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Elok Mulyoutami, Pratiknyo Purnomosidhi, Asep Suryadi, Iskak Nugky, Nikolas Hanggawali, Gerhard Sabastian, Suci Anggrayani, James M Roshetko

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Abstract

Implementation of land restoration needs to be adjusted to local conditions to be more efficient and effective. Local communities are the actors with the best understanding of the environment because they have been managing it for generations. For restoration to fit with local conditions, local knowledge of, and experience with, restoration and environmental functions need to be acknowledged. Communities' knowledge of the different types of soil and plants needs to be documented as a reference when selecting types of plants that have conservation value and are able to bring benefits to a community. The communities of Haharu Sub-district, Sumba Timur District, Nusa Tenggara Timur Province, Indonesia have developed their knowledge and farming practices based on their subsistence need for food. They have worked with limited land size, low precipitation, rocky ground and thin soil, deploying various semi-traditional conservation efforts developed by their ancestors, such as the 'timbak' system for productive land and 'ramang' for fallow. The introduction of intercropping was aimed at strengthening food security. Practices were adapted based on the new knowledge that they gained from interaction among community members and with people from outside their communities. Local knowledge could not be separated from the local belief system, known as 'marapu'. Communities' knowledge still needed to be strengthened in 1) pest and plant diseases and how to overcome them; 2) Production of good quality seeds and seedlings; 3) water management.

Keywords

Local knowledge, savanna, restoration, land management, agroforestry, Sumba, Indonesia, dryland

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Foreword

The majority of Sumba Timur District and almost all of Haharu Sub-District is covered by savanna, resulting in a low level of water debit (Rengganis 2017). The topography is undulating, with hilly areas and a flat coastal area, leading to difficulty in water access for some communities. These conditions have been exacerbated by a decrease in forest cover.

Formerly known as Sandalwood Island, the forest area on Sumba declined significantly during the 20th century and was almost entirely lost by the early 2000s. Sitompul et al (2004) indicated that by 2004, remaining forest cover was around 11% of the total size of the island, with other land cover in the form of open forest and savanna. Over-harvesting of valuable native trees — sandalwood (*Santalum album*), 'lobung' (*Decaspermium* sp), 'injuwatu' (*Pleiogynium timorense*) and 'kosambi' (*Schleichera oleosa*) — resulted in almost total degradation of most of the land area.

Specific causes have been 1) large-scale timber extraction; 2) repeated clearance and burning of savanna for attempted cultivation; 3) freely grazing livestock; and 4) unsustainable fuelwood harvesting. The almost complete absence of trees in the savannas, combined with limited rainfall, leads to annual water shortages and sub-optimal food production exacerbated by poor soil and water-management practices. Sulaiman and Webb (2015) classified Sumba as 'severely vulnerable to food and nutrition insecurity'.

To overcome the deteriorating environmental conditions in Haharu Sub-District, restoration of forest ecological functions is necessary. Any restoration program would need to adapt to local conditions to be more efficient and effective. Local communities are the actors with the best understanding of the environment because they have been managing it for generations (Pawluck et al 1992, Mulyoutami et al 2014). For restoration to fit with local conditions, local knowledge of, and experience with, restoration and environmental functions need to be acknowledged. Communities' knowledge of the different types of soils and plants needs to be documented as a reference when selecting types of plants that have conservation value and are able to bring benefits to a community.

There had been various efforts to restore environmental functions. Most were implemented along with economic development by selecting crops with high economic value that were able to improve community livelihoods. The selection of economic crops needs to consider local plant types with high conservation values that also produce traditional benefits for the community. Participatory plant or crop identification based on local knowledge should identify not only the plants but also the best restoration models that can bring multiple benefits. Any development program initiated by external people should consider local knowledge in order to be more suitable with local environmental conditions (Pawluck et al 1992, Mulyoutami et al 2004, Joshi et al 2004, Njurumana 2006).

Local knowledge is community-owned knowledge of an ecological system, all the different components within it and the relationships among components (Joshi et al 2008). This knowledge develops from a community's observation of the ecology, topography, society and culture in the place where they live. It's called 'local' because this knowledge is unique in its nature and frequently differs between groups (Njurumana 2006, Warren and Rajasekaran 1993). Although it's called local, however, this knowledge has an evolutionary characteristic where non-traditional values are able to configure it, whether or not traditional values are included in the knowledge. Following Thrupp's (1989) admonition to not romanticize the local or traditional knowledge, this study aimed to document local knowledge about managing the environment to support restoration work that fits with local conditions. Community involvement in this study was essential.

Methods

The study was conducted in all villages in Haharu Sub-District, including those newly established as a result of a village division process in 2016. Data collection was conducted over two weeks in March 2017. Investigation and documentation adapted the 'knowledge-based system' approach that had been applied in various socio-ecological systems (Sinclair and Walker 1998). Local knowledge was collected in an interview process involving 28 informants, using in-depth interview techniques applied to both individuals and groups. Informant selection targeted those with the greatest knowledge, that is, 13 informants; the remainder of the informants were self-selected. In the group interviews, a triangulation process was conducted by involving some participants.

Local knowledge was arranged in a unitary statement that had one meaning (Walker et al 1995). The statements were input to the Agro-ecological Knowledge Toolkit. The toolkit was used to document the knowledge in a database for ease of access. Another benefit of the toolkit was its ability to present local knowledge in diagrams so that the knowledge plot could be easily understood. Using an 'utilitarian' base (Sinclair and Walker 1999), the local knowledge was combined with scientific knowledge to develop suitable technologies to be applied in the development of agriculture and agroforestry for land restoration, food security and livelihoods' improvement.

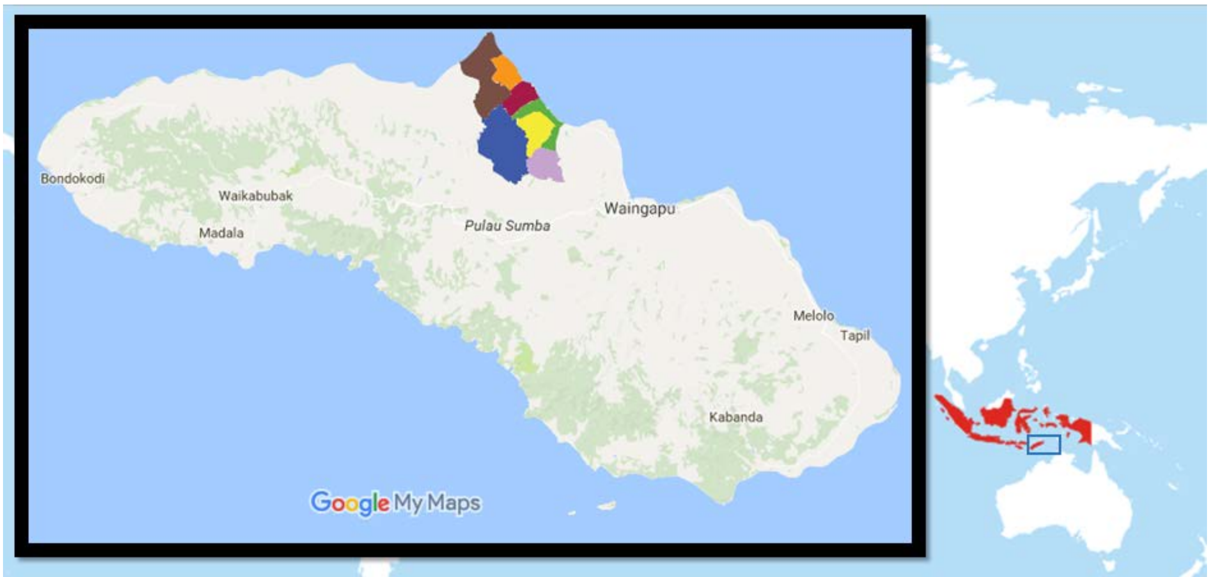

Figure 1. The study area in Haharu Sub-District, Sumba Timur District, Indonesia

The landscape and typology of Haharu

The Haharu landscape features a coastal area and inland a large number of hills covered by savanna. Clusters of trees dominate narrow valleys in between the barren hills. Parts of the hills feature substantial areas of rocky outcrops that make it difficult for trees to take root and grow. Other parts of the hills are covered by a layer of white stones (‘watu puda’) or claystones that contain water. Taking into consideration the topography, physical characteristics of the rocks, soils and distance from villages to the coast, the Haharu Sub-District landscape was divided into three parts (Table 1). The table contain local definition of soil and stone characters based on community perception and equipped with technical term from geological maps by Effendi and Apandi (1994).

Table 1. Land typology, Haharu Sub-District, Sumba Timur District, Indonesia

Landscape group	**1. Highland (DT/Dataran Tinggi)**		**2. Undulatory coastal with part of a watershed (P/DAS – Pantai/Daerah Aliran Sungai)**		**3. Undulatory coastal (P – Pantai/Coastal)**
Village name	Mbatapuhu, Prailangina, Matawai Pandangu	Kalamba	Rambangaru, Praibakul and Kadahang		Napu and Wunga
Distance from village centre to the coast	Far		Coastal		Medium
Topography	Highland, hills		Undulatory coastal plain		Undulatory coastal plain
River	Not available	Available	Available		Not available
Stone character (community perception)	White stones with deep depth		Rocks (reefal limestone)		Rocks (reefal limestone)
Geological map (Effendi and Apandi, 1994)	Kananggar Formation (‘Tmpk’)		Dominated by Kaliangga Formation (‘Qpk’)	Kananggar Formation (‘Tmpk’)	Kaliangga Formation (‘Qpk’)
	Marly sandstone, tuffaceous sandstone, tuffes, sandy marl, limestone intercalation		Reefal limestone with 50–100 m depth Marly sandstone, tuffaceous sandstone, tuffes, napal sandy marl, limestone intercalation		Reefal limestone with 50–100 m depth
Type of land use	‘Woka palindi’/‘Woka uma’ ‘Woka lola’ ‘Mondu’		Woka palindi/woka uma Mondu		Woka palindi Woka uma
Depth of water source (community perception)	50–100 m		10–50 m		10–50 m ‘Way kulup’ ‘Mata wai’ or ‘Lindi’
Humidity	High		Low		Low

Source: Community interviews, Effendi and Apandi 1994 (geological map), Zulfikar et al 2001. Note: Tmpk and Qpk is the terminology to describe sedimentary limestone dominated in an area that used in the map.

Land-use types and area topography

Mulyoutami et al (2016) described different types of land use in the Haharu landscape from the coast to the hills, including community settlements (Figure 2). The descriptions were based on local knowledge, in which the definitions were uniquely applied, that is, found only on Sumba. The local communities differentiated land types they managed based on the location of the land, whether the land was close to a water source, in a valley or on high land. The division of the land types is described in Figure 2 and Table 2 as presented by Mulyoutami et al (2016), with some added data and corrections.

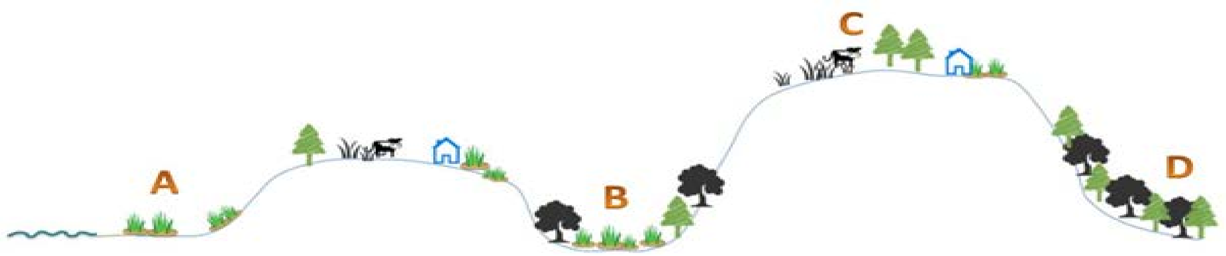

Figure 2. Land-use typology based on land location

Table 2. Local understanding of land-use typology based on land location

Land use	A. 'Mondu' (watershed)	'Maradda' (savanna)	B. Woka lola (farm land in valleys)	C. Woka (farm land): woka palindi, woka uma	D. Forest area ('utang'/'jamu')
Vegetation type	Wetland rice, maize ('kamborung'), sweet potato, tomato ('ambalai'), chilli ('mbakuhawu'), bitter squash, pumpkin ('kallah'), fruit trees	'Kehi'/Indian ash tree Grass (*Pennisetum* spp).	Dryland rice, maize, sweet potato, sorghum ('watar hamu')	Maize ('kamborung'), cashew nut, peanut ('manila'), pigeon pea ('kacang gude'), coconut ('kokur')	'Kehi'/Indian ash tree Teakwood
Type of soil (local perception)	Black soil Sandy soil Mixed soil	Humus soil ('hung') Sandy soil	Black soil Grey soil	Red soil Black soil White soil	Fertile black soil
Gender role	Male (50%), Female (50%)	Male (60%), Female (40%)	Male (50%), Female (50%)	Male (40%), Female (60%)	Male (80%), Female (20%)
Water source	A nearby river	From between limestones	Small spring Rainwater container	Rainwater container Wells (a few)	Small spring Rainwater container
Planting time	By the end of the wet season (to avoid floods)	-	During the wet season (depending on rainfall)	During the wet season but can be planted throughout the year	-

Land use	A. 'Mondu' (watershed)	'Maradda' (savanna)	B. Woka lola (farm land in valleys)	C. Woka (farm land): woka palindi, woka uma	D. Forest area ('utang'/'jamu')
Land ownership	Community land; people who are able to manage the land, usually people with the same family name or he/she should have special permission from the landowning family	Family land; it can be used by anyone who lives in the same village ('paraingu')	In some areas the land is community joint ownership; in others it is also individually owned	Usually owned by individuals	Joint ownership (sometimes owned by maramba/high caste members)

Planting patterns and land management

Most of the communities in Haharu Sub-District conducted seasonal farming. When the wet season began, they planted food crops. The communities put store in the prediction that the rains would start at the beginning of December, usually with a few days of low-intensity rainfall that increased in intensity for 4–5 months.

Rain increased the soil humidity required by plants to grow and to produce an adequate harvest. Based on the rainfall prediction, one-to-two months before the first rain the communities would prepare their farm land, hoeing and loosening the soil so that when the rain came the soil would be ready for planting. To prevent harvest failure, the communities usually waited for the rain to continue for several days, during which time they monitored soil humidity. When the soil was sufficiently humid, they planted. Palekahelu (2010) described a condition in which there was 'false' rain in 2008: it only rained for a few days. As a result, many farmers experienced harvest failure. Learning from that experience, the communities no longer planted immediately the first rain began but would first monitor the rain pattern before taking further action.

Local rainfall wisdom (statements gathered from multi interviews with local community)

The best time for planting is when the soil is humid

The best soil humidity will be after it has rained 3–4 times

Too great rain intensity causes the underground water level to rise too high

Soil that contains too much water [muddy] causes plants not to grow well

Plants won't grow well when they are submerged too long under water

Referring to Table 1 and Figure 2, the practice of planting twice in a year mostly was done in the DT area where soil humidity was sufficiently high. In a small part of the highlands, Prailangina, the community was able to plant up to three times a year. In this area, maize (Sumbanese: 'kambaru' or 'kamborung') was planted in the first season (first two months) followed by 'jagung rote' (Indonesian; sorghum (*Sorghum bicolor* L)) that was usually diversified with sticky maize (*Zea mays* L. *sinensis* Kulesh). The second planting season extended for 3–4 months. In Kalamba (DT area) and in Praibakul (P-DAS area), in addition to maize the communities also planted peanut (*Arachis hypogaea*) in the first planting season. The annual planting pattern is illustrated in Table 3.

Table 3. Seasonal calendar and planting patterns based on land typology

		Month												
	Land typology*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Notes**
Land preparation	A, B, C											•		
Wet season	A, B, C	•	•	•									•	
Lola	A													
2 planting seasons Maize		•	•										•	Planted in season 1
Sorghum and sticky maize				•	•	•	•							Planted in season 2
Peanut		•	•	•	•	•							•	Planted in season 1, 2
1 planting season Maize		•	•										•	Planted at the same time; maize planted one week earlier
Sorghum		•	•	•										
'Iwi' (bitter yam)		•	•		•	•								Planted in between maize and sorghum
Palindi	A, B, C													
Maize		•	•										•	
Sweet potato				•	•									
Cassava				•	•									
***Mondu*/watershed**	A, B													
Maize		•	•	•		•	•	•		•	•	•		

*Note: * Land typology refers to Figure 2*

The community had recognized that the high level of humidity in the DT (Table 1, Figure 2) area was caused by a thick underground layer of claystones. Claystone humidity caused the upper part of the soil layer to become humid. Despite the high humidity, the claystones did not retain water; available water was far below the claystones layer. Consequently, in the highland, water access was more difficult. To obtain water, wells had to be dug deeper than 20 m, up to hundreds of metres.

Generally, the P-DAS and P communities, who usually farmed far from the river, only had one planting season, precisely when the first rains began. According to community knowledge, the soil in this area was not able to absorb water to maintain humidity. The dry soil was usually hard, reddish in colour with high infiltration ability so that it was not able to retain water. In this area, manure was needed to not only increase soil fertility but also because it had a high humidity level. Since the soil quickly became dry, after the first planting season ended nothing more was planted until the following year.

The type of stone in the P-DAS and P areas was reefal limestone or locally called as rock ('watu atur'). This type of reefal limestone did not absorb water, therefore, the soil on top of the rocks was dry. However, an underground water source was not too far from the surface, at 5–30 m. The challenge in accessing the water was mainly because of the thick layer of reefal limestone on the surface so it required a drilling measure. Water was able to be found in natural containers in the reefal limestone in the form of small ponds, called 'way kulup' (Palekahelu 2010, Mulyoutami 2016). In P area, frequently the groundwater was affected by seawater intrusion and it was not able to be consumed.

Figures 2 and 4 show community experience of when and where agricultural activities could be undertaken in the valleys (lola) (B) and highlands (palindi) (C) surrounding their homes. Community perceptions were that the soil types and fertility levels of both lands were different. The soil in lola was black with humus content and more fertile compared to the soil in the palindi. The community reported that soil fertility in lola was gained from surface runoff from the palindi that concentrated in the lola during the wet season. The surface soil was quite fertile also because the community in this area frequently used manure in their agricultural practice.

Palindi land was dominated by reefal limestone and dry black soil with a thin layer of humus. To create a seasonal planting location surrounding their settlement, some of the community members applied fertilizer to soil placed on top of the limestone surrounding their homes or gardens. The soil was taken from a fertile location, such as from where trees grew, the banks of rivers or from fallow land. The community used manure to increase soil fertility by adding it on top of the soil up to a certain level of thickness (around 10–20 cm) so that it was able to grow short-rooted food crops.

The community who farmed next to the watershed (mondu) (A) were able to plant three times a year. Some community members who had land in the watershed had received a water pump to draw river water so that they were able to irrigate during water shortages. The pump operated around two times per week to draw the river water to higher land along a small canal so that the soil could absorb it. The community members who did not have access to a water pump planted 1–2 times per year and they watered the plants manually. On this land, the community also planted peanut and some vegetables in addition to maize.

Forest land was mostly located in deep valleys that made it impossible to access and be used as an agricultural plot. The boundaries of forest land were clear, further discouraging access. During the study, it was found that people usually accessed forests to look for ‘iwi’ (‘sikapa’ or ‘gadung’: forest or bitter yam (*Dioscorea hispida* Dennst), especially during periods of food insecurity.

There were different patterns of how the community planted food crops, described in Table 3. The community usually adjusted the planting pattern to the land size, labour availability, family food needs and preferences, such as whether the family preferred maize or sorghum. Other factors included plants required for religious rituals, for food diversification and in anticipation of harvest failure. The planting patterns described in this study were general patterns applied by the communities, however, there were wide variations, even in each separate community.

For those communities who applied two planting seasons, in the first they usually planted maize and in the second, sorghum, although some only planted maize in both planting seasons. In each maize and sorghum planting season, there were different varieties of each planted, including ‘sticky’ and coloured maize varieties, such as black, red and yellow. Some community members only planted peanut in both planting seasons, especially in the Praibakul area.

There were other communities who planted maize and sorghum at the same time during one planting season, following two planting patterns: 1) Maize was planted first, followed one month later by sorghum between the maize plants. After four months, the maize was harvested and the sorghum was allowed to grow taller. The communities' perceptions were that sorghum grew more quickly and had higher and lusher leaves compared to maize. Maize was harvested just before the sorghum leaves becoming lusher; and 2) Sorghum was planted along the sides of the plot and maize in the middle of the plot. The time difference between the sorghum and maize plantings was around 1–2 weeks. The communities planted maize earlier than sorghum, which would be harvested later than the maize. When the sorghum plants grew taller, they would not shade the maize.

Land classification and the beginning of land formation

The communities differentiated land types based on the history of land use. Part of the land was originally forest ('utang') and the other was originally savanna ('padang'). Whenever a community transformed savanna into land for cultivation, then the area would be called 'woka' or farm land. When a community transformed young forest or shrub land ('jamu') into farm land, it became known as 'kanguma'. The soil in kanguma, in general, was highly fertile.

Woka and kanguma referred to land that was used to produce food crops. However, after 3–4 harvests, the land would experience a decrease in yield. A fallow period was required to increase soil fertility.

Figure 3. 'Ramang': productive land that was not cultivated but left fallow for a time

Woka and kanguma were short versions of the swidden or shifting cultivation that was applied by the communities in the past; land lay fallow, often for more than 20 years. Stimulated by an increasing population and decreasing availability of land, the fallow period was shortened to 3–6 years.

This shortened fallow period was also noted in Amarasi Village, Nusa Tenggara Timur Province, by some researchers. Agus et al (2007) explained that the Amarasi system with its shortened fallow period, used 'turi' trees (*Sesbania grandiflora* Pers) to restore soil fertility. The Amarasi communities also reaped economic value from the various types of trees they planted or which grew spontaneously.

In Haharu Sub-District, the shortened fallow system was called 'ramang' (Figure 3). *Sesbania grandiflora* was allowed to grow freely to restore fertility. Some non-governmental organizations and government agencies introduced plants to the communities and provided knowledge of plant types that grew fast and which could be direct planted or allowed to spontaneously grow to restore land functions, such as *Calliandra*.

Examining tree density, the communities classified forest into two: 1) utang (old forest); and 2) jamu (young forest). Utang was an extensive forested area with a high density of tall and large diameter trees and a substantial amount of other types of vegetation. In Haharu Sub-District, there were only a few areas that had utang, typically in deep and steep valleys that were difficult to access and convert to agricultural land. From a scientific perspective, the age of a forest can be determined by its tree size and density. Based on these indicators, utang was more than 60 years-old.

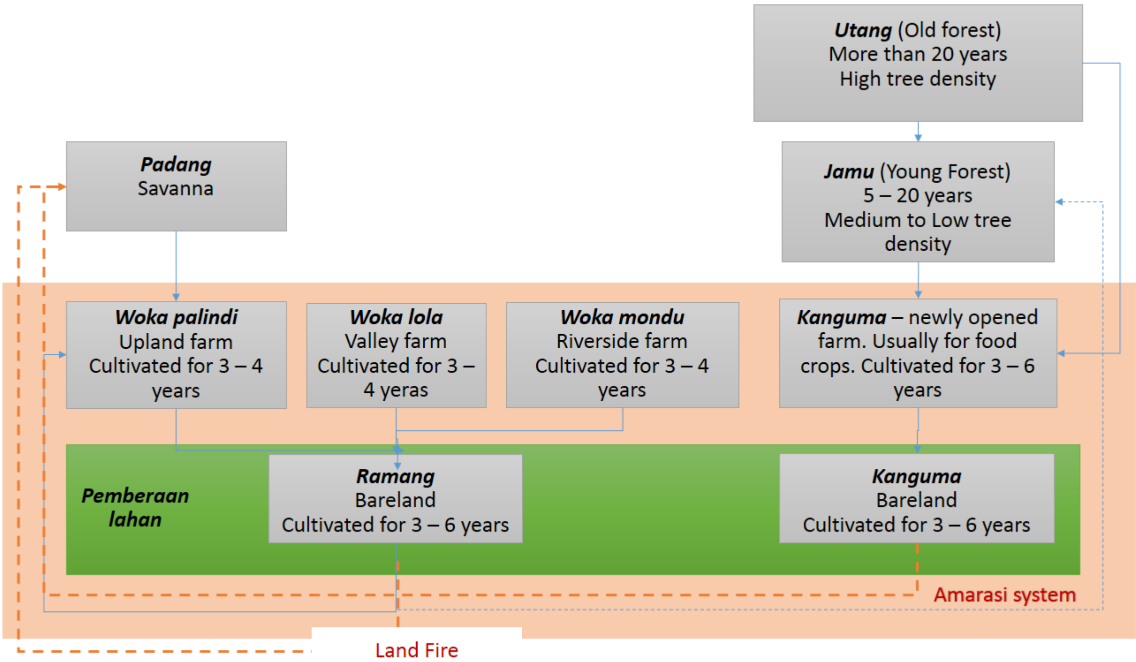

Figure 4. Land classification based on tree density, age and previous land use

Jamu was a small forested area with a low density of short and small diameter trees with a limited amount of other types of vegetation (around 10 types). Jamu were found mostly in valleys and near springs, occasionally in the highland or savanna. Systematically, the local understanding of forest classification and land use based on the previous land-use pattern is described in Figure 4.

The soil and its characteristics

The communities differentiated several types of soil in different areas in Haharu Sub-District. The communities' soil classification system was based on the physical characteristics of soil that were able to be seen and touched, that is, on colour and texture, as in many parts of the planet (Barrera-Bassols and Zinck 2003).

Communities' knowledge of the unseen processes that occurred in soil, such as the rise and fall of fertility and its relation to microorganisms and compost, lacked accuracy, as described by Wartenberg (2016) in a study of farmers' perceptions and land classification in neighbouring Sulawesi Island. Some communities understood that there was a link between the dominant type of limestone found in an area and the soil condition in the same place. This knowledge was not only based on observable soil and limestone characteristics but also on the communities' abilities to understand their landscapes' conditions and connect them with the soil characteristics in an area. Ettema (1994) argued that this was soil classification based on a community's perceptual dimension. For example, referring to Table 1, black soil in the DT area was more fertile because it was in close proximity to claystones. The soil was moister because the claystones were able to retain water. Njurumana (2007) identified a system in Ramuk Village where it was possible to use the claystone soil for farming and to grow trees with long lifespans. Its condition was different from the black soil in the P-DAS and P areas, which was relatively dry because the type of underground limestone was reefal limestone that did not retain water. Njurumana (2007) indicated that sandy clay was able to reduce the surface runoff because it had a high infiltration capability. This knowledge then led the communities to decide whether to apply one or two planting seasons a year. Detailed descriptions of soil types recognized by the communities appear in Table 4.

Table 4. Community knowledge of soil types and their characteristics

Type of soil	'Tana hung' (humus soil)	Black soil	Red-black soil	Silt soil (Black soil mixed with silt)	Sandy black soil	White soil	Red soil
Structure	Loose	Rather loose	Hard and sticky	A little bit harder	Loose	Hard	Sticky
Particle content	Sand, loam	Loam	Clay	Silt	Sandy	-	Clay
Water-holding capacity	Medium	High	High	Medium	Low	High	High
Soil organic matter	High	High	Medium	High	Medium	Low	High
Location	Lola (valleys) Palindi (few only)	Lola (valleys) Palindi	Palindi	Palindi	Savanna Palindi Mondu	Savanna	Savanna

'Timbak'/'Lambang': land and water conservation for farming

Some community members recognized the importance of conservation techniques on their land, especially in lola, on sloping land and river banks. A local conservation technique — terracing, known as 'timbak' — was applied extensively, especially, in most of the DT area and small parts of the P-DAS and P areas. Timbak originally referred to terracing to hold soil and prevent erosion. In practice, communities often combined timbak with bench terracing ('guludan'), to prevent the humus layer being carried away by water as surface runoff. For land in valleys, timbak was also useful for restraining material washed down from the highland so that it did not ruin the woka lola. In addition to ecological functions, timbak also served as a land boundary. Njurumana (2007) explained a traditional soil-and-water conservation model applied in Ramuk Village that was similar to timbak, known as 'palambang'.

The timbak can be built in three ways.

1) Mechanical → A terrace system where the vertical side of the terrace is reinforced by soil and stones placed on the terrace without cement. The aim is to enable water flow between the stones.
2) Vegetative → A terrace system where the horizontal side of the terrace is reinforced by plants that become a 'living fence'. The plant types planted for this purpose were white leadtree ('lamtoro', *Leucaena leucocephala*), calliandra ('kaliandra', *Callyandra calotirsus*), 'gamal' (*Gliricidia sepium*) and Indian ash tree ('kehi', *Lannea coromandelica*).

3) Mechanical–vegetative → A terrace system where the sides of the terrace are reinforced by soil and stones and some plants or woods branches gained from ‘palotang’ planted on the terrace. Palotang is the trimming of trees that grow wild in the savanna, the aim being to accelerate the growth of the tree.

Figure 5. Timbak: land conservation using vegetative and semi-mechanical techniques

The function of plants in food-crop land

The communities well understood the relationship between tree types and soil fertility. Almost all of the community members interviewed during the study said that the trees growing on farm land were beneficial for soil fertility. The existence of certain tree types in the fields ensured that the communities no longer had to search elsewhere for leaves to cover the soil after harvests in order to restore soil fertility.

The tree types that grew freely on the communities’ land were *Sesbania grandiflora*, *Leucaena leucocephala* and *Gliricidia sepium*. The community used the leaves to fertilize the soil. *Sesbania* was considered the most beneficial tree for the soil because the leaves, which were processed to become fertilizer or humus, were able to increase fertility. These trees had a deep and cold root type that was able to hold nitrogen. The soil where *Sesbania* grew had a relatively high fertility. Although parts of the *Sesbania* roots reached the surface, however, they did not spread too far. In Haharu, people were interested in planting *Sesbania* on their productive land and when they let it lie fallow the soil’s fertility would recover in a relatively short period of time. Kieft (2007) noted that *Sesbania*, compared to *Leucaena leucocephala*, was also preferred by communities on the neighbouring island of Timor. Some of the farmers did not like *Leucaena* because it was considered invasive and competed with other plants on productive land. Further, this plant was quite vulnerable to attack by the psyllid pest. In 1985, an attack by *Heteropsylla cubana* killed most *Leucaena* on the island. Other members of the community considered that *Leucaena* were more fertile and could restore soil fertility with reduced fallow time between planting seasons (Djogo 1994, Yuksel et al 1999, Piggin 2003). As livestock feed, *leucocephala* had high nutritional value (Nulik 1998, Yuksel et al 1999, Hau and Nulik 2012). The introduction of *Leucaena* in Nusa Tenggara Timur began around 1930 in the Amarasi area (Djogo 1994), fully supported by the local government.

Gliricidia sepium was also considered to contribute to soil fertility and suitable for the soil condition. Just like *Sesbania*, *Gliricidia* had a deep-rooting system and was able to fertilize the soil. *Gliricidia* could become a 'living fence', however, there needed to be sufficient space between individual trees because its stem shape was not straight.

The Indian ash tree ('kehi', *Lannea coromandelica*) was prioritized for use as a fence. Its stem grew straight (when it was trimmed regularly) and was considered very suitable as a boundary fence. Additionally, this tree grew easily and was well adapted to all soil conditions in Sumba Timur. *Lannea* also fertilized the soil. Besides that, livestock liked this plant very much. Houses with *Lannea* fences were a local 'trademark', especially, in Haharu and, generally, in Sumba Timur. However, *Lannea* roots tended to emerge at the surface and cause damage. Further, Frans Wiila (head of the Forest Protection Unit, part of the Forestry and Plantation Agency in Sumba, personal communication) explained that *Lannea* consumed a lot of water, therefore, it was not suitable to be planted near springs. The communities stated that *Lannea* could not be planted next to food crops because of their rooting structure and high demand for water. Thus, *Lannea* required regular trimming. Trimming prevented the roots from spreading and encouraged the stems to grow straight and tall with a small diameter.

Some community members recognized that trees' functions on their farm land was not just as natural fertilizer, however, they were also able to cool the surrounding air. A large number of community members planted trees, or just let wild trees grow, on their farm land for shade. Typically, shade trees were those that were able to grow well and had small leaves ('gala-gala'), such as 'lontar' (*Borassus flabellifer*) and *Sesbania*.

Varieties of food crops planted as seeds

Maize

The Haharu communities prioritized farming patterns that were able to fulfill their subsistence needs, which because of the dry conditions were necessarily seasonal. Three types of crop planted frequently in Haharu were maize, sorghum and peanut (Mulyoutami et al 2016). Fowler (2005) said that maize and peanut became the very important subsistence livelihood sources for the people in Sumba since the mid-1500s. Moreover, Fowler (2005) indicated that maize is not only for their staple crop, but it has sacred symbol and used for the customary ceremony. Hundred years later till recently, maize and sorghum were planted to also fulfill their cash needs.

The Haharu community, as with the Sumba community in general, had seeds of various food crops that were very suitable for the environmental conditions and were easy to manage. Through development programs and other sources of external information shared with the communities, new types of food crops that were considered superior had been introduced. For the Sumba communities, maize was very important for religious ceremonies as well as for daily consumption, although Fowler (2005) and Martens (2013) noted that maize was an introduced plant.

Sorghum was categorized as a 'more local' crop compared to maize. However, there was another earlier plant, called 'jelai', 'jali', 'hanjeli' or 'komangge' in Sumbanese and, in English, 'Job's tears', 'adlay' or 'adlay millet' (*Coix lacryma-jobi* L) (Fowler 2005). As well, the communities in Kambera and in some villages in Haharu were still familiar with 'kani' (Sumbanese), 'jewawut' (Indonesian) or 'foxtail millet' (*Setaria italica*). Both plants were once dominant. However, the length of their planting times, smaller productivity and difficult post-harvest management compared to rice and maize caused a decline in their popularity.

There were three maize categories that were usually planted by the local community. The first category embraced the various local seed types, including the regular, sticky and black, yellow and white coloured varieties. These local maizes had low productivity, however, their adaptation level to the soil was high, they were highly durable and could be stored for a long time. They were still frequently planted, especially by communities in the DT area (Mbatapuhu and Prailangina) because the varieties were more durable when they were stored traditionally, that is, in the 'karandi' system in which the plants were bundled together and tied in a tree.

The second category was open-pollinated maize, a superior type, which, unlike other superior types, could be reproduced in situ two or three times by the communities. This type was planted a lot in the P-DAS and P areas like Kadahang and Praibakul. Varieties included Bisma, Srikandi Kuning, Srikandi Putih and Lamuru varieties; the latter being used most. Lamuru was originally a superior type released by the Agriculture Research and Development Agency in cooperation with some companies around 2010 in the Nusa Tengarra Timur Maize Province Program (Vel and Nugrohowardhani 2012). The most important consideration was that the seeds were suitable to the local climate, particularly, the dry conditions in both Nusa Tenggara Barat and Nusa Tenggara Timur provinces.

The third category was hybrid maize. This was a new type of seed. It was not able to be reproduced like the open-pollinated types. Hybrid maize production was the highest, however, it had the lowest durability. Subagio and Aqil (2013) mapped the development of maize varieties in some areas in Nusa Tenggara Timur and found that the use of local seeds was still dominant in Sumba Timur, with only a few community members planting the open-pollinated type and even less planting the new hybrid type. Interviews conducted with the communities as part of this study found several maize types that were generally planted in Haharu Sub-District (Table 5).

Table 5. Maize types and their different characters

Comparison attributes	Red maize (local)	White maize (local)	Sticky maize (local)	Hybrid maize	Open-pollinated maize (Lamuru)
Planting time	4 months			3 months	3 – 4 months
Durability against heat	Less durable	Less durable	Durable	Durable	Less durable
Storage method	Karandi (hung)	Karandi (hung)	Karandi (wee hung)	Inside a sack	Inside a sack more often than karandi
Storage time	Long time	Long time	Long time	Not durable	Medium
Density	Low	Low	Low	High	High
Seed	Frequent	Frequent	Frequent	Cannot	Maximum 3 times

Comparison attributes	Red maize (local)	White maize (local)	Sticky maize (local)	Hybrid maize	Open-pollinated maize (Lamuru)
reproduction					
Suitability for the land	High	High	High	Medium	High
Vulnerability to disease	High	High	High	Low	Medium
Fertilizer need	Low	Low	Low	High	Medium

Community members who planted two maize types reported that the open-pollinated maize was usually planted in the second planting season because it was considered more resistant to heat. The local maize usually was planted in the first planting season because it was considered to require high humidity and it was not resistant to heat.

The communities planted local maize in different ways. The most common was planting several types of local maize in one farming land. They planted each type of local maize in each different plot. At the time of this study, only three local maize types were usually planted. Mixing the maize varieties in one planting season was a strategy to prevent severe harvest failure. A similar strategy was also implemented by Dayak communities in Kalimantan who planted rice and by Papuan communities who planted sweet potatoes (Mulyoutami et al 2010).

Sorghum

The communities had usually planted local seeds of sorghum ('watar' in Sumbanese), which included black, white and red varieties. As for maize, in one planting season they planted various local varieties. The aim of planting local seeds was for food security and to conserve the seeds. Similar with sorghum farmers in Ghana (Kudadjie 2006), planting various local varieties aimed to observe the seeds that were able to survive environmental changes. White sorghum had been planted the most by Haharu communities. They preferred this sorghum type because of its taste and softer texture that allowed it to be processed more easily. The white sorghum variety was able to survive as the ecosystem gradually changed.

At the time of this study, however, sorghum was rarely planted because of the difficulty of processing. Nonetheless, Subagio and Aqil (2015) stated that communities only processed sorghum from time to time because it was considered a low-class food compared to maize and rice. Additionally, the limited amount of farm land led the community to prioritize maize for their staple food and peanut for sale.

The communities were of the opinion that taking care of sorghum was very easy. Sorghum didn't depend on rainfall; its water need was low compared to maize and peanut. Nevertheless, maize was still a priority because it was able to be managed intensively (Fowler 2005) and it was easier to process maize into food items compared to sorghum. Vel and Nugrohowardhani (2012) stated that sorghum planting was decreasing because its price was not as competitive as maize, furthermore, there was no government program that supported sorghum development. It was also said that sorghum was not pest resistant, especially when stored.

Some community members planted both maize and sorghum. Aside from maize for ritual purposes, food diversification and anticipation of food failure were the factors that led the community to plant different types of crops. There were two planting patterns found: 1) Maize was planted first and then one month later sorghum was planted in between the maize. After 4 months, the maize was harvested and the sorghum was left to grow taller. The community members considered that sorghum had a faster growing time with higher and lusher leaves compared to maize. Maize was harvested just before the sorghum leaves were becoming lusher; and 2) Sorghum was planted on the sides of a plot and maize in the middle. The consideration was the harvest time for sorghum was later than maize so that when the sorghum grew higher it didn't hamper the maize.

Peanut

Sumba peanut was a high-quality local type famous for its unique taste. It was in high demand in the market. Haharu was the main peanut-producing area in Sumba Timur District.

Peanut production relied on sufficient rainfall because high humidity was needed to be optimally productive. The communities were familiar with two peanut types planted in Sumba: 1) 'kacang gali' (dug peanut) and 'kacang cabut' (pulled-out peanut). The peanut characteristics that the communities were familiar with are summarized in Table 6.

Table 6. Most common peanut types

	Local peanut	Introduced peanut
Planting distance	20 x 20 cm	40 x 40 cm
Planting period	4 months	3 months
Harvest method	By digging	By pulling out
Taste	Good taste, sweet and smells good	Less sweet, neutral smell
Production amount	On average, 1 pod has 3 beans. The pod is dense and fills the skin. Low production level	On average, 1 pod has 2 beans. The pod is small and not dense. High production level
Harvest time and labour	High	Low
Morphology	Valencia (creeping)	Spanish

Some farmers still applied traditional planting pattern to cultivate peanut. Peanut was planted as a monoculture or diversified (intercropped) with maize and sorghum. Iswanto et al (2015) stated that with the intercropping system, peanut should be planted 4–5 days after maize or sorghum. This system did not use planting beds. Three peanut beans were planted directly per hole, which was made with a stick, spaced 30 x 40 cm. The communities believed that the planting spacing would be able to increase the quality and quantity of the harvest. However, the Peanut and Tuber Plant Research Agency (Balai Penelitian Tanaman Aneka Kacang dan Umbi/Balikabi) recommended smaller planting spacings of 40 x 20 cm or 40 x 15 cm and use of fewer beans (usually only one). In general, the communities did not apply fertilizer although some community members used manure to increase production. The land was weeded one-to-two weeks after planting until the 60th day.

In Kalamba, the land was in a valley where some trees grew surrounding the community peanut land (Picture 6). Besides the harvests from the trees, they created shady places for the farmers and their leaves were a source of natural fertilizer.

After harvest, some community members left the peanut leaves on the land and let their livestock graze them. This was done with awareness that the leaves that were not consumed would become natural fertilizer along with livestock manure.

Figure 6. The peanut farming land in Kalamba, with some trees such as 'lontar' (*Borassus flabellifer*) and 'turi' (*Sesbania grandiflora* Pers)

Tuber crops

Tuber crops were an alternative food source for the communities. During a prolonged dry season, community members would enter the remnant forests to gather bitter yam (*Dioscorea hispida* Dennst) that grew wild or had been planted by their ancestors. Since bitter yam contained poison and was difficult to process, it was not the main food source for the community.

Some Haharu community members who inhabited the P-DAS location planted tuber crops in their gardens (woka uma), such as 'lutang', 'gembili' or lesser yam (*Dioscorea esculenta*), 'luwaye' or cassava (*Manihot esculenta*), 'katapu' or sweet potato (*Ipomoea batatas*), 'luwa' or coconut yam (*Dioscorea alata*). In Mbatapuhu, in the land located in the valley ('lola'), the farmers planted different types of yam, called 'luwa'. Luwa was planted beneath trees (usually *Sesbania grandiflora* Pers) that grew in between maize and peanut. The *Sesbania* were beneficial as they provided shade and natural fertilizer in the form of leaves. Various yam types that were planted included 'luwa hareu apeu', 'luwa mandu', 'luwa kambu', 'luwa kamelarara' and 'luwa enggal', which featured different colours of tuber, such as white, ivory and purple. Further research into the various food crops in Haharu would enrich community knowledge and support food security.

Figure 7. Farm land in the valley in Mbatapuhu, with different food crops planted in one location

Note: The *Sesbania grandiflora* Pers was used as a supporting structure for the *Dioscorea alata*

Local community knowledge

The savanna was a blessing and at the same time also a distinct challenge for the Sumba Timur communities. The simplicity of the landscape produced a correspondingly simple knowledge system but it was enough to support community life. Orr et al (2012) argued that the Sumba Timur communities had their own views on trees, forests and deforestation that varied from community to community and landscape to landscape.

The challenge was how to manage land that was mostly limestones and grass with low precipitation. Agricultural activity was mostly to fulfill subsistence needs. When there was a harvest failure, tubers were gathered from the remnant forests to fulfil daily food needs.

In cultivating the land, the communities still practised semi-traditional conservation techniques that were established by their ancestors, such as ‘timbak’ for productive land and ‘ramang’ for fallow land (refer to Figure 4). Adjustments in field practice were made based on new knowledge gained during interaction both internally and also externally. Community knowledge could not be separated from the local marapu belief system.

Marapu and management of natural resources

Marapu was a local belief system that bound community members to their life centre, that is, their ‘kampung’ or ‘paraingu’ where their ancestors resided (Palekahelu 2010). Marapu formed individual and community identities and maintained bonds to nature and with another humans. The heart of marapu was the natural environment, causing adherents to care about human behaviour and its impact on the environment. Nature was the source of life and its sustainability needed to be managed.

Three important components of marapu focused on the interrelation between the community and the natural environment, that is, how the community should 1) preserve the natural environment; 2) use natural resources efficiently; and 3) fairly, without over-exploitation.

Immanuel and Singgih (2010) described how community members gave meaning to nature and natural changes that were tightly related to marapu, forming the basis of local knowledge, along with social development, politics and the economy.

With the introduction of religions from outside of Sumba Timur, marapu began to fade. Vel and Makabombu (2010) and Fowler (2003) described how communities had begun to have less interest in implementing forest protection and conservation efforts for some plant types and increased interest in taking benefits from nature, correlating with a decrease in marapu ritual practices.

The natural phenomena that originally had been observed for guidance in managing the natural environment were not easy to recognize without marapu rituals. The rituals not only aided recognition but, critically, guidance in management. Ritual knowledge of the past could be blended with contemporary knowledge to create dynamic, informed management.

Local knowledge and food security

The communities developed their knowledge and local practices based on their subsistence needs, depending on their local conditions, the size of their farm land, low precipitation, rocky landscapes with thin layers of soil, and other factors that required specific skills and knowledge in natural-resource management.

In one area, intercropping maximized production and became the community’s choice for fulfilling their subsistence needs. The lola management model in Mbatapuhu and other villages in the lowlands (DT) allowed different types of food crops to be planted together in a farm plot. The planting pattern took into consideration the crops’ characteristics, the rainfall and soil conditions. Although the communities’ knowledge was simple, it was proven to support their daily needs, creating a form of safety net. Nevertheless, efforts to maximize the farms’ productivity were still needed. Particularly because of the difficult farming conditions, improved, labour-efficient techniques were required for tuber crops, fertilizing and land clearing.

Post-harvest processing of all food crops also needed improved techniques. For example, bitter yam was a high-nutrition product, however, the fresh product was difficult to process. Therefore, the community only planted this crop during drought periods. Coconut yam was also a high-nutrition plant but was easy to cultivate (Trimanto and Hapsari 2015). Likewise, sorghum (Kudadjie 2006), Job’s tears and foxtail millet were low in sugar and carbohydrate, recommending them for healthier diets. Martens (2013), however, stated that these plants had fewer harvests compared to rice or maize and both their planting and post-harvest processing periods were longer, therefore, they were less preferred. Improved processing technology should be developed before these local crops disappear.

Knowledge production: local traditional and external

Local knowledge in Sumba Timur was tightly related to the marapu belief system passed down from generation to generation. Some community members said that the practice of timbak, or terracing, that they applied was traditional knowledge from their ancestors. However, this practice had undergone changes since its initiation. In the past, only vegetative timbak was practised but by the time of this study mechanical timbak, and combinations of both practices, were applied. Similarly, with the selection of the type of plant to be used for timbak fencing, in the past, maize outgrowth leftover from the harvest was used but later a number of different types of plant were used. Presentation of knowledge from outside the villages, such as from non-governmental organizations working in Haharu, added to local communities' traditional knowledge.

The entire Haharu community was quite open to receiving new knowledge and innovations. However, they did not necessarily directly apply new knowledge. The knowledge that was easily acceptable was that which corresponded most closely to local conditions and did not require high costs or much labour. For example, new knowledge about herbicides was not well applied. Although understanding that an herbicide was intended to easily rid the land of weeds, community members unfortunately applied it incorrectly, which caused the soil to become drier, leading to a decrease in yields. From this experience of applying the knowledge they had gained, community members also observed the results and tried to improve. We were able to see in this example how community knowledge developed over time. The communities' openness in accepting innovation and their willingness to learn were the keys to developing knowledge and technologies that could increase their farms' productivity.

Participatory and adaptive approaches are required when external parties, such as agricultural extension officers and private-sector staff, wish to assist the communities increase their knowledge and skills. Successful examples should be established that can be replicated by other community members.

To conserve springs, the local community selected the native plants that grew around them. Local knowledge was that these plants were better at protecting the water source. *Gliricidia sepium* introduced by people external to Haharu was frequently planted in the sub-district, however, the communities did not see any benefit of the plant for water protection. The trees were used just to feed their livestock. At that time, the communities grew *Gliricidia* because the ready-to-plant saplings were provided by an external party. To collect saplings from the forest required more work yet the communities still maintained that forest trees held higher conservation value for the springs. The *Gliricidia* saplings were available and could be directly planted, therefore, the planting process was quicker.

This begs two questions: 1) Would the communities continue to plant when saplings were no longer provided by an external party? and 2) What was the survival rate of planted trees in land rehabilitation programs?

Propagation of saplings is a crucial part of any planting program implemented at community level. A community has to be able to do it themselves or be able to collect saplings from a forest to ensure that the planting would be successful. However, we observed that the Haharu communities' knowledge of propagation and maintenance was not sufficient for them to be able to make decisions about plantings, rather, decisions were more determined by practical needs.

Thus, in a community development and environmental restoration program, building of community capacity should be the core of a sustainable strategy. Such a strategy should seek to ensure that the community does not fall back on purely pragmatic decision making that does not bring sufficient impact in the long term.

Gaps in local knowledge

Through observation and experience, the communities had learned how to manage their land and environment to fulfill their needs. They had classified land and soil types, confirmed by scientific knowledge, which helped the communities make decisions about how to manage their land. Soil classifications established by the communities focused on the soils' characteristics, similar to those used by other communities in other parts of the globe, that is, a soil's texture and colour (Ettema 1994). As presented by Weinstock (1984), the communities in Sumba Timur also had physical and perception dimensions as part of their classification of soils and land. For land, the physical dimension was the location's topography, the characteristics of the rocks, and the soil colour and texture.

The perception dimension was derived from experience in managing the land. Some community members through their perception were able to describe soil and land classifications at a landscape scale. However, their understanding was not adequate for observing the cause and effect relations among the concepts. The communities did not systematically formulate their knowledge, therefore, they needed intensive assistance. Documentation of local knowledge would assist with developing that knowledge. A participatory approach and direct practice in the field would help the communities increase their knowledge and build greater concrete understanding of the cause and effect relations among the components of their environment. The advisory approach of 'farmer to farmer' has been a proven effective strategy in developing community knowledge (Martini et al 2016). The approach does not only document knowledge but also shares knowledge between farmers, strengthening capacity (Martini et al 2016).

There were several gaps in local knowledge that needed to be filled.

1) Pests and diseases and how to overcome them

The communities were able to describe in detail the types of diseases that attacked their food crops, especially, maize and peanut. However, they did not know their names nor how to overcome. The agricultural extension officers sometimes were not able to provide a solution and, finally, the choice was to let the crops die.

2) Quality seed and sapling production

The selection of seeds, seedlings or saplings for planting on agricultural or barren land for conservation purposes was still limited to the types available in the remnant forests. Propagation involved planting saplings directly into the soil, with a resultant low success rate. Through a knowledge development and sharing process, the communities would learn how to dig suitable planting holes, apply fertilizer and water as necessary and measure survival rates. This would increase the success of any planting program. High-quality seedlings or saplings that were not available locally but had high conservation or economic value should also be cultivated using improved nursery techniques.

3) Dependence on rainfall

As a result of the dry climate, the range of plants available for selection was limited. The planting periods should also be adjusted to better fit with rainfall. A more comprehensive understanding needed to be developed of how the communities manage their land along with a corresponding implementation of efforts to ensure greater availability of water.

Future challenges

Ramang and timbak are examples of land management combining ecological and economic functions. The systems not only provided a harvest for the people who cultivated the land but also served as environmental services providers, especially, related to increases in hydrological functions. Improving local knowledge of ramang, especially, regarding selection of plants that could provide both economic and environmental benefits, is needed to maximize benefits from the land.

Selection of alternative trees should consider suitability with the specific location, a factor that was well understood by the communities (Mulyoutami 2014, Njurumana 2008). In this matter, a combination of local and scientific knowledge is required to optimize land conservation efforts and to increase environmental and hydrological functions. The species selected as priorities by the Haharu communities, which could be fully integrated into the ramang and timbak systems, were *Sesbania grandiflora* Pers, *Leucaena leucocephala*, *Gliricidia sepium* and *Lannea coromandelica*.

To reduce dependence on rainfall, development of technology and knowledge needs to be implemented, as outlined below.

1) A landscape-wide perspective is required prior to implementation of rehabilitation measures to provide an effective and sustainable solution. Planting a combination of local and introduced trees surrounding springs could be applied, in close consultation with local communities.
2) At the plot level, rainwater needs to be contained for irrigation during droughts. Water-containment principles, such as 'way kulup', can be adopted to optimize the use of available local material, for example, retention of water in limestone pools.
3) Plants should be selected that are most tolerant of local climate and environmental conditions

Caution should be exercised in the use of local community knowledge, particularly, in the instance of parties who would like to use it for their own benefit rather than that of the communities of Haharu Sub-District and Sumba Timur District. Safeguards are needed to ensure that the communities reap the benefits of their local knowledge and that it is protected for their own use. Exploration of the application of intellectual property rights regarding local community knowledge should be undertaken. Mulyoutami et al (2009) highlighted the importance of establishing a reward mechanism for community knowledge that is not used for the community's interest.

This study was conducted through an interview process with key informants gained from a snowball sampling system. The method used in this study was not designed to understand the distribution of knowledge, the amount of knowledge nor what kinds of knowledge were recognized by the Haharu community as a whole. Further study is needed to understand the distribution of knowledge and whether such knowledge introduced to a community was fully distributed and adopted.

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Attachment: List of plants and their locations identified with the communities

Food crops

Local name	Popular	Latin	Function	Farm land in valley (*woka lola*)	Farm land on highland (*woka palindi*)	Forest (*utang*)	Unused land (*ramang/ kanguma*)	Shrub (*jamu*)	Land on a river bank (*mondu*)	Homegarden (*woka uma*)	Ricefield
Kabo'ta	Elephant foot yam, *Suweg*	*Amorphophallus campanulatus*	Alternative food		•		•	•			
Iowa katta	Zaminkand, *Porang, Iles-iles*	*Amorphophallus oncophillus*	Animal feed (market potential)		•		•	•			
Manila	Peanut	*Arachis hypogaea*		•	•				•	•	
Walawi	Pigeon pea	*Cajanus cajan*	Food and market								
Komangge	Job's tears	*Coix lacryma-jobi* L	Supplementary food	•					•	•	
Luwa hareu apeu, **Luwa mandu, Luwa kambu, Luwa kamelarara, Luwa engal**	Yam Coconut yam Sweet potato	*Dioscorea alata*	Alternative food	•	•			•		•	
Lutang	Lesser yam *Gembili*	*Dioscorea esculenta*	Alternative food	•	•			•		•	
Iwi	Bitter yam *Gadung*	*Dioscorea hispida* Dennst	Alternative food			•		•			
Katapu	White yam	*Ipomoe batatas*	Alternative food	•	•			•		•	
Katapu merah	Red yam	*Ipomoe batatas*	Alternative food	•	•			•		•	
Luwaye	Cassava	*Manihot esculenta*	Alternative food	•	•			•		•	
Padi	Rice	*Oryza sativa*	Staple food		•				•		•
Kani	Foxtail millet	*Setaria italica*	Supplementary food	•					•	•	
Watar hamu	Sorghum	*Sorghum bicolor* L	Staple food (some)	•	•				•	•	
Kamborung	Maize	*Zea mays*	Staple food	•	•				•	•	

Perennial plants

Local name	**Popular**	**Latin**	**Farm land in valley (*woka lola*)**	**Forest (*utang*)**	**Farm land in highland (*woka palindi*)**	**Savanna (*maradda*)**	**Shrub (*jamu*)**	**Homegarden (*woka uma*)**	**Fallow (*ramang /kanguma)***	**Spring (*mata wai)***
Yepohambaku	*Aisuli*	*Acacia oraria*			•	•	•		•	
Karing ah		*Acacia* sp			•	•	•		•	
Billa **Bakuwa**	Bael fruit, *Maja* *Mojo*	*Aegle marmelos*			•		•		•	
Mangasu apu/Wangga Tupi		*Albizia procera*			•	•	•		•	
Ritta		*Alstonia scholaris*		•	•	•	•		•	
Halai		*Alstonia spectabilis*		•	•	•	•		•	
Wangga Kollu		*Alyxia buxifolia*		•	•		•			•
Mente	Cashew	*Anacardium occidentale*						•		
Anona	Custard apple *Srikaya*	*Annona squamosal*			•			•		
Pinang	Betel nut	*Areca catechu*			•			•	•	
Sukun	Breadfruit	*Artocarpus altilis*			•			•		
Nangka	Jackfruit	*Artocarpus heterophyllus*			•			•		
Talicu		*Barringtonia* sp			•		•		•	•
Lontar		*Borassus flabellifer*	•		•			•	•	
Kamalu Pau	Mangga hutan	*Buchania arborescens*		•	•		•		•	•
Kalliandra		*Calliandra calothyrsus*	•		•		•	•	•	
Dora	*Nyamplung*	*Calophyllum inophyllum* Linn			•		•			•
Sakura Sumba	Apple blossom tree *Johar*	*Cassia javanica*			•	•		•	•	
Kokur	Coconut	*Cocos nucifera*	•		•					
Kananggar		*Dillenia* sp			•	•	•		•	
Wudi	Indian coral tree *Dadap*	*Erythrina variegate*			•				•	•
Unknown		Exocarpus		•	•				•	•
Wangga		*Ficus* sp		•	•		•		•	•
Gamal		*Gliricidia sepium*			•	•		•	•	
Jaluk		*Glochidion littorale*			•		•		•	

Local name	**Popular**	**Latin**	**Farm land in valley** (*woka lola*)	**Forest** (*utang*)	**Farm land in highland** (*woka palindi*)	**Savanna** (*maradda*)	**Shrub** (*jamu*)	**Homegarden** (*woka uma*)	**Fallow** (*ramang /kanguma)*	**Spring** (*mata wai)*
Jati putih	*Gmelina*	*Gmelina arborea*			•			•		
Kapaluh		*Grewira acuminate*			•		•		•	
Unknown	Coastal cottonwood, *Waru*	*Hibiscus teleaceaus*			•		•	•	•	
Kehi/Kedondong pagar	Indian ash tree	*Lannea coromandelica*	•		•			•	•	
Lamtoro	White leadtree	*Leucaena leucocephala*	•		•		•	•	•	
Ndinu Bara atau Ndinu Putih		*Macaranga tanarius*		•	•		•	•	•	
Nara	Red Kamala *Kamala*	*Mallotus phillipensis*		•			•			
Kapilut		*Planchonella obovate*		•	•		•		•	
Injuwatu		*Pleiogynium timoriense*		•			•			•
Kawilu		*Premna japonica*			•		•		•	
Rokarunggut/Ramu/ **Ai Kenawa (Sumba)**	Red sandalwood *Angsana*	*Ptereocarpus indicus*		•	•		•		•	
Kapapa Kalta		*Rhincosia minima*			•		•		•	
Cendana		*Santalum album*			•			•		
Nuru (Injung hutan)	Soapberry tree *Kedondong hutan*	*Sapindus saponaria*		•	•		•		•	
Jamba	Ceylon oak *Kesambi*	*Scheilechera oleosa*		•	•	•	•		•	
Johar	Cassia tree	*Senna siamea*			•	•	•	•	•	
Gala-gala	*Turi*	*Sesbania grandiflora* Pers	•		•			•	•	
Bakau		*Sonneratia* spp								
Kedondong		*Spondias dulcis*			•			•	•	
Kalumbang/Kelumpang	*Kepuh Java/ Kayu nias*	*Sterculia foetida*		•	•		•		•	•
Mahoni	Mahogany	*Swietenia mahagony*	•		•	•		•	•	•
Lobung	*Salam* (Bayleaf)	*Syzygium polyanthum*	•	•	•		•		•	•
Asam		*Tamarindus indica*			•	•		•		
Jati	Teakwood	*Tectona grandis*			•			•	•	
Cimung/nggai		*Timonius Timon*		•	•	•	•		•	•
Kaparak		*Trema* sp		•	•	•	•		•	•
Andalinga		Unknown		•			•			•

Local name	**Popular**	**Latin**	**Farm land in valley** **(*woka lola*)**	**Forest** **(*utang*)**	**Farm land in highland** **(*woka palindi*)**	**Savanna** **(*maradda*)**	**Shrub** **(*jamu*)**	**Homegarden** **(*woka uma*)**	**Fallow** **(*ramang /kanguma)***	**Spring** **(*mata wai)***
Hambolu		Unknown				•	•	•		•
Hayeyu		Unknown				•	•	•		•
Kalituahu		Unknown			•	•	•	•	•	
Kambu		Unknown			•	•	•		•	
Kanjilu		Unknown				•	•	•		•
Karunggut		Unknown		•	•		•			•
Katang		Unknown		•	•		•			•
Kayu Pappa		Unknown		•	•		•	•		•
Lehu		Unknown		•	•		•	•		•
Lenduwacu		Unknown		•	•		•	•		•
Lolu		Unknown		•	•		•			•
Lumbundaba		Unknown		•	•		•			•
Mandiduau		Unknown		•	•		•			•
Rikawudu		Unknown		•	•	•			•	
Tai bahu		Unknown		•						•
Tai manginung		Unknown		•						•
Tangarang		Unknown				•		•		•
Kom	Appeldam *Bidara*	*Ziziphus mauritiana*		•	•	•		•	•	

Grass, shrubs and herbs

Local name	Others	Latin	Livestock feed
Illah		*Andropogon* sp	•
Pahomba		*Andropogon* sp	•
Katewul		*Andropogon* sp	•
Marut belar		*Andropogon* sp	•
Kandaung (lewa)		*Axonopus*	•
Pahomba		*Chloris barbata*	•
Tailonga atau Tai Belalang		*Chromolaena odorata*	•
Maninuai		*Chrysopogon aciculatus*	•
Ndaica		*Cynodon dactilon*	•
Kamel manila		*Desmodium heterophyllum*	•
Kanda Wung		*Digitaria sanguinalis* (*Harig vingergras*)	•
Mbatakambaku atau Patalutut atau Hondkarambo		*Eleusina indica*	•
Kamelanara atau Reha		*Fimbristyllis*	•
Kateoul		*Heteropogon tricitus*	•
Waluway atau Illah atau Kajuku langina atau Prai langina		*Heteropogon contortus*	•
Kapumbung		*Heteropogon triciteus*	•
Wisu	Reed	*Imperata cylindrical*	
Wora	True indigo, *Tarum*	*Indigofera tinctoria*	
Unknown		*Ischaenum timorense*	
Mangata		*Paspalum conjugatum*	•
Rumba jawa	King grass	*Pennisetum purpureum*	•
Kepapang		*Phaseolus lunatus*	
Sirih/piper		*Piper betle*	
Kambaung atau Kandaung		*Pogonatherum crinitum*	•
Bunga Kapapang		*Rynchosiu*	
Murukapuka or Moru kapuka		*Sorghum nitidum*	•
Kamelawata (Lewa), Rapu (Haharu)		*Sorghum propinquum*	•
Pahomba		*Sorgum halepansa*	•
Kukumiao		*Stylosanthes* sp	
Marut Panju		*Themeda arguens* or *Themeda triandra*	•
Matbarong		Unknown	•

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