Land use change, climate change and river basin management: a preliminary study in small river basin of Batang Paninggahan, West Sumatra, Indonesia

Rudi Febriamansyah[#], Yuerlita, Sugeng Nugroho

[#]Faculty of Agriculture, Andalas University,

email: r_febriamansyah@agr.unand.ac.id

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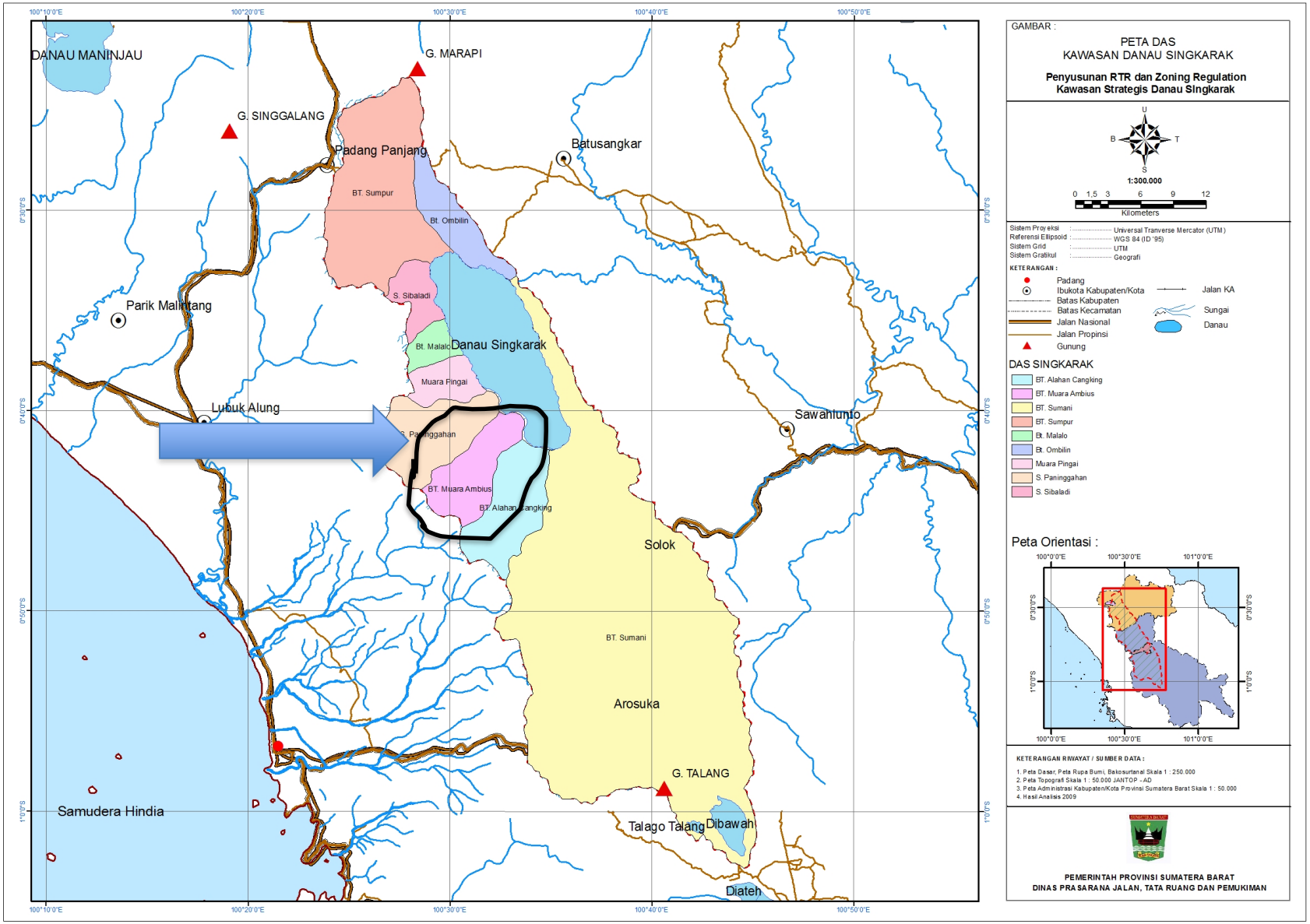
The research site



Introduction

Problems in the research site

- **Degraded catchment area**
- **Expansion of mixed plantation in the upstream catchment**
- **Fluctuation of water level at Lake Singkarak – influencing the ecosystem of *Bilih* fish**
- **The decreasing of water availabilities for rice cultivation, especially in dry season**
- **Upstream and downstream issues**

Main goal of research: to develop a DSS platform that integrates social, economic and hydrological aspects to contribute significantly to the management of river basin and improving community welfare.

Specific goal of this preliminary study (first step): to explore the condition of river basin from socio, economic and eco-hydrological aspects that are important to identify specific management problems in the basin and find potential alternatives for the development of watershed management model.

Research Methods

- PRA, indepth interview and questionnaire survey
- Secondary data analysis from:
  - Satelite data, climatic recorded data, and othersAnalisa deskriptif untuk sosial ekonomi dan ekologi
- Quantitave analysis of hydrology

Result and Discussion

A. Overview of the research site

- Paninggahan subbasin is located in Nagari (or Village) Paninggahan, District of Solok, West Sumatera. Consisted of six jorong (hamlet).
- Area of Paninggahan subbasin is about 57.70 Km^2, with the length of river of about 15.24 Km.
- Luas DAS paninggahan adalah 57,70 km^2
- Average temperature: 24.3^{O}C – 25.4^{O}C,
- Domestic water needs comes from springs and river
- Land use of the subbasin:

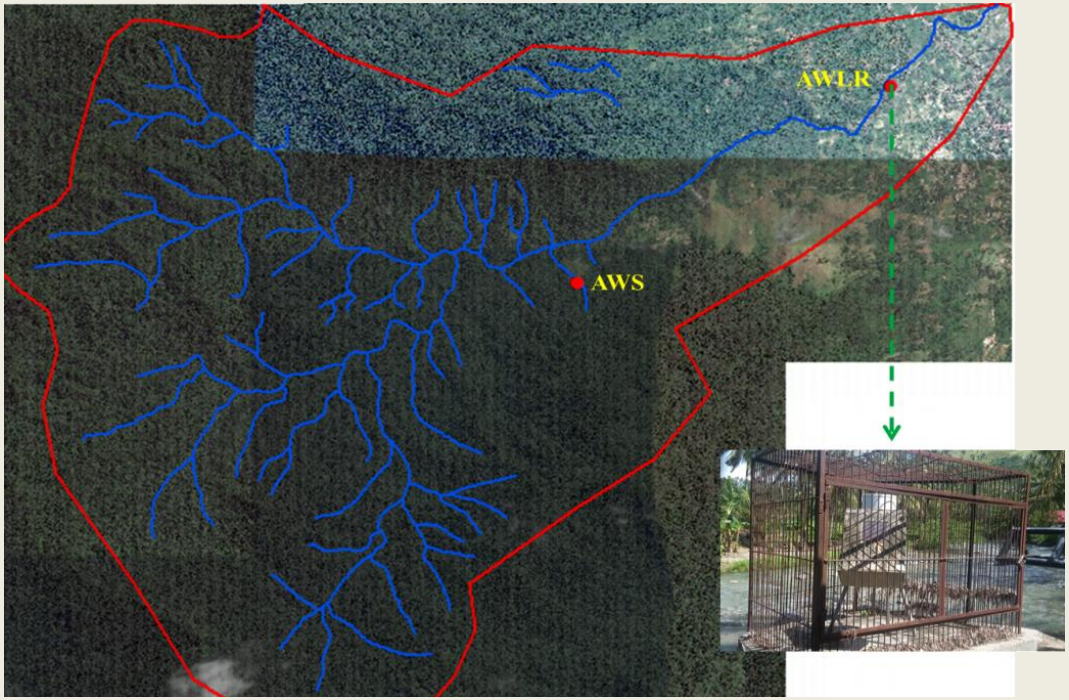
No.	Land uses	Ha	%
1	Settlement	104.70	1.1%
2	Schools	590.89	6.3%
3	Mosques & Public fac.	0.23	0.0%
4	Paddy field	499.22	5.3%
5	Mix garden	17.27	0.2%
6	Plantation (coffee etc.)	23.90	0.3%
7	*Semak* (shrubs)	1,055.10	11.3%
8	Forest	6,198.25	66.3%
9	Water body (river etc.)	852.52	9.1%
	TOTAL	9,342.08	100%

Socio-economic profiles

- Majority are rice farmers and mixed plantations in their agroforest area (called *parak*)
- Around 15% HH also working as fishermen of *bilih* fish (an endemic) in Lake Singkarak
- Some paddy field area in two main irrigation systems in this subbasin might be cultivated for three times of rice/year, some others could be only twice or even one rice season only.
- Averagely, from one harvest of rice, farmers may earn income for about 14 -20 million rupiah/ha/season.
- Farmers still use chemicals fertilizers and also chemical pesticides
- In their parak: they have cloves, *petai*, pinang, durian and fruit crops.

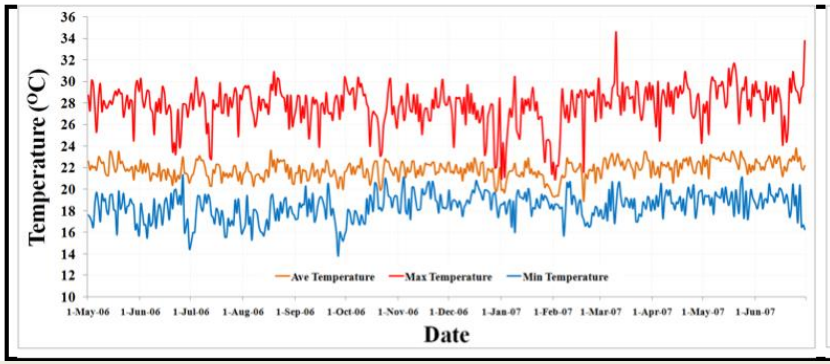
Climatic profiles

Earlier in 2005, there are AWS and AWLR in this subbasin, but could only be operated for about one year, from May 2006 to June 2007

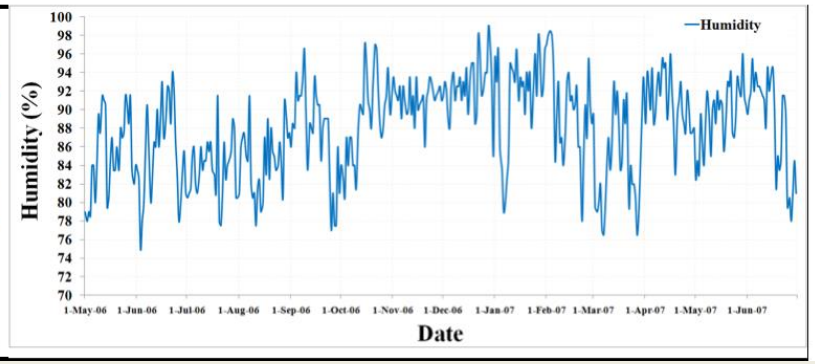


Position of AWS and AWLR at Paninggahan subbasin

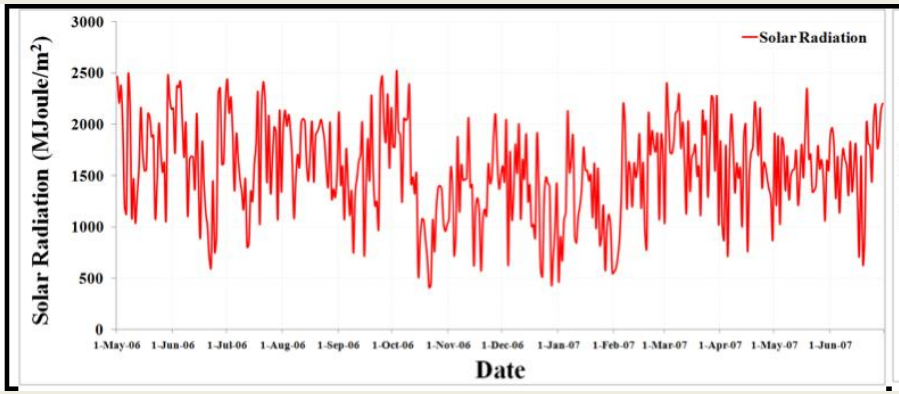
Climatic recorded data from May 2006 - June 2007



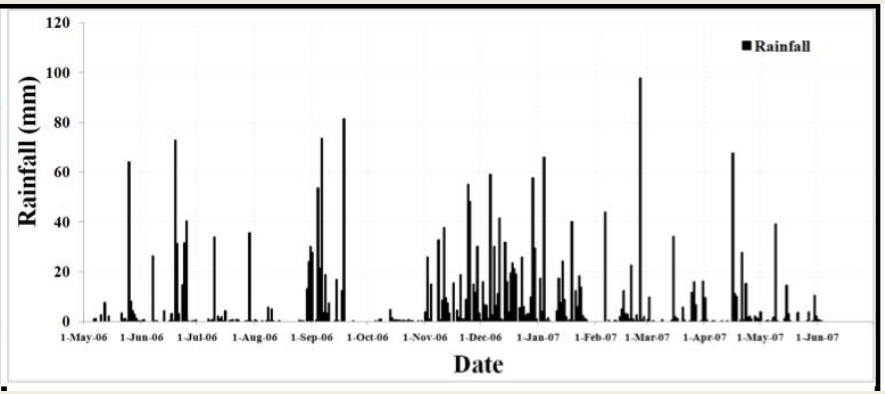
(a) Temperature



(b) Humidity

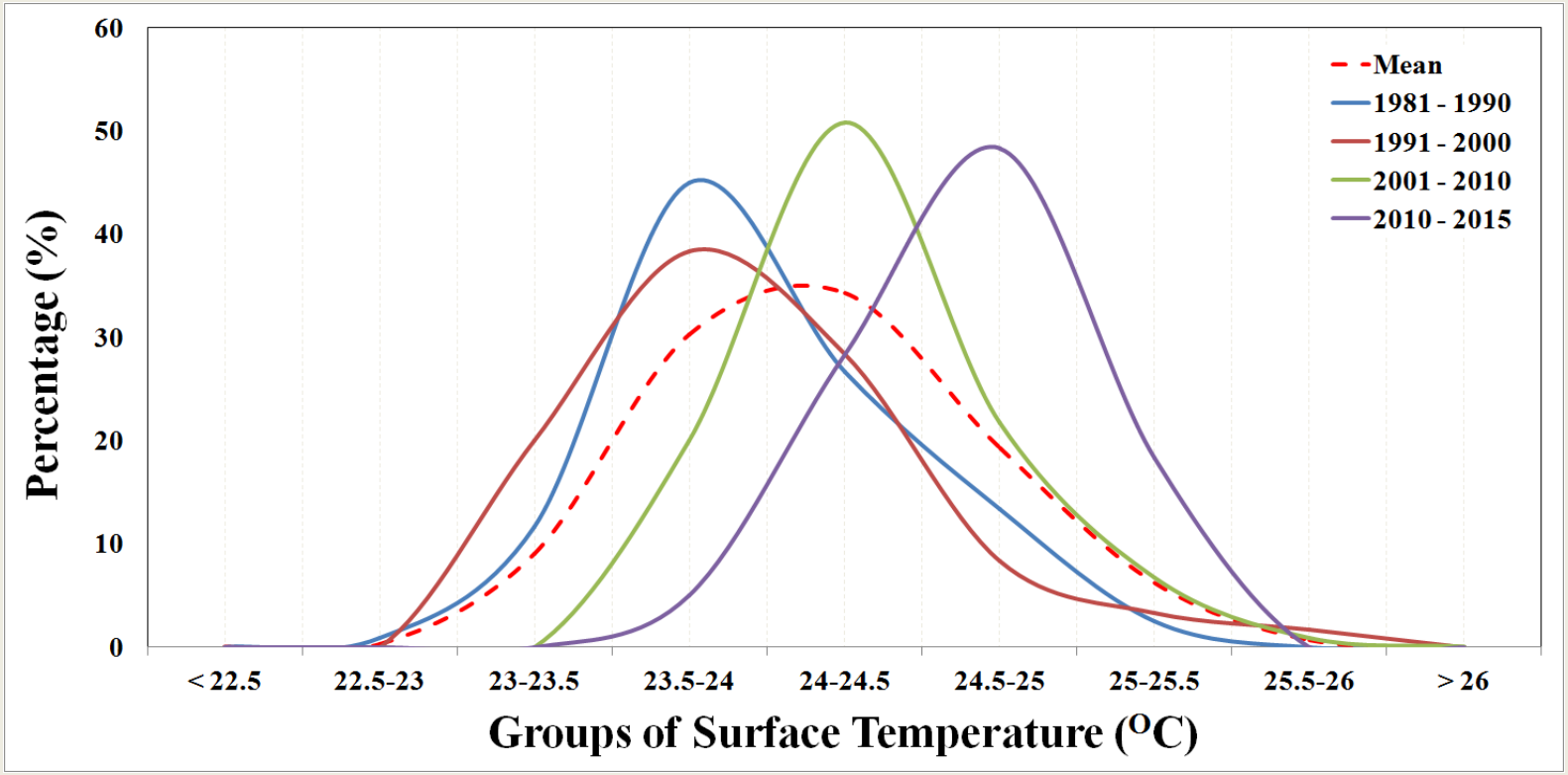


(c) Solar Radiation



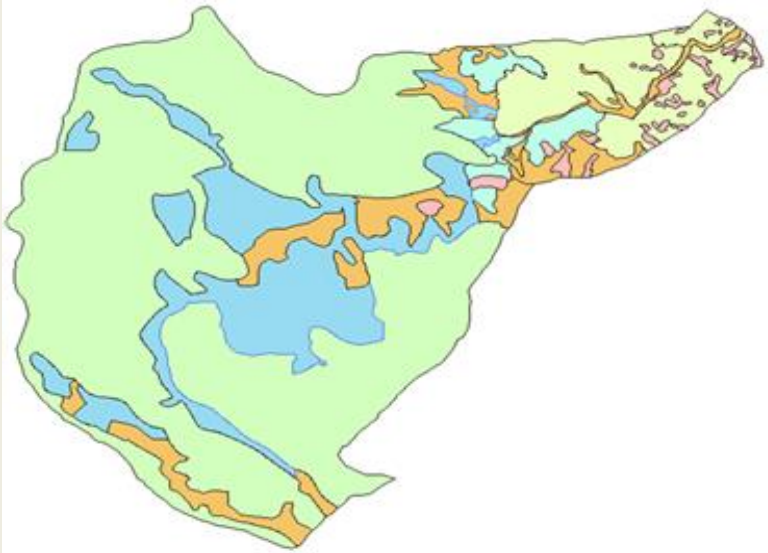
(d) Rainfall/Precipitation

Climatic analysis

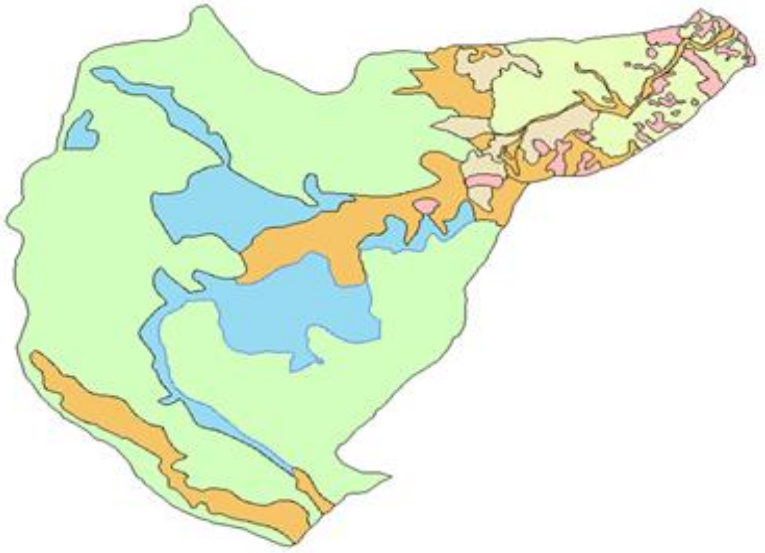


Shifting pattern of decadecal period of temperature in Paninggahan, from 1981-2015

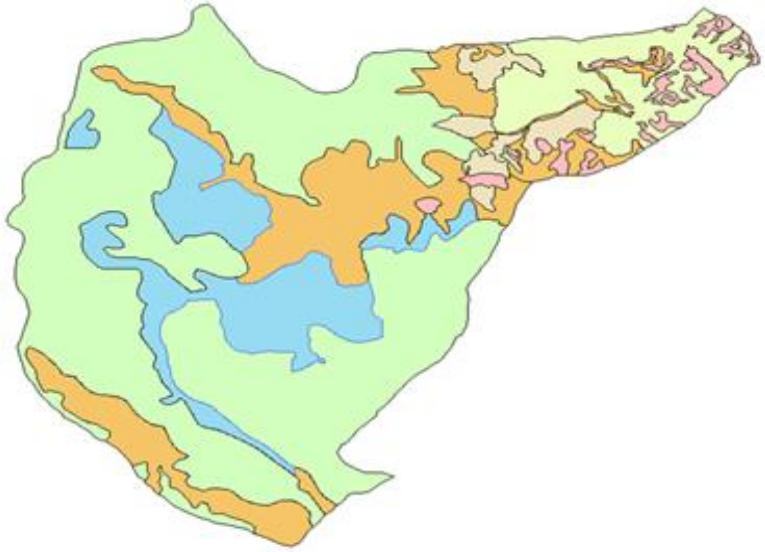
Land use changes



Land use1992



Land use 2002



Land use 2007

Legend

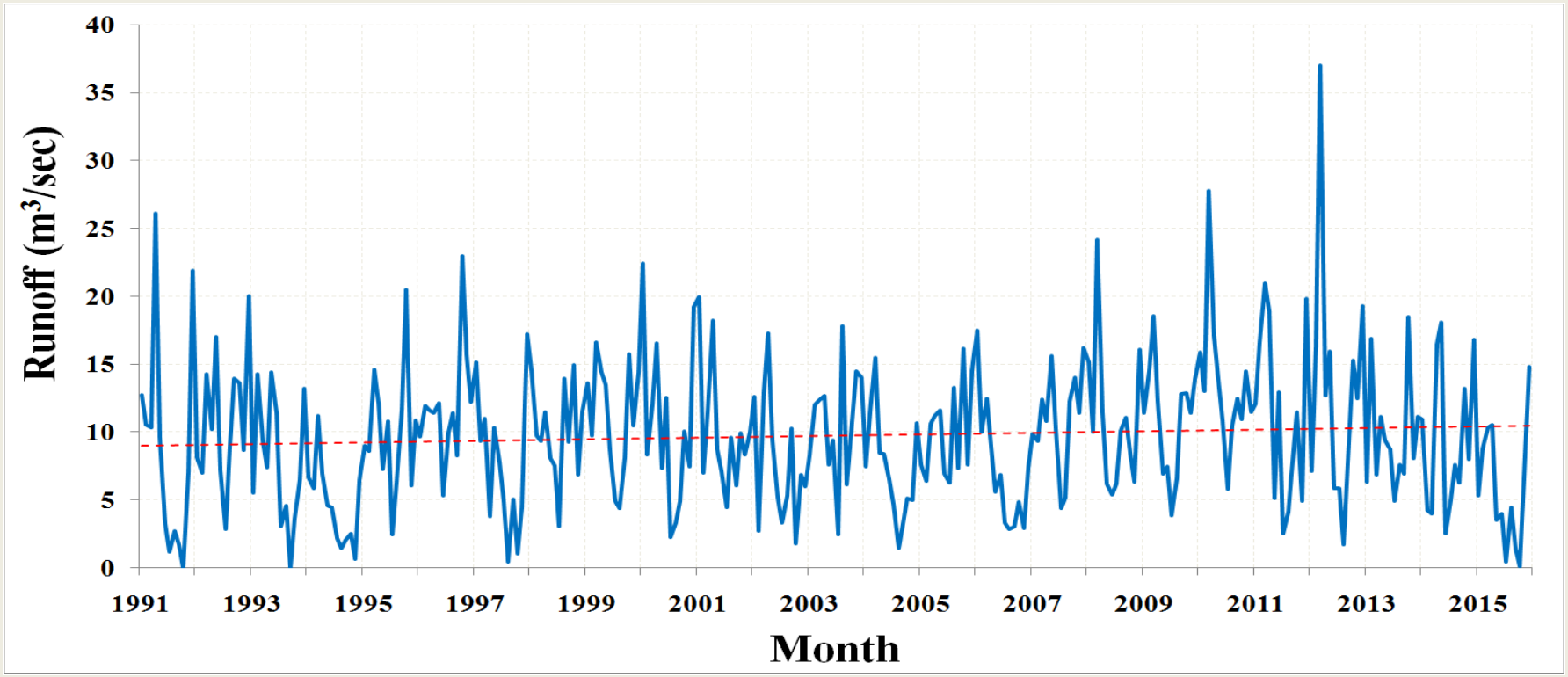
- Scrubs
- Forest
- Mix Plantations
- Settlement
- Rice Fields
- Dry Land Crops

Land use changes

No.	Land Use	1992		2002		2007		Changes 1992-2007 (%)
		Ha	(%)	Ha	(%)	Ha	(%)	
1.	Shrubs	998.31	16.96	823.99	14.00	831.18	14.12	-2.84
2.	Forest	3544.27	60.21	3481.65	59.15	3151.82	53.55	-6.67
3.	Mix plantations	556.76	9.46	782.13	13.29	1088.48	18.49	9.03
4.	Settlement	94.93	1.61	142.31	2.42	146.90	2.50	0.88
5.	Rice-fields	511.78	8.69	473.36	8.04	487.43	8.28	-0.41
6.	dryland crops	180.16	3.06	182.78	3.11	180.41	3.06	0.00
	Total area	5886.22	100	5886.22	100	5886.22	100	0.0

The changes of water resources

- Further hydrology analysis could not be done from this limited recorded data
- This study then uses the data series of climatic data from http://chg.geog.ucsb.edu/data/chirps/index.html and apply CHIRPS model to generate new rainfall runoff regression model. After implementing such the validation test, this study has obtained new rainfall-runoff regression model with R^2=76.7%.



Predicted monthly discharge flow of Paninggahan river from 1991 to 2015

The water resources management

Irrigation systems in Paninggahan subbasin

No.	Name of Irrigation systems (*Bandar*)	Management status	Location (at Jorong)	Area (ha)
1	Rotan	Noformal management	Sabarang	20
2	Pauh	GP3A *	Parumahan	275
3	Batu Basih	No formal management	Sabarang	n.a
4	Lubuk Panjang	No formal management	Sabarang	n.a
5	Batu Puruih	No formal management	Parumahan	n.a
6	Bandar Bunian	P3A **	Sabarang	97
7	No name	No formal management	Parumahan	n.a

*GP3A is a collective of irrigation water user associations

**P3A is one irrigation water user association

Semi technical irrigation systems in Paninggahan

Traditional irrigations system in Paninggahan

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WRM issues (1)

- In general, the availability of water resources in the Paninggahan River is sufficient for agricultural land in this area.
- But the potential for water deficit is caused by irregular planting times, especially during the dry season. The current rice fields located around all traditional irrigation systems like Bandar Rotan, Bandar Batu Basih and Bandar Lubuk Panjang face water shortages due to inadequate conditions of their irrigation infrastructures.
- This condition can threaten the existence of existing fields in the area. Evidently, some of the rice fields in the area have been abandoned by farmers and converted into mixed plantations for perennial crops (called *parak*).

WRM issues (2)

- Although most of traditional irrigation systems frequently faces water shortage and the destruction of their traditional irrigation infrastructures, they still able to overcome these problem by implementing their self-help traditions leaded by their local leaders, such as *Kepala Jorong* (Jorong headman) and their *Tuo banda.*
- Farmers in these traditional systems used to contribute money and their working time at each harvest or planting period for maintenance of their irrigation networks. The amounts of money are varies between Rp 10,000-15,000 per harvest period.
- It is in contrary with the Semi Technical Irrigation systems like in Bandar Pauh and Bandar Bunian, where the P3A and the GP3A used to depends on the assistance from government. They are lack of initiative for their self-help actions when they faced the problems on their irrigation infrastructures.

Conclusions: findings and further research agenda

- In general, at this preliminary staget, this study has identified all the data needed to develop a platform model for sustainable catchment management, ranging from ecohydrological aspects data, socio-institutional aspects, as well as the economic aspects of the resource.
- The result of ecohydrology aspect analysis in the form of the relationship analysis between climate and the availability of water resources is the main modeling study that will be used to predict changes of water availability in the future as a result of land use change in the upstream catchment area.
- Meanwhile, in the downstream area, changes in planting patterns and also the adjustment of planting season will also be applicable in the modeling of this subbasin management.

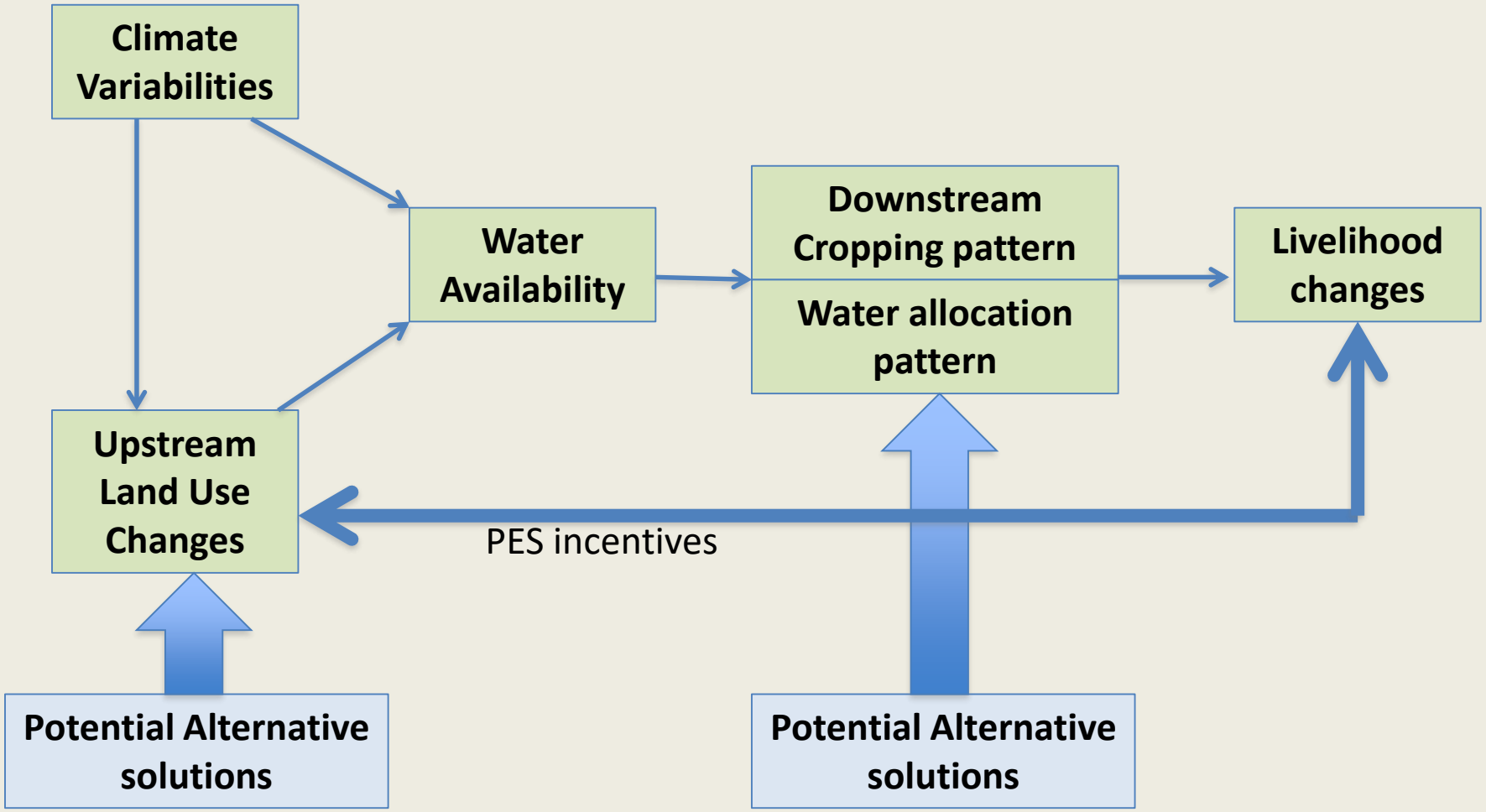
Conclusions (2)

- The exploration of interested parties in managing this sub-basin that includes local leaders and irrigation managers will be important in building a participatory model (following ***Ostrom's principles***).
- The simulation results of subbasin management models in digital form will be then discussed with all stakeholders to determine a number of sustainable subbasin management actions, which can ensure the availability of water for all economic activities of the community.

further research agenda

- Further study activities will be continued, especially to develop the simulation model of subbasin management and identifying alternative actions to be simulated in a digitally built model. The integrated model template will at least include sub-sub model:
  - The relationship model between upland land use and the availability of water in the river
  - The input-output relationship model of the whole agricultural system and integrate that into spatial modelling
  - The relationship model between the changes in cropping and planting season patterns and the availability of irrigation systems
  - The economic impact analysis of any solution alternatives
- WE ARE STILL DEVELOPING THIS PROPOSAL TO GET SUPPORT FROM DONORS

Integrated Basin Management Model: The Framework



THANK YOU VERY MUCH