Watershed Management –

To address Climate Change Issues

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Introduction to climate change?

- Climate change is real and it is not a variability not caused naturally by earth but by the human activity primarily due to the burning of fossil fuels like Coal, Oil and Gas producing Greenhouse gases.

Source: 1.What is climate change? United Nations

Where do greenhouse gas emissions come from?

The world emits around 50 billion tons of greenhouse gases each year

Global greenhouse gas emissions source: -

- **73.2 %** from Energy (electricity, heat and transport)
- **18.4 %** from Agriculture, Forestry and Land Use
- **5.2 %** from Direct Industrial Processes
- **3.2 %** from Waste

- **High Carbon energy source (84%)**
  - Coal: 27.6%
  - Oil: 31.6%
  - Gas: 25%
- **Low carbon energy source (16%): -**
  - Nuclear: 4.4%
  - Hydropower: 7%
  - Wind: 2.6%
  - Solar: 1.4%
  - Other renewables: 0.5%

More than 60 % of total Greenhouse gas is from fossil fuel energy only.

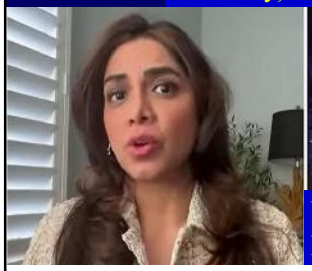
Source: Our World in Data, by Hannah Ritchie and Max Roser

What is happening in the Climate change?

- With rise of temperature, atmosphere will hold more water vapor therefore there will be more intense rain.
- As temperature raises it becomes more likely that precipitation falls as rain rather than snow.
- Warmer atmosphere causes earlier snow melt keeping the mountain dry.
- Warmer atmosphere will suck out moisture from the ground through evaporation and evapo-transpiration processes leaving the drier soil therefore causing more water scarcity.
- Warmer atmosphere can hold more moisture causing more convection, therefore there will be more thunderstorm and more tropical cyclones.

Issues

Leaders from most polluting countries (US, China, France, Germany) did not participate the COP 29 summit at Baku



US First Most Polluting Nation Withdraw from Paris Climate Accord

Indicate Lack of Commitment by Most Polluting Nations

- As a rule of thumb, polluters must pay.
- This is one of the key issues yet to be addressed.

Issues

- Energy being the key factor for development, instead of deemphasizing energy production from fossil fuels most of polluting countries are geared to produce more energy using **fossils fuels** to fulfill their evergrowing energy needs.
- Different low carbon energy sources mainly solar and wind have been under consideration but this has not been able to replace high carbon energy sources that is from coal, oil and gas.
- Reducing carbon emission has not been successfully adopted therefore, worse days are still ahead!

Issues

- "Loss and Damage" fund established by COP 27 is a strategy to provide financial and technical assistance for the **real losses** incurred due to climate change to the communities, countries, and ecosystems of economically developing nations.
- For the economical reasons in the developing countries peoples have settled in flood plains, coastal low-lying areas, and steep slopes, which will be the hardest hit areas by the adverse impacts of climate change.
- In the lack of data, hazard mapping and policy restricting living in hazard areas, assessment of **increased damage** due to climate change would be more challenging task for utilization of "Loss and Damage Fund".

Implications of Climate Change for Nepal

- Although Nepal contributes only 0.027% to the global production of greenhouse gases[1] to climate change, but faces sever impacts as there is **no border for the impact of climate change.**
- Nepal will observe **Four Major impacts** of climate changes: -
  1. Impact of Rise of temperature
  - Impact of Erratic rainfall causing
  2. Too much rain,
  3. Too little rain; and
  4. Shifting of the rainfall period

1. Nepal First NDC.pdf

Impact of Temperature Rise

- Extreme heat caused living unbearable making heat strokes a common incidence.
- Making the living tolerable will demand more water and energy for cooling and drinking.
- Extreme heat making the land and vegetation dry, so the area will be subject to more wild fires.
- Increase temperature will melt snow more quickly **drying mountain water towers.**
- Rise in temperature will also bring changes in forest composition and shifting of the vegetation zones including crops and cropping patterns.

Impacts of Temperature Rise in Agriculture

- Growing the same crop will demand more water due to more evapotranspiration.
- Analysis carried out on crop water requirement for maize, wheat and rice for Terai (Nepalganj), Mountain (Jumla); and Hills (Kathmandu and Pokhara) indicates that crop water requirement will be increased by: -
  - 3% for maize,
  - 4% for wheat and
  - 5% for rice for **every Celsius degree rise in temperature.**
- Management of more water for agriculture will be the key challenge for the country.

If the temperature exceeds Absolute Maximum temperature the Crop Production will be adversely affected.

Month	Maximum Temperature (°C) (1990-2020)			
	Nepalganj	Jumla	Pokhara	Kathmandu
January	20	14	20	19.4
February	26	16	23	22.2
March	31	19	27	26.1
April	37	22	30	28.3
May	38	24	31	29.4
June	37	26	31	29.4
July	34	25	31	28.9
August	33	25	31	28.9
September	33	25	30	28.3
October	32	22	28	27.2
November	28	19	24	23.3
December	23	17	21	20.0
Year	31	21	27	26.1

Source: https://www.climatestotravel.com/climate/nepal

Species	Absolute Max. °C
Rice	36
Wheat	27
Potato	30
Millet	45
Barley	40
Buch Wheat	40
Maize	47

Rice production will be affected in Nepalganj (Terai Region)

Wheat production will be affected except Jumla (Mountain Region)

Potato will be affected in Nepalganj, Pokhara (Terai and Valley Regions)

http://ecocrop.fao.org/ecocrop/srv/en/cropFindForm

Impact of Erratic Rainfall

- **Too much rain** in terms of total quantity and high rainfall intensity disturbs the water cycle specifically causing landslide and flood;
- **Too little rain** caused water scarcity: -
  - For plant growth and cultivation,
  - For generating the runoff feeding the river system keeping the river dry
  - For supplying water serving the population creating difficult livelihood and
  - Results Extreme dryness of land and vegetation triggering the wildfire;
- **Shifting of the seasonal rainfall period** affects crop cultivation period and its production compared to prevailing cultivation practices.

Impact of Erratic Rainfall

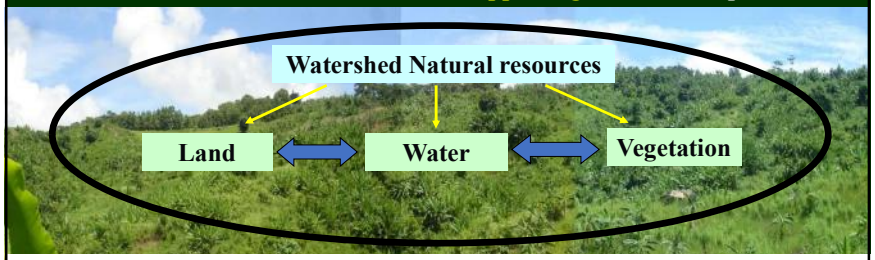
- Soil erosion, landslides, floods and fires **due to erratic rain** will have a **negative impact on the land's productive capacity** degrading the agriculture production, quality of water and vegetation.
- **Degraded environmental conditions** will suppress the growth of the natural vegetation **allowing weeds to grow** degrading the forests' biodiversity.
- **Sedimentation of the wetlands and polluting water** reduce the **functionality of the wetlands to regulate the water** in the river system and **degrades the habitat of the water plants and animals** especially migratory birds.

In summary climate change

- Degrade the quality of natural resources such as land, water and vegetation, which are the basis for livelihood.
- Therefore, **mitigation, rehabilitation and adaptation strategies** to address the degradation of the natural resources mainly land, water and vegetation caused by climate change became the utmost priority for the betterment of livelihood.
- That means **Watershed Management need to be emphasized!**

Watershed Management is the

Nature's Law based Holistic Management of the Land, Water and Vegetation Considering the Watershed as a working unit for getting optimal benefits from these resources supporting livelihood improvement.



How the Land, Water and Vegetation resources are used has Interlinked impact on production, water availability and water induced disasters Affecting Livelihood

- **Watershed management** focuses on
  - **Rational management of land use** in fulfilling human basic needs
  - Proper Management of water resources received as rain and snow through its collection, conservation and utilization in
    - Fulfilling human needs and
    - Reducing the water induced disasters such as landslides, flood and drought.
- Therefore, **Watershed Management became** most important to address the impact of climate change.

Watershed Management

- **Different conservation activities are implemented**
  - To protect land from erosion and slope failure,
  - To drain water safely
  - To make water seep into the ground making water available in the rivers and springs for human use

Watershed Management

Climate Change Mitigation Strategy will be three folds

- **First,** ***Reduce the production of greenhouse gases***, which is the main cause of the climate change;
- **Second,** ***Manage the greenhouse gases*** produced due to natural and human activities, and
- **Third,** ***Address the impact of climate change as an adaptation strategy*** for sustainable management of natural resources.

Reducing Production of Greenhouse Gases includes

- ***Protect naturally found carbon sinks*** such as forests, permafrost, lakes and wetlands, where significant carbons were sequestrated.
- **Manage the other sectors** such as agriculture, forestry, pasture and land use properly so that production of greenhouse gases would be reduced. This includes activities such as: -
  - Proper land use,
  - Promotion of compost in agriculture,
  - Degraded land rehabilitation,
  - Proper use of inorganic fertilizer,
  - Management of animal waste through bio-gas production, etc.
- ***Promotion of*** the ***low carbon energy generation*** such as hydro-power, solar and wind.

Hydro-power: Plays key to role in reducing GHG Production as it contribute only 7% of GHG compare to 84% from fossil fuel.

- Nepal has a **great potential role** in producing **low carbon source energy** contributing to reducing the greenhouse gases production as a mitigating measure to climate change.
- However, due to **Watershed degradation** the economical potential of Hydro-power projects is greatly endangered by the sedimentation problem.
- Sedimentation in the Kulekhani reservoir represents a good example

19-20 July 1993, Kulekhani watershed observed 535 mm of rain in 24 hours. Deposited 5.19 million cu. m. of sediment in the reservoir.

Sedimentation survey indicated that in 17 years (1979 to 1995) the life span of the reservoir is reduced to half from 50 Years disrupting the Economy of Hydro-power

1993 disastrous rainfall in the Kulekhani watershed

Stream bank erosion and **landslide** were the major source for sediment

Disastrous rainfall affect very less in Properly Conserved Borrow Peat

Proved conservation measures can greatly reduce the impact of disastrous rain.

2009

Sediment is the Key Problem in Hydro-power Generation in Nepal -

- Watershed management is the key measures to reduce sediment in the rivers and reservoirs, therefore
- Government must adopt a policy making Watershed Management as an integral part of all water resource projects such as hydro-power, irrigation, drinking water, etc.
- **Planning and implementation of watershed management** should be geared to the **science-based package treatment** rather than incomplete haphazard planning and implementation guided by irrational top-down administration.
- **This has been a Key problem of today's planning and implementation!**

Managing Greenhouse Gases includes: -

- Carbon sequestration on the plants, soils, woods and wetlands and lakes.
- This includes the Activities such as: -
  - Forest management maintaining **healthy forests** storing carbon dioxide in the forest with multi storey mixed forest composition;
  - Managing organic matter in the forest soil by allowing the undergrowth, protecting forests from fires, etc.;
  - Promoting wood in the furniture industries and development infrastructures, and
  - Protecting the lakes/reservoirs and wetlands for carbon sequestration

Addressing the Impacts of Climate Change

1. **Too much rain** in terms of total quantity and high intensity rain causing erosion specifically landslide and flood;
2. **Too little rain** not sufficient to moisten the soil for plant growth and generate runoff to feed the river system; and
3. **Shifting of the rainfall period** affecting the prevailing cultivation practices.

Monsoon Rainfall Pattern

June to September	October to May
80% Annual Rainfall	20% of Annual Rainfall
Too Much Period	**Too Little Period**
Flood and Landslide	**Drought and Fires**

- Every part of the country suffers from consequences of **too much** and **too little** rain.
- With **climate change these consequences** of too much and too little rain will be more serious.

Addressing the Impacts of Climate Change

- **Controlling the rainfall** is beyond human capacity,
- What we can do is **management of the water falling on the ground** (rain/snow) **to reduce the impacts caused by "Too much" and "Too little" rain** through different watershed management activities.
- This includes **harvesting**, **conservation**, **storage** and **optimal utilization** of the available water, which are the key components of watershed management.

Shifting of the Rainfall

- Shifting of Rainfall Period makes either
  - Too much if it rains when not expected

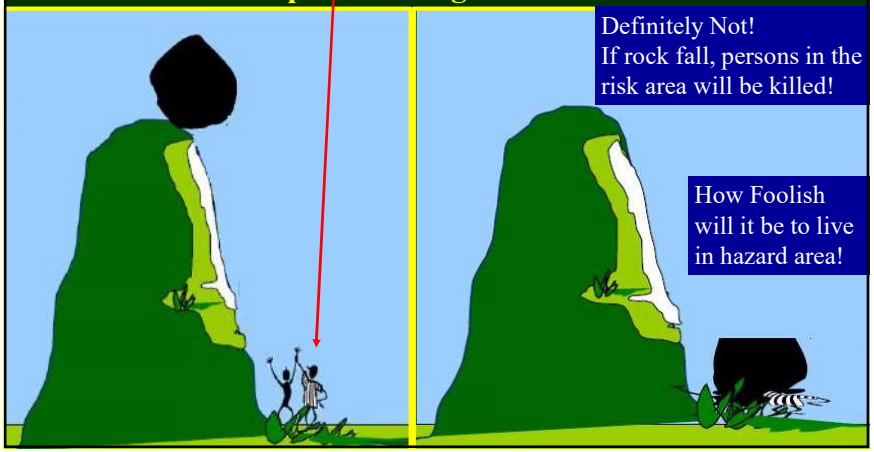
    Or
  - Too little when it does not rain when expected.
- This creates the situation of **too much** or **too little** compared to the prevailing rainfall pattern.
- The mitigation measures for shifting of the rainfall period will be same as the activities to address **too much** and **too little** scenarios.

Adaptation to Climate Change Impacts

Two key adaptation strategies to address the impact of climate change are: -

- Hazard mapping and avoiding to face the danger, and
- Holistic management of water through watershed management

Should the People be Living below Such Risk Zone!



Hazard Mapping

- **Prevention is better than cure!**
- So, **identification** of the vulnerable areas to water induced disasters and **avoid living and restricting construction** in such areas can save life and property from such disasters.
- So, preparation of **hazard maps** indicating areas highly vulnerable to **flood**, **landslide**, **GLOF** (Glacial Outburst Flood) and **drought** and **restricting construction of habitation and infrastructures** will be a **crucial adaptation strategy** to the climate change.
- This should be the responsibility of the government to restrict the people **Where to Live** and **Where not to Live**!

Unfortunately, so far government had failed to address this adequately!

Probability of High Intense Rain Covering Whole Area of the Watershed is Rare !

Table 2. Rainfall Record, Kathmandu Valley (Pradeep Shrestha, Facebook)

Station	Rainfall in mm. (28 Sept. 2024)
Panipokhari	206.6
Airport	239.7
Budhanilkantha	178.3
Jitpur phedi	178.3
Nagarjun	205.4
Godavari	311.6
Khumaltar	294.4
Tikathali	264
Khokana	297.3
Chapagaun	323.5
Nankhel	194.5

But if it happened Flood is Obvious!!! 28 September 2024-Kathmandu

This is **Flood Hazard Area!** No construction must be allowed here!!

Holistic Management of Water

- **Holistic management of total available water** for different sectors of livelihood against all **climatic uncertainties** would be a key adaptation strategy to address the impacts of climate change.
- It is basically through harvesting, storing, conservation and optimal utilization of available water in the form of rain, snow and moisture.
- **What is needed to do is: -**
  - **First Identify and delineate all interlinked areas as a functional management unit,** where all available water could be harvested, stored, conserved, and utilized.
  - **Watershed or a community could be such unit for harvesting, storing and conservation of the water. But in term of utilization, it could be a cross watershed or village as well.**

Holistic Management of Water

- **What Next after the identification of functional unit? : -**
  - Within such a functional unit, Prepare a complete watershed management Plan to address the different impacts of climate change.
  - Prepare action plan and budget in coordination and partnership with the local government to implement.
  - Implementation of such plan would be a crucial part to address the impacts of climate change.

Holistic Management of Water

- This involves **First** Estimation of
  - Total water available in terms of rain, snow and moisture
  - Total potential runoff,
  - Total water potential to harvest in ponds, reservoirs, and Tanks
  - Total water potential to recharge into the ground.
- **Second is to** Estimate of total water needs for Agriculture, Drinking and household use, Environment, Industries and Recreation.
- **Lastly,** Water distribution creating balance between supply and demand would be a key to the successful management of available water as an adaptation strategy to climate change.

This aspect so far has not been considered well in planning.

Institutional Need

- Holistic Management of Key Natural Resources: Land, Water and Vegetation is a more complex and challenging task and demand fully capacitated functioning **multi-disciplinary Institutions** at all levels of Government with well defined functional linkage.
- Constitution of the country, 2072 endowed the watershed management to the local government.
- However, the government has been weak to arrange institutional setup and provide financial and technical support required for the local government to administer the watershed management at the local level.

What is there for Watershed Management?

- Currently, there is an institutional set up to address the watershed management at the
  - Central and Provincial level
  - But functioning more or less independently without a functional relationship in between and more so with the local government, undermining the constitutional spirit of the country.
  - Soil and Watershed Management Office : Koshi: 2, Madesh: 4, **Bagmati: 7,** Gandaki: 2, Lumbini: 4, Karnali: 2, Sudur Pashchim: 3
- Current organization assigned for the implementation of the watershed management program **lacks multidisciplinary staffing**, and **its institutional capacity and status** is **not compatible to the importance demanded by the sector**.
- This is more so to implement the watershed management, **addressing the impact of climate change**.

What is needed?

- **Strong multidisciplinary organization** with properly defined roles and responsibilities and **functional relationships** at all levels of government
- **Strengthening capacity of the local government** to implement watershed management as per the constitution **became utmost essential.**
- Watershed management activities addressing the impact of climate change need to be surveyed, designed and implemented as a holistic package, which needs multidisciplinary knowledge and inputs.
- Generally, sectoral disciplinary educated staff lacks knowledge and skill in the holistic management of the watershed; therefore, the professionals working in the watershed management demand a strong capacity development program.

Watershed Management is Nothing But!

Putting the conservation cap throughout the watershed area!!
Following the management principle: Start where rain hit first!!!

Watershed Management Activities suggested to be carried out to address the different types of impact from Climate and Climate change

Reducing Production of Greenhouse Gases	
Promotion of Low carbon energy Generation	Promotion of Low carbon energy generation: - • Hydro-power, • Solar • Wind
Protection of Carbon Sinks	Protection of Carbon Sinks • Forests, • Permafrost, • Lakes and • Wetlands
Management of agriculture, forestry and pasture lands	• Proper land use such as pasture and grazing land management, • Compost making and promotion of compost in the agriculture fields, • Degraded land rehabilitation, • Conservation plantation, • Silvi-pasture management • Hay making, • System of rice intensification, • Promotion of proper use of inorganic fertilizer, • Management of animal waste through bio-gas production,

Managing Greenhouse Gases (Carbon Sequestration)	
In plants	• Maintaining a Healthy Forest (through Managing Multi Storey Mixed Forest storing carbon dioxide in the plants.
Soils	• Sustainable soil management (Maintaining organic matter in the forest soil through forest management growing allowing the undergrowth) • Protecting forests from fires, etc.
Wood	• Promotion of wood in the furniture industries and development infrastructures
Wetlands and Lakes	• Wetland conservation / Management • Protecting the lakes/reservoirs and wetlands for carbon sequestration

Addressing the Impacts of Climate Change		
Too much rain	Splash / Sheet Erosion	Barren degraded lands • Degraded land rehabilitation • Conservation Plantation (Eye brow pit, Contour Trench, Hill side ditch/bund, Hill side contour bench) • Silvi-pasture management • Fodder/Grass planting Agriculture Lands • Fruit tree plantation, • SALT/On-farm Conservation • Conservation farming • Agro-forestry development • Cover crop • Multiple cropping
	Gully erosion	Gully Treatment

Addressing the Impacts of Climate Change

Too much Rain	**Landslide**	• Landslide inventory and documentation, • Landslide Hazard mapping, • Landslide treatment, • Torrent control • Landslide early warning system
	Development Infrastructure Protection	• Trail improvement, • Road slope stabilization,
	Water Management	• Conservation pond / reservoir • Roof water harvesting • Ground water recharge structure construction (pits/trench/well /pond/ reservoir) • Diversion channel • Drainage Management • Irrigation channel improvement

Addressing the Impacts of Climate Change

Too much rain	**Flood**	• River/Stream bank protection structures • River bed plantation / River Bed Farming/Upliftment • Run-off harvesting structure (dam) construction • Sedimentation / Siltation management • Ground water recharge structure construction • Green belt/Shelterbelt development • Buffer strip development • Drainage management • Dredging • Flood Bypass canal • Flood detention dam / pond • Flood Hazard Mapping • Flood early warning

Addressing the Impacts of Climate Change

Too Little Rain (Water Scarcity)	**Water scarcity for agriculture**	• Irrigation channel improvement • Conservation pond/reservoir • Dry land farming (Rainfed farming / Drought resistance crop / Crop demanding less water / Moisture conservation farming techniques) • Mulching (Organic, Inorganic including plastic covering) • Conservation irrigation • Sub-surface water harvesting • System of rice /wheat intensification • Run-off harvesting dam construction
	Water scarcity for household use	• Water source identification • Water source protection / Springshed Management • Roof water harvesting • Catchment restoration • Ground water recharge structure construction (pits/trench/well/ pond/reservoir) in the catchment • Cross catchment water supply scheme