Can tree-based bioenergy from agroforestry support landscape restoration, food and energy security, climate and livelihood goals?

Himlal Baral

17 November 2021

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CIFOR-ICRAF in a nutshell

+2000 projects completed in 92 countries

193 active partnerships to develop and implement transformative solutions

Developed more than 25,000 publications and knowledge products

More than 200,000 people from 185 countries have participated in GLF's in-person and online events, workshops and learning opportunities

Our mission

Making landscapes and forests more resilient to benefit people and the planet

What do we do?

Developing evidence-based, **actionable solutions** to address the most pressing global challenges of our time. In this context, we work with a broad range of partners to **transform** the way landscapes and forests are being used. We also drive the international **dialogue** on landscape and forest matters by convening international fora and digital events.

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Energy from Forests and Trees

- Forests and trees are a vital natural resource upon which people rely for firewood, shelter and to power machinery and industrial activities.
- Globally, some 2.5 billion people use traditional biomass, such as wood and charcoal, for cooking and heating. It can also be converted into heat, electricity and liquid fuels.
- In recent years, a modern form of energy derived from biomass, known as bioenergy, has become more common.
- Bioenergy offers the potential to sustainably meet growing energy needs with the added benefits of restoring degraded land and providing food and livelihoods for local communities.

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GROWING INTEREST ON BIOENERGY

- 30% rise in global energy demand to 2040 (IEA, 2016)
- Hundreds of millions of people will still left in 2040 without basic energy services (IEA, 2016)
- The Paris Agreement on CC – ‘transformative change in the energy sector’ is key to reach the agreement
- SD is not possible without access to sustainable energy – SDG 7
- National goal/target related to renewable energy including bioenergy… e.g., Indonesia 23% by 2025…
- Potential linkage between bioenergy and restoration goals

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FOOD, FUEL, ENVIRONMENT OR SDGs?

International/national goals and commitments

Actions and inputs

Results

Outputs, co-benefits

Impacts

UNITED NATIONS PARIS CLIMATE AGREEMENT SIGNING CEREMONY 22 APRIL 2016

United Nations Convention to Combat Desertification

Convention on Biological Diversity

BONN CHALLENGE

7 AFFORDABLE AND CLEAN ENERGY

STRATEGY FOR IMPLEMENTATION OF NDC (NATIONALLY DETERMINED CONTRIBUTION)

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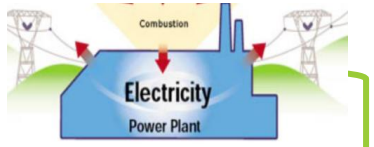
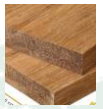
Private and public investments

4-R approach, right tree on right landscape…





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If we manage the land sustainably, we can meet all

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TREE BASED BIOENERGY FRON AGROFORESTRY LANDSCAPE RESTORATION

- CIFOR and partners investigating the opportunities to restore degraded forests and landscapes while producing bioenergy (and foods) using climate smart agroforestry methods.

- This approach can simultaneously help to achieve other national targets such as food and energy security in rural and isolated locations and greenhouse gas emissions reductions and providing multiple ecosystem services.

- Lessons and good practices can be scaled up and scaled out in many islands in Indonesia and other parts of Asia

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KEY QUESTIONS

- Q1: How can **sustainable bioenergy** be developed to avoid the **food-energy-environment trilemma** with alternative feedstocks while **restoring degraded** lands?
- Q2: What are the **most promising species** to achieve **efficient bioenergy** production from degraded land? Species characters, **productivity** and additional **environmental values**?
- Q3: What are the **socio-economic and environmental benefits and challenges** of bio-energy plantation on degraded land?

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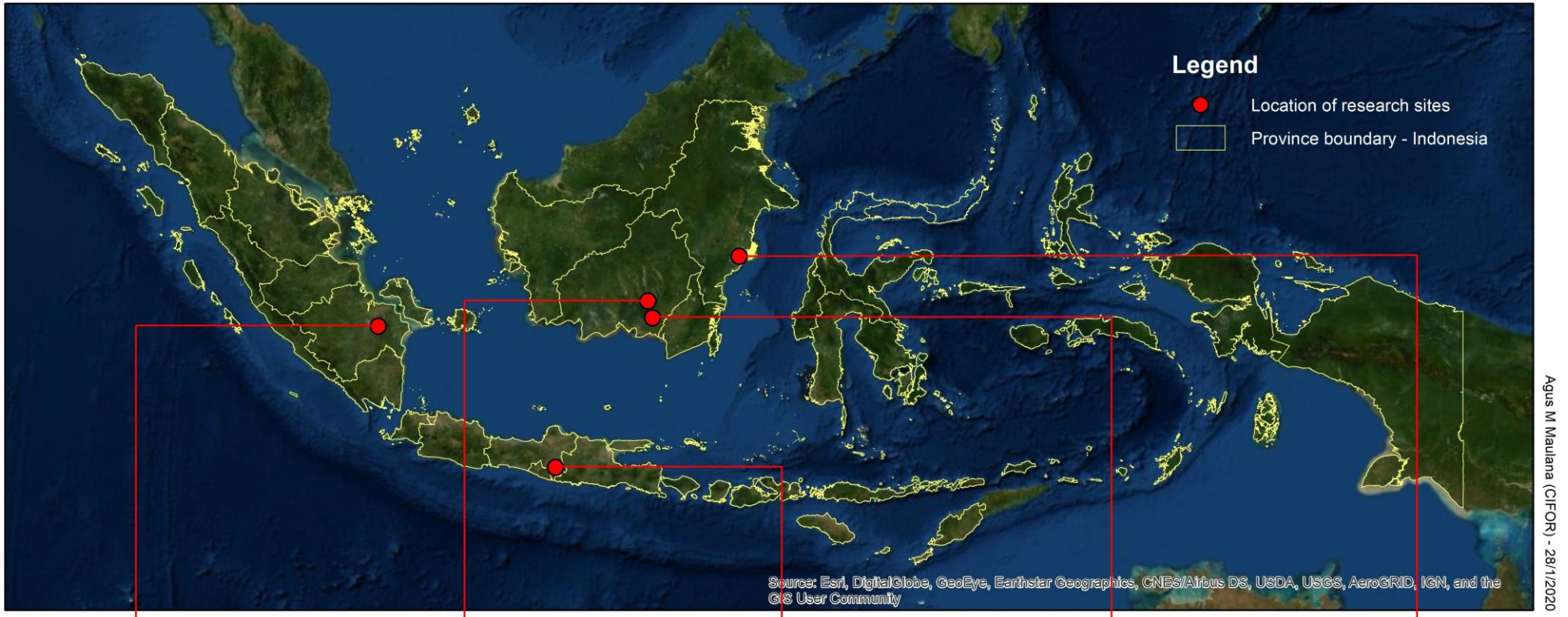
PROJECT LOCATIONS



Perigi, Ogan Komering Ilir, South Sumatra

Buntoi, Pulang Pisau, Central Kalimantan

Giriwono, Wonogiri, Cental Java

Kalampangan, Palangkaraya, Central Kalimantan

TRH Bukit Soeharto, Kutai Kartanegara, East Kalimantan

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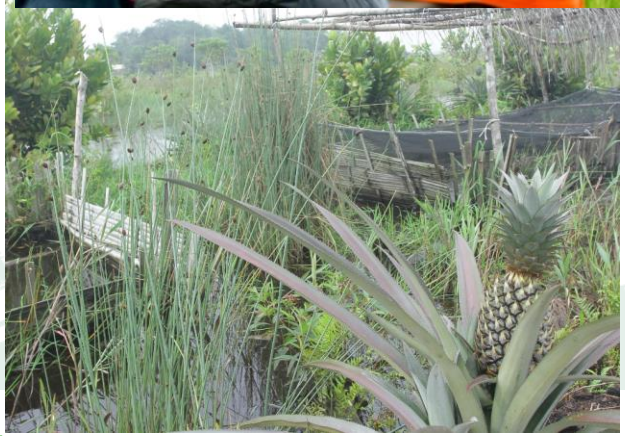
PROJECT ACTIVITIES – KEY COMPONENTS

- **Component I:** Reviewing/mapping policies, land availability, species suitability, potential productivity, community perceptions – opportunities and challenges;
- **Component II:** Establishing research/demo trial of key bioenergy species (trees not herbaceous plants) on various types of degraded land in Central/East Kalimantan, South Sumatra;
- **Component III:** Laboratory/chemical analysis – fuel/energy productivity/efficiency
- **Stakeholder engagement and capacity building:** work with local/national partners – universities and community groups
- **Potential for scaling up** these activities and linking to restoration of degraded land for biomass production – private and corporate investors



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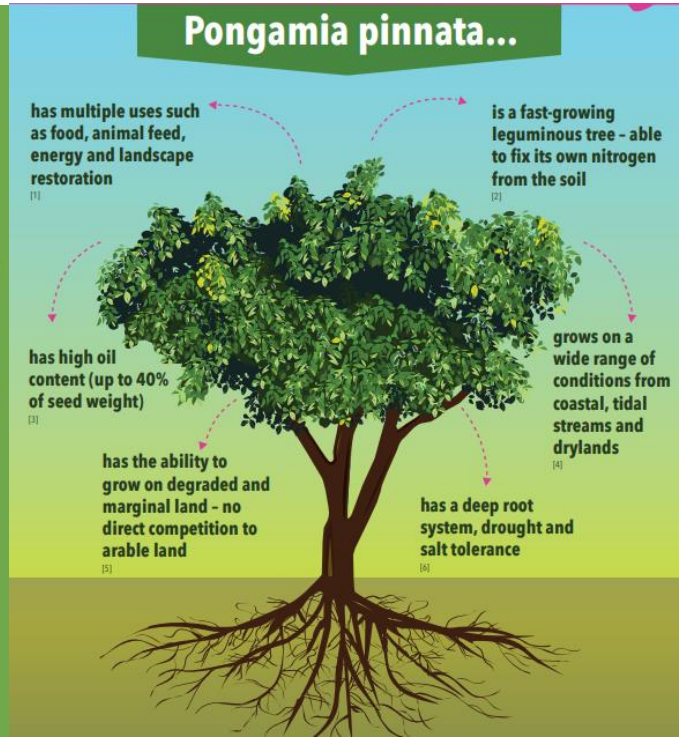
NYAMPLUNG / TAMANU TREE

BAMBOO

PONGAMIA



- **Easy to grow**
- **Multifunctionality**
- **Native to the region**
- **Bioenergy and restoration**

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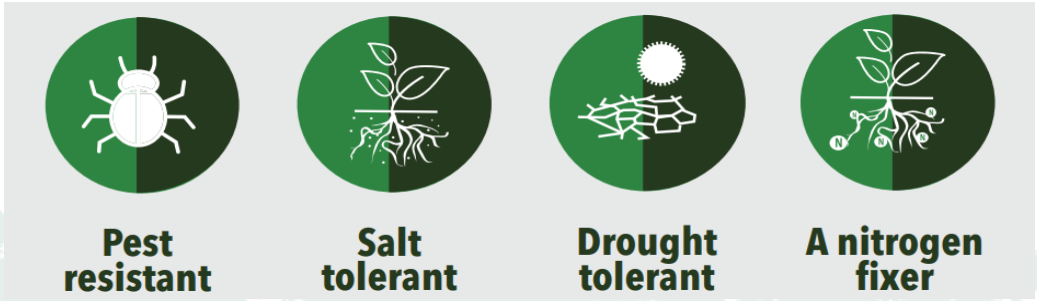
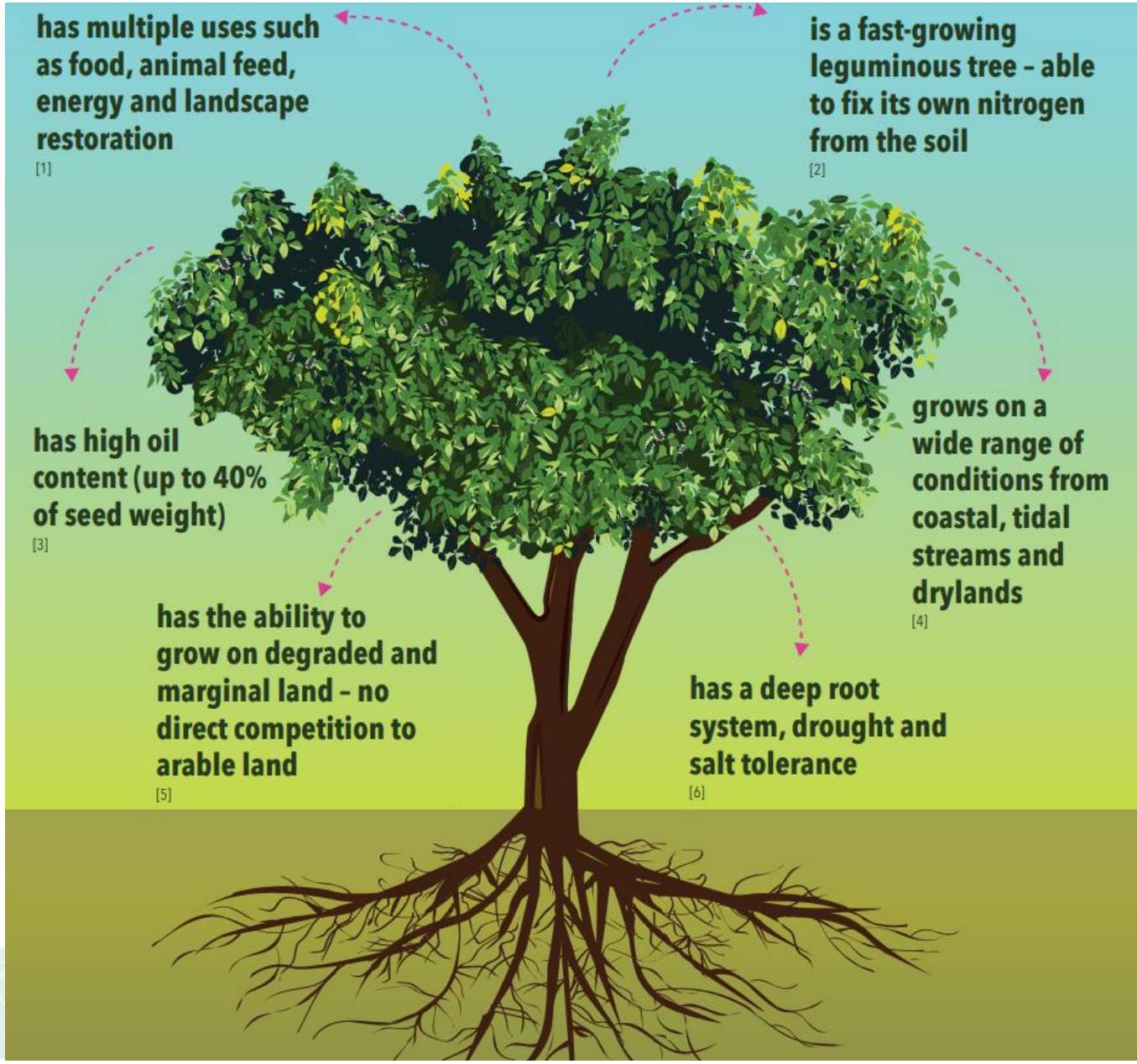
ABOUT PONGAMIA

- Pongamia pinnata, (syn. Millettia pinnata), also known as the malapari or karanja tree, has a large native distribution including India.
- The species is also cultivated in India, Africa, Australia, the United States, and other countries.
- Grows well on degraded and marginal land.





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MULTIPLE USES OF PONGAMIA

N2-fixation [8]

Honey [9]

Food supplement [10]

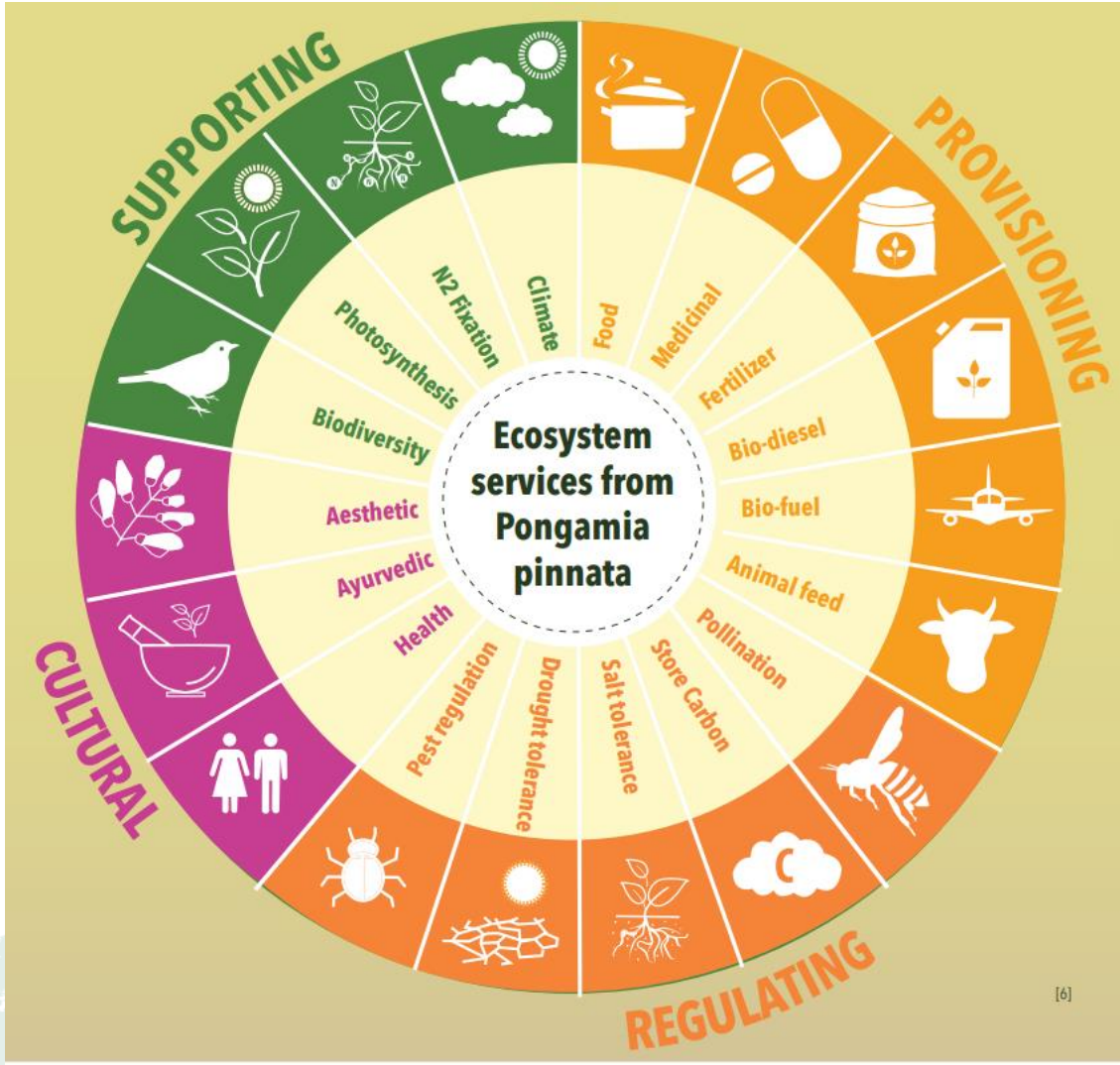
Essential oil [11]

Bio-diesel [12]

Aviation biofuel [13]

Organic fertilizer [14]

Supports biodiversity [6]



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Short Note

Screening Potential Bioenergy Production of Tree Species in Degraded and Marginal Land in the Tropics

Nils Borchard [1,2,*], Medha Bulusu [1], Ann-Michelle Hartwig [3], Matthias Ulrich [4], Soo Min Lee [5] and Himlal Baral [1]

Species	Biomass		Bio-Oil and Biodiesel			Sugar or Starch and Bioethanol		
	Mg ha^{-1} yr^{-1}	GJ ha^{-1} yr^{-1}	Mg ha^{-1} yr^{-1}	kL ha^{-1} yr^{-1}	GJ ha^{-1} yr^{-1}	Mg ha^{-1} yr^{-1}	kL ha^{-1} yr^{-1}	GJ ha^{-1} yr^{-1}
Species that tolerate poor soils, moist and dry environments								
Agathis borneensis (Warb.)	1.0–1.7	19–31	-/-	-/-	-/-	-/-	-/-	-/-
Aleurites moluccana (L.)	3.6–5.7	67–105	0.5–6.0	0.5–6.0	16–194	-/-	-/-	-/-
Arenga pinnata (Wurmb)	-/-	-/-	-/-	-/-	-/-	20 (Su)	2.0–12.8	43–268
Azadirachta indica (A.Juss.)	-/-	-/-	0.1–2.7	0.1–2.7	4–87	-/-	-/-	-/-
Borassus flabellifer (L.)	-/-	-/-	-/-	-/-	-/-	20 (Su)	1.2–12.8	25–268
Calliandra calothyrsus (Meisn.)	6.0–24.0	111–444	-/-	-/-	-/-	-/-	-/-	-/-
Calophyllum inophyllum (L.)	-/-	-/-	2.0–6.0	2.0–5.9	65–194	-/-	-/-	-/-
Ceiba pentandra (L.)	-/-	-/-	1.3–4.8	1.3–4.8	42–155	-/-	-/-	-/-
Croton megalocarpus (Hutch)	-/-	-/-	1.6–4.5	1.6–4.5	52–145	-/-	-/-	-/-
Croton tiglium (L.)	-/-	-/-	0.2–0.9	0.2–0.9	6–29	-/-	-/-	-/-
Gliricidia sepium (Jacq.)	2.0–12.0	37–222	-/-	-/-	-/-	-/-	-/-	-/-
Neolamarckia cadamba (Roxb.)	1.8–12.9	33–239	-/-	-/-	-/-	-/-	-/-	-/-
Pongamia pinnata (L.)	-/-	-/-	0.9–9.0	0.9–8.9	29–290	-/-	-/-	-/-
Reutealis trisperma (Blanco)	-/-	-/-	Yes	-/-	-/-	-/-	-/-	-/-
Vernicia fordii (Hemsl.)	-/-	-/-	0.3–1.0	0.2–1.0	8–32	-/-	-/-	-/-
Zapoteca tetragona (Willd.)	Yes	-/-	-/-	-/-	-/-	-/-	-/-	-/-
Species that tolerate continuously wet and waterlogged or temporarily flooded soils								
Calamus caesius (Blume)	1.5–3.0	28–56	-/-	-/-	-/-	-/-	-/-	-/-
Cerbera manghas (L.)	-/-	-/-	2.2	2.2	71	-/-	-/-	-/-
Combretocarpus rotundatus (Miq.)	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
Dyera polyphylla (Miq.)	5.4–14.0	100–259	-/-	-/-	-/-	-/-	-/-	-/-
Erythrina excelsa (Baker)	Yes	-/-	-/-	-/-	-/-	-/-	-/-	-/-
Euterpe oleracea (Mart.)	-/-	-/-	-/-	-/-	-/-	0.2–3.8 (Su)	0.1 –2.4	2–50
Melaleuca cajuputi (Powell)	Yes	-/-	-/-	-/-	-/-	-/-	-/-	-/-
Metroxylon sagu (Rottb.)	-/-	-/-	-/-	-/-	-/-	15–24 (St)	9.6–15.3	201–321
Fleroya ledermannii (K.Krause)	2.7–3.2	49–59	-/-	-/-	-/-	-/-	-/-	-/-
Nypa fruticans (Wurmb.)	-/-	-/-	-/-	-/-	-/-	3–22 (Su)	1.9–14.0	40–295
Palaquium ridleyi (King & Gamble)	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
Pentadesma butyracea (Sabine)	-/-	-/-	0.6–8.0	0.6–7.9	20–258	-/-	-/-	-/-
Phoenix reclinata (Jacq.)	Yes	-/-	-/-	-/-	-/-	-/-	-/-	-/-
Sandoricum koetjape (Burm.f.)	-/-	-/-	-/-	-/-	-/-	Yes	-/-	-/-
Sesbania bispinosa (Jacq.)	8.0–17.0	148–315	-/-	-/-	-/-	-/-	-/-	-/-
Spondias mombin (L.)	0.2–0.6	4–10	-/-	-/-	-/-	-/-	-/-	-/-
Symphonia globulifera (L.f.)	Yes	-/-	-/-	-/-	-/-	-/-	-/-	-/-

-/- no data available.

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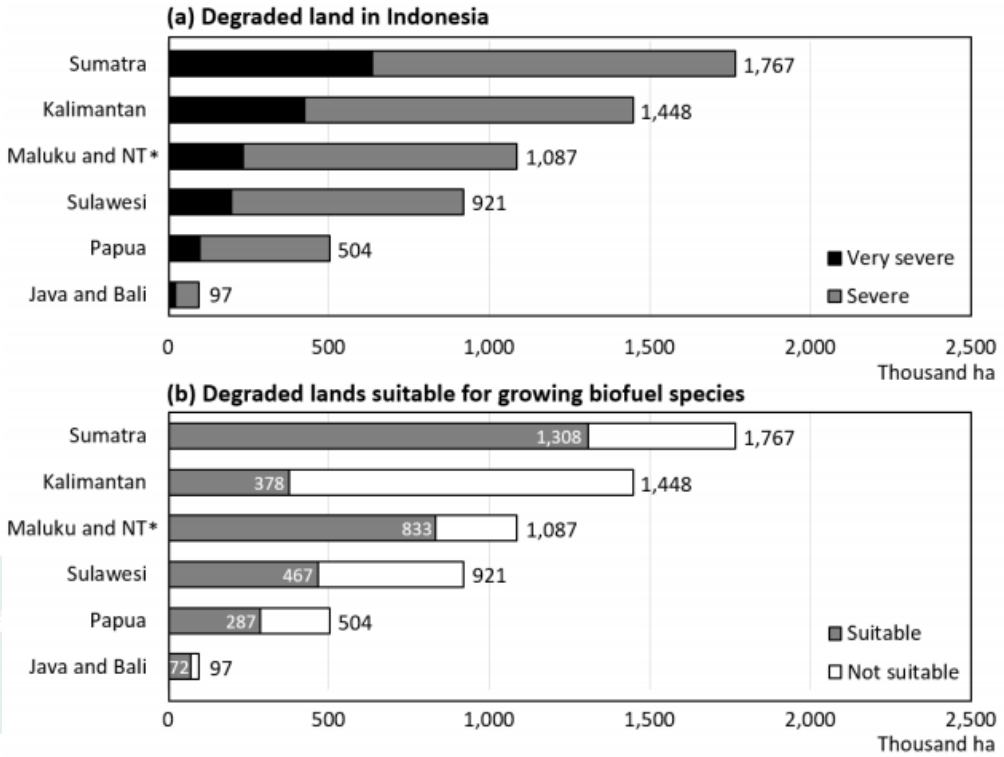
Article

Spatial Assessment of Degraded Lands for Biofuel Production in Indonesia

Wanggi Jaung [1,2,*], Edi Wiraguna [3,4], Beni Okarda [2], Yustina Artati [2], Chun Sheng Goh [5,6], Ramdhoni Syahru [4], Budi Leksono [7], Lilik Budi Prasetyo [4], Soo Min Lee [8] and Himlal Baral [2]



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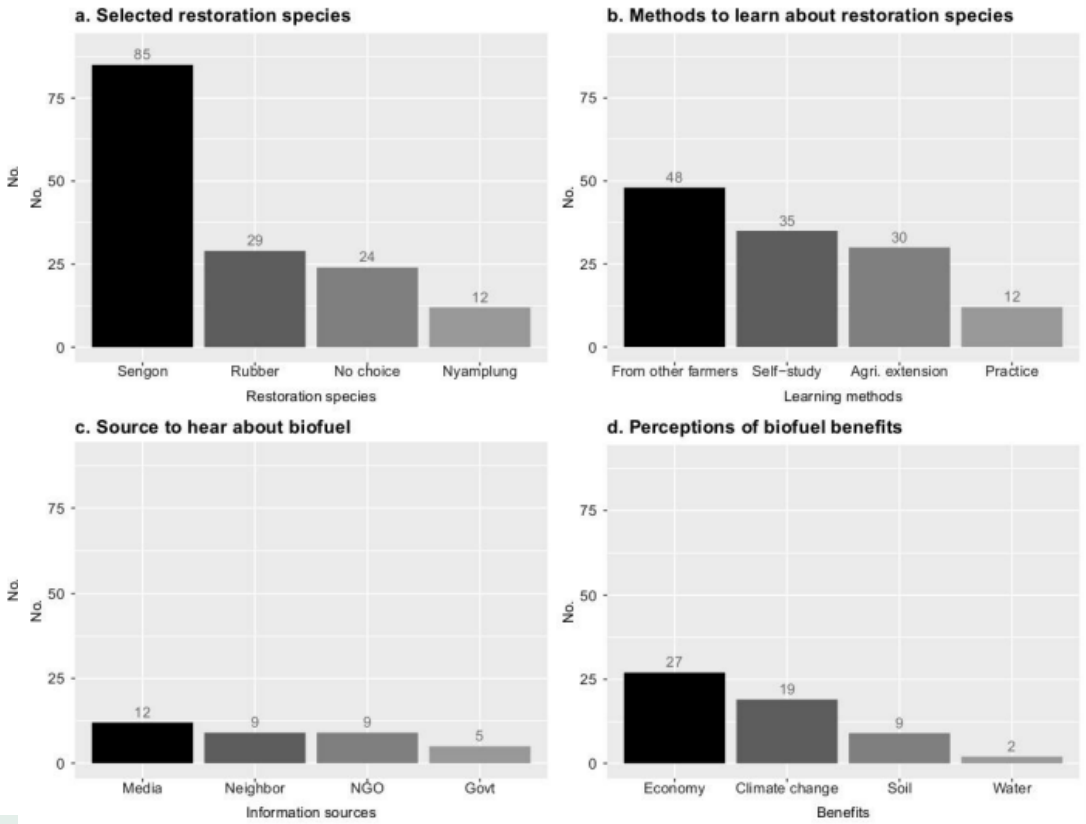
Article

Bioenergy Production on Degraded Land: Landowner Perceptions in Central Kalimantan, Indonesia

Yustina Artati [1,*], Wanggi Jaung [1,2], Kartika Sari Juniwaty [1], Sarah Andini [1], Soo Min Lee [3], Hendrik Segah [4,5] and Himlal Baral [1]



land

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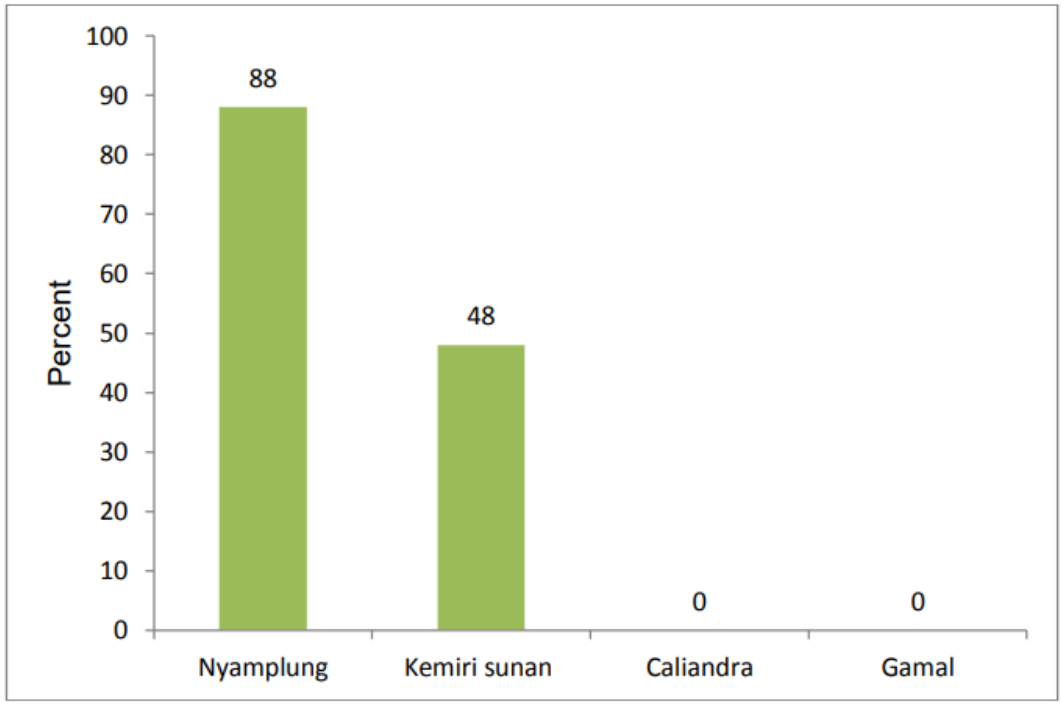
Article

Assessment of Suitability of Tree Species for Bioenergy Production on Burned and Degraded Peatlands in Central Kalimantan, Indonesia

Siti Maimunah [1], Syed Ajijur Rahman [2,*], Yusuf B. Samsudin [2], Yustina Artati [2], Trifosa Iin Simamora [2], Sarah Andini [2], Soo Min Lee [3] and Himlal Baral [2]



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Opinion

Bamboo as an Alternative Bioenergy Crop and Powerful Ally for Land Restoration in Indonesia

Roshan Sharma [1,2,*], Jaya Wahono [3] and Himlal Baral [2]

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3 Clean Power Indonesia, Graha Mitra 8th Floor #804 Jl. Gatot Subroto 24, Jakarta 12930, Indonesia; jaywahono@gmail.com
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check for updates

Table 1. Fuel characteristics of bamboo compared to other biomass sources.

Biomass Type	Ash (%)	Moisture (%)	Volatile Matter (%)	Heating Value (kJ/kg)
Rice husk	12.73	12.05	56.98	14.63
Palm shell	3.66	12.12	68.31	18.44
Corn stalk	3.80	41.69	46.98	11.63
Bamboo	2.70	5.80	71.70	17.58
Acacia *	0.36	11.2	65.7	17.40

Source: [23] and [26]*.

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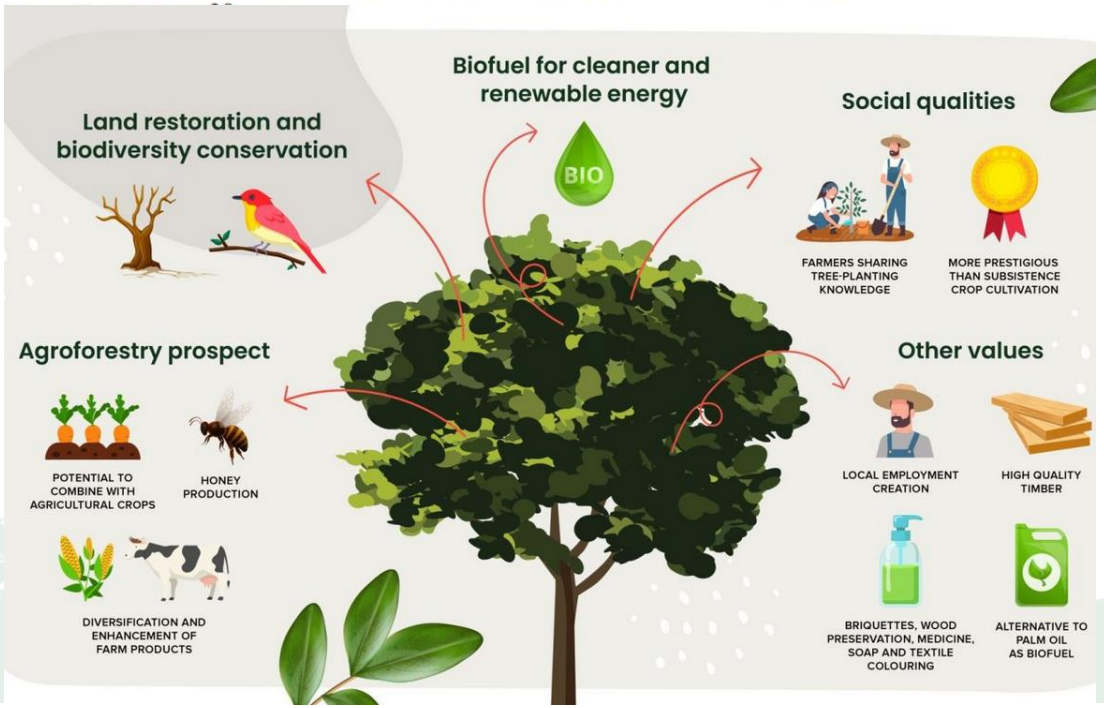
DOI: 10.1002/fes3.165

ORIGINAL RESEARCH

WILEY Food and Energy Security

Integrating bioenergy and food production on degraded landscapes in Indonesia for improved socioeconomic and environmental outcomes

Syed Ajijur Rahman[1,2] | Himlal Baral[3] | Roshan Sharma[4] | Yusuf B. Samsudin[3] | Maximilian Meyer[5] | Michaela Lo[3] | Yustina Artati[3] | Trifosa Iin Simamora[3] | Sarah Andini[3] | Budi Leksono[6] | James M. Roshetko[7] | Soo Min Lee[8] |



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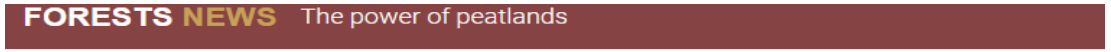
FOREST NEWS… EXAMPLES


FORESTS NEWS "Restoration belongs to the community"

NEWS

"Restoration belongs to the community"

In Central Kalimantan, a village takes its chances on the tamanu tree


FORESTS NEWS The power of peatlands

NEWS

The power of peatlands

Sustainable bioenergy from tropical peat forests

NEWS

Pongamia: Potential benefits for restoration and bioenergy in Indonesia

FEATURE

Bioenergy: A solution to three problems?

Scientists take a comprehensive look into the potential of bioenergy crops, from seeds to sales

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NEWS

Biofuel-friendly trees may boost landscape restoration efforts in Indonesia

Research shows nyamplung could be most adaptive bioenergy tree for degraded peatlands

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OPINIONS

What bamboo forests do for nature and human well-being

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LAND AVAILABILITY FOR BIOENERGY PLANTATION

- **Common myth:** There is not enough land on which to grow biofuel crops. Currently, they supplant much needed food crops and environmental conservation areas

- **Fact:** Our research suggests large areas of degraded and underutilized land is available in Indonesia (and globally). The degraded land can be restored with climate-smart agroforestry systems that support food, energy and environmental conservation goals (Jaung et al. 2018)

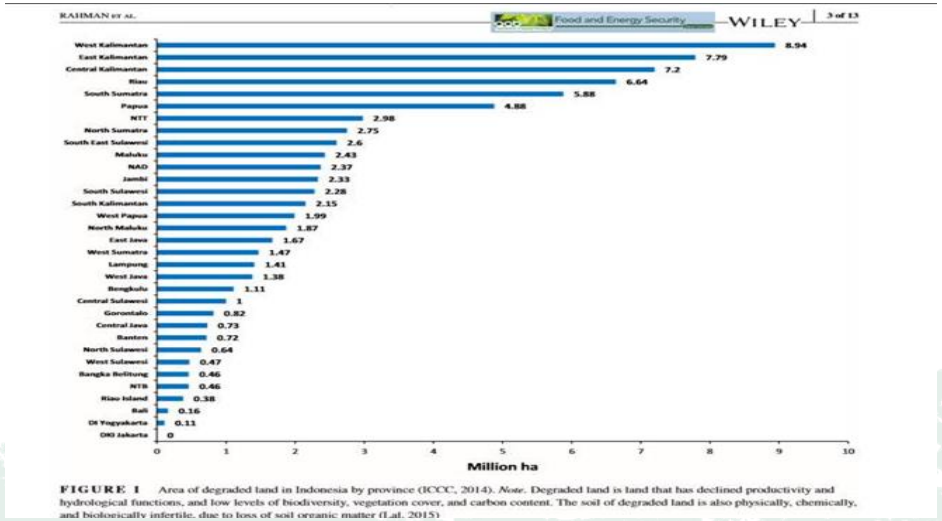

FIGURE 1 Area of degraded land in Indonesia by province (ICCC, 2014). *Note*. Degraded land is land that has declined productivity and hydrological functions, and low levels of biodiversity, vegetation cover, and carbon content. The soil of degraded land is also physically, chemically, and biologically infertile, due to loss of soil organic matter (Lal, 2015)

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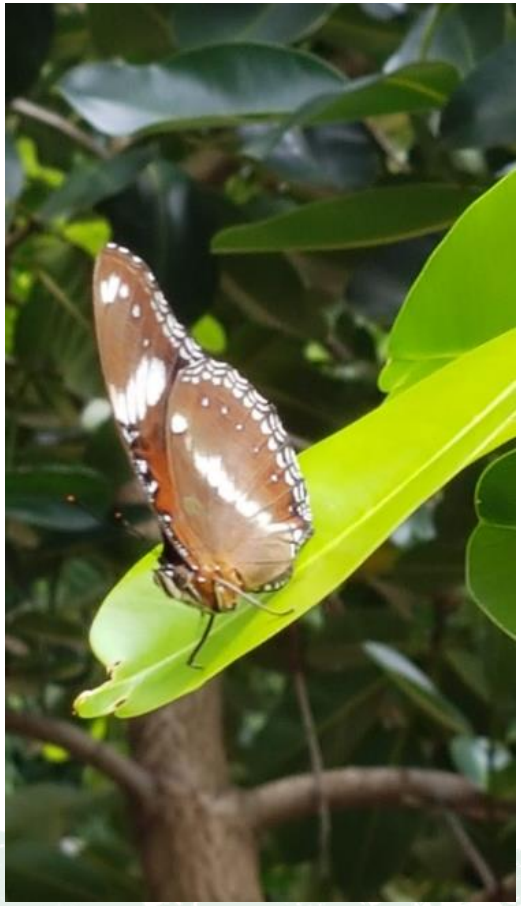
BIOENERGY AND ENVIRONMENT



- **Common myth:** Bioenergy plantations destroy native vegetation and lead to biodiversity loss

- **Facts:** Initial findings from our work in Indonesia demonstrate that bioenergy plantations on **degraded land are a promising approach for land restoration and enhance native biodiversity**. Our two-year-old bioenergy research and demonstration plot is colonized by several bird species and such insects as bees and butterflies.

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FUEL OR FOOD

- **Common myth:** Bioenergy plantations displace food production areas and increase food prices.

- **Fact:** Our research from Indonesia shows that bioenergy and food production, including rice, pineapple and fish can be combined at plot and landscape scale - increasing the value of the land, enhancing food security and supporting rural livelihoods

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KEY MESSAGES

- If done appropriately, tree-based bioenergy, can be an effective means to enhance food and energy security while supporting climate and development goals
- There are wide range of approaches and tools available – from simple to complex.
  - Right crops in right landscape
  - Right business model
  - Respecting community rights
- Dissemination of best practices and identify potential for scaling up/improving existing models – through public, private partnership

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