**Sumatra Journal of Disaster, Geography and Geography Education**
ISSN: 2580-4030 (Print) 2580-1775 (Online)
Vol 1, No. 2, (pp. 39-48), December, 2017
http://sjdgge.ppj.unp.ac.id

# Climate Change Mitigation in Practice: Ecosystem Restoration Around Lake Singkarak, Sumatra

**Paul Burgers**
$CO_2$ Operate Netherland
Email: p.burgers@co2operate.nl

## Abstract

An increasing important component of climate change mitigation is restoring degraded lands, while improving the economies of communities living in and around degraded forests. The national Low Emission Development Strategies (LEDS) in Indonesia have put ecosystem restoration and sustainable forest management (including social forestry) in degraded areas upfront. In line with the Indonesian and global climate change policies, a Dutch-based social enterprise named CO2 Operate, has been running a Voluntary Carbon Mechanism (VCM) scheme in West Sumatra's Singkarak Lake watershed since 2009. The scheme is entirely financed through private sector carbon offsetting. In close collaboration with the Provincial Forestry Department and local partners in education, the VCM scheme brings back tree cover to restore ecosystem functions on the degraded slopes of lake Singkarak. A combination of Assisted Natural Regeneration (ANR) and tree planting brings both significant environmental and livelihood improvements. The ecological and cost effective approach allows for even the poorest farmers to join and improve their livelihoods. It brings back a forested landscape and its associated biodiversity within 5 years, while significant carbon sequestration above and below ground fits the low emission development of the Indonesian government to mitigate climate change.

**Keywords:** Climate Change, Mitigation, Ecosystem Restoration

## Introduction

Tropical forests have at least three crucial roles to play, ranging from the local to the global level. First of all, compared to other ecosystems tropical forests are areas of extremely high biodiversity. It is estimated that tropical forests hold over 50% of the terrestrial biodiversity of our planet. Secondly, over two billion people depend directly on tropical forests for their food, income, and medicines or indirectly through the ecosystem services tropical forests provide. Finally, tropical forests are important regulators of our global climate. Tropical forests store about 25% of the global carbon (Poorter *et al*, 2015; Hermon, 2017).

Processes of land use change, which lead to deforestation will not only decrease local and regional ecosystem functions, it causes the release of large amounts of carbon at the global level. Released carbon reacts with oxygen to become carbon dioxide. Carbon dioxide is one of the most important greenhouse gases causing climate change. The IPCC calculated that the land use and land use change sector (referred to as the AFOLU sector) contributes to almost 25% of the global GHG emissions (Smith *et al*, 2014). Whereas investments in low-carbon energy infrastructure, including renewable energy, are increasing globally, a more concerted effort in the land use sector to mitigate climate change is now required. This will be particularly crucial in countries where the AFOLU sector contributes extensively to processes of climate change. Indonesia is one such country where the AFOLU sector is a major contributor to national greenhouse gas emissions.

The AFOLU sector in Indonesia contributes to around 63% of the total national GHG emissions (NDC Indonesia, 2016). Indonesian forests are under severe pressure of degradation and conversion into other land uses. Over 30 million hectares of forest and its associated biodiversity have already disappeared over the past decades. Climate action tracker estimates that deforestation in Indonesia contributes to over 70% of national GHG emissions, placing Indonesia in the top 5 of largest $CO_2$ emitters in the world (http://climateactiontracker.org/countries/indonesia.html). The high deforestation rates in Indonesia affect the livelihoods of over 60 million people, who directly depend on the forest for their survival. Deforested areas and associated with it, the loss of biodiversity and ecosystem services, means that many communities face problems with soil fertility and water regulation as forest ecosystems degrade. This causes a downward spiral, as degraded forests become increasingly susceptible to (wild) fires. Repeated fires will cause further degradation, leaving a fire-climax grassy vegetation, known as Imperata Cylindrica, as the dominant vegetation. It is estimated, that in Indonesia there is around 8.5 million ha of these fire-climax Imperata Cylindrica grasslands (Garrity *et al*, 1996; Friess, 2017). In the absence of cost-effective and small scale farmer-adapted technologies to restore ecosystems, while providing a sustainable income at the same time, these degraded areas remain idle. The mitigation potential of the land use sector, realized through land rehabilitation and ecosystem restoration of Imperata grasslands in particular can make a significant and immediate contribution to achieving Indonesia's climate change mitigation targets.

## Climate Change and Land Degradation Policies in Indonesia

The Indonesian climate plan, the Nationally Determined Contribution (NDC) of 2016 states that the Indonesian government aims to reduce emissions by 29%, i.e. 835 MTon $CO_{2e}$ by 2030 compared to the Business as Usual (BaU) scenario. Most of this goal (87%) is to be achieved by reducing emissions from deforestation and peat land conversion (MER, 2016; NDC 2016). Low emission development strategies are laid out in the national Low Emission Development Strategies (LEDS) of Indonesia. LEDS first emerged under the United Nations Framework Convention on Climate Change (UNFCCC) in 2008. LEDS are generally used to describe forward-looking national economic development plans or strategies that encompass low-emission and/or climate-resilient economic growth (Clapp et al, 2010). Land rehabilitation and improving the economies of communities living in and around degraded forests and other land-sector domains, such as agriculture, receive a prominent position in the LEDS (http://www.asialeds.org/resource/indonesias-low-emission-development-strategy/). The term 'degraded' has been used in multiple contexts in Indonesian law and policy. It generally denotes land that contains less than 35 MG of carbon per hectare, or land that is legally designated as degraded (Republic of Indonesia, 2015; Gingold et al 2012). Land degradation assessments in Indonesia reveal 15.5 M ha in two (2) high priority rehabilitation categories: i.e. 7.0 M ha abandoned land ("tanah terlantar yang kondisinya sangat kritis") and 8.5 M ha of "alang alang" grassland (Imperata cylindrica), (FAO, 2010) .

If planned well, the reversal of land degradation can serve several important benefits simultaneously. In this respect, climate-smart land management practices nearly always come with adaptation co-benefits. Their more efficient use of resources and inputs ensure greater food and water security, and build community resilience while, at the same time, sequestering carbon, both above- and below ground (UNCCD, 2017). In the Intended National Determined contributions (INDC), countries across the globe, including Indonesia, have laid out the steps they will take to address climate change in their own country. In Indonesia, a major component of the INDC is the restoration of ecosystem functions and sustainable forest management (including social forestry) in degraded areas through the active participation of the private sector, civil society organizations, local communities and vulnerable groups, especially adat communities and women, both in the planning and implementation stages (NDC of Indonesia, November 2016).

*Sumatra Journal of Disaster, Geography and Geography Education*
ISSN: 2580-4030 (Print) 2580-1775 (Online)
Vol 1, No. 2, (pp. 39-48), December, 2017
http://sjdgge.ppj.unp.ac.id

## Climate Change Mitigation Policies in West Sumatra

In line with national policies, West Sumatra has implemented policies to mitigate climate change. Mitigation is key in these policies and the forest sector plays an important role. In West Sumatra, land and forest rehabilitation programs are carried out as part of a community empowerment strategy which includes:

- Regional strategic planning for middle term development (RPJMD)
- Regional Action Plan Policies to reduce Greenhouse Gases (RAD-GRK West Sumatra)
- Provincial Strategy Action Plan (SRAP) Policy for REDD$^+$ in West Sumatra
- Provincial Policy Priorities for Forest Plan (PCTR) in West Sumatra

These programs are geared at land under the control of the provincial and district authorities in West Sumatra. This means that these policies and programs do not include the village adat land. Although it is particularly mentioned in the 2016 NDC that adat communities should actively participate, local government agencies in West Sumatra have no official control over these village areas. Since the colonial period and under subsequent Indonesian governments, the pre-colonial adat system was neglected. Since decentralization in the early 2000s the nagari system was re-installed as a recognized village and land administration system in West Sumatra. To reinforce the nagari as the guardian of the customary law (hukum adat) and to specify its jurisdiction, the Regional Government of West Sumatra enacted two laws between 2000 and 2008: Law No. 9/2000 repealed by Law No. 2/2007 and Law No. 6/2008 on communal land tenure (Tegnan, 2015).

Although the local government authorities have no official control over these lands, they can and are willing to support activities here. They recognize the fact, that in order to make their own programs successful, degraded adat village lands in particular, which are often adjacent to state forest lands, can play an important role. $CO_2$ Operate BV has stepped into this gap through the restoration of these degraded, imperata-covered, adat lands into productive forested areas. Funding of the restoration activities come from private-sector companies in the EU, wishing to off-set their carbon emissions. Reforestation of Imperata grasslands contributes considerably to climate change mitigation through increasing the above- and below-ground carbon storage. Increasing the amount of carbon in the soil will support soil fertility processes.

If planned well, reforestation will restore biodiversity and other ecosystems services, support climate change mitigation, while simultaneously improving people's livelihoods. The provincial Forestry Department has provided valuable support ever since the start of $CO_2$ Operate's program in West Sumatra. The gulagula food forest started in 2009. Activities have been implemented in close collaboration with staff and students of the teacher's college STKIP in two districts, namely Agam district (35 ha) and around lake Singkarak in Solok district (33 ha). In 2017-2018 another 100 ha will be implemented. In this paper, we focus on the activities around lake Singkarak. The reasons are that our future activities will concentrate in the lake Singkarak river basin. This is in line with priorities of the provincial Department of Forestry. The lake Singkarak river basin is considered a high priority area for ecosystem rehabilitation.

## The Singkarak River Basin

The Singkarak river basin belongs to two districts (kabupaten in the Indonesian language).These are kabupaten Tanah Datar in the northern part and kabupaten Solok in the southern part of the lake. The lake is a deep depression in the rift valley of the Bukit Barisan mountain range. It takes in water from five streams and rivers from surrounding slopes, while the river basin feeds into important connecting rivers. The lake's natural outflow is via the Ombilin River. Singkarak Basin is an elongated basin from Mt Merapi in the north and Lake Danau Di Bawah in the south. It is part of the depression of Semangko faults, bound by mountainous area of Bukit Barisan in the west, and tertiary fold in the east. (Sandy, 1985) . The main soil types on the slopes around the lake are lithosols and Rendzina (Laumonier, 1996). Developed on limestones, these soils are poor in organic matter and have high erosion risks.

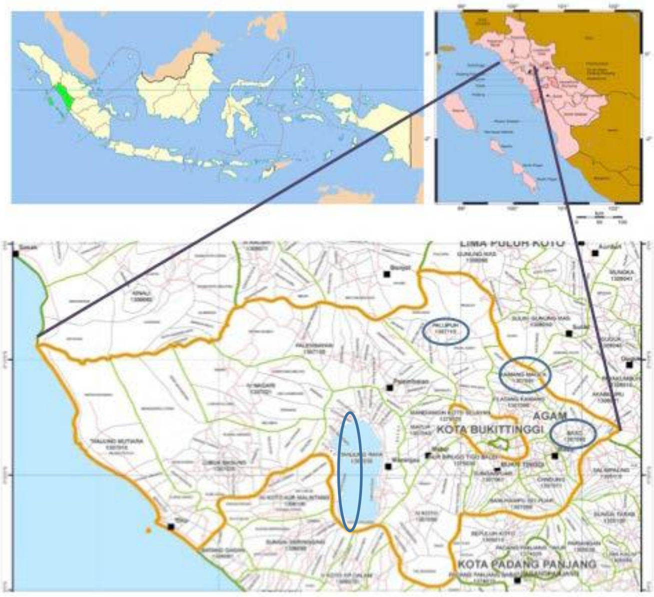


**Figure 1.** The Food Forest Sites (blue circles) in Indonesia/West Sumatra province

The Singkarak river basin is situated in the Minangkabau heartland. The Minangkabau are known for its matrilineal organization of society. Land inheritance largely follows the female lines of the family. The nagari (minang version of village) is the lowest organizational unit, and recognized as such by the Indonesian authorities. The nagari comprises the village and agricultural land. The boundaries of a nagari usually coincide with a (sub)-water catchment. Indigenous traditions in governing the land continue to be strong. Landwnership — or more precisely, the right to use the land — is governed through locally defined rules called adat (von Benda-Beckmann and von Benda-Beckmann 2004). The adat council is the highest governmental body of the nagari. The nagari leaders govern and enforce norms and conventions for the sake of overall prosperity, including a sustainable management of their own water resources.

## Degrading Environmental Ecosystem Functions

The Singkarak river basin provides important environmental and socio-economic ecosystem service functions. Hydrological service functions and biodiversity protection are among the most important environmental functions. Not only to provide clean drinking water and irrigation water for rice cultivation to the communities living here. In addition, a 175 MW hydro-electricity power-plant was developed in the 1990s. Situated at the outflow of the lake (Peranginangin et al, 2004), this power-plant requires sufficient and stable water levels in the lake.

Good functioning ecosystems on the hills in particular in this river basin are crucial to provide the needed ecosystem services. However, forests on the slopes around lake Singkarak have been depleted since the colonial era to provide wood for coal mines. Local communities have since long used these deforested hills for mixed-tree cultivation, including clove trees and various types of fruit trees. Government-sponsored programs have also brought pine tree plantations to the hilly areas. However, in the 1970s pests killed most of the productive and non-productive trees. Tree-crop cultivation was abandoned. It left many people devastated without financial means or alternatives to rebuild this livelihood option. According to the local

Sumatra Journal of Disaster, Geography and Geography Education
ISSN: 2580-4030 (Print) 2580-1775 (Online)
Vol 1, No. 2, (pp. 39-48), December, 2017
http://sjdgge.ppj.unp.ac.id

people, a large scale pine tree plantation project from the government has aggravated the degradation of the hill sides. They claim that pine trees cause soils to dry up (Leimona et al, 2015). Ever since, recurrent wildfires have turned these hillsides into fire-climax Imperata cylindrica (or alang-alang) grasslands, which continue to exist up until today. About 32% of the area surrounding the lake (18 664 hectare) is now considered critical land, covered by Imperata grassland, while rice paddy (21%), upland crops (17%) and other uses (30%) make up the rest.

Once Imperata establishes it becomes hard for other plant and tree species to establish and grow, as Imperata outcompetes any other plan species. Wildfires speed up vigorous resprouting and fast regrowth of imperata (Wibowo etr al, 1997). Consequently, Imperata cylindrica establishes very strongly, making it harder for other plant species to establish and making the area even more susceptible to wildfires. It is known that once Imperata grasslands establish, it becomes hard to reclaim and convert the land for agriculture. The costs of replacing the original ecosystem goods and services from the forest including timber products, fire stability and soil nutrients — rise sharply as Imperata grasses spread (Chaplin et al, 2000). For instance, a study by Mikkila et al (1997) for instance estimated that converting Imperata grasslands into a tree plantation will cost around U$ 840 per ha. This makes it very costly for resource-poor farmers to restore these areas, while the investment has a high risk of literally going up in smoke, as Imperata grasslands burn easy and often out of control. The level of biodiversity is also low in Imperata grassland, and with it reduces the resilience of ecosystems to environmental change.

## Degrading Socio-Economic Ecosystem Functions

In broader terms, important socio-economic functions of the Singkarak river basin consist of income from fishing (total 76.5%), domestic water-use, and irrigation water for rice production. Rice cultivation, managed by the female members of a suku (clan) is an intrinsic part of minang culture, and is crucial for food security. It provides an important in-kind contribution to family wealth. Both irrigated rice cultivation and fishing mean that the livelihoods of the people depend highly on the natural ecosystem. Although fishing is considered important to earn a cash income, figure 3 shows that fish stocks decreased tremendously between 1996-2003. This has not recovered ever since.


**Figure 2.** Fish production decline in Lake Singkarak ,1988-2004
Source: Yuerlita & Perret (2010)

The main reasons for this decline are inappropriate fishing techniques and increased sedimentation and eutrophication which cause the death of the endemic bilih fish (ikan bilih). The reliability of the irrigation water has also been significantly reduced as the ecosystem functions of the river basin continue to deteriorate. This negatively impacts on rice yields. Over the past years, rice yields dropped from an average of 4.2 tons/ha earlier to 3.1 tons/ha nowadays. A combination of decreasing opportunities of the barren hills to regulate water flows in combination with more intense rainfall, floods increase. In 2016 for instance, almost the entire rice harvest was destroyed as ricefields were flooded after days of continuous rain in several nagari around the lake.

Decrease in income from fishing and the established Imperata grasslands on former agricultural land has significantly increased livelihood vulnerability. Poverty is widespread in the river basin. Looking at income data, in subdistrict junjung sirih, where nagari Paninggahan is situated, the area of the VCM scheme, the average monthly income at sub-district level is between 1.3 million to 1.5 million Indonesian Rupiah per month, or around € 91 on average (Tri Martial, 2012). In nagari Paninggahan, village data show that the situation is even worse; around 1 million rupiah (about € 70) per month. This is almost half the official minimum wage for West Sumatra, set at RP 1,945,000 per month for 2017 (around € 136 per month).

## Establishing a VCM Scheme

With the challenges mentioned here on increasing poverty, which hampers investment in degraded agricultural lands, CO2 Operate BV, in close collaboration with their local partners and the local community of nagari Paninggahan, began developing a voluntary carbon scheme which would enable climate change mitigation by ecosystem restoration on the degraded hills. The VCM scheme appeared to be the first real-life carbon-trading scheme in Indonesia. It closely followed Indonesian climate change policy, earning it strong support from the authorities in dealing with procedures, permits and even seedling provision. The scheme is implemented on village land. Off-setting contracts from the private sector in Europe would cover the establishment costs of mixed agroforestry on the hills. Establishment costs turned out to be relatively low, as $CO_2$ Operate together with FAO developed a cost-effective and labour-saving technique to bring back tree cover on Imperata grasslands (Burgers et al, 2014). A combination of Assisted Natural Regeneration (ANR) and the planting of economic valuable trees provide a quick establishment of tree cover.

### Food Forest Restoration by Assisted Natural Regeneration (ANR) and Tree Planting

The concept, principles and procedures for implementing Assisted Natural Regeneration (ANR), combined with tree planting, are fully consistent with the emphasis on climate change mitigation through restoration of tree cover for carbon enhancement contained in the Indonesian government priorities. A number of activities must be applied in restoring forests via ANR. These are social preparation/collective action, selection and liberation of the preferred natural growth, maintenance and protection of the natural regeneration. These can be combined by setting up a fire-break. However, the community decided to keep an eye on possible fires themselves, and not to develop a fire-break. It turned out, that since the project began, (wild) fires also disappeared. The participants said that since people knew about the program, they became very cautious.

### Social Preparation

If any attempts to restore Imperata grassland landscapes are to be successful, collective action could make a difference. Over the years, we have built a strong collaboration with important stakeholders in landscape restoration at national, decentralized- and the nagari level. These are important for the success of restoration activities. Using Free, Prior and Informed Consent (FPIC), we started negotiating with the communities and local government bodies to reach consensus about the restoration efforts and the components in the performance-based contract between $CO^2$ Operate BV, the Village Adat council and the farmers. It would give them the right to give or withhold their consent to the proposed activities. The established farmer groups were coordinated by the village elites, in line with the Adat hierarchical system. The strong chieftaincy caused other group members to be reluctant to speak out about their ideas and

**Sumatra Journal of Disaster, Geography and Geography Education**
ISSN: 2580-4030 (Print) 2580-1775 (Online)
Vol 1, No. 2, (pp. 39-48), December, 2017
http://sjdgge.ppj.unp.ac.id

concerns about the performance of the project, which also decreased participants' motivation. The farmer-participants requested for a new, more open and direct agreement between $CO^2$ Operate BV and the farmer groups only. New farmer groups were setup with horizontal social relations, without the direct participation of the Adat village elites. This process of democratization also increased the effective participation within and between farmer groups. $CO^2$ Operate BV staff supported the new farmer groups (kelompok) to apply for a formal status (cooperative). It enabled each farmer group to open a cooperative bank-account, so that carbon payments could be made directly into the cooperative account. This new lay-out of the farmer groups made restoration efforts very effective.

The big advantage of Assisted Natural Regeneration is that Imperata grasslands no longer need to be uprooted and removed, but are simply pressed, using a lodging board. Small, indigenous tree seedlings, which are found in between the Imperata grasses, are protected and allowed to grow after pressing the grasses. This greatly reduces the competition from grasses, bushes and vines that hinder growth of the trees. Restoration of tree cover can happen in a relatively few years instead of 10-20 years. With adequate rain and good implementation, impressive ANR results are usually evident in less than 3 years. Restoration of tree cover can happen in a relatively few years instead of 10-20 years. With adequate rain and good implementation, impressive ANR results are usually evident in less than 5 years.

This technology has shown a tree growth beyond expectations. Quick gains in carbon stocks were achieved. The growth of the present indigenous species was no longer suppressed. The farmers appeared very enthusiastic about the ANR practices, especially in combination with the planting of economic valuable agroforestry trees, as the fast-growing indigenous trees provide favourable micro-climatic conditions for the planted economic valuable trees. In addition, the pressed Imperata grasses form a thick isolation blanket, thereby reducing soil temperatures and conserving moisture. Even after a 5-6 weeks dry period we found that the soils below the pressed Imperata remained moist. Another big advantage is the fact that the decaying Imperata provides additional carbon to the soil. The "trapped" moisture and added carbon in the soil most likely explain the rather fast accumulation of soil carbon and fast growth of the trees.

Figure 3 below shows the amount of carbon that is being sequestered since the start in 2009. Despite the fact, that in 2009 and 2010 a drought caused by El nino severely hampered carbon sequestration in the beginning, carbon sequestration has been quite impressive ever since.

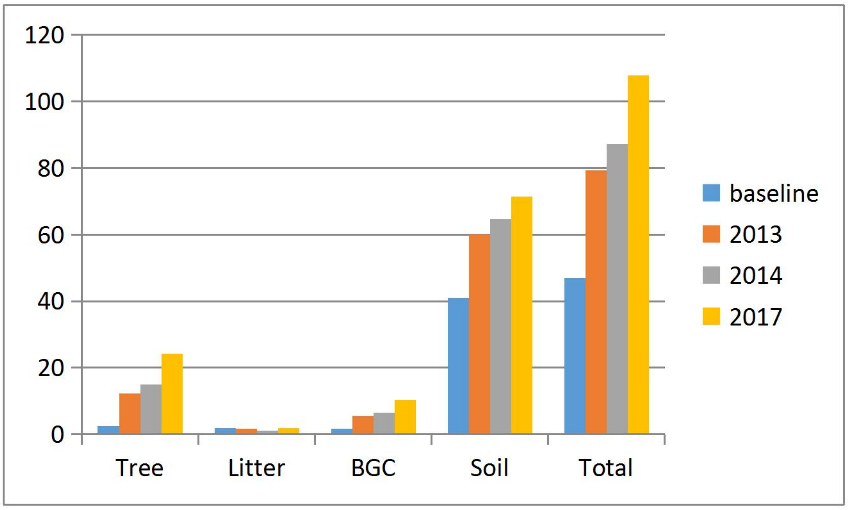


**Figure 3.** Carbon sequestration (Ton/ha) from grassland conversion (baseline) to food forest.
Sources: Field data carbon assessment 2013, 2014, 2017; baseline data from Yassir, 2012, Megawati et al, 2014.

**Sumatra Journal of Disaster, Geography and Geography Education**
ISSN: 2580-4030 (Print) 2580-1775 (Online)
Vol 1, No. 2, (pp. 39-48), December, 2017
http://sjdgge.ppj.unp.ac.id

ANR is a practical strategy to apply in restoring forests. ANR also significantly reduces costs. Traditional reforestation practices involve: seedling production, site preparation, planting, maintenance and protection. To rehabilitate the high priority 15.5. M ha target set by the Indonesian government from the present until Year 2030, the annual target would be 1.03 M ha (1.5 M ha ÷15 years =1.03 M ha/yr. If conventional reforestation practices are applied, at the prevailing average cost of US$1,000 (approx Rp. 12,000,000), the annual budget would need to be around US One Billion US Dollars (. That would be a huge challenge in terms of inputs from field personnel, government financial management and scheduling.

As a general rule, no costs are incurred in ANR for seedling production, site preparation and planting. Thus costs are much lower than in traditional reforestation. It turned out that Application of ANR at the average cost of US$250 per hectare brings about a 75% reduction in costs. Moreover the end result would be highly diverse forests consisting of native species and planted income-generating trees with significant carbon sequestration potential, thus contributing to reduction emission targets.

**Biodiversity enhancement**

Our experiences have proven that within 5 years a biodiverse food forest establishes which combines the growth of indigenous species with planted agroforestry trees. Besides providing better incomes and a more diverse food pattern for the local community, this forest-like structure begins to provide increasing corridor and habitat functions for a growing number of animals and plants. After 3-4 years more and more proof was found that an increasing number of animals were roaming around in the gula gula food forest. This ranged from animal tracks to animal-induced damage to the trees. Furthermore, the farmers see and hear an increasing sound of various types of birds. The farmers judge that the birds divert their flying routes nowadays and use the food forest to eat and find shelter when flying from one patch of forest to another. To get an impression of what animals are present, two camera traps were set up in the site. It turned out, that representative animals from each trophic level roam around in the restoration sites, making a complete food chain. This indicates that environmental conditions in the gula gula food forest sites resemble rainforest conditions.

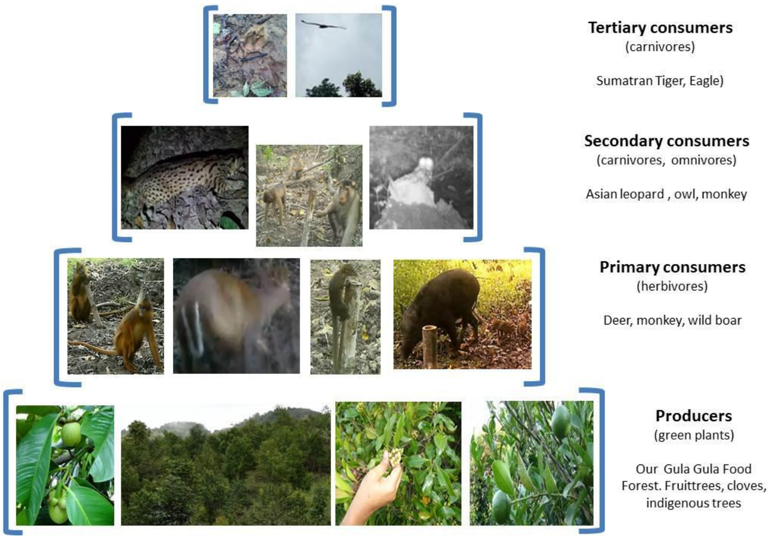


**Figure 4.** Return of the food chain in the Gula Gula food forest
Source: author's pictures and taken from installed wild trap cameras

## Conclusion

Although it was generally assumed that restoration of Imperata grasslands through VCM schemes may not be possible, the experiences presented here show that, here is huge potential in restoring degraded Imperata grasslands. Assisted Natural Regeneration (ANR) dramatically expedites forest restoration, especially on denuded grasslands and degraded forest areas. ANR is simple to teach and easy to learn and apply. Where restoration of Imperata grassland is often seen as too costly, ANR takes advantage of wild seedlings already growing in an area. Root systems of these seedlings are already in place. Therefore, the trees can grow rapidly when competition is removed or reduced. Another good point for applying ANR is to enhance plant diversity. Naturally-regenerated vegetation will almost always comprise a mixture of species. Therefore, ANR produces a more diverse and multilayered vegetative cover than traditional reforestation. This diversity helps ensure environmental stability and, if planned well, can contribute significantly to poverty reduction. eradication is very desirable in areas intended for watersheds and wild animal habitats. It could contribute significantly to achieving targets set by the Indonesian government to achieve climate change mitigation objectives through forest restoration.

## References

Burgers, P., H. Iskandar, B.Angkawijaya, R. Pandu Permana, A. Farida. (2014). Restoring productive landscapes through the voluntary carbon market in West Sumatra. ETFRN Newsletter 56. Towards productive landscapes. pp. 132-139

Clapp, C., G. Briner and K. Karousakis. (2010). "Low-Emission Development Strategies (LEDS): Technical, Institutional and Policy Lessons", OECD/IEA Climate Change Expert Group Papers, No. 2010/02, OECD Publishing, Paris.http://dx.doi.org/10.1787/5k451mzrnt37-en

Climate action tracker: http://climateactiontracker.org/countries/indonesia.html

Forestry Department Food and Agriculture Organization of the United Nations (2010)

Friess, A. D. (2017) Ecotourism as a Tool for Mangrove Conservation. Sumatra Journal of Disaster, Geography and Geography Education. Vol. 1 No. 1. pp: 24-35

Global forest resources asssessment 2010. Country report: Indonesia. FRA2010/095, Rome

Garrity, D.P., M. Soekardi, M. van Noordwijk *et al.* (1996). The Imperata grasslands of tropical Asia: area, distribution, and typology. Agroforestry Systems December 1996, Volume 36, Issue 1–3, pp 3–29.

Hermon, D. (2017) Climate Change Mitigation. Radja Grafindo. Jakarta

Kuusipalo, J., T.S. Hadi, P. Lattunen, A. Otsamo, A. (1996). Restoration of land productivity and environment through reforestation of imperata cylindrica grasslands. New Zealand Journal of Forestry Science 26(1/2). pp. 307-319

Megawati, K., Warda, Arianingsih, I. *et al.* (2014). Cadangan karbon tanah sekitar danau tambing di kawasan taman nasional lore lindu. Warta Rimba,volume 2, nomor 1, Juni 2014. Hal: 112-119.

Mikkila, M. A. Otsamo, J. Kuusipalo. (1997). Financial, economic and environmental profitability of reforestation of Imperata grasslands in Indonesia. Forest Ecology and Management. Volume 99, Issues 1–2, December 1997, Pages 247-259.

Smith P., M. Bustamante, H. Ahammad, H. Clark, H. Dong *et al.* (2014). Agriculture, Forestry and Other Land Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Poorter, L, M. T. van der Sande, E. J. M. M. Arets, M. Peña-Claros *et al.* (2015). Diversity enhances carbon storage in tropical forests. Global Ecology and Biogeography 24: 1314-1328.

UNCCD. (2015). Land Matters for Climate: Reducing the Gap and Approaching the Target. http://www2.unccd.int/publications/land-matters-climate-reducing-gap-and-approaching-target

Wicke, B. (2011). 'Exploring Land Use Changes and the Role of Palm Oil Production in Indonesia and Malaysia'. Land Use Policy 28(1): 193-206.

Policy brief. (2014). Biodiverse forests in West Sumatra, Indonesia, with assisted natural regeneration (ANR). A policy brief prepared for FAO, Bangkok, 2014.

Yassir,I. (2012). Soil carbon stocks and changes upon forest regeneration in East Kalimantan- Indonesia, 176 pages. PhD Thesis, Wageningen University, Wageningen, The Netherlands. ISBN 978-90-6464-576-1

Yuerlita and Perret , S. (2010). Livelihood features of small scale fishing communities: A case from Singkarak lake, WestSumatra, Indonesia. International journal of environmental and rural development 1-2. pp 94-101.