Consultative workshop on

“Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin”, Nepal, 10th Jan 2013

Organized by

Nepal Development Research Institute

Supported by

Climate and Development Knowledge Network

Global Change System for Analysis, Research and Training

A consultative workshop on "Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal' with support from CDKN and START was organized on 10th January, 2013 at Hotel Himalaya in Kathmandu, Nepal. A one day workshop was aimed at bringing together the eminent personnel from governmental administration, non-governmental organizations, academia, researchers and donor agencies to discuss on the ongoing project and more precisely, the workshop was intended in assembling some stimulating suggestions and opinions. The outcomes of the workshop are documented in this report. The ideas generated in the workshop were anticipated for further enhancement of the ongoing research and also to help develop strategies for the future.

The workshop was structured into three sessions and is as follows:

A. Inaugural Session

Dr. Rijan Bhakta Kayastha, the Co- Investigator of the project commenced the programme with his outstanding inaugural speech highlighting the importance of research related to Koshi High Dam Project.

He further expressed the significance of snow and glacier research in the region to gain knowledge about its state, distribution, process as water storage and problems resulting from changes in cryosphere and runoff. He also expected the best use from the outcomes of the ongoing research by the policy makers at the end.

Dr. Laxmi Prasad Devkota, the Principal Investigator of the project highlighted the different aspects of the project. He mainly focused on the objectives of the research to assess the impact of the climate variability and change through modeling approach. He further explained the following objectives, listed as follows:

- Advancing knowledge on climate change impact on water resources
- Revisiting the design standard / values of the infrastructure the proposed Koshi High Dam
- Assessment of Socio-economic Vulnerability and Exposure of critical infrastructures
- Contributing to policy formulation process on climate resilient development
- Awareness building to stakeholders including local communities and Training of new generation

He then explained the integration of the modeling part as an input to assess the socio-economic vulnerability of the local people with respect to the recurrent flood disasters in the study area. He further elaborated about the project sites and the methodologies to be adopted, expected impacts and outputs of this project and the significance of the project in climate disaster mitigation and adaptation.

Additionally, he highlighted the importance of this research in aiding the national policy process in disaster risk reduction and climate change adaptation.

Ram Chandra Khanal, a CDKN representative to Nepal, further emphasized on CDKN and its working areas like DDR, Climate Financing, and Climate Navigation.

He extended his positive thoughts on the objectives of the CDKN project, highlighting on the past and present vulnerability assessment carried out by the government and different organizations on different parts of the country. He is also sure about that CDKN playing major role in enhancing the science and research.

Yuba Raj Bhusal, a member secretary of National Planning Committee, and the Chief Guest of the programme, congratulated NDRI for being representative of CDKN project on Koshi Basin. He congratulated NDRI for involving students in such research programmes and commended on NDRI efforts for conducting the research on Koshi high dam projects despite of many political, social, environmental and technical issues in the area. He further expressed that despite the climate change ramification on Himalayas and water volume on long term, maximum benefits through research on different perspective (hydrological, climatological, environmental, forestry etc) should be reaped. He suggested focusing on different water conflicts, trans-boundary policies to mitigate water issues in the Koshi Basin. He was sure that this project will help people adapt to the existing situation emphasizing on the institutionalization, policy adjustment and formulation. He even assured that CDKN project results will definitely be incorporated in policy and adjusted in National Planning. He wished success to NDRI and to come out with concrete results in future at the end of the programme and also expected the result to be beneficial especially for vulnerable people residing in the area.

Dr. Jay Kumar Gurung, a member secretary of NDRI, gave his vote of thanks on behalf of NDRI to all those guests for sparing their time despite their busy schedule on this closing speech of the first session. Additionally he elaborated on the newness in researches through this project. He was sure that there are myriad of problems to be handled carefully, different constricting technicalities to be addressed in this ambitious project. But he was sure by minimizing such uncertainties that this project will take a solid form coordinating with experts and government explicitly.

B. Presentation Session

Presentations were held on Climate Data and Model, Snowmelt Runoff Model, Hydrologic and Hydrological Modeling, Socio-economic vulnerability assessment and Policy and Strategy emphasizing the methodologies being followed and also with slight sharing of the results being achieved. Different questions were raised on the validity of models, methodological challenges and suggestions were given on the different matters for holistic assessment of Koshi River Basin. Mainly questions were raised on vulnerability assessment and identification of indicators. The key highlights of presentation on each subject matter are shown in Annex and the themes are assembled as follows:

Theme 1: Climate Data and Model

Theme 2: Snowmelt Runoff Model

Theme 3: Hydrologic and Hydrological Model

Theme 4: Socio-economic vulnerability assessment

Theme 5: Policy and Strategy

C. Group Discussion Session

A total of 34 participants from government, non-government, international agencies, academic institutions and concerned stakeholders attended the workshop. In order to collect some bolstering ideas and suggestion, the professionals were grouped into two themes viz. technical and socio-economic vulnerability assessment group which was facilitated by Dr. Laxmi Prasad Devkota, PI of the Project. The major points for discussion are grouped as follows:

Technical Group

- What design standard should be prioritized?
- What model/scenario should be used? How to handle difference from one model to another?
- How to handle snow covered area for future scenarios?
- How to handle land use changes in the future scenarios?
- Cases and locations of dam breaks and embankment breaching?

Socio-economic vulnerability assessment group

- What are the major vulnerability indicators to be assessed?
- What are the major variables to be considered for risk assessment (population, agriculture, major infrastructures)?
- Is weight identification for considered factors for the vulnerability assessment appropriate?
- Survey technique, sampling, site selection, sample size
- Number of focus group discussion and key informant interview (more/less/enough)
- Is the selection of indicators for the research suitable?

Policy and strategies group

- How to connect this research with national policy?
- How awareness building of stakeholders including local communities and training of new generation be made more effective?
- What are the policy questions that should be prioritized?

Outcomes of the discussion

Intensive discussion was made by the participants within each group and a short presentation was then given from the two groups. Mr. Tirtha Adhikari presented the feedbacks from technical thematic group depicting some technical possibilities for the betterment of the current research and the major points are listed as follows:

a. Design Standards:

- % change in peak flows due to climate change needs to be assessed, which governs the design standards of the Proposed Dam.
- Due to the higher return period (10000 years) considered for very important structures such as the high dam (reported 30000 cumecs), climate change effect might be nominal towards the design standard of the dam. However for the sediment, the issue needs to be handled.
- Sediment load will increase due to the melting of the permafrost zone due to the climate change.

b. Models/Scenarios to be used:

- Sediment load will increase due to the melting of the permafrost zone due to the climate change.
- For hydrological modeling, HBV light should be used for the comparison with the SRM model output.

c. Handling of snow cover area for future:

- Existing snow cover area change, trend analysis considering projected temperature and precipitation.

d. Handling of land use data:

- If past and current land use change with population and development activities trend can be considered, it would be better.

e. Cases and location of dam breaks and embankment breaching:

- Contour maps should be analyzed.
- Existing embankment level needs to be considered.
- Excess sediment load
- Identification of the sediment deposition and scouring area within the river reaches.

Mr. Kesav Adhikari presented the feedback from the socio-economic vulnerability assessment and policy and strategy thematic group and the points are breakdown as follows:

a. Site Selection:

- Do not need to consider embankment if the research focuses on high dam rather should focus on high dam fail scenario.
- Real vulnerable size should be determined.
- May also focus on frequency of flood, Intensity of flood and duration of flood.

b. Sample Size:

- Sample size should be numerically quantified.
- Vulnerability area and numbers should be determined.
- Number of KII should be increased. Interview from stakeholders in order to know historical trend of flood risk, loss and damage scenario.

c. Weight identification for proposed indicators:

- For weight identification priorities should be given to household survey (Pair wise comparison)
- Household survey, stakeholders and implementing partners would be the main actor or concern people for weight identification.
- Need to review Vulnerability indicators of neighboring countries i.e. South Asian countries.
- Flood damage reduction data might predict from the data prepared by India/Bihar.

d. Objective function:

- Dam height.
- How we use the water
- Inland navigation

e. Policy and strategy feedback:

- Consideration of upstream dams
- Flood Proofing and Climate resilient building code
- Glacier adaptation measure
- Water Induce Protection policies
- Training and awareness before implement ‘LAPA’

Agenda of Workshop

Consultative Workshop On
Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin
Organized by
Nepal Development Research Institute
Date: 22 February Venue: Hotel Himalaya, Kupondle

Inaugural Session

Time	Activities
10: 00- 10:10	Calling upon Dias
10: 10: -10: 15	Welcome speech by Dr. Rijan B. Kayastha, CI:NDRI-CDKN/START Study Team
10: 15- 10: 45	Highlights of the Research Project: Dr. Laxmi Devkota/ PI:NDRI-CDKN/START Study Team
10:45-10:55	Remarks by Mr. Ram Chandra Khanal/ CDKN Representative for Nepal
10:55-11:10	Remarks by Chief Guest: Mr. Yuba Raj Bhusal, Member-Secretary, National Planning Commission
11:10-11:15	Vote of Thanks and closing Remarks by Chair: Dr. Jaya Kumar Gurung, Secretary, NDRI

11:15-11:35 Tea/Coffee Break
11:35- 11:45 Group Photo

Feedback/Consultation Session

Moderator: Dr. Laxmi Devkota/PI NDRI-CDKN/START Study Team

Time	Activities
11:45-12:00	Theme1: Climate Data: Mr. Dhiraj Gyawali/RA - CDKN/START Study Team
12:00- 12:15	Theme2: Snow Runoff Modeling: Ms Anita Khadka/RA: NDRI-CDKN/START Study Team
12:15-12:30	Theme3: Hydrological and Hydraulic Modeling: Mr. DibeshShrestha/RA:NDRI-CDKN/START Study Team
12:30-12:45	Theme4: Socio-economic Vulnerability: Dr. Manjeshori Singh/CI : NDRI-CDKN/START Study Team
12:45-12:55	Theme5: Climate Change Adaptation Strategies: Dr. Sunil B. Shrestha/ CI : NDRI-CDKN/START Study Team
12:55-13:05	Thematic group formation and selection of thematic leader for each group
13:05-13:50	Group discussion

13:50-14:50 Lunch

14:50-15:40	Presentations from each thematic group
15:40-16:00	Response to the issues/Closing of the workshop by the moderator

Participants

Government agencies			
S.N.	**Name**	**Institution**	**Position**
1	Ashish B. Khanal	DOI	SDE
2	BisheshworKoirala	DDC	SSM
3	Gauri S. Bassi	DWIDP	DDG
4	KapilGnawali	DHM	Hydrologist DHM
5	Keshav D. Adhikari	DOED	S.E
6	MurariNiraula	NPC	Planning officer
7	RabinathBabuShrestha	DWIDP	SDC
8	SujanSubedi	MoSTE	Meteorologist
9	Suresh Chand Pradhan	DHM	Hydrologist
10	Yuba Raj Bhusal	NPC	Member Secretary

Non-government agencies			
S.N.	**Name**	**Institution**	**Position**
11	Anil Pokhrel	World Bank	DRM Specialist
12	ArunBhaktaShrestha	ICIMOD	Project Manager
13	BimalaDevkota	NCCKMC/ NAST	Senior S. Officer
14	Jagat K. Bhusal	SOHAM	Chairman
15	Ram Chandra Khanal	CDKN	NCC
16	Ram ManoharShrestha	AIT	
17	Ramesh AnandaVaidya	ICIMOD	Senior Advisor/IWHM
18	BasuDevPandey	NDRI	President
19	Jaya K. Gurung	NDRI	Secretary
20	LaxmiDevkota	NDRI	Senior Researcher
21	RupaBhandari	NDRI	Finance Officer
22	Sunil BabuShrestha	NDRI	Co-Investigator
23	ManjeshworiSIngh	NDRI	Treasurer
24	Dhiraj Raj Gyawali	NDRI	Research Associate
25	Anita Khadka	NDRI	Research Associate

Academia			
S.N.	**Name**	**Institution**	**Position**
26	Gunjan Silwal	CDES	Student
27	Jeevan Chhetri	CAS	Student
28	Jiban M. Poudel	CDSA	Lecturer
29	Rajesh Sada	NEC	Research Coordinator
30	Rekha Uprety	CDSA	Student
31	Rijan Bhakta Kayastha	KU	Asst. Prof.
32	Surya Naryan Shrestha	IOE	Student
33	Susmita Dhakal	CDES	Lecturer
34	Tirta R. Adhikari	CDHM	Lecturer

Socio-economic vulnerability assessment Team		
S.N.	**Name**	**Organization**
1	Bimala Devkota	NAST
2	Bisheshwor Koirala	DDC
3	Jeevan Chhetri	CAS
4	Keshab Dhoj Adhikari	DOED
5	Manjeshwori Singh	NDRI
6	Murari Niraula	NPC
7	Ram Manohar Shrestha	AIT
8	Rekha Uprety	CDSA
9	Sunil Babu Shreshta	NDRI
10	Susmita Dhakal	CDES

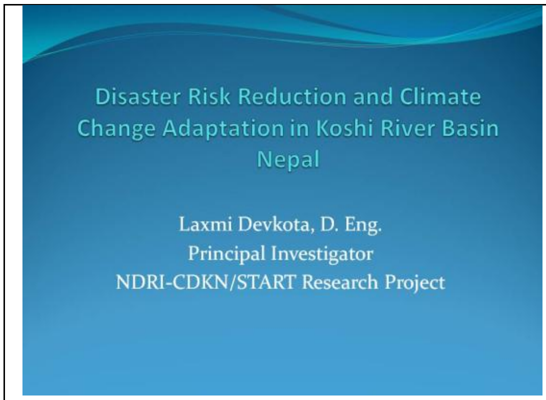
Technical Team		
S.N.	**Name**	**Organization**
1	Anita Khadka	NDRI
2	Dhiraj Raj Gywali	NDRI
3	Gunjan Silwal	CDES
4	Jagat K. Bhusal	SOHAM
5	Kapil Gnawali	DHM
6	Rabinath Babu Shrestha	SDE/DWIDP
7	Ram Chandra Khanal	CDKN
8	Rijan B. Kayastha	KU
9	Suresh C. Pradhan	DHM
10	Surya Naryan Shrestha	IOE
11	Tirtha Raj Adhikari	CDHM

NDRI-CDKN/START Study Team		
S.N	Name	Position
1	Dr. Laxmi Devkota	Principal Investigator
2	Dr. Manjeshwori Singh	Co-Investigator
3	Dr. Sunil Babu Shrestha	Co-Investigator
4	Dr. Rijan Bhakta Kayastha	Co-Investigator
5	Dibesh Shrestha	Research Associate
6	Dhiraj Gyawali	Research Associate
7	Anita Khadka	Research Associate

Glimpses of the workshop

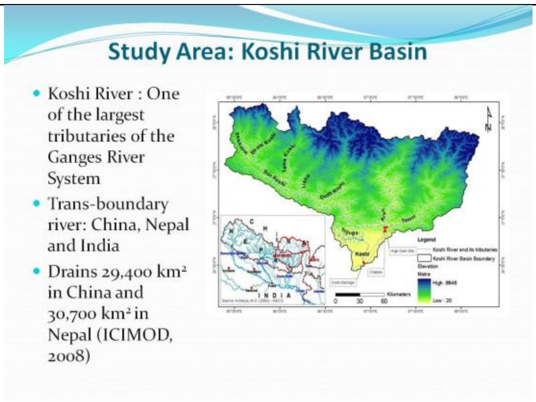
Annexure:

Annex I: Introductory presentation by Dr. Laxmi Prasad Devkota, the Principle Investigator of the project



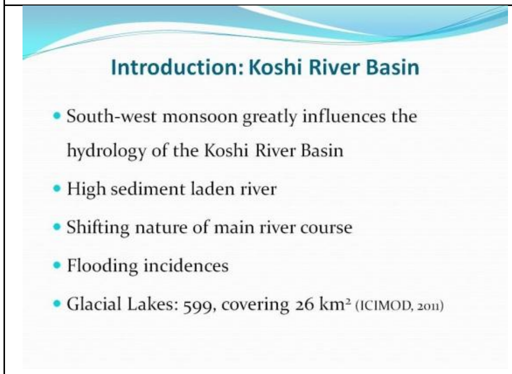
Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin Nepal

Laxmi Devkota, D. Eng.
Principal Investigator
NDRI-CDKN/START Research Project



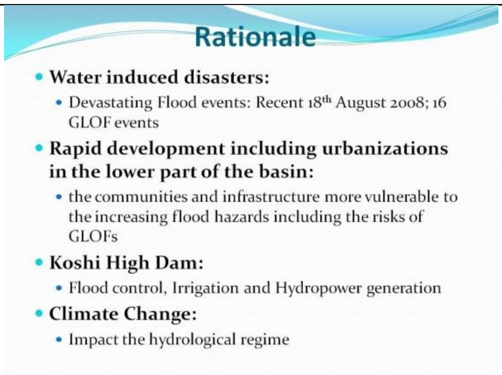
Study Area: Koshi River Basin

- Koshi River : One of the largest tributaries of the Ganges River System
- Trans-boundary river: China, Nepal and India
- Drains 29,400 km² in China and 30,700 km² in Nepal (ICIMOD, 2008)



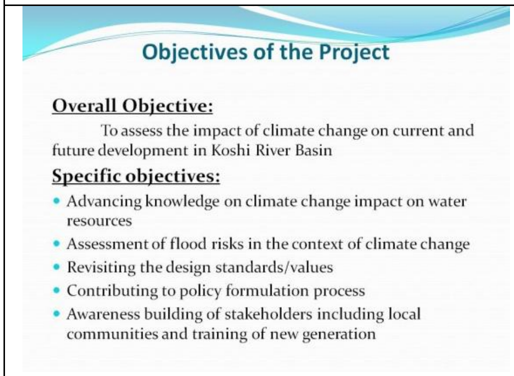
Introduction: Koshi River Basin

- South-west monsoon greatly influences the hydrology of the Koshi River Basin
- High sediment laden river
- Shifting nature of main river course
- Flooding incidences
- Glacial Lakes: 599, covering 26 km² (ICIMOD, 2011)



Rationale

- **Water induced disasters:**
  - Devastating Flood events: Recent 18th August 2008; 16 GLOF events
- **Rapid development including urbanizations in the lower part of the basin:**
  - the communities and infrastructure more vulnerable to the increasing flood hazards including the risks of GLOFs
- **Koshi High Dam:**
  - Flood control, Irrigation and Hydropower generation
- **Climate Change:**
  - Impact the hydrological regime



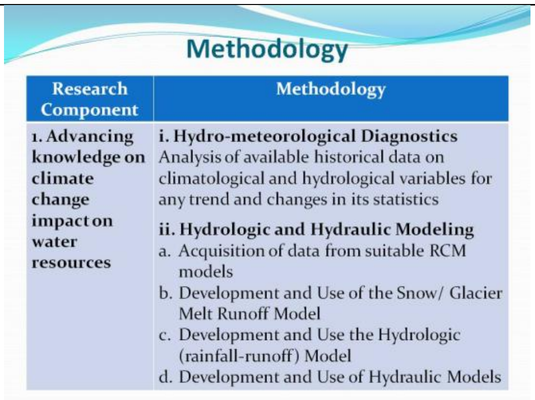
Objectives of the Project

Overall Objective:

To assess the impact of climate change on current and future development in Koshi River Basin

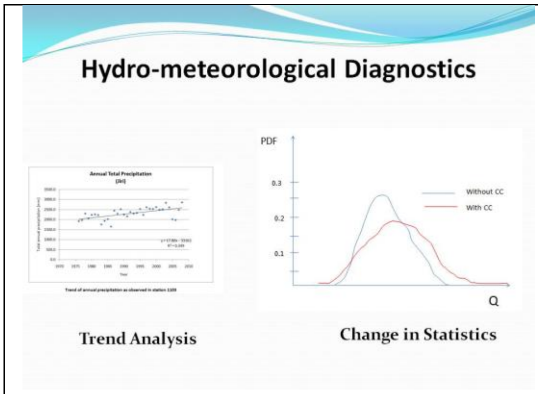
Specific objectives:

- Advancing knowledge on climate change impact on water resources
- Assessment of flood risks in the context of climate change
- Revisiting the design standards/values
- Contributing to policy formulation process
- Awareness building of stakeholders including local communities and training of new generation



Methodology

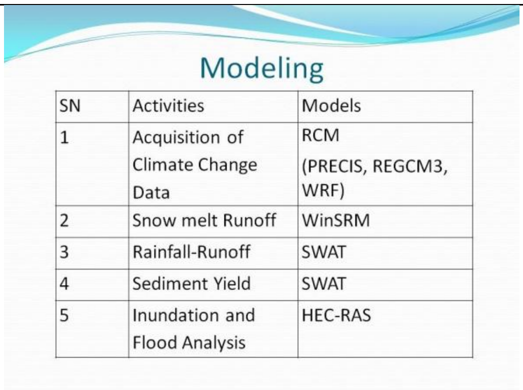
Research Component	Methodology
1. Advancing knowledge on climate change impact on water resources	**i. Hydro-meteorological Diagnostics** Analysis of available historical data on climatological and hydrological variables for any trend and changes in its statistics **ii. Hydrologic and Hydraulic Modeling** a. Acquisition of data from suitable RCM models b. Development and Use of the Snow/ Glacier Melt Runoff Model c. Development and Use the Hydrologic (rainfall-runoff) Model d. Development and Use of Hydraulic Models



Hydro-meteorological Diagnostics

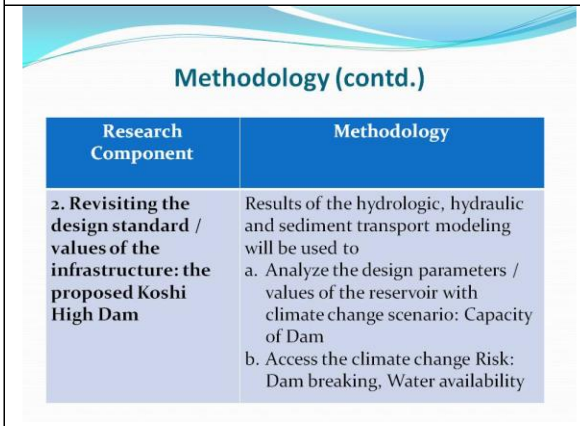
Trend Analysis

Change in Statistics



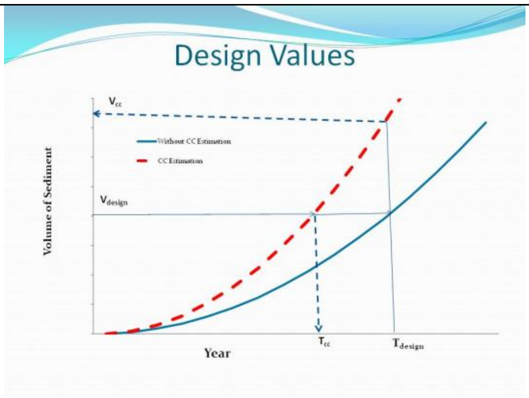
Modeling

SN	Activities	Models
1	Acquisition of Climate Change Data	RCM (PRECIS, REGCM3, WRF)
2	Snow melt Runoff	WinSRM
3	Rainfall-Runoff	SWAT
4	Sediment Yield	SWAT
5	Inundation and Flood Analysis	HEC-RAS

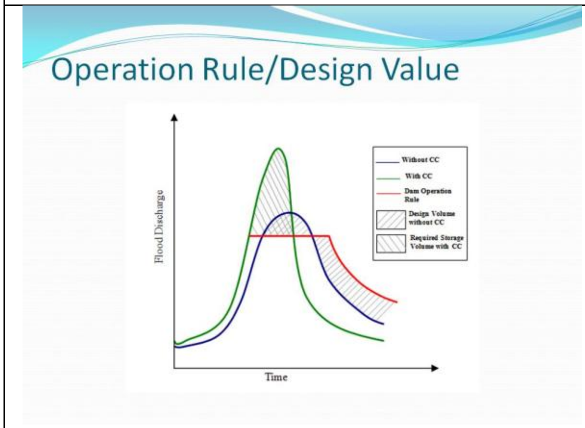


Methodology (contd.)

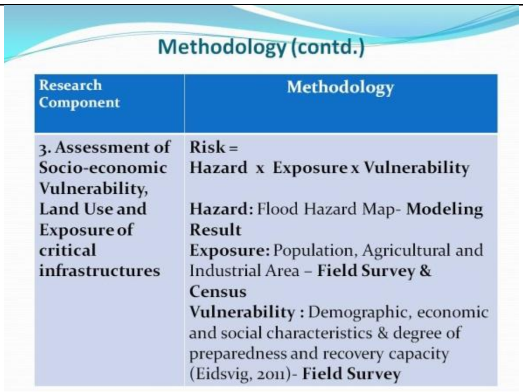
Research Component	Methodology
2. Revisiting the design standard / values of the infrastructure: the proposed Koshi High Dam	Results of the hydrologic, hydraulic and sediment transport modeling will be used to a. Analyze the design parameters / values of the reservoir with climate change scenario: Capacity of Dam b. Access the climate change Risk: Dam breaking, Water availability



Design Values

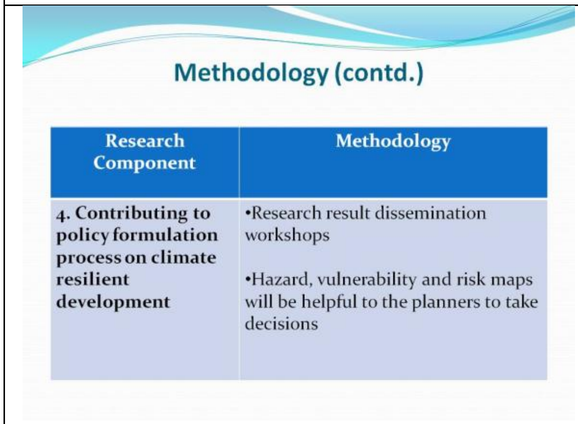


Operation Rule/Design Value



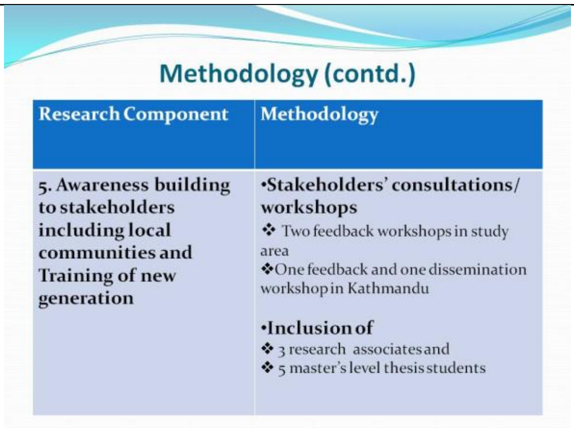
Methodology (contd.)

Research Component	Methodology
3. Assessment of Socio-economic Vulnerability, Land Use and Exposure of critical infrastructures	**Risk =** **Hazard x Exposure x Vulnerability** **Hazard:** Flood Hazard Map- **Modeling Result** **Exposure:** Population, Agricultural and Industrial Area – **Field Survey & Census** **Vulnerability :** Demographic, economic and social characteristics & degree of preparedness and recovery capacity (Eidsvig, 2011)- **Field Survey**



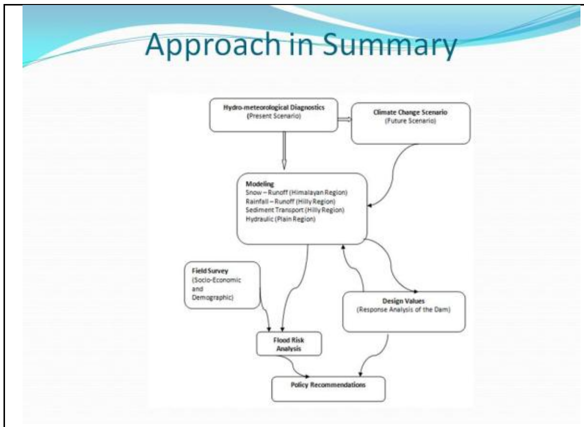
Methodology (contd.)

Research Component	Methodology
4. Contributing to policy formulation process on climate resilient development	•Research result dissemination workshops •Hazard, vulnerability and risk maps will be helpful to the planners to take decisions

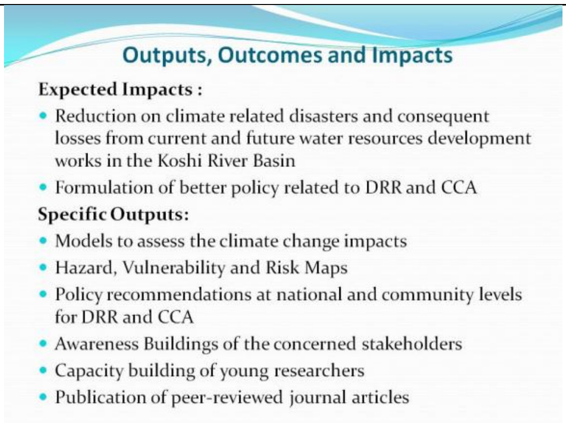


Methodology (contd.)

Research Component	Methodology
5. Awareness building to stakeholders including local communities and Training of new generation	**•Stakeholders' consultations/ workshops** ❖ Two feedback workshops in study area ❖One feedback and one dissemination workshop in Kathmandu **•Inclusion of** ❖ 3 research associates and ❖ 5 master's level thesis students



Approach in Summary



Outputs, Outcomes and Impacts

Expected Impacts :

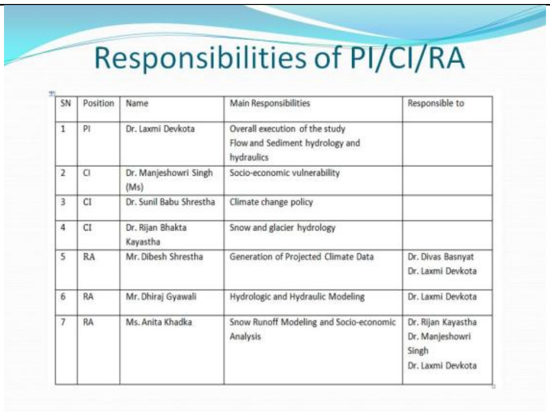
- Reduction on climate related disasters and consequent losses from current and future water resources development works in the Koshi River Basin
- Formulation of better policy related to DRR and CCA

Specific Outputs:

- Models to assess the climate change impacts
- Hazard, Vulnerability and Risk Maps
- Policy recommendations at national and community levels for DRR and CCA
- Awareness Buildings of the concerned stakeholders
- Capacity building of young researchers
- Publication of peer-reviewed journal articles

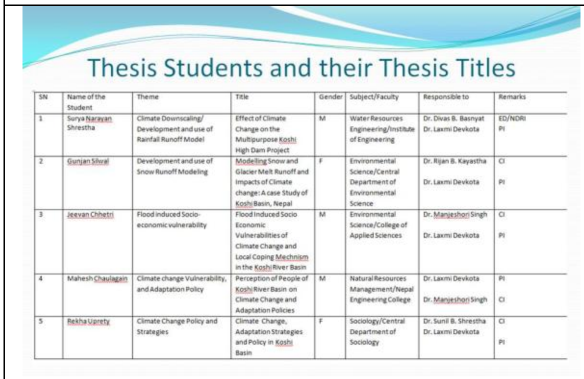
Study Team

A. Investigators:		4 Persons
PI:	Dr. Laxmi Devkota	
CI:	Dr. Manjeshowri Singh	
CI:	Dr. Sunil Babu Shrestha	
CI:	Dr. Rijan B. Kayastha	
B. Research Associates		3 Persons
	Mr. Dibesh Shrestha	
	Mr. Dhiraj Gyawali	
	Ms. Anita Khadka	
C. Thesis Students:		5 Persons
	Mr. Surya Narayan Shrestha	
	Ms. Gunjan Silwal	
	Mr. Jeevan Chhetri	
	Mr. Mahesh Chaulagain	
	Mr. Rekha Uprety	



Responsibilities of PI/CI/RA

SN	Position	Name	Main Responsibilities	Responsible to
1	PI	Dr. Laxmi Devkota	Overall execution of the study Flow and Sediment hydrology and hydraulics	
2	CI	Dr. Manjeshowri Singh (Ms)	Socio-economic vulnerability	
3	CI	Dr. Sunil Babu Shrestha	Climate change policy	
4	CI	Dr. Rijan Bhakta Kayastha	Snow and glacier hydrology	
5	RA	Mr. Dibesh Shrestha	Generation of Projected Climate Data	Dr. Divas Basnyat Dr. Laxmi Devkota
6	RA	Mr. Dhiraj Gyawali	Hydrologic and Hydraulic Modeling	Dr. Laxmi Devkota
7	RA	Ms. Anita Khadka	Snow Runoff Modeling and Socio-economic Analysis	Dr. Rijan Kayastha Dr. Manjeshowri Singh Dr. Laxmi Devkota



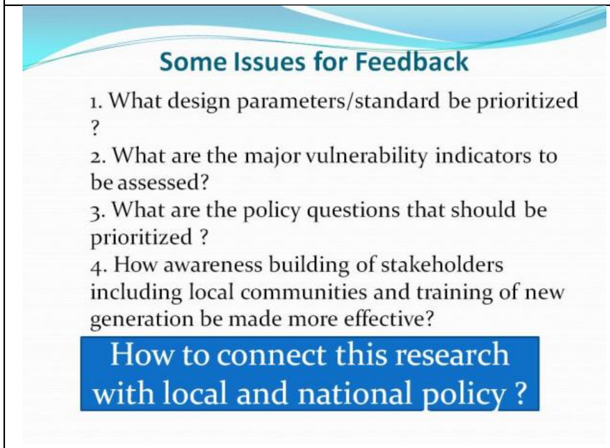
Thesis Students and their Thesis Titles

SN	Name of the Student	Theme	Title	Gender	Subject/Faculty	Responsible to	Remarks
1	Surya Narayan Shrestha	Climate Downscaling/ Development and use of Rainfall Runoff Model	Effect of Climate Change on the Multipurpose Koshi High Dam Project	M	Water Resources Engineering/Institute of Engineering	Dr. Divas B. Basnyat Dr. Laxmi Devkota	ED/NDRI PI
2	Gunjan Silwal	Development and use of Snow Runoff Modeling	Modelling Snow and Glacier Melt Runoff and Impacts of Climate change: A case Study of Koshi Basin, Nepal	F	Environmental Science/Central Department of Environmental Science	Dr. Rijan B. Kayastha Dr. Laxmi Devkota	CI PI
3	Jeevan Chhetri	Flood induced Socio-economic vulnerability	Flood Induced Socio Economic Vulnerabilities of Climate Change and Local Coping Mechnism in the Koshi River Basin	M	Environmental Science/College of Applied Sciences	Dr. Manjeshori Singh Dr. Laxmi Devkota	CI PI
4	Mahesh Chaulagain	Climate change Vulnerability, and Adaptation Policy	Perception of People of Koshi River Basin on Climate Change and Adaptation Policies	M	Natural Resources Management/Nepal Engineering College	Dr. Laxmi Devkota Dr. Manjeshori Singh	PI CI
5	Rekha Uprety	Climate Change Policy and Strategies	Climate Change, Adaptation Strategies and Policy in Koshi Basin	F	Sociology/Central Department of Sociology	Dr. Sunil B. Shrestha Dr. Laxmi Devkota	CI PI

Steering Committee

Coordinator:	Dr. Divas B. Basnyat
Members:	Prof. Ram Manohar Shrestha
	Dr. Madan Lall Shrestha
	Dr. Guna Nidhi Paudel
	Dr. Krishna Pahari
	Mr. Keshav Dhoj Adhikari
	Mr. Gauri Shankar Bassi
Member-Secretary	Dr. Laxmi Devkota

Funded by:
Climate and **D**evelopment **K**nowledge **N**etwork (CDKN) and
Global Change **S**ys**T**em for **A**nalysis, **R**esearch and **T**raining (START)



Some Issues for Feedback

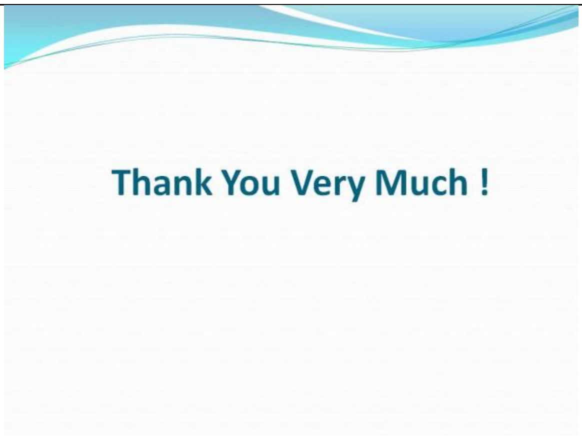
1. What design parameters/standard be prioritized ?

2. What are the major vulnerability indicators to be assessed?

3. What are the policy questions that should be prioritized ?

4. How awareness building of stakeholders including local communities and training of new generation be made more effective?

How to connect this research with local and national policy ?

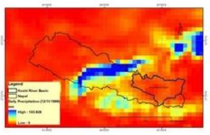


Thank You Very Much !

Annex II. Application of Climate data from RCM in Koshi River Basin- by Mr. Dhiraj Gyawali, Research Associate on behalf of Mr. Dibesh Shrestha

Nepal Development Research Institute

"Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal"



Application of Climate data from RCM in Koshi River Basin
Presented by:
Dibesh Shrestha
M.Sc. In Interdisciplinary Water Resources Management
Research Associate, NDRI

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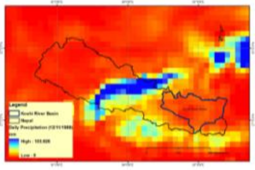
Climate Data (RCM)

- Regional Climate Model Data

RCM	PRECIS
Parent GCM	HADCM3Q0
IPCC Scenario	A1B
Validated period	1970-2000
Downscaled period	2020-2060
Horizontal Resolution	25 km
Temporal Resolution	Daily
Variables	Rainfall, Temperature (Mean, Max and Min), RH, Ground Speed, Sea Level Pressure

Daily precipitation (in mm) of 12/11/1999 as per PRECIS HadCM3Q0



Data Source:
Department of Hydrology and Meteorology

Bias Correction

- Bias is basically deviation between simulated value and observed value
- <u>Different methods of Bias Correction:</u>
- Gamma transformation method: Hay et al. (2002) the corrected precipitation data did not contain the day-to-day variability which was present in the observed data set.
- Linear correction Approach: Adjusts the mean precipitation, but leaves the CV unaffected, because both mean and standard deviation are multiplied by the same factor (Leander and Buishland, 2007).
- Hybrid quantile method
- <u>Power transformation method:</u>
  - ➢ Relatively simpler to apply than gamma method
  - ➢ Corrects the CV of the data
  - ➢ Our assumption: In case of Nepal, the method should preserve the day-to-day variability of the precipitation (should be examined during this study)

Power Transformation Method of Bias correction

- Non-linear method
- Corrects the Coefficient of Variation and Mean
- **$P_{corr} = a \times P^{b}$**

Where,

P_{corr} = Bias corrected daily precipitation amount

P = Uncorrected RCM daily precipitation amount

b = Parameter corresponding to CV of the observed daily precipitation

a = Parameter corresponding to mean of the observed daily precipitation

---

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Determination of parameters a and b

- Divide the whole year into the block of 5 days, i.e. no. of blocks is 73
- Determination of parameter a and b for each73 blocks of the year
- Selection of window length of 65 days (30 days before and after the considered 5 days period/ block), 45 days (20days before and after)
- Data set available from 1976 to 1999 (24 years)

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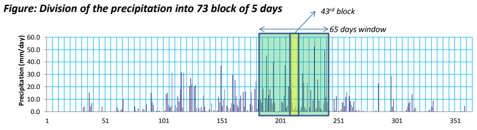
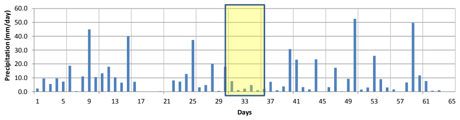
Determination of parameters a and b

Figure: Division of the precipitation into 73 block of 5 days



43rd block with 65 days of window size (including 30 days before and after 43rd block)



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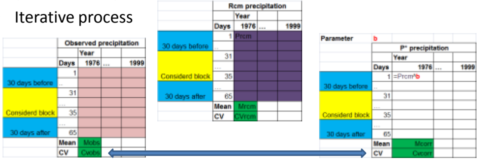
Determination of parameter *b*

- Is done such that CV of the corrected daily precipitation matches the CV of the observed daily precipitation.
- P* = Prcm^{b} where, P* = Transformed precipitation (intermediate)
- Iterative process



The value of parameter ***b*** that makes CV of corrected precipitation data set equal to that of observed is the required value.

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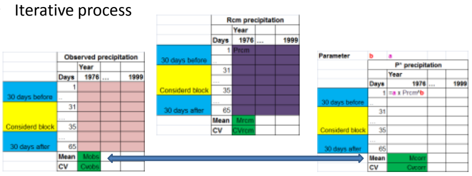
Determination of parameter *a*

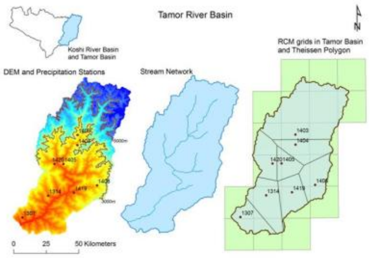
- Is done such that mean of the corrected daily precipitation matches the mean of the observed daily precipitation.
- Pcorr = ***a*** x Prcm^{b}
- Iterative process



The value of parameter ***a*** that makes **mean** of corrected precipitation data set equal to that of observed is the required value.

Application to Koshi River Basin

- Sub-basin wise bias correction
- Application to Tamor River Basin
- RCM: PRECIS HadCM3



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Use of Theissen polygon method

- 8 precipitation stations in Tamor Basin
- Value of precipitation from RCM at the station is transferred to the existing stations using the Theissen polygon method for the **bias correction** because:
  - ➢ SWAT model use the point input and not gridded data
  - ➢ Theissen polygon has advantage over nearest neighbourhood estimation as it induces the spatial variation
  - ➢ Theissen polygon was chosen over the elevation-wise correction as all the stations lie below the elevation of 3000m
- **Final RCM value assigned to each station for bias correction is weighted average of all grid values in theissen polygon area corresponding to that station**

Results from Bias Correction

Example: Station 1405

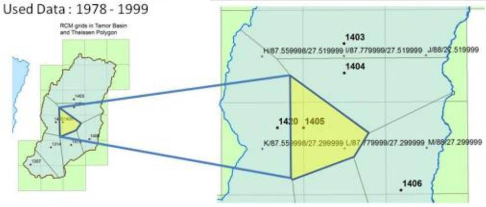
Observed Data Available:

1978 to 2008

RCM Data available: 1970 to 1999

Used Data : 1978 - 1999

Grid_ID	Latitude	Longitude	Area (sq.km)	Contributing Factor
H	27.519999	87.559998	20.63	0.064
I	27.519999	87.779999	14.32	0.044
K	27.299999	87.559998	68.46	0.211
L	27.299999	87.779999	220.86	0.681
Total			**324.27**	**1.00**



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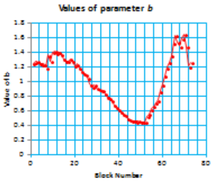
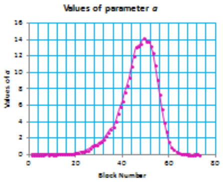
Parameters *b* and *a*

Value of *b*



Values of *a*



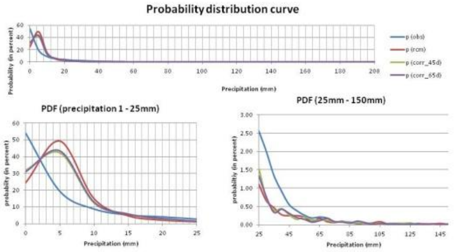
Comparison: Descriptive Statistics

- Descriptive Statistics

Descriptive Statistics	*Pobs*	*Prcm*	*Pcorr_1405_45d*	*Pcorr_1405_65d*
Mean	5.56	5.14	4.71	4.72
Standard Error	0.13	0.16	0.12	0.12
Standard Deviation	11.58	14.35	10.61	10.89
Sample Variance	134.10	205.80	112.62	118.49
Kurtosis	19.35	342.90	47.52	56.46
Skewness	3.64	13.35	5.77	6.24
Range	134.70	557.67	154.09	177.79
Minimum	0.00	0.00	0.00	0.00
Maximum	134.70	557.67	154.09	177.79
Sum	44681.70	41339.18	37851.65	37935.79
RMSE		11.86	18.74	14.51

Comparison: Probability distribution

- Probability distribution curve



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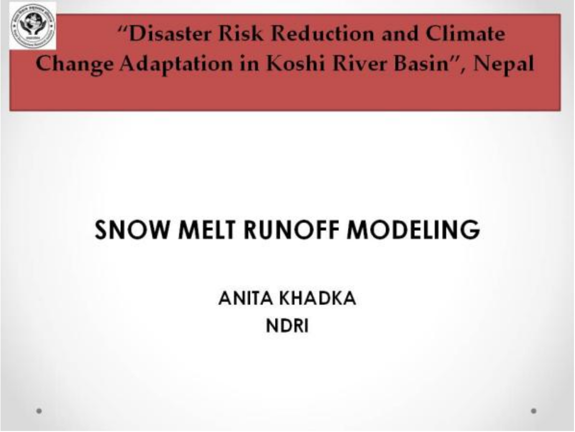
Way Forward

- Evaluation of bias correction in other stations over basin
- Bias correction in other sub-basins
- Application of bias corrected data in SWAT and Win-SRM Model of Koshi River Basin for future scenario

Thank you!

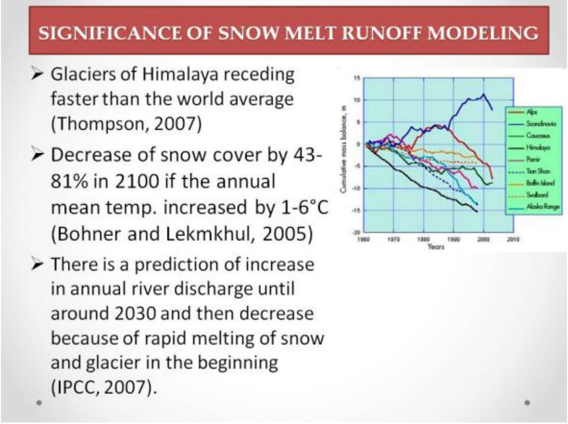
iii. Snow Melt Runoff Modeling - by Ms. Anita Khadka, Research Associate



"Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin", Nepal

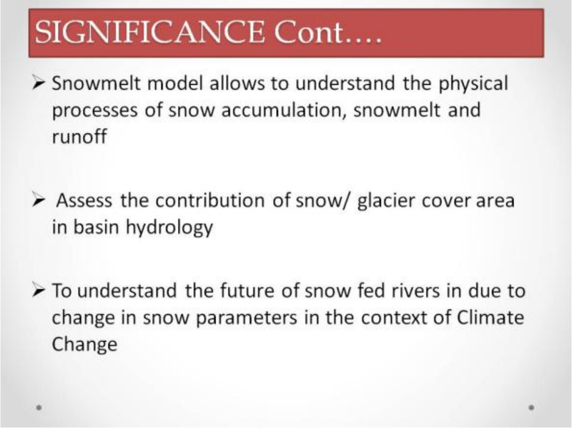
SNOW MELT RUNOFF MODELING

ANITA KHADKA
NDRI



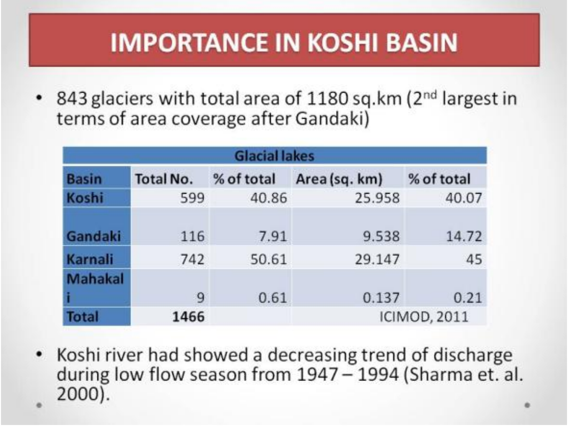
SIGNIFICANCE OF SNOW MELT RUNOFF MODELING

- Glaciers of Himalaya receding faster than the world average (Thompson, 2007)
- Decrease of snow cover by 43-81% in 2100 if the annual mean temp. increased by 1-6°C (Bohner and Lekmkhul, 2005)
- There is a prediction of increase in annual river discharge until around 2030 and then decrease because of rapid melting of snow and glacier in the beginning (IPCC, 2007).



SIGNIFICANCE Cont….

- Snowmelt model allows to understand the physical processes of snow accumulation, snowmelt and runoff
- Assess the contribution of snow/ glacier cover area in basin hydrology
- To understand the future of snow fed rivers in due to change in snow parameters in the context of Climate Change

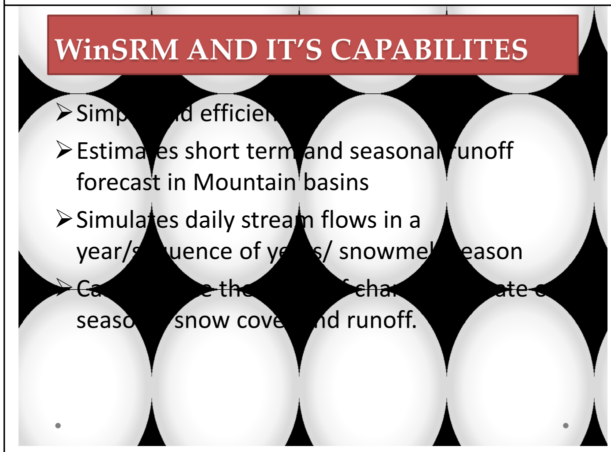


IMPORTANCE IN KOSHI BASIN

- 843 glaciers with total area of 1180 sq.km (2nd largest in terms of area coverage after Gandaki)

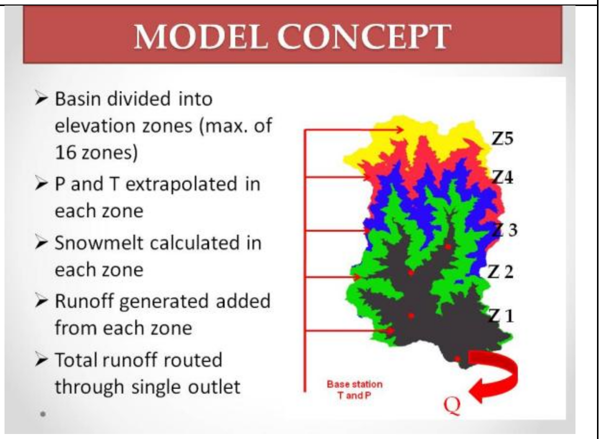
Glacial lakes				
Basin	Total No.	% of total	Area (sq. km)	% of total
Koshi	599	40.86	25.958	40.07
Gandaki	116	7.91	9.538	14.72
Karnali	742	50.61	29.147	45
Mahakali	9	0.61	0.137	0.21
Total	**1466**		ICIMOD, 2011	

- Koshi river had showed a decreasing trend of discharge during low flow season from 1947 – 1994 (Sharma et. al. 2000).



WinSRM AND IT'S CAPABILITES

- Simp[illegible]d efficien[illegible]
- Estimates short term and seasonal runoff forecast in Mountain basins
- Simulates daily stream flows in a year/sequence of years/ snowmelt season
- Ca[illegible]e the [illegible]f cha[illegible]ate c[illegible] seaso[illegible] snow cove[illegible]nd runoff.



MODEL CONCEPT

- Basin divided into elevation zones (max. of 16 zones)
- P and T extrapolated in each zone
- Snowmelt calculated in each zone
- Runoff generated added from each zone
- Total runoff routed through single outlet

SRM INPUT

- Variables

Temperature | Precipitation | Snow cover area

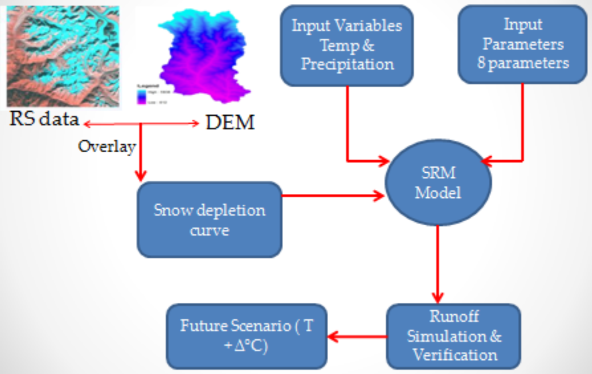
- **Parameters**
  - Degree day factor (a)
  - Runoff coefficient (Cs & Cr)
  - Recession coefficient (k)
  - Temp. Lapse rate (γ)
  - Critical temperature (Tcrit)
  - Rainfall contributing area(RCA)
  - Time lag (L)

STUDY BASIN

- 6 sub-basins of koshi rive basin
- Basin divided at an interval of 600m

Sub-basins	Area (km^2)	Elevation (m)	Area >4500
Tamor	4,002	358-8387	1.410
Arun	26,271	879-8776	21,360
Dudhkoshi	3,713	432-8746	1,670
Likhu	851	519-6855	120
Tamakoshi	2,925	797-7311	1,750
Sunkoshi	3,592	595-7938	1,810

METHODOLOGY



VARIABLES

- Temperature extrapolation

$$\Delta T = \gamma.(h_{st} - \bar{h}).\frac{1}{100}$$

Where,

- ΔT = change in temperature at respective zone.
- γ = is the temperature lapse rate
- $\bar{h}_{st}$ = is the height of base station
- = is the mean height of respective zone

VARIABLES

- Pre[illegible]ion as[illegible]ction [illegible]ude (Seko[illegible]. 1987)

$P_Z = P_{BH}$ when Z<4000m

= P[illegible][1+0.0003 (Z - [illegible]000)] when Z= [illegible]00m to 5000m

= [illegible] Z> 5000[illegible]

- Snow Cover Area
  - MODIS data (2000 to 2010 year)

QUALITY ASSESSMENT

Goodness of fit (R^2) Nash & Sutcliffe

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(Q_i - Q_i^{'})^2}{\sum_{i=1}^{n}(Q_i - \bar{Q})^2}$$

where;

Q_i : measured daily discharge

$Q_i^{'}$: computed daily discharge

$\bar{Q}$: average measured discharge of the season under study

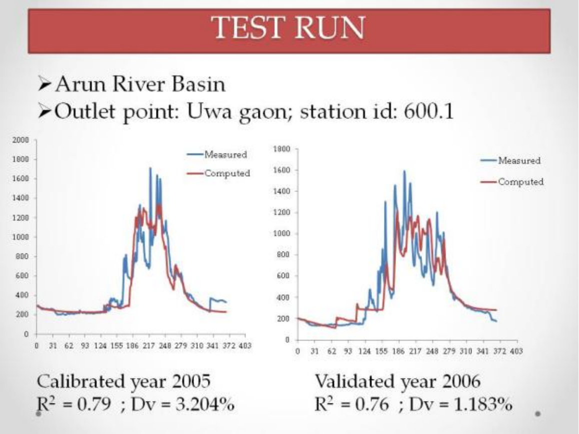
n : number of daily discharge values

Volume Difference

$$D_V[\%] = \frac{V - V^{'}}{V} \cdot 100$$

V : measured runoff volume

$V^{'}$: simulated/forcasted runoff volume

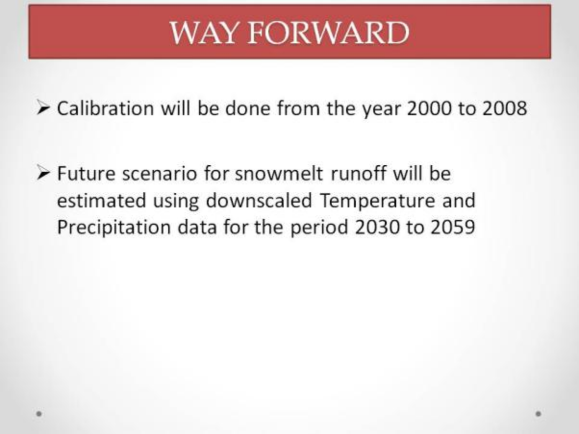


TEST RUN

- ➢Arun River Basin
- ➢Outlet point: Uwa gaon; station id: 600.1

Calibrated year 2005
$R^2 = 0.79$; Dv = 3.204%

Validated year 2006
$R^2 = 0.76$; Dv = 1.183%

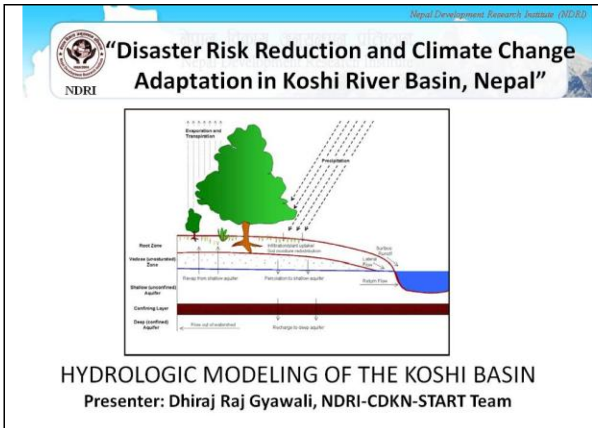


WAY FORWARD

- ➢ Calibration will be done from the year 2000 to 2008
- ➢ Future scenario for snowmelt runoff will be estimated using downscaled Temperature and Precipitation data for the period 2030 to 2059

THANK YOU

iv. Hydrologic modeling of the Koshi Basin - Mr. Dhiraj Gyawali, Research Associate



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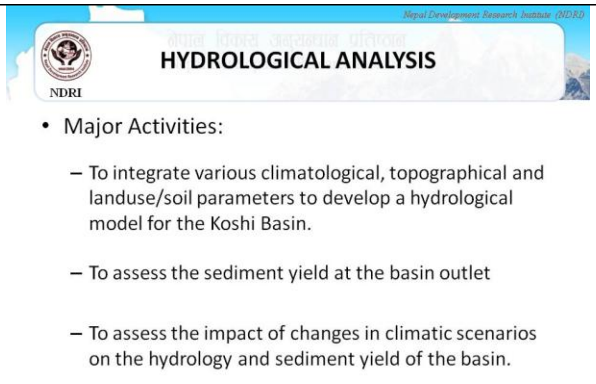
“Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal”

HYDROLOGIC MODELING OF THE KOSHI BASIN

Presenter: Dhiraj Raj Gyawali, NDRI-CDKN-START Team



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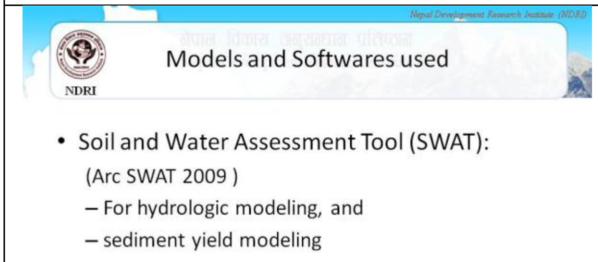
HYDROLOGICAL ANALYSIS

- Major Activities:
  - To integrate various climatological, topographical and landuse/soil parameters to develop a hydrological model for the Koshi Basin.
  - To assess the sediment yield at the basin outlet
  - To assess the impact of changes in climatic scenarios on the hydrology and sediment yield of the basin.



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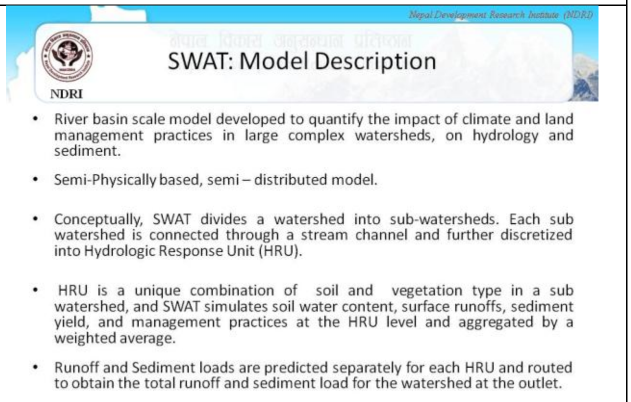
Models and Softwares used

- Soil and Water Assessment Tool (SWAT):

  (Arc SWAT 2009)
  - For hydrologic modeling, and
  - sediment yield modeling



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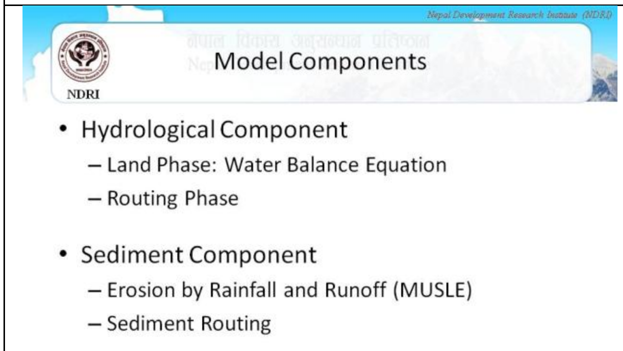
SWAT: Model Description

- River basin scale model developed to quantify the impact of climate and land management practices in large complex watersheds, on hydrology and sediment.
- Semi-Physically based, semi – distributed model.
- Conceptually, SWAT divides a watershed into sub-watersheds. Each sub watershed is connected through a stream channel and further discretized into Hydrologic Response Unit (HRU).
- HRU is a unique combination of soil and vegetation type in a sub watershed, and SWAT simulates soil water content, surface runoffs, sediment yield, and management practices at the HRU level and aggregated by a weighted average.
- Runoff and Sediment loads are predicted separately for each HRU and routed to obtain the total runoff and sediment load for the watershed at the outlet.



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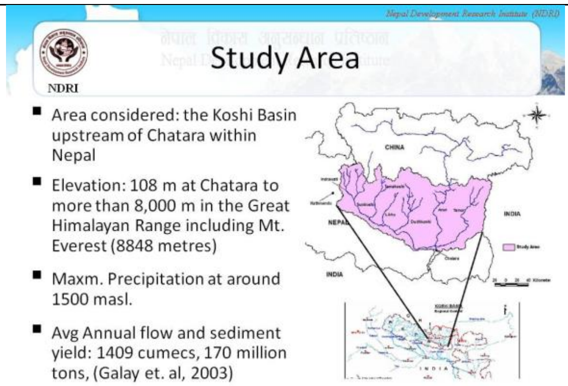
Model Components

- Hydrological Component
  - Land Phase: Water Balance Equation
  - Routing Phase
- Sediment Component
  - Erosion by Rainfall and Runoff (MUSLE)
  - Sediment Routing



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Study Area

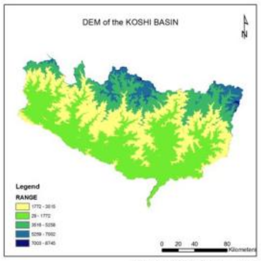
- Area considered: the Koshi Basin upstream of Chatara within Nepal
- Elevation: 108 m at Chatara to more than 8,000 m in the Great Himalayan Range including Mt. Everest (8848 metres)
- Maxm. Precipitation at around 1500 masl.
- Avg Annual flow and sediment yield: 1409 cumecs, 170 million tons, (Galay et. al, 2003)

Input Data

- **Spatial Data**
  - Digital Elevation Model (Aster DEM)
  - Land Use Map (*Source: Department of Survey*)
  - Soil Map and Soil Properties (*Source: FAO Soil Map and Soil Database*)
- **Time Series Data** (*Source: Dept. of Hydrology and Meteorology)*
  - Meteorological data (Rainfall , Maximum and minimum Temperature, Relative humidity, Sunshine hours, Wind speed) for Weather generating Stations
  - Meteorological data (Rainfall and Temperature) for Weather Stations
- **Flow and Sediment data at the outlet:** For calibration and validation

Input Data (Contd.)

- Topographical Data (Aster GDEM v 2.0*)



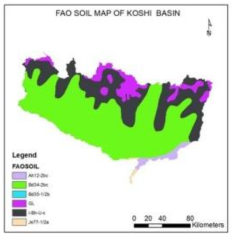
*Aster GDEM is a property of METI and NASA

Input Data (Contd.)

- Landuse Data (*Source: Department of Survey*)

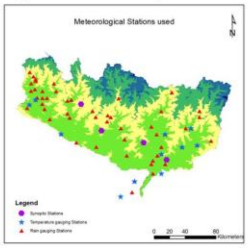
Input Data (Contd.)

- Soil Data (*Source: FAO soil Map & Soil property Database)*)



Input Data (Contd.)

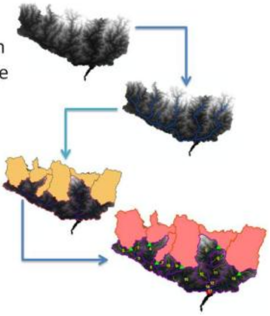
- Meteorological data (*Source: DHM*)*



**Department of Hydrology and Meteorology*

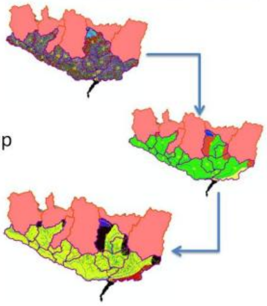
METHODOLOGY

MODEL SETUP



- Watershed Delineation
- Initial Stream and subbasin outlets definition: Drainage area threshold approach
- Addition of the basin outlet: Chatara
- Addition of Inlet Points
- Basin Delineation and calculation of basin parameters.

MODEL SETUP (contd.)



- HRU Analysis
  - Landuse map with corresponding Lookup table
  - Soil map and soil lookup table
  - Multiple slope discretization
  - HRU overlay

MODEL SETUP (contd.)

- Importing Climatic data
- Inlet flows addition,
  - Tamor: *Majhitar, Stn ID: 684*
  - Arun: *Uwa Gaon, Stn ID: 600.1*
  - Dudhkoshi: *Rabuwa Bazar, Stn ID: 670*
  - Likhu: *Sangutar, Stn ID: 660*
  - Tamakoshi: *Busti, Stn ID: 647*
  - Sunkoshi: *Pachuwarghat, Stn ID: 630*

MODEL SETUP (contd.)

- Warm up Period: 1976 – 1985
- Calibration Period: 1991 – 2000
- Validation Period: 2001 – 2005

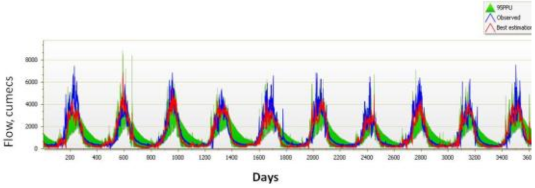
Sensitivity Analysis

- Latin Hypercube - One factor at a time
- Demonstrates the impact that change to an individual parameter has on the model response.

PARAMETERS	RANK
Cn2	1
ESCO	2
Canmx	3
Ch_K2	4
Gwqmn	5
Soil_Awc	6
Gw_Revap	7
Sol_Z	8
Blai	9
Alpha_Bf	10

Calibration (1991 – 2000)

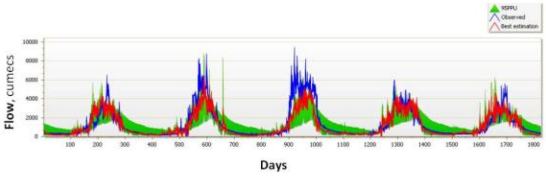
- SUFI-2 Algorithm using SWAT-CUP



CALIBRATION SUMMARY	
NSE	R^2
0.80	0.81

Validation (2001-2005)

- SUFI-2 Algorithm using SWAT-CUP



VALIDATION SUMMARY	
NSE	R^2
0.75	0.77

Way Forward

- Calibration and validation of sediment yield at the outlet
- Incorporation of the projected RCM data into the calibrated hydrologic model to calculate the flows and sediment yield for forecast period.
- Calculation of the flow statistics for the forecast period
- Hydraulic Analysis

Hydraulic Analysis

- Pre-Ras Application (TIN Model, Flow Paths, C/S, Banks and Levees) using Hec- GeoRAS
- 1D Flow Model using HEC-RAS
- Post Geo-Ras Application
- Flood Prone Area Delineation: Dam and Embankment Breaching Cases

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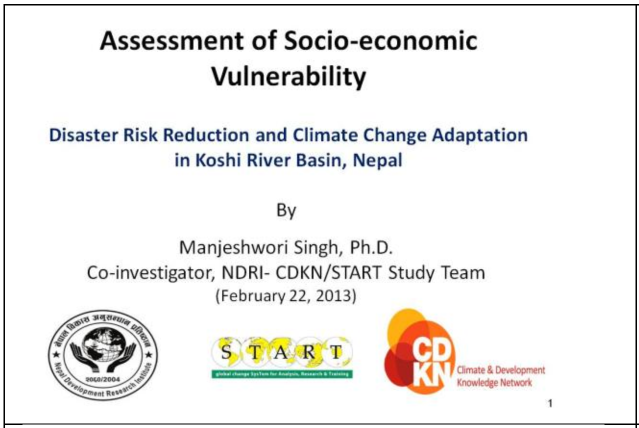
THANK YOU

v. Assessment of Socio-economic Vulnerability - by Dr. Manjeshwori Singh, Co-investigator

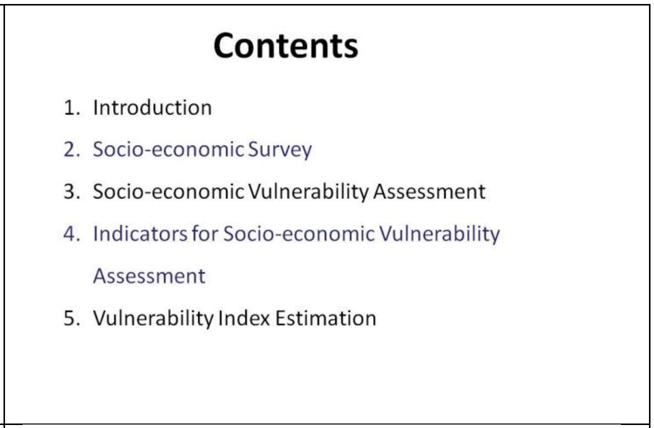


Assessment of Socio-economic Vulnerability

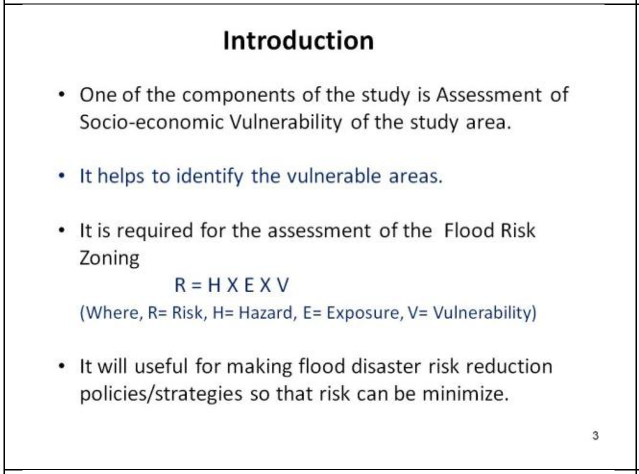
Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal

By

Manjeshwori Singh, Ph.D.
Co-investigator, NDRI- CDKN/START Study Team
(February 22, 2013)



Contents

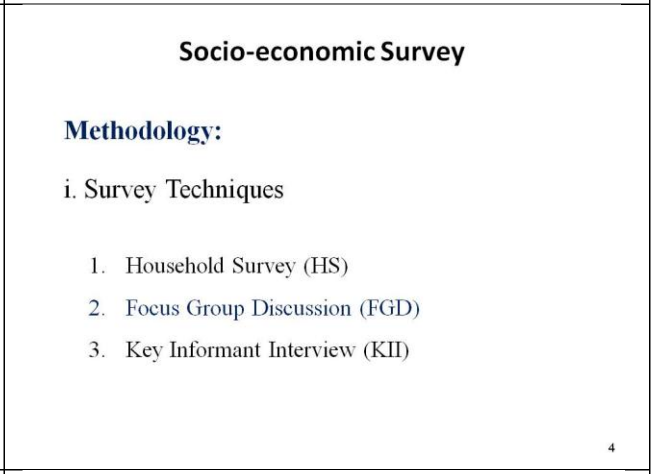


Introduction

- One of the components of the study is Assessment of Socio-economic Vulnerability of the study area.
- It helps to identify the vulnerable areas.
- It is required for the assessment of the Flood Risk Zoning

  R = H X E X V

  (Where, R= Risk, H= Hazard, E= Exposure, V= Vulnerability)
- It will useful for making flood disaster risk reduction policies/strategies so that risk can be minimize.

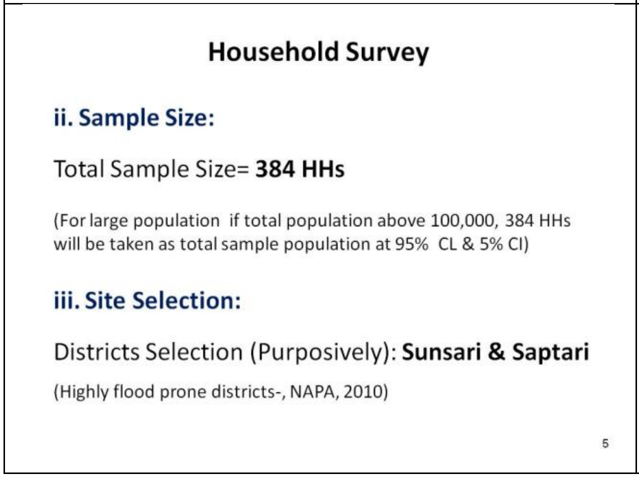


Socio-economic Survey

Methodology:

i. Survey Techniques

1. Household Survey (HS)
2. Focus Group Discussion (FGD)
3. Key Informant Interview (KII)



Household Survey

ii. Sample Size:

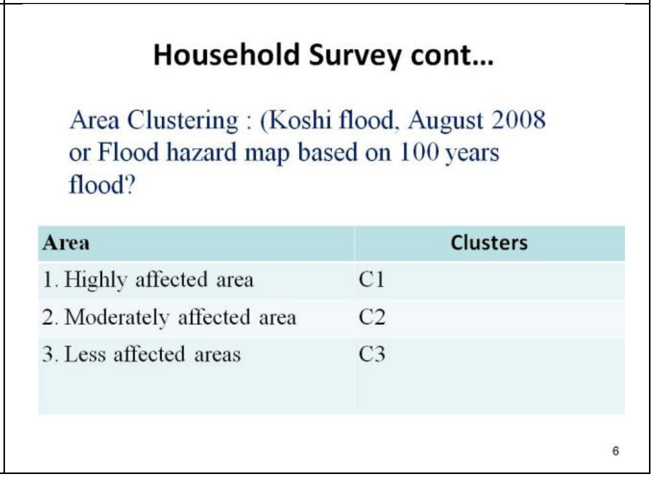
Total Sample Size= **384 HHs**

(For large population if total population above 100,000, 384 HHs will be taken as total sample population at 95% CL & 5% CI)

iii. Site Selection:

Districts Selection (Purposively): **Sunsari & Saptari**

(Highly flood prone districts-, NAPA, 2010)



Household Survey cont...

Area Clustering : (Koshi flood, August 2008 or Flood hazard map based on 100 years flood?

Area	Clusters
1. Highly affected area	C1
2. Moderately affected area	C2
3. Less affected areas	C3

Household Survey cont…

iv. Sample Distribution:

Population proportionate sampling
HH Selection: Random

v. Sample Design:

Semi-structure questionnaires & Checklist

Household Survey cont…

2. Focus Group Discussion (FGD):
At least one FGD in each cluster.
Total FGDs = 6

3. Key Informant Interview (KII):
5 KII in each cluster = 15
KII (national level) = 5
Total KIIs = 20

Socio-economic Vulnerability Assessment

Factors considered for the Assessment;

- Demography
- Economy
- Social Aspect
- Preparedness
- Recovery

Indicators for Socio-economic Vulnerability Assessment (Eidsvig, 2011)

Indicatlors	Weights (Range 1-3)	Criteria for Indicator Ranking (1: Low vulnerability and 4 high vulnerability)
Demographic Indicators (weight: w_1, Value: V_1)		
Age distribution	1	1. Less than 20% population aged less than 10 years and above 65 years and disabled population 2. 20-30% population aged less than 10 years and above 65 years and disabled population 3. 30-50% population aged less than 10 years and above 65 years and disabled population 4. More than 50% population aged less than 10 years and above 65 years and disabled population
House Type (based on roof type)	2	1. RCC 2. GI/Asbestos sheet 3. Clay/tiles 4. Thatched roof

Indicators….

Indicators	Weights (Range 1-3)	Criteria for Indicator Ranking (1: Low vulnerability and 4 high vulnerability)
Economic Indicators (weight: w_2, Value: V_2)		
Income	3	1. Greater than $ 2 per capita per day 2. Between $ 1-$2 per capita per day 3. Between $ 0.5-$1 per capita per day 4. Less than $ 0.5 per capita per day
Land holding	2	1. Less than 20% population is dependent on agricultural land for primary source of income 2. 20-40% population is dependent on agricultural land for primary source of income 3. 40-60% population is dependent on agricultural land for primary source of income 4. Above 60% population is dependent on agricultural land for primary source of income

Indicators cont…

Social Indicators(weight: w_3, Value: V_3)		
Education level	2	1. More than 50% is literate 2. 40%-50% population is literate 3. 30%-40% population is literate 4. Less than 20% population literate
Access to communication	3	1. Access to more than one unit of telephone/mobile 2. Access to at least one unit of telephone/mobile 3. Not access to telephone/mobile in own home 4. No telephone/mobile in the community
Mobility	1	1. Access to private car 2. Access to motorbike 3. Access to cycle 4. None
Market facility	2	1. Less than 1 km distance 2. Within 2 km distance 3. Within 2-4 km distance 4. More than 4 Km distance
Drinking water	3	1. Access in own house 2. Access in neighbor's house 3. Available in community 4. None

Indicators cont…

Preparedness Indicators(weight: w_4, Value: V_4)		
Hazard Evaluation	2	1. Community based detailed map available 2. Basic map available 3. Map under preparation 4. No
Emergency response	2	1. Good transportation (road) and organized response group in place 2. Good transportation or organized response group in place 3. Self-organized local group only 4. None
Early warning system	3	1. Advanced (24 hrs Radio, TV, Automatic siren, 1 day ahead) 2. Average (24 hrs Radio, TV, Manual Siren, same day) 3. Basic (Telephone, Mike) 4. None
Evacuation place	2	1. Less than 1 km distance 2. 1-2 km distance 3. Greater than 2 km distance 4. None
Insurance (life/property/any kind of insurance)	1	1. Life and all Property 2. Life of > 50% family members 3. Life of < 50% family members 4. None
First aid services	1	1. Adequate and in own home 2. Adequate and in community level 3. Limited 4. None

Indicators cont...

Indicators	Weights (Range 1-3)	Criteria for Indicator Ranking (1: Low vulnerability and 4 high vulnerability)
Recovery Indicators (weight: w_5, Value: V_5)		
Health institution	2	1. Less than 1 km distance. 2. 1-2 km distance 3. 2-4 km distance. 4. More than 4 Km distance.
Disaster fund	2	1. Both local level and government 2. Local and non-government level 3. Local only 4. No

Vulnerability Index Estimation

The level of vulnerability is estimated as;
e.g. Calculation of Demographic indicator

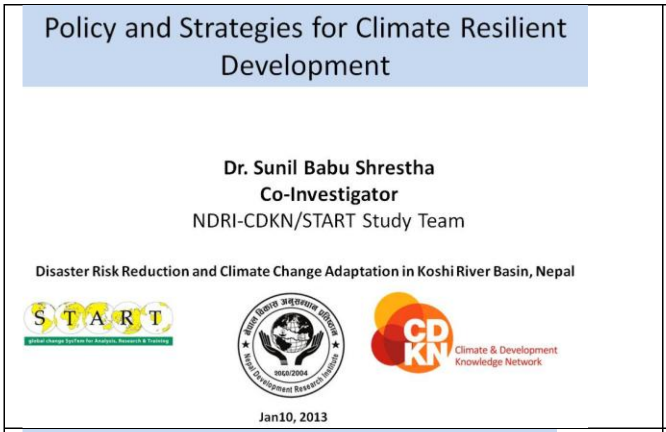
$$v_1 = \frac{w^1v^1 + w^2v^2 + w^3v^3 + w^4v^4}{w^1 + w^2 + w^3 + w^4}$$

Vulnerability Index (V) is estimated as;

$$V = \frac{w_1v_1 + w_2v_2 + w_3v_3 + w_4v_4 + w_5v_5}{w_1 + w_2 + w_3 + w_4 + w_5}$$

THANK YOU VERY MUCH!

vi. Policy and Strategies for Climate Resilient Development

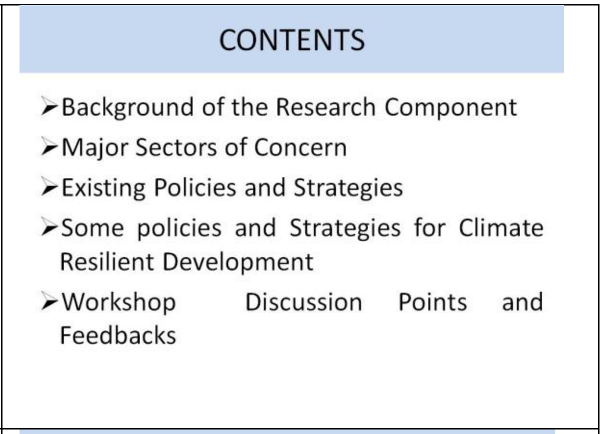


Policy and Strategies for Climate Resilient Development

Dr. Sunil Babu Shrestha
Co-Investigator
NDRI-CDKN/START Study Team

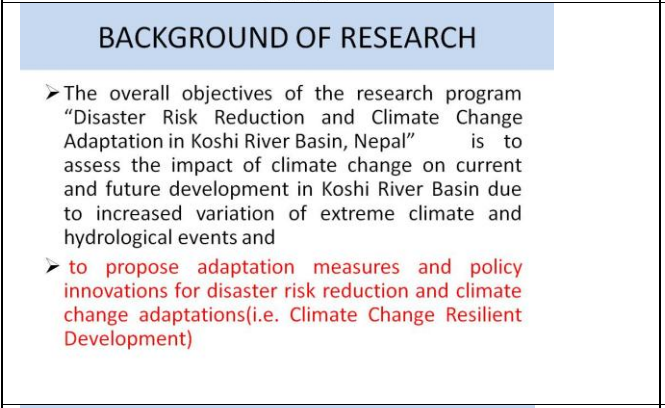
Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal

Jan10, 2013



CONTENTS

- Background of the Research Component
- Major Sectors of Concern
- Existing Policies and Strategies
- Some policies and Strategies for Climate Resilient Development
- Workshop Discussion Points and Feedbacks



BACKGROUND OF RESEARCH

- The overall objectives of the research program "Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal" is to assess the impact of climate change on current and future development in Koshi River Basin due to increased variation of extreme climate and hydrological events and
- to propose adaptation measures and policy innovations for disaster risk reduction and climate change adaptations(i.e. Climate Change Resilient Development)

MAJOR SECTORS OF CONCERN

❑ Physical Sector
- Settlements
- Infrastructure
- Dam

❑ Socio-Economic Sector
- Lives and Properties
- Business
- Agriculture

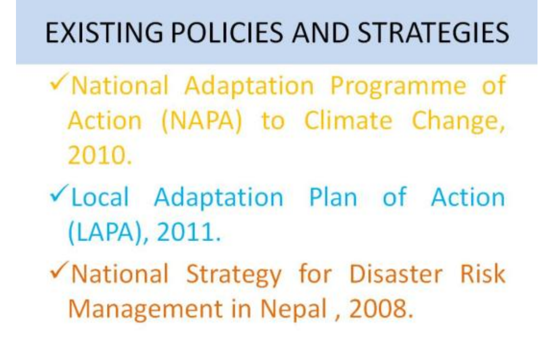
❑ Environment Sector
- Land and Soil
- Vegetation

EXISTING POLICIES AND STRATEGIES

✓ **Climate Change Policy, 2011.**

The mission of this policy is to

- address the adverse impacts of climate change
- utilize the opportunities created from it to improve the livelihoods
- achieve climate-friendly physical and social and economic development.

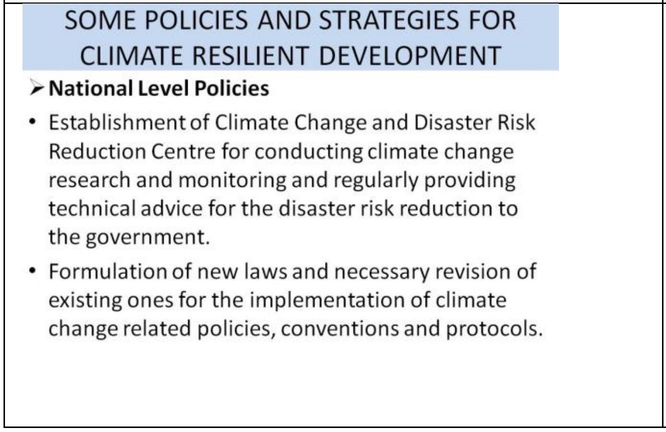


EXISTING POLICIES AND STRATEGIES

✓ National Adaptation Programme of Action (NAPA) to Climate Change, 2010.

✓ Local Adaptation Plan of Action (LAPA), 2011.

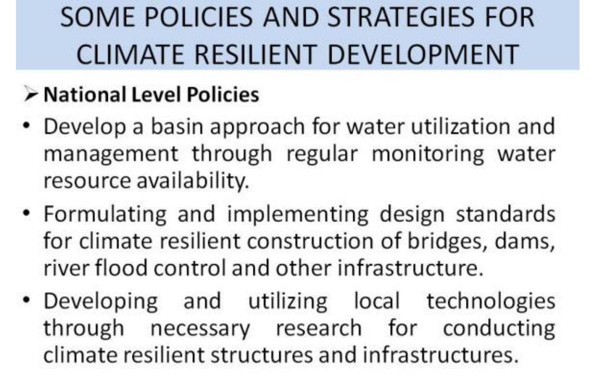
✓ National Strategy for Disaster Risk Management in Nepal , 2008.



SOME POLICIES AND STRATEGIES FOR CLIMATE RESILIENT DEVELOPMENT

National Level Policies

- Establishment of Climate Change and Disaster Risk Reduction Centre for conducting climate change research and monitoring and regularly providing technical advice for the disaster risk reduction to the government.
- Formulation of new laws and necessary revision of existing ones for the implementation of climate change related policies, conventions and protocols.



SOME POLICIES AND STRATEGIES FOR CLIMATE RESILIENT DEVELOPMENT

National Level Policies

- Develop a basin approach for water utilization and management through regular monitoring water resource availability.
- Formulating and implementing design standards for climate resilient construction of bridges, dams, river flood control and other infrastructure.
- Developing and utilizing local technologies through necessary research for conducting climate resilient structures and infrastructures.

SOME POLICIES AND STRATEGIES FOR CLIMATE RESILIENT DEVELOPMENT

➢ **National Level Strategies**

- Develop system of real time data acquisition system in vulnerable areas and prepare appropriate Climate Forecasting models for Nepal and regularly updating it based on regional climate model.
- Introducing disaster insurance in climate change affected areas for different sectors.

SOME POLICIES AND STRATEGIES FOR RECOMMENDATION

➢ **National Level Strategies**

- Design of major projects based on the Climate Change Impact Assessment (CCIA)
- Emphasize on implementing regular public awareness and capacity building programmes on climate change and adaptation measures through multi stakeholder participation.

SOME POLICIES AND STRATEGIES FOR CLIMATE RESILIENT DEVELOPMENT

➢ **Local Level Strategies**

- Prepare Risk Sensitive land use maps and adopt accordingly.
- Enforcing Building Codes in risk sensitive areas incorporating climate change dimension.
- Allocate the maximum available fund (about 75%) for field level climate change activities and emphasize for improving the living standard of people by maximum utilization of the opportunities created from the climate related funds and agreements.

SOME POLICIES AND STRATEGIES FOR RECOMMENDATION

➢ **Local Level Strategies**

- Identify, develop and utilize agriculture varieties /species that can tolerate floods (too much water).
- Identify the flood prone areas and prohibit the development of human settlement in those areas.
- To develop early warning system of possible flood or disaster to minimize the adverse impacts.

SOME POLICIES AND STRATEGIES FOR CLIMATE RESILIENT DEVELOPMENT

➢ **Local Level Strategies**

- Establish Climate Change and Disaster Risk Reduction Information Center for providing related information including service to the people at the time of disaster (eg. Steps to be followed)
- Identify and establish evacuation spaces and emergency shelters and prepare post disaster plan in partnership of all stakeholders including line agencies, local government, NGOs and private sector)

WORKSHOP DISCUSSION POINTS / FEEDBACKS

➢ Identification of more sectors/issues linked with Koshi High Dam for Climate Resilient Development.

➢ Formulation of policies and strategies linked with Koshi High Dam for Climate Resilient Development.

Thanks for your Kind Attention!