceptions of wealth can be extended to vulnerability, with the ***facilitator*** ensuring that both ***risk*** and ***coping mechanisms*** are considered by participants in their criteria for vulnerability.

- Next, a process of ***community mapping*** and ***ranking*** of individual households is facilitated.
- This can involve defining ***levels*** or ***wealth*** or ***vulnerability***.
- The entire process is often repeated with reference groups as well to compare findings and ensure consistency.
- PWR can be conducted as a public exercise or with key informants.

- For economic strengthening practitioners, vulnerability assessment can ***provide powerful data*** useful for ***policy, project design, strategic planning***, and ***project targeting.***
- Vulnerability assessments should assess ***risk*** as well as ***coping*** to be ***forward-looking, dynamic measures.***
- The way vulnerability is measured and conceptualized will depend on the ***purpose of conducting an assessment***, and there are a variety of tools and frameworks available to inform the process.

- Vulnerability assessments should never utilize "***off-the-shelf***" tools, but must be tailored to ***specific contexts***.
- The best way to do this is to mix quantitative and qualitative methods, incorporating community perspectives and definitions of vulnerability.

1.5. Risk Assessment

- ***Risk assessment*** is a process to ***determine the nature*** and ***extent of risk*** by ***analyzing potential hazards*** and evaluating existing conditions of vulnerability/capacity that could pose a potential threat or harm to people, property, livelihoods, and the environment on which they depend.

- The process of conducting a ***risk assessment*** is based on a review of both technical features of hazards such as their ***location***, ***intensity***, ***frequency***, and ***probability***, and also the analysis of the physical, social and economic dimensions of vulnerability, while taking particular account of the coping capabilities pertinent to the risk scenarios.

- **Risk assessment** is a means not only to understand the risks that society faces, with their potential probabilities and impacts, but also to provide a framework to determine the ***effectiveness of disaster risk management, risk prevention and/or risk mitigation***.

- It would be spurious to pretend that we fully understand all the hazards that society faces and their potential consequences.

- The process of risk assessment requires a structured approach.
- Without such a process, risks may be overlooked or implicit assumptions may be made.
- A risk assessment process requires ***transparency***, ***opening up assumptions*** and ***options to challenge***, ***discussion*** and ***review***.

- For UNDP, a comprehensive ***risk assessment*** consists of the following steps:

Step 1: Understanding of ***current situation, needs*** and ***gaps*** to assess what already exists, avoid duplication of efforts, and build on existing information and capacities.

  - This is done through a systematic inventory and evaluation of existing risk assessment studies, available data and information, and current institutional framework and capabilities

Step 2: ***Hazard assessment to identify the nature, location, intensity*** and ***likelihood*** of major hazards prevailing in a community or society.

Step 3: ***Exposure assessment*** to identify population and assets at risk and delineate disaster prone areas.

Step 4: ***Vulnerability analysis*** to determine the capacity (or lack of it) of elements at risk to withstand the given hazard scenarios!

Step 5: *Loss/impact analysis* to estimate ***potential losses of exposed population***, property, services, livelihoods and environment, and assess their potential impacts on society

Step 6: *Risk profiling and evaluation* to identify cost-effective risk reduction options in terms of the socio-economic concerns of a society and its capacity for risk reduction

Step 7: *Formulation or revision of DRR strategies and action plans* that include setting priorities, allocating resources (financial or human) and initiating DRR programs.

1.5.1. key elements of risk assessment

- It can be argued that the process of risk assessment and modelling is more important than the results obtained.
- Risk assessment does not need to be as complex as a full stochastic model to add real value.
- Similarly, it is a common misunderstanding that a lack of good-quality, homogeneous data invalidates risk assessment.
- Any risk assessment methodology requires assumptions to be brought to light and so opened to challenge.
- Assumptions can then be reviewed, compared and stressed, identifying areas of inconsistency, illogicality, sensitivity and where further research should be concentrated.

The **key steps** in risk assessment are:

1. ***Identify the hazards which might affect the system or environment being studied***. It is important to think beyond events or combinations of events that have occurred in order to consider those that may occur.
2. ***Assess the likelihood or probability that hazards might occur***: inputs to this process include history, modelling, experience, corporate memory, science, experimentation and testing.
3. ***Determine the exposure to the hazard***, i.e. who or what is at risk.
4. ***Estimate the vulnerability of that hazard*** to the entity exposed in order to calculate the physical or financial impact upon that entity should the event occur.
5. ***Estimate the potential financial*** and/or ***social consequences of events of different magnitudes.***

1.5.2. Risk Treatment Measures

- Risk treatment measures refers to ***disaster risk management countermeasures*** that can be developed based on the information obtained from the process of risk analysis (hazard, vulnerability, capacity analyses) and can be applied to avoid, reduce, transfer or retain the risk.
- Disaster risk treatment measures are commonly divided into '**risk control**' and '**risk finance**'.
- **Risk control** is further broken down into '***risk avoidance***' and '***risk reduction***,' while '***risk finance***' is composed of '***risk transfer***' and '***risk retention***'.

1.6. Disaster Risk Science and Disaster Risk Management

- **Disaster risk science** is the discipline which studies the ***hazard mechanism, disaster process, dynamics modeling, spatial and temporal patterns of disaster impact (effects and losses), emergency response, and risk governance paradigms of disaster systems***.
- It is a ***multi-disciplinary***, ***cross-disciplinary***, and ***trans-disciplinary*** field of study.
- Its theory, methodology, technology, and governance systems must be broadly developed from the perspectives of ***science*** and ***engineering***, as well as the ***humanities and social sciences.***

- The structure of disaster risk science is different from that of the ***Earth science system***, which is divided into Earth spheres (such as geology, geography, atmospheric science, oceanology and ecology, and so on), or divided by basic science linkage (such as geomathematics, geophysics, geochemistry, geometrics, digital Earth, and so on).
- By contrast, the division of ***disaster risk science*** is closer to that of the study of the cryosphere.

(Qin et al., 2017)

- Disaster risk science includes not only basic studies, namely, theory and methodology, but also ***systematic application-oriented research*** and ***development***, namely, ***response technologies*** and ***governance approaches*** and their ***integration***.
- Because the disaster system is a ***giant, complex system***, its corresponding ***disaster risk science*** naturally is a ***disciplinary group***, which can be further divided into ***three pillars***:
  - ❑disaster science,
  - ❑disaster technology, and
  - ❑disaster governance

- **Disaster science** mainly focuses on the ***structure, function, properties***, and ***dynamics*** of disaster systems.
- Research on disaster systems' structure includes the study of ***hazards***, ***socioeconomic exposure***, and the ***environment***.
- Research on the function of disaster systems includes studies on hazardousness (threat or danger), socioeconomic vulnerability, and environmental stability.

- ***Research on the properties of disaster systems*** refers to studies that explore their interconnectedness, regionality, complexity, and coupling features.
- ***Research on disaster system dynamics*** refers to the mechanism, processes, and evolution of these systems.
- Disaster science can be further divided into fields such as hazardology, hazardous environment studies, and exposure science.

- **Disaster technology** mainly focuses on the R&D of disaster systems' metrics and statistics, disaster response technologies, disaster and risk management technologies, and technology integration.
- Disaster system metrics and statistics includes ***disaster monitoring*** (site and station based, or using remote sensing data and big data), ***forecasting***, ***early warning***, ***loss estimation*** (statistics and relative impact), ***disaster modeling*** (experimental, numerical, and scenario modeling of mechanisms and impacts), ***disaster risk assessment*** (quantitative, semiquantitative, qualitative), and ***disaster risk simulation***.

- Disaster response technology includes technologies for ***prevention*** (inventory, maps, regionalization, plans and planning, fortification standards, insurance), ***resilience*** (structural measures, retrofitting, relocation, site improvement), and ***relief*** (rapid assessment, aid to victims, organizing assistance and funding, distribution of material and funds), and ***their integration.***

- Disaster and risk management technology covers disaster management (regulation, standard, procedure, method, statistical indicator system, mapping, logistic, online service and automation, information system), disaster risk management (regulation, standard, procedure, method, mapping, premium setting, loss assessment, insurance, financing, online service and automation, information system), and disaster emergency management (regulation, standard, procedure, method, plan, logistic, institution, online service and automation, information system) and technologies.
- Disaster technology can be divided into disaster metrics and statistics, disaster response technology, and disaster and risk management technology.

- **Disaster governance** mainly focuses on developing approaches and methods of preparedness, adaptation, emergency response, recovery and reconstruction, and their integration.
- ***Disaster preparedness*** and adaptation management includes **capacity building** for the management of inventories, shelters, and command system; disaster response schemes, plans and standards, and disaster response media communication, campaign, and education.
- Emergency response management covers emergency command and rescue systems, logistics and allocation of goods and materials, and joint defense and control.

- Recovery and reconstruction management covers rehabilitation, carrying capacity assessment, ground safety assessment, and reconstruction planning.
- According to the topics/fields mentioned above, ***disaster governance*** can be divided into disaster preparedness governance, disaster emergency governance, and disaster recovery and reconstruction governance.

1.6.1. Geospatial Science Applications for Disaster Management

- Geographic Information Systems (***GIS***), Remote Sensing (***RS***), and Global Positioning Systems (***GPS***) have gained much attention for their applications in disaster management and are increasingly utilized throughout the entire disaster management cycle as a tool to support decision making (Mileti, 1999).

Application of Remote sensing in disaster management

- Remote sensing technique is an effective science to ***minimize loss of life***, ***effective mitigation***, ***preparedness response*** and ***recovery***.
- For any hazard and disaster to know the ***intensity***, ***damage*** and ***ways to provide immediate helps*** require accurate, frequent and almost instant data.
- These data can be provided by ***satellite imageries*** through remote sensing.

- Remote sensing is a ***satellite-based technology*** that enable for example in studying **cyclones**.
- It gives risk modelling for predictive analysis and movement of cyclone.
- ***Mapping of cyclone affected areas*** also observe through the satellite images.
- For the purpose to study cyclonic hazard and disaster ***Insat3A***, ***Quicksat***, ***Radar***, ***Meteosat*** and ***Kalpana-1*** satellites are used.

- These satellites provide early warning of cyclones and also give the long-range climate modelling for the climatic hazards. It also gives mapping areas for escape routes in the cyclone affected area.
- Cyclone monitoring also possible with the help of remote sensing.
- This geospatial technology provides impact assessment and damage assessment.

- After the ***strike of earthquake***, remote sensing provides earthquake affected regions maps.
- With the help of previous and current satellite image comparison is possible for damage assessment and building stock assessment.
- It also provides planning routes for search and rescue operation in the site.
- To locate the rehabilitation sites remote sensing technology helps to identify.
- ***PALSAR***, ***SPOT***, ***IRS***, ***IKONOS*** satellites are used for the ***monitoring*** and ***earthquake risk reduction.***

- In the ***flood affected area*** remote sensing plays effective role for making flood prone area mapping area, delimitations of flood plains, flood detection and early warning, flood mapping evacuation, flood forecasting etc.
- ***AMSR-E*** and ***Kalpana 1*** satellites are used for ***flood hazard*** and ***its management.***

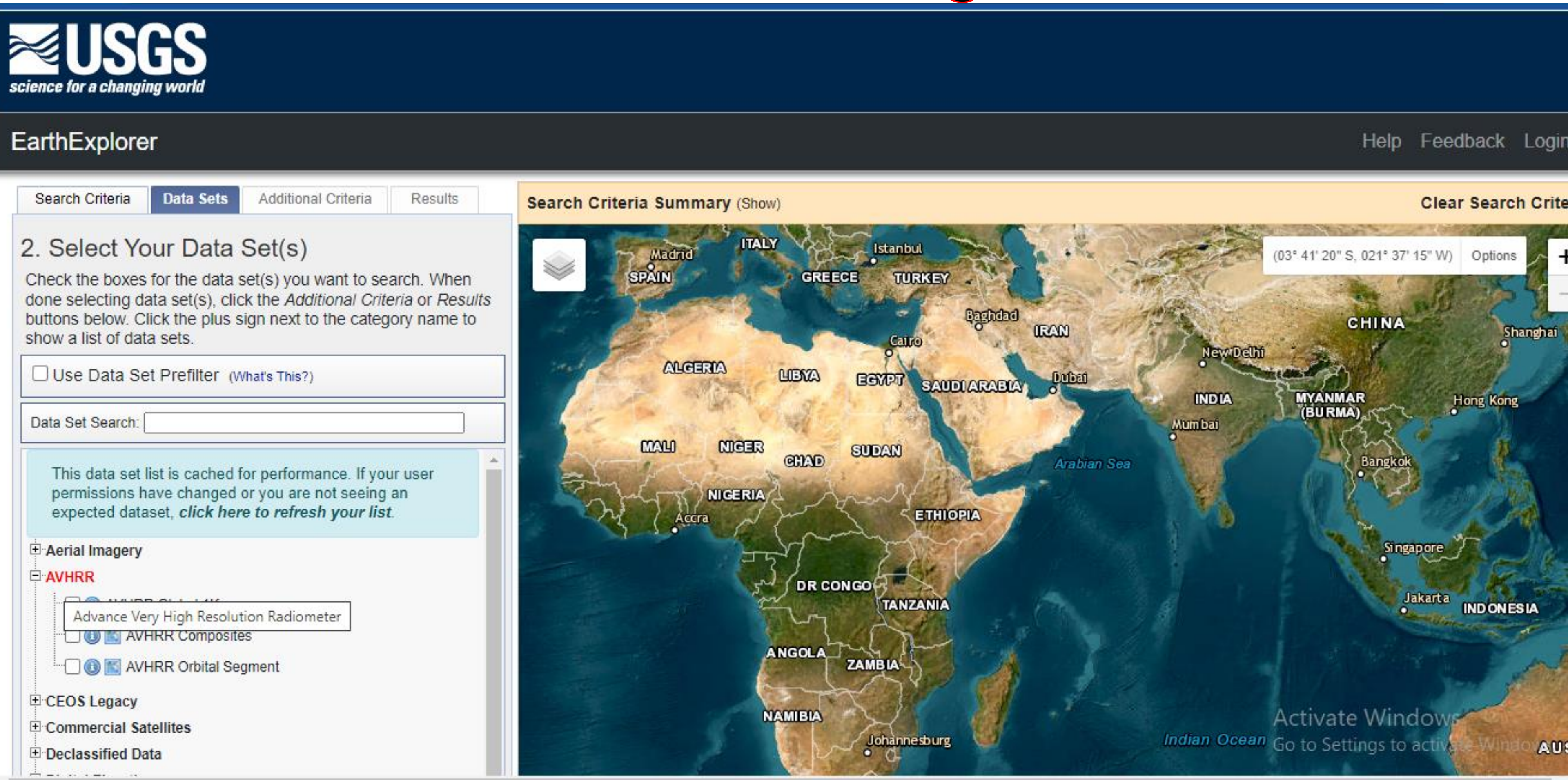
Landslide in one the natural hazard mostly happens in the hilly and mountainous region. In that region accessibility and connectivity is very poor.

- Landslide affects on the surrounding area. After the strike of land sliding, it is very inaccessible area to reach the site. Remote sensing will helps for damage assessment.
- A comparative study is possible with the pre and post landslide satellite images.
- RS provides digital elevation model, landslide affected area mapping, risk modelling to reduce the impact and damage.
- **IRS, INSAR, SPOT, PALSAR and IKONOS 2,** these satellites are used for the landslide study.

In **drought situation**, remote sensing also very useful for risk modelling, land water management planning, vulnerability analysis etc.

- Images of drought prone areas give the information of amount of loss of vegetation cover and assess the damage.
- For this purpose, ***EEWS, NET, AVHRR, MODDIS*** and ***SPOT*** satellites are useful.

For example


USGS
science for a changing world
EarthExplorer
Help
Feedback
Search Criteria
Data Sets
Additional Criteria
Results
2. Select Your Data Set(s)
Check the boxes for the data set(s) you want to search. When done selecting data set(s), click the Additional Criteria or Results buttons below. Click the plus sign next to the category name to show a list of data sets.
Use Data Set Prefilter (What's This?)
Data Set Search:
This data set list is cached for performance. If your user permissions have changed or you are not seeing an expected dataset, click here to refresh your list.
Aerial Imagery
AVHRR
Advance Very High Resolution Radiometer
AVHRR Composites
AVHRR Orbital Segment
CEOS Legacy
Commercial Satellites
Declassified Data
Search Criteria Summary (Show)
(03° 41' 20" S, 021° 37' 15" W)
Options

Volcanic eruption is also one of the major hazards.

- Field study is not possible after the volcanic eruption at particular place.
- Remote sensing technology helps to emission monitoring and also giving thermal alerts.
- After the eruption of volcano, lava flow mapping and evacuation planning is possible due to remote sensing.
- ***MODIS***, ***HYPERION***, ***AVHRR*** satellites are useful for ***volcanic study***.

Application of GIS for Disaster Risk Management

- In a multi-hazard assessment, the relationships between different hazards should be studied, especially for cascading hazards.
- The use of ***earth observation*** (EO) products and **geographic information systems** (GIS) has become an *integrated*, *well developed* and *successful tool* in disaster risk management.
- New GIS techniques, in particular, are revolutionizing the potential capacity to analyze ***hazards***, ***vulnerability*** and ***risks***, and ***plan*** for ***disasters***.
- GIS software packages are used for information ***storage***, ***situation analysis*** and ***modelling*** (Twigg, 2004)

- GIS is very useful for ***during*** the ***emergency situation*** and ***hazard area mapping***.
- This geospatial technology is useful in ***merging the data from the various sources.***
- It is helpful in ***modelling of disaster risk***.
- Its main key role is to *provide decision making system in disaster management.*
- GIS also ***predict*** the ***level of damage***, ***forecasting*** of ***water level***, ***lava flow*** etc.

- Disaster risk management benefits greatly from the use of GIS technology because spatial methodologies can be fully explored throughout the assessment process.
- One of the key advantages of using GIS-based tools for the risk decision-making process is the possibility to use '***what if***' analysis by varying parameters and generating alternative scenarios in a spatial context.

(Longley et al., 2005)

Application of GPS in Disaster Management

- Global positioning system (GPS) is ***satellite navigation system***. It is useful for identify the geographical location.
- GPS plays very effective role in ***disaster situation***, because this device is functioning in ***anywhere*** and ***any weather*** condition.
- It gives precise location to reach the particular location and provides the help.
- The device plays vital role during the response and recovery stages after the strike of hazards.

1.7. Disaster Vs development/underdevelopment

- Disaster management and economic development have become two major public policies for many developed and developing countries in recent years.
- While focusing on development goals, the leaders in these countries have to adjust their policies and priorities and rearrange valuable resources to deal with occurrences and challenges of a variety of disasters, which are directly or indirectly related to economic development.

- Disasters and their consequences may produce severe negative effects on economic and social development of communities and interrupt their planned development goals and policies.
- On the other hand, disaster management, especially disaster recovery, may also provide opportunities for policymakers and community leaders to reconsider their policy priorities and use valuable resources for the consideration of sustainable economic development.

- The relationship between disaster and development is a dynamic one and its implications, positive or negative ones, depends on the unique social and cultural make up of local communities and the managerial capacity of their disaster and development.
- **Unlike disaster** responses, ***development*** tends to be "***forward-focused***", reaching for the attainment of long-term goals and set on advancing the economic and social environment.

(Fordham, 2006)

- The relationship between disaster and development is important from the perspective of sustainable development.

- ***Unsustainable development strategies*** are key reasons for ***increased cost of disasters*** (FEMA, 2000).

- The idea of integrating disaster and development to understand their relationship is relatively new (just after 1980s).
- The interdependent (and blurred) relationship between disasters and development is extremely complex and requires new strategies to address both.

(UNISDR, 2013)

- Disaster recovery efforts should include sustainable development perspectives with an aim of vulnerability reduction.

(Bankoff et al., 2004; McEntire, 2004)

Disaster Recovery and Sustainable Development

- Disasters can be seen as a "window of opportunity" for development and well-planned development can certainly reduce impacts of disasters.
- Laura Reese (2006) claims that many of the lessons of disaster response and recovery can be applied to economic recovery as well.
- The important characteristics for an effective disaster recovery and redevelopment, include ***commitment, cooperation, creativity, inclusivity,*** and ***flexibility***.