Swidden Agriculture, food security and environment in semiarid area of Timor – Indonesia

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Abstract. Despite policies implemented to minimise Swidden Agriculture (SA) practices, it remains in semi-arid areas of Timor Island. A study of SA was conducted in Manikin Watershed (MW) of West Timor during 2017 to 2019 in order to understand the nature of SA using Agro-ecosystems approach and to analyse the strengths of SA for sustainable upland farming management. The research applied survey method in data collection. Qualitative data analysed using thematic analysis descriptively and mapping spacial analysis using open access of SAGAGIS. The results showed that Agro-ecosystem characteristics of SA at MW have characterised by Low Productivity, Low Stability, High Equitability, High Adaptability, and High Autonomous. High adaptability and some important components which are suits with resource poor farmers becomes the main reasons why upland farmers keep practicing SA. The strengths of SA lies on the farmers’ perception that SA as an adaptive and suitable system of semi-arid upland farmers’ circumstances: saving labour, only need simple equipments, easy to applied, no external inputs used, fertilize the soil/crops, and harvest guarantee for at least one food crop. The SA have strengths to be improved and developed as a productive and sustainable farming model that suitable for semi-arid upland communities.

1. Introduction
Swidden Agriculture (SA) or Slash-and-burn cultivation is generally considered as a agricultural system that damaging resources. As [1] stated that researchers have revealed that swidden agriculture have more negatives impacts rather than its positive impacts for the community in the semi-arid area [2], however swidden agriculture remain in many areas as part of rural landscape as the safety components of diversified systems [3] and declining in swidden agriculture in the upland led to significat decline in preexisting livelihood security and the ecosystem services supporting this security [4].

Swidden agriculture contributed to the critical land due to deforestation [2,5], increase run-off and soil erosion [6], soil mineral depletion and transforms mineral nutrients into unavailable forms [7,8], damaging soil and organic matters and hidrological functioning of soils [9,10], and triggers some species of grass that easy to burn [11,12]. It is also creates broader environmental problems like flooding and landslides [9,13], biodiversity loosens and global warm [14]. Only few scientists shows the positive aspects of slash and burn besides its negative impacts that is a suitable option for the community in the dryland areas and maintain high level of biodiversity [15,16] like for the communities in West Timor.

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As considered harmful for natural resources, swidden agriculture is always outside of the agricultural development mainstreams. There is no effort to improve swidden agriculture, instead it wanted to change into intensive system that boast production. Indeed, paradigm used simply to maximise production and not considered other characteristics of the systems such as stability, equitability, adaptability and autonomous [2,17-19].

By the mainstream view, agricultural performance have normally reckoned based on the productivity. In the last decades, agricultural development paradigm in developed countries have fundamentally changes. Agriculture is no longer seen merely by optimizing production inputs and infrastructures, instead as an agroecosystem that has complexity interactions among components, it produces balance performance (traded-off) [17-20].

Efforts to changes swidden agriculture into more intensive and have high productivity have long been done [6,9,21-23]. Nevertheless, swidden agriculture is still a dominant agricultural system practiced in Timor Island, particularly in the West Timor. It is considered that this system is practical and simple to the applied. It is no need land plough, HYVs, chemical fertilizer and pesticides which require sophisticated knowledge and skill. It is only need machete or “tofa” [21]. However, swidden agriculture system is more complex [4,24].

Discourse of slash and burn is also take place for watershed. Watershed management is multidiscipline and multi sectors and therefore it is problematic and controversial. [25] showed that there were at least six importants issues in watershed management in developing countries such as who will get the benefit most, benefit offered to the people involved watershed management, focus of WM : structural of vegetatif, focus on rehabilitation or prevention and how far the WM integrated.

Manikin watershed is one of the strategic watershed in West Timor. Based on the DEM SRTM 30 metres analysis, it has 11,234.75 ha wide which almost all 10,920.05 ha or 97,2% from the total watershed area and only 2.8% part of the Kupang town that is in Kolhua village. Therefore, Manikin watershed is not purely Inter Watershed due to only small portion of the Kupang town included into the watershed area.

Based on the watershed characteristic identification [26], Manikin watershed categorised as small watershed, form long from upstream in the South and downstream in the North such as in Bay of Kupang. Another important aspect of Manikin watershed is that there are around 178.68 ha of rice field in the downstream as one of the main ricefield in Kupang district that receives water from the Manikin river.

Like in the other watershed in Indonesia, inter-area character and wide critical areas in the watershed creates negative external impacts. Critical areas in the upstream creates negative external impacts for the communities in the downstream. It is probably happening in Manikin watershed due to intensive swidden agriculture practices and extensive livestock rearing in the middle and upstream.

Manikin watershed management is not only managing biophysical watershed area, but also effort to improve the quality of live for people within the area. It is not easy to realise it due to agricultural development in the dryland areas particularly in the upstream of the watershed is more complex than in the downstream [27,28]. Land resources in the upstream is limited by slopes and accessibility as well.

Study related to the swidden agriculture particularly in the upstream of watershed area in Timor is rarely. Research conducted by [21] and [15] and most recently by Fallo [15] was more on the anthropology aspect and land management related to sedimentation. Those research are useful in documenting swidden agriculture process but less taken into consideration of biodiversity, biosecurity, and food security which are base for designing to improve the swidden agriculture system. The paper organised into four main sections. After this Introduction, the second section discussed Methodology shortly. The third section is Results and Discussions which elaborated main findings of the research. The last section is a Conclusion drawn from previous sections.
2. Materials and methods

2.1. Research site and materials
The research was conducted in Manikin watershed (MW) of Kupang District – West Timor. MW is chosen purposively based on its significance to supply irrigation water in downstream of Kupang bay mainly for rice and horticulture crops; while swidden agriculture practices in the upstream that needs to be well managed for healthy watershed environment.

Population of the research is all households that applied swidden agriculture in the Middle and Upstream of Manikin Watershed. Therefore, based on the administration area, the population distributed in the villages in the Upstream are as follows: West Bema, North Bemata, Oeltua, Kuaklalo, Oeletsala, Bismarak, Oben, Bokong, Tunbaun, To’obaun, Soba, and Niukbaun. Four villages have chosen purposively such as East Baumata and North Baumata in the Middle of Watershed; while in the Upstream is Oben and Soba villages.

2.2. Data analysis
Purposive sampling employed to determine villages for research sites in MW based on the population number involved in swidden agriculturism and location distance from home and forest. The research employs mixed model study [29] that combine qualitative and quantitative approach so-called concurrent mixed model design [30]. The research used primary and secondary data. For primary data employs in-depth interviews and/or field observation; while for secondary data mainly taken from Statistical Data.

3. Results and discussion

3.1. General description of research site and SA
Manikin watershed categorised as small watershed, long shape and started from the South for the upstream and down to Kupang bay for downstream. Based on Strahler river type clasification, there are 5 river types with total cumulative 3,309 km with the elevation of 30%, and consists of four formation such as Alluvial, coral limestone, Bobonaro complex, and Noele formation. The result of Landsat 8 OLI 2017 analysis showed land covers dominated with savannah/bush with Total 5,323 ha or 47.36% and followed with cultivated upland with total 1,783 ha or 15.86% (Table 1).

| River type | Number | Commulative long (km) |
|------------|--------|-----------------------|
| 1          | 94     | 70,545                |
| 2          | 38     | 36,816                |
| 3          | 23     | 19,811                |
| 4          | 20     | 13,411                |
| 5          | 6      | 3,309                 |

Source: Tabulated/analysis from secondary data

Manikin watershed dominated in the elevation 100 up to < 300 m asl which consists of 5,913.42 ha or 52.63% of overall watershed (Table 2). Southern part of watershed is considered upstream area or water catchman area due to it is in the higher elevation, while northern part is considered as downstream zone. Total population in three sub-districts is 44,277. Highest population in Taebenu and followed West Amarasi and the last Nekamese. The highest farmers population is in the East Baumata village (68%) and followed with Soba, and Oben, while the lowest population in North Baumata. Total area for maize cropping in West Amarasi was 875 ha and in Nekamese was 805.9 ha.

Like in other parts of Timor Island, swidden agriculture have been practiced by upland communities in Timor for generations. At the present, the land cultivated only for 2 - 3 years before fallowed around 5 – 7 years, depend on the vegetation growth or soil fertility. Farmers started do cutting the trees/scrubs
normally in the beginning of dry season and let it dry and burning it before rainy starts. Depend on land size and vegetation density, the process normally took around 3 months started on June up to September/October.

Table 2. Elevation distribution of Manikin Watershed.

| Elevation (m asl) | Area (Ha) | %    |
|-------------------|-----------|------|
| 0 - 99            | 2,141.30  | 19.06|
| 100 - 199         | 2,906.26  | 25.87|
| 200 - 299         | 3,007.16  | 26.76|
| 300 - 399         | 2,153.41  | 19.17|
| 400 - 500         | 1,027.50  | 9.15 |

Source: Secondary data analysed

Before set fire, farmers prepare fire break or Ta’sako in Meto language to avoid wild fire burning unwanted area. Farmers do set fire all dry biomass in the land so-called Kono or fire scratch. Planted will be done soon after the first rainy started which normally happening in November or December. Farmers applied mixed-cropping pattern that dominated with maize crop followed with pumpkin (Cucurbita moscata, Durch), rice bean (Vigna unguiculata, Thurb), and cucumber (Cucumis sativus, L). Farmers do weeding around 3 weeks after planting using simple equipment called Tofa. There is no chemical fertilizer and pesticide used.

Swidden agriculture in Timor is not merely considered as technical product. It can be seen based on the pattern, orientation (practical), decision, content (technical component), process and output that relatively similar among communities in a region and between neighbouring region or areas.

3.2. Farmers actor dimension and the dynamic of Swidden Agriculture

78% of respondents in Manikin watershed were in the productive category, while the rest 22% in the unproductive category. 44% of respondents were only finished primary school. Total respondents never attending school up to finish primary school was 59 % which mean average education level was low. Average number of household member was 6 persons. 29% of household has household members more than 6 persons. The main asset of the household were upland and house garden. 17% of household does not own upland; 22% own upland with size less than 0.5 ha. Average household income was 31 million IDR/year which 17.98 million IDR or 58% comes from agriculture and Rp 13.02 million or 42% comes from non-agriculture. This composition explains that farming is still main source of livelihoods of people in Manikin watershed. Livestock contributed almost 63% of the household income while from the crops was only 37%. Nominal income from non-agriculture 5.3 million IDR/year; agricultural labour 4.2 million IDR/year and from non-agricultural labour 3.5 million IDR/year. Farmers expenses mainly for food 12.54 million IDR/year (60%) and non-food 8.36 million IDR/year (40%). Therefore, total household expenses was 20.9 million IDR/year. This means that average household expenses per month was 1.74 million IDR or close to minimum wage of labour in ENT.

Over the years SA practices, SA have shape farming practices and environment in semi-arid areas of Timor. The dynamics and trend of swidden agriculture in Manikin watershed is summarised in Table 3.

Although, swidden agriculture remains practiced, there have been changes in land use and land covers. In general the dynamics of land use can be divided into three pattern: (1) Around 20 farmers employs rotation system from: primary/secondary forest to slash and burn to cultivation to fallowed/bush/secondary forest and then return the cycle; (2) Around 50% farmers apply: primary/secondary forest to slash and burn to cultivation to mamar (local agroforestry); (3) Around 30% farmers apply: primary/secondary forest to slash and burn to cultivation to agrosilvopasture (30%).

Table 3. Dynamics of land use in Manikin Watershed.

| Pattern Description                                                                 | Percentage |
|-------------------------------------------------------------------------------------|------------|
| Primary/secondary forest to slash and burn to cultivation to fallowed/bush/secondary | 20%        |
| Forest to slash and burn to cultivation to mamar (local agroforestry)               | 50%        |
| Primary/secondary forest to slash and burn to cultivation to agrosilvopasture       | 30%        |
Table 3. Dynamics of SA in Manikin Watershed.

| Aspects                  | Food production | Economy/Market | Ecology | Socio-cultural |
|--------------------------|-----------------|----------------|---------|----------------|
| Food crops diversity     | Decrease        | Increase       | Decrease| Remain         |
| Forages (Leucaena)       | Increase        | Increase       | Increase| Remain         |
| Cattle fattening         | Remain          | Increase       | Increase| Changes        |
| Fallow period            | Remain          | Remain         | Remain  | Remain         |

Source: Primary data/Interpretation based on the in-depth interview.

3.3. Agroecosystem characteristics of MW and suggestion for improvement

Agroecosystem characteristics of swidden agriculture in Manikin watershed have characterised by Low Productivity per commodity, nevertheless in overall categorised as medium due to no external input used and minimize risks. Maize productivity 2.4-2.8 t/ha, pumpkin 10 – 15 ton/ha, and rice bean 2 ton/ha which is lower than national average.

Low stability productivity tends to be declining in short periods of planting seasons; High Equitability due to more than 80 % of households settled in Manikin watershed have been practicing swidden agriculture; High Adaptability due to in unfavourable environment, the slash and burn system is still produce fair level of food crops for household consumption; and it has High Autonomous due to the system have fully operated by farmer’ household and almost no external input used. High adaptability and some important components (e.g. without external input used, save labour, it needs only simple equipments, and better performance of the crops as fire neutralise pH of soil) which are suits with marginal or resource poor farmers becomes the main reasons why upland farmers in the Manikin watershed keep practicing the slash and burn system.

It was clearly that by SA within high population pressure have contributed food unsecurity in semi-arid area. However there are some agricultural innovations or component technology that can be introduced/adapted to improve the system such as implementing some conservation agricultural principles [31] such as minimal soil disturbance, permanent soil cover and crop rotations, sthrengthening mixed-cropping system and adapting some High Yield Varieties (HYVs).

In order to preserve the system by maximizing its positive aspects and minimizing its negative impacts, some principle suggested such as minimise environment damage during land preparation, introduce some components to improve crop production, no change indigenous or existing commodities that strongly related to the local people’ staple, low cost and easy to be adopted, tends to be permanent farming, and broadening Mamar or local agroforestry local.

4. Conclusions and recommendations

4.1. Conclusions

Agroecosystem characteristics of swidden agriculture in Manikin watershed have characterised by low Productivity, low stability, high equitability, high adaptability, and high autonomy. The strength of swidden agriculture system in Manikin watershed lies in the assumption that this system can improve soil fertility and practical implementation of the system that suit with farmers’ circumstances. Besides, farmers do mixed cropping pattern as a strategy to minimise risk in low and erratic rainfall. The crops being planted are supporting the system and part of the main diet of local community. The system have probability to be developed to becomes sustainable permanent farming. Scenario that can be suggested are developing mamar system or local agroforestry system and developing alley cropping system into existing local agroforestry or Improved Dryland farming System/IDFS’ like using permanent planting hole (PPH).
4.2. Recommendations
To realize sustainable agriculture in the swidden agriculture system, improved farming system/IFS is a realistic approach that suitable with farmers’ circumstances of Manikin watershed. The IFS emphasize in improving/adapting High Yield Varieties (HYVs), cropping pattern to increase crops population and improvement techniques in land preparation. It needs to improve farmers’ capacity in order to accelerate adoption process of technical innovations like through training and farmers’ cross visit.

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