Toward Watershed Resilience Through Climate Change Mitigation and Adaptation :

Case Study of Singkarak Watershed, West Sumatra - Indonesia

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OUTLINE

1. Watershed and climate change
2. Description on Singkarak watershed
3. Impact of change in rainfall and landuse into water resource in Singkarak watershed
4. Community role toward watershed resilience
5. Lesson learned and input for policy maker for Singkarak watershed management toward climate resilience watershed

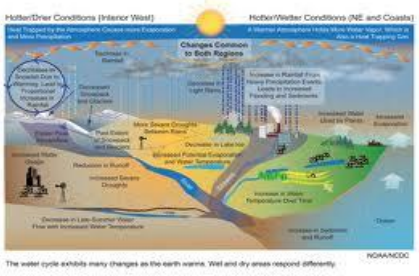
WATERSHED AND CLIMATE CHANGE

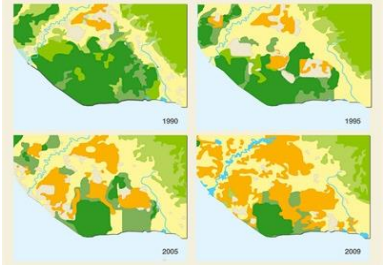
WATERSHED FUNCTIONS

Hydrological :
- Collect water
- Storage of water
- Discharge of water

Ecological :
- Chemical reactions
- Habitat for flora and fauna (biological element of ecosystem)

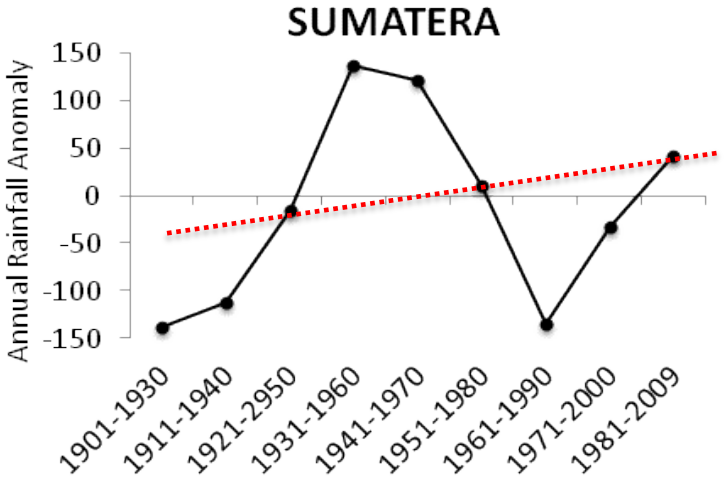
CLIMATE & LANDUSE CHANGE



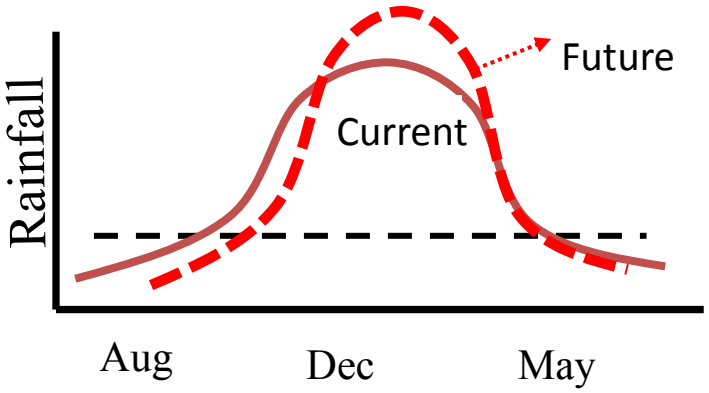


WATERSHED AND CLIMATE CHANGE

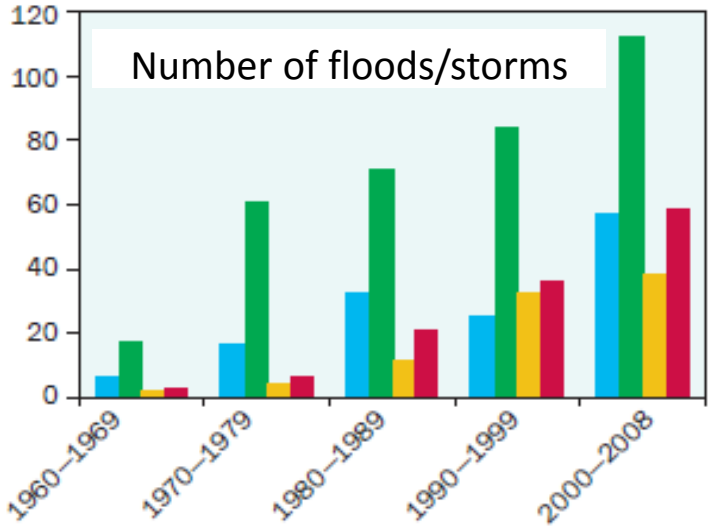
Climate change
- Change in rainfall variability
- Change in rainfall pattern
- Change in rain season
- Increase ‘extreme’ event



Source: Faqih, 2012



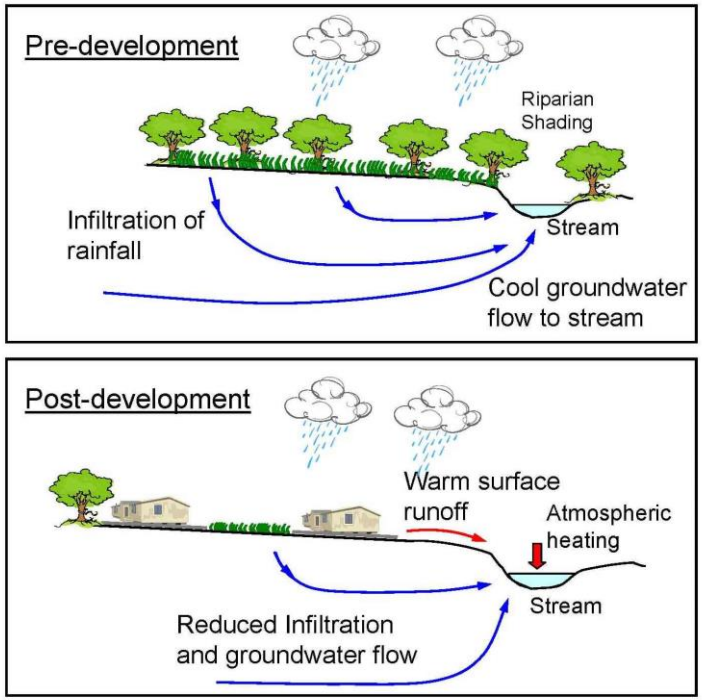
Source: Boer, 2013

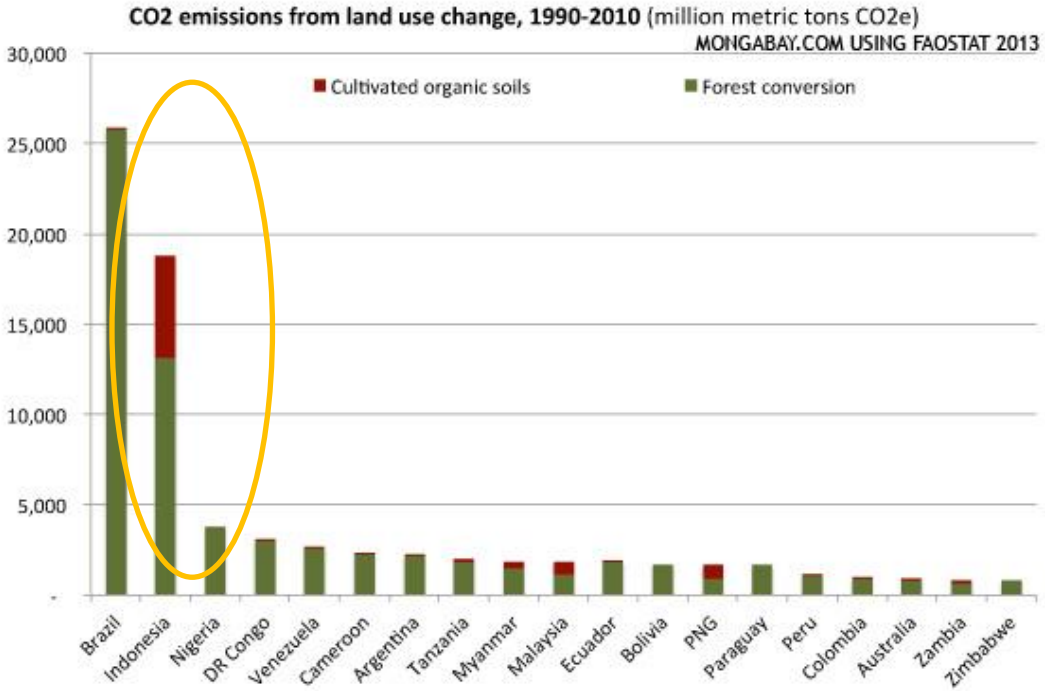


WATERSHED AND CLIMATE CHANGE

Land use change

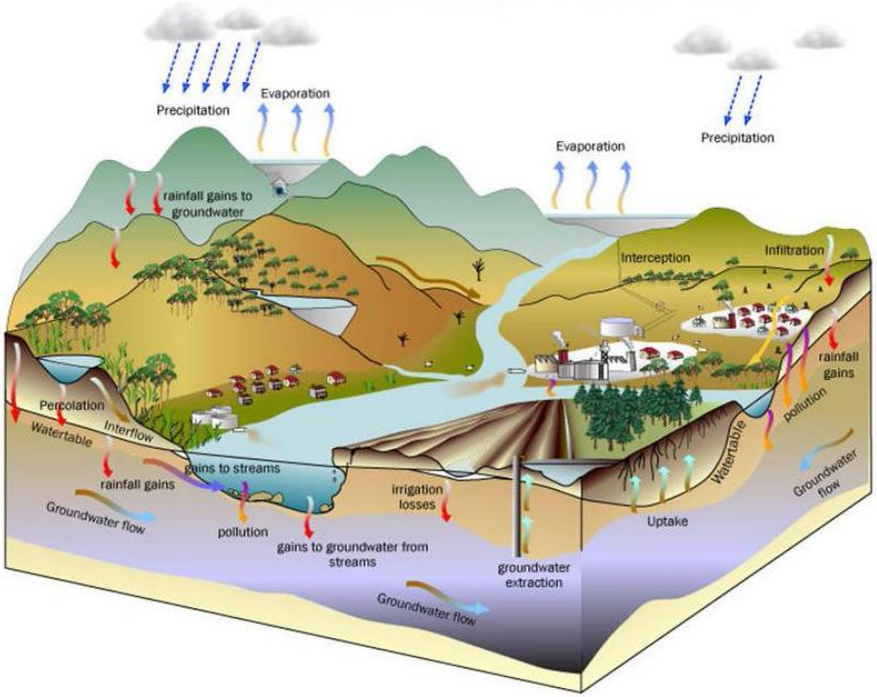
- Increase drainage
- Soil compaction
- Change in watershed ecosystem
- CO_2 emission





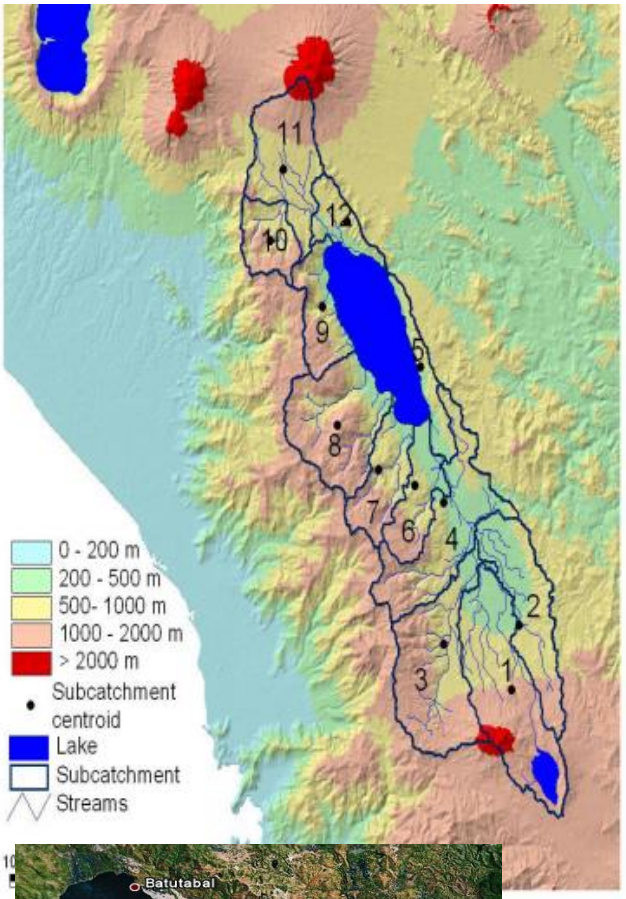
WATERSHED AND CLIMATE CHANGE

Sustainable watershed management



Watershed resilience toward climate change

SINGKARAK WATERSHED



- Located in West Sumatra province
- Administrative : two districts (Solok & Tanah Datar)
- Singkarak watershed area ~ 1135 km^2
- Lake area ~ 108 km
- Population ~ 440,000 inhabitants
- 6 major rivers into the lake & 1 river outflow
- Intensive upland agriculture & fishing ~ 70%
- Forest cover 15% of western part of the basin
- Rainfall (1990 – 2009) ~ 1700 – 3200 mm/y

Singkarak lake provides :

Local endemic fish ~
ikan bilih

SINGKARAK WATERSHED

- The region is a rain-shadow area which usually dry and uncertainty of rainfall

- The shift of rainfall pattern in Singkarak ~ indication of climate change

Period	A	M	J	J	A	S	O	N	D	J	F	M
1951-1975												
1976-2000												
1976-2003												

Western part of Sumatra : max rain ~ nov & dec, min rain ~ jul & aug

Using Schmith-Fergusson of wet & dry month identification

	dry month: < 60 mm
	humid month : 60 - 100 mm
	wet month: > 100mm

Sumber : Febriamansyah, 2013

SINGKARAK WATERSHED

- Fluctuation of lake water level 1999 – 2009 ~ 3,5 m :
  impact to Ombilin river outflow (2 m^3/dt rain season, 6 m^3/dt dry season – after HEPP operation) ~~ decrease 30% water for downstream paddy field

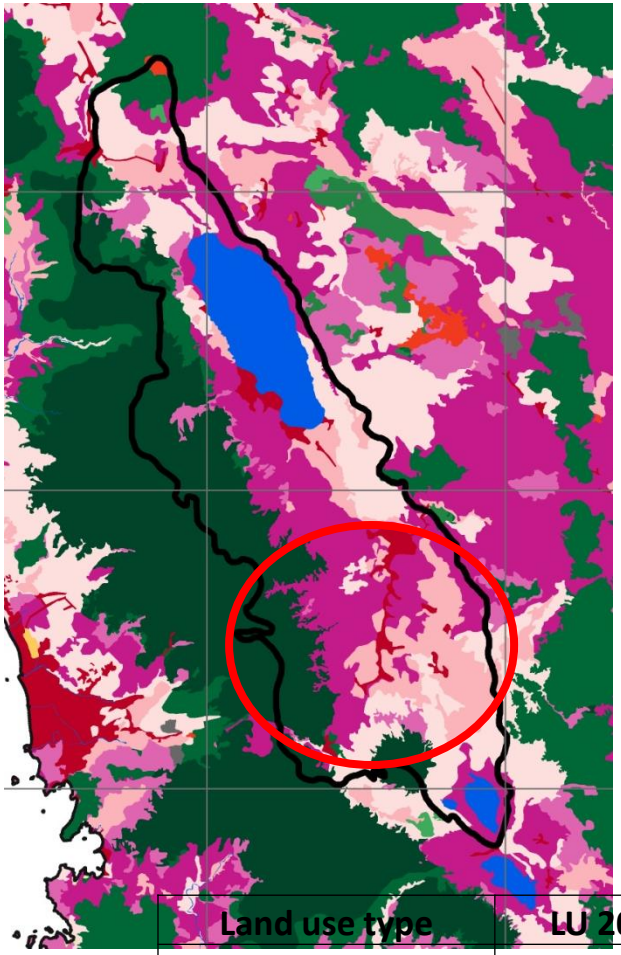
- Erosion & sedimentation due to highly intensive agriculture and land use change in the upper watershed eg. Erosion rate Sumani sub-catchment ~ 46 – 47 ton / year ~~ lake water quality

SINGKARAK WATERSHED

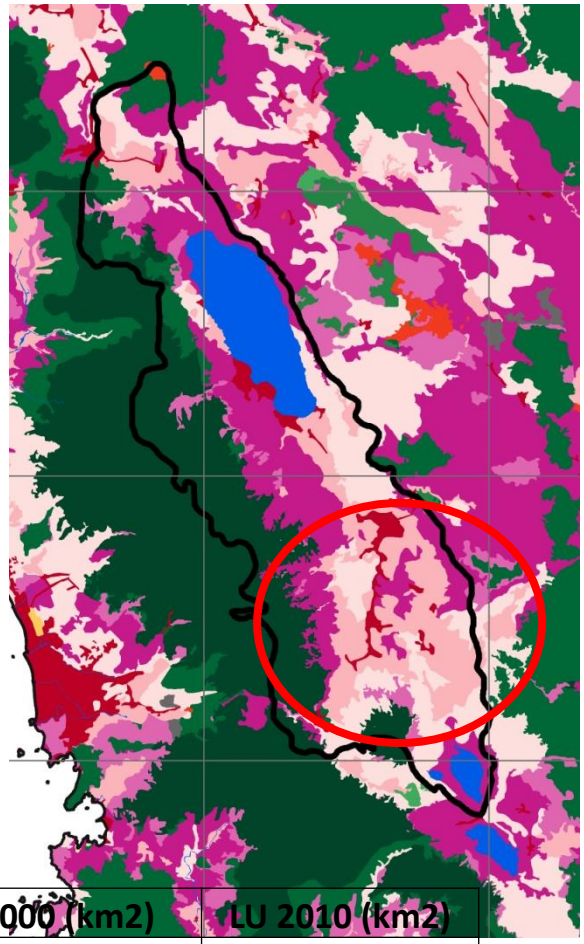
Critical land (2010)

Critical land ~ 272 km^2 (2010)
~ 23% total area watershed

2000



2010



Land use type	LU 2000 (km2)	LU 2010 (km2)
Forest	316,48	309,85
Shrubs	37,10	42,07
Mixed garde	1,77	0,11
Houses	36,59	36,59
Bare land	2,58	2,72
Water body	120,55	120,55
Dry agriculture field	487,68	436,72
Paddy field	145,71	199,85

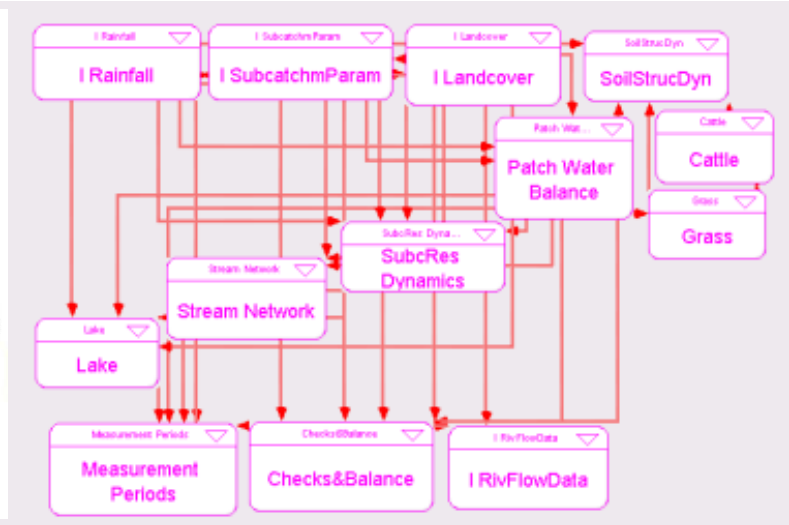
IMPACT OF LAND USE CHANGE TO SINGKARAK WATER RESOURCE

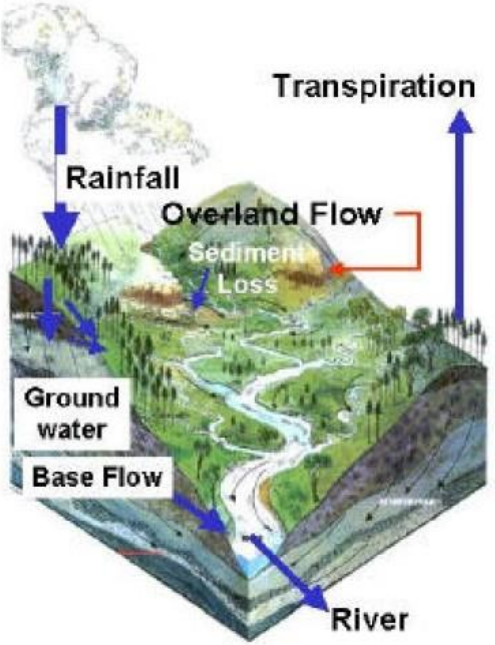
- Using GenRiver model (developed by World Agroforestry Center – South East Asia Program) to assess the effect of LU change and Rainfall

- GenRiver is a distributed process-based model that extends a plot- level water balance to subcatchment level.

- It was developed for data -scarce situations and is based on empirical equations and can be used for as a tool to explore our understanding of historical changes in river flow due to land use change.

$$P = E + \Delta S + Q$$



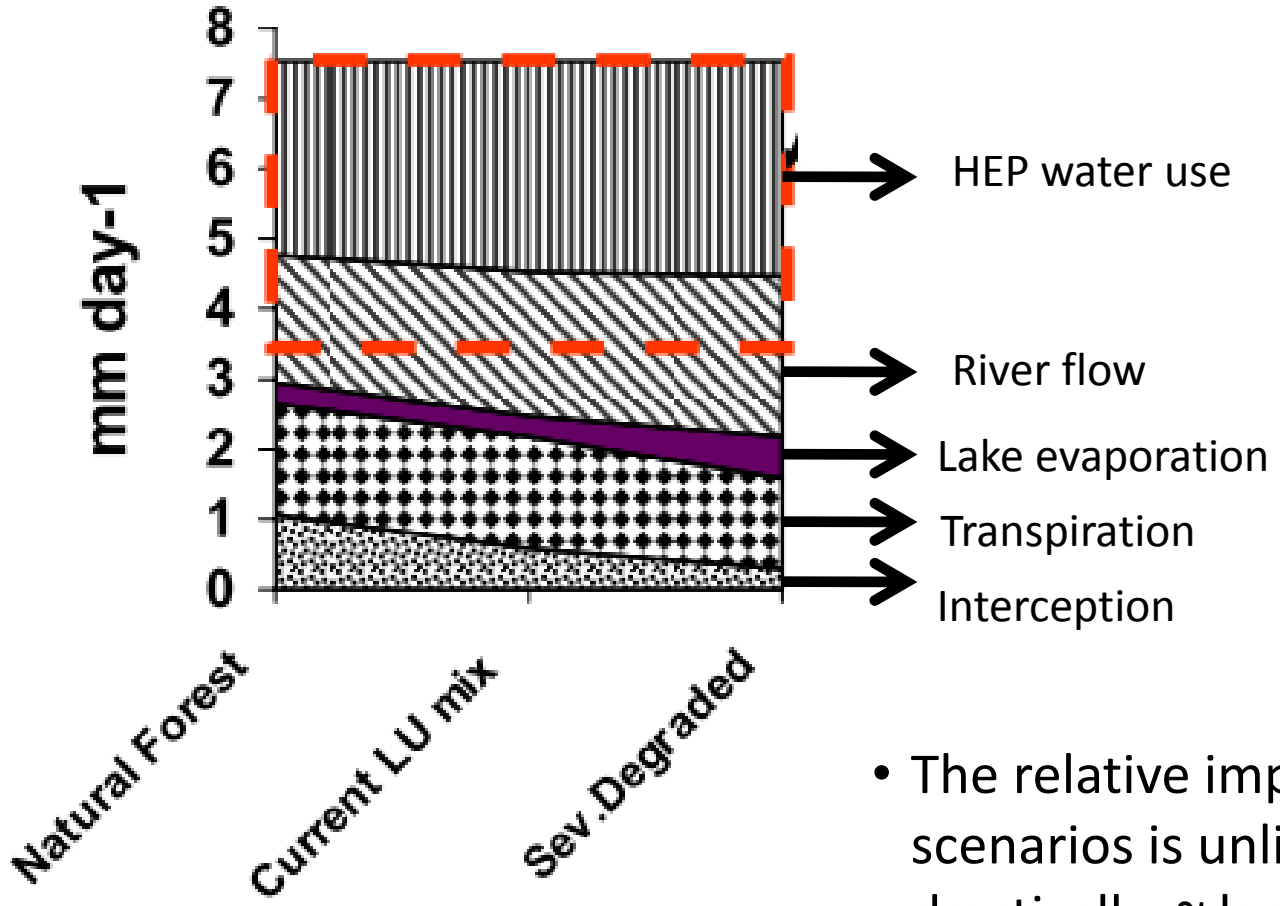


GenRiver sectors :

1. Water balance
2. Stream network
3. Land cover
4. Sub-catchment paramaeters

IMPACT OF LAND USE CHANGE TO SINGKARAK WATER RESOURCE

- Genriver result of various scenarios



- The relative impact of LU change scenarios is unlikely to change drastically ~ large basin area
- The effect of LU change in smaller scale : details on sub catchment

IMPACT OF LAND USE CHANGE TO SINGKARAK WATER RESOURCE

What can we learn from GenRiver simulation ?

- LU change in smaller scale basin can have considerable effect on river flow

- More forest will reduce river flow during the rainy season and will increase river flow during the dry season ~ flooding and drought risk

Land use type	Land use area (Ha)			
	thn 2007	skenario 1	skenario 2	skenario 3
Shrubs	831.2	882.93	588.62	76
Forest	3151.8	1765.86	1471.55	1570
Mixed garden	1088.5	2001.308	588.62	3500
Houses	146.9	294.31	1765.86	200
Paddy field	487.4	588.62	1177.24	350
Agriculrural land	180.4	353.172	294.31	190

Source : Nurwindah, 2009

Scenario 1 : 30% forest decrease from 2007
Scenario 2 : 30% forest decrease form scenario 1 (smallest forest area)
Scenario 3 : increase rate based on tren of LU change trend

IMPACT OF LAND USE CHANGE TO SINGKARAK WATER RESOURCE

What can we learn from GenRiver simulation ?

Bulan	Q (m^3/detik)			
	th 2007	skenario 1	skenario 2	skenario 3
Januari	10.107	10.155	10.377	10.122
Pebruari	7.679	7.813	8.121	7.819
Maret	4.719	4.757	4.907	4.750
April	2.358	2.251	2.191	2.250
Mei	1.649	1.640	1.728	1.640
Juni	1.795	1.914	2.221	1.908
Juli	0.934	0.913	0.676	0.923
Agustus	0.530	0.517	0.421	0.512
September	1.527	1.553	1.584	1.550
Oktober	0.492	0.420	0.189	0.430
Nopember	1.216	1.311	1.687	1.262
Desember	4.026	4.076	4.234	4.062
Total	37.032	37.321	38.336	37.228
Qrata	3.086	3.110	3.195	3.102
Qmaks	10.107	10.155	10.377	10.122
Qmin	0.492	0.420	0.189	0.430
Qmaks/Qmin	20.536	24.179	54.937	23.544

Source : Nurwindah, 2009

Scenario 2 : less forest

- Highest total river flow

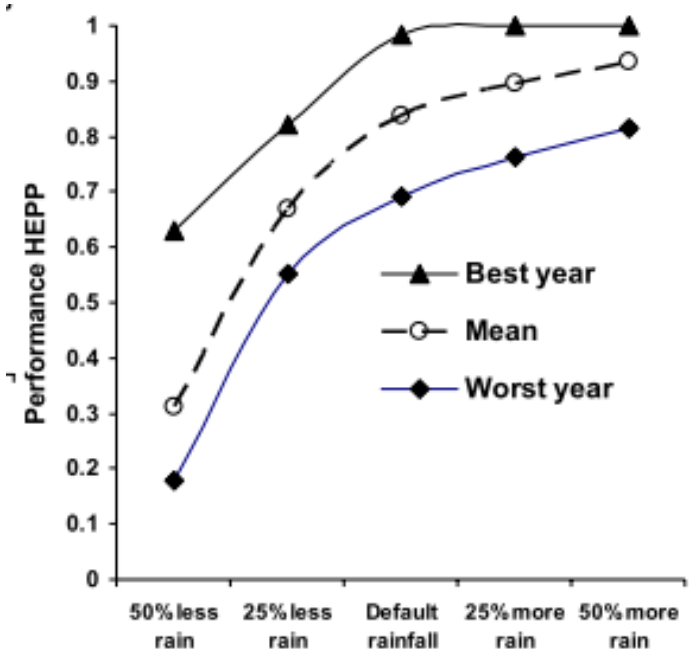
- Highest ratio Qmaks/Qmin ~ LU change will reduce infiltration rate ~ risk of flooding and drought

IMPACT OF LAND USE CHANGE TO SINGKARAK WATER RESOURCE

What can we learn from GenRiver simulation ?

- Land-use change—particularly increased effective impervious area—could potentially have greater effects on the erosion , sedimentation, flooding, land stability, water quality, and aquatic habitat

- Climatic variation influences performance of HEP more than LU change in the basin



The rainfall scenario based on proportion to the default rainfall

COMMUNITY ROLES TOWARD WATERSHED RESILIENCE

- Resilience : the ability of a social or ecological system to absorb disturbances while reaining the same basic structure and ways of funtioning, the capacity of self-organization and the capacity to adapt to stress and change (IPCC)

- Watershed resilience : how to reduce the vurnerability and risk of climate change impacts on watershed ~ prepare for climate change in the watershed

COMMUNITY ROLES TOWARD WATERSHED RESILIENCE

- Farmers in Paninggahan village : emission reduction through agrofrestry joining Voluntary Carbon Market (VCM) scheme

- Farmers practices Assisted Natural Regenarion (ANR) in imperata grassland before planting the tree ~ land rehabilitation

Imperata grassland surrounding Singkarak Lake

Found many natural (economic valuable) seedlings in between imperata

Cinnamon seedling under the imperata

Pineapples under the imperata

COMMUNITY ROLES TOWARD WATERSHED RESILIENCE

Protect natural tree seeding and press the imperata

Imperata dried out – can stay for 2 months wihout management :
provide soil moisture
Imperata died and tree will grow

COMMUNITY ROLES TOWARD WATERSHED RESILIENCE

Natural accuring trees and planted trees grows fast :
3 years ~ 3 – 4 m == quick gains in carbon sequistration
ANR : a climate resilient practice for carbon sequestration

COMMUNITY ROLES TOWARD WATERSHED RESILIENCE

- 30.65 ha of ANR site = VCM site in Paninggahan village through VCM facilitated by CO2 Operate BV (The Netherlands)

Baseline : Carbon stock in VCM sites (Paninggahan village)

Imperata grassland

No	Plot	Total carbon (ton c/ha)
1	BP P1	25.2
2	BP P2	4.9
3	TD P3	4.0
4	TD P7	20.9
5	TM P10	4.3
	Total	**59.4**
	Average	**11.9**

Shrubs

No	Plot	Total carbon (ton c/ha)
1	BP P3	17.9
2	BP P4	23.0
3	TD P4	8.6
4	TD P6	30.5
5	TM P7	23.3
6	TM P9	38.4
	Total	**141.7**
	Average	**23.6**

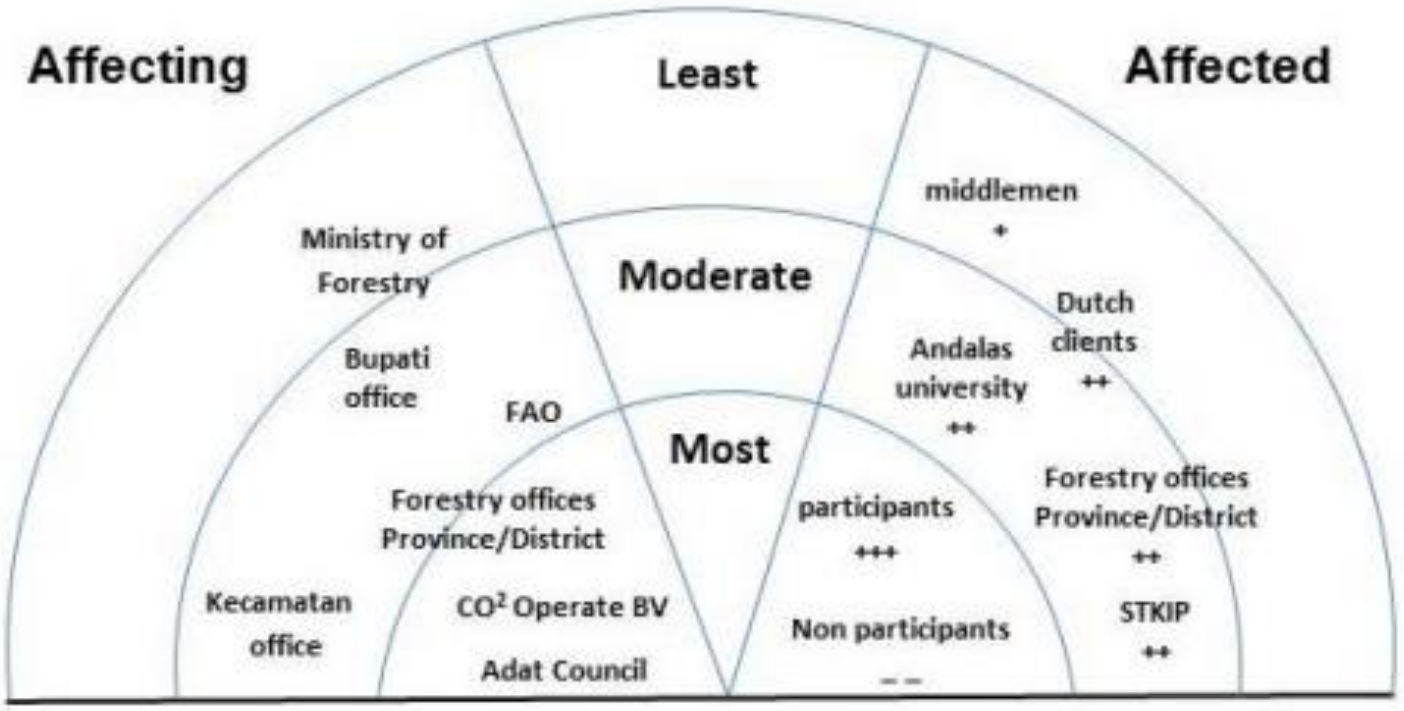
COMMUNITY ROLES TOWARD WATERSHED RESILIENCE

Comparasion with other carbon stock related research :

Yuniawati (2011) : Carbon stock on 2,3, 4 years old of Acacia Crassicarpa which grow on the peat land range to 12 – 36 ton C/ha

Relatively have the same range of carbon stock from imperata and shrubs land with range of 11 – 23 ton C/ha **~ have potential carbon stock with better soil and tree managements**

COMMUNITY ROLES TOWARD WATERSHED RESILIENCE



Rainbow diagram with stake holders affecting or being affected by landscape restoration (Source : Burgers, et al 2014)

LESSON LEARNED AND INPUT FOR POLICY MAKERS

- Details and specific study on response of hydrological funtion of Singkarak watershed under climate change projection

- Combination scheme that generate short term benefit (such as carbon payment or short rotation crops) and longer economic benefit (such as harvestable agroforestry trees) can be an alternative and effective part of carbon mitigation to improve watershed resilience toward climate change

- Sustainable water managament will enhance the waterhed resilence toward climate change

- Continuation of broad restoration effort lead to broad rural development

- The strong and well-defined customary and convention influenced the VCM institutional set up


THANK YOU
TERIMA KASIH