Optimizing Marginal Land Productivity by Growing Sweet Sorghum for Bioenergy

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IAEA RAS5070-9003 Project Report From Indonesia

(Year-1 and 2 Progress Report - July 2017)

Background

- Indonesia is tropical country which is generally influenced by monsoon climate. It is characterized by high rainfall during rainy season and dry during the dry season, each of it is six months. So that it is potentially draught during the dry season.
- Soils are generally developed at mature stage and they are low fertility and acidic reaction in nature. In addition, the soils developed on the sloping land of mountainous area are shallow in depth as resulted from accelerated erosion.
- The abundant of mining activities might lead to land degradation and the formation of marginal land. In addition, mining activities under certain conditions may lead to the expose of heavy metals that resulting soil and water contamination in the mine area

- Fertile soil utilization is recommended for growing food crops, while unfertile soils that occupy the marginal land are utilized as for other crops production. Especially soils with the constraints of contamination of heavy metals are not used for food production.
- The development of bioethanol from sweet sorghum, that is now as a national priority program, is directed to use marginal lands so as not to disrupt food production.

Project Objectives:

- Study the addition of nitrogen fertilizer to Vertisol in the increase of sorghum productivity
- Utilizing land with shallow soil solum and sloping land for sorghum cultivation in bioethanol development
- Study the tailings of the gold processing unit and soils in mining areas for sweet sorghum cultivation

Research program

1. Nitrogen application on the Vertisol and it effect on the sorghum growth (CRP 16947) on 2016
2. Developing bioethanol using sweet sorghum stem juice on the marginal land, cooperating with Energy and Mineral Resources Research and Development Agency (2015-2019)
3. Utilization of the post gold mining land for growing sweet sorghum as feedstock of bioethanol production, funding from Ministry of Research, Technology and Higher Education program 2016-2018
4. All the conducted research used the seeds of sweet sorghum varieties of Samurai 1 and Samurai 2, as mutan varieties resulting from irradiation technique, BATAN

1. Study of Nitrogen fertilizer on marginal land

- Rate of urea application were 0, 30, 60, 90 kg/ha)
- On Vertisol developed from limestoneat with drought prone area, Yogyakarta
- Using 3 mutant varieties of sorghum (Pahat, Samurai 1 and Samurai 2)
- Plot size 4x5 m2, randomized block design with 3 replications

Field experiment

Result

Nitrogen application was significant for plant growth, but not for biomass weight

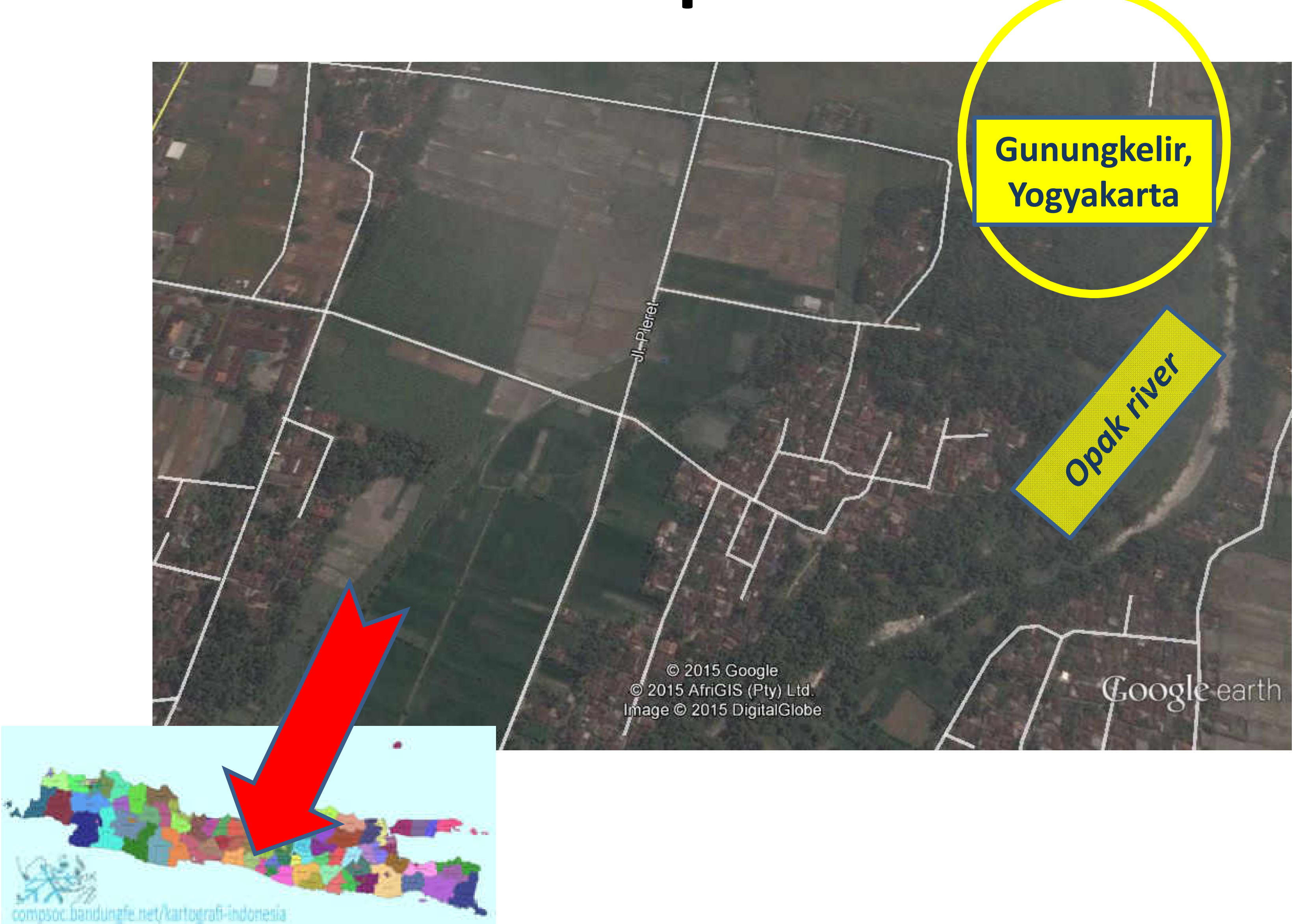
2. Developing bioethanol using sweet sorghum stem juice on the marginal land

Experimental station of bioenergy crops

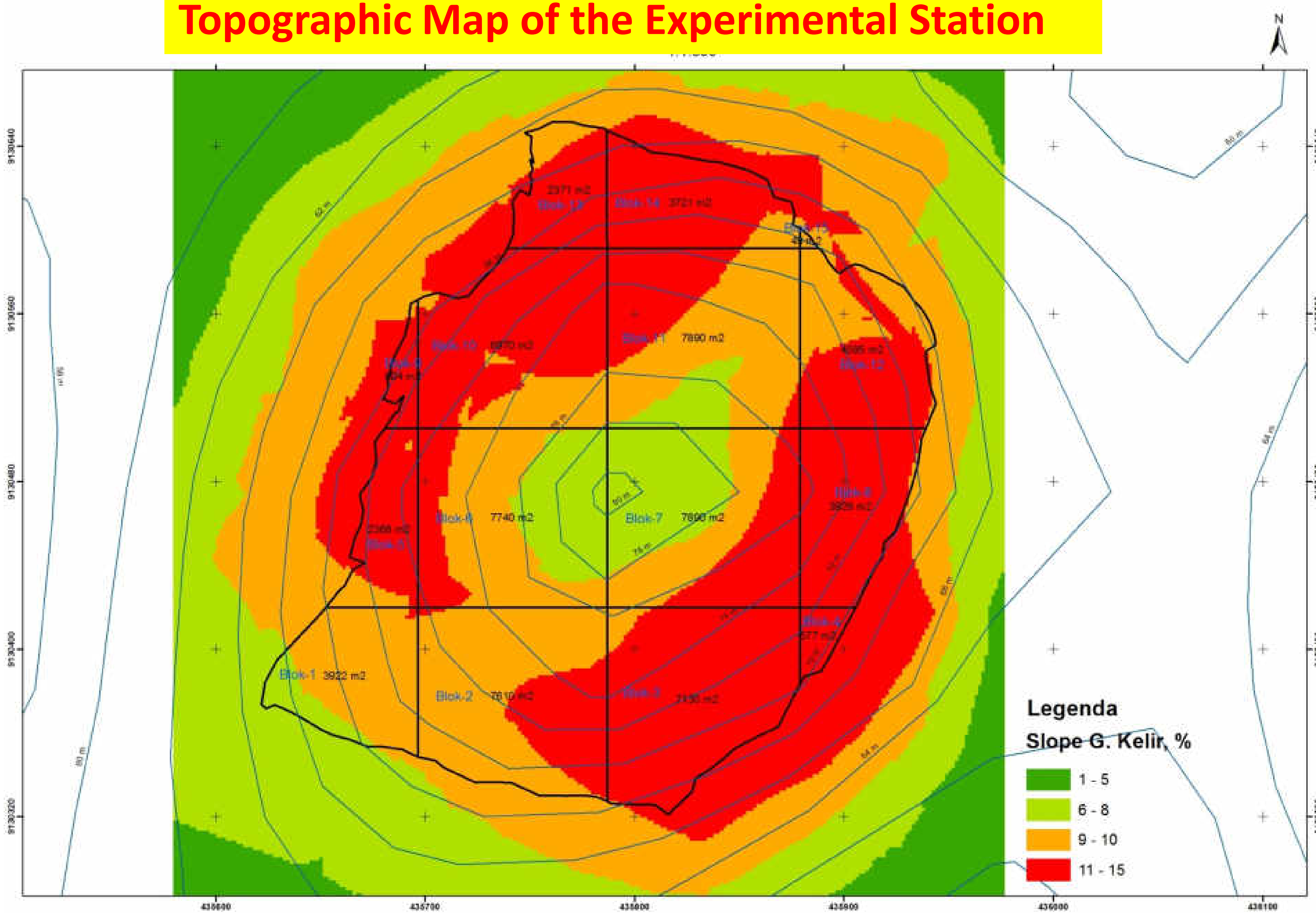
Land properties:

- **Steepslope**
- **Shallow depth soil**
- **Draught in dry season**

Location of the Experimental Station



Topographic Map of the Experimental Station



Cultivation of sweet sorghum

Results

- **Production of the sorghum stem in the marginal land is 30-40 ton/ha**
- **Water content is 70%**
- **Brix number $\geq$16%**
- **Potentially extracted juice is 50%**
- **Juice production is 15.000 sd 20.000 liter/ha**

Laboratory of Bioethanol

Producing juice from sweet sorghum stem

Juice Sterilization

Fermentation unit

Distillation unit

Director General of Oil and Gas (1) and Head of Energy and Mineral Resources Research and Development Agency (2) checked the non-fuel grade bio ethanol

3. Study of sorghum growth on the post mining soil

- Experiment on contaminated media (tailings and soils)
- Using sweet sorghum mutan variety of Samurai 1
- Analysis of heavy metals in leaf, stem, and grain using XRF

Types of planting media used in the research

No	Media	Sources
1	Alteration 2	Soils in the mining area (2)
2	Paddy soil 1	Potentially contaminated paddy soil (1)
3	Contaminated soil 1	Potentially contaminated soil from the amalgamation process (1)
4	Contaminated soil 2	Potentially contaminated soil from the amalgamation process (2)
5	Contaminated soil 3	Potentially contaminated soil from the amalgamation process (3)
6	Contaminated soil 4	Potentially contaminated soil from the amalgamation process (4)
7	Contaminated soil 5	Potentially contaminated soil from the amalgamation process (5)
8	Alteration 1	Soils in the mining area (1)
9	Non Contaminated soil	Soils in the non mining environment
10	Paddy soil 2	Potentially contaminated paddy soil (2)
11	Tailings	Solid waste material from amalgamation process

Content of heavy metals in the soil and tailings in the gold mining environment

No	Element	Min	Max	Units
1	Fe	1.65	7.04	%
2	Mn	0.04	0.60	%
3	Pb	1.00	598.00	ppm
4	Hg	1.00	874.00	ppm
5	As	1.00	238.00	ppm
6	Co	-	-	ppm

Growing media

Sweet sorghum growth on post mining soil

Results

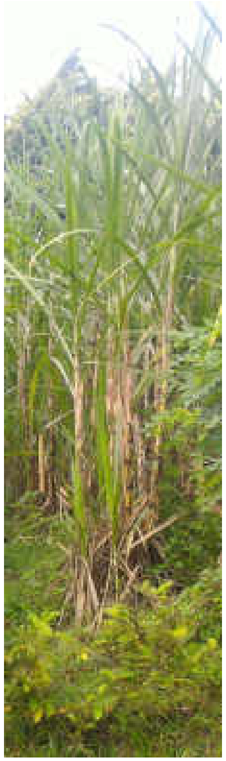
- The sweet sorghum variety of Samurai 1 grew normally on the gold mining area
- It did not uptake mercury (Hg) and Lead (Pb) from contaminated media (soils and tailings)
- Fe, Mn, As, Cu were absrobed to the leaf, stem and grain

Future Work Plan

- Developing bioethanol production on marginal land using sweet sorghum mutan varieties as feed stock at farmer community (in cooperation with the ministry of energy and mineral resources)
- Collaboration with National Company of coal mining (PTBA) in developing sorghum-based bioethanol production on marginal land
- Collaboration with ethanol Factory (PT Madukismo) in developing bioethanol industry
- Supporting Goverment to prepare the utilization of the non-fuel grade bioethanol as the fuel of household stove

Cooperation wit farmers to cultivate sweet sorghum for producing bioethanol

Present: Ethanol production from molasses



Future:
Collaboration for Ethanol production from juice of sorghum stem

Ethanol fuel stove

- Indonesia as archipelago country needs a special supply for household fuels in the remote area or small islands
- By producing ethanol as household fuel for each area, it is more easily to supply reach energy adequacy

EBD

- Rice production:
- EBD : 7.52 tons/ha
- Non-EBD : 7.04 tons/ha

Thank you