



# AGROFORESTRY IN THE RING OF FIRE: Resilient Livelihoods in Dynamic Volcanic Landscapes in East Java, Indonesia



I. Volcanoes: Life Starts as Ash



II. Spirited Mountain Springs



III. Water Towers: Regulating  
Services for Lowlands



VI. Ecotourism: Healing Services



V. Specialty Farms



IV. Resilient Mountain Livelihoods

VII. Governance: Ensuring sustainability, bouncing forward, keeping it all together

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## Agroforestri Khas Pegunungan Nusantara: Jendela Jawa Timur



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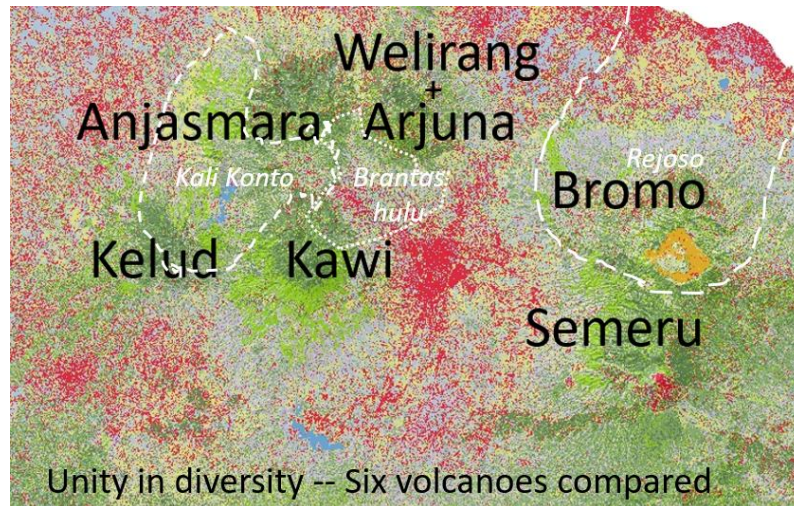
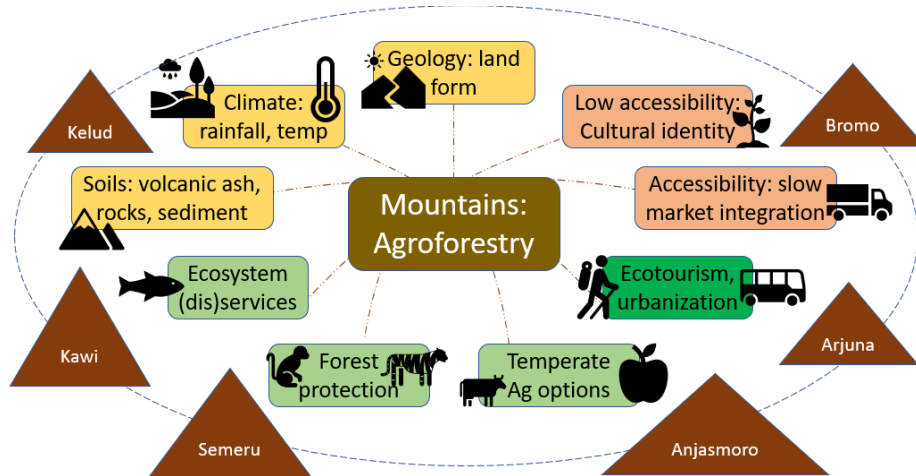
## Synthesis

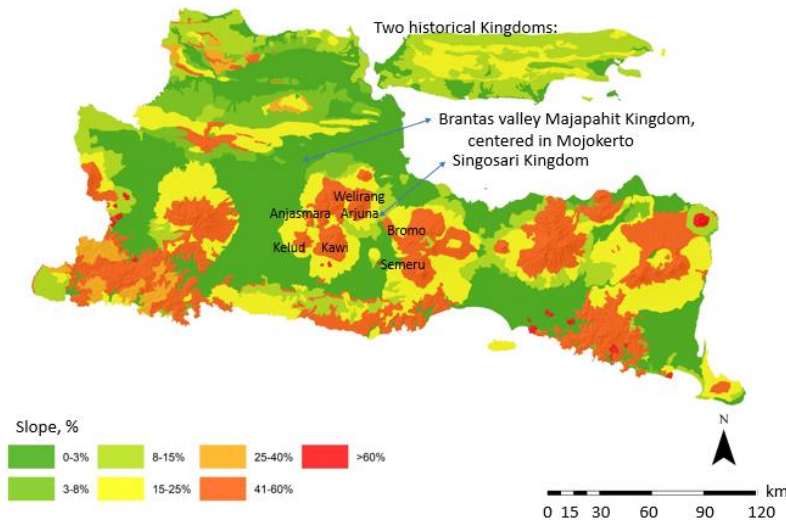
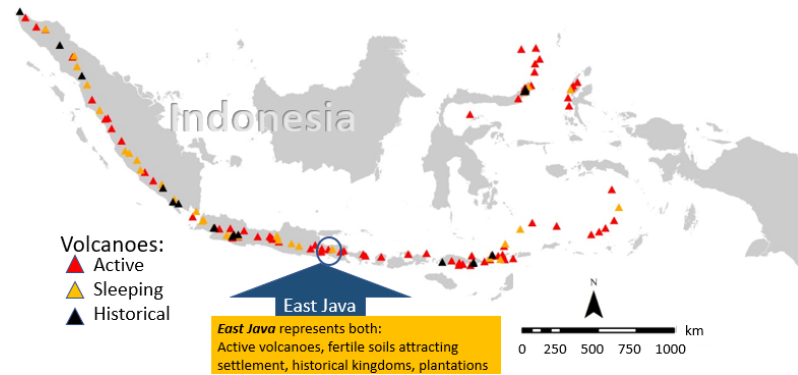
The volcanic mountains of East Java, part of the global ring of fire, interact with coastal zone lowlands, ecologically, socially and economically. Forests, trees and agroforestry are part of that relationship. By reviewing six mountains around Malang (Kelud, Kawi, Bromo, Anjasmoro, Arjuna-Welirang, and Semeru), we explored seven narratives that together show resilient livelihoods in dynamic landscapes, with threats, challenges and shift opportunities:

- I. **Life starts as ash:** Volcanic soils, the summum of soil fertility, start with destructive ash rains during eruptions; the *Wayang Gunung* tradition shows the two sides of mountains: harmony and conflict. The native tree *Parasponia rigida* or 'Anggrung Hijau' traps ash, starts soil formation capturing carbon.
- II. **Spirited mountain springs:** Volcanoes remind us of the power of nature; spirited mountain springs, with sacred trees (e.g. *Ficus benjamina* or 'Beringin'), offered safe water and retreats from warring lowland kingdoms; temples appreciated the hydrological cycle, including the 'source of clouds' *Sumberawan*).
- III. **Water towers:** mountains and their (agro)forests provide regulating services for lowlands, through climate regulation, securing rainfall and reliable groundwater flows to feed lowland irrigation systems, supply safe drinking water and sources of hydropower; forest zonation represents the lowland interest in 'protective' forests, such as plantations of *Pinus merkusii* (native to Sumatera), mountain-top national parks protect relevant biodiversity.
- IV. **Resilient mountain livelihoods:** food crops on sloping land led to landslides, but coffee-based agroforestry allowed a partial market-based 'outsourcing' of staple foods; diverse agroforests meanwhile support healthy diets with spices, fruits, vegetables; farm-grown substituted for forest-derived timber, such as *Falcataria moluccana* or 'Sengon', one of the first trees to be deregulated for farmer use; through sand-mining people directly benefit from volcanic ash.

- V. **Specialty farms, shifting markets**: Opportunities for temperate vegetables, potatoes, dairy production, and apples allowed further farm specialization, but market opportunities keep shifting; local durians, (*Durio zibethinus* or “Durian”) however, are still appreciated; ornamentals (flowers) transition to next stage.
- VI. **Ecotourism and healing services**: Beyond sources of water and specialty products, mountains have become a place for healing for urban middle-class domestic tourists, creating new livelihood opportunities; the landscape helps to rediscover spirituality, the beauty of waterfalls, springs and mountain views (including *Casuarina junghuhniana* or ‘Cemara Gunung’)
- VII. **Governance** in this context means bouncing forward, ensuring sustain-agility, keeping it all together. The raintree (*Samanea saman* or ‘Trembesi’) with its wide canopy forms a symbol. People primarily live in valleys and most mountains cross borders of local jurisdictions; forest institutions, in contrast, focus on middle and high-elevation zones; societies are organized around main rivers, e.g. the Brantas river authority as coordinating mechanism; shifting stakeholders of the various co-existing phases (I – VI) of the landscape form a special challenge for achieving SDGs, with tradeoffs between basic securities, identity and cross-generational well-being.

Agroforestry’s many faces reflect these narratives and shape ways forward, integrating across forest- and agriculture-based policies, water and land-based lowland interests, product- and services.

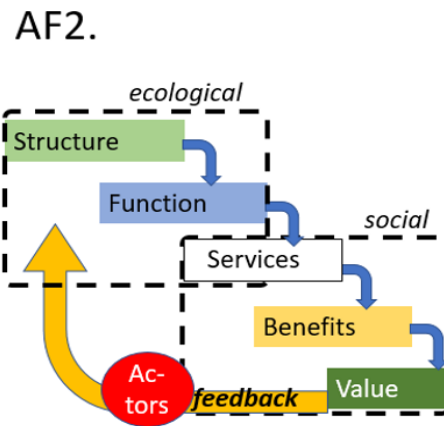




## Setting the Scene

As part of the global ‘ring of fire’, where the collision of shifting shelves gives rise to volcanic activity, both the positives (fertile soil: rice) and negatives (disasters) of volcanic mountains are evident in current land use and demography. East Java has lowland peneplains and steep mountains – with the study area containing a fair share of the overall diversity.

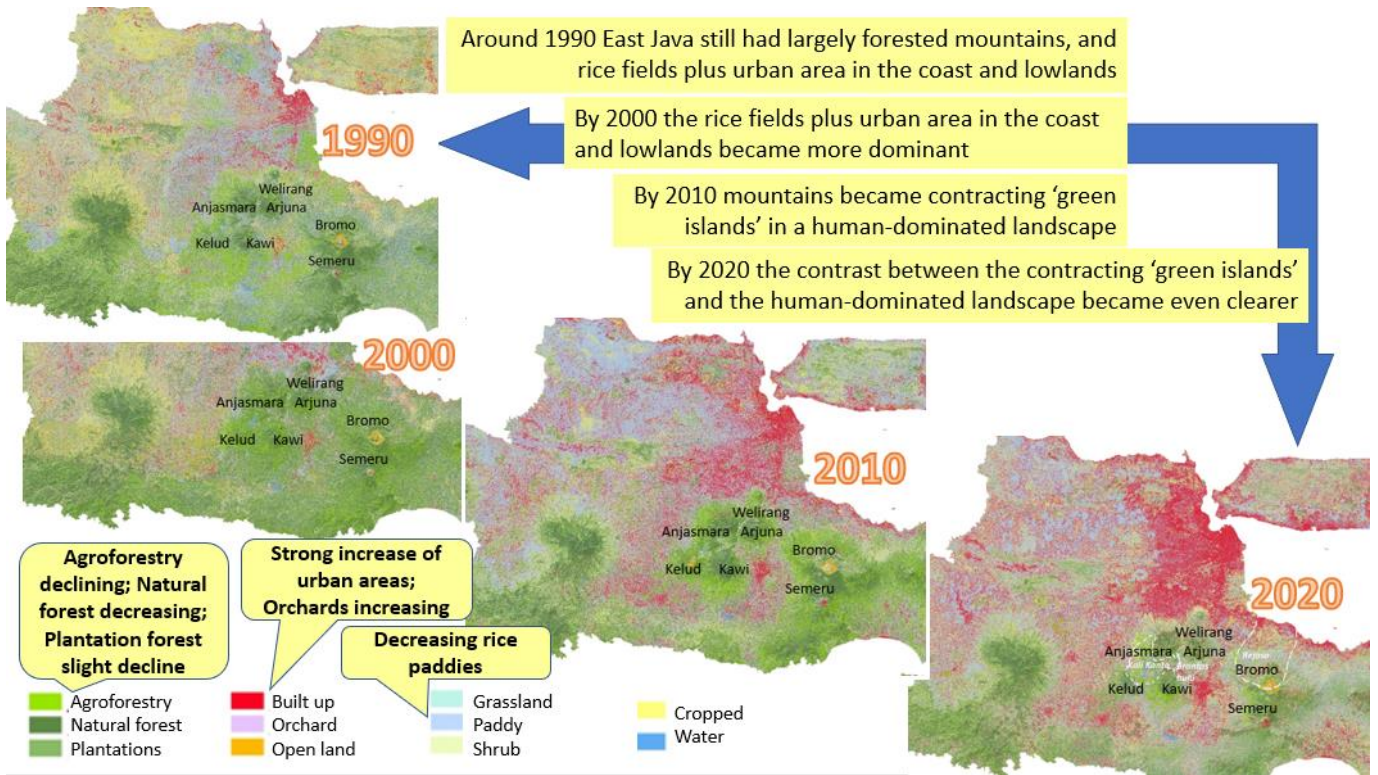
Malang is in the upper part of the Brantas basin, while being accessible from Pasuruan in the Rejoso basin. Historically the Singosari kingdom, close to the current Malang, competed with the Majapahit kingdom in Mojokerto. Malang is surrounded by six mountains, with different perspectives on an overall storyline of how lives and landscapes in the East Java mountains change.

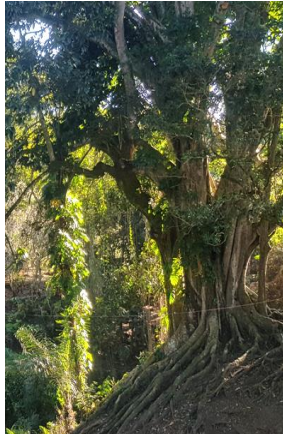


Tropical agroforestry has many faces, with relevance for different phases of landscape and livelihood change.

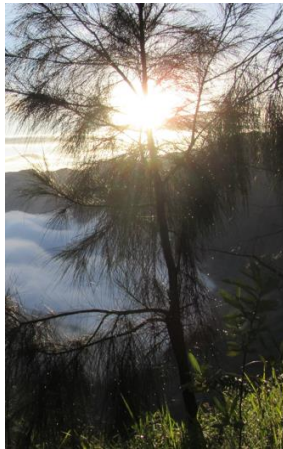


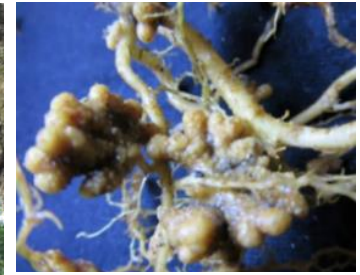
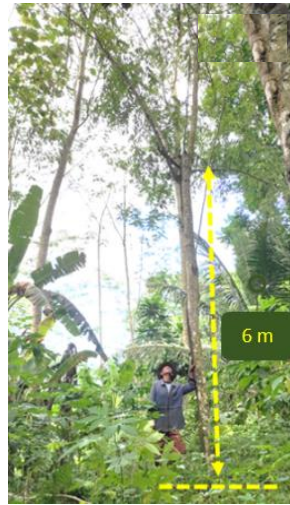




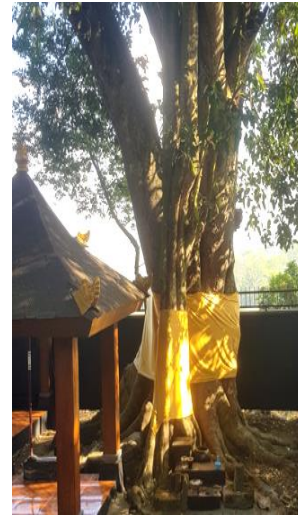


## Seven trees that tell the story





Who	<i>Parasponia rigida</i> (family: Cannabaceae); locally known as “Anggrung Hijau”, native to East Java
Where	Sheltered places near tops of volcanoes as seed source, germinating in ash deposits along the streams
Special feature	Nodules with Rhizobium, as only plant genus outside Leguminosae to do so
How connected to people	As the first tree to grow after ash deposition, it stabilizes slopes; farmers take wildings to their agroforestry gardens to speed up recovery of soil fertility; leaves and branches can be used as fodder for goats and cows



Who	<i>Ficus benjamina</i> (family: Moraceae), Locally known as Beringin. Native to East Java
Where	Grow on wet places (springs, shallow groundwater, riparian zone forest)
Special feature	Adventitious roots, allow branches to become rooted, and the tree to 'walk'; birds like the fruits
How connected to people	Traditionally protected sites (punden), often now in places where people gather, and enjoy its shade. Seen as indicator of water availability: does the tree make the soil wet or only indicates wetness?



Who	<i>Pinus merkusii</i> (family: Pinaceae) Locally known as Pinus (introduced from Sumatera)
Where	Planted in middle zone on slopping land, under management by state forest company
Special feature	Sensitive to fire; resin can be tapped for various industrial uses under 'social forestry' schemes
How connected to people	Slope protection; tug of war between forest authorities a local community over land rights; a change of rules allowing grass (for cut-and-carry) and coffee has reduced conflicts and increased contributions to the local economy



Who	<i>Falcataria moluccana</i> (family: Fabaceae) Locally known as Sengon. Native to Eastern Indonesia
Where	Best below 800 masl. Disease 'kanker batang' (caused by <i>Uromycladium falcatarium</i> ) problems at higher elevation
Special feature	N-fixation with Rhizobium; the wood can be easily identified by its smell
How connected to people	Farmers have been allowed to manage and harvest outside forestry control; harvesting in coffee gardens can be damage coffee (requires skill); wood of low density, but many uses



Who	<i>Durio zibethinus</i> (family: Malvaceae) Locally known as Duren/Durian. Native to East Java
Where	Best below 800 masl; high rainfall
Special feature	Variation in fruits (taste, quality); thick skin, only few insects can penetrate
How connected to people	Price remains good, there is never enough? Opportunity for further specialization?

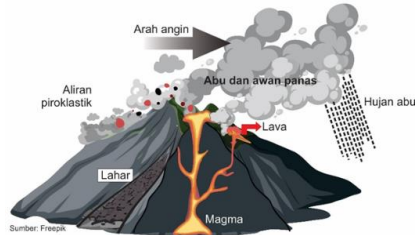


Who	<i>Casuarina junghuniana</i> (family: Casuarinaceae) Locally known as Cemara Gunung. Native to East Java
Where	Mountain tops (cloud forest)
Special feature	Nodules with Frankia; survives resistant/resilient after fire (dense wood), canopy can capture atmospheric moisture; half-open shade
How connected to people	Slope stabilization, windbreaks, Tengger cultural significance





Who	<i>Samanea saman</i> (family: Fabaceae) Locally known as Trembesi, native to East Java
Where	In urban areas, shade public meeting places
Special feature	Wide canopy; helps with microclimate regulation
How connected to people	Edible seeds, but low price, maybe tradition is getting list? Traditional markets Shade tree for roads and urban parks (alun-alun)



Sumber: Freepik

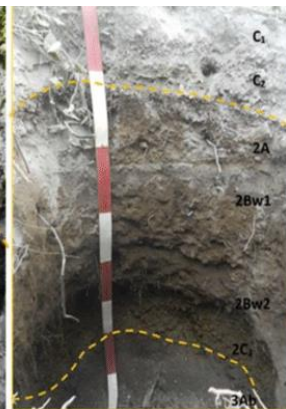


## I. Life Starts as Ash

Volcanic soils, the summum of soil fertility, start with destructive ash rains during eruptions; some endemic trees are adapted to this environment; soil formation depends on capturing carbon through vegetation



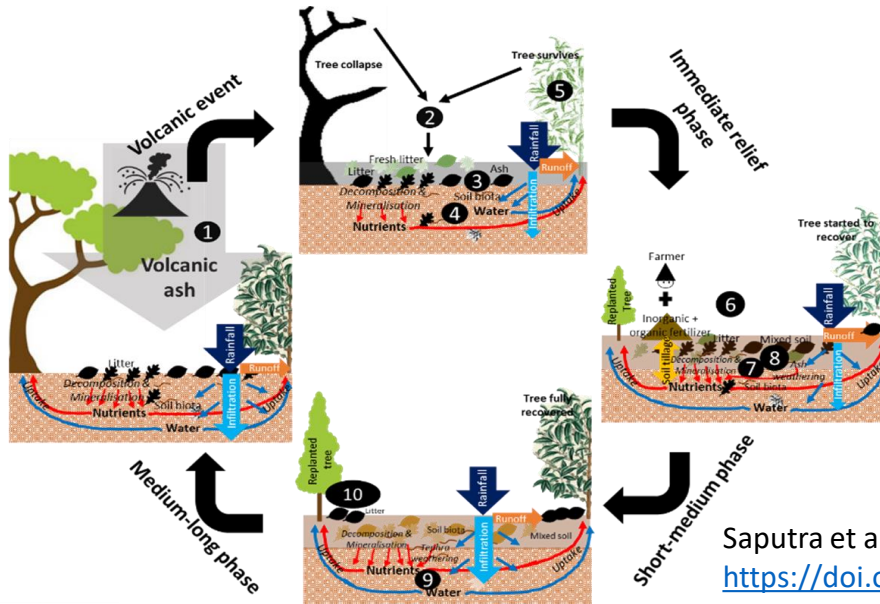
Upper Zone



Middle Zone



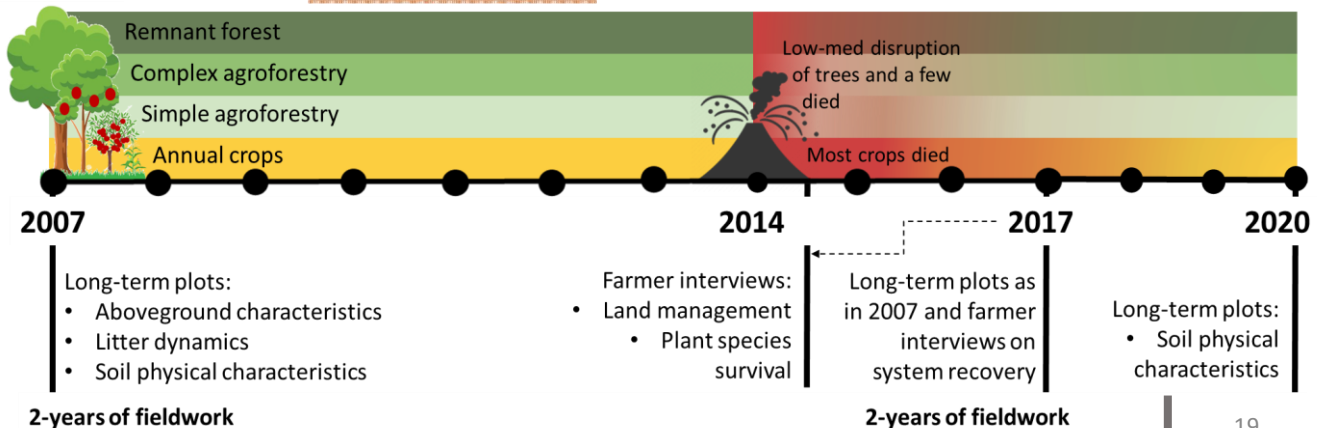
Lower Zone



In long-term research plots in the cycle of ash deposition, recovery of protective litter layer, vegetation and human livelihoods has been analyzed, to better understand the various components of ‘resilient agroforestry livelihoods’ – see Box 4.1 on Mt Kelud, and Box 8.3 on local knowledge of soil biota in this context.

Saputra et al., 2022

<https://doi.org/10.1007/s11104-022-05322-7>

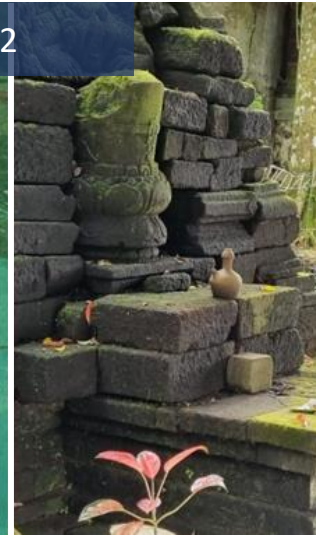
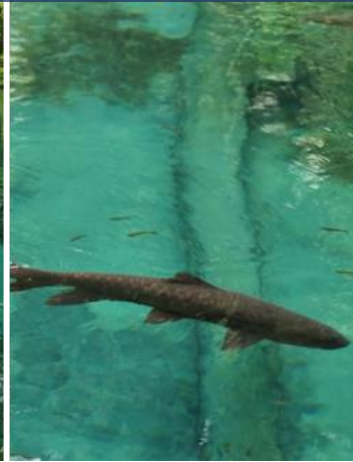


**The Wayang Gunungan tradition shows the two sides of mountains: harmony and conflict.**



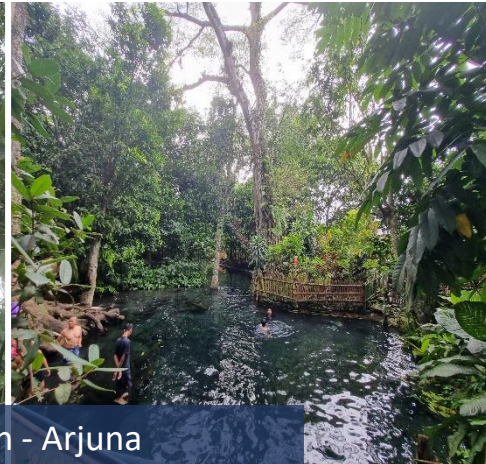
In the Wayang story-telling tradition, all stories start with the Gunungan in the middle of the display. One side shows a harmonious place where a tree of life connects birds, monkeys, buffalo and tigers, guarding, along with spirits, over a house where people can be safe. Until, the story flips and fire, volcanic eruptions, human conflicts and human lives are once again tested for their resilience. At the end of the story (many hours, or even a whole night), the Gunungan is once again in the middle of the scene, the light switches on and the mountain once again takes its role as connector of disasters and the harmonious periods in between – keep your vigilance while appreciating the richness of nature.

Rambut Monte: Box 5.2



## II. Spirited Mountain Springs

Volcanoes remind us of the power of nature; spirited mountain springs, offered safe water but also retreats from warring lowland kingdoms; some still have function as retreats.



Umbulan - Arjuna



Sacred trees (such as *Ficus benjamina* or 'beringin') protect springs



Temples appreciated the hydrological cycle (such as the 'source-of- clouds' spring *Sumberawan*).

Box 8.4. Stupa Sumberawan.  
Old guardian and new locked gate



Mahameru



Mountains, water, guardian spirits and 'uncles from the forest' are all respected as protectors of human lives and harmony.

The 'bersih desa' village cleansing rituals have survived shifts in the dominant religion.



Bromo



### III. Water Towers: Regulating Services for Lowlands

Water towers: mountains and their (agro)forests provide regulating services for lowlands, through climate regulation, securing rainfall and reliable groundwater flows to feed lowland irrigation systems, supply safe drinking water or hydropower. Part of the problem is water over-use, part reduced infiltration; 7.4: principles for infiltration-friendly agro-forestry



Unregulated,  
24/7 irrigation



Irrigation

Brantas





Ash/sand harvests for income,  
reducing sedimentation



Box 4.2 Kali Konto as  
Indonesia's first  
Integrated Watershed  
Management program in  
the 1980's, upstream of  
the Selorejo reservoir,  
filling up with sediment

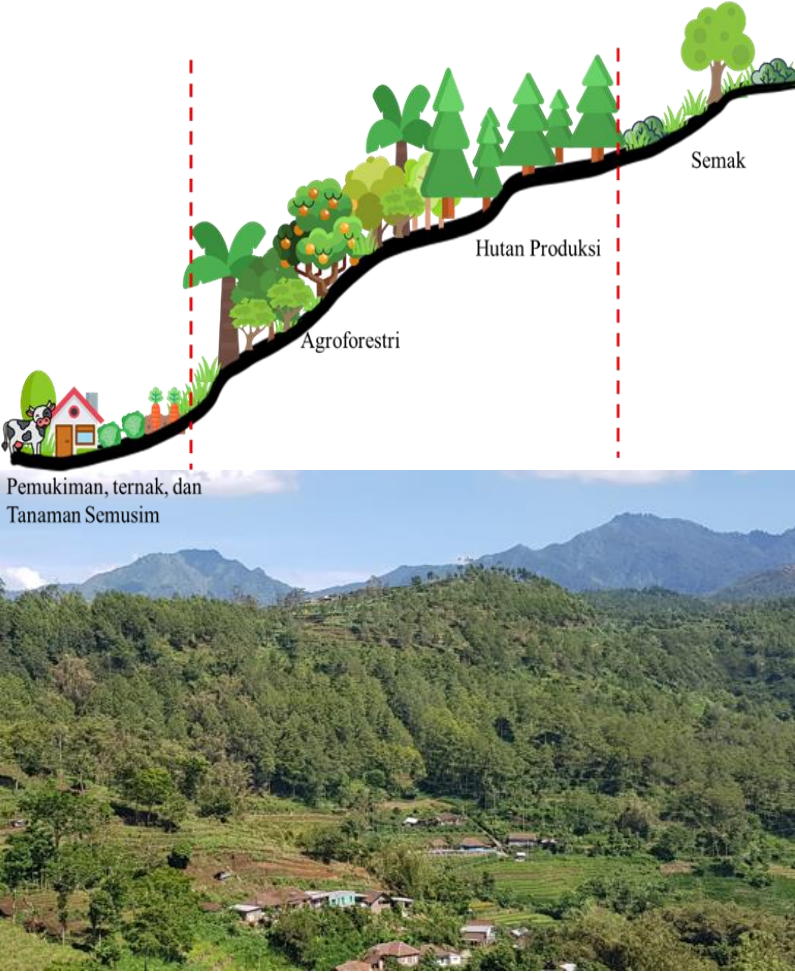


Protective forests (Hutan lindung) in Indonesia's forest zonation represents the lowland interest in healthy watersheds. On Java this zone includes plantations of Pinus merkusii (native to Sumatra). In the past only tapping of resin provided local income, conflicts were common; now agroforestry is negotiated



Box 8.1. describes the joint forest management with local farmers in UB Forest, midslope on the Arjuna mountain

## IV. Resilient Mountain Livelihoods



Resilient mountain livelihoods: food crops on sloping land led to landslides, but coffee-based agroforestry allowed a partial market-based ‘outsourcing’ of staple foods; diverse agroforests meanwhile support healthy diets with spices, fruits, vegetables; farm-grown substituted for forest-derived timber, such as *Falcataria moluccana* or ‘sengon’, one of the first trees to be deregulated for farmer use; sand-mining provides a way to benefit from volcanic ash, and reduce siltation of reservoirs, but elsewhere contributes to soil degradation.

Fig. 4.3 Transect on the slopes of Mount Kelud see also Box 7.1



Local sawmill based on sengon wood, from woodlots or agroforestry systems on farm



In middle zone on Mt Bromo, tree-based systems still grow between the rocks; topsoil is scarce



Commodity diversity reduces risk



Coffee: harvested ripe and green mixed



Agroforestry landscape in Ngantang: fodder cut-and-carry for dairy, grass in mixed coffee, rice fields, complex coffee agroforestry, calliandra hedgerows in fodder grass field.

Coffee agroforestry Box 7.2.



## V. Specialty Farms: Shifting Markets



Potato, vegetables: erosion-prone crops, but high income



Opportunities for temperate vegetables, potatoes, dairy production, and apples allowed further farm specialization, but market opportunities keep shifting; local durians, (*Durio zibethinus* or 'duren') however, are still appreciated; ornamentals (flowers) transition to next stage



Manure pollutes the streams



Ornamentals



Durian nursery



Box 5.1. Happy farmers with specialty coffee, cherry picked to be ripe

Box 7.1 Well-managed shaded coffee gardens





## VI. Ecotourism: Healing Services



Beyond sources of water and specialty products, mountains have become a place for healing for urban middle-class domestic tourists, creating new livelihood opportunities; the landscape helps to rediscover spirituality, the beauty of waterfalls, springs and mountain views





Selfie spots for income



Figure 7.2. Desa Tosari



Edelweis's domestication

Box 6.1 Soil compaction in Bromo National park?



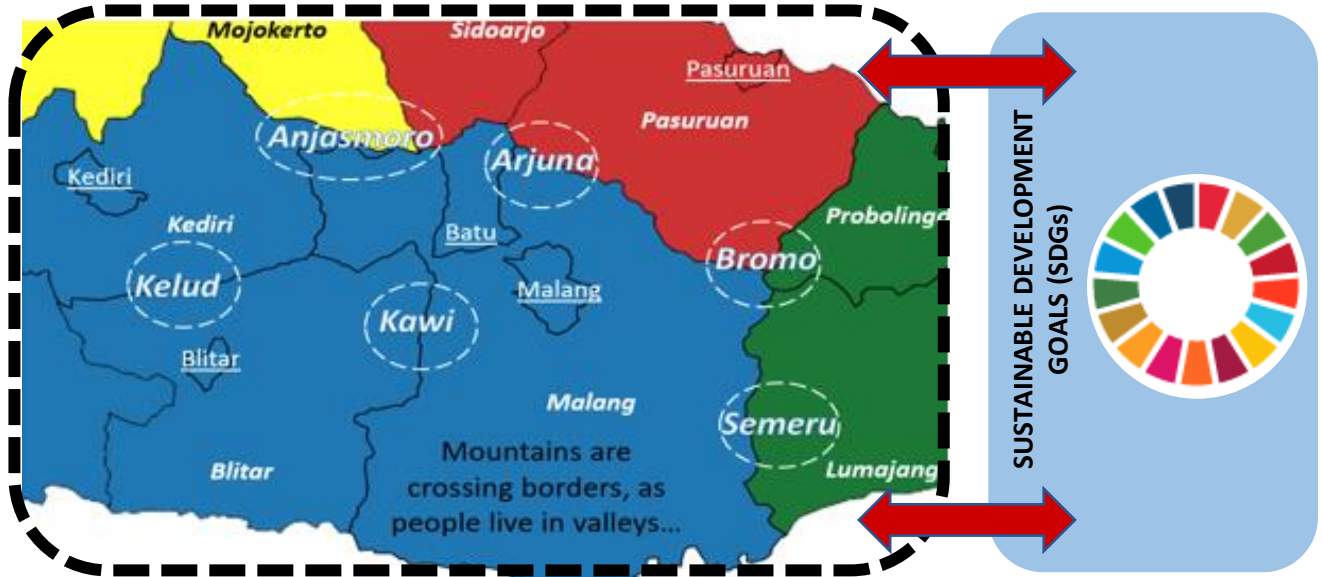
## VII. Governance: Keeping It All Together

Governance has as challenge to keep it all together. All six perspectives discussed coexist, with direct stakeholders. Historically, however, lowland societies (people primarily live in valleys), water management to meet their needs (water flows from upland to lowlands), forest management (mostly on slopes), and biodiversity (National parks, mostly mountain tops) have had their own institutions and trajectories. Valley-based local jurisdictions have mountains as borders. Forest institutions, in contrast, focus on middle and high-elevation zones. The main rivers, Brantas, Rejoso, have coordinating mechanism (Brantas river authority, Rejoso watershed forum). The shifting stakeholders of the various co-existing phases (I – VI) of the landscape form a special challenge for achieving sustainable development goals (SDGs). Tradeoffs exist between basic securities (including food, water, health, income), identity (e.g. for Tengger mountain people) and cross-generational well-being.

*Rejoso kita*: effort to connect farmers - government-private sector to jointly manage water in better ways.

Forest policy is a national issue, with limited space for local forest management units to innovate, but new ideas piloted in the UB-educational forest area have a chance to influence national rules.





Poverty (SDG 1)



Food & Nutrition (SDG 2)



Health (SDG 3)



Gender Equality (SDG 5)



Affordable Clean Energy (SDG 7)



Sustainable Cities (SDG 11)



Responsible Consumption/ Production (SDG 12)



Climate Change (SDG 13)



Terrestrial Ecosystems (SDG 15)

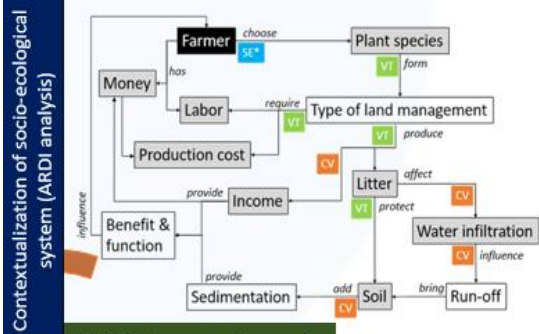


Justice & Strong Institutions (SDG 16)



Agroforestry's many faces reflect these narratives and shape ways forward, integrating across forest- and agriculture-based policies, water and land-based lowland interests, product- and service-based economy  
 New ways to connect stakeholders to landscape-level commitments and decisions: Serious games.

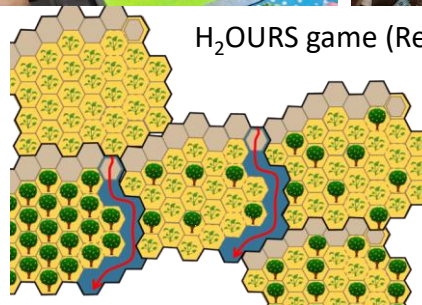
FORCES (plot- level – Rika Ratna Sari)



FORCES game elements



H<sub>2</sub>OURS game (Rejoso – Lisa Tanika)



## Suggested further reading

### Setting the scene

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Mulyoutami EP et al. 2023?. Agroforests where instrumental and relational values of nature intersect. *In review*.

Tanika L et al. 2023?. Securing rainfall in relational and instrumental perspectives. *In review*.

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### Water towers: regulating services for lowlands

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## Suggested further reading

### Resilient mountain livelihoods

Sudharta Ka, Hakim Al, Fadhilah Ma, Fadzil Mn, Prayogo C, Kusuma Z, Suprayogo D. 2022. Soil organic matter and nitrogen in varying management types of coffee-pine agroforestry systems and their effect on coffee bean yield. *Biodiversitas Journal of Biological Diversity* 23(11).

### Specialty farms: shifting markets

Duguma LA, van Noordwijk M, Minang PA, Muthee K. 2021. COVID-19 pandemic and agroecosystem resilience: Early insights for building better futures. *Sustainability* 13(3):1278.

Rowe RL, Prayogo C, Oakley S, Hairiah K, van Noordwijk M, Wicaksono KP, Kurniawan S, Fitch A, Cahyono ED, Suprayogo D, McNamara NP. 2022. Improved coffee management by farmers in state forest plantations in Indonesia: an experimental platform. *Land* 11(5):671.

van Noordwijk M, Martini E, Gusli S, Roshetko J, Leimona B, Nguyen MP. 2021. Cocoa and coffee in Asia: contrasts and similarities in production and value addition. In: *Tree -*

*Commodities and Resilient Green Economies in Africa*. Minang PA, Duguma LA, van Noordwijk M (Eds). World Agroforestry (ICRAF), Nairobi, Kenya.

### Ecotourism: healing services

van Noordwijk M. 2021. Agroforestry-Based Ecosystem Services: Reconciling Values of Humans and Nature in Sustainable Development. *Land* 10(7), 699.

### Governance: keeping it all together

van Noordwijk M, Duguma LA, Dewi S, Leimona B, Catacutan DC, Lusiana B, Öborn I, Hairiah K, Minang P, Ekadinata A, Martini E. 2019. Agroforestry into its fifth decade: local responses to global challenges and goals in the Anthropocene. In: *Sustainable Development through Trees on Farms: Agroforestry in Its Fifth Decade*; van Noordwijk, M., Ed. pp 397-418.

van Noordwijk M, Speelman E, Hofstede GJ, Farida A, Abdurrahim AY, Miccolis A, Hakim AL, Wamucii CN, Lagneau E, Andreotti F, Kimbowa G. et al. 2020. Sustainable agroforestry landscape management: Changing the game. *Land* 9(8):243.

Agroforestry's many faces reflect these narratives and shape ways forward, integrating across forest- and agriculture-based policies, water and land-based lowland interests, product- and services.

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