Soil and water management towards sustainable agriculture in Malaka District, NTT Province of Indonesia

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Abstract. The study was conducted to ascertain the restoration benefits of using assisted natural shifting cultivation in the dry land dominate agricultural activities in semi-arid developing nations such as in Malaka District of Indonesia. Common problems faced would include rapid population growth, land degradation, high dependence on rainfall, limited production factors, limited human resources, prone to natural disasters and other problems that can cause crop failure impacted food security of the population. This paper presents the results of a participatory and collaborative study to formulate an appropriate dryland farming strategy for farmers in Malaka District – NTT. This study was conducted through literature study, presentations and participatory discussions with 32 farmer group representatives, local governments and NGOs. The results indicate that stakeholders were agreeing to increase soil and water conservation efforts through the application of agroforestry and conservation agriculture, especially on sloping land. Farmers groups were expecting sustainable assistance in production input and expertise and active involvement of local governments and NGOs. Meanwhile, the local government expects the involvement of all parties, especially the farming community participation in managing land and water by taking into account the balance of the ecosystem. Moreover, stakeholders were aware of the importance of establishing forums or institutions that could facilitate multi-stakeholder cooperation and encouraging sustainable agriculture planning, regulations and practice from village to district level.

Key Words: agroforestry, collaborative, conservation agriculture system, land and water management, participatory, shifting cultivation.

Introduction. Regarding the level of culture and agricultural technology, agriculture can be grouped into food gathering agriculture, shifting cultivation, intensive cultivation and agro-industry. Basically, agricultural activities in the NTT province are aimed at meeting food needs for families (subsistence) as well as for trading purposes (commercial). Agriculture to mainly consumption (subsistence) generally takes place in developing countries, and usually consists of three types, namely shifting cultivation, permanent subsistence agriculture and pastoralism (Koehuan 2015).

Corn (*Zea mays* L.) and rice (*Oryza sativa* L.) are the main food crops in the semi-arid region of West Timor which is one of the main islands of the NTT Province, where the District of Malaka is located. Agriculture is the most important livelihood for about 61% of the population. However, most of the population in the West Timor still relies on traditional subsistence agriculture in the form of shifting cultivation whilst an intensive agriculture has not provided much benefit to the majority of the population. Moreover, the El Nino Southern Oscillation also had a major impact on the island, resulting in a very long dry season. During the rainy season, the timing and intensity of rainfall become irregular, threatening plant growth and production leading to threat food security in this region (Koehuan et al 2020a, 2020b).

Shifting cultivation is the most complex and multifaceted form of agriculture in the world. Its highly diverse land use systems have been evolving since as early as 10,000 BC in a broad range of distinct socioeconomic and ecological conditions. Shifting cultivation encompasses cropping systems such as horticulture and annual cropping,

perennial tree crops, animal husbandry, and management of forests and fallows in sequential or rotational cycles (Thrupp et al 1997). Moreover, Mathur & Bhattacharya (2022) explained that shifting cultivation systems or swidden agriculture or slash and burn agriculture denote agricultural practices undertaken through a dynamic cycle of rotational farming, primarily in the tropical regions and countries that hold global importance for their biodiversity and carbon sequestration. It is an estimate; the South-Asian population (excluding China and Cambodia) rely on shifting cultivation ranges between 14 and 34 million. Basic shifting cultivation cycles that commonly practice in the developing countries is presented in Figure 1.

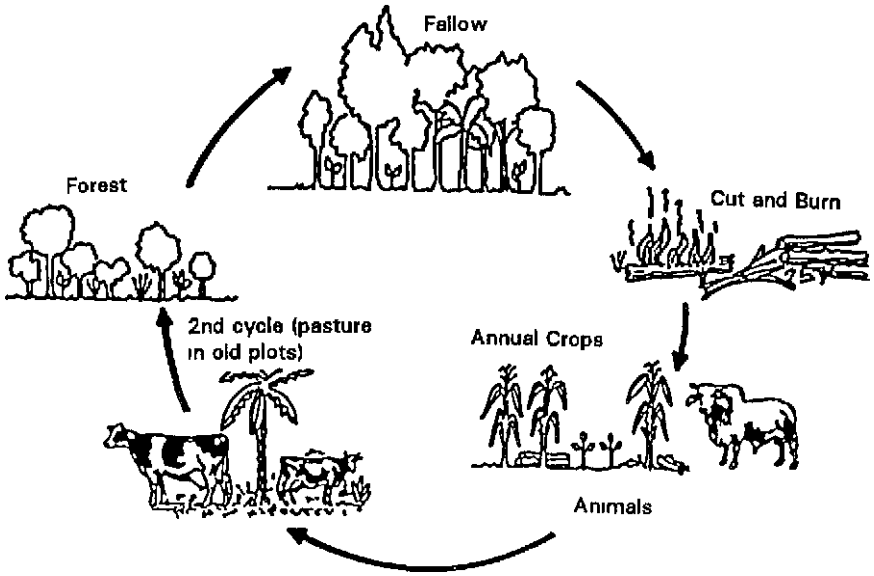


Figure 1. Basic shifting cultivation cycle (source: Thrupp et al 1997)).

According to Foenay (2000) 80% of the population of NTT province relies on dry land agriculture for their livelihood, most of them still carry out shifting cultivation activities, and only about 10% of the population relies on rice fields and commercial agriculture. This is in line with what Suradisastra (2001) stated, that the traditional culture of the eastern part of Indonesia including NTT Province is basically a shifting cultivation and hunter-gatherer culture with low productivity levels, but with high sustainability. This means that almost every member of the community is able to carry out these activities in a sustainable manner because these activities require little production input.

Fox (2000) stated that shifting cultivation and grazing also affect land use and land cover. Although land use has not changed significantly for decades, due to population growth demands and food needs, more land is needed and a shorter fallow period, this results in faster land use changes. In terms of environmental conservation, Fox (2000) stated that for the context of NTT province, shifting cultivation is more ecologically and culturally suitable in terms of the ability to maintain biodiversity compared to commercial sedentary agriculture which tends to cultivate certain commodities. He suggested it is better to increase crop productivity and efforts to maintain soil fertility in such swidden farming systems.

Mundita (2000) stated that the shifting cultivation system in NTT Province is not easy to accept new varieties with high yields or use artificial fertilizers to maintain soil fertility. Shifting farmers are generally subsistence farmers who only meet their food supply, do not have strong capital to purchase the seeds and fertilizers they need. Another problem is the land use conflict between shifting cultivation and pasture.

The use of fire in shifting cultivation is very important. Myers et al (2000) explained that fire is used to burn the remains of wood and plants that have been cut and dried previously. Burning materials will produce nutrients for plants, control weed growth, maintain top soil fertility, maintain top soil structure so as to increase infiltration and increase soil binding capacity to water and soil nutrients. Burning also causes the growth of young grass which is useful for grazing livestock. However, after the burning

and planting process, the soil condition becomes prone to erosion due to changes in land cover; the soil becomes easily eroded, especially on hillsides. Djoeroemana et al (2000) stated that uncontrolled burning of shifting fields and pastures can inflict forest damage. Even though forests are one of the livelihoods for the people of NTT province, forest products in the form of wood and non-timber are very beneficial for the lives of rural communities.

According to Therik (2000) the shifting cultivation cultural system in Timor Island, especially the Meto, Tetun and Bunak ethnic groups, has the components of crop and land allocation. The main crop components are maize, sorghum and dry land rice. These plants have cultural and economic value. Other plants that cultivated are including millet, flax, tourist bean and tubers. Regarding land allocation, Therik (2000) explains that the ancient Timorese divide it into three parts, namely: prohibited land, dwelling land and cultivation land. Sacred or prohibited land use was strictly limited to activities regulated by local customary leaders for indigenous custom ceremonies; residential and agricultural activities were prohibited from using this land. Residential land was allocating for housing and social activities whilst cultivated land was allocated for food agriculture activities.

Nowadays, in the developing nations are growing concerns to practice agriculture sustainability that seeks to balance environment, social and economic factors in agriculture. The emerging models are including agroforestry and conservation agriculture system (CAS). In recent years, agroforestry has gained increasing attention as an option to simultaneously alleviate poverty, provide ecological benefits, and mitigate climate change (Nöldeke et al 2021). Agroforestry is the agriculture and forestry modification for sustainable land use patterns. It maintains and increases optimal overall yields by combining food crops, annuals, and tree crops of economic value, with or without livestock or domesticated fish, on land and at the same time it should be suitable with practical management methods, which are in accordance with the social and cultural conditions of the local population, as well as the economic and ecological conditions of the area (Riswan 1995).

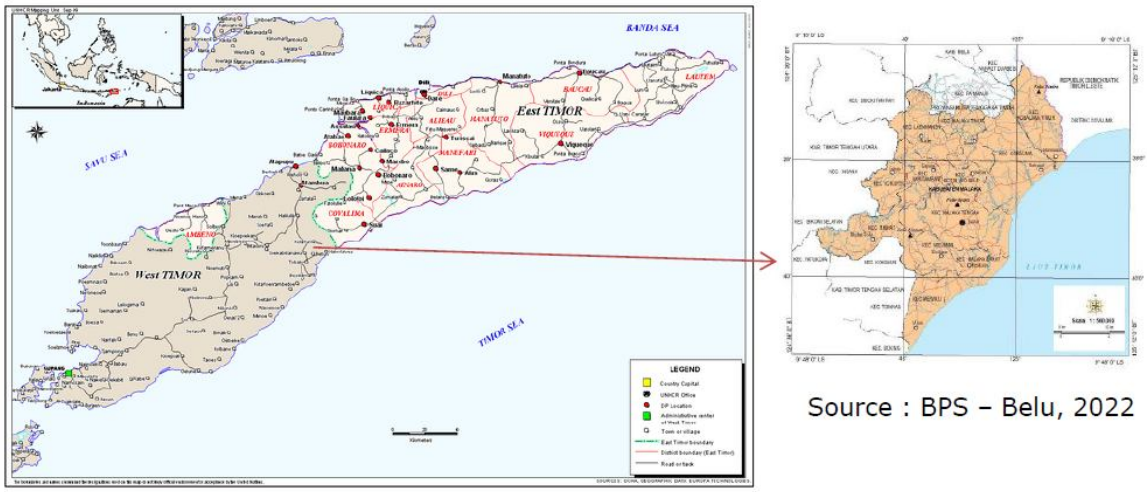
Agroforestry represents a promising approach to protect agricultural production and improve farmer resilience to climate risks, particularly in tropical regions, as it offers numerous economic and environmental benefits. As a mixed practice of tree crops, agroforestry provides ecosystem services such as production of food and non-food products, regulation of water and nutrient cycles, prevention of soil erosion and carbon sequestration. The emerging benefits of agroforestry range from small to regional and even global scales. Consequently, the synergies between the provision of ecosystem services and income opportunities make agroforestry systems a powerful solution to counteract deforestation, protect livelihoods, alleviate poverty and mitigate climate change. Despite the various benefits highlighted by research, smallholder uptake of agroforestry remains low in many regions (Nöldeke et al 2021).

Sinukaban (2013) revealed that the CAS is an agricultural system that integrates soil and water conservation techniques into existing agricultural systems with the aim of increasing farmers' income, improving farmer welfare and simultaneously suppressing erosion so that the agricultural system can sustainable. The main objective of a conservation farming system is not to apply soil conservation measures alone but to maintain sustainable agriculture. Furthermore, FAO (2022) explained that conservation agriculture is a concept in support of sustainable land management, environmental protection and climate change adaptation and mitigation. CAS principles are including minimum mechanical soil disturbance (no/zero-tillage), permanent soil cover and crop rotations that are universally applicable in all agricultural landscapes and cropping systems.

Therefore, this participatory study furthermore aims to find ways in which shifting cultivation as a main agricultural practice in a district of the developing nation could be improved by the application of sustainable soil and water management.

Material and Method

Description of the study site. Malaka district is a part of the province of East Nusa Tenggara, Indonesia. The district was established on 14 December 2012, comprising twelve sub-districts which had formerly been the southern part of Belu district. Astronomically, Malaka district is located at 9°34′02″S 124°54′27″E. Malaka district has 1.160,63 km^2 areas with hilly and mountainous morphology condition and slopes more than 50%. In the East this district has a border with Republic democratic of Timor-Leste (RDTL) (BPS-Belu 2022). The Malaka district map is presented in Figure 2.



Source : https://reliefweb.int/map/indonesia/east-and-west-timor-september-1999

Figure 2. Malaka district (https://en.wikipedia.org/wiki/Malaka_Regency).

This study applied a literature study to obtain information on previous research related to dryland agriculture and its problems, prepares and presents the results of a literature study to stakeholders that consisting of 32 persons represent the heads of farmer groups, NGOs and local government elements. Subsequently, a participatory discussion was conducted to acquire input from stakeholders from the district of Malaka, The East Nusa Tenggara (NTT) province of Indonesia. The multi-stakeholder dialogues are presented in Figure 3.

Figure 3. Multi-stakeholders dialogue.

Results and Discussion

Farmer group perception. The results of group discussions which were then presented in plenary discussions among farmer groups indicated that all farmer groups that carried out shifting cultivation were willing to change towards better agriculture practice. Agricultural alternative that are perceived to be in accordance with the natural, cultural, technological and economic conditions of farmer groups were agroforestry (60%). The type of agroforestry chosen by most of the farmer groups is alley cropping (60%). Meanwhile, each 20% of farmer groups chose conservation agriculture system (CAS) on slopes with integrated agriculture, forest-plant-food-animals.

Based on the selection of farmer groups, it can be implied that the farmer groups already have an understanding of agricultural systems that are in accordance with local environmental conditions and culture. These choices were a rational choice based on the long experience of farmers and the awareness for sustainable agriculture. Moreover, farmer groups have an understanding of natural degradation due to the practice of land conversion and have the will to maintain the sustainability of agriculture production through the application of environmentally friendly agriculture system (soil and water conservation) to obtain economic benefits in the short, medium and long term.

With regard to the selection of plant species to be cultivated in agroforestry, in general, farmer groups were still interested in mainstream commodities which are commonly cultivated such as corn (*Zea mays*), green beans (*Phaseolus vulgaris*), cassava (*Manihot esculenta*), and *lamtoro (Leucaena leucocephala*). In terms of water use, those commodities have proven to be able to survive in dry land. The selection of *lamtoro* plants indicated that there is an understanding of farmers regarding soil conservation efforts and economic benefits, because *lamtoro* is a natural nitrogen source, has a root system that can increase infiltration and is one of the popular animal feeds in the NTT province.

Malaka District has an average advantage over other regions of NTT Province because it has better soil moisture. So it has a comparative advantage in the growing season. The average area of NTT only has one Growing season while most farmer groups in Malaka district are able to plant two growing season (80%), even 20% of farmer groups are able to plant three growing season. The first growing season generally starts in December. Second growing season begins in April, and the third growing season begins in August or known locally as "*Ahuk lean*".

However, farmer groups identified a shortage of almost all agriculture production factors (high quality seeds, tractors, fertilizers, labor and pesticides). The only factor that was considered sufficient was water (60%). All farmer groups acknowledge the shortage of tractors, fertilizers and pesticides. 60% of farmer groups admit the shortage of better seeds and labor. The brain drain of young people from the agriculture sector has caused a shortage of labor in the agriculture sector to be felt.

The willingness of farmers to implement environmentally friendly agriculture that taking into consideration soil and water management aspects is generally hampered by the capacity of human resources and the ability to obtain production factors. Between the two the limited agriculture production factors is believed to be the most significant. Nevertheless, some of farmer groups have been able to propose collaborative plans such as farmers in charge of arranging the seasonal planting calendar and land preparation instead of fully directed by local governments.

The farmer groups demand that the villages' government can encourage and monitor the activities of farmer groups and attract assistance from the sub-district level. The farmer groups further expect the sub-district government to be able to submit proposals to the district in order to seek assistances such as crops and livestock, expertise, and provide razor wire for fences.

Farmers' groups further expect the District development planning and coordinating agency (BAPPEDA) to coordinate agriculture development planning in district level. The technical agencies such as the Malaka District agriculture agency could provide better seeds of food crops (corn, peanuts, green beans, rice, and beans), plows/tractors, water, fertilizers, pesticides, agriculture tools and equipment, as well as corn grinder, organic

fertilizer grinder and technical assistance. The Plantation and Forestry agency can help provide plant seeds (mahogany, *lamtoro*, elephant grass, cashew nuts). The Livestock service agency can assist in the supply of cows, goats, pigs, chickens. NGOs by farmer groups are expected to be able to assist groups in their respective villages, conduct training on an ongoing basis, facilitate proposals to relevant agencies, and collaborate with farmer groups continuously. Farmer groups also agreed to form a working group (*Pokja*) that consisting of farmers, local governments, community leaders, NGOs and other related stakeholders. The working group (*Pokja*) will facilitate communication and coordination of multi-stakeholders participation.

Local government and NGO perception. With regard to the results of the FAO survey on soil health where soil health in Malaka District was categorized as not good; the district government highlights the importance of agriculture that pays attention to the balance of the ecosystem. The district government and NGOs were working on the application of CAS, among others, through minimal tillage/hole systems, the use of seeds as needed, and the use of organic fertilizers. This land and water management effort is carried out through demonstration plots so that it is still on a small scale.

The results of the efforts showed an increase in yields when compared to traditional farming systems. The experience of implementing CAS with the intercropping system was not too difficult and can be carried out individually or in groups has shown success, for example: farmer group *Suka Maju* got a corn yield of 6 tons ha^{-1} which was higher than the conventional pattern of 2.25 tons ha^{-1}. The experience of other farmers group after received socialization from NGO and participate CAS in demonstration plots on rocky land by plowing holes, applied organic fertilizer and manure yielded an average harvest of 4.5 tons ha^{-1}.

This potential for success has prompted local governments and NGOs to expect more practical training for farmers and agricultural field instructors through the Field Agricultural School (FAS/SPL). Additionally, agricultural field need to receive further training in effective communication techniques. Moreover, due to the crop-animal trade-off, it was expected that the village government provide a village regulation regarding the distribution of land use for livestock and agriculture as has been done by the Bereliku Farmer Group. To support and ensure the future implementation of soil and water management through CAS in Malaka dsitrict, it is necessary to support by Village regulation or higher government regulations. Furthermore, in terms of crops that currently focusing on corn, which has been cultivated by majority of farmers, in the future it needs to be expanded to other commodities such as horticulture.

Observing the potential and benefits of implementing soil and water conservation through CAS, the village government emphasizes that soil and water management through CAS needs to be expanded to reach more people. The village government itself will help disseminate CAS techniques to the community/farmer groups. Several village governments have drafted regulations supported CAS application. However, the village government suggests that it needs to be supported by the Sub-district and District regulations so that legality will more powerful. Moreover, to ensure the sustainability of land and water management efforts, continuous training and mentoring of farmers is needed as well as for the related multi-stakeholders.

Conclusions. Shifting cultivation has become the backbone of agriculture in the NTT Province, especially in the Malaka District. However, the population growth caused increased demand for food and nutrition; coupling with land degradation leading to production degradation as well as facing other potential natural disasters; shifting cultivation needs to be transformed. The application of land and water management is believed to be able to maintain land sustainability and subsequently agricultural sustainability. Farmer groups, local governments and NGOs have agreed to participate and develop conservation-oriented soil and water management practices in the form of agroforestry and conservation agricultural system (CAS). However, there are several limitations identified which include lack of agricultural production factors as well as related knowledge and assistance. For this reason, multi-stakeholder cooperation is

needed to plan, implement, monitor and evaluate the activities. Moreover, all parties agree to collaborate further through a coordination forum or *Pokja* and subsequently strengthening the regulations at all level.

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Conflict of interest. The author declares that there is no conflict of interest.

References

BPS-Belu (Statistics of Belu Regency), 2022 [Malaka Regency in figures]. BPS-Statistics of Belu Regency. [in Indonesian]

Djoeroemana S., Semangun H., Saragih B., Sulthoni A., 2000 The implications of fire management and reforestation for economic development in East Nusa Tenggara. In: Fire and Sustainable Agricultural and Forestry Development in Eastern Indonesia and Northern Australia. Proceedings of an international workshop held at Northern Territory University, Darwin, Australia, 13-15 April 1999. Russell-Smith J., Hill G., Djoeroemana S., Myers B. (eds), Australian Center for International Agricultural Research Canberra, pp. 52-55.

FAO, 2022 Conservation agriculture. Food and Agriculture Organization of the United Nations, Rome, Italy, 2 pp.

Foenay E. L., 2000 Shifting cultivation and fire: a challenge to NTT's development. In: Fire and Sustainable Agricultural and Forestry Development in Eastern Indonesia and Northern Australia. Proceedings of an international workshop held at Northern Territory University, Darwin, Australia, 13-15 April 1999. Russell-Smith J., Hill G., Djoeroemana S., Myers B. (eds), Australian Center for International Agricultural Research Canberra, pp. 18-20.

Fox J., 2000 Land-use and land-cover change in East Nusa Tenggara, Indonesia. In: Fire and Sustainable Agricultural and Forestry Development in Eastern Indonesia and Northern Australia. Proceedings of an international workshop held at Northern Territory University, Darwin, Australia, 13-15 April 1999. Russell-Smith J., Hill G., Djoeroemana S., Myers B. (eds), Australian Center for International Agricultural Research Canberra, pp. 32-38.

Koehuan J. E., 2015 Final report: consultant for training on the link between shifting cultivation and disaster risk reduction. ACTED-FAO, 81pp.

Koehuan J. E., Suharto B., Djoyowasito G., Wignyanto, 2020 Rice water total factor productivity growth of West Timor region, Indonesia 2000-2015: a novel parametric approach. AES Bioflux 12(2):110-122.

Koehuan J. E., Suharto B., Djoyowasito G., Susanawati L. D., 2020b Water total factor productivity growth of rice and corn crops using data envelopment analysis – malmquist index (West Timor, Indonesia). Agricultural Engineering International: CIGR Journal 22(4):20-30.

Mathur I., Bhattacharya P., 2022 Transition from shifting cultivation to agroforestry: a case study of regrouped villages in Tripura, India. Environmental Challenges 7: 100471.

Mundita W., 2000 Fire and the management of agricultural systems in East Nusa Tenggara. In: Fire and Sustainable Agricultural and Forestry Development in Eastern Indonesia and Northern Australia. Proceedings of an international workshop held at Northern Territory University, Darwin, Australia, 13-15 April 1999. Russell-Smith J., Hill G., Djoeroemana S., Myers B. (eds), Australian Center for International Agricultural Research Canberra, pp. 56-61.

Myers B., Hill G., Russell-Smith J., 2000 Background to the Project “The use of fire in land management in Eastern Indonesia and Northern Australia”. In: Fire and Sustainable Agricultural and Forestry Development in Eastern Indonesia and Northern Australia. Proceedings of an international workshop held at Northern Territory University, Darwin, Australia, 13-15 April 1999. Russell-Smith J., Hill G., Djoeroemana S., Myers B. (eds), Australian Center for International Agricultural Research Canberra, pp. 13-17.

Nöldeke B., Winter E., Laumonier Y., Simamora T., 2021 Simulating agroforestry adoption in rural Indonesia: the potential of trees on farms for livelihoods and environment. Land 10(4):385.
Riswan S., 1995 [Development of agroforestry systems in Eastern Indonesia]. [in Indonesian]
Sinukaban R., 2013 Potential and strategies for utilizing dry and acid dry land for sustainable agricultural development. Proceedings of the National Seminar on "Intensification of Suboptimal Land Management to Support National Food Self-sufficiency", Palembang 20-21 September 2013.
Suradisastra K., 2001 Context of cultural ecology of Eastern Indonesia in optimizing dry land.
Therik T., 2000 The role of fire in swidden cultivation: a Timor case study. In: Fire and Sustainable Agricultural and Forestry Development in Eastern Indonesia and Northern Australia. Proceedings of an international workshop held at Northern Territory University, Darwin, Australia, 13-15 April 1999. Russell-Smith J., Hill G., Djoeroemana S., Myers B. (eds), Australian Center for International Agricultural Research Canberra, pp. 77-79.
Thrupp L. A., Hecht S., Browder J., 1997 The diversity and dynamics of shifting cultivation: myths, realities, and policy implications. World Resources Institute, The United States of America, 48 pp.
*** https://en.wikipedia.org/wiki/Malaka_Regency map. Accessed: June, 2022.

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