Impact of climate change and land use change on future stream flow : Case study in Inle lake watershed

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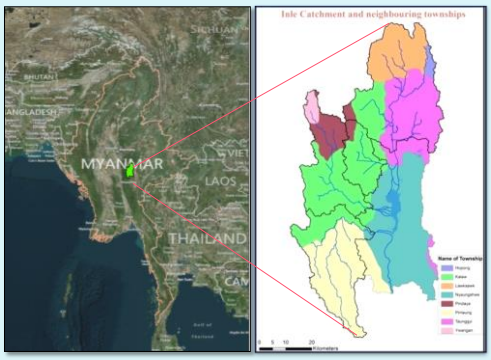
Study Area

Physical Characteristic of study area

Location and of Inle catchment



Name	Inle catchment
Location	N19° 58′ 0″ - 20° 43′ 05″ E96° 50′ - 96° 57′ Southern Shan state
Size	Myanmar second largest lake (46.4 km² (2010))
Elevation	884 m (amsl)
Length	11.2 km
Breadth	4.8 km
Water depth	Range 2.1 m -6.2 m
shape	oval
Catchment area	4197.17 km²
Surrounded towns	Taungyi, Pintaya, Pinlaung, Naungshwe, Hopone, kalaw, Yetsauk, Ywangan
population	growth rate 1.02%

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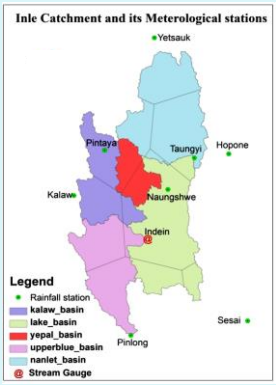
Study Area (continued)



Basin	Nanlat	Yepal	Kalaw	Upperblue	Lake-region
Area(km^2)	1205.03	310.26	656.44	808.12	1217.32
Area percentage	28.7 %	7.4 %	15.6 %	19.3 %	29 %

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Objective of the research

Main Objective

- to quantify the impact of rainfall and land-use change on the future stream flows to the Inle Lake

Specific Objectives

1. To estimate future rainfall by SDSM statistical downscaling
2. To analyze the trend of land use change for future land use maps
3. To develop a hydrological model at data available basin and to apply for the whole Inle catchment
4. To evaluate the impact of rainfall and land-use change on future stream flows

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Recommendation

- For hydrological model, rainfall data which are reasonable or with high correlated data should be used and it is also recommended to make comparison analysis with other GCM to get the best fit data for the study area.
- The quality of DEM should be with high resolution and update data to get the correct watershed and current flow network.
- The land use maps should be detail classified for hydrological point of view to get appropriate hydrological response according to their land cove type.
- Based on the message from the analysis, increased in water availability in monsoon period will fill up the lake in a short time. Thus, it is recommended that the local authority should consider some measure to increase the storage capacity of the lake for dry season water stress compensation.
- Other factor to reduce the water storage capacity is sediment transport into the lake. To quantify the correct volume of discharge to the lake, the further research should be made for sediment transport budget.
- The lake is almost full of floating garden and the loss of water from the floating farm should be researched for water budget.
- As local people have to live in nearby village and in lake village, water quality monitoring system and the quality research are also recommended.

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Research Methodology

Over all flow chart

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Data applied in the Research

Data Source	Data type	available year	scale	remark
Department of Forest	land use maps	1990,2000, 2010	30 m x 30m	with 5 classifications
Department of Forest	soil map	-	-	FAO classification
Department of Meteorology and Hydrology	rainfall data	2000-2002, 2007, 2010	daily average	For 4 stations (Taungyi, Kalaw, Naungshwe, Pinlong)
Department of Agriculture	rainfall data	2000-2002, 2007 ,2010	daily average	for 3 stations (Sesai, Pintaya, Yatsauk)
Department of hydropower	stream flow data	2000	daily average	Indein gauge station (upperblue)
APHRODITES	rainfall	1961-2007	daily average	0.5x0.25 grid cell
USGS- ASTER	DEM	-	30m x 30m	-

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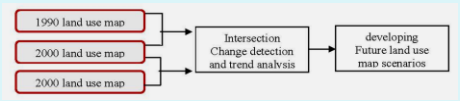
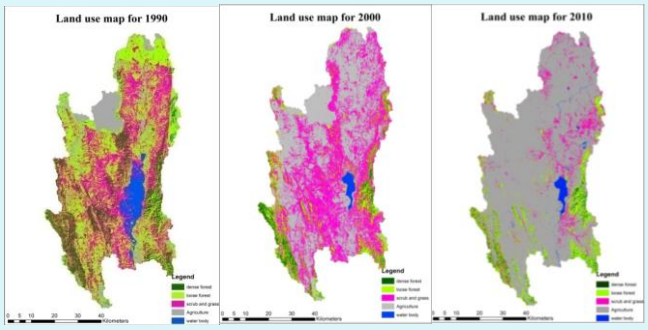
Land use change analysis and discussion for future land use map

Flow chart for land use analysis and Comparison of land use maps





Thick forest	thin forest	Scrub/grass	Agriculture	Water body

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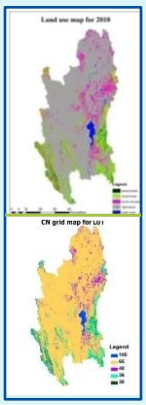
land use type	% in 1990	% in 2000	% in 2010	change rate (1990-2000)	change rate (2000-2010)	Possibility of change
Thick forest	11.70	3.29	1.83	-0.28	-0.56	Prohibited
Thin forest	39.10	10.69	8.12	-0.27	-0.76	Prohibited
grass/scrub	31.18	34.68	5.60	1.11	-0.16	Possible
agriculture	13.62	50.27	83.07	3.69	1.65	possible
Water body	4.41	1.07	1.38	-0.24	1.29	-
total	100.00	100.00	100.00	-	-	-

Maximum possible change 5.6% from grass/scrub

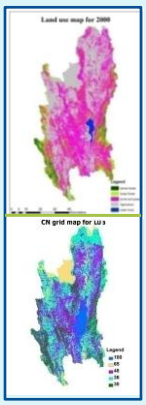
Developing future land use policy and land use maps

Land use scenario LU1 and CN map



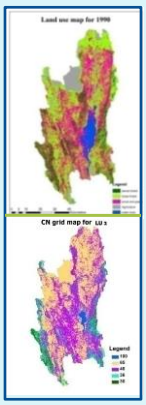
LU1 - on going with present 2010 map

Land use scenario LU2 and CN map



LU2 – restoration 2030 as in 2000 map

Land use scenario LU3 and CN map



LU3 – restoration 2050 as in 1990 map

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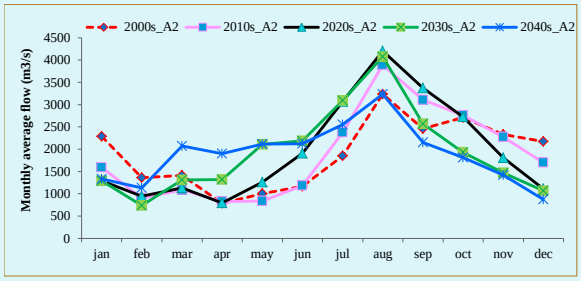
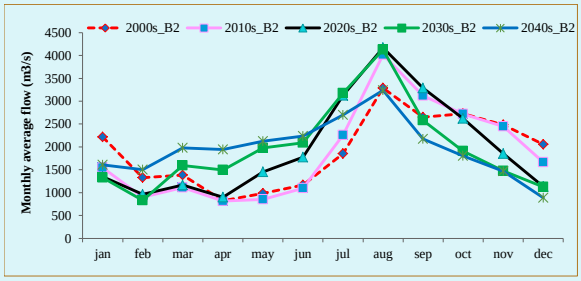
Impacts of precipitation change on stream flow

Impact on Monthly Average flow Hydrograph



peak flow -- in August
lowest level -- in April
flow decrease -- Jan to March
Oct to Dec
(except 2040s)
flow increases – Jun to September
(except 2040s)
highest flow – 2020s
lowest flow – 2040s



peak flow -- in August
lowest level -- in April
flow decrease -- Jan to Feb
Oct to Dec
(except 2040s)
flow increases – Jun to September
(except 2040s)
highest flow – 2020s
lowest flow – 2040s

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Impacts of precipitation change on stream flow

Impact of Water availability (seasonal and annual analysis)

Season	Average Water Availability at basic period (mm)	Future percentage change in water Availability (relative to the base period)			
A2 scenario analysis					
	2000s_A2	2010s_A2	2020s_A2	2030s_A2	2040s_A2
pre monsoon	139	-23.31	-20.80	-1.25	24.95
monsoon	177	21.14	44.27	36.86	15.54
post monsoon	146	-6.49	-21.68	-38.05	-43.01
Annual	462	-0.98	3.81	1.67	0.18
B2 scenario analysis					
	2000s_B2	2010s_B2	2020s_B2	2030s_B2	2040s_B2
pre monsoon	137	-22.19	-13.47	7.35	36.07
monsoon	182	17.05	37.84	33.70	15.42
post monsoon	148	-5.85	-22.83	-37.88	-42.76
Annual	466	-1.70	3.60	3.33	3.07

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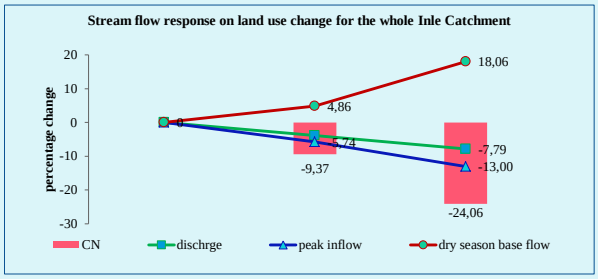
Impacts of land use change on stream flow



Land use type	2010 LU1	2030 LU2	% change	2050 LU3	% change
CN	63.14	57.22	-9.37	47.95	-24.1
Discharge (Mm^3)	1438.1	1383.3	-3.81	1326.1	-7.8
peak inflow(m^3s^{-1})	163.8	154.4	-5.74	142.5	-13.0
dry season base flow(Mm^3)	414.3	434.4	4.8	489.1	18.0

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New finding - 1

Annual precipitation change for future scenarios A2 and B2

% change (relative to 2000s)	2010s	2020s	2030s	2040s
annual % change, A2	(-0.1) – (+0.1)	3.2 – 4.8	2.0 – 5.3	1.2 - 2.5
annual % change, B2	(-0.1) – (-0.2)	5.0 – 6.0	3.1 – 4.1	4.5 - 5.5

(a) Impact of precipitation change on stream flow (A2, B2 scenarios)

Annual water availability change for future scenarios A2 and B2

% change (relative to 2000s)	2010s	2020s	2030s	2040s
% change, A2	-0.98	3.81	1.67	0.18
% change, B2	-1.7	3.6	3.33	3.07

Seasonal water availability change for future scenarios A2 and B2

% change (relative to 2000s)	2010s	2020s	2030s	2040s
Monsoon , A2	21.14	44.27	36.86	15.54
Post Monsoon, A2	-6.49	-21.68	-38.05	-43.01
Monsoon , B2	17.05	37.84	33.70	15.42
Post Monsoon, B2	-5.85	-22.83	-37.88	-42.76

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New finding - 2

(b) land use change impact on stream flow for scenario LU1, LU2, LU3

Land use type	LU1-LU2(% change)	LU1-LU3(% change)
CN	-9.37	-24.1
Discharge (Mm^3)	-3.81	-7.8
Peak inflow(m^3s^{-1})	-5.74	-13.0
dry season base flow(Mm^3)	4.8	18.0

(c) Impact of precipitation and land-use change impact on stream flows

Annual water availability change for future scenarios

% change	2010s	2020s	2030s	2040s
LU1A2	-0.43	3.10	0.84	-0.03
LU2A2	-0.69	3.06	0.82	-0.04
LU3A2	-0.79	2.97	0.77	-0.07
LU1B2	-0.55	3.74	3.32	3.03
LU2B2	-0.79	3.70	3.30	3.02
LU3B2	-0.89	3.60	3.25	2.99

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